Cat. No. 122

SURPLUS CONVERSION HANDBOOK

Including "Command Sets"

INCLUDING:

AN/ARC-1
AN/ARC-3
AN/ARC-4
AN/ARC-5
ARC-36
ARC-49
AN/ART-13
ATA
ATC-1
BC-191F
BC-224
BC-312
BC-314
BC-342
BC-344
BC-348
BC-375E
BC-453
BC-454
BC-455
BC-457A
BC-458A
BC-459A
BC-603
BC-604
BC-620
BC-624A
BC-625A
BC-659
BC-669
BC-683
BC-684
BC-696A
BC-779
BC-794
BC-946
BC-1004
BC-1068A
CBY-52232
PE-73
PE-103
R-129/U
RAX-1
SCR-177
SCR-188
SCR-193
SCR-274N
SCR-399
SCR-499
SCR-508
SCR-509
SCR-510
SCR-522
SCR-528
SCR-542
SCR-608
SCR-609
SCR-628

AND OTHERS

Technical Series

by

Tom Kneitel, K3FLL/WB2AAI

$3

SURPLUS CONVERSION HANDBOOK

Including "Command Sets"

Edited by

Tom Kneitel, K3FLL/WB2AAI

COWAN PUBLISHING CORP.
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In memory of my father.

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introduction

The past two decades have seen such national institutions as the mumu, the hula hoop, and the Edsel come into being and then sink into oblivion. There are only two things left from the past, Ed Sullivan and military surplus radio gear. Yes, even after 20 years it is still possible to work up complete (and good) ham station from this equipment—and do it for far less loot than putting a commercially manufactured ham station on the air. And the really best part of it all is the fact that the equipment lends itself to giving lazy non-equipment constructing goof-offs some man hours behind a warm soldering gun.

Surplus prices aren't too different than they were right after the war. You can still buy ARC-5 and 274N transmitters for $5 and receivers for $7, the ART-13 (a 100 watt fone/CW transmitter for 20, 40 and 75 meters) is available for about $40, and the great BC-342 receiver can still be picked up for less than $50. The reason why these pieces of gear are so relatively inexpensive is that you are going to have to add some elbow grease and solder to get them in operation. Not that they are defective, it's just that they run on such improbable things as 400 CPS or 24 volts, or sometimes the frequencies covered don't include a ham band, or the crazy thing was designed for remote controlled operation. Whatever it is, you aren't going to take very much surplus gear home, plug it right in, and be the hit of the band.

While it is true that there have been numerous articles regarding how to convert various pieces of surplus gear for ham operation, most of them seem to have been buried away in old and unlocatable issues of ham magazines. If you've already bought a piece of surplus equipment only to find that the conversion instructions can't be obtained you know the feeling of horror and frustration as you decide whether to use the thing as a doorstop or to give as a birthday gift for your nephew (a CB'er).

We hope that this jim-dandy, handy, volume will be the answer to your problems. It contains complete conversion data on all *of the ARC-5 and SCR-274N Command Sets, and on all manner of other transmitters and receivers which are worth the trouble to convert for ham use. The hearty souls who originally devised the conversions in this manual did their good work many years ago—most have moved since last heard from, some are silent keys, others have long since forgotten any details of the conversions they engineered. In other words, if you are stumped by a description of something in this book, lots of luck; because we have no more idea of the answer than you. We have gone over these conversions as carefully as possible, however, and have attempted to eliminate any confusing points.*

On page 5 you will find a lengthy appendix of equipment described in this volume. Because many pieces of surplus gear have almost identical circuits, although having different names, we have also listed the various "first cousins" of the equipments described in the conversions.

Thanks for the production work on this book go to Solomon Nussbaum, who rues the day the government invented surplus; and to David Saltman of The Elgin Press, who warned me that the photographs in this book (which were reprinted from ancient magazine articles) were going to come out lousy.

Other volumes of interest to anyone working with surplus are "Surplus Schematics Handbook," by Ken Grayson, W2HDM, available for $2.50 from Cowan Publishing, 14 Vanderventer Ave., Port Washington, N. Y. 11050; and "Index To Surplus," by Roy Pafenberg, W4WKM, $1.50, from 73, Inc., Peterborough, N. H. The first book contains schematics of some 116 pieces of surplus gear. The second book is a bibliography of conversion articles appearing in ham magazines from 1945 to 1961.

Tom Kneitel, K3FLL/WB2AAI

CONTENTS

CHAPTER I.
Complete Stations 16
CHAPTER II.
Transmitters 61
CHAPTER III.
Frequency Control 97
CHAPTER IV.
Mobile 111
CHAPTER V.
Modulation 125
CHAPTER VI.
Interference 131
CHAPTER VII.
Receivers 137
CHAPTER VIII.
Power 186
CHAPTER IX.
Miscellaneous 191

CONVERSIONS IN THIS BOOK

Note: Equipments shown with one asterisk (*) are covered under "Command Rcvrs.", those with two asterisks (**) are listed under "Command Trans."

ARA .... *
ARC-1 28
ARC-3 37
ARC-4 .... 43, 47, 48, 50
ARC-5 .... * & **
ARC-36 37
ARC-49 37
ART-13 .... 81, 86, 91
ATA .... **
ATC-1 .... 81, 86, 91
BC-191 .... 94, 96
BC-224 .... 171, 176
BC-312 .... 171, 176
BC-314 .... 171, 176
BC-342 .... 171, 176
BC-344 .... 171, 176
BC-348 .... 171, 176
BC-375 .... 94, 96
BC-453 .... *
BC-454 .... *
BC-455 .... *
BC-457 .... **
BC-458 .... **
BC-459 .... **
BC-603 151
BC-604 77
BC-620 23
BC-624 .... 43, 50
BC-625 .... 43, 47, 48, 50
BC-659 23
BC-669 54
BC-683 151
BC-684 77
BC-696 .... **
BC-779 .... 157, 166
BC-794 .... 157, 166
BC-942 185
BC-946 .... *
BC-1004 .... 157, 166
BC-1068A 179
CBY-52232 .... **
Command Rcvrs. 9, 16, 21, 104, 109, 111, 137, 140, 144, 145, 146, 147, 148, 181, 182, 133, 192
Command Trans. 9, 16, 21, 61, 64, 65, 70, 72, 73, 74, 75, 76, 80, 96, 98, 104, 111, 125, 127, 131, 133
HQ-120 .... 157, 166
HQ-129X 157, 166
PE-73 186
PE-103 111
R10A .... *
R11A/ARC-5 .... *
R22/ARC-5 .... *
R23/ARC-5 .... *
R24/ARC-5 .... *
R25/ARC-5 .... *
R26/ARC-5 .... *
R27/ARC-5 .... *
R28/ARC-5 185
R112/ARC-5 185
R129/U 157, 166
R148/ARC-5 .... *
RAT .... *
RAV .... *
RAX-1 .... *
RBD .... *
RT-18/ARC-1 28
SCR-177 .... 94, 96, 171, 176
SCR-188 .... 94, 96, 171, 176
SCR-193 .... 94, 96, 171, 176
SCR-274N .... * & **
SCR-399 .... 171, 176
SCR-499 .... 171, 176
SCR-508 .... 77, 151
SCR-509 23
SCR-510 23
SCR-522 .... 43, 47, 48, 50
SCR-528 .... 77, 151
SCR-542 .... 43, 47, 48, 50
SCR-608 .... 77, 151
SCR-609 23
SCR-610 23
SCR-628 .... 77, 151
SP-200 .... 157, 166
SP-210 .... 157, 166
SP-400 .... 157, 166
T15/ARC-5 .... **
T16/ARC-5 .... **
T17/ARC-5 .... **
T18/ARC-5 .... **
T18/ARC-5 .... **
T19/ARC-5 .... **
T20/ARC-5 .... **
T21/ARC-5 .... **
T22/ARC-5 .... **
T47/ART-13 .... 81, 86, 91
Type "K" .... * & **
Crystals 97

General

SURPLUS LINGO

KNOWING WHAT YOU BOUGHT

One of the biggest problems confronting the surplus addict is how to convert when no information is available. It seems a shame that you might have a perfectly good piece of equipment and find that you don't know how to get it on the air. This is the general case—or so our mailbag leads us to believe. Converting surplus equipment is not difficult providing certain procedures are followed. For the most part, test equipment is simple and not expensive. A good volt-ohm-milliammeter and perhaps a grid-dip oscillator are the basic instruments. Occasionally a signal generator and an oscilloscope may be required, but these are usually easy to borrow.

Of course the first step in converting any surplus is to select the equipment. This may sound silly, but I have often seen someone select a piece of equipment just to convert and then find that the job just cannot be done . . . as a matter of fact I've done it myself. Othertimes it may prove actually cheaper to go out and buy a commercial item and save quite a bit of money . . . not to mention time and headaches. Some gear just doesn't lend itself to surplus conversion. But in any case, having decided that you want to convert a piece of equipment obtain it in the best possible condition you can afford. Try to get a schematic with it—unless you like to circuit trace. Quite a few sources exist for obtaining diagrams and manuals just in case—but that is an additional effort you have to go through. Make sure too, that you get all tubes and plugs that you might need—trying to find that crazy power plug late some Sunday evening just to let you get on the air isn't conducive to happiness.

The second step in surplus conversion is to get the equipment working. The usual answer to this is that, "I'm not using it for the original purpose," well so much more the reason. Maybe some critical part is faulty and you never knew it. Of course you can also find out the power supply requirements and the tuning range as well as other feature which will allow you to modify with a lot less effort. Once operating, you can modify the equipment by sections and check each change as you go along by turning on the power—unless an extensive alteration is underway.

The third step in any conversion is to decide exactly what it is that you want to convert. You can refer to handbooks, magazines, your own experience or other hams to find out how to do it. Perhaps one article showed a conversion, some section of which you want to use. Well then disregard all but the section that you want and do just what has to be done.

The fourth step is to verify your conversions. Check the circuit for shorts and correct wiring and apply the rated voltage. Tuning and many other adjustments may be made by means of the grid-dip oscillator. Once the circuit is working try and optimize your work. Perhaps a resistor somewhere can be slightly changed to increase the gain and perhaps some feedback will help out in stabilizing the operation of another stage. Don't be afraid of making these changes but always have some mean value to start with.

The fifth step is the one that is usually overlooked. Keep a log. You would be surprised how often you may want to refer back to that change that you made and find that you have no information except in your head. This is especially true if you want to swap some day and you suddenly need the circuit, but lo and behold it doesn't exist.

Selecting the right piece of surplus for what you want to do is not difficult now-a-days. More equipment seems to be hitting the market every day. Of course some gear will function right in our ham bands without modification of any kind, but will it do it with any degree

Set or equipment indicator letters

type of installation	type of equipment	purpose
A Airborne (installed and operated in aircraft)	A Invisible light, heat radiation	A Auxiliary assemblies (not complete operating sets used with or part of two or more sets or sets series)
B Underwater mobile, submarine	B Pigeon	B Bombing
C Air transportable (inactivated, do not use)	C Carrier	C Communications (receiving and transmitting)
D Pilotless carrier	D Radiac	D Direction finder and/or reconnaissance
	E Nupac	E Ejection and/or release
F Fixed	F Photographic	
G Ground, general ground use (includes two or more ground type installations)	G Telegraph or teletype	G Fire control or searchlight directing
		H Recording and/or reproducing (graphic meterological and sound)
	I Interphone and public address	
	J Electro-mechanical (not otherwise covered)	
K Amphibious	K Telemetering	
	L Countermeasures	L Searchlight control (inactivated, use "G")
M Ground, mobile (installed as operating unit in a vehicle which has no function other than transporting the equipment)	M Meterological	M Maintenance and test assemblies (including tools)
	N Sound in air	N Navigational aids (including altimeters, beacons, compasses, racons, depth sounding approach, and landing)
P Pack or portable (animal or man)	P Radar	P Reproducing (inactivated, do not use)
	Q Sonar and underwater sound	Q Special, or combination of purposes
	R Radio	R Receiving, passive detecting
S Water surface craft	S Special types, magnetic, etc., or combinations of types	S Detecting and/or range and bearing
T Ground, transportable	T Telephone (wire)	T Transmitting
U General utility (includes two or more general installation classes, airborne, shipboard, and ground)		
V Ground, vehicular (installed in vehicle designed for functions other than carrying electronic equipment, etc., such as tanks)	V Visual and visible light	
W Water surface and underwater	W Armament (peculiar to armament, not otherwise covered)	W Control
	X Facsimile or television	X Identification and recognition

of efficiency. Is it worth spending a couple of hundred dollars on a fifty watt transmitter for 220 Mc when the input will be almost a kilowatt and you have to supply all of that power? Sometimes it definitely pays to buy a piece of gear just to use some section of it. Perhaps a power supply may lend itself to something you have. Much 400 cycle equipment is available today which cannot be used on standard 60 cycle power lines. As a result a new power supply will be required before any other conversion is started.

Much thought should be given to surplus which performs one special function only. For example one beautiful VHF receiver has been around for several years and at a good price . . . for parts. One look at the schematic will tell you that it is a superhet and requires a separate local oscillator (from some other gear) to make it work. On top of that it gives only 150 and 90 cycles output, not exactly suited for voice. I don't mean to be discouraging, just practical.

On the other hand the BC-312 and the BC-348 receivers once so popular are hardly heard of yet still around. They offer so much per dollar with the least effort that it seems amazing that more has not been done with them. We hope to correct that too.

Designations

One of the things which is highly misunderstood by most hams (and surplus dealers too) is the system of designating equipments in the Armed Forces. Several systems are currently employed, but only one is being continued. The modern method sometimes called the AN system follows a standard pattern lets the name of the equipment denote its usage. The ARC-5's are in this category. Officially they are known as the AN/ARC-5 (Some were known under the SCR-274N number). The AN designated it as military and the ARC-5 means *A*ircraft, *R*adio, *C*ommunications, fifth system. Table 1 is a complete breakdown on this nomenclature. Individual subdivisions of equipment are given titles as T-21/ARC for a transmitter and R-28/ARC for a receiver, for specific identifications.

Until the advent of this system the Signal Corps used a serial system such as SCR-522 (Signal Corps Radio model 522), which had basic components such as the BC-624, BC-625 (transmitter and receiver) and control box and a power supply each with their own number. The Navy used two systems simultaneously—one for identification and one for accounting purposes. Both have been supplanted by the AN system. Navy equipment could be identified as to usage by the first letter of the two or three letter identification. T would be indicitive of a transmitter, R for a receiver, D for direction finder and S was used for Radars. The letter "O" was for test equipment and L for frequency measuring or generating equipment. The "M" was applied to special equipments. For Aircraft the letter A was used as a prefix to any of the above.

The second system used by the Navy has caused much confusion. At one time all equipment in the Navy was designated by a two, three or four letter symbol and five digits. The first letter always being "C", and stood for the word *contractor*. The following letters identified the particlar contractor. CUT, for example meant that the United Transformer Company made that particular piece of equipment, while CRC stood for RCA and CG for General Electric. The first two numbers, in the following five digits, identified a particular equipment class such as 46 for a receiver and 30 for an electron tube. The following three numbers were serial numbers, thus several manufacturers may have made an identical part, the identity number would be the same for all but the "C" symbol would be different. Thus CRC 46136 would be an RCA manufactured receiver. To this day the Navy still identifies all manufacturers and contractors by this system.

Equipment and Service	Function	Freq Range Megacycles	Conversion Band	Conversion Required	Value $	Original Voltages	Misc. Notes
TCS (Navy)	R-T 2 units	1.5 to 12	160 to 40 (higher if reworked)	Power Sup.	35 per unit	12, 24 DC 110 DC 110 AC	Excel. buy MO and Xtal FB Novice 25 W CW
TDZ (Navy)	T	200-400	144 & 220	Heavy Power Supply	X	Various	Very big for power out. Pretuned Channels
RDZ (Navy)	R	200-400	144 & 220	Power Supply	X	Various	FB for VHF
TBS (Navy)	T-R 2 units	60-80	6 & 10	Power	35 per unit	Various	Xtal Control on both 50W A3
MBF (Navy)	T-R	60-80	6 & 10	Minor Coil Changes	30	110V AC & DC	5W A3 FB if in Good Condition
TBX (Navy)	T-R	T 2.0-4.5 R 2.0-8.0	80	Power Supply	X	Batt & Hand Gener.	8W CW 5W A3
TBY (Navy)	T-R	27-80	10 & 6	None	30	Battery	MOPA has built in Calibrator
TBW (Navy)	T	0.35-1.0 3-18	80-40-20	None	45	Gas Gen	FB Novice 100W CW 35 A3
RAL (Navy)	R	0.30-23	160 to 20	None	20	6V Fil 180 B+	TBF Rec
RBM (Navy)	R	0.2-2.0 2.0-20.0 (2 units)	80-20	Power Supply	X	6V Fil 200 B+	Compact Selective
RBZ (Navy)	R	2.0-5.8	80	None	40	Batteries	Miniature Superhet
ARB (Navy)	R	0.195-9.05	180-40	Power Supply	30	24 DC	FB for Conv. Variable IF
GF (Navy)	T	3.0-4.5 6.0-9.05	80 to 20	Power Supply	X	14 or 28	Has VFO
BC-191	T	1.5-18	160 to 20	Power Supply	X	12, VDC	Plug-in heads VFO or 5 Xtal 400 W CW 300 W A3
BC-221	Frequency Meter	0.02-20		Batteries	100	- - - - -	Can be used as VFO
BC-375	T	1.5-18	160 to 20	Power Supply	60	24 VDC	Plug in heads VFO or 5 Xtal 400 W CW 300 W A3
BC-610	T	2.0-18	80 to 20	Power Supply		24 VDC	VFO or Xtal 400 W CW 300 W A3
BC 624	Receiver portion of SCR-522 Equipment						
BC 625	Transmitter portion of SCR-522 Equipment						
BC-639	R	100-156	144 Mc	none	40	110 VAC	One channel Xtal Control
BC-645	R-T	420	420-220 Mc	Fair amount of Conversion Required	30	12 or 24 VDC	IFF Set MOPA superregen receiver
BC-669	R-T	1.6-4.5	80 (also Marine use)	Power Supply	90	24 VDC	4 Xtal plus VFO 45 W A3
BC-779	R	0.1-0.4 2.5-20	80 to 20	none	X	110-VAC	Similar to "Super Pro"
BC-794	R	1.25-40	80 to 10	none	X	110-VAC	Similar to "Super Pro"
BC-906	Oscillator and Field Strength Meter	140-225	144 & 220	none	8.00	Battery	General purpose
BC-1023	R	75 Mc	Any band	Power Supply	4.30	24 VDC	Marker Beacon Superregenerative rec.
BC-1206	R	0.195-0.425	Q-5er	Power Supply	4.00	24 VDC	24 V Plate and Fils. Earphone output
BC-1335	R-T	27-38.5	35-50 Mc.	None for 30 MC	30.00	6 or 12 VDC	4 W F3 See CQ Dec 57
GO-9 (Navy)	T	0.3-0.6 3.0-18.1	80 to 20	Power Supply	X	120V at 800 cps and 28VDC	VFO 100 W CW 75 W A3
ATD (Navy)	T	0.3 to 18	180 to 20	Power Supply	50.00	28 VDC	50 W CW 40 W A3 (conservative) 4 plug in units
AN/ARC-1	R-T	100-156	144 Mc	None	X	28 VDC	10 Xtal channels 8W A3
AN/ARC-3	R-T	100-156	144 Mc	None	X	28 VDC	Auto-tune 10 Channels Xtal control 8 W A3
AN/ARC-4	R-T	140-144	144 Mc	None	30	12 or 24 VDC	4 Channels Xtal Control 8 W A3
AN/ARC-5 (HF-Band)	R-T Separate Units	0.5-9.1(T) 0.19-9.1(R)	Any	Power Supply	4.00 up	24 VDC	See "Command Set" Handbook
AN/ARC-5 (VHF-Band)	R-T Separate Units	100-156	144	Power Supply	20 per unit	24 VDC	4 Channel Xtal Control
AN/ARR-11	R	0.2-0.5 1.5-18.1	180 to 20	Power Supply	X	24 VDC	6 Band Receiver
AN/ART-13	T	0.2-1.5 2.0-18.1	180 to 20	Power Supply	250	28 VDC	11 Preset VFO Channels
ATC (Navy)	Navy equivalent of AN/ART-13						
AN/APN-1	R-T	420	420	Power Supply	3.00	24 VDC	MOPA 1/2 Watt Needs Modulator
AN/ARR-2	R	234-258	220	Power Supply and Oscillator	4.00	24 VDC	Requires separate local oscillator. Fine for VHF parts
SCR-508 SCR-528	R-T	20-27.9	10 & 15 M.	Power Supply	35	12 VDC	30 W F3 Xtal Control 10 Channels
SCR-509 SCR-510	R-T	20-27.9	10 & 15 M	Battery or Vibrapack	X	- - - - -	1.8 W F3 2 Xtals
SCR-522 SCR-542	R-T	100-156	144 Mc	Power Supply	40.00	24 VDC 12 VDC	4 preset Xtal Channels 8 W A3
SCR-536	R-T	3.5-6.0	80 M	Batteries	120 pair	Batteries	0.02 W A3 (BC-611 is individual handy-talkie)
SCR-608 SCR-628	R-T	27.0-38.9	10 M	Power Supply	35	12 VDC	30 W F3 Xtal Control 10 Channels (BC-603 & 604)
SCR-609 SCR-610	R-T	27.0-38.9	10 M	Battery or Vibrapack	X	- - - - -	1.8 W F3 2 Xtals

THE COMMAND SET ROUNDUP

THE SURPLUS BONANZA

In spite of the many articles published about "Command Sets" in the past several years there remains an insatiable appetite among new amateurs for conversion data on the *BC-274N* and *ARC-5* equipments.

Information on the following points is in demand:

1. Basic conversion data.
2. Power supply requirements.
3. Simple modification to crystal control for Novice use.
4. Modifying 4-5.3 Mc. *(BC-457)* and 5.3-7 Mc. *(BC-458)* units to cover amateur frequencies.
5. Transmitter de-TVI'ing information.
6. Receiver data.

This "final-final" article will attempt to assemble the above information in one place for the benefit of all concerned.

The Basic Transmitter Circuit

Although they have different nomenclatures and cover different frequency ranges, all "Command" transmitters utilize the basic circuit shown in *Fig. 1*. A 1626 variable-frequency oscillator drives an amplifier, consisting of a pair of 1625's in parallel. A 1629 "magic eye" tube, in conjunction with a quartz crystal, serves as a frequency calibrator.

A roller-type antenna coil, adjusted by means of a thumb wheel through the front panel permits using almost any *non-resonant* length of wire as a *Marconi* antenna. Antenna coupling is varied, also from the front panel, by a pivoted link coil inside the amplifier coil.

Rated transmitter input is about 90 watts on CW and half that on 'phone. All tubes have 12.6-volt filaments wired in series-parallel and operated from a 25-volt (nominal) d.c. source.

The two important differences between the *BC-* and *ARC-5* model transmitters are in the method of plate feed to the 1625's and the power sockets on the rear. In the *ARC-5's*, an r-f choke feeds the voltage directly to the plates, and a 0.0004-μfd. blocking condenser keeps the d-c voltage off of the tank coil. In the *BC*-models, the plate voltage is fed through the 1625 tank coil. This difference has no practical effect on the operation of the transmitters.

Of more immediate importance are the differences in the power sockets, which are noted in *Fig. 1*.

Adapting The Transmitters

Few amateurs have 25 volts of d.c. available; therefore it is necessary to modify the filament circuit of the transmitters for a-c operation. Either 12.6 or 25 volts may be used. For 25-volt operation, the modification entails three steps:

1. Remove the two resistors *(R70* and *R77)* connected to *pin 8* of the 1629 tube socket. Replace them with a single 2500-ohm, ½-watt resistor connected between *pin 8* and the chassis (ground).

2. Jam both relays *(K53* and *K54)* closed.

3. Mount a key jack in the lower right-hand corner of the front panel. Disconnect the 1625 cathodes from relay *K53* and the 51,000-ohm resistor *(R75)* across it. Connect the cathodes to the jack through a 50-ohm, two-watt resistor. Bypass the cathode of each 1625 tube *(pin 6)* to the metal shell of the tube socket with .005-μfd., 600-volt, disc ceramic condensers *(Centralab DD-502)*. The 50-ohm resistor eliminates the effect of having the "dots" on a slightly different frequency than the "dashes," as sometimes happens when a "bug" key is used.

Operating the filaments on twelve volts requires one additional step:

4. Ground *pin 7* of the remaining 1625 socket (one is already grounded). Tie *pin 1* of the two sockets together and to *pin 2* of the 1629 socket. Remove the 126-ohm resistor *(R71)*, which is connected across *pins 2* and *7* of the 1629 socket and mounted on the rear chassis wall. Transfer the wire connecting *pin 7* of the 1629 socket and the oscillator coil terminal strip to *pin 2* of the socket. Ground *pin 7* of the socket, and connect *pin 2* to the filament terminal on the power socket *(pin 6* on *BC*-models and *pin 5* on *ARC-5*'s.)

This completes the basic conversion.

Power Supply

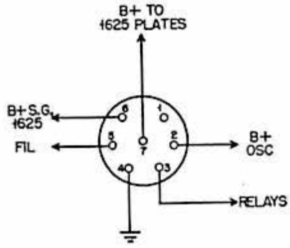
The power supply shown in *Fig. 2* will furnish all power for 75-watt operation of the "Command" transmitters. This level probably represents the best compromise between power output, signal quality, and power supply cost.

Oscillator plate voltage is relatively critical for best results. Approximately 200 volts gives essentially "zero-drift" operation. Either higher or lower voltage causes a frequency drift in one direction or the other. Actually, optimum voltage varies from transmitter to transmitter, but is usually quite close to 200 volts. Fortunately, a deviation of ten or fifteen volts does not degrade performance appreciably. Regulation of the oscillator plate voltage is highly recommended. Two VR-105 tubes in series may be used, between B+ and ground, as shown.

Six hundred volts a-c on the plates slightly exceeds the 550-volt maximum rating of the 5U4G rectifier tube, but such operation does not apparently reduce tube life, especially if the maximum current drawn does not exceed 200 milliamperes. Because the 5U4G is being slightly overloaded, fusing the primary circuit of the transformers is a wise precaution so that, should the tube arc over at the end of its useful life, the fuse and not the transformer will blow.

The transformer, *T1*, in the parts list is one of the very few available stock items that delivers sufficient plate voltage for our purpose and has two 6.3-volt filament windings that may be connected in series to provide 12.6 volts to light the tubes in the transmitter. Transformers with only a single 6.3-volt winding may be used in conjunction with an additional 6.3-volt, two-ampere filament transformer. Connect its primary in parallel with the primary of the plate transformer, and connect the two 6.3-volt windings in series.

The most desirable filter condenser for the power supply is an oil-filled, 1,000-volt unit,



ARC-5 Power Plug Connections.
(REAR VIEW OUTSIDE)

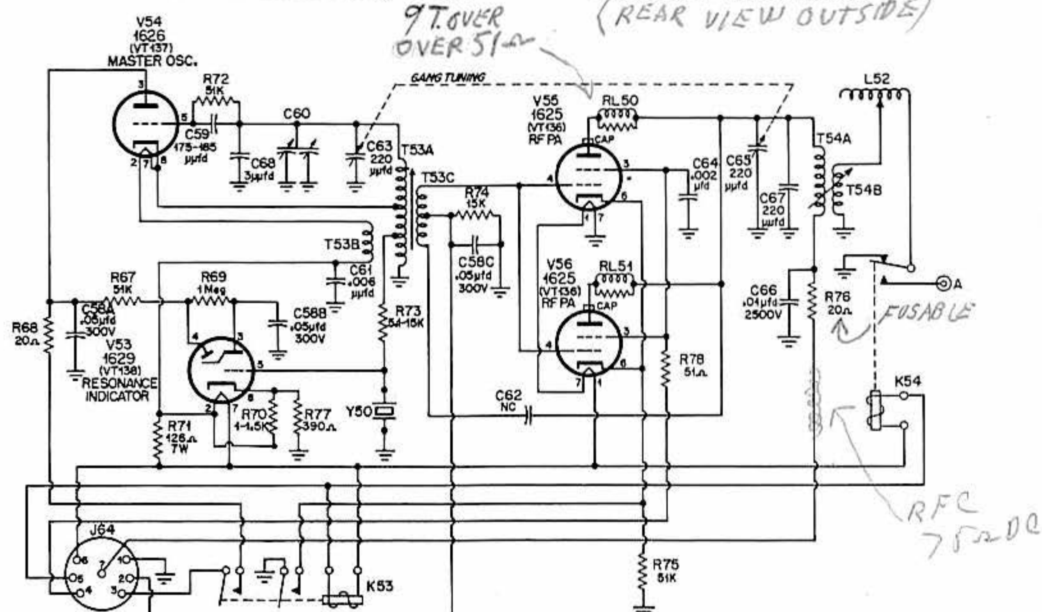


Fig. 1. Typical Command Set transmitter wiring schematic with power plug connections for the "BC-" series.

with a capacity of 4.0 μfd., or more. However, where economy is important, two 8.0 or 16.0-μfd. electrolytic condensers connected in series may be used, with 100,000-ohm 1-watt resistors across each one to equalize the voltage drops.

Probably the easiest way to bring power to the transmitter is through a five-conductor cable soldered directly to the transmitter power socket and terminated in a five-prong male plug for connection to the power supply. Proper terminals to use on the power socket are shown in *Fig. 1*.

To connect the cable to the transmitter, bare and tin about ½-inch of each conductor, and solder them into the appropriate terminals of the power socket. Fasten the cable to the back of the transmitter with a clamp to prevent straining the connections.

Operating and Tuning Up A Command Transmitter

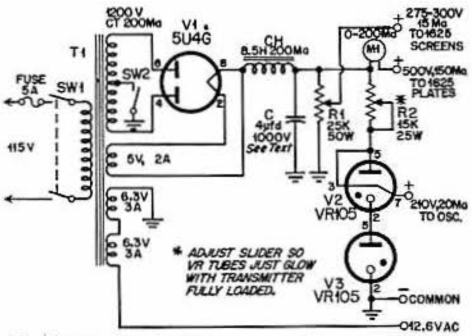
Operating a "Command" transmitter differs little from operating any other transmitter, except in the use of the crystal calibrator, which works in this manner: Normally, the "eye" of the 1629 tube is nearly closed, but when the 1626 oscillator is tuned to the frequency of the calibrating crystal, the "eye" opens to its full width. The transmitter dial reading should then be the same as the frequency marking of the crystal. If it is not, the calibration is corrected by inserting a screwdriver through the slide-covered opening in the transmitter cover and adjusting oscillator condenser *C68*.

Calibrating crystals of other frequencies can be substituted for the one furnished with the transmitter by plugging them into *pins 1* and *3* of the crystal socket.

To load a random length end-fed antenna, connect it to the antenna terminal and ground the transmitter case. Set the link coupling control to about half scale and rotate the antenna loading coil for maximum 1625 plate current, re-adjusting *C65* as necessary to keep the 1625 tank circuit tuned to resonance. Adjust coupling to draw the desired plate current.

Antenna lengths that are an integral multiple of ¼-wave long may be difficult to load, unless a 100-μμfd. variable condenser is available. Connect it *in series with the antenna* for lengths an *odd* multiple of a quarter-wave, and *between the antenna terminal and the case* for lengths that are multiples of a half-wave.

A center-fed doublet using a low-impedance line may be loaded by setting the rotary inductance to minimum inductance and connecting one antenna lead to the antenna post and the other to ground (chassis). Although this theoretically unbalances the antenna system, there does not seem to be any difference in results, on 3.5 and 7 Mc. If insufficient loading is obtained, even with the coupling control set to maximum, a few turns of well-insulated wire may be wound around the bottom (cold end)



T1—Power transformer, 1200v., 200ma., ct.: 5v., 3amp.; 6.3v., 3amp.: 6.3v., 3 amp. (Stancor #8414 or equiv.)
Ch—8.5h., 200ma. (Stancor #C1721 or equiv.)
C—4 μfd. 1000v., oil filled (Cornell-Dubilier TJU, or equiv).
R1—25,000 ohms, 50w. with slider (Ohmite 0585 or equiv).
R2—15,000 ohms, 25w. with slider (Ohmite 0387 or equiv).
SW1—d.p.s.t. toggle.
SW2—s.p.s.t. toggle.
Fuse—5amp.
V1—5U4G
V2—OC3/VR105
V3—OC3/VR105
M1—200ma. milliameter (Triplett 227T or equiv).
Chassis—10 x 17 x 2" 3 octal tube sockets.
Note: meter may be mounted on power supply chassis or at transmitter.

Fig. 2. Parts list and wiring schematic of a power supply suitable for use with the Command Set transmitters. Although the rectifier tube is slightly overloaded no damage should result if the primary of the transformer is fused. The oscillator voltage must be regulated for v-f-o operation.

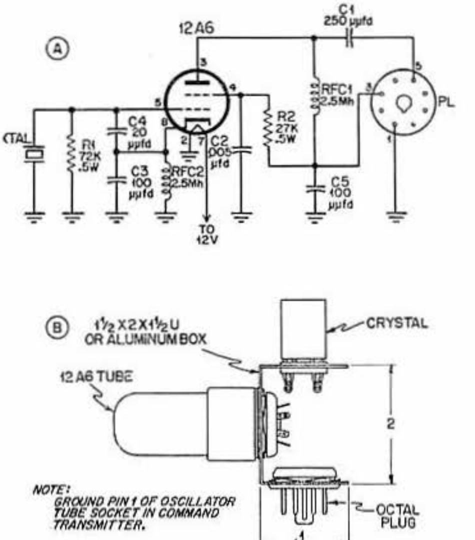
of the 1625 tank coil and connected in series with the link.

Crystal Control

There are two methods of modifying "Command" transmitters for crystal control, which is mandatory for Novice operation. One is to rewire the oscillator for crystal control. The other is to build a plug-in adapter.

An adapter has the advantage that the transmitter is easily restored to variable frequency control by unplugging it and inserting the regular oscillator tube. The diagram *(Fig. 3)* is a modification of the previous adapter, using a 12A6 tetrode in place of the original triode, since it is a more vigorous oscillator with "sluggish" crystals. However, the triode circuit also works well and uses fewer parts. To use the latter, omit *C2, C3, C4, R2,* and *RFC2,* and connect *pin 8* of the tube socket directly to the common ground point.

There are no special precautions required in constructing the adapter, except to position the octal plug so that the oscillator tube extends horizontally over the crystal and 1629 tube sockets when the adapter is plugged into the 1626 socket. Ground *pin 1* of the 1626 socket to use the adapter and connect the external filament wire from the adapter to the "hot" side of the filament supply. Apply not more than 250 volts to the oscillator B+ pin on the power socket. The voltage need not be regulated.



C1—250 μμfd. 600v. ceramic.
C2—.005 μfd. 600v. ceramic.
C3, C5—100 μμfd. 600v. ceramic.
C4—20 μμfd. 600v. ceramic.
R1—72,000 ohm ½w.
R2—27,000 ohm ½w.
RFC1, RFC2—2.5 mh. r-f chokes
PL—Octal plug, male (base of metal tube or Amphenol CP8).
VT—12A6 or 1626 (see text).
Xtal—3.5 or 7 Mc. crystal.
Built-in U bracket bent of aluminum or aluminum box approx. 1½ x 1½ x 2".
To use adapter, ground pin 1 of 1626 tube in transmitter.

Fig. 3. This adapter may be used with any Command transmitter by following the instructions given in the text on the previous page. A partial structural view is shown in "B" and a schematic (parts list above) is shown in "A."

Without plate or screen voltage on the 1625's, adjust the main transmitter dial until the oscillator functions smoothly. Then apply voltage to the 1625's and resonate the 1625 tank circuit by adjusting *C65*. Antenna tuning and loading are described previously.

Utilizing the BC-457 and BC-458

So far, it has been assumed that 3-4 Mc. or 7-9.1 Mc. transmitters, which cover the 3.5 and 7-Mc., amateur bands, respectively, are available. However, 4-5.3 Mc. and 5.3-7 Mc. units are more plentiful and can be modified to cover these and other bands quite easily.

To cover the 3.5-Mc. band with a 4-5.3 Mc. *BC-457* unit, set the oscillator padding condenser *C60* (under the oscillator coil shield) to maximum capacity and re-resonate the 1625 stage with *C65*. The oscillator coil shield must be in place while this is being done.

The easiest way to cover the 7-Mc. band with a 5.3-7 Mc., *BC-458* unit is to decrease the capacity of both padding condensers just enough to permit covering the entire band. A better way is to short out three turns from the top of each coil, before adjusting the padders.

By shorting out the top turn on each coil, removing two rotor plates from each of the ganged condensers, and judiciously juggling the setting of the coil slugs and padders, it is possible to make the 7-Mc. band start at 6.0 on the dial and end at 6.3, giving direct frequency calibration by mentally adding *1* to the dial reading.

Covering Other Bands

Modifying the frequency range of "Command" transmitters to cover other bands requires changes ranging from working on the coils to completely rebuilding the unit. Some of the more-successful methods will be described briefly in the following few paragraphs, with full details to be found in the reference articles.

160 Meters: If the scarce 2.1-3 Mc. *BC-456* transmitter is available, set the padding condensers to approximately maximum capacity. Otherwise, the coils of one of the higher-frequency units may be rewound. A new oscillator coil contains 36 turns of #20 enameled wire, with the cathode of the 1626 connected to the eighteenth turn. The 1626 filament wires *(pins 2* and *7)* are cut completely free of the oscillator coil. Disconnect the neutralizing condenser from the oscillator coil and move *R74* and *C58C* to that terminal. Set oscillator padder to maximum capacity. Rewind the amplifier coil with 34½ turns #18, enameled wire. Tune to resonance with *C65*.

20 Meters: The simplest method of covering 14 Mc. with a "Command" transmitter is to use a 7-9.1 Mc. *BC-459* unit. Disconnect tuning condenser *C67*, and use *C65* to tune the 1625 stage as a 14-Mc. doubler. Disconnect neutralizing condenser from the oscillator coil. Move *R74* to that terminal. Replace *C58C* with an 0.002-μfd. mica condenser. A much better method is to insert a frequency multiplier between oscillator and revamp the amplifier.

15 Meters: With a 7-9.1 Mc. *BC-459* unit, add a frequency multiplier between the oscillator and amplifier. Rewind the amplifier coil to have 5 turns, double spaced.

The conversions using an added multiplier stage may have it installed in the space originally occupied by the 1629 calibrator tube socket.

10 and 6 Meters: Operation on these bands requires practically a complete rebuilding job. The process has been described fully in several articles.

Adding Another Stage To The Command Transmitter

Installing an untuned stage between the oscillator and the amplifier of a "Command" transmitter reduces reaction, resulting in better keying, which is discussed a bit later, and eliminates the possibility of frequency modulation when the 1625's are amplitude modulated for 'phone work. Also, as mentioned above, an extra frequency multiplier is usually required to operate the amateur bands above 7.3 Mc. *Figure 4* is a suitable circuit for either application.

A 2.5 mh. r-f choke acts as the plate load impedance when the stage is to be used as an isolating stage, and a slug-tuned coil is substituted for the choke when a frequency multiplier is required. The switch and coil shown in the dashed lines permits using the stage for either purpose. Of course, for this feature to be of any value, a similar switch must be added to the 1625 tank circuit. Then one transmitter may be used on two adjacent bands.

Rewire the crystal socket for the tube, mount the coil on a scrap of metal in place of the 1629 tube socket, and mount the switch on the rear or side lip of the chassis.

The simplest modification of the 1625 tank circuit for two-band operation is to mount another switch on the side of the chassis behind *C65* and *C67* (See *Fig. 1* and bottom photograph) and wire it so that when it is open, *C67* is out of the circuit. Resonance is obtained on the new frequency near minimum capacity of *C65*. It is convenient to add an external shaft and dial to *C65* for adjustment.

Alternatively, the switch may be mounted above the chassis and used to short out the top half of the turns on the amplifier coil *T54*. Resonance on either band will then occur at approximately the same setting of *C65*, depending upon how accurately the tap is placed. Ganged tuning of the oscillator and amplifier is retained. Also a more favorable L/C ratio in the tank circuit for harmonic discrimination is obtained.

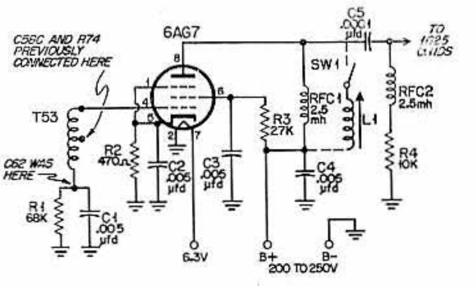
De-TVI'ng The Command Set Transmitter

"Command" set transmitters are notorious TVI producers. However, there are tremendous differences in the TVI produced by apparently identical units. Some are very nearly "clean," and others are just the contrary. Also, the oscillator of one may be full of TVI, with the amplifier relatively clean, or vice versa, or both stages may contribute their share to the overall confusion.

The first step in de-TVI'ing the transmitter is to improve the effectiveness of the bypassing under the chassis, and to cool off the power and key leads. The ingredients required are a handful of 0.005-µfd. disc ceramic condensers and about five feet of shielded wire. Carry out as many of the following steps as are necessary to clean up your troubles:

1. Bypass to ground each of the following points: screen grid of each 1625 *(pin 3)*, plate of 1626 *(pin 3)*, target of 1629 *(pin 3)*, the centertap of the 1625 grid coil, and the point where the filament voltage is fed into the oscillator coil. Disconnect and remove the three-section, 0.05-µfd. condenser *(C58)* mounted on rear lip of the chassis.

2. Replace the leads from the power socket to the various points within the transmitter with shielded conductors, grounding the shield wherever possible throughout its length, especially at each end. At the same time, shorten all ground leads as much as possible and remove unused components and conductors. In low TV-signal areas, it is also desirable to bypass each terminal of the power socket with an 0.005-µfd. disc ceramic condenser. The important point in installing these bypasses is to keep their lead length to an irreducible minimum.



C1, C2, C3, C4—0.005 µfd. 600 v. disc ceramics.
C5—0.0001 µfd. mica or ceramic.
L1—Wound on National XR-50 or equiv. slug-tuned forms 7 Mc. 20 T. #20, enam. close wound. 14 Mc. 10 T. #20, enam. spaced to occupy ½ inch. 21 Mc. 7 T. #20, enam. spaced to occupy ½ inch. (One only required.)
R1—68 K, ½w.
R2—470 ohms, 2w.
R3—27 K, 1w. (May be varied to adjust excitation to 1625's).
R4—10 K, ½w.
RFC1, RFC2—2.5 mh. 50 ma. radio-frequency chokes.
SW1—S.p.s.t rotary switch, preferably ceramic insulated (Centralab 2043 or equiv.) A similar switch is used in the 1625 stage, described in text.

Fig. 4: Diagram of an isolating stage or frequency multiplier which may be substituted in the frequency calibrator stage space of "Command" transmitters. Referring to Fig. 1, the wire between the oscillator coil (T53) and the 1625 grids is removed from the grids and connected to pin 4 of the 6AG7 socket, and the output of the 6AG7 connected to the 1625 grids. Other changes required are to remove the 1625 neutralizing condenser (C62) and disconnect C58C and R74 from the oscillator coil terminal strip. Connect R1 and C1 to the terminal to which C62 was previously connected. When only an isolating stage is required, L1 and SW1 are omitted, and when only a frequency multiplier is required, L1 is substituted for RFC1, SW1 again being omitted

3. With the bottom plate in place, the bottom of the transmitter is quite well shielded, even though there is a theoretical possibility of r-f leakage along the crack between the edges of the chassis and the plate. Use all screws and press the plate firmly into place while tightening them.

4. Another good method of improving the shielding is as follows: Remove the rotary antenna coil and cover the holes in the front panel with a piece of scrap aluminum. Next, bend a piece of bronze screening, 12 x 15 inches, into a trough to fit inside the cover. Then solder another piece across the open back of the trough. When the cover is screwed into place, the screen is clamped firmly between it and the chassis. Pay particular attention to the openings near the rear of the cover at the bottom. They may be sealed off by soldering the edge of the screening at this point.

5. Other methods of improving the shielding of the cover include backing up the ventilating louvres with perforated sheet metal and sealing the tube-access openings on the top with electronic weatherstripping.

6. Undoubtedly the most efficient way to keep harmonic energy out of the antenna circuit is to substitute a coaxial fitting for the original output terminal and feed the antenna through a low-pass filter, in conjunction with an antenna tuner if necessary. Any conventional link-coupled antenna tuner may be used. Also, by remounting the original rotary coil on a small metal base and link coupling it to the transmitter, it will function in much the same fashion as it did before being removed from the transmitter.

After the coil is remounted, close wind a three-turn link of stiff, well-insulated wire (about #16) of a diameter just sufficient to slip over the rotary coil. Slip the link coil over one end of the rotary coil, with the link fitting between the coil and the rod upon which the roller slides. Terminate the link winding in a coaxial cable chassis fitting mounted on the base on a small angle plate. The fitting serves the dual purpose of supporting the link winding and bringing r-f power from the transmitter to the tuner.

Ground the end of the rotary coil under the link winding and connect the roller to the antenna. Adjustment and limitations of the loading coil will be as already described, but with the possibility of inserting a low-pass filter in the link line for further attenuation of harmonic output from the transmitter.

Alternate Keying Methods

The problem of which is the best method of keying "Command" transmitters has caused more hair tearing than any other question. When operated conservatively, excellent keying can be obtained on 3.5 Mc., and good keying on 7 Mc. On the higher frequency bands, however, keying is seldom better than passable, unless a frequency multiplier has been inserted between the oscillator and power amplifier in the course of the modification, and if only the 1625's are keyed.

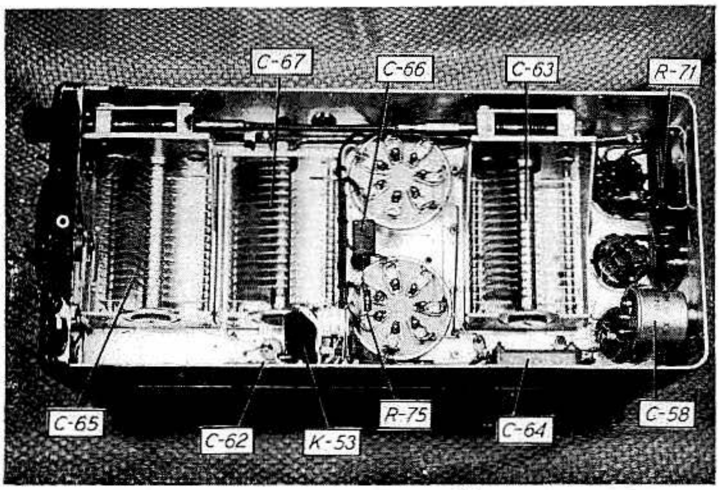
In our opinion, on 3.5 and 7 Mc., straight cathode keying of the 1625's is as good as any type, and better than some. It suffers the disadvantage of not permitting "break-in." Keying the oscillator permits "break-in" operation, but almost invariably accentuates chirps. Expedients used to permit oscillator keying include keying the B— lead of the power supply, keying oscillator B+ and amplifier screens simultaneously through a relay, and replacing the jumper between *pins 7* and *8* on the 1626 socket with a 0.002-μfd. condenser and connecting *pin 8* to the key jack through a 2.5-mh. r-f choke.

Modulation

The transmitters work well on phone at inputs of approximately fifty to sixty watts. In fact, many amateurs run considerably higher power than this on phone, without too much trouble. For an input of fifty watts, any modulator capable of delivering twenty-five watts of audio power may be used. Assuming a 1625 tube plate voltage of 500 volts and a total current of 100 milliamperes, the modulation transformer should be capable of matching the plate load impedance of the modulator tubes to a 5000-ohm load. The screens of the 1625's should be modulated as well as the plates. This is most easily accomplished by feeding the screen voltage through a 10-henry, 50-milliampere filter choke, which will allow them to be self-modulated.

Command Receivers

The most commonly available "Command" receivers are the *BC-453*, covering 190-550 kc; the *BC-454*, covering 3-6 Mc; and the *BC-455*,



Bottom view of the typical Command type transmitter.

covering 6-9 Mc. They all use the same, basic, six-tube circuit, with the filaments of the 12.6-volt tubes wired in series-parallel for operation from twenty-five volts.

As in the case of the transmitters, there are both *BC-* and *ARC-5* models, but the only important difference between them is that the *ARC-5* receivers use a 12SG7 tube in the second i-f stage, while the *BC* models use a 12SK7 tube.

The receivers are quite sensitive and stable, but the two units that cover the amateur 3.5 and 7-Mc. bands leave much to be desired from the selectivity standpoint. Nevertheless, they make excellent "first" or standby receivers. The bibliography contains many references to articles describing how to cover these and other bands with "Command" receivers.

The *BC-453,* 190-550 kc., receiver has proved to be an extremely useful gadget around many amateur shacks. It uses an 85-kc., i-f amplifier, which is very selective. By tuning the main dial to 455 kc., the standard intermediate frequency of most communications receivers, and using a wire connected to the antenna post of the *BC-453* with the other end wrapped loosely around the lead from the last i-f transformer to the second detector in the communications receiver, the combination becomes an extremely selective "dual-conversion" receiver.

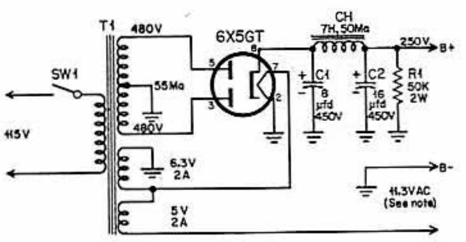
Some amateurs however, just take the i-f transformers from the *BC-453* to build a selective i-f channel in less space.

Modifying The Receivers

To use the receivers in amateur service entails adding a gain control, a beat-oscillator switch and a phone jack, and building a power supply. Also, as it is easier to obtain 12.6 volts than twenty-five volts, it is usually necessary to rewire the filaments in parallel for twelve-volt operation. When this is done, the six-volt equivalents of the original tubes may be substituted and the receivers then operated from a six-volt filament source.

The logical place to mount the new gain control, phone jack, and beat-oscillator switch is on the front panel in the space occupied by the adapter box. Remove the screws holding the box in place. Unplug it and remove the aluminum box holding the socket into which the adapter plugged. Mark the wires that were connected to *pins 1, 4,* and *5.* Remove the rest. Cover the hole in the panel with a flat piece of aluminum upon which is mounted a midget, 25,000-ohm wire-wound potentiometer, flanked by a s.p.d.t. toggle switch and a small phone jack.

Ground the middle terminal of the potentiometer and one terminal of the switch to the ground lug of the phone jack. Connect the *No. 1* wire to the *left-hand* terminal of the potentiometer (viewed from the back with terminals down), wire *No. 5* to the switch, and wire *No. 4* to the phone jack.



T1—Power transformer. 480v., 55ma., c.t., 5v., 2amp.; 6.3v., 2amp. (Stancor PC-8402 or equiv.)
Ch—7 h., 50ma. filter choke. (Stancor C-1707 or equiv.)
C1, C2—dual 8 µfd., 450v. electrolytic.
R1—50,000 ohm, 2w.
SW1—s.p.s.t. toggle.
Octal tube socket
6X5GT tube
7 x 7 x 2" chassis
Additional receiver conversion parts:
25,000-ohm, wire-wound pot. small size.
S.p.s.t. toggle switch.
Single-circuit phone jack

Fig. 5. Wiring schematic and parts list of a power supply unit suitable to operate the Command Set receivers.

To rewire the filaments of tubes, ground one filament pin of each tube socket and connect the other filament pins of each socket together and to *Pin 2* of the three-terminal plug at the rear of the receiver. *Pins 2* and *7* are the filament terminals on all tubes, except the 12SR7 and 12SG7, on which they are *pins 7* and *8.*

Connect power to the three-terminal plug thusly: B— and one side of the filament circuit to *pin 1;* twelve volts, a.c., to *pin 2;* and 200 to 250 volts, d.c., at fifty milliamperes, to *pin 3.*

WARNING! Do not apply more than 250 volts to the receiver; otherwise there is danger of blowing some of the condensers in it.

Figure 5 is the diagram of a power supply suitable for use with "Command" receivers. It is conventional, except for the 6X5 rectifier tube and the use of two filament windings connected in series to operate the tubes in the receiver. The total of 11.3 volts is a little low, but it will satisfactorily operate the receiver.

Obviously, this article just scratches the surface of the vein of information available on the use of "Command" equipment, but we hope that, combined with the bibliography, it serves a useful purpose.

Complete Stations

THE COMPLETE ARC-5 STATION

HAVE YOU EVER noticed the maze of interconnecting wires, key leads, "outboard meters" and other paraphernalia which so often characterizes portable operation? And balancing a bug on the edge of an orange crate doesn't make for the smoothest sending on the air, either.

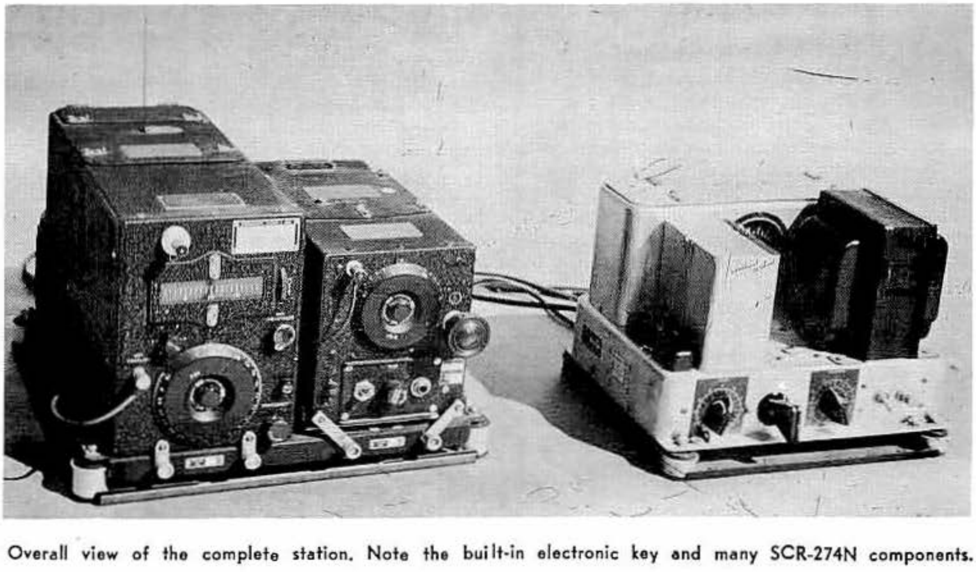
The writer must confess to his share of just such installations. But recently when the need arose for an auxiliary layout at W6OWP, it was decided that the new rig would be different. It would be easy to put on the air. And a few of the operating comforts of the home rig would be incorporated. Then, to add the final touch, the transmitted signal must conform to fixed station standards—no excusing a chirpy signal on the basis of "operating portable hr, OM."

An SCR-274N—the familiar Command Set—was chosen as the basic equipment, both from the standpoint of utility and availability at reasonable cost. Either 40-or 80-meter units may be used, depending on range within which it is desired to operate. At this writing, all SCR-274N components used in the author's set are still advertised by surplus dealers. Here are the items used and SCR designations:

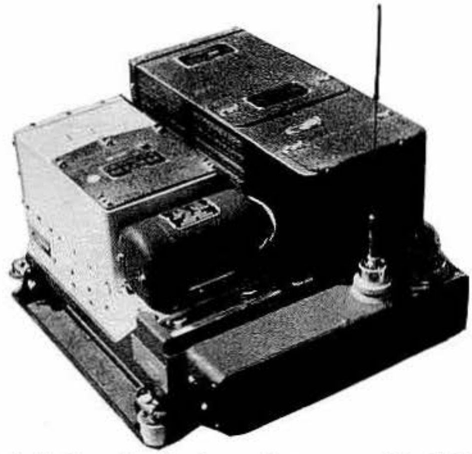
- Transmitter, BC-459 or BC-457 (latter retuned to 3.5-mc band)
- Receiver, BC-455 or BC-454
- Modulator Unit BC-456 (chassis only used)
- Dual Transmitter Rack FT-226
- Transmitter rack shock mounts FT-227
- Modulator unit shock mounts FT-225
- Triple-Receiver rack FT-220 (Used for parts only)
- Antenna Relay unit BC-442 (Meter only used)
- Receiver Dynamotor DM-32

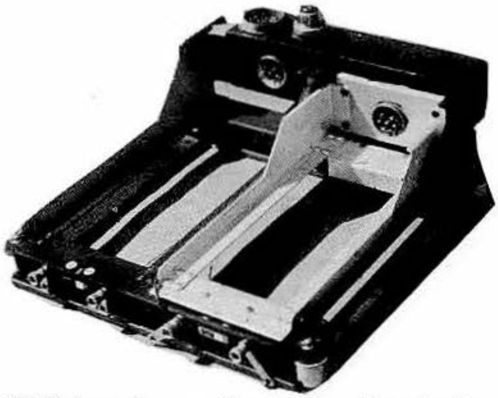
Two major units comprise the station proper: (1) the transmitter and receiver, mounted together in rack FT-226 and, (2) the power supply, keyer and controls, built as one unit on the BC-456 modulator chassis. Shock mounts listed above are used for the respective units. Inter-unit wiring is by means of cable and plugs.

To provide receiver accomodation in the dual transmitter rack, a section from the receiver rack is cut and fitted into the right-hand compartment.



Overall view of the complete station. Note the built-in electronic key and many SCR-274N components.





Left: Rear view showing receiver power unit built into DM-32 dynamotor case. The receiving antenna is plugged into a banana jack mounted in one of the two original connectors on rear deck of the rack. Receiver gain-dropping relay for transmitting is mounted inside the rear compartment. Right: Dual transmitter rack with receiver rack installed in right hand compartment. The author converted both 80- and 40- meter Command units. Desired frequency range is covered by plugging in proper transmitter and receiver.

This is chiefly a hack-saw job and step-by-step details will not be given. The photograph shows the final result. The male power plug in the right rear section of the transmitter rack is removed, thus providing an opening for connections to the receiver.

The BC-456 modulator is stripped of all major components, a procedure not nearly as wasteful as it might appear. The present low cost of these units can be written off on the basis of the tubes and chassis alone. The power supply/keyer as seen in the photograph is *not* a converted BC-456. The chassis is all the present and former units have in common.

Transmitter Electrical Conversion

Basically, the Command transmitter consists of a Hartley oscillator inductively coupled to a neutralized parallel beam tube power amplifier. Because of the lack of an isolation stage, keying and antenna loading must be arranged to minimize reaction on the oscillator if a satisfactory signal is to be had.

Oscillator keying is the logical choice in view of the original circuitry since there can be no isolation of a keyed stage from the oscillator without drastic circuit changes. Furthermore the most click-free form of triode oscillator keying is blocked-grid.

To provide power supply load voltage stabilization, the final stage is self-biased to draw 100 ma key-up plate current, nominal loaded current being this same value. However, a swing of 30% can be tolerated without serious signal deterioration with average power supplies.

The combination of these two relatively simple modifications results in an exceptionally clean c.w. signal. Power input (loaded) runs between 50 and 75 watts. It must be conceded that this conversion will not run the power claimed for certain other arrangements. It was felt, however, that the added signal quality made up the difference—especially since a 60-watt high voltage supply is about all a small rig such as this would normally require.

Pertinent circuit data is contained in *Fig. 1.* The former relay control line connection is removed from terminal #5 on the transmitter power socket and this pin is used for the keying lead. Other pin connections are unchanged.

The oscillator grid leak is cut free on the coil side of the grid condenser, then connected through an r.f. choke to pin #5, as shown in *Fig. 1.* Blocking bias of around 100 volts negative is applied from an external source through a 250,000-ohm resistor. Grounding pin #5 keys the transmitter. No other pin connections are changed.

The cathode bias resistor for the 1625s and its associated bypass condenser are located adjacent to the screen grid bypass to the side of the oscillator tuning condenser. If a cathode bypass similar in type to the one used originally for the screen is available, the two may be mounted together by removing the existing mounting screws and replacing with ones of sufficient length to secure both capacitors.

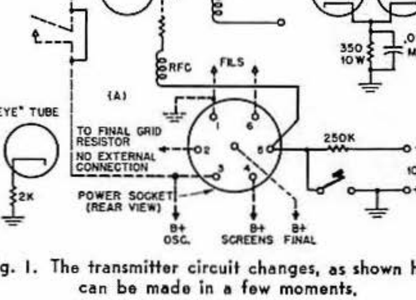


Fig. 1. The transmitter circuit changes, as shown here, can be made in a few moments.

Neither the under-chassis control relay nor the one in the antenna circuit is used. In the latter, the spring contact is soldered directly to the antenna post. In the former, the cathode connection is cut free, the wiring being changed to permanently ground the cathodes through the added 350-ohm self-biasing resistor. The former 51,000-ohm standby bias resistor is removed. The oscillator plate contacts on the control relay are short-circuited by wiring together the contact connections.

Normal operation of the electric-eye tube is achieved by removing the two resistors connected to the eye-tube cathode and replacing them with a single 2000-ohm 1-watt resistor to ground.

Except for wiring filaments in parallel, the only other transmitter change is removal of the chassis ground from the antenna coupling coil. The low side of this coil is connected to an insulated binding post installed in place of the antenna coupling lock. Since the transmitter chassis is common with the ground side of the a.c. line (the result of a receiver half-wave rectifier power supply), the antenna isolation becomes desirable.

Ordinarily, the short antenna used for portable work loads satisfactorily against the a.c. line as a "ground."

The manner of obtaining screen and oscillator plate voltages is important to the proper functioning of this conversion arrangement. A bleeder of from twenty to thirty thousand ohms should be used across the power supply. Oscillator plate voltage is obtained from a tap and should be adjusted to give 150 to 175 volts under load. Screen voltage should be obtained through a series resistor of approximately 15,000 ohms connected to B+. These points are mentioned for the benefit of the reader interested only in the transmitter conversion. The

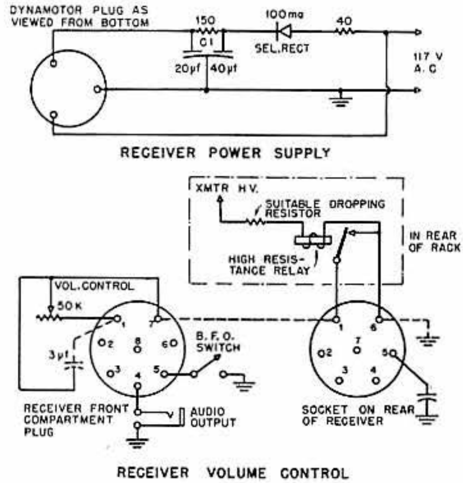


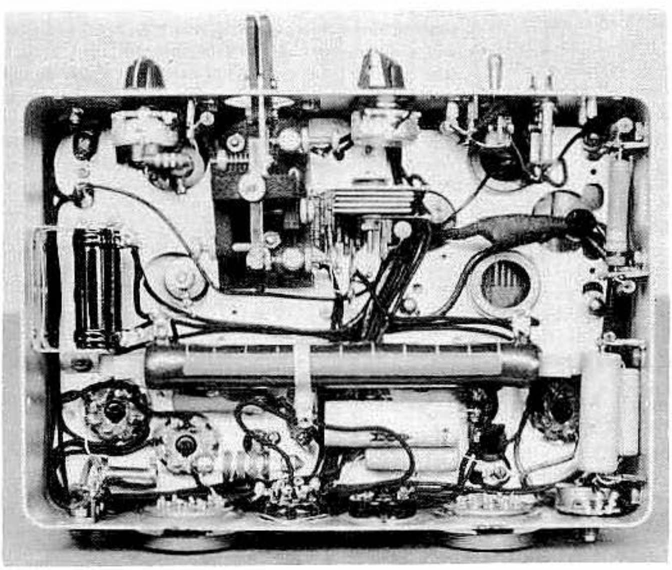
Fig. 2. The receiver power supply (top) fits into the dynamotor housing nicely, and the volume control circuit changes are simple.

required circuit is incorporated in the power unit to be described in a later portion of this article.

Receiver Electrical Conversion

In principle, the receiver conversion follows the lines of previous suggestions carried in the pages of *CQ*. Filaments are wired in series and a 50L6 is substituted for the 12A6 output tube.

Instead of returning the volume control ground lead directly to ground, it is connected to *pin 7* in the front receiver compartment. This pin con-



Under-chassis view of power-supply/keyer unit. Note compactness without undue crowding of parts.

nects to *pin 1* on the rear power socket. The return then reaches ground through contacts of a relay in the rear deck of the rack. This relay operates whenever the transmitter high voltage is applied, opening the volume control ground return. This drops receiver gain to a comfortable level for monitoring the transmitted signal.

Effectiveness of this arrangement requires changing the ground connection of the 3-μf volume control line bypass condenser from chassis to volume control ground return line. This condenser is fastened to the inside front of the receiver adjacent to the control compartment. Since the case serves as its ground connection, it is necessary to mount the condenser on an insulated bracket. This can be made from a composition tie-point connector. The case is then re-connected to the volume control ground return as shown in *Fig. 2*.

The c.w. selectivity of both the BC-455 and BC-454 will be improved by connecting a .02-μf bypass condenser across the audio output. This is most easily done under the chassis and to the rear of the set. *Pin 5* is common with the audio output pin on the front receiver plug. No effort was made to increase bandspread.

Ease of tuning, however, will be enhanced if a wedge-fit knob is substituted for the wobbly, spline-type currently sold for command receivers. A simple five-cent plastic drawer pull can be altered to provide a very satisfactory control. The tapped hole in the base of the pull is first enlarged with a 7/32" drill. Then excess outside stock is trimmed off until the base fits freely into the dial collar. A little pressure will force the new knob onto the tuning shaft spline.

Power supply for the receiver is a half-wave selenium rectifier and filter housed in what was formerly receiver dynamotor DM-32. Once the field coils and armature are removed from the original power unit, there is ample space for mounting the 100 ma rectifier, a dual 40-20 μf 150-volt tubular filter and two resistors making up the assembly.

The a.c. connection is made by means of a line cord directly to this supply rather than through the receiver power socket. Since the supply is a.c.-d.c. a recommended hookup method is shown in the circuit diagram. In this way, the receiver may be used independently of the portable set-up by merely grounding the volume control line at the rear socket (*pin 1* to *pin 6*). The male plug removed from the right-hand section of the transmitter rack when installing the receiver compartment makes a handy shorting plug by merely soldering these two pins together.

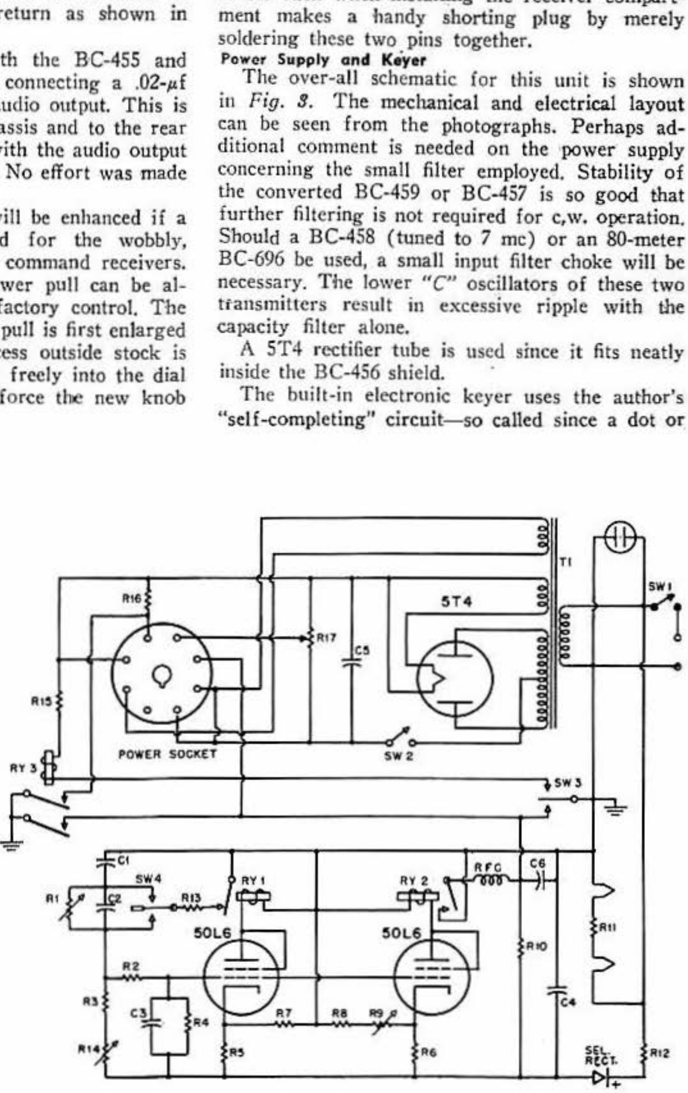
Power Supply and Keyer

The over-all schematic for this unit is shown in *Fig. 3*. The mechanical and electrical layout can be seen from the photographs. Perhaps additional comment is needed on the power supply concerning the small filter employed. Stability of the converted BC-459 or BC-457 is so good that further filtering is not required for c.w. operation. Should a BC-458 (tuned to 7 mc) or an 80-meter BC-696 be used, a small input filter choke will be necessary. The lower "*C*" oscillators of these two transmitters result in excessive ripple with the capacity filter alone.

A 5T4 rectifier tube is used since it fits neatly inside the BC-456 shield.

The built-in electronic keyer uses the author's "self-completing" circuit—so called since a dot or

Fig. 3. Power supply-keyer.
C1—.1 μf, 600 w.v.
C2—.03 μf, 600 w.v.
C3—.05 μf, 600 w.v.
C4—40 μf, 150 v. filter.
C5—10 μf, 150 v. filter.
C6—.002 μf.
R1—.5 meg. variable.
R2, R3—.25 meg., 1/2 w.
R4—4 meg., 1/2 w.
R5, R6—2200 ohms, 1 w.
R7—10,000 ohms, 2 w.
R8—7000 ohms, 1 w.
R9—5000 ohms, variable.
R10—.25 meg., 1 w.
R11—150 ohms, 5 w.
R12—40 ohms, 1 w.
R13—500 ohms, 1/2 w.
R14—2 meg., variable.
R15—Refer to text.
R16—15,000 ohms, 25 w.
R17—25,000 ohms, 100 w.
T1—Power Transformer.
Ry1, Ry2—Pulse relay, 3500 ohms.
Ry3—Refer to text.
Sw1—A.C. switch.
Sw2—H.V. switch.
Sw3—Refer to text.
Sw4—Key lever.
RFC—2 1/2 mh. choke.



dash once started completes itself automatically. This assures freedom from clipping and makes for easier, more uniform sending.

Electrically, the circuit consists of two stages. The first, or pulse stage, develops the basic timing voltage for the automatic dots or dashes. The second stage shapes the operating cycle of the keying relay to conform with correct telegraph mark-to-space characteristics.

Tubes used are 50L6s. These, together with their associated plate circuit relays, are housed in the BC-456 shield enclosure.

A half-wave selenium rectifier furnishes d.c. for the keyer and supplies the blocking bias for the transmitter oscillator keying. The polarity of the selenium stack should be strictly observed in connecting the circuit in the manner shown.

Speed and shaping controls are mounted on the chassis front to the left and right respectively of the key lever. The a.c. line switch is mounted on the speed control potentiometer. The shaping control adjusts keying from light to heavy to suit the operator's particular style. As a general rule, sending with an automatic key sounds better when adjusted on the "heavy" side since a natural tendency to exaggerate letter spacing is less noticeable.

Fixed adjustment, wiping contact relays of identical characteristics are a must for the keyer circuit shown. Either short or long telephone type 2000 to 4000-ohm relays are satisfactory. High quality capacitors, preferably of the new plastic-moulded type, should be used at C_1, C_2, and C_3.

R_1 in the timing circuit sets dot-to-dash ratio. Adjustment should be made starting from minimum resistance to a value which gives correct ratio. Should difficulty with dot distortion be encountered, the rule to follow is: if first dots of a series are foreshortened, add capacity to C_1 and readjust R_1; if the opposite condition prevails, increase capacity of C_2 and readjust R_1. Note that this rule applies only when distortion is present at a setting of R_1 where the correct dot-dash ratio otherwise prevails.

Operating Controls

Transmitter high voltage off or on is controlled by a switch (SW_2) in the transformer center tap. This switch is next to the keyer shaping control. When thrown to the "on" position, a low-current relay (Ry_3) mounted in the rear deck of the transmitter/receiver rack is energized, removing the volume control ground return as described earlier. A second switch (SW_3)—a three-position one removed from the FT-220 receiver rack—is mounted adjacent to the high voltage control. In its "up" position, a second low-current relay (Ry_4) in the power unit is energized. Contacts are connected to short the oscillator key line and at the same time reduce final screen voltage to zero. This serves as a QRP position for QRM-less setting frequency. With the switch in center position, the transmitter is set for normal sending with the electronic keyer. In the "down" position, the key line is shorted for tune-up purposes.

The low-current relays referred to may be any of numerous listings by surplus houses. Coil resistance is usually five to ten thousand ohms and appropriate series resistors must, of course, be chosen.

The plate current meter was taken from antenna relay unit BC-442. This meter has a 10-ma scale. A length of resistance wire shunted across the terminals boosts the range to 100 ma. The exact shunt was found by cut-and-try.

Although available, the original SCR plugs are not used. Standard octal connectors have been substituted for utility. The two small SCR female plugs on the modulator chassis were removed. In one of these an octal socket was mounted and in the other a 117 v. socket for the receiver power cord was placed. Polarity of the latter is clearly marked to match the polarity of receiver line plug. This precaution is necessary because of the separate half-wave rectifiers working off the a.c. line. Using a common ground and only running a hot leg to the a.c. is a desirable safety precaution.

A second octal socket is mounted on the back plate of the transmitter/receiver rack and wired to the appropriate transmitter plug terminals as shown in the diagram. All wiring to the original sockets on the rack is removed. The plug for the smaller of these is fittted with a banana jack and rewired to provide the antenna connection for the receiver. The lead from the socket to the front of the receiver runs in the channel between the two compartments. A six-wire power cable was made up for interconnecting the two units.

For all normal portable operation, a 4-foot whip of #14 steel wire, fitted with a banana plug to mount in the jack, provided above serves as the receiving antenna. This has proved entirely adequate. And it has the advantage of evening up the ratio of transmitted power to received signal. In other words, if you hear 'em, you can work 'em.

For transmitting, a short antenna worked against ground was the system for which the Command transmitters were designed. In the writer's case, a 12-foot whip with a universal-type mounting bracket is used. The whip plus a nominal span of lead-in usually gives a length which can be satisfactorily loaded. Except where a direct external ground to the antenna coupling coil is needed for loading, a wire connects the low side of this coil to chassis, which should be well grounded, and the antenna is tuned up.

Where the total length of antenna, lead-in and ground connection exceeds thirty feet, a 50-$\mu\mu$f series variable condenser is required in the antenna circuit.

The writer has operated the rig described from a score of QTHs in a half dozen western states. The dozens of enjoyable QSOs attest to its good performance. It beats anything of a comparable nature used in 19 years of hamming.

POWER HOUSE *Portable*

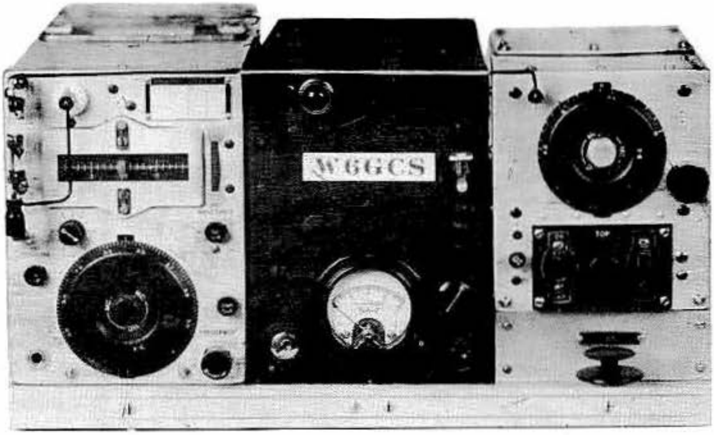


Fig. 1. The complete station. From left to right the units are: transmitter, a-c power supply, and receiver. The hand key is mounted underneath the receiver.

This article does not deal with the conversion of the individual transmitters and receivers of the SCR-274N, but rather is a suggested method of incorporating the converted units into an efficient portable station.

Fig. 1 shows the portable station ready for operation simply by plugging in the a-c line cord and connecting up an antenna. To the left is the transmitter, in the center is the power supply built into an old transmitter cabinet, and to the right is the receiver covering the corresponding frequencies of the transmitter. The baseboard is a solid piece of white pine, one inch thick, twelve inches wide and fifteen and one-half inches long. Under each corner is a rubber foot. The chrome metal trim on the front of the baseboard serves not only to beautify, but as a common ground for all three units.

The receiver is raised to match the height of the other units by building a small shelf from two pieces of white pine, $3/4 \times 1\text{-}5/8 \times 12$ inches. A small metal panel is fitted to the front underneath the receiver and in this space is placed the hand key with the knob extending about one and one-half inches out from the panel. The tail room in this shelf can be used to hold a key-click filter which is generally necessary for the SCR-274N.

The antenna changeover switch is mounted on the upper left-hand corner of the transmitter. This switch is a simple SPDT knife switch obtainable in most dime stores. A No. 12 wire runs across the face of the units from the switch to the receiver antenna post.

The Power Supply

A fly-cutter hole has been cut in the lower center of the front panel to take the $2\frac{1}{4}$ inch, 0–200 d-c milliammeter. Inside the power supply cabinet the meter is just under and clear of the deck of the chassis. This meter is connected in series with the high-voltage lead to the plates of the final amplifier tubes.

At the lower left of the panel is a key lock switch of the ordinary auto ignition type. It prevents anyone, other than the holder of the key, from putting the station on the air accidentally or intentionally. Turning this switch on connects in the a-c line to the primaries of the three heater transformers. The a.c. is applied to the primary of the plate transformer through a switch on the upper right side of the front panel. Since there is no room for a time delay relay within the power supply cabinet this switch has been arranged to prevent the application of the high voltage to the rectifier tubes before they are properly heated. The movable lock must be swung to the right side before this switch can be actuated.

At the right of the milliammeter is a DPDT rotary switch which throws the high voltages either to the transmitter or the receiver. Some care must be exercised here to select a switch with adequate insulation or substitute a relay.

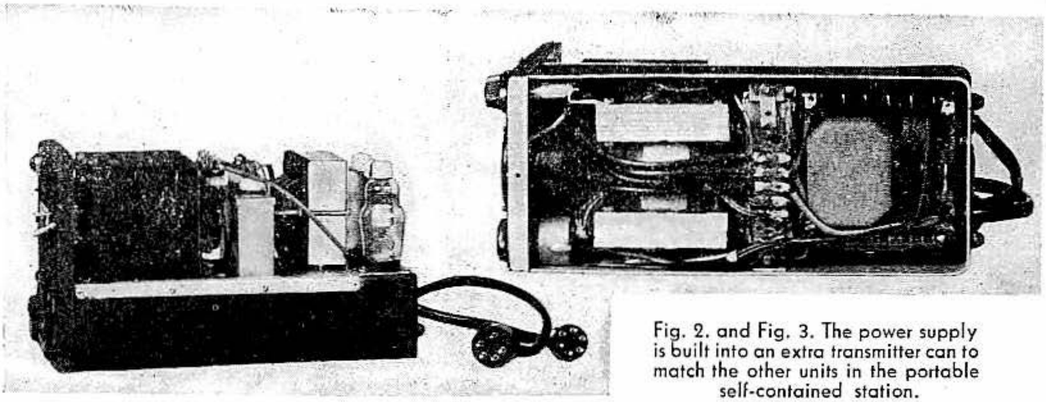


Fig. 2. and Fig. 3. The power supply is built into an extra transmitter can to match the other units in the portable self-contained station.

Fig. 2 and *Fig. 3* show the side and bottom of the power supply. On the top of the deck near the front panel is the plate transformer. Next is the 3-μf oil-filled condenser and then the choke, and finally the two 816 mercury vapor rectifiers. These tubes are mounted in the holes that were once occupied by the oscillator and magic eye tubes. The center hole (where the calibrating crystal was located) is left open for ventilation.

On the underside of the chassis is mounted the two 24-volt heater transformers and 2½-volt 10-ampere filament transformer for the rectifier tubes. On each side of this transformer are the two 50-watt resistors, mounted to the back of the chassis through 2½-inch carriage bolts. The 117 v. a-c line enters through a female socket on the back skirt of the chassis; beside it is the a-c fuse.

The heater and high-voltage leads are cabled out through rubber grommeted holes on each side of the a-c plug. Tube base connectors are used and the leads are sufficiently long to reach the sockets on the backs of the transmitter and receiver.

Operation

Practically no difficulties should be encountered either in setting up these units or getting them on the air. For loudspeaker reception we have cut a hole in the rear of the receiver can and a two-inch speaker is mounted over it. A small output transformer is mounted at the side of the speaker. When in operation the front middle slide on the lid of the receiver is opened for sound release.

With the power supply shown in *Fig. 4* the measured voltages were as follows:

Final plate	650 volts
Final screen	275 volts
Oscillator plate	235 volts
Receiver	260 volts

With the transmitter in operation the milliammeter should read about 180 ma.

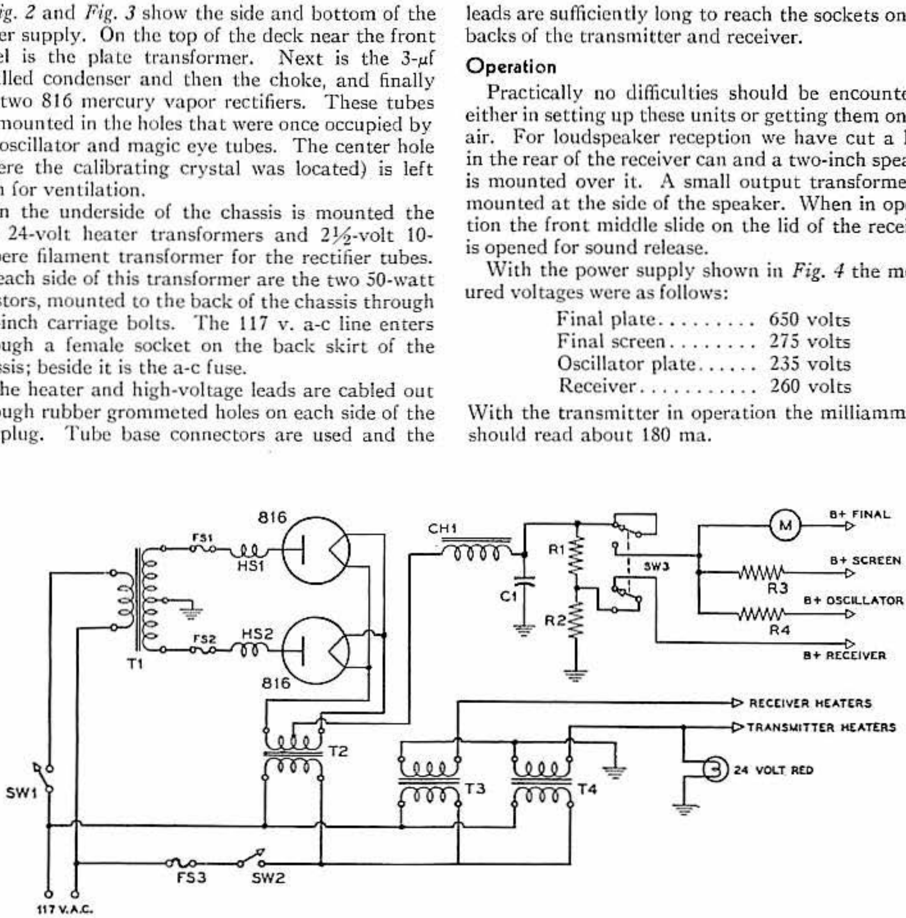


Fig. 4. Wiring diagram of the power supply.

C1—3.0 μf, 2000-volt oil filled.
R1—6000 ohms, 50 watts.
R2—50,000 ohms, 50 watts.
R3—18,500 ohms, 25 watts.
R4—20,000 ohms, 25 watts.
T1—Power transformer 1500 volts c.t. (Stancor 3535).
T2—Filament transformer 2½ volts, 10 amps c.t. (U.T.C. 53S).
T3, T4—Filament transformers, 24 volts.
HS1, HS2—Hash suppressor (Millen).
FS1, FS2—Fuse, 500 ma (Littlefuse).
FS3—Fuse, 6 amps.
CH1—Filter choke, 20 henry, 250 ma (INCA D-4).
SW1—Effort switch (see text).
SW2—Key lock auto ignition switch.
SW3—DPDT switch h.v. insulation.
M—milliammeter, 0-200 (Triplett).

THE BC-659 & BC-620

Because of the similarity between this and the BC-620, only the BC-659 will be covered here, but any changes are applicable to both equipments. The BC-659 is an FM transmitter receiver covering the frequency range of 27.0 to 38.9 *mc*. The receiver is a superheterodyne with an *if* frequency of 4.3 *mc*. The receiver is crystal controlled. The transmitter has an output of 1.5 watts which should produce a range of about 5 miles minimum. The transmitter is *vfo* in operation, but held on frequency by the receiver, which detects the signal (in a discriminator) and corrects any oscillator drift by means of a reactance tube across the oscillator. By this means only one crystal is used to obtain almost crystal stability in the transmitter.

The actual conversion of the BC-659 is one of supplying power and mounting in your car or home. Power required for the transmitter is 150 volts B plus at 50 *ma* and 7½ volts *dc* at 0.3 amp for the filaments. The receiver power is 1.5 volts at 0.94 amps filament supply and 90 volts at 28 *ma* for B plus. On transmit the current consumed by the receiver increases to 48 *ma*. While we used batteries for our installation several power supplies are available to allow operation from six, twelve or twenty four volts. The PE-117-C will supply power from six or twelve volt inputs while the PE-120-A operates from all three inputs.

Tuning The Receiver

The frequency of the output is of course dependent upon the crystal used. The actual crystal frequency is the channel frequency minus the 4.3 *mc* intermediate frequency divided by four. For example 29,300 *kc* would be 29,300 less 4300, divided by four, which gives 6250 *kc* as our required frequency. The three digit number of the channel stamped on the crystal holder is the frequency in megacycles, providing the decimal point is placed before the last digit.

Two crystals are provided, and a front panel switch selects the desired channel, which can be any frequency within the range of the equipment. The channel switch selects the appropriate pretuned circuit elements. Tuning is accomplished by first presetting the receiver. Remove the BC-659 from its case and set switches SW-1 and SW-2 to OFF. Set the panel meter to CHECK. Insert the crystals in the proper channel sockets with nameplates facing outboard from each other. Plug in the mike and headset and set the trimmers of each stage according to Table I. Don't force any of the trimmers and if a setting is far from that shown in the table recheck the other settings since something is wrong. The test meter may be used for several measurements. When the OFF-ALIGN switch is in its normal position it allows the meter to read the filament voltage, plate voltage as shown in Table II. When the OFF-ALIGN switch is in the off position it enables the meter to measure several additional equipment functions as shown in Table III. Use of the test meter in aligning the BC-659 is simple. The receiver is aligned first by setting the OFF-ALIGN switch to align. Set the volume control full on and note the meter reading. This should be between 1.5 and 2.5. Hold the pin probe free and note the meter reading. If there isn't a change of at least 5 divisions replace the 3D6 or BA-40 (the battery) or both. A Fahn-

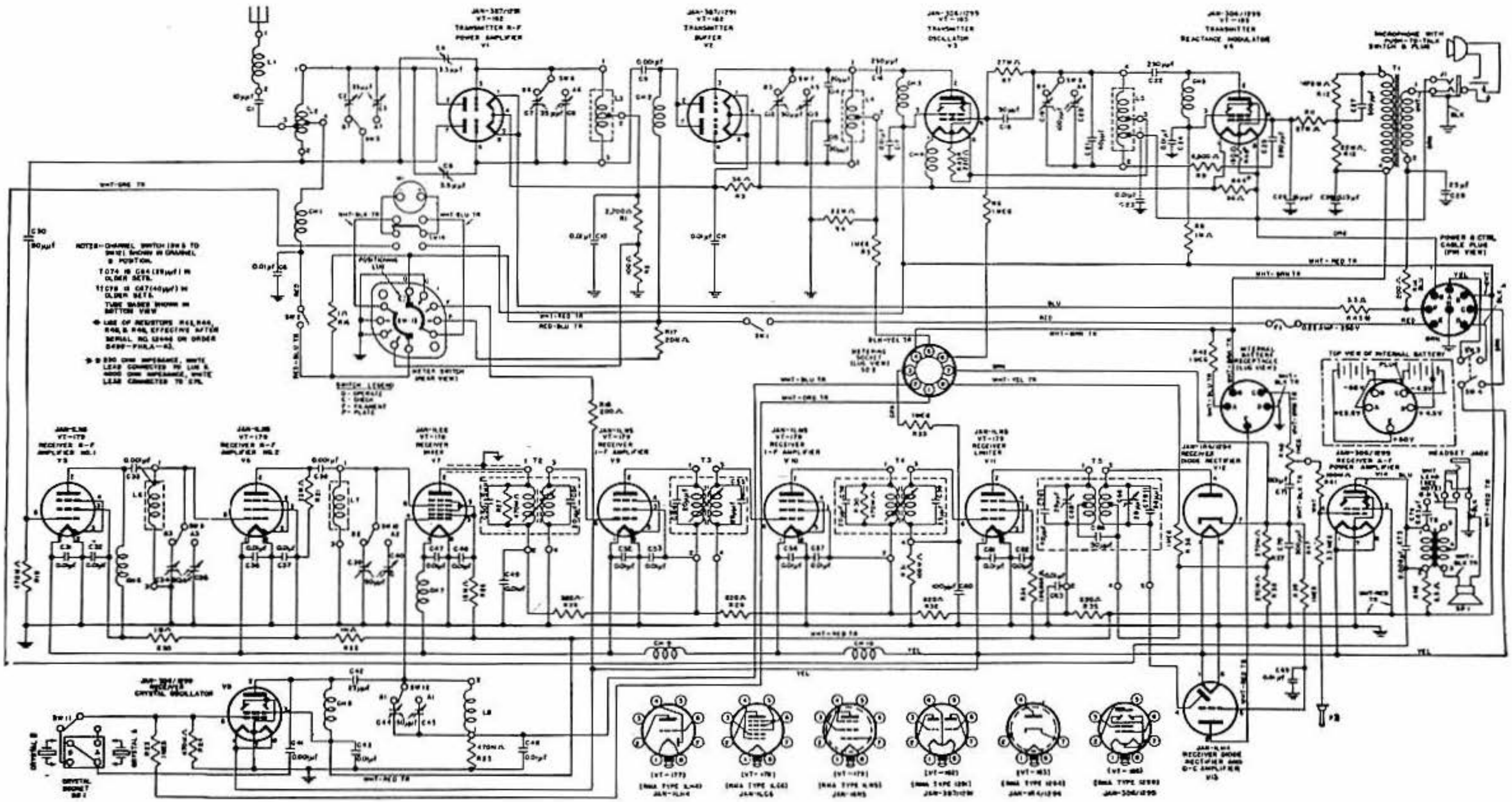


Fig. 1—Diagram of the BC-659 receiver and transmitter.

stock clip normally holds the test probe when not in use. The receiver is aligned by inserting a crystal in the proper socket and with the volume control fully clockwise the meter should read zero with the probe in pin 1. A reading of five divisions or more means a bad crystal or tube (V-8). Now insert the plug into pin 2 and tune A-1 (B-1) for minimum. Now insert the probe into pin 8 and tune the receiver mixer A-2 (B-2) for maximum headset noise. The meter should dip slightly at this setting. Now tune A-3 (B-3) for maximum noise and a meter dip, and the same for A-7 (B-7). You may have to tune up the stages slightly again for best results.

Transmitter

To set up the transmitter it is necessary to calibrate the meter. You'll have to have a good battery (BA-41). Ground the probe and note the meter reading. Now, with the probe held free again note the meter reading. Reduce the volume control settings until the difference between the two readings is exactly 4½ divisions and then keep the setting fixed for the remainder of the alignment.

Remove V-5 (first *rf* amplifier). Insert the probe in pin 3 and slowly tune A-4 (B-4). More than one dip will be found, but the correct one gives the biggest meter deflection but remains close to the original setting. This adjustment is critical. When completed replace the tube (V-5).

Press the mike switch and note the reading with the probe hold free. Now insert the probe into pin 4 of the metering socket and carefully and slowly make a slight readjustment of A-4 (B-4) in the direction that brings the meter exactly one division less than it was when the probe was free. Listening in the headset will allow you to hear a rushing noise if the adjustment A-4 (B-4) has been moved too far. If so go back and remove V-5 and adjust A-4 (B-4) again since you got on the wrong dip. If your voice can be heard in the headset when speaking in the mike you know you are right. Now insert the probe in pin 5, press the mike switch and tune A-5 (B-5) for minimum. Replace the probe in the Fahnstock clip, and set the OFF-ALIGN switch to OFF. Set SW-1 to on. Tune A-6 (B-6) to maximum on the panel meter. For this adjustment don't press the mike button until you are ready to make the adjustment fast . . . so as to prevent damage to the final tubes.

Set SW-2 to ON, turn the panel meter switch to operate and when ready to adjust A-7 (B-7) for minimum quickly press the button and make this adjustment. This should be practically on if set according to Table I.

This completes the overall adjustments. The equipment is now ready for use and either earphones or the loudspeaker may be used. The mike is a T-17 although any good carbon mike may be used.

Table I

Approximate Trimmer Settings

Channel	A1-B1 Receiver oscillator	A2-B2 Mixer	A3-B3 R-f grid	A4-B4 Transmitter oscillator	A5-B5 Buffer	A6-B6 Power amplifier	A7-B7 P-a plate
270	0.0	1.0	0.8	0.2	0.4	0.0	1.0
280	0.6	1.0	1.4	1.1	1.2	0.7	1.8
290	1.4	2.4	2.0	1.7	1.7	1.3	2.4
300	2.2	3.0	2.4	2.3	2.2	1.8	2.8
310	2.9	3.6	3.1	2.8	2.7	2.3	3.1
320	3.6	4.1	3.8	3.5	3.3	3.0	3.8
330	4.0	4.2	4.2	3.9	3.7	3.4	3.9
340	4.1	4.6	4.5	4.2	3.9	3.7	4.0
350	4.6	5.0	4.7	4.5	4.0	3.9	4.1
360	4.9	5.2	4.8	4.8	4.5	4.2	4.2
370	5.4	5.5	5.2	5.2	4.9	4.6	4.7
380	5.6	5.6	5.3	5.5	5.0	4.8	4.8
389	5.8	5.8	5.4	5.9	5.1	5.0	5.0

Note. A red dot on each trimmer shaft indicates the side of the slot that should be toward the dial card. The width of the slot is about one-tenth division. In case the red dot has worn off, its proper location can be found by meshing the capacitor fully. The end of the slot near the 0 of the 0-to-6 scale is the end that should carry the red dot.

Table II

Readings on Panel Meter
(Transmit position)

Switch position	Correct reading	Circuit checked
Fil.	2 or more	Rec fil voltage
Plate	2 or more	Trans B voltage
Check	1.5 or more	P-a grid current
Oper.	Less than 1[1]	P-a plate current
Oper.	1.8 to 3[2]	P-a plate current

[1] Antenna disconnected.
[2] Antenna connected.

Table III

Pin No.	Voltage
1	Receiver oscillator grid.
2	Receiver converter injection grid.
3	Receiver limiter grid.
4	Reactance modulator grid (d-c amplifier output).
5	Transmitter buffer grid.
6	Transmitter oscillator grid.
7	Receiver discriminator output.
8	Output of one discriminator diode (Tube JAN-1LH4, VT-177).

MORE ABOUT 659'S & 620'S

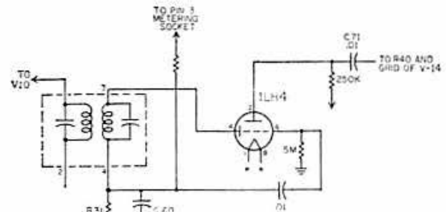


Fig. 1—AM detector and audio stage.

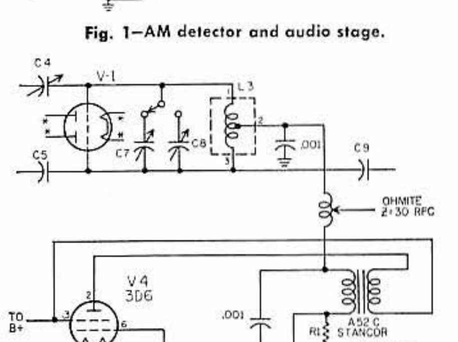


Fig. 2—Grid leak modulator.

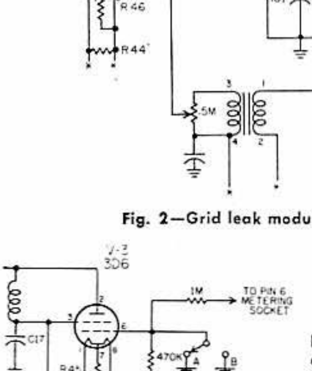


Fig. 3—Transmitter oscillator

The audio, detector and limiter stage must be revamped in order to allow the receiver to detect AM. The 1LH4 in the set (V-13) should be removed and placed in the socket V-11. V-11 (1LN5) is not used. Instead the circuit shown in fig. 4 is wired in, replacing the original circuitry. This means the removal of R-34, C-62, C-63, R-35 and R-36. Likewise, T-5 could be removed, except that it would leave a chassis hole that would be unsightly. V-12 (1R4) serves no purpose and could also be removed. Likewise, remove R-37, R-38, R-39, C-69 and C-70. C-71 is used for coupling, and the side going to the junction of C-70, R-37 and pin 7 V-12 should be connected to pin 2 of the ILH4 we are now using as our detector and first audio stages. If reception is too broad, as it may well be, you can improve the sensitivity and the selectivity simultaneously by removing the resistors R-27 and R-30. These are located within the *if* transformers T-2 and T-4 and will require removal of the shield-can in order to accomplish this. It may also be necessary to realign the *if* transformers after removing the resistors. The intermediate frequency is 4.3 *mc*.

The receiver *rf* and mixer stages are already at the correct frequency. There are no changes necessary in any of the equipments, since there is sufficient overlap in the band of each. We purposely left the receiver crystal controlled, so that there would be no drift of tuning—especially in mobile service and also in consideration of the fact that the channel spacing is so close.

The transmitter must be crystal controlled in order to comply with the FCC regulations of the Class D service. To make the oscillator comply with regulations it will be necessary to rewire it. This involves removing the reactance circuits, such as C-22, CH-5, and R-9 so as to allow the reactance tube to be used as an audio amplifier. The emphasis network in the grid must also be deleted. This means removing R-12, R-13 and C-27. A one-half megohm potentiometer should be mounted on the front panel and wired in across the mike transformer, T-1, to allow for modulation control. The potentiometer arm should be connected to pin 6 of V-4. Mount a small transformer on the chassis near the rear where there is sufficient room. This is used to grid-modulate the transmitter. This type of modulation was chosen so as to prevent having to add a more expensive modulator of the transistor or tube type for full plate modulation. The efficiency of grid modulation is not as great as you would find in a plate modulated set, but the power output is not reduced appreciably. The transformer is a Stancor type A-52C, although any small single plate to single grid or push pull grids may be used. Electrically it is connected in the grid of the *rf* power amplifier as shown in fig. 2. No noticeable effect of modulation distortion was noted in spite of the fact that it is not a good idea to grid modulate a stage which obtains its bias by grid-leak methods.

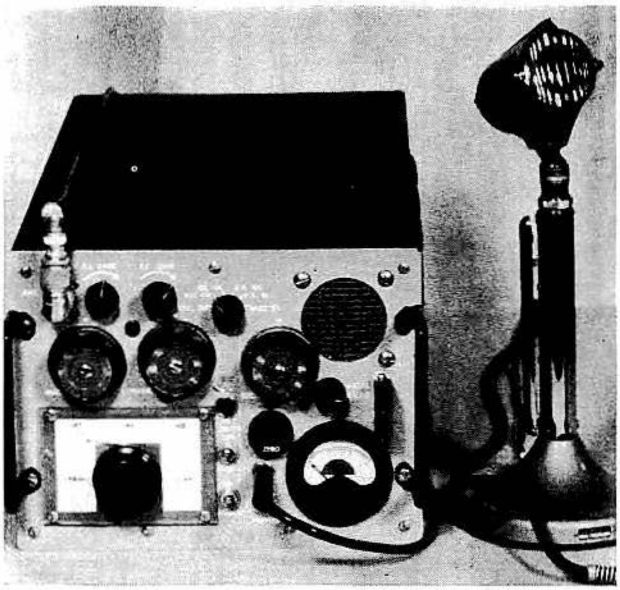
In order to use crystal control on the transmitter it will be necessary to remove C-19, C-21 and the oscillator coil L-5. It is not necessary to physically remove L-5, although we will have to mount our crystal socket somewhere. We chose to mount it where C-19 and C-20 were previously located. The socket is a dual crystal socket made by Cinch-Jones under part number 2K4. The oscillator is wired in as in fig. 3. Basically it is a Pierce type, with a tank circuit tuned to the second harmonic in the plate circuit. The screen of the tube is actually the plate of the oscillator. By using a dual crystal socket it is possible to use two crystals and make full use of the two channel feature of the equipment. Figure 3 shows the new oscillator wiring.

Tuning the Equipment

The receiver should be tuned first. Insert the proper crystals into the desired channels and set SW-1 and SW-2 to the OFF position. Set the OFF-ALIGN switch to the ALIGN position and turn the equipment on, making sure that the volume control is full on. When the probe is not in use it should be in its Fahnestock clip, but now insert it into pin 1 of the metering socket. Set the panel meter switch to CHECK. Adjust the receiver oscillator trimmer to make a maximum reading on the meter. Make sure that you are adjusting the one corresponding to the channel that you are setting. You should be able to get a reading of about 5 divisions. Now put the probe into the pin number 2. Adjust the mixer grid control for a maximum reading on the meter and then peak the *rf* grid control for maximum noise with the probe in pin 3 of the metering socket. Maximum noise in the loudspeaker of the equipment or in the headset should now be obtained by again peaking the mixer and *rf* controls. No attempt should be made to try to get maximum output by adjusting the *if* amplifiers unless you have suitable alignment equipment (see CQ May 1959). If you have a station to listen to, or if you have a suitable signal generator, grid dipper or other signal source, you may tune up on that, trying to obtain maximum signal output. A reduction in noise and improvement in signal may also be obtained on some sets by a careful re-adjustment of the receiver oscillator tuning.

Tuning the transmitter is a little more tricky. It involves the use of a microphone with a press to talk button (carbon microphone) and only when the adjustment is actually going to be made should the button be depressed so as not to overload any tubes with excess current. With the probe in pin 6 press the mike button and check the transmit crystal oscillator for voltage. This should be several divisions on the meter. Now, insert the probe into pin 5 of the metering socket and again press the mike button long enough to adjust the BUFFER-GRID for minimum meter dip. Now replace the meter probe into its holder and set the OFF-ALIGN switch to OFF. The remaining adjustments are made using the panel switch. Set the SW-1 switch to ON and when ready to make the adjustment, press the mike switch and tune the P.A. GRID for minimum, releasing the button as soon as the adjustment is made. Next, set SW-2 to ON and set the meter switch to OPER. Press the mike switch when you are ready to adjust the P.A. PLATE and do it quickly. The P.A. PLATE should be adjusted to minimum.

THE ARC-1



The RT-18/ARC-1, major component of the AN/ARC-1 Aircraft Radio Equipment, offers many attractive possibilities as an amateur conversion project. The equipment, as supplied, operates from a 24 volt battery source and provides two-way radio telephone communication on any one of ten pre-set channels in the frequency range of 100 to 156 megacycles. In addition, a separate receiver section provides optional continuous monitoring of a single "guard channel" in the same band.

The physical size of the unit, 7½" high x 10⅞" wide x 19⅝" deep (exclusive of shock mounting base and front panel controls), makes it suitable for table top, home station use. Very good performance may be expected since the transmitter puts out an easy 8 watts and the receiver is of late World War II design. The conversion is actually not too complicated but a better picture of the task can be obtained by listing the retained, deleted and added features:

Retained

1. Basic transmitter and receiver circuitry.
2. Basic guard channel receiver circuitry.
3. Front panel meter switch, RF gain control, on-off switch, microphone and head set jacks and squelch switch.
4. Equipment case.
5. Existing 24 volt DC carbon microphone and control relay circuitry.

Deleted

1. Shock mount base.
2. Auto-Tune assemblies and drive motor.
3. Crystal bank and selector switch.
4. DC operated main power contactor.
5. Meter jack.
6. Existing front panel.
7. Plug-in dynamotor assembly.

Added

1. New front panel.
2. Audio gain control.
3. Internal speaker and line matching transformer.
4. Guard channel on-off switch.
5. Self contained *VFO*.
6. *VFO*-crystal switch.
7. Crystal socket.
8. *VFO* spotting switch.
9. *VFO* filament and B+ voltage regulator assembly.
10. Self contained, plug-in, B+, 24 volt *dc* control and 24 *ac* filament power supply assembly.
11. Pilot light.
12. Front panel extension of the three required tuning controls.
13. External 115 to 115 volt power line isolation transformer.

While conversion of this equipment is not recommended unless at least the "Handbook of Operating Instructions" is at hand, a brief description of the RT-18/ARC-1, contained in that manual, is offered for those considering the purchase of this readily available item. An external view of the unmodified set is shown in the photograph. All electrical connections, except the antenna, are made through a single plug on the rear of the set. A removable front panel cover protects the crystal units and the service adjustment controls. The case is secured by two Dzus fasteners at the rear of the unit. The main chassis supports a motor driven channel selector, just behind the front panel, and a plug-in 24 volt dynamotor mounted in a separate compartment. The central portion of the chassis contains the *if* and *af* circuits and mounts the individual receiver main-channel *rf*, guard channel *rf* and transmitter *rf* assemblies. Most power supply filter and control components are mounted on the dynamotor shelf and the front panel.

The receiver main-channel *rf* assembly consists of an *rf* amplifier stage, a mixer stage and a four stage crystal oscillator, frequency multiplier and amplifier section. This section generates a heterodyne frequency 9.72 megacycles below the carrier frequency for direct use in the receiver mixer and for use in the transmitter section as described later. Output from the mixer is a 9.72 megacycle *if* signal. All stages are gang tuned by an 8 section variable capacitor which is driven by the REC channel selector head.

The guard channel receiver *rf* assembly performs the same functions as the main-channel *rf* assembly, except that each stage in this section is tuned to a pre-set net frequency. The crystal unit for this section is located under a shield at the rear of the assembly. The 9.72 megacycle *if* output of this section is also coupled to the input of the *if* amplifier section.

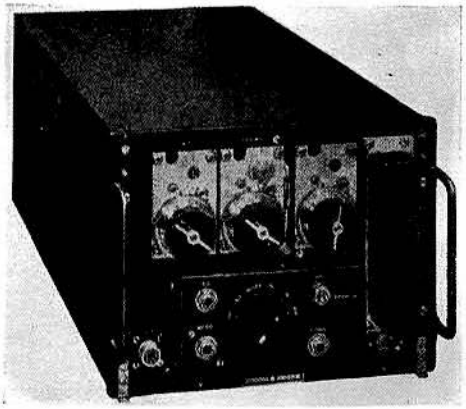
The *rf* portion of the transmitter is built as a separate sub-assembly, with certain components mounted on the channel selector casting. This section is excited by the receiver main-channel heterodyne signal which is 9.72 megacycles below the desired carrier frequency. The output of a 9.72 megacycle crystal oscillator is combined with the above signal in a balanced modulator circuit to produce the air frequency. This signal is amplified in a push-pull driver and a push-pull *pa* stage which is plate and screen modulated. All stages are tuned by ganged roller inductors driven by the TRANS channel selector head. The antenna tuning-loading coil and capacitor are driven by the ANT channel selector head.

The *if* amplifier section consists of three stages assembled on the main chassis. This section amplifies the output frequency signals (9.72 megacycles) of both the main-channel and guard channel *rf* assemblies.

The audio frequency circuits for both the transmitter and receiver are also assembled on the main chassis. The receiver circuits consist of a detector-amplifier stage, noise limiter and squelch stage, *avc* control stage and two parallel output stages with separate output transformers. The transmitter audio section consists of a microphone preamplifier stage, phase inverter stage and a push-pull class AB power amplifier stage to plate modulate the *rf* power amplifier stage.

The channel selector assembly is mounted directly behind the front panel and enables remote control of the transmitter-receiver. Since this assembly cannot be used in the conversion because of its outrageous *dc* power requirements, it will not be described.

AN/ARC 1 before modification.



The crystal units used in the main-channel transmitter-receiver and in the guard channel receiver are type CR-1A/AR or CR-1B/AR units. Crystal frequencies for any given air frequencies may be determined by the following formula:

$$f_{c.u.} = \frac{f_c - 9.72}{18} \times 1000$$

where $f_{c.u.}$ is the crystal unit frequency in kilocycles and f_c is the air frequency in megacycles. The same formula applies when the *vfo* described in this conversion is used.

Power Supplies

A few words are now in order on the various considerations which led to the choice of power supply options specified. First, use of the autotune system was ruled out by the extremely high starting current required by the drive motor. The remaining 24 volt *dc* load consists of microphone and relay current, well within the 500 *ma* rating of replacement type silicon rectifiers. Since the conversion is greatly simplified if the existing filament wiring is not disturbed, 24 volts *ac* was deemed a fixed requirement. The B+ requirement is quite substantial, 350 volts (nominal) at 350 *ma*, and a conventional transformer-tube rectifier supply would be very bulky and heavy. Since it was desired to make the conversion as nearly as possible self contained, the compact silicon rectifier voltage tripler circuit was selected. The 115 volt *ac* input to this circuit must be isolated from the power line for safety reasons and because the B− is not returned to chassis ground in the receive condition. The ideal transformer for this application is a split primary, 115-230 volts to 24 volts at 8 to 10 amperes, which would fit in the available space on the plug-in power supply plate shown in the photographs. Such a transformer, wired as shown, should easily supply 115 volts at a little over one ampere and 24 volts at 3 to 4 amperes. The author could not locate a suitable unit, so a replacement type transformer was rewound to supply 24 volts at 4 amperes and an external plug-in isolation transformer was used in the model shown.

Conversion

Now for the actual conversion. Remove the unit from the shock mounted base, loosen the two single turn fasteners on the rear of the case and slide off the cover. Remove the main power and control connector, J-401, from the base; remove all wiring, clean up and plug into the transmitter-receiver. Discard the mounting base. The following steps separate the 24 volt filament circuits, which may be operated from *ac*, from the control circuits, which require less than 500 *ma dc*, and terminates them on the dynamotor connector, J-105. These changes also provide 115 volt *ac* power, controlled by a front panel switch, to this connector. The 115 volt *ac* power cord is terminated on pins A1 and 5 on the external connector, P-101.

AC Power Modifications

1. Turn the unit on its left side and locate R-294, (730 ohm, 30 watt) which blocks access to relays K-103 and K-104. Remove the two screws securing the bracket on which this resistor is mounted and fold out of the chassis.

2. Remove the four flat head screws securing K-103, the relay toward the rear of the chassis. Remove all but one of the screws securing relay K-104 and twist the relay slightly to allow K-103 to be removed from the chassis. Reinstall relay K-104.

3. Locate the small gauge white-red tracer lead on K-103 relay coil. Unsolder this wire and connect to pin 3 of J-105.

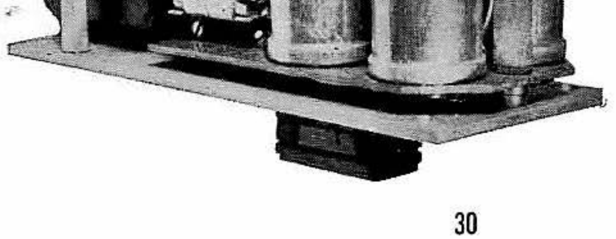
4. Locate the single heavy white wire which is connected to the other coil lug and to one contact of K-103. Unsolder this wire and connect to pin 5 of J-105.

5. Unsolder the two heavy white leads from the remaining contact of K-103. One of these wires terminates on one coil terminal of K-104 and the other on the rearmost terminal of the filament choke, L-153. Unsolder and discard both leads along with relay, K-103.

6. Remove the remaining heavy white lead from the rearmost terminal of L-153. Unsolder the other end of this wire from the adjacent microphone dropping resistor, R-156 (500 ohm, 1½ watt). Discard this lead.

7. Remove the remaining heavy white lead from the coil terminal of K-104 referred to in step 5 above. Connect this lead to the rearmost terminal of the filament choke, L-153.

8. Locate antenna changeover relay K-101. Remove and discard the white lead which



connects one coil terminal of this relay to pin 3 of adjacent terminal board, E-106.

9. Form an insulated wire into the existing cable runs, to interconnect the now vacant coil terminals of relays K-101 and K-104; the previously referred to terminal of R-156 and pin 6 of dynamotor connector, J-105.

10. Remount the R-294 bracket assembly and dress wiring as required.

11. Run a heavy jumper from pin 2 of P-101 to pin 2 of J-105. This will permit use of an external 24 volt transformer if this option is selected.

Control Head And Front Panel Modifications

Carefully examine the front panel and control head wiring. It will be noted that, in addition to the antenna cable, two main cable runs enter this compartment. The Auto-Tune cable terminates on terminal board E-101. The cable to and including this board will be retained. The crystal socket assembly will be discarded. The antenna cable and jack will be retained along with all cabling and most of the jacks and controls on the jack panel assembly. The following steps cover removal of the front panel and Auto-Tune assembly and installation of a new control sub-panel.

1. Remove the screws mounting the antenna connector, J-103. Swing the jack free and reinstall the hardware on the jack to avoid loss.

2. Remove the toggle switch, S-104, without disturbing the wiring.

3. Disconnect the red wire from the lug protruding through the 2f oscillator shield at the front of the main-channel assembly and the ground strap from the crystal socket assembly where it is soldered at the oscillator shield.

4. Remove and discard the four screws on three sides of the jack panel which secure it in the front panel.

5. Remove the carrying handles, brackets for the mounting base and the five additional nickel plated screws around the edge of the front panel. Remove the front panel leaving the jack panel in place. Discard the brackets for the mounting base and reinstall the panel mounting hardware in the chassis frame for safe keeping. The front panel and crystal assembly may be discarded after removing one crystal socket for future use.

6. Remove and retain the knobs from the three Auto-Tune selector units. Loosen the set screws in the coupling at the rear of the receive selector head. Remove the three selector heads be removing the short Phillips head screw at the top of the rear plate and the lower two screws on the front plate of each unit. Carefully knock out the pins securing the gears on the rear of the antenna and transmitter selector heads. Retain these gears along with the knobs. The Auto-Tune heads may be discarded after removing the dial index pointers.

7. Remove the cable clamps on the front edge of the frame and on the channel selector casting. Remove the mounting screws of terminal board E-101 and clip all 13 wires leading to the channel selector components. Leave the cable from the main chassis attached to the board.

8. On the top side of the chassis, disconnect the coaxial transmission line (W-105) from the roller coil, T-105.

9. Loosen the set screws in the coupling at the channel selector end of the shaft for roller coil, L-113.

10. On the right side of the chassis, remove the cover to the main-channel *rf* assembly and unhook the spring from the pin on the ganged capacitor gear. Discard the coupling.

11. On the bottom of the chassis, disconnect coils L-117, L-118 and capacitors C-129, C-130 from roller coil T-104. Do not distort the coils in this operation.

12. Loosen the set screws in the coupling at coil T-104.

13. Remove the three channel selector casting mounting screws and carefully pull the channel selector assembly through the front of the chassis.

14. Remove and discard all Auto-Tune components from the main selector assembly casting, except roller coils T-104, T-105, drive assembly for roller coil L-113 and idler gears and hardware associated with the above components.

15. Carefully note method of assembly, then remove and retain all remaining components and tuning drive hardware mentioned in step 14 above.

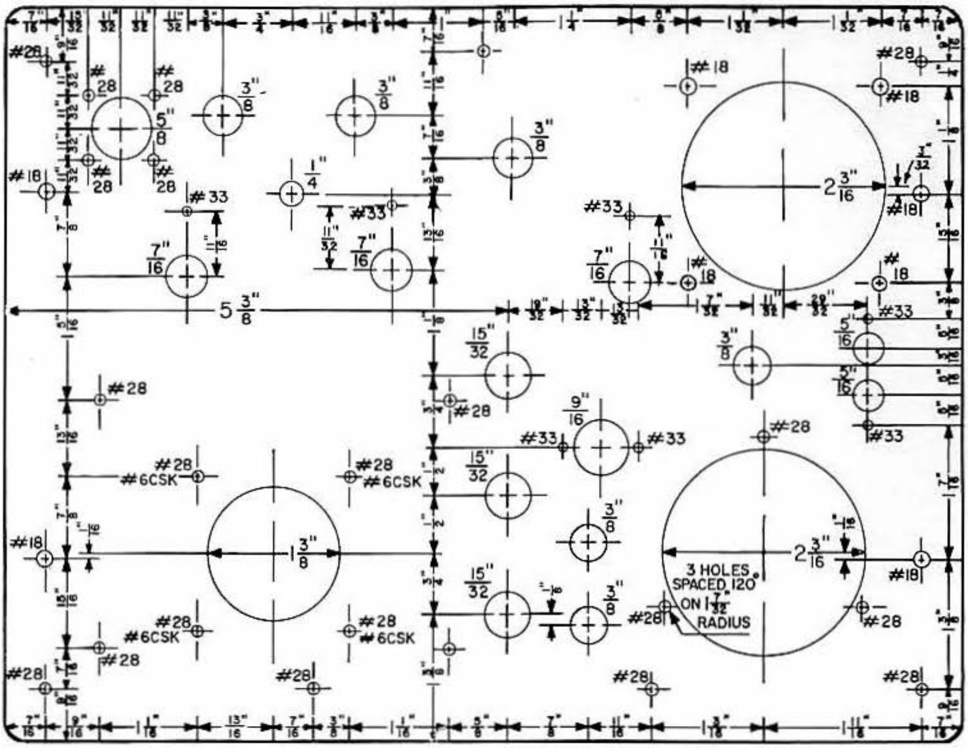
16A. Using a hack saw, cut the channel selector line shaft brackets off flush with the main casting. Using a large, coarse file, milling machine or shaper, evenly remove all projections from the front of the casting until the base plate measures 5/16″ at the thickest points. Carefully remount all components and hardware removed in step 15 above.

Or

16B. Fabricate a new sub-panel from aluminum stock, using the old channel selector casting as a drilling template for precise location of the required holes. Mount the various parts and hardware removed in step 15 above. The idler gears coupling the various drives will have to be spaced out from the panel to permit proper mesh of the gears.

17. Locate the required position of the drive gears removed in step 6 above. The 76 tooth gear drives the antenna tuning components and the 62 tooth gear drives the transmitter tuning components. Accurately locate these centers, then drill and tap the panel for 6-32, being careful not to damage parts mounted on the back of the panel.

18. Secure three hubs from ¼″ flexible shaft couplings. Accurately center two of these on the face of the two gears referred to in step



MATERIAL: 14 GAUGE ALUMINUM.
FINISH: MACHINE SANDED, PRIMED AND PAINTED 2 COATS SEMI-GLOSS BLACK.

Fig. 1—Front panel details.

17 above. Center the other on the capacitor drive gear of the main-channel *rf* assembly. Using a large, hot iron, sweat solder these couplings securely in place.

19. Fabricate two idler gear spindles from 9/32" aluminum or brass rod, drilled and tapped 6-32. Install 6-32 studs in the posts and mount on the panel. Dimension these posts so that proper mesh is achieved when the drive gears are mounted with the original hubs to the rear. The centers of the new couplings should line up with the locations of the old selector head drive shafts. Check the gears for smooth operation and adjust until this is achieved.

20. Remount the control sub-panel by reversing the procedures outlined in steps 8, 9, 11, 12 and 13 above. The upper left mounting screw should be reversed and used to mount a 2½" aluminum or brass, ½" hexagonal post. Drill this post and mount terminal board E-101 as shown in the photographs. Carefully check completed work. Check the control gears for 360° rotation and insure that component settings have retained their original relationships. Inspect solder connections for shorts. At this stage, the cable terminating on terminal board E-101, from the main chassis, should be the only wiring attached to it. Switch, S-104 and the antenna connector, J-103, should be free and connected to their original leads. The jack and control panel should be free and all original wiring intact, aside from the unterminated lug projecting from the 2f oscillator compartment as mentioned in step 3 above.

21. Fabricate the voltage regulator sub-chassis in accordance with fig. 3. The photographs show two electrolytic capacitors not shown in the diagram. These were required because the 500 volt units specified in the parts list were not available on the local market, and series connection of available capacitors was required. Mount the 7 and 9 pin sockets and the wire wound dropping resistor as shown. Mount the filament dropping resistors and wire in accordance with fig. 5, leaving the four external leads about 18" long.

22. Fabricate and finish the new front panel in accordance with fig. 1. The four *vfo* dial scale mounting holes, the four dial drive mounting holes and the dial drive clearance hole are located for mounting a dial and drive fabricated from a National Velvet Vernier assembly salvaged from a BC-375 tuning unit. If a commercial dial and drive is used, modify the panel layout accordingly. Mount the front panel temporarily, as shown in the photograph, to sim-

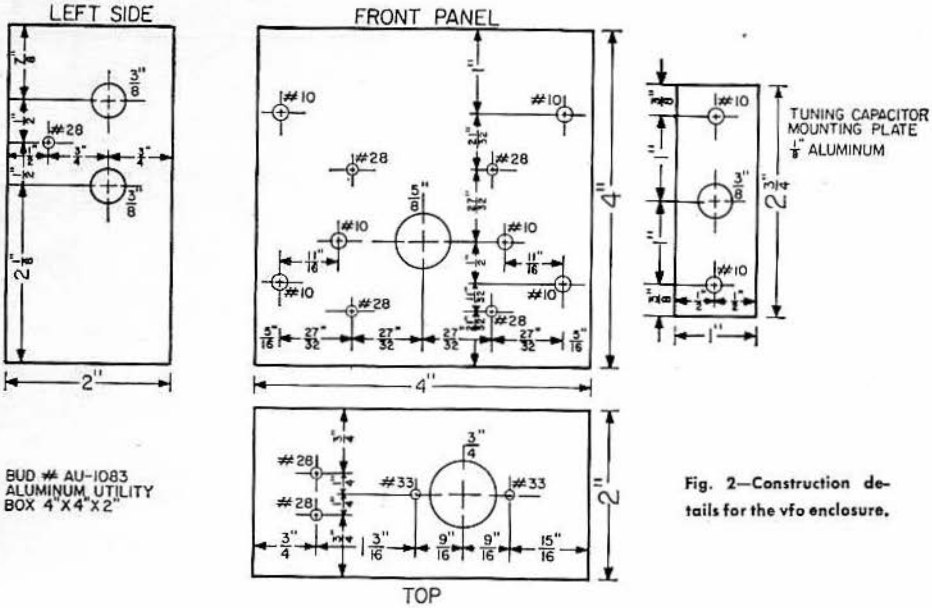


Fig. 2—Construction details for the vfo enclosure.

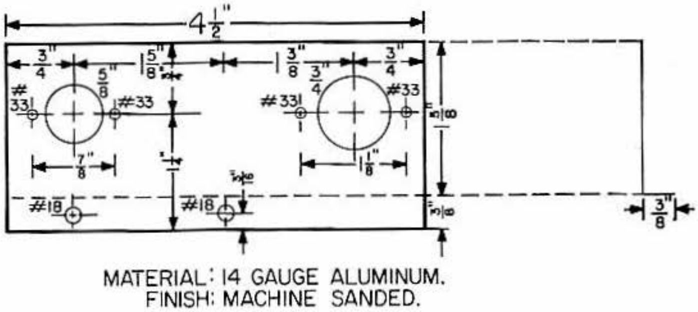


Fig. 3—Voltage regulator bracket.

plify assembly and wiring.

23. Drill and finish the front panel of the Bud #AU-1083 utility box and the *vfo* tuning capacitor plate in accordance with fig. 2. Mount the tuning capacitor to the plate and secure the plate, using ⅜" spacers between the rear of the panel and the mounting plate. Carefully remove one hub and coupling from an ICA #2142 flexible shaft coupling; notch or drill to accept the coupling screws on the rear of the National dial drive and mount in place of the former oversize coupling and stop plate. Using ¾" flat head, 6-32 machine screws, secure the dial drive and the *vfo* front panel to the rear of the main panel. Use ⅜" post spacers between the rear of the dial drive and the *vfo* front panel. Tighten the coupling set screws and check alignment of the capacitor shaft to insure smooth operation.

24. Install panel bushings, such as ICA #1250, to pass the three tuning dial shafts. Install the various other panel mounted components in their indicated locations. Install the output transformer on the speaker. This is T1 as shown in fig. 5 and is a line matching transformer. Ground one voice coil terminal and one side of both the primary and secondary of the transformer and connect the other secondary lead to the remaining voice coil terminal.

25. Fabricate a new 15" cable from RG-58/U, using the original connectors, between relay K-101 and connector, J-103, and plug into the relay. Using a length of two conductor shielded wire, run from the vicinity of V-122, along existing cable harnesses, through the cutout in the Auto-Tune panel. Dress an insulated lead from the vicinity of R-176, through the above mentioned cutout, leaving sufficient length to terminate on the new front panel.

26. Form these leads, the new antenna lead and the two existing harnesses into one cable, tape and securely clamp to the front panel support frame in the vicinity of the relocated terminal board, E-101. Form the wiring from

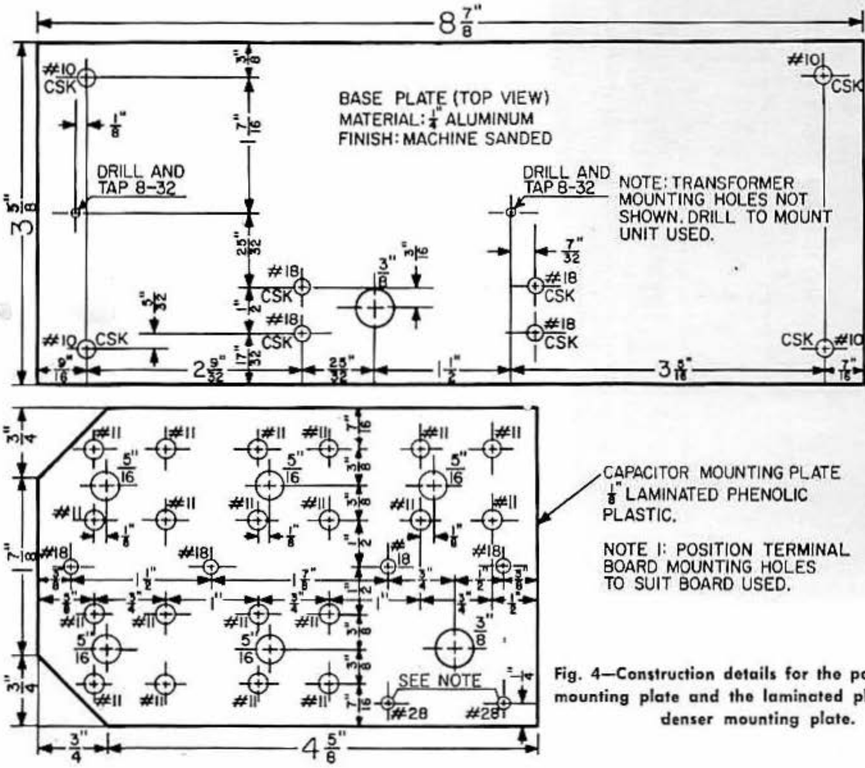


Fig. 4—Construction details for the power supply mounting plate and the laminated phenolic condenser mounting plate.

the voltage regulator sub-assembly in the channel formed by the Auto-Tune sub-panel and the chassis frame to the vicinity of terminal board E-101. Form the front panel control wiring harness to the new control locations, as shown in the photographs, shortening the leads as required to permit a neat installation.

27. The following changes should now be made in the wiring of the front panel components:

A. Former meter jack, J-101, is discarded and the leads run directly to the new meter.

B. Leads from the momentary contact switch. C-105 (original squelch switch). are reconnected to the new squelch toggle and S-105 becomes the new *vfo* spotting switch.

C. Former phone jack, J-104, is replaced by a shorting type and wired in accordance with fig. 5. The speaker matching transformer is connected to the shorting contact.

D. The sensitivity control, R-274, is replaced with a long shaft control of the same value.

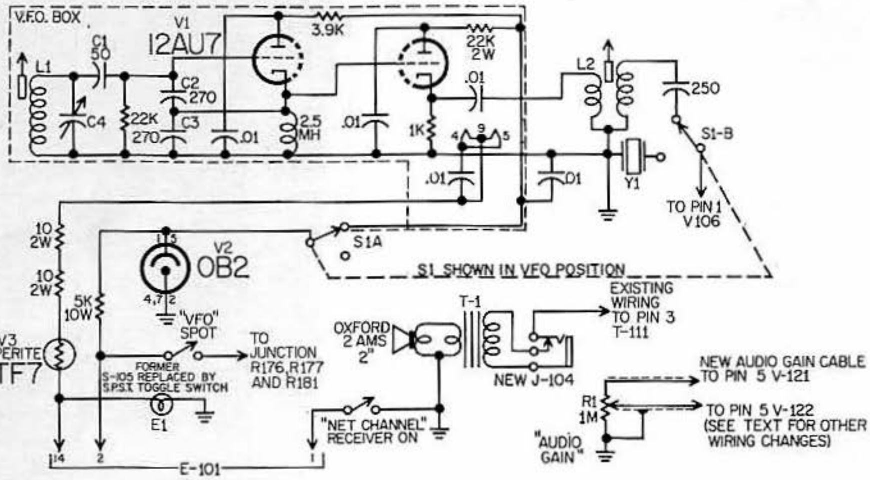
VFO And Additional Wiring

The previous conversion steps should have resulted in a clean job, with the only unterminated leads being the shielded pair from the audio section, the single wire from the vicinity of R-176 and the new leads from the voltage regulator sub-assembly. Since the cable terminating on terminal board E-101 leads to the main power connector, P-101, and many of the required circuit points are also terminated there; some of the wiring will be accomplished by installing jumpers on the mating connector, J-401.

1. Install wiring to control the guard channel receiver by running a lead from pin 1 of terminal board E-101 to one side of the new "Net Channel Receiver" toggle switch. Ground the other side of this switch. Complete the circuit by installing a jumper from pin 6 to pin 18 of connector J-401.

2. Connect B+ to the voltage regulator dropping resistor and one contact of the *vfo* spotting switch by running a lead between these points and hence to pin 2 of terminal board E-101. Complete this circuit by connecting a jumper between pin 15 and pin 19 of connector J-401. Connect the single insulated lead in the vicinity of R-176 to the junction point of R-176, R-177, R-178 and R-181. Connect the other end of this lead to the vacant *vfo* spotting switch terminal.

3. Connect 28 volts *ac* to the voltage regulator sub-assembly and the panel mounted pilot light by connecting the lead from pin 2 of the ballast tube to pin 14 of terminal board E-101,



L1—14 turns #22 wire on ¾" slug tuned ceramic form.
L2—Primary: 10 turns #26 enamel wire, close wound over ground end of the primary.
L2—Secondary: 40 turns #26 enamel wire, close wound on ⅜" slug tuned form.
C1, C2, C3—Silver Mica

C4—Hammarlund MC-20S (See text).
All other capacitors are mica.
T1—Thordarson 26S58.
S1—Mallory 3122J DPDT.
Y1—7460 kc to 7682.2 kc.
E1—Pilot Lamp 28 v, .07 amp bayonet base, GE #1829.

Fig. 5—VFO and front panel wiring.

and hence to one terminal of the pilot light. Ground the other terminal of this lamp.

4. Terminate the shielded pair cable on the new audio gain control. The shield should connect to the counterclockwise terminal and this terminal should be grounded. Examine pins 5 of the tube sockets for V-121 and V-122. Remove and discard the jumper between pin 5 of V-122 and V-121. Remove and discard the grid resistor R-227, side tone coupling components R-164 and C-173, and the tie points used to mount these parts. The only lead remaining on pins 5 of these sockets should be the coupling capacitor, C-242, terminated on the socket of V-121. Connect the lead going to the high side of the audio gain control to this terminal. Connect the lead going to the center arm of the control to pin 5 of V-122 and the shield to a convenient ground terminal.

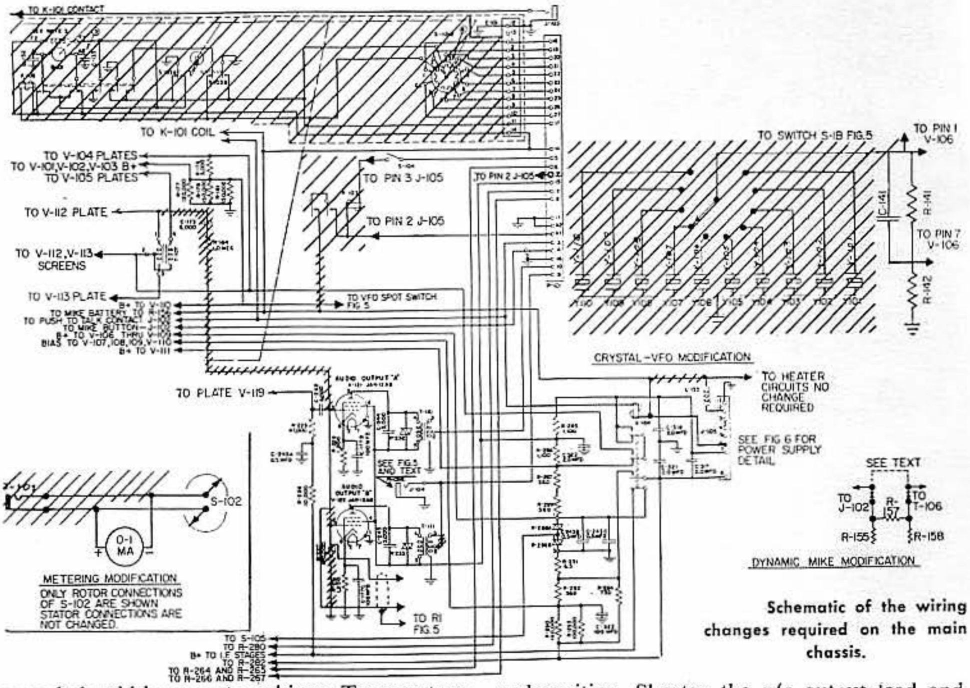
5. Drill, punch and finish the *vfo* box as shown in fig. 2. Mount the *vfo* components in the box and wire as shown in fig. 5. Complete as much wiring as possible before mounting the box. Panel mounting holes should be enlarged and the box secured to the front panel with 8-32 machine screws, lock washers and nuts. The *rf* output cable should be a length of RG-58/U cable. Parts placement, mounting and wiring must be in accordance with good *vfo* construction practice. The B+ and filament supply leads should now be connected to the *vfo*. The filament lead runs directly from the voltage regulator sub-assembly, while the B+ lead is routed through the switch, S-1A, as shown in fig. 5. Now, check your work in the *vfo* assembly. Reasonable care will result in a unit that is fully adequate for the purpose, while sloppy work and flimsy wiring will cause the output signal to wander all over the band.

6. Fabricate and mount the *vfo* output matching transformer, L-2, on a small angle bracket and secure under the speaker mounting screw nearest the *vfo*-crystal switch. Terminate the *vfo* output cable on this coil and wire it, the *vfo*-crystal switch and crystal socket, as shown in fig. 5. Bare, solid wire should be used, with the 250 mmf output capacitor mounted by its leads. Run a short, direct, temporary lead between the wiper arm of the switch, S-1B, and the lug protruding from the front of the 2f compartment of the main-channel *rf* assembly.

7. Carefully check all completed work. There should be no unterminated leads or loose components and cabling, lead dress and parts mounting should equal the commercial appearance of the original unit.

Test And Adjustment

Turn the completed set on and "smoke test". A few voltage measurements should disclose any obvious wiring errors. Plug in a microphone and the relays should close when the "push to talk" switch is closed. Switch the set to *vfo* position and tune the *vfo* signal in on a frequency meter or receiver with crystal calibrator. The frequency range of the *vfo* should be 7460 to 7682.2 kilocycles, with a small overlap at each end. Conventional techniques apply and, by adjustment of the plug in L1 and by removal and bending of plates in C4, the proper



Schematic of the wiring changes required on the main chassis.

spread should be easy to achieve. Temperature compensation was not required in the original model. However, if warm up drift proves excessive, a few mmf of N-750 ceramic capacitor, compensated for by backing out the slug on L1, should do the trick. Fasten the back cover on the *vfo* assembly and adjust L1 if required.

Set the *vfo* in mid-band, throw the meter switch to MIX I_g and peak the meter by adjusting the slug in L2. This adjustment is broad and should hold fairly constant across the band. Connect an antenna, turn the squelch and guard channel receiver off and turn up the audio and *rf* gain controls. Tune the *vfo* across the band and peak received signals with the REC dial. Pressing the *vfo* spotting switch will enable exact zero beat with received signals. Turn on the squelch and the receiver should be quiet until the squelch is tripped. This should be accomplished by any signal appreciably above the noise level.

A preliminary check of transmitter operation should now be made. Connect a 6 to 10 watt lamp to the antenna jack. Set the *vfo* to mid-band, throw the meter switch to MIX I_g and peak the meter, using the REC dial. Throw the meter switch to PA I_g, press the mike button and adjust the TRANS dial for maximum meter reading. Turn the meter switch to PA I_k and adjust the ANT dial for between .6 and .8 *ma.* The dummy load should light to more than normal brilliance. Speak into the microphone and the lamp brightness should increase on voice peaks.

Now that the complete unit is checked out, reverse the front panel and mount in the normal position. Shorten the *vfo* output lead and run a ground strap from the crystal socket to the ground lug on the front of the 2f compartment. Cut appropriate length ¼" shafts and mount on the three drive couplings. The TRANS and ANT shafts should be secured in position by installing ¼" shaft collars directly behind the front panel bushings. Install control knobs and apply appropriate marking decals to the panel. Calibrate the *vfo* dial, using a frequency meter or communications receiver with crystal calibrator.

While this completes the conversion, a final check of transmitter alignment should be made. Tune the transmitter, into lamp load, for maximum output on a frequency near the center of the band. Turn the power off and, without disturbing the alignment, loosen the shaft couplings ganging the various TRANS roller inductors. Turn the set on and adjust each one for maximum output. Turn the power off and carefully tighten all couplings. The following chart shows meter readings that should be obtained:

CIRCUIT	METER READING, MA	MULTIPLIER
OSC I_g	0.10 - 0.20	1
MIX I_g (Reception)	0.20 - 0.60	3
MIX I_g (Transmission)	0.35 - 0.65	3
DRIVER I_g	0 - 1.00	1
PA I_g	0.30 - 1.00	5
PA I_k	0.60 - 0.80	100
MOD I_k	0.60 - 0.90	100

THE ARC-3

WHEN the Air Force, at long last, sounded the death knell for the C45 aircraft and these ships started arriving at the salvage depots in large numbers, it was an indication that the much sought after ARC-3 radios would soon become available in large quantities. Two years ago these sets would have brought over two hundred and fifty dollars; now they are available for less than thirty dollars.

The eight channel AN/ARC-3 and its modified counterparts, the ARC-36 (sixteen channels), and the ARC-49 (forty-eight channels), have seen fifteen years of continuous service and doubtless will see many more. They have been installed in almost every kind of vehicle and aircraft from jeeps, gas trucks, and APUs to fighters, Goonie Birds, 123s, and commercial carrier aircraft.

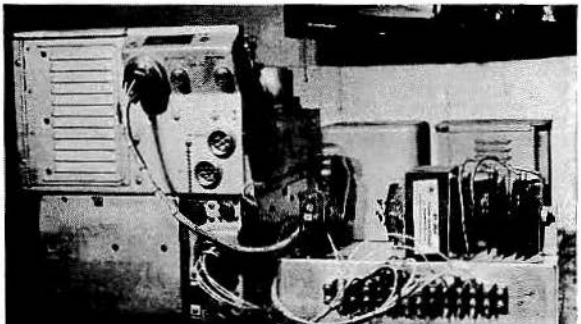
Basically, the ARC-3 is a modernized SCR 522 but with more channels, a better tuning system, a more sensitive receiver, a more powerful transmitter, and much better stability in receiver and transmitter. It is designed to transmit and receive a.m. signals on any of eight crystal controlled channels in the 100 to 156 mc Band.

The receiver is a single conversion superhet with an i.f. of 12 mc. The crystal oscillator/multiplier chain employs multiplications of from 11 to 18 times, depending upon the frequency to be received. For the 144 to 148 mc band, crystals between 8250 kc and 8500 kc are required. To calculate the crystal for a particular frequency in the two meter band, subtract 12 mc and divide by sixteen. The crystal should be cut to operate into a 25 to 35 mmf load.

The receiver tube lineup is a 6AK5 r.f. amplifier feeding a 9001 mixer into three 12SG7 i.f. amplifiers and a 12H6 detector. Two 12SN7s, a 12A6, and 12SL7 are used in the squelch, a.n.l., a.v.c. and first and second audio amplifiers. A 9002 is used as the crystal oscillator and is followed by five 6AK5 multipliers. A 12SH7 controls the auto-tune system. Receiver specifications are as follows:

RECEIVER

Antenna Z	50 Ohms.
Audio Output Z	Hi, 600 Ohms.
	Lo, 30 Ohms.
Primary Power Input	24 Volts d.c., 1.45 A.
	210 Volts d.c., 125 Ma.
Sensitivity at 146 Mc	3.48 μv for 10:1 s/n.



Front view of the converted ARC-3 receiver (top), transmitter and power supply. The Amperite time delay relay can be seen on the left in front of the 5U4. The crystal selector switch shown in fig. 2 was added after the picture was taken.

A.v.c. Characteristics	10 to 1000 μv=6 db, max.
Selectivity	335 kc at −6 db.
Squelch Range	0-10 μv.
A.f. Response	3 db, 300 to 4000 c.p.s.

Transmitter

The ARC-3 transmitter also has eight channels, is crystal controlled and auto tuned. The crystal multiplication, for any output frequency, is eighteen times. Thus, for two meter operation crystals lying between 8000 and 8222 kc are required. Again, as in the receiver, the crystals should be cut for operation into a 25 to 35 mmf load.

The tube line up is a 6V6 crystal oscillator driving a 6V6 multiplier which drives an 832-A push pull tripler which drives an 832-A final amplifier. The modulator consists of a 6J5 driving push pull 6L6s. There is also a 6V6 sidetone amplifier and tone oscillator and a 12SH7 auto-tune control tube. Technical specifications are as follows:

TRANSMITTER

D.c. Power Input	30 Watts.
R.f. Power Output	10/15 Watts at 146 Mc.
Primary Power Input	24 Volts d.c., 2.4 A.
	410 Volts d.c., 325 Ma.

Auto-Tune

The auto-tune system employed in the ARC-3 is quite accurate and useful. In the transmitter it is only necessary to plug in a crystal of the desired frequency and the set will automatically tune itself up. In the receiver the same is true except that it is necessary to preset the eight thumb wheels (behind the front panel) to the approximate frequency to be used. The thumb wheels are necessary to prevent the receiver from tuning up on an undesired harmonic.

Electrically, the transmitter tune up follows this procedure. First let's assume that the channel A selector button has just been pressed. In the instant when all of the crystal selector relays are not energized, 24 volts passes through the normally closed contacts of all the crystal relays which are connected in series. In the transmitter this 24 volts is applied to relay K_{107}, which upon closing, locks itself closed by the application of 24 volts from one set of its own contacts, and simultaneously causes relay K_{108} to close which in turn causes K_{117} and K_{102} to close. Relay K_{109} then closes connecting the channel A crystal to the oscillator. With the application of B plus from the closing of K_{102}, relay K_{103} in the plate circuit of V_{105} (12SH7) will close, start the tuning motor, engage the clutch, and release the brake. Thus, the tuning system is put into operation. The tuning capacitors, being calibrated and tracked over only 180 degrees of rotation, must be prevented from stopping on the "back" 180 degrees. To accomplish this, cam O_{101} is provided and causes switch S_{101_A} to open in the "back" 180 degrees which in turn prevents the stopping of the tuning motor until after cam O_{101} *opens* S_{101_B}. Switch S_{101_B} momentarily causes relays K_{107}, K_{108} and K_{117} to open. This is to prevent the tuning motor from continuing to operate if no crystal is in the socket or some other malfunction occurs. As the tuning motor continues to run, the tuned circuit in the grid of V_{104} (832-A) passes into resonance and a negative grid bias is developed across R_{123} and R_{124}. This grid bias is applied to the grid of V_{105}, the 12SH7 control tube, and causes its plate current to decrease which, in turn, causes relay K_{103} to open thus stopping the tuning motor, releasing the brake and disengaging the clutch.

In the receiver the sequence is almost the same in that the application of 24 volts to the set causes relay K_{206} through K_{215} to momentarily apply 24 volts through the normally closed contacts of its s.p.d.t. section to relay K_{204} which in turn closes K_{205} and locks itself closed. When V_{207}, the 12SH7, draws plate current, K_{201} closes, starts the tuning motor, engages the clutch and releases the brake. Cams O_{201} and O_{202} along with S_{201} and S_{202} prevent tune-up in the uncalibrated portion of the capacitor rotation. When the crystal oscillator harmonic generator circuits become tuned to a harmonic of the crystal, grid current flows in the harmonic generator V_{206} which places a bias on the grid of V_{207} causing relay K_{201} to open which thus stops the tuning motor, etc. To prevent the set from tuning up on the wrong harmonic, thumb wheel selectors are provided which short circuit the screen of V_{205} to ground except when the tuning capacitor shafts are turned to the frequency selected on the thumb wheel.

Conversion to 117 Volt Operation

To convert the units to 117 volt operation, no real modifications of the equipment are necessary with the exception of increasing the audio output so as to provide sufficient volume to drive a loud speaker. The conversion really boils down to building a power supply and making up some interconnecting cables and a control box.

If no plugs are available to fit the receiver and transmitter, a make-shift connector can be made from old tube sockets that have the round metal type contacts by breaking these apart and pushing them over the banana plug pins of the transmitter and receiver. By pouring liquid silicone rubber or similar material into the socket a make shift plug can be made or, if desired, the tube socket contacts can be soldered directly to the banana pins and left

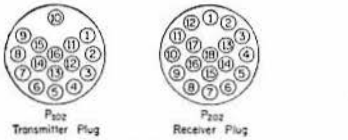


Fig. 1—Pin arrangements of the power plugs for the receiver and the transmitter.

permanently attached thereto. Figure 1 shows the location of the pins for P_{102} and P_{202}.

The power supply diagrammed in figure 2 will supply all the voltages necessary to operate both the receiver and transmitter including intermittent operation of the auto-tune drive motors and the relays. One point worth mentioning is the use of an Amperite thermal delay tube in the 5U4GB Filament. This is to prevent B plus from being applied to the transmitter and receiver while the tubes are cold. If this does happen, the transmitter will come on, the tuning motors will start, and the set may tune itself up incorrectly.

Disabling The Auto-Tune

If the set is to be used primarily to receive and transmit on one frequency only and it is desired to prevent the auto-tune mechanism from operating each time the set is turned off and on, the auto-tune feature can be disabled by tuning the set up, on channel A, to the desired frequency and then inserting a small piece of cardboard between the two top most contacts (the s.p.d.t. set) of the crystal selector relays K_{206} in the receiver and K_{109} in the transmitter. Access to the relay contacts can be had by removing the two relay cover screws accessible through the crystal compartment door. Disabling these two relays will prevent recycling of the auto-tune relays thus preventing the set from retuning itself each time power is applied.

Manual Tuning

Manual tuning of the set can be accomplished by releasing the two spline set screws on the collet between the motor right angle drive and the clutch, and shifting the collet so as to permanently engage the motor to the tuning capacitor drive. The small knurled knob on the motor can then be used to manually tune the set. This procedure is the same for both the transmitter and receiver.

Inceased Audio

To increase the audio output to a level suitable to drive a loudspeaker, move the end of capacitor C_{294}, which is connected to the junction of R_{277} and R_{278}, over to pin 2 of V_{215}. This defeats the voltage divider formed by these resistors and thus applies full audio voltage to the system.

To remotely control the squelch on the receiver it is necessary to connect a wire from the arm of the squelch control R_{272}, to pin 10 (an unused pin) of plug P_{202}. Turn R_{272} fully clockwise. A 5K pot connected between pin 10 of plug P_{202} and ground (as shown in fig. 2) can then be used to remotely control the squelch threshold level.

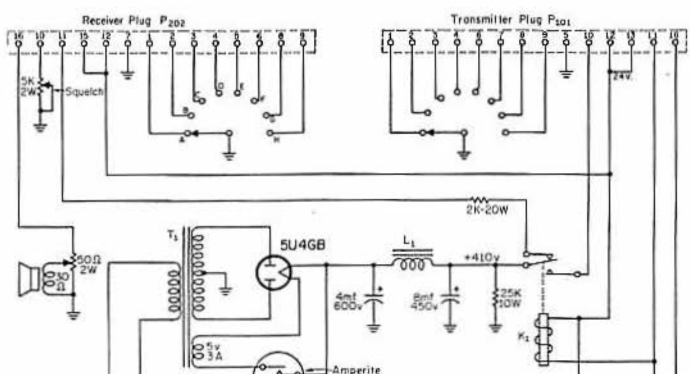


Fig. 2—Diagram of the power supply and remote control for use with auto-tune operation.

CR_1—Bridge rectifier, 36 volts a.c. max @ 4.8 amp. International Rectifier J29B5.

K_1—s.p.d.t. relay, 24 v.d.c. coil.

L_1—5 h @ 325 ma.

T_1—800 v.c.t. @ 325 ma, 5v @ 3A.

T_2—29.7 v.a.c. @ 6A. Stancor RT204.

Increased Transmitter Output

The transmitter power output can be increased considerably by changing the 832A final amplifier to an Amperex 6252. The increased efficiency of the 6252 will, in many cases, almost double the actual power output into the antenna. No changes in the transmitter are necessary other than to retune the grid and plate circuits slightly. A 5894 may also be used but it will require changing of the tank and grid coil inductances to obtain tracking.

The large can directly behind the crystal bank in the transmitter is a barometric gain control on the microphone amplifier so that the modulation level varies with altitude. It can be removed and the gain control operated manually if desired.

12 Volt Operation

For 12 volt operation the auto-tune feature will not operate reliably in that the clutch and brake solenoids will not function without hair line adjustment. Permanent disabling of the auto-tune mechanism may be accomplished in the receiver by bending the relay contacts of K_{206} so that the contacts are in the closed position at all times. If FT-243 crystals are going to be used, the socket for V_{207} (the auto-tune control) can be used as a crystal socket by removing the leads between pins 1 and 3 and 3 and 5, connecting the crystal lead from pin 6 of V_{201} to pin 3 on V_{207} socket, and plugging the crystal between pin 3 and 1 on the V_{207} socket. If this is done, the entire crystal relay bank and sockets can be removed.

Receiver Conversion

To disable the auto-tune in the transmitter, bend the contacts of relay K_{109} in the closed position. Unplug K_{103} and K_{105}. All the other relays seem to work fine on twelve volts with no modifications.

To convert the transmitter filaments for twelve volt operation:

1. Remove the white wire with brown tracer from pin 1 of V_{103} and reconnect it to pin 7 of V_{103}. Ground pin 1 of V_{103}.
2. Remove two white wires with red and black tracers which connect to pin 2 of V_{107}. One of the wires connects to R_{130}, a large 10 watt resistor. Clip and remove this wire. The other wire should be connected to pin 7 of V_{108}. Ground pin 2 of V_{107}.
3. Locate R_{129}, a 10 watt resistor located near V_{101}. Remove the wire which connects one end of R_{129} to pin 2 of V_{101}.
4. Locate R_{131} and connect a jumper across its terminals.
5. Locate R_{132} (a tapped 10 watt resistor) and connect a jumper between the center terminal and the end where 3 white wires connect.
6. Locate R_{138} and connect a jumper across its terminals.

To rewire the receiver filaments for 12 volt operation, proceed as follows:

1. Remove the white wire with brown tracer from pin 7 of V_{216} and reconnect it to pin 8 of V_{216}. Ground pin 7 of V_{217}.
2. Remove the white wire with brown tracer from pin 8 of V_{215} and reconnect it to pin 7 of V_{215}. Ground pin 7 of V_{215}.
3. Remove the white wire with brown tracer from pin 2 of V_{210} and reconnect it to pin 7 of V_{210}. Ground pin 2 of V_{210}.
4. Remove the white wire with brown tracer from pin 7 of V_{207} and reconnect it to pin 2 of V_{207}. Ground pin 7 of V_{207}.
5. Remove the white wire with brown tracer from pin 3 of V_{203} and ground the wire. Connect a jumper wire from pin 5 of V_{201} to pin 3 of V_{203}.
6. Remove the white wire with brown tracer from C_{204} on the oscillator/multiplier chassis and reconnect it to C_{206}. Ground C_{204} by bending its center pin over and soldering it to the frame.

Transmitter Alignment

Test points have been provided, connected to P_{101}, located on the front panel, which are intended for use with test set TS-178/ARM-1. This test set consists of a 50 μa meter, a selector switch, a 1 meg resistor and a 10 meg resistor. The 50 μa meter is connected directly across each test point pin and ground for all test points except for the A+ and B+ terminals where the 1 meg and 10 meg respectively are connected in series with the meter.

The chart in Table I indicates the terminal to which the 50 μa meter should be connected, the approximate meter reading obtained, and the adjustment to be tuned.

Table I

Meter to Ground and	Tune	For	Current
Pin 1			10-35
Pin 2	C_{108}	Max	12-45
Pin 3	C_{115}	Max	12-45
Pin 5	C_{122}	Max	
Pin 6	C_{129}	Min	
—	C_{130} & L_{109}	Max r.f. Output	

The two adjustments, C_{130} and the output coupling link, L_{109}, can be adjusted for maximum output in the two meter band but a compromise adjustment is necessary for tracking the 100 to 156 mc spread.

Receiver Alignment

As in the transmitter, test points have been connected to plug P_{201}.

Crystal Oscillator Alignment—With an 8727 kc crystal installed and a 50 μa meter connected between pin 1 of P_{201} and ground, turn the adjustment in Z_{201} as far counter clockwise as possible then clockwise until the meter reads 25 μa.

Fundamental Amplifier Alignment—With an 8100 kc crystal installed and a 50 μa meter connected between pin 2 of P_{201} and ground, turn all three screws on the top of T_{201} all the way counterclockwise. Turn first one and then the other of the outer two screws clockwise a turn at a time until maximum meter reading is obtained. Turn the center screw for maximum. Check on other crystal frequencies to be sure meter reads above 20 μa on all crystals. Repeat if necessary.

Harmonic Generator And R.F. Alignment—Tune a signal generator to the frequency to be received. Be sure that the right harmonic is used, or better yet, use a weak received signal if one is available. Connect the 50 μa meter to pin 5 of P_{201} and ground. Adjust C_{219E} and C_{219D} for maximum reading. Set the squelch control to the edge of noise/silence and adjust C_{247E}, C_{247F}, C_{247G}, and C_{247H} for maximum opening of the squelch. Keep the signal generator output as low as possible during these adjustments.

I.F. Strip Alignment—The i.f. strip used on the ARC-3 is purposely broad. To accomplish the wide bandwidth it was necessary to employ slightly overcoupled i.f. transformers. If an attempt to align the i.f. strip is made simply by adjusting all the i.f.s for maximum output, the symmetry of the i.f. response curve will be destroyed. To properly align this type of i.f. it is necessary to load the primary winding with a resistor so as to "kill" its Q while tuning the secondary. Killing the Q removes the loading effect from the winding being adjusted and thus eliminates any detuning effects caused by the over coupling.

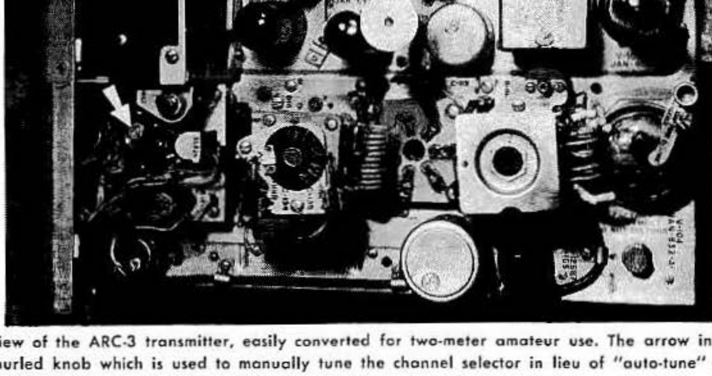
To tune the ARC-3 i.f.'s it is necessary to connect a 680 ohm resistor in series with a 470 mmf capacitor across the primary when tuning the secondary and vice-versa. To be sure the i.f.'s are aligned on exactly 12 mc, use a BC-221 frequency meter or a crystal controlled signal generator to establish the 12 mc signal. Connect the signal generator to a floating (ungrounded) tube shield placed over V_{209} and adjust the i.f.'s as described above for maximum opening of the squelch or for maximum output as indicated on an audio output meter.

Service Notes

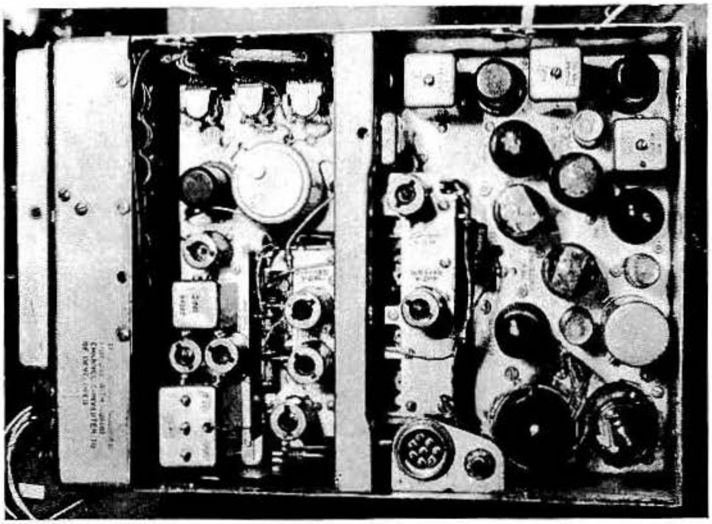
Failure of the squelch control to work and severe overloading can often be traced to C_{292}, a 0.05 mf 200 v moulded capacitor. This large capacitor is located at the back of the receiver with one lead grounded and the other connected to a terminal on the rear apron of the chassis. In four out of five sets checked, this capacitor was faulty.

Tunable Receiver

The receiver can be made tunable by converting V_{204} to a tunable oscillator. This is done by disconnecting the wire connected from T_{201} to pin 5 of V_{204} and connecting a 10K resistor from pin 5 to ground. Next, connect a 50 mmf capacitor from pin 5 of V_{204} to the junction of C_{220} and R_{219}. In some sets it may be necessary to adjust C_{220} either up or down in value to obtain the correct feedback for stable oscillation of V_{204}. Voltage regulation of the B+ for V_{204} will aid the stability somewhat.



Top view of the ARC-3 transmitter, easily converted for two-meter amateur use. The arrow indicates the knurled knob which is used to manually tune the channel selector in lieu of "auto-tune" operation. The Barometric gain-control, referred to in the text, is the large round component at the top left. The round calibrated dial indicates the approximate r.f. operating frequency.



Top view of the ARC-3 receiver chassis. The knurled knob for manual tuning is located atop the motor in the lower right corner. Plug P_{201}, the test plus, is located to the right of the crossbar. When converting to continuous tuning the wiring changes are made in the area of V_{204}, the bottom tube on the multiplier subchassis to the left of the crossbar.

By making the receiver tunable and connecting the control tube grid (V_{207}) to the a.v.c. line, a "signal seeking" receiver can be made. Connected in this manner, the receiver will hunt for a signal unless a.v.c. voltage is high enough to bias V_{207} to cutoff.

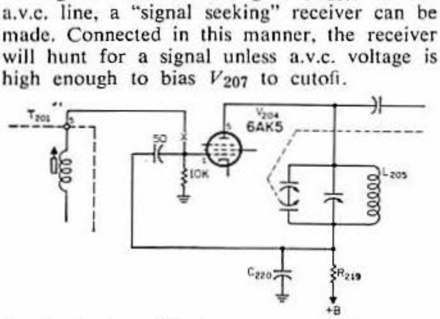


Fig. 3—Circuit modifications to convert the receiver to continuous tuning.

S Meter

For an S meter, a milliameter can be connected in series with R_{255}, the screen resistor for V_{211}, in the conventional fashion. Other S meter circuits can be adapted if desired. The current range of the S meter should be from 0-1 ma with a suitable shunt to zero the meter under no-signal conditions.

Rack Mounting

Both the receiver and transmitter are suitable for rack mounting by turning them sideways and mounting them on six two inch standoffs placed between the side panel and the rack panel. The two inch setback will allow a speaker, on/off switches, and other controls to be mounted between the panel and the set.

THE ARC-4 ALIAS SCR-522

Of all the VHF bands, Two Meters has seen the greatest activity. A significant portion of the present population of that band may be attributed to the opening of two meters to Novice 'phone operation.

A Novice license is in effect a one-year written permission, to acquire experience and familiarity with radio apparatus and operating technique.

Unfortunately, the Novice is not gaining his experience in "easy stages" when he tackles 144 Mc first, because of the many special problems associated with v-h-f circuits. Short leads, well-planned layouts, etc. are not automatically brought within the ability of the Novice with the arrival of his ticket. Thus it is that the newcomer (and many an oldtimer as well) turns to items of surplus equipment in order to gain the "knack" of v-h-f construction.

Post-war operation on two meters using modern stabilized transmitter techniques received its shot in the arm from the widespread employment of the military miracle, the SCR-522. Although many seasoned oldtimers have graduated to home-constructed rigs it is safe to estimate that a very large number of them gained their first contact with crystal-controlled two-meter operation through conversion of he 522.

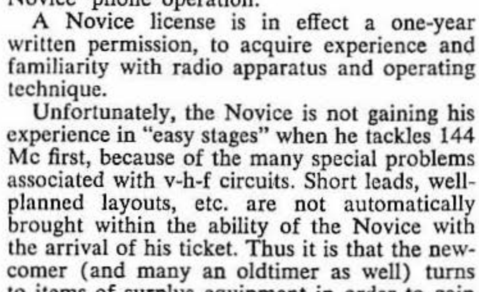


FIG. 1a ORIGINAL CRYSTAL OSCILLATOR CIRCUIT

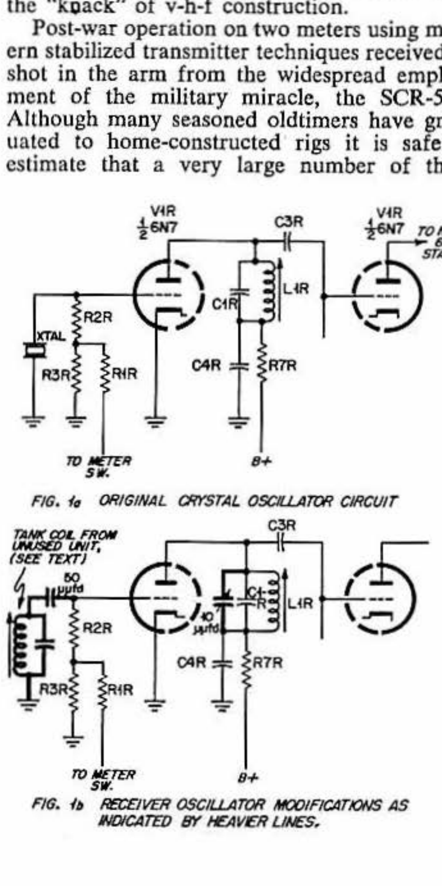


FIG. 1b RECEIVER OSCILLATOR MODIFICATIONS AS INDICATED BY HEAVIER LINES.

The BC-625

When amateur radio was given the green light after the wartime shutdown these SCR-522 transmitters (BC-625) were available for as little as $15. Little by little, yielding to the inexorable pressure of supply and demand, the price has crept up to a minimum of $50. This is the present-day price less power supply. Investigation has disclosed few other satisfactory surplus items available in sufficient quantities to replace the 522's.

The "Sleeper"

One of the few possibilities appears to have been neglected unduly. This is the ARC-4 war-surplus transmitter-receiver unit. The ARC-4 can be purchased complete with all tubes and dynamotor for $27.95, and is quite easily converted to a neat and efficient two-meter station. Complete conversion adds about $35 to this figure. This means you can get on the air, sending *and* receiving, for around $65!

As a consequence of the lack of published data on the modification required to adapt the ARC-4 few of them are heard on the air. The

Parts List For Conversion

A-C Power Supply delivering 350-400 vdc @ 200 ma. and 12 vdc @ 5 a.
1—10 μμfd. APC type variable condenser
1—30K, 1 Watt resistor
1—15 μμfd. mica condenser
1—100 μμfd. mica
1—National Type MCN dial
1—Flexible Shaft of necessary length
1—Millen type 39001 Flexible coupling
1—feed-through bushing, 7/16" mounting
2—¼" spacers, to mount dial.
1—FT-243 type crystal on any frequency between 6000 and 6160 kc.
1—single-button carbon mike, 100 ohms.
1—0-1 d-c milliammeter and plug, sleeve positive
1—pair headphones, any impedance, 500 ohms preferred
1—500K volume control
Assorted hardware, knobs, plugs, etc. as required

writer has accomplished the conversion successfully and is well pleased with the results obtained. To make it possible for others to duplicate these results the changes necessary have been boiled down to a series of step-by-step instructions, planned to take the amateur through the proceeding in the least painful manner.

General Data

Of what does the ARC-4 consist? It is a complete transmitter-receiver unit, designed to operate on any of four crystal-controlled channels in the 140-144 Mc range. Originally manufactured as an aircraft unit, the rig is powered by a 12-volt dynamotor supply and is, therefore, ideal for mobile operation. 6000 kc crystals are used in the transmitter section. This frequency is multiplied 24 times in four stages. The oscillator triples the crystal frequency and it is doubled in each of the three following stages.

The final amplifier uses an 832-A, which is fully modulated by a pair of class AB 6L6's. Push-to-talk technique is employed and the rig can be coupled to antennas fed with 50-70 ohm cable.

A ten-tube, crystal-controlled superheterodyne constitutes the receiver section of the ARC-4. Two radio-frequency "front-ends" are provided, both feeding a common i.f., 2nd detector and audio. One of these, the "plane-to-plane" unit, is to be removed while the other, the "plane-to-ground" unit, is to be reworked so that it can be tuned across the band, instead of being "rock-bound" at spot frequencies.

The rig has its own power-supply filter circuits but lacks the a-c transformer and rectifier. The only unusual part of the power supply is the need for filtered 12-volt d.c., required to energize the filament, microphone and relay circuits.

The chassis housing the transmitter-receiver unit is 10¾" high, 8¾" wide and 19" deep.

METER POSITION	TUNE	FOR	READING
Osc. IG	——	——	.2 -.6
2nd HG IG	L2R	MAX	.1 -.14
3rd HG IG	L3R	MAX	.08-1.
——	L4R	MAX AVC VOLTAGE*	

*Measured on VTVM plugged between 2nd terminal back on the plug-in socket strip and ground.

Fig. 2. The receiver tuning chart. All readings on 0-1 dcma meter, plugged into "TEST METER" jack on panel, with sleeve positive.

Getting Started

Before actually making your purchase, ascertain that the company from whom you plan to buy your ARC-4 supplies the schematic and parts list for the equipment. These are too large for publication here.

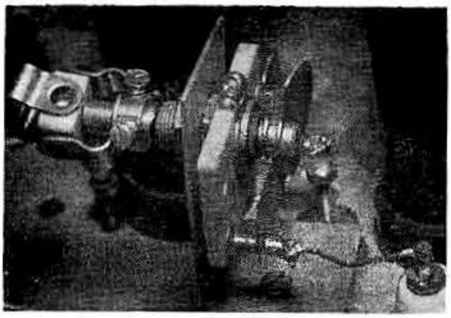
When the rig arrives check to see that nothing has been damaged in transportation. Remove the aluminum cabinet by twisting each of the screw-like fasteners on the back of the case until a click is heard. Pull off the case. Don't be afraid to exert a little force—nothing will be harmed by doing so. See that all the tubes are in place. At this point it might be well to check the tubes, replacing any found defective. Take a look at the underside of the chassis. Though it appears complicated, you will find that *every* soldered joint is accessible.

To accomplish the conversion you will need the following tools, in addition to the parts mentioned in the text: Screwdriver, soldering iron with small tip (a soldering gun may be used); rosin-core solder; long-nosed pliers; wire snippers and a 7/16" drill. Now we are all set to go to work.

Receiver Modification

In its military aircraft function the receiver

Front Panel of the converted ARC-4. Note position of tuning dial and volume control.



Detail of variable condenser mounting. Note short lead to feed-through bushing, and shaft coupling.

used a 6N7 crystal oscillator with output on 8500 kc. This was multiplied 18 times to a frequency in the neighborhood of 153 Mc. The injection of this frequency into the mixer stage, along with an incoming 143 Mc signal produced a difference frequency of 10 Mc which was amplified by the three stages of i.f. By changing crystals for others near 8500 kc the "channel" to which the receiver is responsive can be altered.

In order for the receiver to be usable in the amateur fashion the oscillator must be made tunable across a range sufficient, when multiplied 18 times, to track from 144-148 Mc. We do this by substituting a tuned circuit for the crystal and tuning the plate circuit of the oscillator with a variable condenser. This is shown diagramatically in figures *1a* and *1b*.

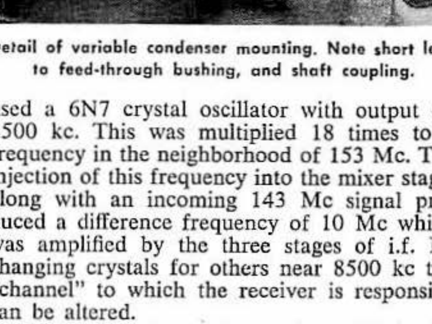


FIG. 3a ORIGINAL AUDIO CIRCUIT.

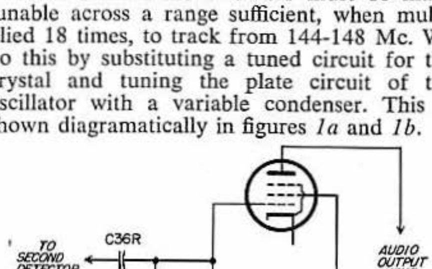


FIG. 3b MODIFIED AUDIO CIRCUIT.

Begin the conversion by removing the plane-to-ground r-f unit. To do so you will have to remove the machine screw at each corner of the plug-in unit and pull the length of coax from the i-f transformer. It will then be found that the plug-in section can be removed by a steady upward pull.

Remove the sides of the plug-in unit and locate the coil inside that has the largest number of turns on it. Make sure that the small condenser connected across the coil is intact. Carefully take out this coil and condenser. Also remove a 50 $\mu\mu$fd ceramic condenser from the unit. On the back of the ARC-4 panel is a metal slide where the trimmer condensers of the plug-in unit were located. Take out this slide.

Returning to the main unit, you will see a short length of metal co-ax running from one of the sockets on the plug-in strip to a feed-through bushing. Now drill a 7/16″ hole between the bakelite plug-in strip and the crystal sockets. Mount the coil you have just removed from the r-f unit in this hole. Also mount a new ceramic feed-through bushing with a 7/16″ hole where the old one was.

A good soldered ground connection should be made to one end of the coil. Wire the 50 $\mu\mu$fd ceramic condenser between the top end of the coil and the lug on the resistor board to which a wire running from the selector relays is connected. Then remove this lead.

Mount a 10 $\mu\mu$fd APC type variable condenser near where the feed-through bushing is located (see photo). Ground the rotor, and run the shortest possible lead from the stator through the feed-through bushing and then to pin #6 of the 6N7 oscillator tube.

A *National* type *MCN* dial is mounted on the front panel. It is supported on ¼″ spacers so that no large hole in the front panel need be drilled to accommodate the drive mechanism. The shaft coupling of the dial is placed so that it extends through the hole marked "*ANT*" at the top center of the panel. If the condenser shaft is not in line with the dial coupling smooth control is obtainable by using a flexible shaft extension of the desired length and a *Millen* type 39001 coupling on the condenser shaft.

Assuming that the power supply to be described in the following portion of this article has been constructed, the receiver can now be tuned up. Set a communications receiver or a grid-dip meter to 8555 kc, and with the ARC-4 tuning condenser set at maximum, tune L1R in the oscillator circuit (not the one you just installed) until the oscillator is heard in the communications receiver or g.d.o. Now set the receiver or grid-dip meter to 8800 kc and, with the tuning condenser of the ARC-4 at minimum, increase the capacitance until the oscillator is again heard. Tune the coil you installed for the best possible bandspread, or until you can cover 8500-8800 kc in about 70 or 80 dial divisions. After this is done tune up the other circuits with the slugs for maximum meter readings (see the chart in *Fig. 2*).

Double conversion, which provides better selectivity, can be had if a communications receiver is available for use with the ARC-4. The antenna terminal of the communications receiver is coupled to the i.f. output of the v-h-f unit by wrapping a piece of insulated hookup wire around pin #4 of the last 12SQ7 to the rear of the chassis. This is the second detector diode plate. Run the receiver's r-f gain control (if there is one) at half setting and the a-f gain all the way up. Tune the receiver to 10 Mc, or to where the rushing sound from the ARC-4 is heard. This system of dual conversion gives, in the v-h-f range, all the benefits normally obtainable from the communications receiver, i.e., selectivity, ANL, BFO, AVC, etc. If you use this system you may skip the following paragraph and go on to the next.

In the event that dual conversion is not desired, a volume control must be installed in the ARC-4 for comfortable operating. Mount a 500,000 ohm volume control in the hole marked *"grid"* beneath the tuning dial. Ground one end and substitute the control for R40R as shown in figures 3a and 3b. This resistor is the second one from the front on the terminal board alongside the audio tubes. Connect a wire between the grids of tubes VS7 and VS8R, pin #2 on each tube. The tubes are 12SQ7s.

We can now plug an antenna into the coax connector on the front panel, and a pair of 'phones into the 'phone jack. Adjust the volume control to a comfortable level and set the tuning dial to the middle of the band. With a screwdriver tune the three trimmers at the lower left hand corner of the panel for maximum receiver noise. Now tune around the band for a signal or make a "sked" with a nearby amateur. When a signal is heard readjust the trimmers, always going from left to right, for maximum signal strength. This trimming has to be done four times to cover the entire band. It is very important to do this for no signals will be heard if the trimmers are out of alignment. It may prove to be unhandy at first but you will soon become accustomed to it. If no signals can be heard on the band you may tune for maximum receiver noise, still proceeding from left to right.

Transmitter Modification

Modification of the transmitter is quite simple, requiring only the substitution of two small mica condensers and a little work on the relays. Replace C2T, connected between pins #5 and #8 on the transmitter oscillator tube, with one having a value of 15 $\mu\mu$fd. Also replace the condenser across the oscillator cathode coil with a 100 $\mu\mu$fd unit.

Short the relay which is farthest back on the bottom of the chassis by connecting a lead between the lug on the relay, to which a wire

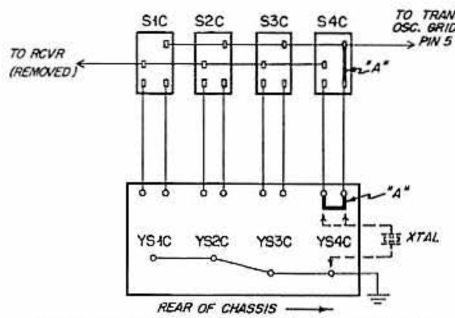


FIG. 4 CRYSTAL SOCKET AND RELAY MODIFICATIONS HEAVY LINES MARKED "A".

with a green tracer is connected, and both of the lugs to which the corresponding crystal socket is wired (see *Fig. 4*). Plug in a crystal of between 6000 and 6160 kc and tune all the transmitter stages for maximum according to the chart in *Fig. 5*. For the Novice Band, crystals ranging from 6045 to 6125 kc should be used. War surplus crystals of the FT-243 type fit the ARC-4 crystal socket. If your meter readings are better than those on the chart, for Heaven's sake don't detune the rig to agree with the chart!

Load up the antenna by increasing the loading capacity (marked "TRAN ANT") a bit and then tuning the r-f amplifier for minimum

METER SW. POSITION	TUNE	FOR	READING
Osc. IG	——	——	.25
1st HG IG	L1T-L2T	MAX	.5
2nd HG IG	L3T-L4T	MAX	.4-.5
3rd HG IG	L5T	MAX	.4
RF AMP IG	C6T	MAX	.25
RF AMP IG	L8T	MAX (on side of chassis)	.25
RF AMP IP	L9T	MIN*	.5
AUDIO AMP	——	——	.9
FILAMENT	——	——	.46
PLATE	——	——	.5†

*before loading antenna
†Or more, depending on plate voltage

Fig. 5. Transmitter tuning chart. All readings on 0-1 dcma meter plugged into test meter jack.

dip. Keep repeating the process until you get the maximum loading while still able to indicate a dip. This might take a little jockeying around before you get the rig properly loaded, but you will soon get the hang of it.

Power Supply

No power circuit modifications need be made if the rig is to be used as a mobile setup. If, however, fixed-station operation is desired, you must construct a power supply. For the sake of portability the a-c supply may be built into the dynamotor compartment, but since this requires working in rather a confined space, it may be preferred to build a separate unit, and connect the two with cable.

Any high-voltage supply delivering 350 to 400 volts d.c. at 200 ma. will be suitable. As before mentioned the filament circuit requires 12 volts d.c. at 5 amperes. To obtain this a toy-train transformer delivering at least 20 volts a.c. in conjunction with a selenium or copper-oxide disc rectifier makes a good combination. The rectifier should be chosen for proper current rating. Any transformer-rectifier combination available capable of 10-15 volts at 5 amps or so will be perfectly satisfactory.

Difficulty will be encountered in locating a plug to fit the socket on the rear of the chassis so a little work will have to be done on the connector. Close inspection will make it obvious that each pin is lettered or numbered. Using insulated hookup wire of #22 or #24 gauge, wire together as groups the following pins: (a) 5, 15 & 16, (b) 1 & 2 (c) A1 & 8, (d) 3, 4, 7, 9, & 10, (e) A2, 16 & 20. Hook a 30,000 ohm 1-watt resistor from A2 to 18. With this arrangement A1 is plus 12 volts d.c. 17 is plus 375 volts and A2 will be the "A" and "B" minus.

It is very important to make good soldered joints, making sure that no two groups are shorted together. This could cause trouble later on. Now hook up your power supply, turn both it and the ARC-4 switch on and make sure that the filaments light up. Also make sure that the power relay at the rear of the chassis closes properly. Plug a single-button carbon microphone into the three-conductor jack on the front panel and by closing the mike circuit with the switch or button, check to see that the changeover relay makes proper contact. If everything seems to be in order you are on the air. If trouble is encountered, check the connections on the power plug and check the power supply voltage.

Any antenna can be coupled to the ARC-4 if the feedline is within the impedance range of 50 to 70 ohms. The writer's antenna is a ground-plane fed with RG 59/U cable. Feedline length is not critical although it is desirable to keep it short (but not under 10 feet). In the case of the writer, the location of the antenna required 150 feet of lead-in yet the performance has been fine and many excellent reports have been received.

If you convert your ARC-4 carefully, in the manner outlined here, you will find its performance leaves little to be desired. The ARC-4 compares favorably with 2-meter rigs costing many times the modest price of the ARC-4.

THE SCR-522 ON 10

First, get the transmitter to work on the v-h-f frequencies for which it was designed to be sure all stages are working properly before 10-meter conversion is started.

The following changes are required to operate the transmitter on 10 meters:

Add 3–13 $\mu\mu$f trimmer condenser across the 12A6 tank coil No. 119. This condenser will be set at approximately 8 to 10 $\mu\mu$f for the tank to tune 10 and 11 meters.

Replace the v.h.f. r-f chokes (127–1, 127–2, 127–3 and 127–4) with 2½ mh, r-f chokes. (These are the r-f chokes in the grid circuits of both 832 tubes).

Replace the 2½ meter hairpin tank No. 120 on the first 832 stage with a ten-meter coil consisting of 12 turns of No. 14 wire ¾-inch diameter and 1¼-inches long. Connect the coupling condensers 109–1 and 109–2 four turns in from each end of the tank coil. If these condensers are connected to the ends of the coil (as they are for 2 meters) the final tube will have too much drive, causing the grid current to be several times the rated current.

Replace the final v-h-f tank and link with a coil consisting of 14 turns of No. 14 wire ¾ inch diameter and 2¼ inches long, spaced 3/8 inch at the center for the link. This link consists of 5 turns of No. 14 wire ¾ inch diameter. Add a 5–15 $\mu\mu$f air padder condenser across the final condenser to have sufficient capacity to tune 11 and 10 meters.

Use forty-meter crystals in the oscillator. The output of the oscillator is on 20 meters. Doubling in the 12A6 gives 10-meter output from this stage. The first 832 tube operates straight through on 10 meters to drive the final 832 tube. We haven't tried eliminating the first 832A driver tube, but it might be done by link coupling between the 12A6 tank coil (No. 119) and the first 832 tank coil (No. 120–10 meter), although it may effect the modulation since the screen of the 832 driver is modulated along with the screen and plate of the final tube.

SCR-522 ON 220

THE INTENT OF THIS ARTICLE is to describe a quick and simple surplus conversion to get you on the 220 mc band with results quite respectable out to 30 miles or so and dependent only on your antenna beyond that range. Based on alteration of the SCR-522 transmitter, it will be obvious that the scheme to be described is equally useful in the VHF ARC-5 series. Since there are probably several thousand of these venerable clunkers outstanding today in the hands of amateurs across the country, it is the writer's hope that perhaps this discussion will result in more use of a fine, though neglected band.

How It All Started

For many years a 522 transmitter had been used on the 2 meter band here with very good results. (There is a rumor prevalent among the locals that the location here was checked for altitude with an aircraft altimeter prior to purchase.) The exceptional performance of this simple gear was attributed to: 1) a 10 element, well matched array and 2) a clear line-of-sight to the horizon about 35 miles away in the direction of Philadelphia. Once in a while speculation of what life was like upstairs on UHF did occur, but being lazy, nothing was done about trying the higher bands. Then one fine day a brother ham informed me that he was selling out, going to Florida, etc. Running down a neatly typed six page list, I found a well known commercially wired 220 mc was being disposed of at 3% of ham net. Protesting the unfairness of this outrageous price, I was lucky to get away with only the converter, a 5 element yagi, and a set of tubes for the unit, and it was but a few nights later when the first 220 mc QSO was received. As I recall it was between Larry, W2NTY, and Mike, K2QWE, two fine operators and real regulars who have done much for the band in this area. I need not add that an intolerable itch developed to talk to the 10 or 12 stations in northern New Jersey and Long Island that were now received regularly in this period of nocturnal eavesdropping. But the question was how.

The Solution—Back To Fundamentals

Back issues of *CQ* were moved to the office and thoroughly searched for several days. However, the available construction articles all involved tubes not on hand or were just more bother than it appeared to be worth. The problem really solved itself one day when the filter on an old receiver dried out and all that was heard was full wave ripple, i.e. 120 cps hum. But it was double the input frequency. Could it be applied to rf? Sure, although here the scheme is called push-push doubling. At this point let it be seriously suggested that the reader dig out his *ARRL Handbook* and read up on this subject. It is all there. Really nothing new or different is being set forth here save possibly how to make this work on VHF.

So there you have it: apply push-push doubling to the final amplifier (the twin tetrode 832) and get on the 220 mc band in a hurry. Now this means that final must be excited at 110 mc. But, remembering that the 522 originally tuned 100 mc to 156 mc, this is fine. All that need be done is to supply a 6 mc crystal and tune the rig to 110 mc indicated on all dials save the last which is not used. Where to get a 6 mc rock? Well, a unit at 6112 kc was purchased from U.S. Crystals, Inc., La Brea Ave., Los Angeles, Calif. It happened I got mine while on a business trip to that area. However, any of the crystal companies advertised in *CQ* should be able to supply crystals in this range, either new or surplus. Naturally the latter are considerably cheaper. Caution: check and find out where the activity is in your neighborhood. Around New York and New Jeresey everyone seems to operate in the bottom 200 kc of the band, while in Philadelphia a common channel of 221.4 mc is used.

For those who must tinker let it be said that the 522 works like a charm delivering power on 110 mc. The one here, which barely lights a 15 watt bulb in normal fashion on 144 mc, really lit up on 110 mc because of the greater drive available.

Another caution note. If you have just rushed out and purchased a new surplus 522 transmitter *do not* alter the tuning range of any of the 4 tank circuits. Most conversions electrically bandspread these controls. If, as is done here, it is desired to occasionally use the rig on 144 mc (with an 8 mc crystal) then the full tuning range of these circuits must be retained.

Now We Have To Do Some Work

Push-push doubling involves driving the pants off the final 832 at 110 mc, strapping the plates together, and tying them to a tuned circuit resonant at 220 mc. This is where some invention was required. First, the paralleled plates double the 832 output capacity, so don't even bother with a conventional parallel tuned circuit. There just isn't any coil left to work with. But another expedient is available which is the series tuned tank. This worked and is the secret of success in this conversion.

One approach to understanding this scheme (neglecting the load for the moment) is to view the tuning capacitor, C_T, as being in series with the tube output capacity, C_o. This series combination then is adjusted to resonate with the in-

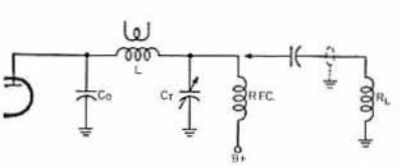


Fig. 1—Diagram of an accepted series tuned circuit suggested by the author. See text for discussion.

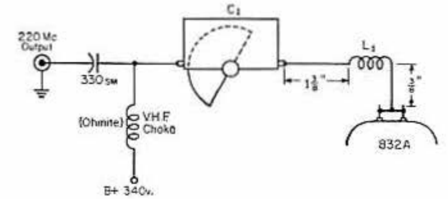


Fig. 2—Actual series tuned circuit applied by the author to his SCR-522 for operation on 220 mc. C_1 is a Cardwell capacitor cut down to a three plate variable with one rotor and two stator plates. Stator plate-to-plate spacing is 1/16". Diameter of rotor plate, 1½". Rotor is grounded. L_1 is 2 turns of tinned #18 wire ⅜" dia., spaced 1".

ductance L at the desired frequency which is 220 mc here. Since C_0 in series with C_T is smaller than either capacitance alone, the result is a coil which, though small, is big enough to work even at 220 mc.

To couple a load to this arrangement, a link arrangement was tried much as shown. This was not particularly successful probably due to the stray capacity introduced by the link. Anyway this was abandoned. The similarity of the series circuit to the "Pi" network was noted and the load applied directly across the tuning capacitor. A blocking capacitor of course is required to avoid shorting out the B-plus in the grounded antenna system. The load at this station is a fairly well matched 75 ohm coaxial line (v.s.w.r. is under 1.5 to 1). It was connected exactly as shown and right off the bat 5 watts were developed at the output. This was later increased to about 8 watts.

Varying the L/C ratio seems to optimize the loading as would be expected. However, the coil dimensions indicated resulted in reasonable output so that little fiddling was done afterward. The writer prefers to operate.

In the diagram are coil dimensions, etc. which worked here with three different 832 tubes. The connection T bar to the 832 plate leads was made out of the pins from an old octal socket and a piece of wire. It should be noted that soft tinned #18 wire was used for the coil and T bar. It was not silver plated though this refinement might help.

Looking at the final amplifier plate compartment of the 522, remove the end cover plate and discard it. Detach the existing tank circuit plate leads and tie down to the butterfly capacitor so they are out of the way (remember that you may want to go on 2 meters sometime). Use electrical tape for this. Mount the new 3 plate tuning capacitor on the top of the compartment, midway between the 832 and the existing butterfly tank period. Wire in the coil, choke, and blocking capacitor to a coax fitting and the transmitter is complete.

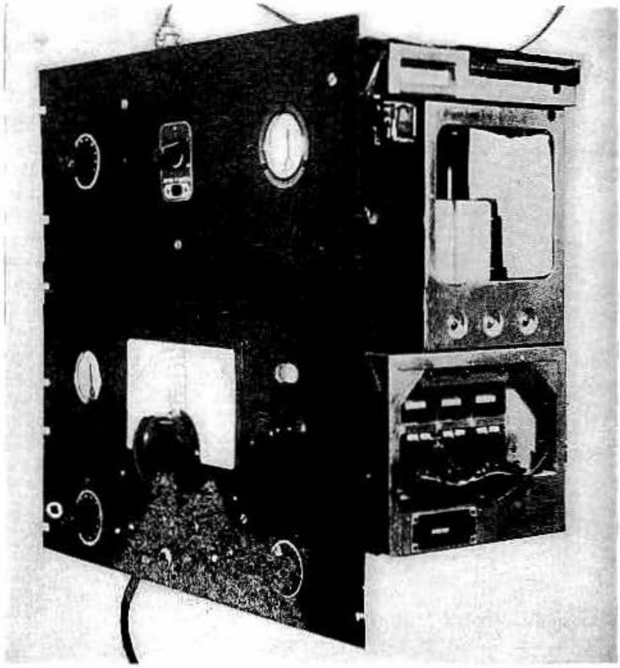
One more operation is required and you will be on the air. The problem is simply that the push-push arrangement will in practice usually have 110 mc drive power in the output due to residual unbalance in the final amplifier. Therefore insert a T fitting in the output coax line and tie in an open ended stub which is cut to be ¼ wavelength at 110 mc. Don't forget line phase velocity factor in cutting this stub. Since it is desired to short the output at 110 mc, the stub must be open on the far end. At 220 mc the stub is effectively out of the circuit and has no effect on the desired band. Considered as a filter, the stub blocks the odd harmonics of 110 mc, i.e. 330 mc, 550 mc, etc., and passes the even orders, i.e. 220 mc, 440 mc, 660 mc, etc. Do not operate without this stub in the line. In areas where UHF TV is in use proper selection of the transmitter crystal will usually move any remaining harmonic problem out from under the TV signal.

For tuneup a Heathkit v.s.w.r. bridge is left in the line as an output indicator at all times. Insert a 6 mc crystal (6112 kc used here) and tune for max. indication on a 0-1 ma meter connected to the 522 meter pins. This procedure applies to meter switch positions 1, 2, and 5. This tunes the transmitter up to the final grids. To tune the final use the v.s.w.r. bridge. Now go back and maximize the output on the bridge by trimming the low frequency stages again. You are now set to operate.

Results are most gratifying considering the effort involved. Local range contacts are easy and beyond the horizon work is a function of your antenna. Though far from DX, this rig easily reaches down beyond Somerville, N. J., from this location (about 25 miles north of New York City.)

In conclusion the conversion outlined will get you on 220 mc with the least fuss. Although it is a cheap way and maybe a little dirty, it works. Try it, and come on a good band.

THE SCR-522 ON 2



Front view of SCR-522. All meters, controls and indicators are added as described in modification steps.

SURPLUS EQUIPMENT now available provides the ham interested in v.h.f. with many opportunities to equip his station with excellent radio gear. Before the war, crystal control on the v.h.f.s posed many a problem, but today this may be solved by units such as the surplus SCR 522-542. This unit, which covers 100-156 mc, is ideal for the amateur because of the 2-meter coverage.

For ham work, the receiver can be converted so that the 2-meter band will cover at least 70% of the bandspread dial. In addition, the transmitter can be pretuned to four different frequencies in the 2-meter band, any of which may be selected automatically. A modulator and speech amplifier complete the unit.

The SCR 522-542 is comprised of a transmitter, BC625A; receiver, BC624A; rack and case.

The rack has a tray which contains cables interconnecting the transmitter, receiver, antenna, power supply, control switches, several 12-volt d-c relays, and the channel control motor and mechanism. Sockets and plugs connect the tray and the transmitter and receiver.

Because it is difficult to get plugs to connect cables between the power supply and rack, the simplest method is to take the necessary parts from the rack. If this is done the 13-volt d-c relay supply will not be needed.

Transmitter Line-Up

The transmitter consists of the following: 6G6G, crystal oscillator; 12A6, first harmonic amplifier; 832, second harmonic amplifier; 832, power amplifier; two 12A6s, modulator; 6SS7, speech amplifier; 6SS7, r-f indicator (not included in many units).

The speech amplifier is designed for a magnetic or low-impedance dynamic mike. As described later, the circuit may be easily adapted to use a single-button carbon mike. Reports on the quality have proved it satisfactory.

The speech amplifier drives the push-pull 12A6s that modulate the screen of the 832 harmonic amplifier and the plates of the 832 final. This arrangement provides 100% modulation.

The dial controls numbered from 1 to 4 from the meter switch are: No. 1—oscillator plate; No. 2—first harmonic amplifier plate; No. 3—second harmonic amplifier plate; No. 4—final amplifier plate.

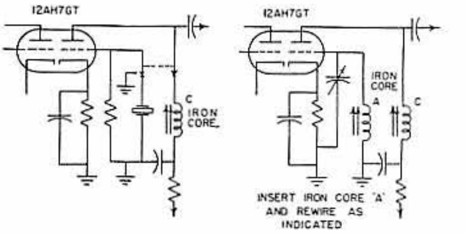


Fig. 1. Circuit changes required to obtain maximum bandspread on the 2-meter band. The iron core is inserted in place of the crystal circuit as indicated in the before and after circuit of the 12AH7GT.

The switch numbered from 1 to 6 connects the 0-1 milliammeter into different sections of the transmitter, at the same time connecting different shunt resistors which change the full-scale deflection readings.

Switch Position	*Current*	*Scale (ma)*
No. 1	First harmonic amplifier plate	0-50
No. 2	Second harmonic amplifier plate	0-100
No. 3	Power amplifier plate	0-100
No. 4	R-F indicator diode	0-1
No. 5	Power amplifier grid	0-2
No. 6	No connection	

Receiver Line-up

As may be seen in the photo, bandspread is read on the National ACN dial. This is coupled to the 25-$\mu\mu$f variable capacitor. To the right of the main tuning dial is the "megacycle control," reading from 100 to 156 mc, which controls the tracking for peak efficiency.

A gear on the megacycle control shaft drives both the oscillator and r-f section variable capacitors. The speed ratio difference for nearly proper tracking of these tuning sections sets a 2⅛-inch pitch diameter gear for the oscillator section and a 2⅞-inch pitch diameter gear for the r-f section. A ½-inch pitch diameter gear connected to the megacycle dial tuning shaft completes the drive.

At the lower right is the audio control and to the left of it a DPDT toggle switch used to control change-over relay No. 412 and the carbon mike voltage. Voltage connections also are made to the red jewel pilot light by this switch in "transmit" position. Directly below the bandspread dial is a male microphone connector.

A 0-10 milliammeter (used as an S-meter) is at the upper left of the receiver panel. Below it is the squelch control. To the right of this is the a-c power supply control switch and the green jewel pilot light.

The 10½" steel panel is fastened to the receiver with 10-32 flat-head machine screws 1⅞ inches long with ⅜ x 1½ inch spacers. Panel holes are drilled to match the threaded holes originally occupied by the red long-shanked screws.

Receiver Conversion

Conversion of the receiver to provide maximum bandspread of the 2-meter band calls for only a few changes, as shown in Fig. 1. These can be made as described in the following step-by-step method.

a) Loosen the 4 Dzus fasteners. Place fingers into recess handles of rack and lift the unit clear of the case. Remove the 4 red long-shanked screws, making sure that the slider mechanism is not engaged. If a channel is engaged, release it by squeezing the motor armature until slider is free. The weight of the receiver and transmitter will disengage the units from the rack.

b) With the bottom of receiver up and in working position, unsolder the lead to No. 5 pin of the 12AH7 tube socket connected to the socket terminal, taping end and placing it aside.

c) Near the two gang capacitors of the oscillator section are four permeability tuned inductors (iron-core coils) used as oscillator plate resonator for crystal tuned channels (Only one of these inductors is to be used in the plate circuit of the receiver so the three extras may be used elsewhere.) Locate channel "A" inductor (by looking at the name plate on the top side). Unsolder terminal with single lead, tape end and place out of the way. Solder connections between this terminal and No. 5 pin of 12AH7 socket.

d) Unsolder the two wires attached to the other end of the channel "A" inductor and ground this terminal. The two leads are soldered together, taped and placed clear of inductor "A".

e) A 25-uuf variable capacitor is mounted to receiver frame near and above the 12AH7 tube. Connect the fixed plate terminal to No. 5 pin of the 12AH7. See Fig. 1.

f) The next change is in the plate circuit. Terminal No. 6 of the 12AH7 socket has three leads soldered to it. Trace each lead (white with broken blue stripe) that goes to the crystal switch. Cut the lead at the 12AH7 terminal and pull it out to the switch. Now trace the lead (white with red and black stripes) from iron-core inductor "C" to the crystal switch, cut at crystal terminal, re-route through hole to terminal No. 6 of the 12AH7 and solder.

g) Take the 10-contact Jones plug from the rack and press it over the male prong. Solder connections to the following terminals:

No. 8—12 volts a.c., No. 3—300 volts d.c., No. 5—300 volts d.c. (Nos. 3 and 5 can be tied together), No. 7—B minus (ground), No. 4, 7—Small p-m speaker.

h) Antenna feeder (52-ohm coaxial cable) with banana plugs attached to the free ends are plugged into the antenna socket (No. 232) near the r-f tuning control.

i) Set r-f and oscillator tuning control pointers to read 145 mc.

Set iron-core inductor "A" screw one thread below surface and set "C" inductor screw to show one thread above the surface. Turn audio and squelch controls clockwise to maximum setting.

j) After checking tubes and all connections made, apply voltages. As the receiver reaches its operating point, hissing or rush noise level will be heard. A peak in the hissing will be found by turning the 25-uuf capacitor from maximum to minimum. Retune both oscillator and r-f controls, increasing peak of hissing level.

k) After locating a station or two, it may be found that part of the band is above or below the range of the 25-uuf capacitor. To correct this, adjust the "C" iron-core inductor a little at a time, either clockwise or counter-clockwise, checking the position of the tuned carrier or station for each adjustment. The use of an r-f signal generator will make the adjustments much easier. By setting the r-f and oscillator controls at 146 mc, good coverage is obtained from 144.7 to 147.4 mc. Any DX station's signal strength can be increased by peakng the r-f and oscillator controls on the incoming signal frequency.

Additional Receiver Improvements

Before making additional changes, a pencil mark should be made on the rotors of the capacitors in the oscillator and r-f sections with these sections tuned to the 2-meter band. With the rotors at these settings the gears can be meshed and locked. This will save time trying to adjust the capacitors with the gears on.

Continuing the step-by-step explanation:

a) Remove plug-in crystal assembly, cutting all leads. Remove crystal selector switch by taking out mounting screws.

b) Using a Bristol set-screw wrench, loosen the 8-32 set screws between the slider mechanism and r-f oscillator sections. Remove slider mechanism mounting screws. Lift mechanism upward, clearing couplers.

c) The 25-uuf variable capacitor and bracket are mounted so that the capacitor is in the space originally occupied by the crystal assembly. The mounting position depends on the type of dial used.

d) The variable oscillator and r-f gang capacitors require an odd-sized coupler. If a ⅜-inch coupler is used, it requires a few shims to center the coupler. Another method is to use a 5/16-inch coupler and drill one side to fit. Standard shafts are then used. These shafts should extend ¾ inch beyond the receiver and the gears already described are mounted on these extended ends.

e) With the oscillator and r-f gears in place, the megacycle dial shaft and gear are set into position and supported by a bracket mounted below the gear assembly.

f) The audio and squelch controls are transferred to the panel and rewired. If the audio control has no extended shaft, a new 150-ohm control is substituted.

g) The microphone terminal is for a single-button carbon mike. Shield grounded and inner wire connected to either terminal No. 6 or No. 7 of the 18-prong connector of rack, or to terminal No. 1 or No. 3 of transformer No. 158. If a low-impedance dynamic microphone is to be used, connections are made to both terminal numbers at either location.

h) The a-c switch is wired to the power transformer primary and to the green jewel pilot light (110-volt a-c type).

i) For improved performance the 12J5 may be replaced with a 12A6, making the following changes:

1) Replace the 1500-ohm resistor with a 400-ohm resistor between pin No. 8 of the 12J5 and ground.
2) Solder connections between pin No. 4 of the same tube and No. 2 terminal of transformer No. 296.
3) Speaker output can be checked between ground and output transformer No. 296. Terminal No. 5=50 ohms impedance; No. 6, 300 ohms; No. 7, 4000 ohms. The speaker output transformer should match one of these impedances for greatest output.

Transmitter Conversion

The following description gives a step-by-step method for converting the transmitter. Mechanical frequency shifting will be described later.

a) Loosen the Dzus fasteners and lift the rack, releasing the transmitter. Unsolder the three wires connected to terminal No. 2 of the 12A6 modulator tube socket. Take continuity reading (with ohmmeter, etc.) between each of the three unsoldered leads and the terminal of relay No. 13 (top side of chassis) located near terminal No. 2 of the 12A6 tube. The wire showing a direct short is taped and placed out of the way. The other two leads are replaced in their original position and resoldered.

The relay is now without a voltage source, but this may be remedied by connecting an insulated wire between the relay terminal and the No. 8 terminal of the Jones plug 123-1, making available the 13-volt d-c terminal if needed.

b) If a magnetic or low-impedance dynamic type microphone is to be used, no changes are necessary in the microphone transformer circuit. To use a carbon mike, cut connection to No. 2 terminal of the microphone transformer and in its place connect the 3 volts of two flashlight cells, grounding the negative. Disconnect microphone when not in use.

c) The transmitter should now be set in its upright position and a female connector added to the Jones plugs No. 123-1 and No. 123-2. Connections to No. 123-1 should be made as follows:

No. 1—Single-button carbon mike.
No. 1, 2—These are used if an electromagnetic or dynamic microphone is to be used.
No. 8—13 volts d.c. (no voltage is necessary without use of rack).

Connections to plug No. 123-2 are:
No. 1—Minus 150 volts bias.
No. 2—12.6 volts a.c.
No. 3—Plus 300 volts d.c.
No. 4—Plus 300 volts d.c.
No. 8—B minus or ground.

Plug 0-1 milliammeter extension into meter socket. Set switch into No. 1 position. (Note 0-1 milliammeter should be shunted with a precision 40-ohm resistor.)

d) Plug suitable crystal into "A" socket.

e) With all connections checked, the transmitter is ready for tuning.

Loosen tuning control lock-nuts until only slight pressure is exerted on the cam. Set top channel slider ("A" channel) in ⅝ inch and lock by inserting a piece of wood ¼ x ¼ x ⅝ inch into space created by movement of slider near crystal selector switch slide, between slider mechanism support and slider "A." Channel slider pressure will hold the wood in place.

f) With the four dials set near the 145-mc marking, these tuning steps should be followed:

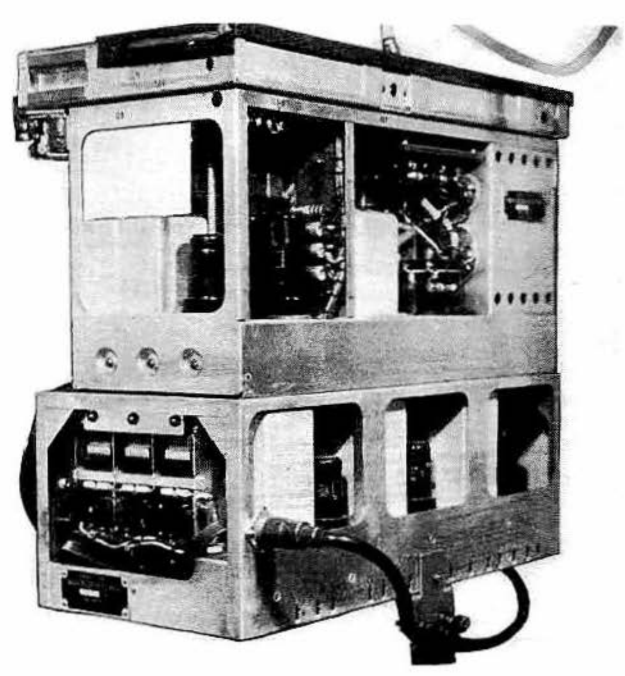
Tuning Control	*Meter SW Position*	*Meter Reading*
No. 1	No. 1	Maximum
No. 2	No. 2	"
No. 3	No. 3	"
No. 4	No. 3	Minimum

g) A 6-8 volt, .25 amp. pilot bulb wired to an extended 2-turn coil should be used to show the point of maximum r.f. while tuning. This also is an excellent means of checking modulation. The brilliancy of the bulb will increase with modulation peaks.

h) With the antenna plugged into the transmitter, tuning steps 3 and 4 are repeated for antenna loading. The meter in No. 3 position should read 6.5 for conservative operation of the transmitter.

Automatic Frequency Shifting

The following information is included for those interested in using motor control for shifting the transmitter frequency.



Rear view of SCR-522 complete with automatic frequency mechanism mounted on top of transmitter.

The photo shows, above the receiver, a 7" x 19" panel with a 1-pole 4-position switch, centered and to the left-hand side. This switch controls the channel control motor that selects any one of the four crystal frequency channels of your choice.

Centered on the panel is the meter switch and dial plate that has been removed from its original place in the transmitter. To the right is the 0-1 milliammeter that connects directly to the switch meter terminal. The panel is supported by two home-made "L"-shaped angles which receive their rigid support by being attached to the rack, as described later.

Continuing the detailed description:

a) Arrange the rack so the side that controls the receiver is toward the front. Remove concentric pivot screw in the center of the shifter crossarms. This screw is near the 2-uf condenser, No. 401.

b) Allow the spacers to drop out by lifting the rack tray at an angle.

The crossarms now can be removed by releasing the arm at the shifter first, then moving the crossarm into an angle so that the key-type pivot and the slot of the crossarm that crosses the center of the tray are in a straight line. Move downward and out it comes. This is repeated for the other three crossarms.

c) Remove screws that hold condenser No. 401, relay No. 411-1, and push-button switch No. 426 in their places. Remove the eight screws holding top center cover plate. Place cover aside. The cable attached to the loose components is pressed out of its position so that it is free.

d) With a hacksaw begin cutting along the outer edge of the center section on the receiver side. Cut a ½-inch "V" slot between socket No. 417 and relay No. 412. With the sawing finished take a flat file and file down the sharp edges.

e) Remove the two screws that hold the 18-contact center socket in place and lift as high as possible, tilting to the side. The following changes to be made will make this socket of no further use.

f) Connections to control switch. Cut five 8-inch lengths of pushback hook-up wire and solder them to the five switch terminals to be used. Connect and solder the other ends to the leads at socket No. 417. Check the numbers marking each terminal carefully to avoid mistakes. Numbers are according to channel order:

Switch	*Channel*	*Socket No. 417*
Pole	—	No. 1
No. 1	"A"	No. 4
No. 2	"B"	No. 5
No. 3	"C"	No. 8
No. 4	"D"	No. 9

Solder and tape each lead as it is unsoldered from its pin number. According to the type of microphone that is to be used, a 2-foot length of shielded single or double-wire mike cable is soldered to the leads from pin No. 6 and No. 7 of the same socket. Another 2-foot length of pushback wire is connected and soldered to the lead from pin No. 17. The socket can now be reset and the screws replaced.

The "V" slot serves as the outlet for these new cables. Make sure to tape the cable at the point where the cable and "V" slot come in contact to prevent a short at some future date.

g) Remove the two screws holding the 12-contact socket No. 420 in place, lifting high enough and tilting so a lead can be soldered to pin No. 11, an unused terminal. Find terminal No. 8 of No. 418-1 Jones contact plug. Follow other cables to this point and cut, connect and solder. Now at the Jones socket No. 419, unsolder three leads attached to terminal No. 8. Make a continuity test between each lead and terminal No. 2 of Jones socket No. 418-2. The one that shows a complete short is resoldered to No. 8 of No. 419. The other two leads connect to terminal No. 8 of No. 418-1. The addition to the circuit is for the d-c relay voltage.

Socket No. 420 is the SCR-522 voltage terminal. Here is a list of these voltages and pin numbers for reference:

Pin No. 2, 10—High voltage, plus 300 volts d.c.
" " 1—Bias, minus 150 volts d.c.
" " 3—Ground to high voltage, bias and low voltages.
" " 4—12.6 volts a.c. for heaters.
" " 11—13 volts d.c. for relays.

If trouble is encountered in getting a plug for the socket used in this unit, the best bet is to obtain a 6-prong plug (cable type). Connect and solder long cable to it, then connect to leads soldered to the pin numbers according to voltage connections of power supply.

h) The rack tray is now placed over the transmitter, and pressed into position. The red long-shanked screws are replaced and tightened.

i) Next are the unmounted relay, condenser and switch. Remove the switch and condenser by cutting the leads near the soldered terminals. The following color coded wires should be soldered to the relay terminals; brown and brown with red stripe to coil; black to moving contact *arm*, and black with brown stripe to fixed contact.

The relay is mounted beneath the rack tray near its original position. A 6-32 ½-inch screw with washer is passed through the open hole formerly occupied by the red screw. The relay is brought to this screw, and is tightened into position. The other two free wires are cut shorter and taped to the cable.

j) The meter switch pointer is removed; the switch nut is loosened and removed. Remove two screws near the meter plug and press switch assembly downward allowing it to support itself. Remove number plate. Now prepare seven 12-inch lengths of hook-up wire.

Make a circuit drawing of the switch terminal numbers and the color coded wire soldered to them. Double check it. Unsolder all leads attached to the switch. Connect and solder the extension leads to each cable wire. Tape and guide the leads through the open section of the transmitter near tuning controls to the other side.

Now check each lead according to circuit drawing and resolder to the meter switch. Two additional leads are soldered to the terminals on the switch occupied by the meter plug contact pins.

k) The panel "L"-angle supports attached to the bottom of the rack tray are held in place by a screw and nut at the holes formerly used by the receiver long-shanked screws. One of the angles is placed between the relay No. 411-1 and tray. To locate where to drill the angles, place transmitter and rack on top of the receiver frame. The back of the transmitter frame should rest on and line up with the back end of the receiver frame.

The panel is set on top of the receiver panel and kept as straight as possible so that the measurements between the panel and the holes and marking for the angles are accurate.

The short end of the angle is also drilled at this time. The angles are placed into their positions with the short end of the "L" upward. The panel is again correctly placed against the angles, a scriber is used to mark the position of the holes on the panel. A hole according to the size of the flat screw used is drilled at this mark through the panel. It is then countersunk so that the head is at panel level.

l) With the transmitter and receiver as they are, power cable connections for the receiver are to be made. Jones socket plugs to fit the 10-prong type used by the receiver and rack are obtained. Three leads 16 inches long of shielded wire are cut. Each lead is connected and soldered to the same number terminal of the plug and socket. The numbers and their uses are:

No. 3—300 volts B plus; No. 5—300 volts B plus; No. 7—B minus (shields); No. 8—13 volts a.c.

The exposed terminals of the plug and sockets can be covered with tape forming an insulation against possible shorts. Make cable connections between the units.

m) The lead from No. 17 of socket No. 417 is now wired to the DPDT switch.

n) The shielded mike lead is now connected and soldered to its terminal. If a carbon mike is used, the DPDT switch on "transmit" completes the mike circuit to ground.

o) The transmitter panel is now completed by mounting the number plate and channel switch into its position. Follow next with the meter switch and plate. Last, the meter is mounted and connections between the meter switch and meter are completed. The panel is remounted to angles and the unit is ready for a recheck in tuning as described earlier.

p) The channel switching meter always changes the channels according to the A-B-C-D rotation, or substitute 1-2-3-4. Example: Unit is tuned to channel "A" or No. 1. By changing switch to channel "D" or No. 4, the motor will shift through channels "B" and "C" before stopping on Channel "D" (No. 4).

To get best results from the mechanism, do not adjust it unless you have had previous experience with such a unit.

Power Requirements

The SCR-522 unit as a whole requires the following voltages and currents:

310 volts, 230 ma d.c., high voltage.

150 volts, 8 ma d.c., bias voltage.

12.6 volts, 3.5 amp. a.c., heater voltage.

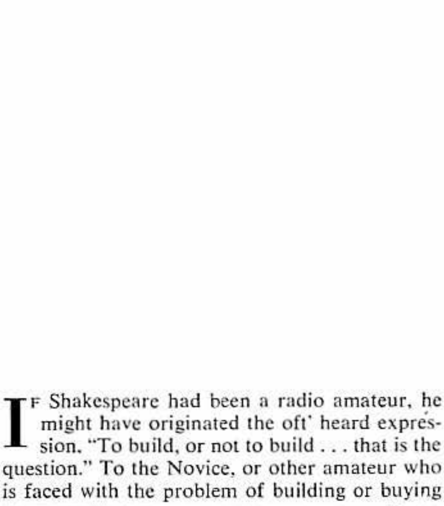
13 volts, 0.5 amp. d.c., relay and motor voltage.

A full-wave selenium or copper-oxide rectifier and a 20-volt a-c source are used to supply d.c.

OPERATION REBUILD:

THE BC-669

If Shakespeare had been a radio amateur, he might have originated the oft' heard expression, "To build, or not to build . . . that is the question." To the Novice, or other amateur who is faced with the problem of building or buying his station equipment, this question may seem as though it has no completely satisfactory answer. After listening to the pros and cons on this argument, the average ham will probably agree that there are as many good reasons for building as there are for buying. Whatever choice he makes will depend upon how much he is influenced by such factors as economy, pride in appearance, operating convenience, pride in accomplishment, and superior design.



Front view of the BC-669. The upper deck contains the transmitter and receiver and the lower deck houses the modulator and speaker.

As a compromise solution to obtain station equipment which offers most of these advantages, I suggest *rebuilding* surplus gear similar to the BC-669. The BC-669 is a well-designed Marine/Mobile radiotelephone Transmitter/Receiver which can be obtained for less than $30. In my opinion, this is one of the best buys that has come over the surplus horizon since surplus sales became a national pastime. With a minimum of effort on the part of the rebuilder, the BC-669 will provide operating convenience which is almost impossible to beat; namely, single control push-to-talk phone operation, the snappiest break-in c.w. operation you'll ever see, and instantaneous QSY to any one of six pretuned frequencies.

In spite of its low price (I think somebody goofed), the BC-669 is a man-sized hunk of gear. It comes equipped with handles so that two men and a boy (the boy is needed for carrying the separate power supply) can move this versatile station outdoors for operation from a field day location, boat, or summer patio. Because the transmitter is crystal controlled and can be operated at a cool 75 watts input, the rig makes an ideal Novice station. For hams other than Novices, the BC-669 can be operated at 100 watts input and makes a dandy second station for net operation or local round-table ragchews when higher power is a dead waste. In an emergency, when your full, or half-gallon rig springs a leak, you can still cover several hundred miles with this rig which runs at 1/10th of a gallon. Pretty good mileage, wot?

Evaluation Check

When the BC-669 was unpacked and set up on the work bench, an evaluation check was made to determine what it was designed to do, what was needed to make it do it, and what could be done to improve it. Here's the list:

1. It can receive and transmit phone signals only.
2. The operating frequency range is 1600-4500 kc.
3. It permits instantaneous QSY to any of six pretuned crystal frequencies.
4. The receiver may be either crystal controlled or continuously tuned over 2 bands.
5. It needs a power supply, a carbon microphone, and a whip antenna to bring it to life.
6. It can be improved by modifying the:
   a. *antenna system* to allow use of more efficient antenna.
   b. *receiver* to permit reception of c.w. and s.s.b.
   c. *transmitter* to provide a choice of c.w. or phone.
   d. *modulator* to permit use of a dynamic or crystal mike.

The discerning reader will note that all the major components of practically every radio station are listed here for construction or modification. This fact gave the OM an idea. Why not let the junior operator, WV2FDZ, who was studying for his General license exam, do the actual rebuilding and let experience do the teaching? And so "Operation Rebuild" was born.

Plan of Attack

The OM and the JO (junior operator) held a briefing in the war room (basement workshop), and it was agreed that Phase I, the construction of the power supply, would be the first step in our plan of attack. The other phases, involving improvements to the antenna, modulator, receiver, and transmitter could be accomplished in any order. These phases, like mopping-up operations, would depend upon the successful completion of Phase I. After completing Phase I and applying power to the set, the need for the other phases would be more apparent.

Detailed plans for each phase of "Operation Rebuild" were laid out by the OM. The actual rebuilding was performed by the 16 year-old JO. Because the JO was studying radio theory in preparation for his General license exam, practical experience in circuit tracing and rebuilding was combined with a course on radio theory fundamentals. During each phase of operations, the JO was encouraged to ask questions whenever some point was not understood.

Description of the BC-669

In any military operation, it's standard operating procedure to become familiar with the features of the terrain before mounting an attack. In the same way, before assaulting the BC-669 with flame thrower and machine gun; oops, I mean, soldering gun and drill, it's a good idea to become familiar with the arrangement and location of the various components.

The entire unit, with the exception of the power supply, is contained within a sturdy metal cabinet measuring 1¾' by 1½' by 1'. This is about the same size as two HQ-170's stacked one on top of the other. The power supply is constructed on a separate chassis and delivers the required voltages through a six-conductor power cable. After the power supply is hooked up to the unit, the BC-669 is ready to go on radiotelephone by merely plugging in a push-to-talk carbon mike and connecting a short wire to the antenna binding post.

A pair of snap clamps on each side of the cabinet permit the upper half of the cabinet to be separated from the lower half. This double deck arrangement greatly facilitates the rebuilding operations. The oscillator and power amplifier stages of the transmitter and the seven-tube superheterodyne receiver occupy the upper deck and the speech amplifier, modulator, and loudspeaker are mounted on the lower deck. As shown in the block diagram, fig. 1, the receiver

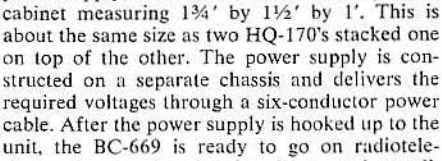


Fig. 1—Block diagram of the receiver portion of the BC-669.

incorporates one stage of r.f. amplification, a separate mixer and high frequency oscillator, one stage of 385 kc i.f. amplification, a noise limiter, and a diode detector followed by two stages of audio amplification.

The local oscillator of the receiver may be tuned continuously over 2 bands or crystal controlled on one of 6 frequencies. (Controlled by the transmitter frequency selector switch) The receiver bandswitch therefore has 4 positions, Crystal 1, Manual 1, Crystal 2, Manual 2.

The transmitter, fig. 2 uses a 6L6 Pierce oscillator circuit which incorporates a six-position crystal selector switch. The oscillator drives the final stage consisting of parallel 807's. The

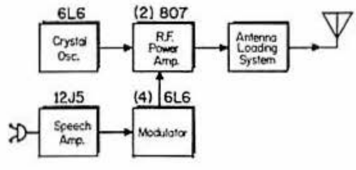


Fig. 2—Block diagram of the transmitter section of the BC-669.

transmitter output circuit is designed to feed a whip or short wire antenna. Pretuned adjustments are provided to permit split-second QSY to any one of six crystal-controlled frequencies by merely flipping an OPERATION CHANNEL switch.

A carbon mike feeds a 12J5 speech amplifier, which in turn drives the four 6L6 modulator tubes hooked up in push-pull parallel.

Power Supply

The BC-669 will operate from any power supply which can deliver the following voltages: 12.6 volts at 5 amperes for the tube filaments, 250 volts d.c. at 100 ma for the receiver plate supply, 400 to 500 volts d.c. at 300 ma for the transmitter plate supply, and 115 volts a.c. for the TRANSMIT-RECEIVE relay.

The power supply which supplies all of the needed voltages was constructed on a metal chassis measuring about 12" by 8" by 2". Actually two separate power supplies were built on the same chassis; a low voltage unit for the receiver, and a high voltage unit for the transmitter. The schematic diagram of this dual power supply is shown in fig. 3.

Conventional circuitry found in any handbook is used, including capacitive input filtering, to provide adequate elimination of hum in both receiver and transmitter power supply units.

Control Circuits

The ON-OFF switch on the power supply chassis turns the receiver on and applies filament voltage to the transmitter. The STANDBY-ON switch on the power supply permits the transmitter high voltage to be turned off during prolonged listening periods, or when making adjustments inside the transmitter. This STANDBY-ON switch can be used as a manual TRANSMIT-RECEIVE (T-R) control during phone operation if the microphone is not equipped with a push-to-talk (p.t.t.) switch. Normally, automatic T-R control is performed by the p.t.t. microphone switch. Closing the microphone switch energizes the d.c. relay RY_2. When energized, relay RY_2 applies 115 volts a.c. to the T-R relay RY_1 which then performs three functions: the antenna is automatically switched from the receiver to the transmitter, the transmitter is activated by the closing of the r.f. cathode line, and the receiver is instantly desensitized.

During p.t.t. phone operation, the high voltage is applied to the modulator tubes through a set of relay contacts on relay RY_2. These contacts were originally used to control the sidetone circuit but since sidetone is about as useful as an 8 handled broom, the removal of this feature introduced no hardship. Simply disconnect the blue lead and the green (shielded) lead on relay RY_2 and connect a pair of leads from these relay contacts to pin 7 of the power input socket and the high voltage line which normally would be connected to pin 7. Figure 4 shows the connec-

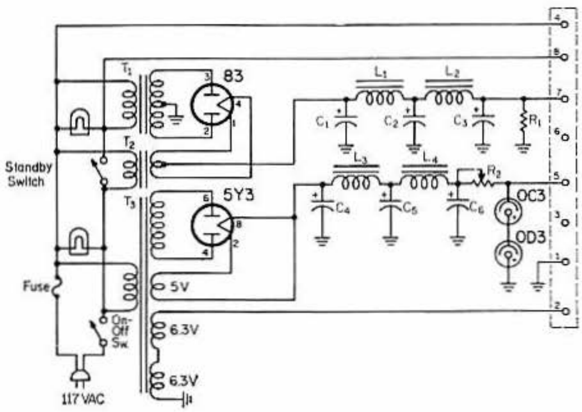


Fig. 3—Diagram of a suitable power supply to be used with the BC-669. The original unit was used as a marine/mobile installation and was powered by a dynamotor.

C_1—2 mf, 1,000 v.
C_2—4 mf, 1,000 v.
C_3—4 mf, 1,000 v.
C_4, C_5, C_6—10 mf, 450 v.
L_1—5/25 h, 300 ma.
L_2—8 h, 300 ma.
L_3—15 h, 100 ma.
L_4—15 h, 100 ma.

tions to relay RY_2. When relay RY_2 is de-energized by releasing the push-to-talk mike switch, the modulator high voltage is automatically removed.

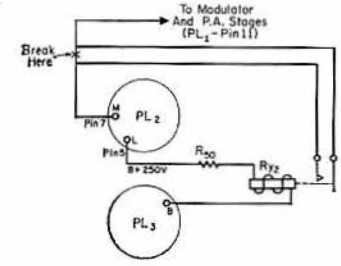


Fig. 4—Connections made to provide push-to-talk operation. The first set of wires on R_2, (sidetone) are removed and a new set of wires are inserted in series with the +B line. See fig. 5 for socket connections.

Power Cable Connections

To connect the voltages to the unit, it was first necessary to remove the odd-ball multi-pin power input socket (lower right corner of panel) and replace it with a common octal socket. The octal socket and the associated power cable were then wired as shown in fig. 5. If your BC-669 is

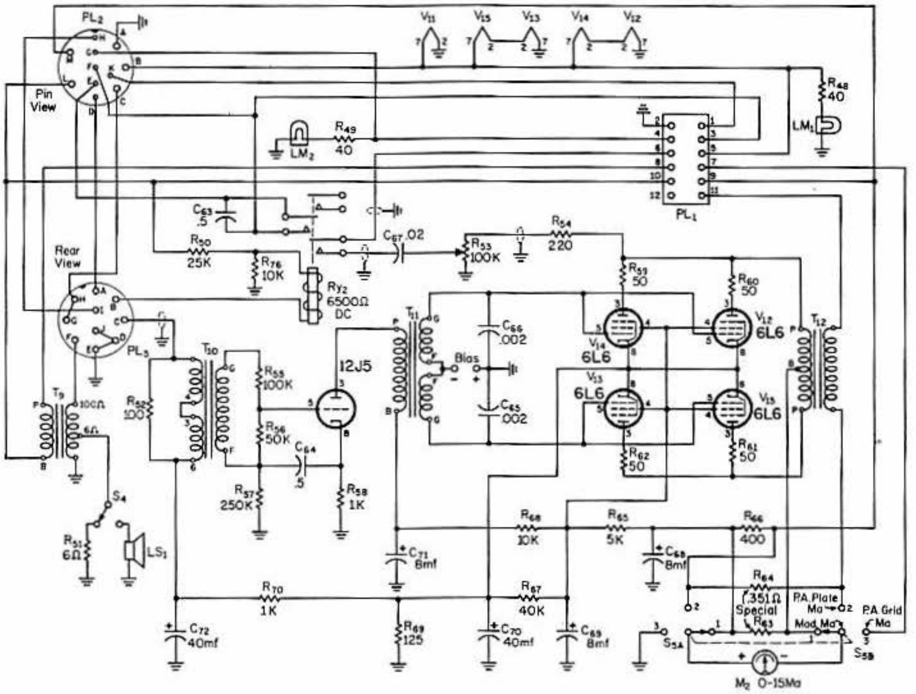
	⏚	12V AC	NC	115V AC	250V DC	NC	500V DC	115V AC
Octal Socket	1	2	3	4	5	6	7	8
Original PL-2 Socket	A	B+G	—	E	L	—	M	K

Fig. 5—The original input power connector is removed and replaced with an octal socket. The connection interchange is shown in the chart above.

"bugfree," that is, no defective tubes or components, the receiver should come to life as soon as the power cable is connected and the ON-OFF switch turned on.

Temporary Carbon Microphone Connections

To save time in testing out transmitter operation, an ordinary carbon mike jack (ring-tip-sleeve) was temporarily installed on the lower left corner of the panel. Short jumper wires were used to connect the ring, tip, and sleeve terminals of the microphone jack to the appropriate B(red), C(shielded), and D(black) leads on the multi-pin socket PL_3 located about one inch away. These jumpered connections are shown in fig. 6. When you are ready to make the change from carbon mike to dynamic or crystal mike, the carbon mike jack can be removed and a mike jack to fit your favorite microphone can be mounted in the same spot.



Modulator circuit prior to modification. A speech amplifier (fig. 7) is added to permit the use of a low level microphone.

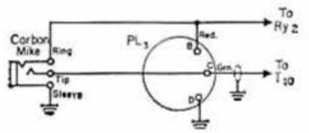


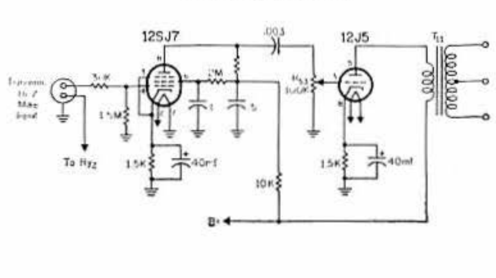
Fig. 6—To temporarily test the unit with a carbon mike a three circuit jack is installed and wired as shown.

Modulator and Speech Amplifier Improvements

When the power was first applied to the transmitter, the static modulator plate current zoomed up past the 300 ma mark on the meter. To reduce this heavy drain on the power supply, which was groaning under the load like a cub scout with his overnight camping gear, a 22.5 volt bias battery was inserted in the grid circuit of the modulator stage. This was accomplished by opening the lead connecting the center-tap of the driver transformer T_{11} to ground. A black insulated wire from C minus of the bias battery, was connected to the center-tap and a red insulated lead from C plus of the battery was connected to the chassis ground connection. With this fixed bias class AB system, static modulator current stays around 10 ma and shoots up to 150 ma on voice peaks for 100 percent modulation. To achieve 100 percent modulation it was necessary to increase the screen voltage on the modulator tubes to 250 volts by shunting the screen resistor with a 10K 5 watt resistor.

The above rearrangements upset the rather complicated system used to derive the carbon mike voltage. Since it was necessary to modify the mike circuit anyway, the entire speech amplifier circuit was rewired to include a resistance coupled 12SJ7. The circuit is shown in fig. 7 and provides plenty of gain for either crystal or high impedance dynamic microphone. The socket for the spare filter unit (located on the lower deck next to the SIDETONE VOLUME control) was removed and replaced by an octal socket. The 12J5 tube was plugged into this socket and wired up as the intermediate audio amplifier stage. The sidetone volume control, R_{53} was rewired to

Fig. 7—Speech amplifier added to the existing 6L6 modulator. The sidetone pot., R_{53}, is used as the volume control for the speech amplifier. See text for full modification.



operate in the grid circuit of the 12J5 where it controls the volume of the speech amplifier. The 12SJ7 preamplifier tube was then plugged into the socket originally used by the 12J5, and the socket wiring was changed accordingly. The carbon mike jack was removed and a shielded 2-pin type mike jack was installed in its place.

Antenna Modifications

The BC-669 incorporates an adjustable antenna loading coil which is designed to load up any random length of wire less than a quarter wavelength. This is fine for mobile or marine use where the antenna length must, for practical purposes, be short. For more efficient operation, a regular doublet antenna using coaxial cable transmission line can be used. To simplify connection to the coax transmission line, a regular SO-239 coax fitting was installed at the top center of the transmitter in place of the original antenna binding post.

The loading coil L_4 was entirely shorted out of the circuit by placing the sliding taps (one for each of the six pretuned channels) as far up on the coil as they can be pushed. These sliding taps on the loading coil are accessible through the door on the upper left of the panel. The sliding taps on the lower end of the plate coil L_3 were used to match the low impedance of the coaxial line. For 50-ohm coaxial line, the proper impedance tap for the 75 meter band was found to be about the second turn from the grounded end.

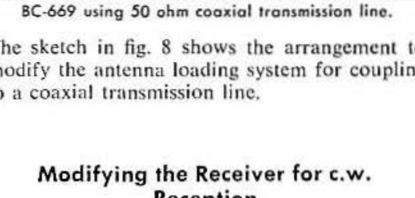


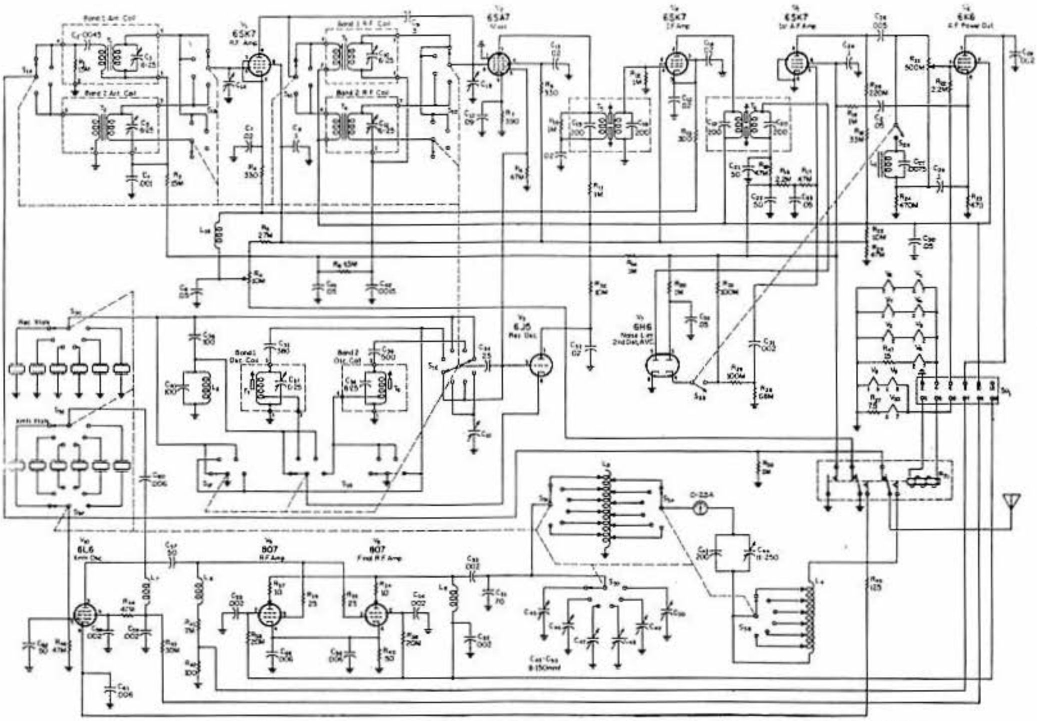
Fig. 8—Antenna loading modifications made to the BC-669 using 50 ohm coaxial transmission line.

The sketch in fig. 8 shows the arrangement to modify the antenna loading system for coupling to a coaxial transmission line.

Modifying the Receiver for c.w. Reception

Because my model of the BC-669 was designed for radiotelephone use only, both the receiver and the transmitter had to be modified to permit c.w. operation. All the receiver needed was the installation of a b.f.o.

A surplus b.f.o. unit designed for use with the BC-342 receiver was obtained. This b.f.o. unit consists of a 455 kc oscillator circuit compactly installed (6C5 tube and all) in an aluminum L-shaped box measuring approximately 2 × 2 × 3 inches. The external controls on the b.f.o. consist of an ON-OFF toggle switch, PITCH control knob, and screwdriver-adjusted tuning capacitor. To get the b.f.o. percolating requires only the appli-

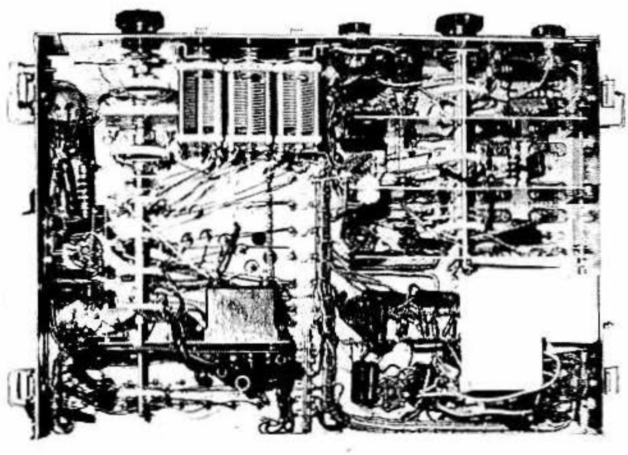


Circuit of the transmitter and receiver prior to modification. In the transmitter, 6 crystals in the oscillator permit instant QSY. The final and antenna tuning circuits are pretuned and selected by the same switch. The receiver is a 2 band job of conventional design with no provisions for c.w. reception. The receiver may also be crystal controlled as explained in the text.

cation of B plus (150 to 200 volts) and filament voltage (6.3 volts). Because of its size and shape, the b.f.o. unit could not be conveniently located with its controls on the front panel of the BC-669. Instead, the unit was installed below the receiver chassis close to the 6H6 (det) and 6K6 (a.f. amp) tube sockets to which the b.f.o. wiring leads are connected.

Before installing the b.f.o. unit, the 455 kc oscillator frequency was reduced to 385 kc by connecting a 100 mmf postage stamp-type mica capacitor across the adjustable tuning capacitor in the b.f.o. After making this change, the b.f.o. variable capacitor tuned to 385 kc at about half of maximum capacity. The installation of the b.f.o. unit as described, places the C.W., ON-OFF and PITCH controls on the right side panel of the BC-669.

Underchassis view of the BC-669 showing the position of the L shaped chassis housing the b.f.o. Because of its configuration the controls had to be mounted on the side of the cabinet.



The wiring connections to the b.f.o. involve five leads as shown in fig. 9. Be sure to scrape the fungus-proofing varnish from the terminals and tube socket pins to which the b.f.o. leads are connected. The B minus lead is connected to a

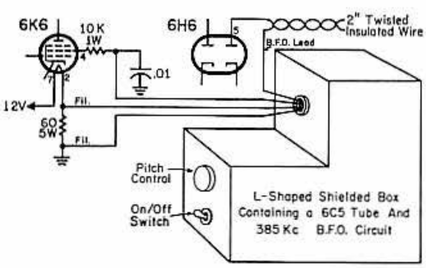


Fig. 9—The addition of a b.f.o. was required to copy c.w. A salvaged b.f.o. from a BC-342 was used here and is connected with only 4 wires. The BC-342 b.f.o. frequency was changed from 455 kc to the BC-669's i.f. of 385 kc by paralleling a 100 mmf capacitor with the b.f.o. tuning capacitor. See text.

chassis ground lug, the B plus lead is connected through a 10K, 1 watt voltage dropping resistor to pin 4 of the 6K6 tube socket. To provide the required 300 ma filament current to the 6C5 b.f.o. tube and the necessary 400 ma filament to the 6K6 tube, the 15 ohm resistor (R_{17}) was removed and replaced with a 60 ohm wire wound resistor. The filament leads of the 6C5 b.f.o. tube were then connected across this 60 ohm shunt resistor.

Removing A.V.C. During C.W. Reception

When the b.f.o. is turned on, it is necessary to short out the a.v.c. circuit. Otherwise, the b.f.o. signal being inserted into the diode detector, will develop a high a.v.c. voltage which noticeably reduces the sensitivity of the receiver.

An a.v.c. ON-OFF toggle switch (s.p.s.t. type) was installed on the right side panel of the set next to the b.f.o. ON-OFF switch. One terminal of the a.v.c. switch was connected to chassis ground, the other terminal was connected to the junction of capacitor C_{43} and resistor R_{34}. These circuit components are in the a.v.c. line and are located on the terminal strip about one inch from the edge of the b.f.o. shielded box.

Modifying the Transmitter for C.W. Operation

Two changes were made to modify the transmitter for c.w. operation. A PHONE-C.W. switch was installed and a couple of keying jacks were mounted on the set. Why two keying jacks? Well, it won't help you to send twice as fast but there is a good reason as you will learn.

The PHONE-C.W. switch is a d.p.d.t. type which is installed at the lower right corner of the unit just below the meter switch. When the PHONE-C.W. switch is in the c.w. position, the B plus lead to the modulator is opened and deactivates this stage. At the same time, other contacts on the

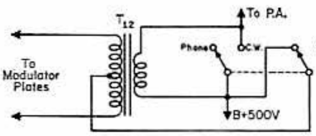


Fig. 10—The addition of a PHONE/CW switch.

switch short circuit the modulator transformer secondary. Figure 10 shows the arrangement of this switch.

Break-in Keying Connections

One of the two keying jacks is located at the lower left corner of the front panel. This jack is an open-circuit type with one terminal grounded to the front panel. The ungrounded terminal of this jack is connected by means of a short jumper wire to the ring-terminal of the microphone jack which is only a few inches away.

When this break-in keying jack is used, closing the key will automatically switch the antenna from the receiver to the transmitter, and desensitize the receiver so that it will be instantly activated when the key is opened. Superior c.w. break-in operation is achieved and recovery time of the receiver is so good that you will hear the

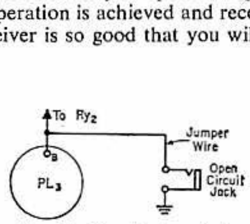
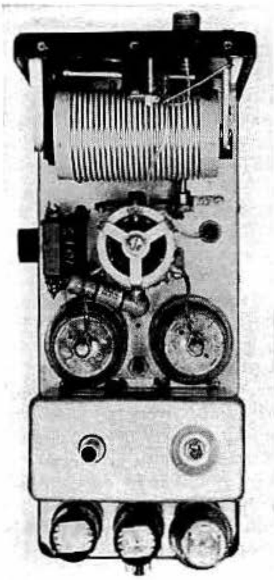
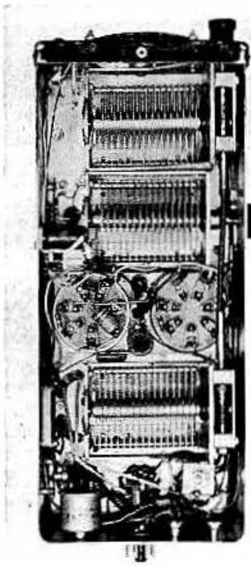


Fig. 11—Break-in key jack.

other station between your own dots and dashes. Figure 11 shows the simple jumpered connection for the break-in keying jack.





ARC-5'S GO DSB

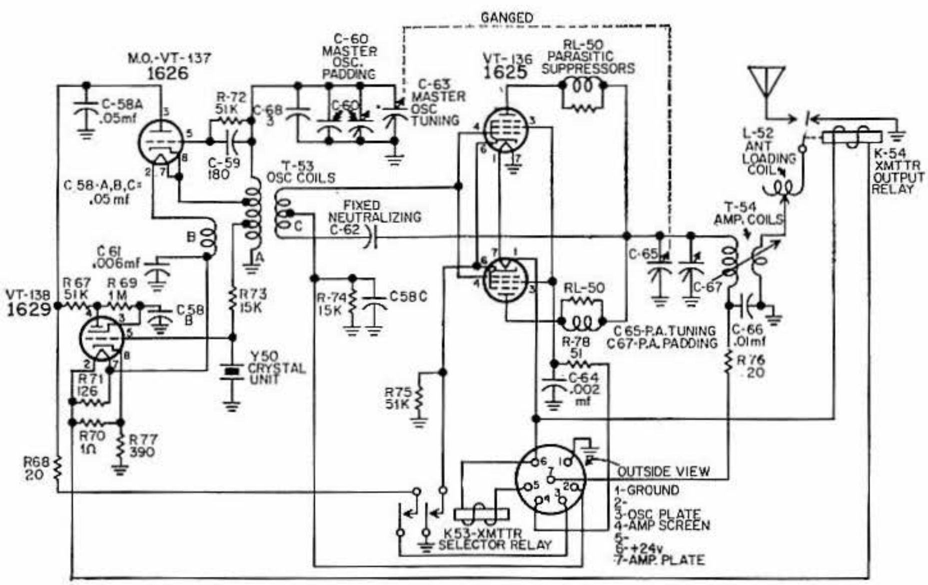


Fig. 1—Unmodified circuit of the BC 458A. (5.3 to 7.mc)

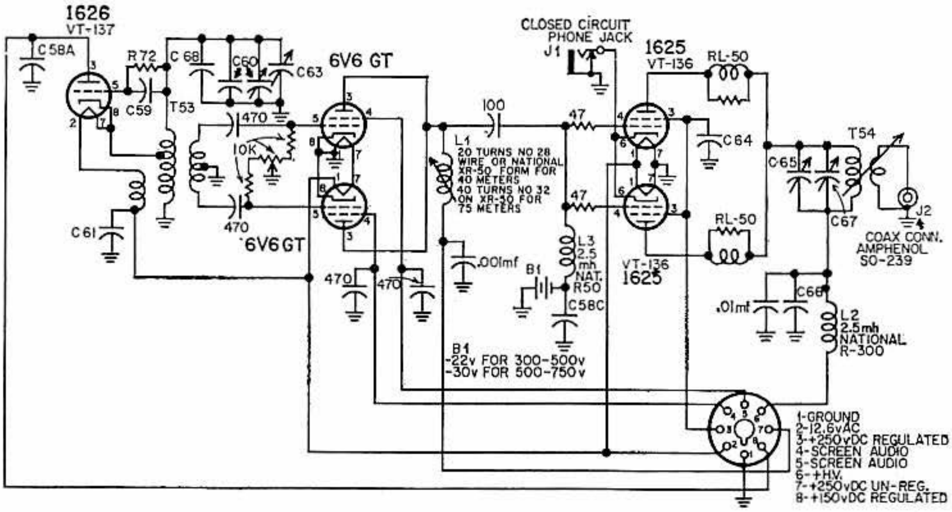


Fig. 2—Circuit of the command transmitter after modification.

Here is a different approach to double sideband conversion of Command Transmitters from those previously proposed. This method was used with good success on both the ARC-5 and BC series of transmitters after difficulty was encountered in trying to convert them to operate as high-level balanced modulators.

Modulators

Instead of connecting the 1625's as a balanced modulator, they were left connected in a normal fashion and operated as a linear amplifier. A low level balanced modulator using two 6V6 tubes was added on the back of the chassis in the sockets formally occupied by the tuning eye tube and crystal. The added modulator was then used to drive the linear amplifier. This method resulted in much improved operation since the low-level stage tended to act as a buffer stage between the oscillator and high-level stage. Previous attempts at trying to drive a high-level modulator with the existing oscillator in the transmitter had resulted in frequency modulation. Also the added tuned circuits of the linear amplifier gave increase harmonic reduction over the high-level modulator.

Conversion

The conversion is not too difficult and may be completed in a couple of evenings by the use of the before and after schematic diagrams. The 1625's and the 1626 filaments may be hooked in parallel and the 6V6's in series for 12-volt operation. The old plug on the back of the transmitter may be removed and an octal plug installed.

The two leads that formally ran to the grids of the 1625's and the neutralizing condenser should be re-routed to run to the sockets on the back. Pins 5 and 6 on each socket may be utilized to hold the 470 mmf blocking capacitors. The 10 k balancing pot may be mounted on the side or back of the chassis and the grid resistors run from pin 5 of the sockets to each side of the control. On the accompanying photographs, this pot is shown pointing out the bottom (since the author's arrangement utilized the standard rack for the transmitter).

Push-pull audio may be brought in the back plug and connected to the screens of the 6V6's. Each screen should be by-passed for *rf* with a 470 mmf condenser.

The plates of the 6V6's may be hooked in parallel and connected to the added tuned circuit. This coil may be added in the space between the 1625's and the oscillator tuning capacitor. The photos show the mounting detail of these components. On BC models of the Command Transmitters, it will be necessary to remount the final by-pass condenser on top of the chassis to make room for this coil. This coil should resonate in the center of the amateur band.

The grid circuit is changed slightly from the old Command Transmitter circuit to improve parasitic suppression. The old grid lead should be moved from pin 4 to pin 5 of each of the 1625's. The 47 ohm resistors may then be added between pins 4 and 5. The coupling capacitor may be hooked from the top of the tuned circuit to the bus wire. A small *rf* choke may be added from pin 2 of one of the 1625's to the bus wire to bring in grid bias. This completes the DSB conversion part of the transmitter. Relay and control circuits may be modified or added as needed.

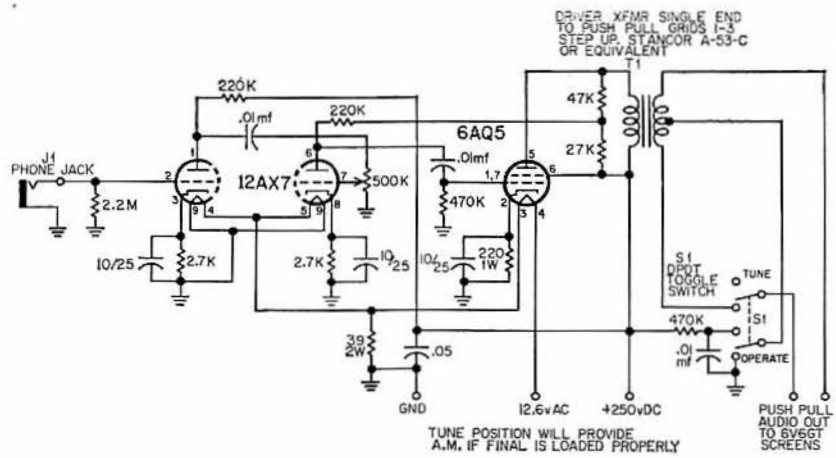


Fig. 3—Circuit of the speech amplifier and modulator.

A schematic diagram of the speech amplifier used is shown but no constructional details are given. If good construction practice is followed in building it, no difficulty should be encountered. A tune-operate switch is provided so that carrier might be inserted to tune the transmitter up. The "Tune" position of the tune-operate switch will also provide amplitude modulation.

Power Supplies

A word should be said here about power supplies. K9DBO's axiom in March 1959 CQ applies here also (quote) "Good signals require good power supplies." The voltage applied to the oscillator should be well regulated by the use of series VR tubes. For best results, separate regulator tubes should be used for the 1625 screens and the oscillator; although a common regulated source did provide a satisfactory operation. The plate voltage may be anything from 300 to 750 volts. The ARRL Handbook may be consulted for the correct bias voltage for linear operation of the 1625's.

Tune Up

Initial tune-up procedure is not too difficult but does require the use of a scope and preferably an audio oscillator. The scope should be connected to provide a two-tone test pattern. The transmitter should be loaded into a dummy load in the tune position and the added slug-tuned coil adjusted for maximum power output or cathode current. The tune-operate switch should be thrown to the operate position and a 400-1000 cycle audio note applied to the speech amplifier. The balance potentiometer should be adjusted until alternate lobes on the two-tone test pattern have equal amplitude. If an audio oscillator is not available, an alternate tune-up procedure is to couple the scope pickup loop tightly to the final tank. Turn the audio control to minimum and apply voltage to the transmitter. If the scope has good sensitivity, a small amount of carrier will appear as the balance control is rotated to either extreme. The balance control should be set for minimum carrier amplitude on the scope.

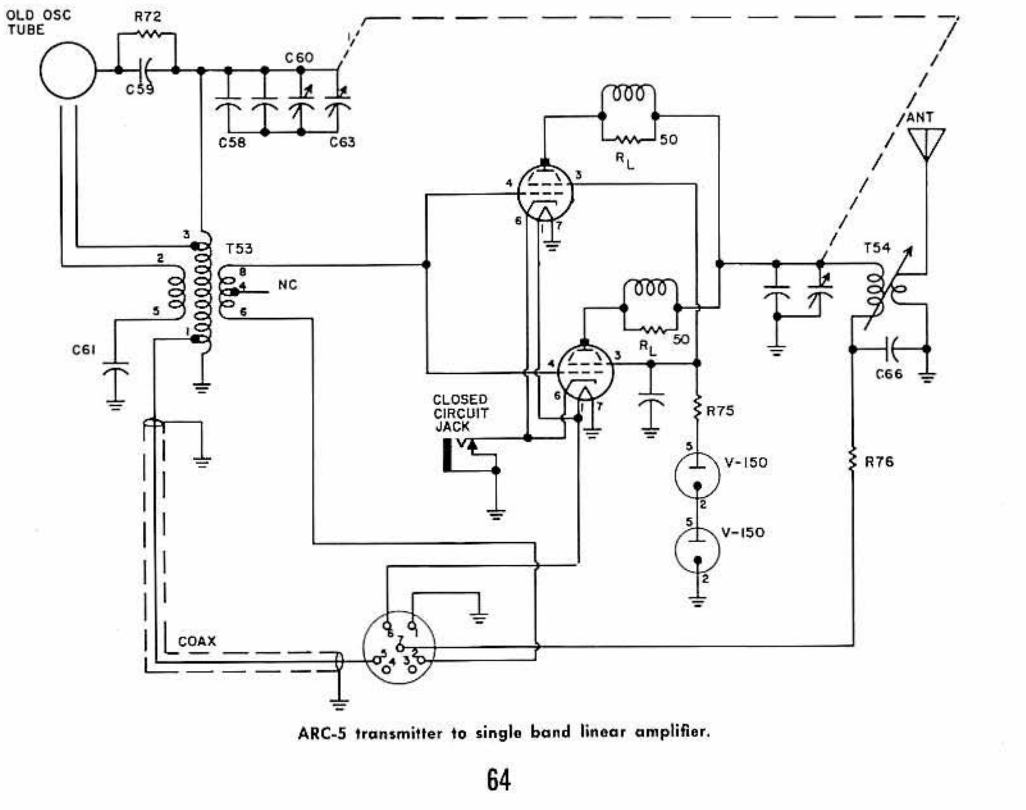
This completes the initial tune up. The transmitter should now be loaded into an antenna and the scope pattern watched as you speak into the microphone. Only the higher voice peaks should tend to be clipped or limited in the final. If heavy clipping is present, the drive to the final should be reduced by detuning the slug-tuned coil between the modulator and final (this might bother some of the purists, but it works). Heavy loading should be used on the final. If low-plate voltages (300-500 volts) are used, you might have to add another link to the final coil. This can consist of two or three turns of wire wrapped tightly around the bottom of the plate tank coil. If oscillations are present in the final, it might be necessary to add another .02 mmf by-pass condenser on the bottom of the plate tank. This condenser may be soldered in parallel with the remounted condenser that was originally in the transmitter. Additional screen by-passing may also be necessary. The parasitic and oscillation problem seems to vary from transmitter to transmitter.

You are now ready to get on the air and enjoy the advantages of sideband. True, most stations will receive you as a single sideband station and this gives you a 3 *db* disadvantage compared to a single sideband station of equal power. But, at least, you have gotten rid of the chief heterodyne cause, the carrier. Most of the sideband boys will not know you are transmitting both sidebands unless you tell them. Stations as far as 1200 miles away were worked with the converted transmitters running a peak power of only 35 watts. So if you have been looking for a cheap way to investigate this sideband business, here it is.

THE ARC-5 AS A LINEAR

We got a fine publication from the Central Kansas Radio Club which has a conversion of the ARC-5 transmitter to a single band linear amplifier. While we haven't tried it out it should work well and add some more power to any station at little cost. Essentially they use the 1625's as before but change the 1629 and crystal to VR-150's, by rewiring, and thereby hold the 1625 screens to 300 volts. The lower terminal of T-53 (oscillator transformer) is removed from C-62 and brought out for bias. Bias is supplied by a pre-amp power transformer a selenium rectifier, a 40 mfd 150 volt capacitor and a 30K potentiometer for adjustment. The 1626 oscillator is removed from its socket and R-73 cut out. A coaxial line, with the shield grounded, is connected to T-53 for signal input. Bypass the 1625 cathodes and filament with 0.01 mfd disc condensers, add a closed circuit jack for metering. The connection from R-74 and C-58C to the centertap of T-53 secondary is also removed. Add an extension to C-67 for final tuning. A O to 1ma meter in the 1625 grid return will show a slight rise on peaks and is actually a worth-while operating aid in AB-2 operation.

AFØHAJ has commented on AF5LHX's conversion (above) by adding that 150 watts PEP is available but with 400 volts on the screens and 1000 volts on the plates 250 watts PEP is available (this greatly exceeds the tube ratings . . . Ed.) He tunes up by using only 150 volts on the screens and then switches to 400. If additional link inductance is necessary wind two or three turns of well insulated wire at the bottom of T-54 in the same direction and connect in series with the link.



ARC-5 transmitter to single band linear amplifier.

Fig. 1. An attractive appearance is easy to attain with 274-N transmitters.

THE SCR-274N SERIES

THE SCR-274N COMMAND SETS have unquestionably been the most popular of all war surplus equipments for conversion to amateur use. The transmitters are by far the most useful of all units included. They not only are used as transmitters directly, but are also very popular as exciters and variable frequency oscillators for larger transmitters.

As is the case in most war surplus items, the amateur use of these excellent little transmitters requires a certain amount of modification. Articles too numerous to mention have been written describing various ways of modifying the units for amateur service, each modification having its own particular advantages and disadvantages. With such a well-designed piece of equipment to start with, it is reasonable to expect that the most satisfactory modification would be the one that disturbed the original circuitry the least. Actually, very little is required in the way of modifications to the sets which cover the amateur bands as is. For instance, the BC-696-A and the BC-459-A cover the 3.4–4 mc band and the 7-mc band respectively. The only absolutely necessary modification to these two units is the provision of a suitable output connection and a means for operating the keying relay. It is also generally desirable to parallel the heaters for 12-volt operation. If the unit is to be used as a VFO for driving a string of multipliers for operation in the higher amateur bands, it is wise to provide for operating the oscillator heater from rectified and fairly well filtered power. This is to prevent the slight amount of frequency modulation at a 60-cycle rate which is present in some instances when raw a.c. is used for the oscillator tube heater power. This frequency modulation is not sufficient to be noticeable on the fundamental or even at twice the oscillator frequency. It is also not present in all sets. It is present in some, however, and in some instance, is very noticeable on 28 mc.

The power requirement for the oscillator tube is rather low, and a 250 ma selenium rectifier followed by about 250 µf of capacity (dry electrolytic) is all that is required. Listen to the 28-mc harmonic of the transmitter with a good receiver. If no a.c. hum is noted, it is safe to say that your particular unit is free from serious 60-cycle frequency modulation.

The original schematic diagram is shown in *Fig. 2*. The modification preferred by the author appears in the modified schematic diagram, *Fig. 4*, which includes the changes required to produce satisfactory keying to be described.

Numerous ways have been suggested for changing the frequency of the BC-457-A (4–5.3 mc) and the BC-458-A (5.3–7 mc) to the amateur frequencies.

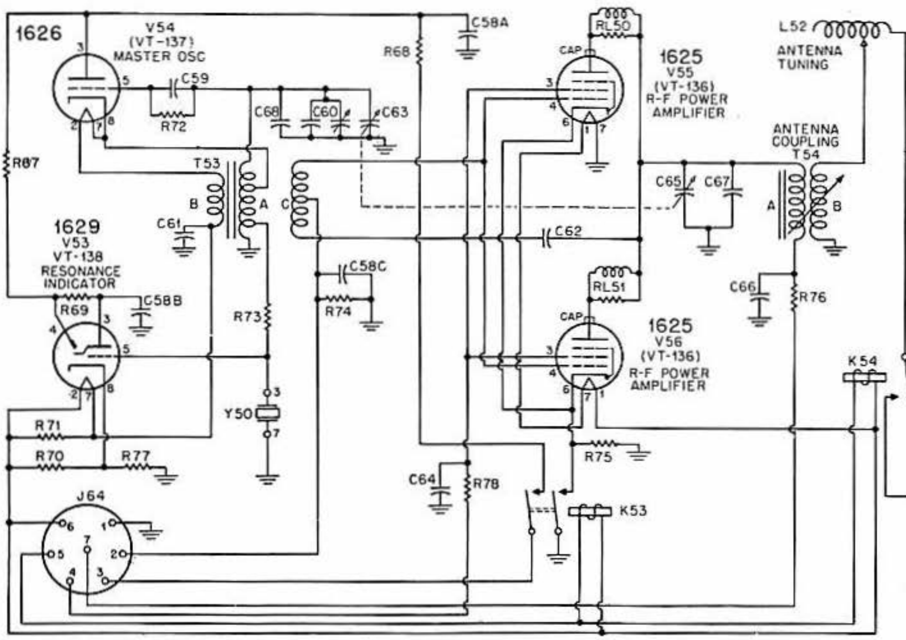


Fig. 2. The original circuit of the 274-N series transmitters.

Most of the suggested systems involve modifications to the inductances of the oscillator and P. A. tank circuits. The BC-457-A may be changed to cover the 3.5 mc amateur band by the simple addition of a good quality capacitor of between 25 μμf and 50 μμf capacity in parallel with the oscillator tuning capacitor, and by a readjustment of the variable padders in both the oscillator and P. A. plate tank circuits. The BC-458-A may be adjusted to cover the 7-mc band by simply adjusting the oscillator and P. A. padder capacitors.

To adjust the BC-457-A to frequency after adding the capacitor to the oscillator circuit, insert a 4-mc crystal in the crystal socket. (An FT-243 type crystal is excellent for this purpose, and is inserted in the socket using pins 3 and 7.) Next, remove the cover from the oscillator coil and capacitor assembly, using care not to disturb the iron core setting (screwdriver slotted screw on top, sealed with blue glyptal). Cut a screwdriver opening in the end of the shield opposite the variable capacitor shaft. Loosen the setscrews which lock the capacitor shaft, and replace the shield cover over the oscillator tuning assembly. Turn on the transmitter, and with the tuning eye in place, adjust the main tuning dial to 5.2. Adjust the oscillator padder until the eye indicates resonance with the crystal. The oscillator is now operating at 4 mc. Remove the oscillator tuning assembly cover, tighten the capacitor shaft lock setscrews, and replace the cover.

Tune the fixed padder of the P. A. stage for resonance as indicated by a minimum of P. A. plate current. If the iron cores in the tuning coils have not been disturbed, or if the coils have not been modified, the tuning will track over the entire range, and the new range will be 3.4 to 4.1 mc. The dial may be

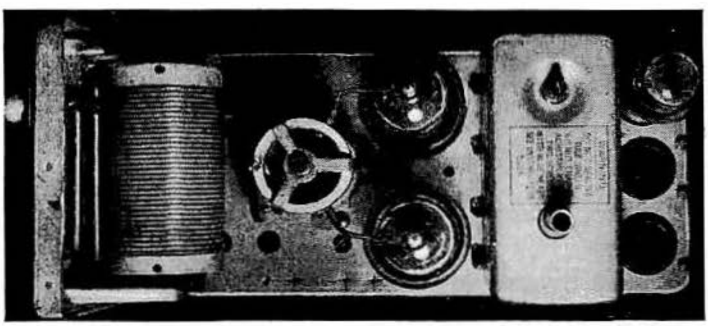


Fig. 3, illustrating the location of the mounting holes for the time constant capacitor C69.

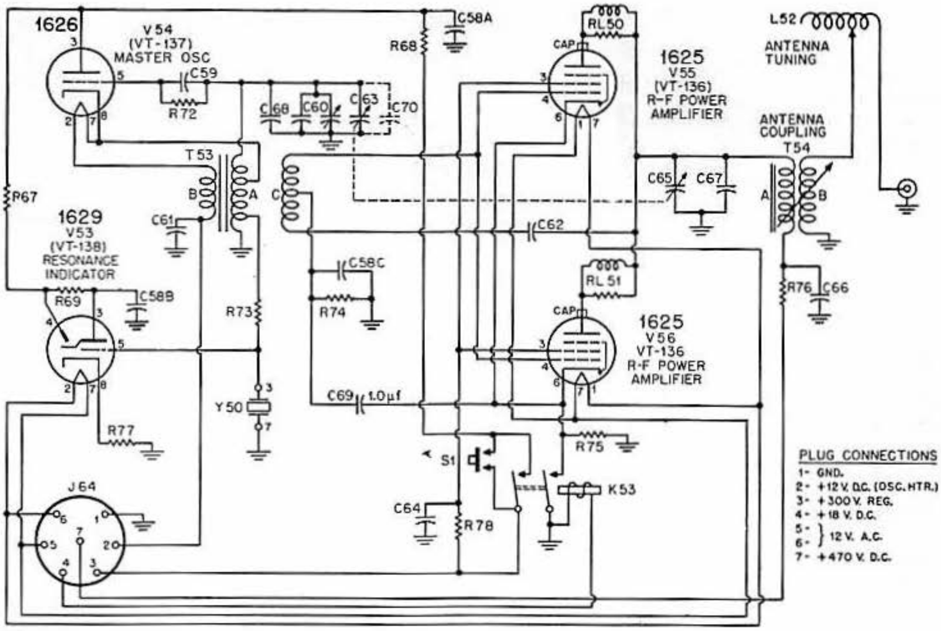


Fig. 4. The circuit of the modified transmitter. K53 is used as the keying relay.

C58A, B, C—.05 µf	C64—.002 µf	C70—25 to 50 µµf (BC-457A only)	R73—10K
C59—.00018 µf	C65—Amp. tuning	RL50, RL51—42 ohms	R74—15K
C60—Osc padder	C66—.01 µf	R67, R72, R75—51K	R77—390 ohms
C61—.006 µf	C67—Amp. padder	R68, R76—20 ohms	R78—51 ohms
C62—Fixed neut. cond.	C68—3µµf	R69—1 meg.	S1—Push button osc. test switch
C63—Osc. tuning	C69—See text		

covered with paper and a new scale inscribed thereon, or the dial may be removed and turned down on a lathe, repainted, new calibration lines painted on, and new numerals added. (A handy numeral set is included in most popular panel marking decal sets.) The same general procedure is used when tuning up the BC-458-A for operation in the 7-mc band, except that a 7.5-mc crystal is used.

If the adjustment of the iron core has been disturbed, the transmitter may be completely realigned by first adjusting the oscillator section for the desired frequency coverage by tuning the padder capacitor at the high frequency end of the tuning range, and by adjusting the iron core at the low frequency end of the tuning range. It may be necessary to repeat this several times to obtain the desired frequency spread or to obtain coincidence between the frequency and the calibration of the dial.

Having adjusted the oscillator, the P. A. tank tuning may be made to track with the oscillator by using a similar procedure. Adjust the capacitance trimmer at the high frequency end of the tuning range, and adjust the inductance trimmer at the low frequency end of the tuning range, repeating the two adjustments until perfect tracking is obtained. This is the same procedure as is used in adjusting the gang-tuned stages of a receiver.

If the SCR-274-N transmitter is to be used as a complete transmitter, or if it is to be used as a keyed VFO, it will be necessary to clean up the keying. Many systems suggested in the past include radical modifications, with the installation of vacuum tube keyers in some instances. Let us bear in mind that whenever we make changes in one of these units, we are modifying a piece of precision apparatus and should disturb it as little as possible.

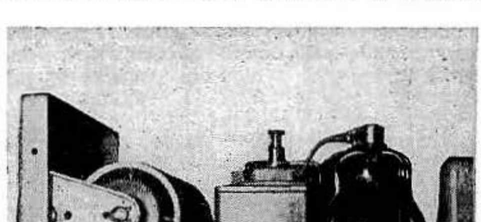
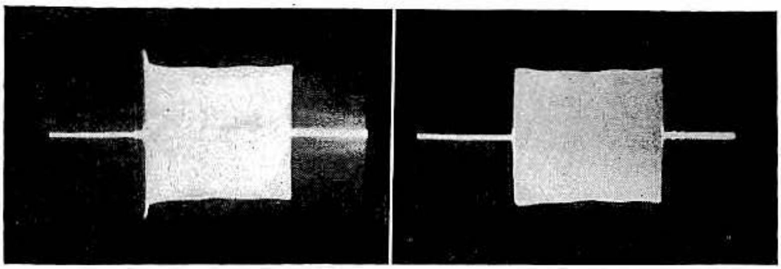


Fig. 5. Side view of the transmitter showing capacitor C69.

Fig. 6, L., the keying oscillogram before modification, and Fig. 7, showing the improvement attained.



Therefore, why not use the keying system included, after cleaning it up so that it is free from clicks, thumps, and chirps?

We have 12.6 volts available from the tube heater supply. From this we can get approximately 17.5 volts of d.c. for operating the keying relay by the simple addition of a low voltage senenium rectifier and a high capacity electrolytic capacitor. The keying relay will follow keying up to more than 40 words per minute with the power thus supplied if the relay armature and contacts are carefully adjusted.

The keying relay is quite noisy as it is. If this noise is objectionable, a short piece of small rubber tubing, soft plastic tubing, or "spaghetti" tubing may be placed over the armature arm stop. If this is done, the armature arm will require re-adjustment so that the relay contacts will open when the relay coil is de-energized. The contacts should be adjusted until the P. A. cathode circuit is closed just slightly before the relay armature comes to rest on the pole face of the relay coil. The contacts closing the circuit to the oscillator plate supply should be adjusted to close before the P. A. cathode circuit is closed. This is important if the operation is to be free from a keying "chirp." If the oscillator plate circuit is closed slightly ahead of the closing of the P. A. cathode circuit, the oscillator frequency will be stable before the power is actually applied to the P. A., and the "chirp" will not be present in the transmitter output.

The keying waveform before modification is shown in *Fig. 6*. Note the sharp spike just ahead of the main keying pulse, and the high amplitude of the start of the pulse. The sharp spike is caused by relay chatter, and the high amplitude at the start of the pulse is due to power supply regulation. Both of these faults are corrected very nicely by the addition of the time constant in the keying system, as is indicated in the oscillogram shown in *Fig. 7*.

The time constant which has been added to the keying circuit is a bit unusual in its operation. While the relay is open, the potential appearing in the cathode to ground circuit of the P.A. tubes will charge capacitor C_{60} through resistor R_{74}. When the relay closes, the terminal of C_{60}, which connects to the P.A. tube cathodes, is connected to ground. C_{60} then discharges through R_{74}, placing a negative potential upon the grids of the P.A. tubes, momentarily holding them at cutoff. As the charge is reduced in C_{60}, the potential across R_{74} is reduced, and the P.A. tubes start operating normally, until the full output is reached. This delaying action is just sufficient to produce a starting slope of approximately 2 milliseconds duration in the keying pulse, resulting in the desirable keying pulse shape shown in *Fig. 7*.

Figure 5 shows the location of C_{60}. This capacitor is a Solar No. XEMRBW6-1. This same type of capacitor is produced by several other manufacturers. (The JAN type designation is CP68B1EF105WK. These units are generally available in the surplus market at less than one dollar.) The mounting of this capacitor is rather simple. It involves the drilling of two one-half inch diameter holes and one small screw hole. One existing screw hole is used. This existing hole is used to fasten a wire clamp on the underneath side of the chassis. This wire connects to the antenna shorting relay. The antenna shorting relay is removed, and the wire is therefore no longer needed. The wire clamp bracket and the wire are both removed. The screw which originally held the clamp in place is now used to fasten one end of the capacitor bracket. The two ½-inch holes and the small screw hole are drilled in line with the wire clamp screw hole and spaced as shown in *Fig. 3*.

One very convenient arrangement when using a SCR-274N transmitter as a complete transmitter for phone-cw, work in the 3.5–4 mc band is shown in *Fig. 1*. The assembly pictured consists of a BC-457-A modified, as shown in *Fig. 4*, together with power supply and modulator units, all mounted on a standard 19-inch relay rack type of panel. The schematic diagram of the power supply, modulator, and the incidental connections between units and to the pilot light, switches, etc., is shown in *Fig. 9*. This arrangement includes a power switch and fuse, a pilot light, a plate current meter, an r.f. output ammeter, and a "phone"-"push-to-talk phone"-"c.w." selector switch. When operating "push-to-talk" phone, the push-to-talk switch connection is plugged into the telegraph keying jack.

An additional filter section is added to the P.A. plate power supply system when the unit is operating as a phone transmitter. This provides ample filtering to produce a hum-free signal for phone work. Type 1625 tubes are used in the modulator, since they are also used in the transmitter. Type 807 tubes could be used with identical results. Either type will provide sufficient power for producing 100% modulation of the power amplifier.

The panel used for mounting the entire system is made from 3/16-inch thick 24ST aluminum, 19 inches wide and 10½ inches high. A cutout is made in the center of the panel to accommodate the transmitter. The transmitter is mounted in place by means of two 5-inch lengths of ½-inch by ½-inch aluminum angle, screwed to the top and bottom of the transmitter and to the panel. The power supply and modulator units are built on 5″ by 10″ standard chassis and are mounted end-on to the panel, with standard chassis panel brackets, two to each unit. The rear view of the unit, *Fig. 8,* shows the appearance of the completed assembly.

The power supply described delivers 470 volts at 170 milliamperes. Under these conditions, the a.c. ripple voltage is 9 volts r.m.s., or 1.92%. The output of the transmitter on c.w. is 38.5 watts, with an input of 56.4 watts to the p.a., representing an efficiency of 68%. The r.f. current into a 52-ohm load is 0.86 amperes. The output when operated with telephone modulation is reduced slightly due to the additional load on the power supply by the modulator tubes. The output under these conditions is approximately 35 watts.

The values given in the parts list of *Fig. 4* are taken from the instruction book covering this particular equipment, with the exception of C_{60} and C_{70}, and are listed for the convenience of those who may not otherwise have access to this information.

The SCR-274-N transmitters will perform very

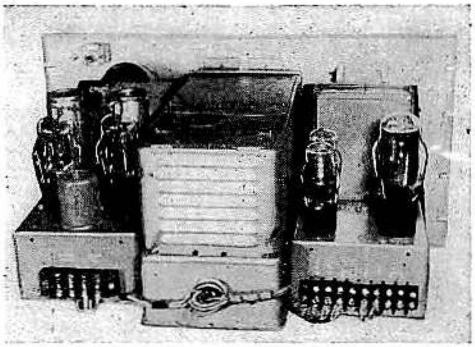


Fig. 8. Rear view of complete phone/c.w. transmitter.

satisfactorily if treated properly and if not altered unnecessarily. Make as few changes to the frequency determining portions of the circuit as possible; don't try to overload the output stage, regulate the plate supply to the oscillator and to the screen grids of the power amplifier, and you will have a signal that will be outstanding in quality and a joy to copy.

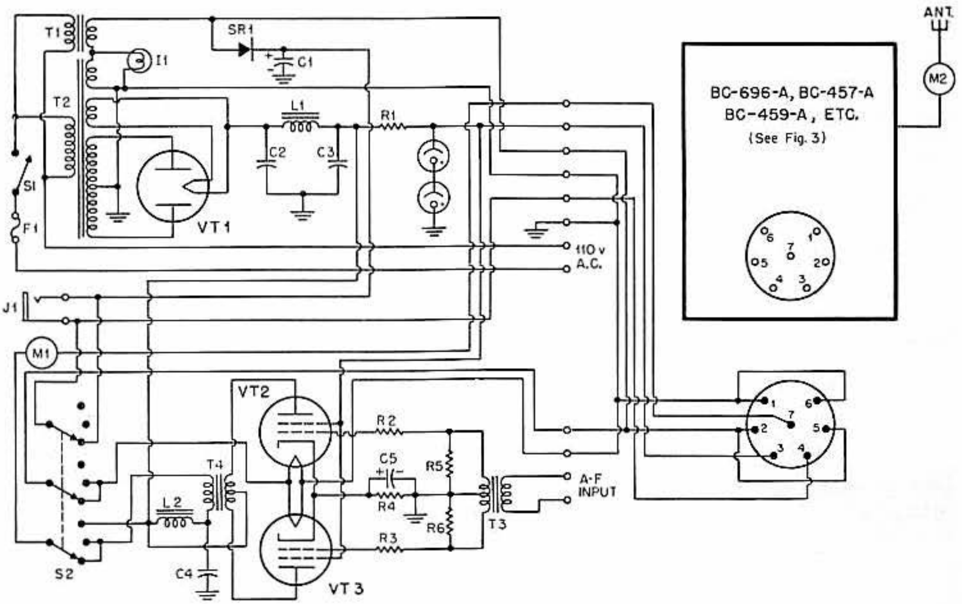


Fig. 9. The power supply, modulator, and interunit cabling.

C1—500 μf. 25-volt dry electrolytic
C2—1 μf, 600 v., oil filled
C3—10 μf, 600 v., oil filled
C4—4 μf, 600 v., oil filled
C5—40 μf, 150 v., dry electrolytic
L1, L2—Thordarson T-20C64 chokes
R1—5K, 20 w., wirewound
R2, R3—500 ohms, 1 w.
R4—250 ohms, 5 w., wirewound
T1—6.3 v. at 3 amp, fil. trans.
T2—Plate and filament transformer, 400 v. each side c.t. at 250 ma. with 6.3 and 5 v. windings
T3—Mike or line to grid trans.
T4—25-watt modulation transformer, select to match p.p. 807s to 3,000-5,000 ohm load
S1—S.p.s.t. toggel switch
S2—Three-pole, 3-position wafer switch
SR1—Seletron 1M1 selenium rectifier
F1—Bussman type 3AG 3-ampere fuse
I1—6.3-volt pilot lamp
J1—Single-circuit jack
M1—0-300 ma d.c. miliammeter
M2—0-3 amp r.f. ammeter

VARIATIONS ON

FOR 80 & 40 METERS

THE PURPOSE of this article is to describe one possible conversion of the ARC-5, or ATA and SCR-274N into a useful 40 and 80-meter v.f.o. Originally this unit was an aircraft command set and hence used the 24–28 volt d-c supply of the plane as its primary source of power. Unlike many other pieces of surplus equipment these units will operate efficiently with only a minimum of modification. As a matter of fact, so little time was spent in connecting them up that it was decided to rebuild them into a rack and panel unit. Thus, we have the foundation of a good ham station with very little encroachment on our time and expense account.

The Circuit

The ARC-5 transmitters are essentially m.o.p.a. A type 1626 (while the 1626 is a more stable oscillator tube, the 12J5 can be substituted) with the plate grounded for r-f is used as a modified Hartley master oscillator. A pair of 1625 tubes (807 with 12.6-volt filaments) are paralleled and form the final amplifier. Grid neutralization is used in this single-ended final stage with the out-of-phase voltage being fed back into the grid coil through a fixed-tune condenser.

The original aircraft antenna was loaded by a combination of rotary link and loading coil. The antenna connects directly to the loading coil through the relay *K54*. A rotary link is inserted in the final amplifier plate tank and is connected through to the loading coil with a moving tap. The tap on the loading coil is arranged to roll along the turns of the coils as it is turned by means of a gear system that extends through the front panel. This type of coupling is especially useful when loading up a Marconi or end-fed Hertz antenna.

The maximum power output of the transmitter while in the plane is about 40 watts on c.w. and 15 watts output on phone with 100 per cent modulation. The model ATA, however, uses screen modulation and has only a power output of about 10 watts on phone. The modified transmitter uses much higher plate voltages and a maximum power input of between 100 and 150 watts may be expected.

These transmitters also incorporate a 1629 (magic eye tube) which is used as a crystal-controlled calibration oscillator. This oscillator does not control the frequency of the transmitter at any time, but simply acts as a check on the calibration of the master oscillator. Most of the units are supplied with a calibration crystal of 3500 kc (BC-456A unit) or one of 8870 kc (BC-459A unit).

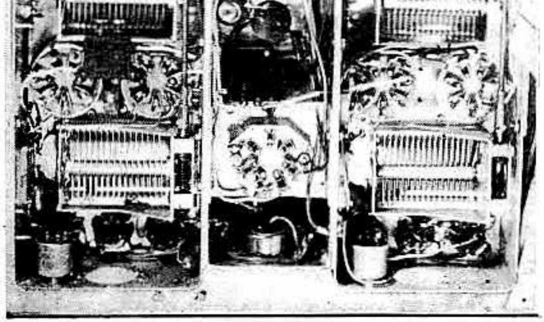
Electrical Modifications

Certain modifications should be made before the transmitter is put into operation. These modifications are as follows:

1. Remove *R71*.
2. Run lead on VT 138 *pin 7* to VT 138 *pin 2* and ground *pin 7*.
3. On one VT 136 *pin 7* is grounded, on the other VT 136 *pin 7* is ungrounded. Work with the ungrounded lead. Remove lead to VT 136 *pin 7* and run to *pin 1*. Ground *pin 7* (thus *pin 7* in both VT 136 tubes will be grounded and one side of the filament input circuit will go to ground).
4. Disconnect *K53* connection to plug terminal 5 and 6. Remove relay.
5. Disconnect *K54* and remove.
6. Remove *R70*.

The 390-ohm cathode resistor, *R77*, used with the 1629 should be replaced with a 1000-ohm ½-watt resistor. The cathodes of both of the 1625 tubes are then tied together and grounded through a SPST switch. This switch serves as a TUNE-TRANSMIT switch enabling the operator to open the cathode circuit of the final amplifier so that the oscillator may be zero-beat without undue interference. A power supply giving 12.6 v. a.c. (6.3 v. transformers in series are satisfactory) and d-c voltages from 500 to 750 at 200 ma and 150 to 250 v. at 50 ma is required.

In certain cases (ours included) it may be advisable to remove the loading coil in the antenna circuit completely. This coil will soak up quite a lot of the r-f that should be in the antenna. When using a coax line the center conductor may be tied into the rotary link in the final tank coil and the link used to load the antenna. The other side of the link is already grounded and it is only necessary to ground the outer braid of the coax line.



Bottom view of SCR-274Ns showing units rack-mounted with switching circuits in between.

THE SCR-274N

Mechanical Modifications

The mechanical arrangement of the ARC-5 did not harmonize with the rest of our rig and it was decided to rebuild into a relay rack. After some thought we evolved the arrangement shown in *Fig. 1.* The 3.0 to 4.0-mc transmitter is on the left and the 7.0 to 9.1-mc transmitter is on the right in the illustration. Above the two v-f-o control dials. The dials are combination indicator and panel lights. They may be adjusted to throw a beam of light in any direction along the panel. A single meter with meter switching is employed in conjunction with a 2-pole 11-position switch and the oscillator plate, final grid, final screen, or final plate currents may be read. Positions are also used to show the oscillator and final plate voltages. The details of this arrangement are not shown here since they may be quite easily worked out and will vary according to the number of meters the reader may have at hand.

The transmitter filament, oscillator plate, and final amplifier circuits are switched by means of the 3-position 3-pole switch in the lower center of the panel. The key jack is directly below this switch. The toggle switch to the right of the key jack is for SEND-RECEIVE and the toggle to the left is for TUNE-TRANSMIT. A pair of indicator lights in the upper center of the panel show which transmitter is in use. The pilot lights may be operated from the 12.6-v. filament supply by inserting a separate 47-ohm 1-watt resistor in series with each 150-ma pilot lamp.

To rebuild the ARC-5 into this arrangement it is first necessary to remove the front panel of the transmitters. Removing the front panel may prove to be the most difficult part of this operation. First remove the dust cover, all of the tubes, the calibration crystal and all of the knobs and dials. The antenna tuner will also come off as it is mounted to the front panel and chassis with 3–48 screws.

Aluminum rivets fasten the front panel to the chassis, but the heads of these rivets (three on each side and one on top center of the chassis) may be cut off with a cold chisel or drilled out. This permits removal of the front panel from the transmitter unit. The front panel of the relay rack may now be marked.

When two of the transmitter units are placed side by side there is sufficient space to mount a narrow chassis between the two and still put them in a standard rack mounting. We decided to place the VR-150 voltage regulator on this small chassis along with the dropping resistors, switches and cable connectors from the power supply. The dimensions of this chassis are 11½" x 3½" x 3". As a matter of fact, a doubler stage could also be built into this chassis if it is desired.

The three units are laid out side by side and bolted together to form one complete unit. The front panel is a regular 19" x 7" plate of black crackle 1/16" inch steel. The layout for drilling the panel requires a little extra care, although bushings should be used where possible to allow for a much greater tolerance. The meter, switch and screw holes may be laid out and drilled without difficulty. When the front panel is completed it is secured to the transmitter unit with two standard chassis end brackets and the various switch shafts and screws through the front panels. Two extra brackets in the center will add considerably to the rigidity of the completed unit.

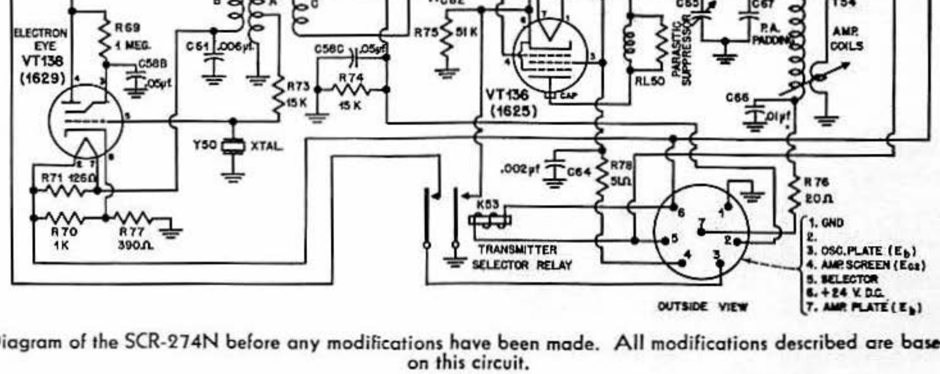


Diagram of the SCR-274N before any modifications have been made. All modifications described are based on this circuit.

We tried several different keying circuits and finally compromised on the simultaneous keying of the oscillator plate and the final screen voltages. This will allow break-in operation while keying the cathodes of the final amplifier will not. A keying relay is used which has been mounted on the rear of the small center chassis. The note sounds very good even though the oscillator is being keyed.

With a power input of about 100 watts we have found the performance of the ARC-5 excellent.

FOR 40 & 20 METERS

By the simple expedient of switching the fixed air padder (across the PA coil) in and out of the circuit, efficient operation may be realized on both 20 and 40 meters. It is necessary to uncouple the PA tuning condenser from the drive and shaft mechanism and run its shaft out the side of the unit through a fixed or flexible coupling. This shaft is at ground potential. The oscillator tuning remains unchanged.

Only 20-meter operation was contemplated at W2VNU/8 so band switching was not incorporated. The "hot" end of the fixed air padder, *C67*, in the schematic was disconnected. There is, however, sufficient space along the side of the unit to mount a SPST switch for bandswitching.

FOR 11 & 10 METERS

As MIGHT BE EXPECTED, our particular interest is a v.f.o. combination capable of working from 11 to 2 meters. The SCR-274N series, particularly the BC-458A and BC-459A, provide a ready answer to the problem. The former unit tunes initially from 5.3 to 7 mc, and the latter unit covers the range 7.0 to 9.1 mc. On 11 meters we use the 4th harmonic of 6.79 to 6.85 mc, on 10 meters we use the 4th harmonic of 7.0 to 7.42 mc, on 6 meters the v.f.o. is between 8.33 and 9.0 mc, while for 2-meter operation we use the 18th harmonic of 8.0 to 8.2 mc.

A first inspection will confirm that little conversion work is necessary to get these v-f-o units on the air. After a clean up with a few drops of light oil mixed with some carbontet applied with a stiff brush, the top shield is taken off by removing the small screws holding it in place. Then, if the unit is to be used strictly for v-f-o operation take the coiled spring lead that is actuated by the antenna change-over relay and solder it to the antenna feed-through post. Note at the same time that variable link coupling is used from the 1625 plates to the variable inductance. By rolling the inductance to "0" on the dial it is effectively removed from the antenna circuit, making a straight lead from the link to the antenna relay.[1] A coax cable is then used from the antenna post to transmitter. An adaptor for coupling the v.f.o. to a crystal stage is shown in *Fig. 1a*.

The filaments of the 274N are wired in series-parallel for a 24-28 d-c volt input. Since 807s require different sockets than 1625s and since there is no 6.3 volt equivalent to the 1626, it is suggested that a 24-volt output transformer be obtained that is capable of supplying about 2 amps. These are now becoming fairly common and should be available from most jobbers.[2]

The next step is to remove the bottom plate and locate relay *K53* which is mounted in the middle of the unit on the left side. This midget relay switches the plate voltage to the *VT137* (1626) and shorts out the biasing resistor *R75* (51,000 ohms). Either remove this relay entirely from the unit or tie it down in the energized position. If the relay is removed, the cathode wires from the 1625s should be grounded to the chassis and the red lead carrying the oscillator plate voltage from socket *pin 3* to *R68* is resoldered directly, in place of running through the relay arms.

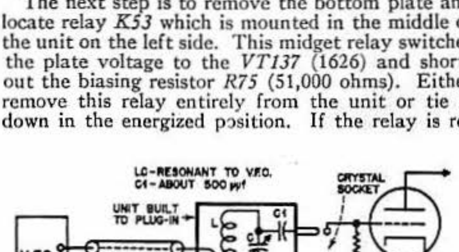
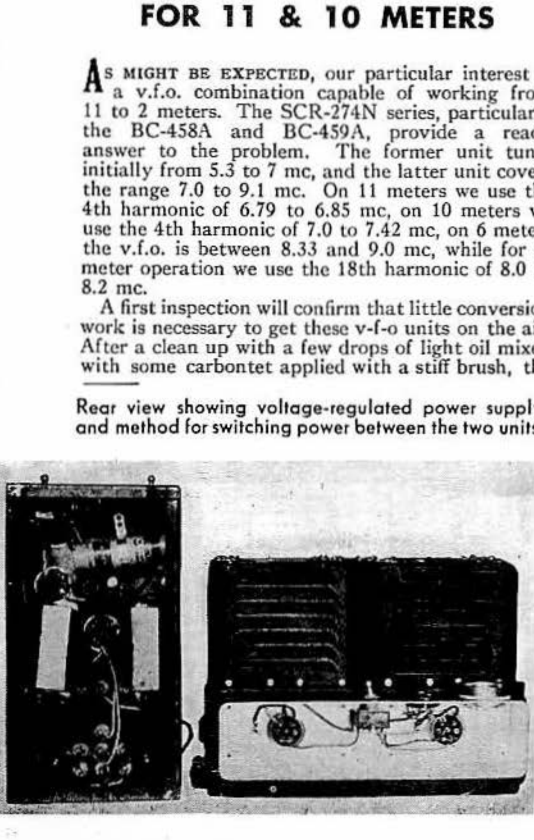


Fig. 1a. Adaptor for coupling v.f.o. to crystal stage
Fig. 1b. Alternate method for coupling to driver stage

It is often worth while to use the magic-eye (1629) and crystal calibrator unit to check the v. .o. in the absence of frequency standard. This un normally would have used the 24-volt d-c filament voltage as the bias on the cathode of the 1629 throu h resistors *R77* and *R70*. To change this part of the circuit over to a-c operation disconnect the cathode lead of

Rear view showing voltage-regulated power supply and method for switching power between the two units.



1 By choosing a reasonably small length of coaxial cable to connect to the transmitter the "antenna" coil of the 274N may be used as shown in *Fig. 1b*. The length of cable, L, multiplied by the capacity of the coax per foot (from the manufactures data this is usually equal to 20 to 30 μμf per foot) resonates with L52 and its associated link provided L is short compared with a quarter-wave at output frequency.

2 The 1625 sockets can be modified in accordance with instructions given on page 27, January 1948, *CQ*, in the article by W2CVV, "Mobile With the SCR-274N."

the 1629 (pin 8) from the junction of these two resistors. Then solder a 2500-ohm 2-watt resistor between the cathode and chassis ground. The magic-eye now operates normally with the eye closing when the v-f-o frequency equals the frequency of the calibrating crystal.

Power Supply and Connections

We were able to obtain a dual rack for our two v-f-o units. These also have socket connections at the rear for the control and power plugs. By removing the screws at the back of the power receptacle box all the wiring becomes accessible. It is best to remove all of the wiring and start out fresh.

Remove the small socket and replace it with a 4-prong socket to handle the voltages coming from the power supply. In the center of the power receptacle box mount a DPDT toggle switch. This switch is to be used to switch the plate and screen voltages from one v.f.o. to the other. The filaments of the two units are wired in parallel.

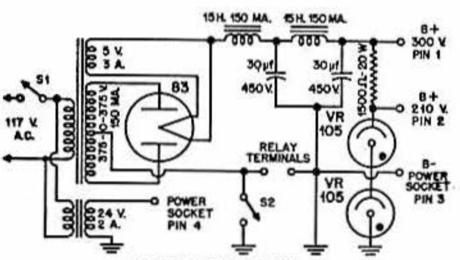


Fig. 2. Voltage regulated power supply recommended for use with the SCR-274N as a v.f.o.

A well-regulated power supply is the key to the stability of any v.f.o. After a number of experiments and checks on the output and drift we arrived at these voltage and current ratings. For strictly stable v.f.o. operation, not more than 300 volts at 100 ma on the plates of the 1625 amplifiers, and 210 volts on the oscillator stage. If the unit is to be used on either 40 or 80 meters 500 volts at 200 ma can be used and still afford a reasonably clean-cut signal. The oscillator voltage must be well-regulated and a suggested power supply is shown in *Fig. 2.* Two VR 105 tubes in series keep the oscillator plate and amplifier screens down to a current drain of between 30 and 40 ma, by providing 210 v. of stabilized d.c. The double section filter in the power supply is worth while, thus keeping the ripple content down.

To set the v.f.o. to a spot frequency chosen on the receiver, a calibrating switch is included in the power supply proper. Since the two units are mounted side by side it enables the operator to set up without causing needless QRM by having the entire transmitter on the air.

Keying

Many types of keying circuits have been tried with this v.f.o. For the author the most satisfactory has been to use relay *K53* and key the cathodes of the 1625 amplifiers. This relay will operate nicely from a 22-volt battery, or through a 10-watt 17,000-ohm resistor from the 300-volt supply. The relay draws about 16 ma from either the battery or the dropping resistor.

SCR-274N ON 160

Putting a Command-Set (*SCR-274N*) transmitter on 160 meters is quite simple, if the following method is employed. Although used specifically with the BC-457, it appears equally applicable to other models.

Oscillator

Remove the shield can covering the oscillator coil and padding condenser. Without dismounting the coil form, strip the wire from it; both the large winding and the small one connected in the filament circuit. Do not, however, disturb the 1625 grid coil which is inside the form.

Rewind the larger coil with thirty-six turns of No. 20, enamelled wire. Close wind the first thirty-three turns, starting at the bottom of the form and complete with the final three turns spaced in the grooves at the top of the form. The winding must be put on tightly to prevent the turns from slipping.

The cathode of the oscillator tube is tapped on the eighteenth turn from the bottom of the winding. Cut loose the oscillator tube filament terminals from all other circuits and connect them directly to the filament heating circuit. Set the oscillator padding condenser to maximum capacity. Then replace the shield and turn the oscillator slug halfway in.

Under the chassis, remove the black wire between the oscillator coil terminal strip and the neutralizing condenser. Move the 15,000-ohm, 1625 grid-bias resistor and its bypass condenser to the terminal previously occupied by the neutralizing condenser lead.

The magic eye assembly is not used, and the neutralizing condenser may also be removed if desired.

Amplifier

Remove the amplifier coil form from the chassis and strip off the old winding. Tightly rewind with 34½ turns of No. 18 enamelled wire. Close wind thirteen of them in the space at the bottom of the form. Continue close winding in the upper part of the form for 18½ turns. Finish off with three turns space wound in the grooves on the form. Replace the coil.

Remove the antenna loading coil and connect the variable link to a coaxial output connector. If later it is found that this does not give enough coupling between the antenna and amplifier, a few turns of insulated wire may be wound over the amplifier coil and connected in series with the variable link.

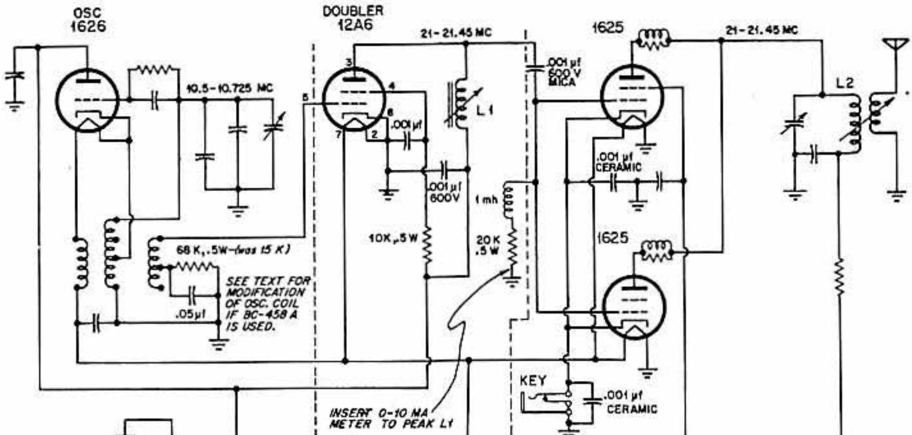
After the coils are modified, apply low voltage to the transmitter and tune the amplifier padding condenser for minimum plate current. Experimentally adjust amplifier and oscillator coil slugs for best tracking of the two circuits across the band.

THE BC-458A & BC-459A ON 15

Command-Set transmitters can be converted to cover the 21-mc band with a minimum of effort. Two conversions, applicable to the BC-459A (7-to-9.1 mc.), and the BC-458A (5.3-to-7 mc.) transmitters are described below. The simpler conversion consists of shifting the oscillator tuning range to cover 10.5 mc. to 10.725 mc. and operating the parallel 1625's as frequency doublers. To accomplish these objectives, do the following:

Next, remove three turns from the top of the amplifier tank coil.

The amplifier padder now becomes the main tuning condenser. Remove its shaft lock, and add a shaft extension, plus a knob, for easy adjustment. It may be necessary to dismount the padder from the chassis to remove the shaft lock and to enlarge the hole in the side of the chassis to accommodate the shaft extension.



NOTE
UNLISTED PARTS ORIGINAL AND UNCHANGED.
L1– 7T #22 PE WIRE ½" LONG, ⅜" DIA CERAMIC SLUG-TUNED FORM.
L2– 5T, DOUBLE SPACED ON ORIGINAL AMPLIFIER COIL FORM.

Fig. 1. Modification schematic. The dotted lines enclose the optional doubler stage, which affords added output and stability.

BC-459A

Oscillator: Decrease the capacity of the padding condenser, located under the oscillator shield can; so that the oscillator tunes to 10.725 mc. when the dial is set to 9.1 mc. The shield must be in place while checking frequency.

Amplifier: First, disconnect both the amplifier tuning condenser (the one ganged with the oscillator condenser) and the neutralizing condenser.

Mount a midget phone jack in the lower left-hand corner of the panel, and connect it between the 1625 cathodes and ground. Bypass the cathodes to ground with a .001 µf. ceramic condenser.

Connect the power supply, plug a key in the jack, check your frequency, tune the 1625 plate tank to resonance, couple an antenna, and you are on 21 mc.

BC-458A

In addition to the above, putting the BC-458A on

21 mc. requires modifying the oscillator coil as well as the amplifier coil. Remove five turns from the top of the oscillator coil, and rewind the amplifier coil. The new winding consists of five turns of the original wire, wound to occupy every other groove on the coil form.

(Using a conventional frequency doubler as an output stage always incurs the risk of radiating appreciable power at both the subharmonic and harmonics of the desired output frequency. A link-coupled antenna tuner will greatly reduce the possibility of such spurious outputs reaching the antenna. Another possibility is to divide the parallelled 1625 grids and excite one from the present point on the oscillator coil assembly and the other from the point previously connected to the neutralizing condenser. This will convert the 1625 stage to a push-push doubler, increasing doubling efficiency and decreasing the probability of output on other frequencies. —Editor.)

A More Efficient Conversion

After the thrill of the first few contacts on the new band has worn off, you may desire to go a step further and add a 12A6 frequency doubler between the oscillator and the 1625's. The added stage will permit the 1625's to operate as straight amplifiers, resulting in increased 21-mc output. It will also improve stability, because of increased isolation between the oscillator and the 1625's.

The portion of the diagram *(Fig. 1)* between the dotted lines gives data on the new doubler stage. To accommodate it, strip all connections from the 1629 tube socket and the crystal socket. Reconnect power leads removed from them to the power plug at the rear. Replace the 1629 socket with a piece of scrap aluminum upon which L1, the slug-tuned 12A6 plate coil, is mounted. Rewire the former crystal socket for the 12A6.

Note that the connection from the oscillator coil that formerly went to the 1625 grids now goes to the 12A6 grid, while the 1625 grids are connected to the 12A6 plate through a .001 μf. condenser.

Connect the grids of the 1625's to ground through a one-milli-henry r-f choke and a 20,000-ohm, ½-watt resistor. Raise the value of the former 1625 grid resistor—now the 12A6 grid resistor—to 68,000 ohms.

Tuning The Doubler

Insert a 0-10 ma. meter between the amplifier grid resistor and ground. With the plate and screen voltage removed from the 1625's, tune the oscillator to the center of the 21-mc band (21,225 kc.), and adjust the slug in *L1* for maximum meter deflection. It should be about five milliamperes at the center of the band, dropping fifteen to twenty per cent at the ends of the band.

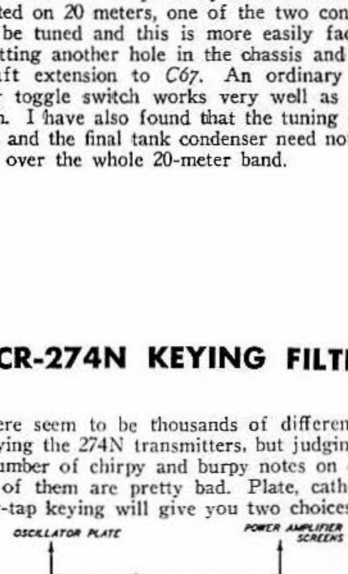
If the grid current exceeds five milliamperes, decrease the size of the coupling condenser between the 12A6 and the 1625's or increase the value of the 12A6 screen resistor.

BC-459A ON 20

This is an improvement over the method suggested by W2VNU/8 (July, 1948, *CQ*, page 44). Instead of switching out the padder (*C67*) switch out the main tuning condenser (*C65*). With this arrangement the tuning condenser does not need to be disconnected from its worm drive shaft, and hence will still track perfectly on 40 meters. When operated on 20 meters, one of the two condensers must be tuned and this is more easily facilitated by cutting another hole in the chassis and adding a shaft extension to *C67*. An ordinary SPST power toggle switch works very well as a band switch. I have also found that the tuning is quite broad and the final tank condenser need not be retuned over the whole 20-meter band.

SCR-274N KEYING FILTER

There seem to be thousands of different ways of keying the 274N transmitters, but judging from the number of chirpy and burpy notes on the air, a lot of them are pretty bad. Plate, cathode, or center-tap keying will give you two choices. One,

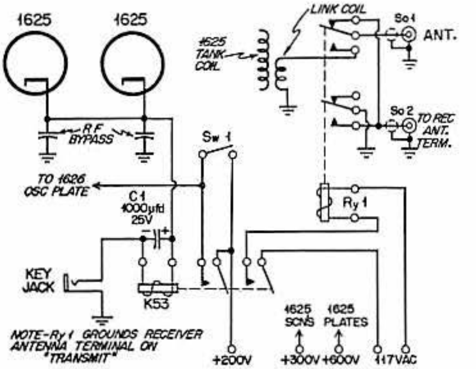


a signal with lots of chirp and no click, or two, a signal with lots of clicks and no chirp. This all depends actually on the amount and type of keying filter. We have examined these different methods using oscillographic techniques. The circuit shown was finally worked out as the best solution. Using the BC-696A we have absolutely no chirp or click on 80 meters. With the BC-459A on 40 meters there is a very slight chirp of about 10 cycles. Keying the oscillator alone is not entirely satisfactory as this will allow the final to break into parasitic oscillations.

274N BREAK IN

After converting an *ARC-5* "Command" transmitter by following standard procedures, I first keyed it in the common B+ lead to the oscillator plate and amplifier screens. This arrangement produced a noticable keying chirp. Next, I tried straight cathode keying of the 1625 tubes. This system worked well, but the constantly-running oscillator prevented working "break-in."

My next step was to combine the advantages of the two keying methods. This was done by the method sketched in *Fig. 1*. I connected the coil of the original transmitter selector relay, *K53*, between the cathode terminals of the 1625's and the key jack. I fed the oscillator plate current through the same set of relay contacts originally used for this purpose. The other pair of contacts control a 117-volt, a-c, antenna changeover relay, which is mounted near the amplifier plate coil. In addition, I connected a 1000 μfd., 25-volt, electrolytic condenser across the relay winding.



C1—1000 μfd., 25v. electrolytic (Sprague TVL 1230 or equiv.)
K53—Original "selector" relay rewired as shown.
Ry1—DPDT antenna changeover relay, 117v. a-c winding (Advance K1504 or equiv.) installed in position previously occupied by old d-c antenna relay.
So1, 2—Coaxial chassis fittings mounted on panel near Ry1.
Sw1—SPST toggle switch mounted on side of transmitter near K53.
Other components normal for a "Command" transmitter converted for amateur use.

Fig. 1.—Simple circuit changes required to achieve chirpless, break-in keying with "Command" transmitters. Full details in text.

Operation

Upon pressing the key, the 1625 cathode current flowing causes *K53* to close. This, in turn, actuates the antenna changeover relay, which switches the antenna from the receiver to the transmitter, and applies plate voltage to the oscillator. The condenser across the relay coil quickly charges up, and its charge holds the relay closed during normal keying pauses, so that the keying is essentially cathode keying of the 1625's. However, a 2 to 4 second pause allows the condenser to discharge through the relay coil. The relay then opens, the oscillator ceases to function, and the antenna is automatically switched back to the receiver.

The "non-swish" *Spot-Tune* switch, *Swl* across the oscillator plate-voltage contacts of the relay permits checking the transmitter frequency and zero-beating a signal without putting a signal on the air. Also closing the switch allows operating the transmitter without the "break-in" feature.

A minimum cathode current of 100 milliamperes is required to operate *K53*. On the other hand, the cathode current should not exceed about 150 milliamperes; otherwise the voltage drop across the relay winding will exceed the 25-volt rating of *C1*. Note that the voltage drop acts as cathode bias on the 1625's; therefore it prevents the plate current from soaring when the key is pressed and the oscillator is not functioning.

This keying system has been in operation for several months with entirely satisfactory results. At keying speeds of five words per minute and over, *K53* stays closed during normal spacing between letters and words, but a slightly longer pause automatically shuts off the oscillator and connects the antenna to the receiver, so that I can listen for "breaks."

THE BC-604

BC-604 Description

The BC-604 is a transmitter for mobile use in the thirty watt output class for operation on twelve or twenty four volts d.c. I receive mine with a DM-35 dynamotor which puts it on twelve volts with little strain. (Twenty four volts requires a DM-37). It covers the frequency range of 20 to 27.9 *mc*, making it a natural for the bands mentioned. A companion receiver is the BC-684, which covers 27.0 to 38.9 *mc*. Note now, and please understand this clearly. This transmitter is not capable of conversion to the Citizen's Band without violating the law, and no correspondence will be answered about any conversion to non-amateur applications.

The 604 originally operated on any ten of 120 crystal controlled channels spaced 120 *kc*. The transmitter is *Frequency Modulated* and used a deviation of plus or minus 40 *kc*. The crystals used were in the 375 to 540 *kc* band and I multiplied 72 times to get to the actual transmitted frequency. The final amplifier is very similar to an 807, while the other tubes are similar to a 6L6. The only problem with these tubes is, that they are directly heated filament types and are wired in a series-parallel string to get the necessary filament voltages. The first thing to do when converting equipment is to get

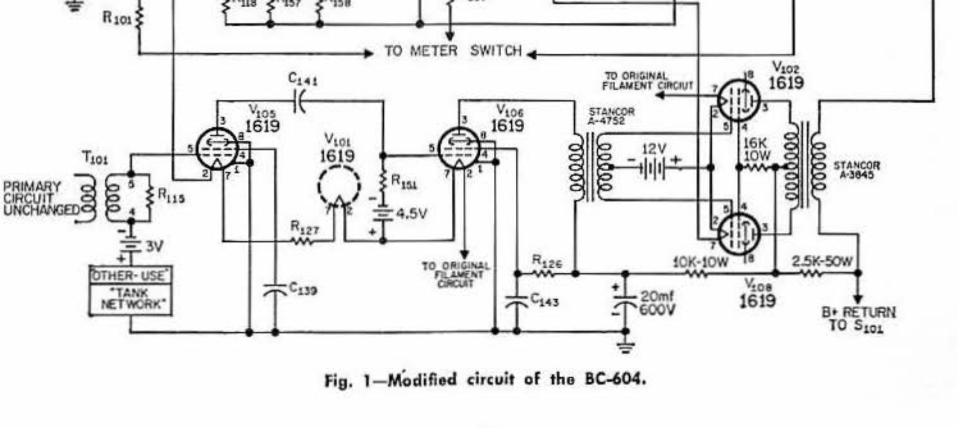


Fig. 1—Modified circuit of the BC-604.

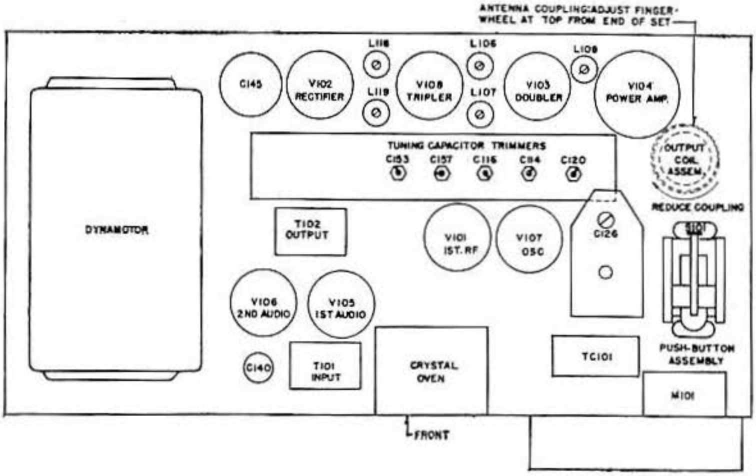


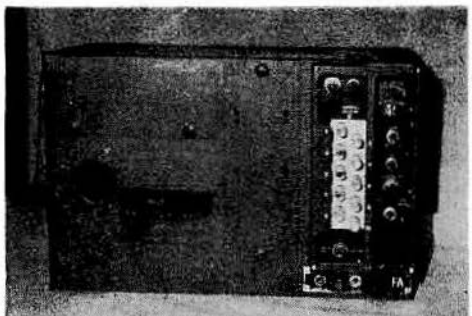
Fig. 2—Top view of the BC-604.

a working model. In this case don't get talked into taking the crystals with the unit unless you are planning to get a single sideband filter out of the deal, since that is about all the crystals are good for. Usually the dynamotor is obtained separately. Also, since the unit weighs about seventy pounds, be careful; the shipping charges are counted in the price.

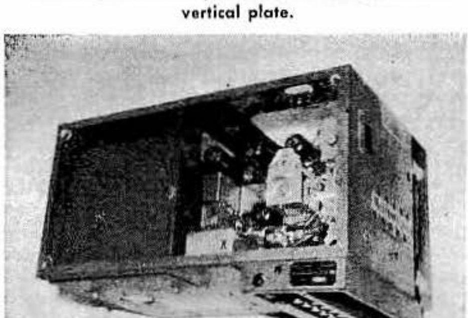
Fortunately, for our purposes, the FT-241 cillator, rewire this section to use the 7 *mc* crystals as far as sockets are concerned, so those surplus and new crystals will work OK in this unit. You will have to rewire the oscillator and make use of the f.m. circuitry for the a.m. modulator.

Conversion

The actual conversion begins by locating the various parts within the transmitter. This is done by removing all of the quick disconnect panels which have quarter-turn type fasteners. This will expose the circuits and it will be necessary to locate the tubes as well as the various sections of the variable capacitors. Starting with the oscillator, rewire this section to use the 7 *mc* crystals needed for the ten and fifteen meter bands. Remove the wire going to L_{102} from pin 3 of V_{107} at the lug of L_{102} and reconnect this to the free lug on C_{114} variable capacitor (second from the end) near V_{107}. Remove the wire going from pin 3 of V_{108} to L_{106}. Remove exactly 16 turns each from L_{106} and L_{107}. Remove the 100K resistor going fro mpin 4 of V_{108} to B plus. This modifies the transmitter so that the oscillator now works at 7 *mc*, while the plate is tuned to 14 *mc*. The tripler circuit now operates as a doubler to 28 *mc* and we are now ready to align the r.f. sections. With the tuning capacitor open completely, adjust C_{120} so that the coil L_{108} is resonant at about 30 *mc*. It will be necessary to use a grid dip oscillator for this operation. Likewise set L_{106} and L_{107} to resonate at 15 *mc* by adjusting C_{114} and C_{116} respectively. Now close the capacitor by means of one of the push buttons or the stud knob near the right handle. The



Front view of the BC-604 showing push button arrangement and control functions. The round plastic window on the left indicates the line voltage in use when the dynamotor is installed. The spare crystal draw is the horizontal panel shown on the left. Active crystals are located behind the vertical plate.



Top view of the unit with the cover removed showing r.f. components on the right and top of the crystal draw on the left. The small holes on the side of the cabinet are individual channel antenna loading capacitor adjustments. The large square hole on the side of the cabinet is the final amplifier tank trimmer.

circuits should resonate at about 10.5 *mc* for the coils L_{106} and L_{107}, while L_{108} should be about 21 *mc*. If this is not obtainable, readjust the slugs within the coils to get the circuits to resonate where they should. A grid dipper is invaluable since it can tell you which way the coils have been adjusted as far as frequency is concerned, and this will enable you to do a faster job.

When this is completed, go to the top of the chassis and check the adjustment of C_{126} the same way C_{120} was adjusted. When transmitting it will be necessary to make additional adjustments which will be discussed later.

The modulator is built up, using the tubes we didn't use before. Twenty five watts of audio will be required, since the power input is in the order of about fifty watts. I used two 1619's in push pull for the modulator, and drove them with the original audio circuitry, making only a slight change. It will be necessary to remove T_{102} from the circuit (it can stay on the chassis if you want to leave it there). In its place connect a driver transformer for the audio power stages. This could be a Stancor type A-4752 or equivalent. It is not critical where it is mounted, and we found that it could easily be mounted on the bracket covering the transmitter trimmer adjustments. The modulation transformer was mounted on the back wall of the transmitter and is a Stancor type A-3845. The nearest ratio of transformer impedances we could find that worked best was the 10,000 to 8,000 ohms. Incidentally, some models have a switch marked, TANK-OTHER USE. This is used to make the carbon mike input less sensitive in a noisy location and thereby improve the transmission. Set it at OTHER USE if you have such a switch.

This equipment was originally used in vehicles with a negative ground. When used in a positive ground car, it will be necessary to provide some bias source such as a battery or dry cell to eliminate this problem. Figure 1 shows the circuit I finally ended up with, and since the battery is inserted properly, there will be no need to worry about how to set the battery. It will be necessary however to reverse the primary connection on the dynamotor for the positive ground cars.

When wiring the modulator, I made use of two tubes which were originally used in the f.m. circuit. The leads may be a little long, both from, and to, the transformers but this shouldn't matter much. If any r.f. is picked up, they could be shielded, but this is probably not necessary.

Power is applied by connecting 12 volts d.c. to pin 1 and the negative terminal (unless changed as mentioned above) to pin 2. The entire transmitter is operated by push to talk, with a dynamotor start relay and an antenna changeover relay all ready built in. A receiver disable relay is also provided.

Tuning Up

Once power has been provided it will only be necessary to press the mike button to get on the air. Tuning up is the next step and should be done as follows: Set a crystal in one position of the crystal socket. Rotate the small knob on the side, until the channel select locking screw is visible through the hole above the push buttons. Loosen this screw and then depress the push button corresponding to the crystal position you inserted the crystal. Put the transmitter ON-OFF switch into the ON position. Press the button on the mike and rotate the knob on the side (with the meter switch in position 1) until maximum current is read with the meter switch in TUNE. Put the meter switch into position 5, and read the grid current. This should be at a maximum value at the setting obtained for the previous reading, (about 30 on the meter), when the side knob is rotated. If the setting is different, then the alignment is at fault and the trimmers and coil slugs will require additional adjustments until they track. Likewise, the reading for position six of the meter switch should also be set properly. This should be a minimum reading, since it is the plate current, and when tracking is proper, as it should be, it will be possible to increase the plate current by loading the transmitter. This is accomplished by setting the loading capacitors for each frequency. These are found on the right side of the unit. Likewise, L_{111}, which is accessible from the top side, is is adjusted for maximum r.f. current as is the general loading. This is done by merely flipping the switch on the front panel to read r.f. current. L_{110} is accessible from the bottom side just above the handle. This is the final amplifier tank coil and should be adjusted as part of the tracking, but may require adjustment as part of the loading.

Once the adjustments for a particular channel are determined, the next set of adjustments are made and the procedure followed again, and again, until all ten channels are preset. This may seem a little tedious, but it is actually a fast operation, since only the knob under the handle and the loading capacitor need be adjusted for each setting. The dial is locked in a manner reverse of that of loosening it, that is, by turning the side knob until the screw is visible within the front panel hole and then tightening it. Some doubt may appear regarding the changing of settings each time, but the push buttons lock the assembly except for the setting being adjusted so no change will occur in those not being adjusted.

It is a good idea not to keep the transmitter on in a transmit condition too long at any one time, since the tubes could easily over heat. The manual for the equipment recommends the use of the equipment only intermittently, which means about five minutes on, fifteen off. This is primarily to protect the dynamotor, and should extend the life of the unit greatly. This need not be followed if the side plates are removed and proper ventillation is provided.

The crystals used should be one fourth of the frequency of the output. For fifteen meters, a 5.25 *mc* crystal will provide an output of 21 *mc*, while 7.3 *mc* crystals will be 29.2 *mc*.

THE BC-696

Wishing to convert a BC-696 to crystal control for Novice operation, I hit upon a very novel way of doing so. A plug-in adapter, using parts costing less than $3.00, changes the 1626 from a variable-frequency to a crystal oscillator. As it requires no modification of the oscillator, v-f-o operation may be restored in a matter of seconds. *Figure 1* and the picture shows the simplicity of the adapter.

This unit was built in an FT-203A adapter from a BC-454. However, a U-bracket, about 1½ x 1½ x 2 inches, will work satisfactorily. The parts arrangement shown in the picture utilizes the available space to good advantage. One word of caution is in order. Do not apply too much pressure while drilling the holes, as the thin aluminum is easily bent.

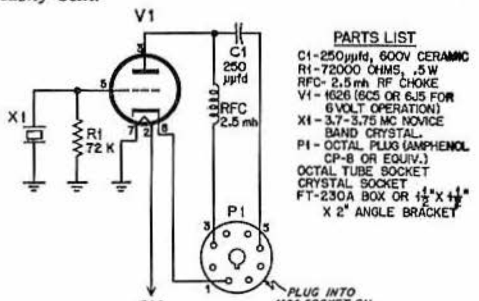
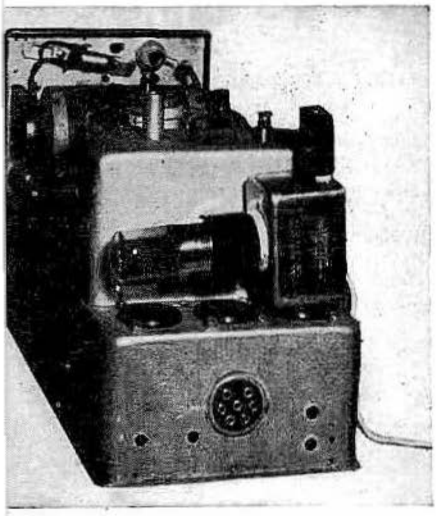


Fig. 1. The wiring schematic reveals that only a very few parts are required. The only circuit change in the Command transmitter is to ground pin #1 of the 1626 socket.

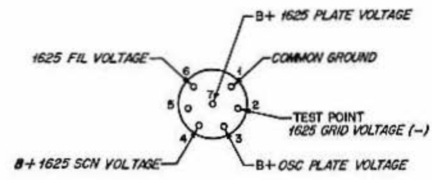
Much of the wiring may be done before the parts are mounted. Mount the tube socket with the keying slot down and the plug P1, with its key to the front.



To prevent possible shorting, insulate the r-f choke, *RFC*, with a layer of tape before wiring it into the circuit.

The only modification required in the BC-696 itself, besides those usually made for amateur operation, is to connect *pin 1* of the 1626 socket to the nearest ground lug.

Remove the 1626 and 1629 tubes and the calibrating crystal from the transmitter. Plug the 1626 and a Novice-band crystal into the adapter, and plug the adapter into the 1626 socket. The unit is now ready for testing.

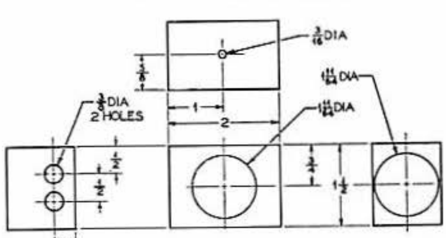


This view of the Command transmitter power plug is shown for reference purposes.

Testing

Apply filament voltage between *pin 2* of *V1* and ground and to the 1625 filaments. Connect a 100-volt, d-c meter between *pin 3* of the power plug on the transmitter, the positive meter terminal to ground and the negative one to the pin.

Set the transmitter dial approximately 100 kilocycles above the crystal frequency and apply a maximum of 250 volts, d.c., to *pin 4* of the power plug. Quickly tune the dial for maximum meter deflection, consistent with the crystal starting every time oscillator plate voltage is applied.



Suggested adapter chassis layout.

Now apply plate and screen voltage to the 1625's and adjust the amplifier padding condenser for minimum plate current. Antenna tuning and loading follow standard procedures described many times in *CQ* and other publications.

Several methods of keying have been tried with this transmitter. The most foolproof method was cathode keying of the 1625's. Oscillator plate and amplifier screen keying also works fine, but oscillator tuning becomes rather critical.

THE ART-13

THE ART/13 TRANSMITTER offers a refreshing variant from the present general run of war surplus equipment. Essentially, the ART/13 is a Collins product using the auto-tune selector. This allows any one of eleven preselected frequencies to be automatically chosen, tuned and operated from a remote position. As if this one feature were not sufficient to warrant further consideration, a *frequency meter type* v.f.o. allows the transmitter to be manually operated on any frequency between 2000 and 18,100 kc with a calibrated accuracy on the order of 1 kc. A Collins pi-network enables practically any type of antenna, excepting two wire balanced lines, to be matched to the final output.

Technical Description

The tube lineup consists of an 837 electron-coupled oscillator operating in the range from 1000 to 1500 kc. This oscillator has excellent frequency stabilization and is sufficiently shielded to rule out any possible broadcast-band interference. The oscillator tuning is broken into two ranges, the first range tuning from 1000 to 1200 kc and the second from 1200 to 1500 kc. Together these two ranges are spread over almost the entire 4000 possible dial divisions, thus a very high order of dial divisions per kc is obtained even on the 10-meter band. Setting up a frequency is much the same procedure as followed in using a frequency meter with calibrating charts and the results are of about the equivalent accuracy.

The 837 low frequency oscillator drives a 1625 (12 volt filament 807) operating as a doubler, tripler or quadrupler depending upon the output frequency. The second frequency multiplier is also a 1625 and is always operated as a tripler. The final amplifier is an 813 which is modulated by a pair of 811s. We have stepped the high voltages up to 1500 volts and a plate input, fully modulated, of about 225 to 250 watts may be reached without exceeding the commercial ratings of the tubes. The lower voltages have also been stepped up to about 450 volts, resulting in somewhat more excitation to the final amplifier in the 10 meter band.

The speech amplifier consists of a 12SJ7 followed by a 6V6G which drives the 811s. Also incorporated in the speech end of the ART/13 is another 6V6G which acts as a sidetone amplifier. The output of this amplifier is delivered to a phone jack labeled "Sidetone No. 1" on the front

The ART/13 with a-c power supply. Equal in size to the average communications receiver, this aircraft transmitter is rated at 200 watts output on phone and c.w. with automatic selection of 11 frequencies on any band from 80 to 10 meters after conversion.

panel. The speech may be monitored by the sidetone amplifier or the keying may be monitored through a built-in audio oscillator when the emission switch is in the c-w position.

A carbon mike may be plugged directly into the mike jack with the modification shown in *Fig. 1*. Quality reports even with a carbon mike have been excellent and the designers claim that the frequency response of the transmitter is about plus or minus 2 db from 300 to 4000 cycles. C-W operation with a high speed key is not advisable, although ordinary hand key operation is satisfactory. The present keying relay appears too sluggish for rapid keying. If necessary, the relay may be removed and the 813 biased to cutoff of about 40 to 50 volts. No bias is necessary with the 1625s. The keying relay, however, permits the same antenna to be used on both the transmitter and receiver. A binding post marked "receive" is located near the antenna post and the receiver lead may be connected to it. The relay also grounds the receiver antenna input while transmitting.

Because of the compact size of the ART/13 after a period of continuous filament operation the transmitter becomes very hot. In fact, the pitch in the modulation transformer may become so warm that it will soften sufficiently to permit the unit to "talk" so loudly that acoustic feedback to the mike may occur. This difficulty was solved by obtaining a small automobile fan which works smoothly from a spare 5-volt filament winding. This forced air draft cools the entire transmitter down to a safe operating point and is practically a necessity. If brush noise results in the receiver from this fan, it may be circumvented by using shielded crystal mike cable and 0.1 μf by-pass condensers.

Generally the ART/13 is sold with a 30 wire cable and/or a power supply plug type U-7/U. The remote control head may also be for sale at the same time and this is especially valuable if remote operation from the living quarters of the house to the transmitter in the attic or cellar is desired. There are a few different models of the ART/13, but the following pointers may be applied to all.

Power Supply

Because the ART/13 is an aircraft transmitter, the question of a power supply is extremely important. There are several models that might be adopted for converting the unit to a.c., but we decided that the best procedure would be to separate the 24-28 volt filament circuits from the relay coil circuits and the auto-tune motor channeling-operate the filaments of the tubes from a 26 volt a-c supply and the d-c circuits from a 26-volt source. This reduces rewiring to a bare

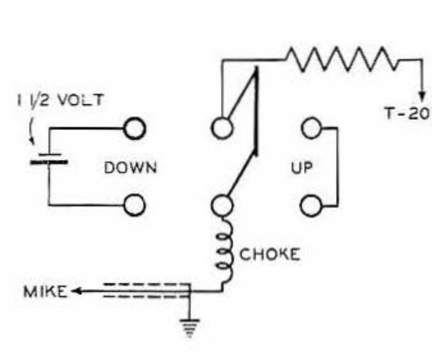


Fig. 1. First modification of the ART/13 is changing the microphone supply to a high level carbon mike by adding a pen-lite battery on the down terminals of the mike switch.

minimum and requires only a low amperage d-c source. The separation is the only obvious solution since it does not appear practical to build a d-c supply capable of delivering 10 amps when the tubes may be operated on a.c. The a-c requirement is 8 amps. Direct current is provided by a 30-volt, 2 amp. transformer, and rectified by two 1-amp. selenium rectifiers operated in parallel. The voltage is filtered by two 100μf 25 w.v. condensers. Other arrangements, equally as good, could be employed, especially certain types of variable voltage battery chargers.

The general power supply in use at W2GQM is shown in *Fig. 2*. The only unconventional arrangement in the power supply is the resistor in series with the center-tap lead of the 1550-volt transformer. It will be noted that the side of the resistor away from the center tap is grounded. The plate current meter is placed across this resistor and actually measures the entire current being drawn from the power supply. This is not usually considered a very desirable feature as the grid currents and screen and modulator currents are also being measured at the same time. This system was employed by the original designers and it was decided to retain it rather than place the meter elsewhere. If the transmitter is tuned in the c-w position, fairly accurate readings may be taken. The exact position of the sliding contact on this resistor must be obtained by experiment and it is suggested that a 25-ohm unit first be tried. The milliammeter is calibrated from 0 to 200 ma, but with the increased plate current from the higher voltages it is necessary to adjust the resistor until the full scale meter reading is actually 400 ma.

Transmitter Conversion to A-C Filaments

The rewiring of the ART/13 to incorporate a-c filament voltages is fairly simple. The first step is to remove the bottom and lower front panels, exposing the autotune mechanisms and the bottom of the transmitter. Remove the screws from the jack mounting strip which is fastened to the lower part of the autotune units *C*, *D*, and *E*. This will allow removal of autotune unit *C*. Unscrew the autotune locking bar on unit *C* and remove it so that the knob and disc may be removed. Unscrewing the locking bar may have to be done with pliers. Remove the knob by unscrewing with one of the special wrenches that are mounted inside the chassis. This knob will not slip off easily and some force must be used. Observe the reading indicated by the knob before removal. If it is not replaced exactly the same way, it will be necessary to experiment after the transmitter is placed in operation, to show what the proper reading of the knob for a given switch setting should be.

Remove the disc behind the knob so that the three screws holding the autotune are accessible. Take out these screws and remove the autotune unit from the chassis. The autotune unit will come loose if pulled forward with a medium amount of pressure. Notice that the coupling between the autotune unit and the switch is composed of a short shaft with a keyed cog on each end. These cogs fit snugly into both the autotune units and switches. When the autotunes are replaced these keyed cogs will automatically align the autotune with the switch. Removal of the autotune *C* allows access to the 1-ohm resistor *R-116* which is shown in *Fig. 3* and is located above and to one side of the motor relay. Remove autotune unit *A* in the same manner. This exposes the speech amplifier power plug which is also shown in the bottom view photo.

Observe that there are three leads connected

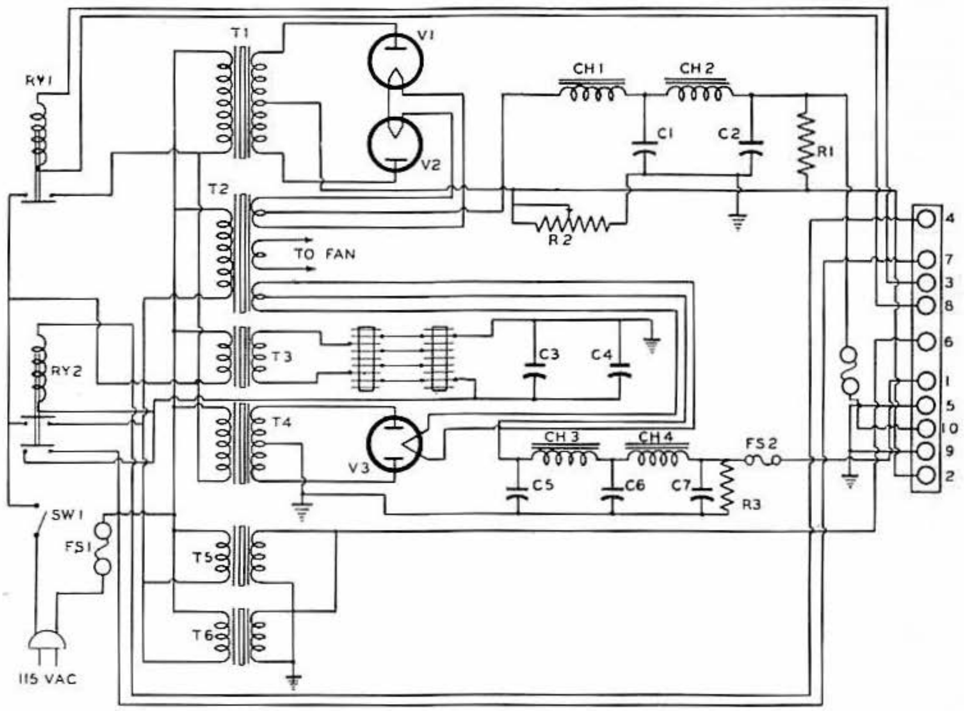


Fig. 2. Circuit diagram of power supply suitable for use with the a-c version of the ART/13.

C1, C2—2 µf, 2000 volt working
C3, C4—100 µf, 25 volt working
C5, C6, C7—8.0 µf at 600 volts working
CH1—300 ma swinging choke
CH2—15 h 300 ma choke
CH3, CH4—15 h 200 ma choke
R1—150,000 ohms, 25 watts
R2—see text
R3—50,000 ohms, 10 watts
FS1—10 amp. fuse
FS2, FS3—500 ma fuse
T1—plate transformer, 3500 volts, c.t.
T2—filament transformer, three 5.0 volt windings at 4.0 amps.
T3—step-down transformer, 30 volt secondary
T4—plate transformer, 600 volts, c.t.
T5, T6—filament transformer, 25 volts at 4.0 amps. each
RY1—relay, plate circuit
RY2—relay, four pole single throw, 26 volt coil
V1, V2—866 rectifiers
V3—5Z3 rectifier
SW1—heavy duty line swing or circuit breaker
Selenium rectifiers, 1 amp. rating each, in parallel

to one side of *R-116* and two leads to the other side. Remove all of them and solder the three leads together and insulate. These leads are on the power side of *R-116*. The other two leads are on the filament side of this resistor and one connects to contact 7 on the speech amplifier power socket while the other runs around through the transmitter and fastens to lug 2 on the oscillator power supply terminal strip.

In our modification, the two leads are fastened one to each side of *R-116*. The lead going to the oscillator is cut where it leaves the bakelite tube mounted at the rear of the transmitter. This wire is then pulled back through the tube and is fastened to the power side of the 0.8 ohm resistor *R-121* which is the filament dropping resistor for these tubes. The other half of the wire is pulled out of the cabling from the oscillator end, run through a hole in the wall, to which control *A* screws, and is fastened to connector 7 on the speech amplifier power plug. Lug 2 on the oscillator power strip connects to the frequency multiplier and the crystal calibrator filaments so the operation just performed connects all these filaments circuits together and to one side of *R-116*. The other side runs to the external power plug connector 6 instead of connector 4. Connector 4 is now used for the d-c relays and channeling motor exclusively.

Conversion to 10 Meters

It is not possible to reach the 10 meter band, using the frequency multipliers in the ART/13. Provision has been made in the transmitter for the addition of a low frequency oscillator if so desired. This arrangement makes it convenient to add a frequency multiplier using another 1625. A chassis may be built around *panel MX-128* to fit very nicely into the space allotted. Without the l-f oscillator the 28-ohm resistor *R-402* is connected across the power input plug and is used to take the place of the 1625 filament drain. This may be removed and the new 1625 doubler filaments connected across the plug. This plug also provides plate and screen voltages, thus greatly simplifying the problem of wiring up the doubler stage for 10 meters. The schematic of the new doubler appears in *Fig. 4*. When completed it is only necessary to plug it in and connect the grid excitation and plate output leads to the appropriate points. No doubler plate tuning condenser is shown in the photo *Fig. 5* as the coil is tuned by its own distributed capacity and rough tuning is accomplished by compressing and expanding the 10 meter tank coil turns.

The 10 meter 813 final tank circuit is mounted on the plate circuit relay *K-105*. In the original design of the ART/13, switching to *low frequency*

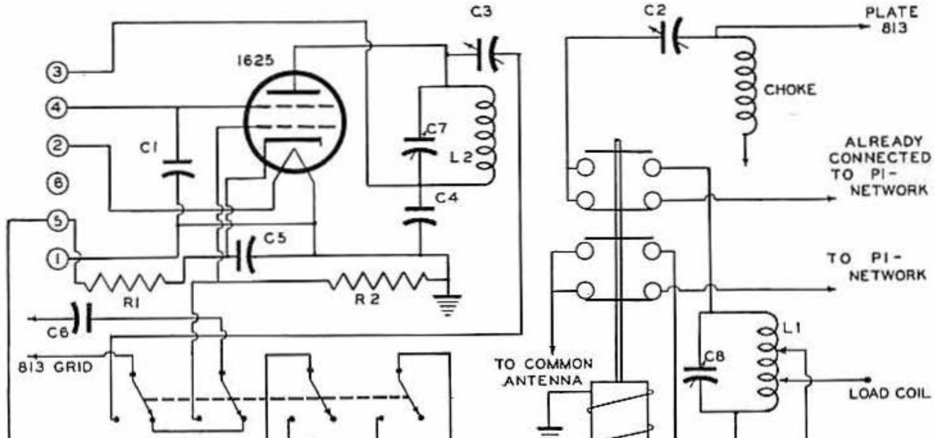


Fig. 4. Circuit diagram of the 10 meter doubler designed for the space occupied by the low frequency oscillator MX-128 before conversion.

C1, C4, C5—.001 μf mica
C2, C6—.002 μf mica
C3—4-40 μμf trimmer
C7—10 or 15 μμf variable
C8—35 μμf variable

R1—1000 ohms 2 watts
R2—100,000 ohms, 1 watt
L1—4 t. No. 10 enamel, 1½" I.D.
L2—4 t. No. 14 enamel, 1½" I.D.

causes this relay to close, which disconnects the antenna coupling system from the 813 plate and transfers it directly to the *load coil* post on the side of the transmitter. External antenna loading is normally used on the low frequencies. Here again, the original low frequency design lends itself readily to 10-meter conversion. The relay contact that provided output for the low frequencies is connected to the *hot* side of the 10 meter tank circuit and the other side is grounded with as short a lead as possible.

The 10 meter tank circuit is composed of a 35 $\mu\mu$f double-spaced condenser and a coil made of No. 10 solid copper wire. It is recommended that the low frequency r-f choke, *L-109*, be removed from the circuit. The .002 μf by-pass condenser *C-128* is then mounted in the same spot, the bottom end of the high frequency r-f choke and the B+ lead connected to one side of it, and the other side grounded. Eliminating the l-f choke and moving the by-pass condenser closer to the high frequency r-f choke shortens the circuit leads and reduces unwanted plate circuit capacities and circulating currents. It also allows the relay contacts, formerly used to short the large choke, to be used for switching the main antenna over to 10 meters. The external load coil is now available for use as a connection for the 10-meter antenna. Simply run a lead from it to the experimentally selected tap on the 10 meter tank coil. This tap is the spot on the coil selected as the one giving the proper loading of the final for the antenna in use.

Although the frequency multiplier unit may be converted to fully automatic 10 meter operation, a much simpler method is shown in *Fig. 4*. This conversion consists of breaking the lead between the 813 grid and its coupling condenser. A four-pole double-throw switch, insulated for r.f., is mounted on the lower rear panel of the transmitter as close to the 813 grid as possible. Connections are then made according to the schematic. When operating on 10 meters, the transmitter controls *A* and *B* are tuned in the normal fashion to one-half the required 10 meter frequency. The setting of controls *C*, *D*, and *E* are otherwise immaterial, although *C* should be placed on a number that closes the internal switch in series with the key.

After throwing the four-pole switch to 10-meter operation the transmitter is turned on. Tune the doubler for maximum 813 grid current with the function switch in "Tune" and the emission switch in the c-w position. Tune the 813 10-meter tank circuit for minimum plate current. The antenna or feeder may then be tapped on for the proper loading, about 180 ma. If the 813 grid current is lower than its value on the other bands, a slightly reduced loading should be used. Remember that the meter indicates the total cathode current to the tube and not the plate current alone. It may be necessary to retune the tank after the feeder is connected, but the antenna system detuning should not be too great, since this is an indication that the antenna system will not resonate.

General Operating Notes

When the emission switch is placed in the m-c-w position, when keyed, the transmitter will be modulated by the built-in audio oscillator. This type of emission is illegal for all but the higher amateur frequencies and the new 11 meter band.

Operators will find that it is very possible to tune the ART/13 on a harmonic of the desired operating frequency. Quite likely this will only happen in the 80 meter and 40 meter bands. However, if the readings of the numbers indicated by dial *C* are in proportion to the output frequency, this will probably never happen. For example, tuning the transmitter up on 80 meters should bring dial *C* somewhere between readings 2 and 6. If a reading around 12 is obtained, the transmitter is tuned on a harmonic. The antenna current readings are not too reliable as the meter is operated by inductive coupling to the antenna lead.

The antenna used at W2GQM for all band operation consists of a 118-foot flat top tapped with a single wire feeder 17 feet from the center. On 75-meter phone, it acts as a single wire feed matched impedance half wave. On 40 and 20 meters it operates as a large T type Marconi, while on 10 meters it is used as matched impedance of seven half waves.

MORE ON ART-13

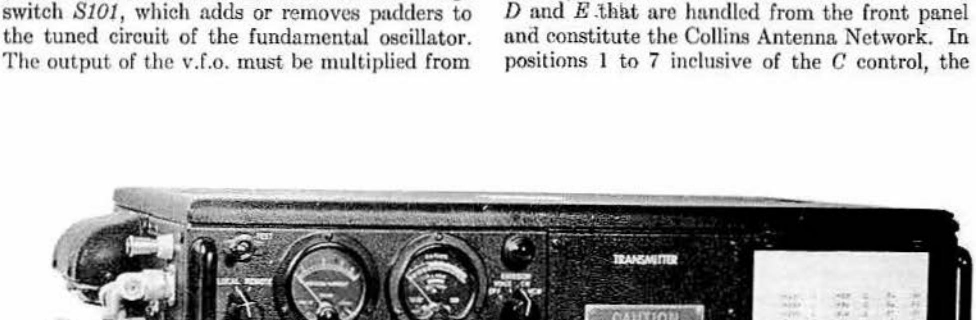
In the November, 1946 issue of CQ, Paul Rafford, W2GQM, described a method of converting the very popular ART/13 transmitter to amateur use. In the light of the experience of these two writers, the *Rafford* method may be simplified by designing a suitable 10-11 meter tank coil and pruning the coils of the master oscillator in such a fashion that the output frequency range extends from 3.4 to 30.6 mc, instead of the original range from 2.0 to 18.1 mc. Although this destroys the frequency calibration as supplied with the ART/13, the transmitter may be easily recalibrated with the aid of a communications receiver and the *CFI* unit built into the ART/13.

Description of the ART/13

The AN/ART/13 or ATC/1 uses an 837 v.f.o. operating between 1000 kc and 1510 kc in two ranges: 1000 to 1200 kc and 1200 to 1510 kc. The band of oscillator frequencies available depends upon the position of the oscillator range switch *S101*, which adds or removes padders to the tuned circuit of the fundamental oscillator. The output of the v.f.o. must be multiplied from two to twelve times to cover the frequency range desired. This is accomplished in two 1625 multiplier stages. The first 1625 operates as a doubler, tripler, or quadrupler; the second 1625 operates only as a tripler. The first multiplier is controlled by switch *S102;* the second by switch *S103*. The positions of *S101*, *S102*, and *S103* are governed by the *A* control on the front panel.

The inductance *L101* in the v.f.o. and the two inductances in the multipliers, *L105* and *L106*, are slug-tuned. The slugs are ganged for simultaneous fine frequency adjustment and are controlled by dial *B* on the front panel.

An 813 is used in the final amplifier and functions at all frequencies as a straight amplifier. From positions 1 to 6 inclusive (2.0 to 6.0 mc) on the *A* control, the output of the first 1625 multiplier is connected to the grid of the 813. In position 7 to 12 (6.0 to 18.1 mc) of the *A* control, the output of the first multiplier drives the second multiplier which in turn feeds the 813 final. The output circuit of the 813 consists of controls *C*, *D* and *E* that are handled from the front panel and constitute the Collins Antenna Network. In positions 1 to 7 inclusive of the *C* control, the



The Collins Autotune AN/ART/13. This model, after conversion, has two additional controls, the high frequency tank condenser dial and the variable antenna link control, located just above the nameplate.

antenna tuning circuit functions as an L network. From positions 8 to 12 the antenna is loaded by a pi-network, while in position 13 the tuner again becomes an L network, but with a small inductor *L114* in shunt with the variometer controlled by *D*.

Converting to Amateur Operation

Since the frequency range below 3.5 mc is just so much waste in the ART/13, it was decided to prune the coils in the oscillator to permit 10-meter operation without the addition of another doubler stage as suggested by Rafford. In order to make the coil changes it is necessary to remove the right side wrap-around panel of the transmitter case. This is accomplished by taking out seven screws in the rear and ten screws at the side of the case. This exposes an aluminum shield that covers the housing of the h-f oscillator coil. This must also be removed. When this is done the multiplier inductances *L105* and *L106* and the oscillator inductance *L101* are exposed to view.

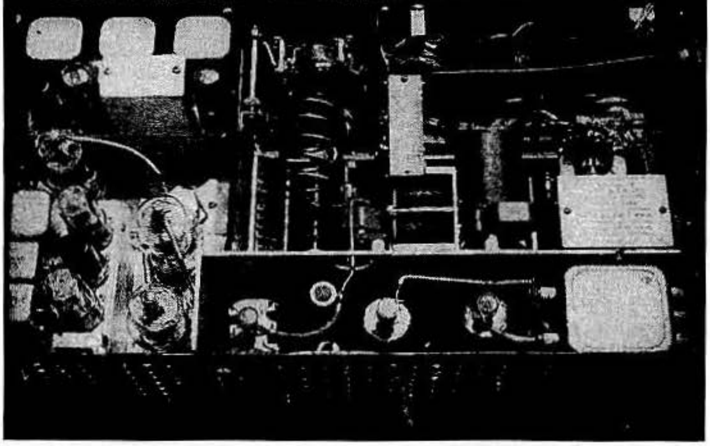
It will be noted that all three coils are wound with a few turns close-wound at one end, a section of widely spaced turns followed by a long section of close-wound turns. The reason for this unconventional method of winding is to obtain a nearly straight-line-frequency calibration for the *B* control. The terminal at the end of the long section of the winding is the cold r-f end. Approximately 40 per cent of the winding is removed from each coil, beginning at the cold r-f terminal.

The oscillator coil *L101* has originally 47 turns and 28 are removed. The first multiplier coil ***L105*** has 28 turns originally, of which 16 are removed. The second multiplier coil *L106* has 9 turns and 5 are removed. These turns may be carefully removed without disturbing the coil forms. It is neither necessary nor advisable to remove the complete coils in order to make the changes. When the correct number of turns have been removed, re-solder the end to the terminal lug.

In extending the frequency range of the transmitter, it is necessary to substitute another tank circuit for the 813 when operating the 10-meter band. Position 13 could not be used for this purpose since a cam-operated switch on the shaft of the *A* control disables the oscillator and the multiplier stages by opening their respective cathode resistor connections. However, it is possible to retain completely automatic 10-meter operation by re-positioning the cam and the connections of the two jumpers on switch *S114*. When this is done the oscillator and the multipliers follow through normally and at the same time the relay *K105* functions to substitute the h-f tank circuit for the Collins network.

In order to make these changes it will be necessary to remove the frequency multiplier unit from the assembly. The following procedure is recommended:

1. Remove tubes and remove the autotune cover plate and bottom plate.
2. Remove autotune unit *A*. This is done by turning the dial locking bar to the unlocked position and unloosening the two No. 10 Bristol set screws in the dial. Then turn the dial and locking bar counterclockwise together until the bar comes free. Remove the dial and locking bar, then remove the dial back plate by loosening the two long screws on the top end of the unit and the short screws on the bottom end of the unit.
3. Lift the autotune unit out, being very careful not to move any of the mechanisms from



Top view of the ART/13 showing placement of parts for the high frequency tank.

the time the unit is loosened until it is again securely in place.

4. Remove the screws holding the seeking switch *S109* to the casting and swing out the switch.
5. Remove the wires leading to the multiplier coils at the rear of the h-f oscillator unit. Remove the buss wire connected to the coupling condenser *C116*.
6. Remove the two screws just behind the second multiplier clamp shell and the two screws just in front of the multiplier clamp shell. This multiplier may now be pulled out sufficiently to remove the nut holding the ground wire lug on the fire-wall assembly. Remove the cable connector *J115* from *P101* in the multiplier unit. The multiplier unit may now be lifted out of the transmitter completely.

It is now possible to move the cam that actuates switch *S114* from its normal position of closing the switch on position 13 to its new position of closing on 12. By reference to the wiring diagram it will be seen that *R130* and *R131* must be kept in the circuit. This is done by placing jumpers across the controlling contacts of *S114*. With these changes completed, the multiplier unit may now be re-installed.

The relay *K105* may be operated manually by a SPST switch shown in *Fig. 1*. With the SPST switch closed, all 11 channels may be set for automatic operation 11 and 10 – or a combination, with the low frequencies available by opening the SPST switch may be set up.

High Frequency Tank Circuit

The next step is to install the new tank coil circuit for the 813 final amplifier. The unit is a conventional one and with the *Bud JC-1540* tuning condenser it will adequately cover the 10 and 11-meter bands. The following procedure is recommended for this installation.

1. Remove all tubes, the leads from *C118*, and finally *C118* itself.
2. Cut the four connections at the terminals of *L109*. Remove the two *L109* tinned wires that connect to relay *K105*. Remove *L109* and install a one-inch standoff insulator in the *L109* mounting hole.
3. Put solder lugs on the heavy insulated wire that carries the B+ and on the No. 10 tinned wire that carries the B+ to the 813. Place lugs under screw at the standoff.
4. Remove the tinned wire between the *Loading Coil* binding post and *K105*. The standoff insulator supporting this wire can be used in step *2* above. The terminal on *K105* will be used for the plate circuit of the 10-meter tank.

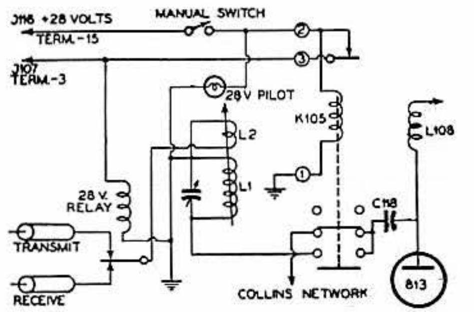


Fig. 1. Circuit of 10-meter tank circuit and method of wiring into transmitter. The variable condenser across *L1* is single section, 50 $\mu\mu$f, Bud JC-1540 or equivalent. *L1* is 5 turns of 1/8" copper tubing 1 1/2" i.d. *L2* is 2 turns of No. 10 wire.

5. Remove the wire from the *Condenser* binding post to the vacuum keying relay. It is necessary to be extremely careful with the keying relay leads as they require a small Bristol wrench.
6. Remove the solder lug from the *Receiver* binding post and solder it to the *Condenser* binding post. The two binding posts on the ceramic bowl now serve as transmit and receive antenna connections for all low frequency positions.
7. Remove the *Receiver* and *Load Coil* binding posts and install two coax feed-thru connectors. These will serve as transmit and receive antenna connections for all h-f positions.
8. Remove the *Low Frequency* front panel and install the 28-volt antenna changeover relay, 10-meter coil and condenser unit. See *Fig. 2* for the suggested positioning.
9. If manual operation is to be used, it will be necessary to install a SPST switch and pilot light and remove and tape the end of wire from terminal *2* of the *K105* holding coil. Replace panel and complete wiring. Substitute a +28 volt lead from terminal #15 *J116* to terminal 2 on *K105*, as shown in *Fig. 1.*

Oscillator Recalibration

After the wiring changes have been made it is necessary to replace the shield cover, the wrap-around cover and the tubes. The condensers for tuning the multiplier stages are accessible from the bottom of the transmitter. To check for oscillation, remove the high voltage fuse and apply the filament voltage. Set *A* control to position one and the *B* control to midscale. With the power level switch at *Tune* and the emission switch at *CW* apply the low voltage to the oscillator. Check for output by touching a neon lamp to the plate of the oscillator and the first multiplier. The second multiplier is checked by switching the *A* control to position seven and then touching the neon lamp to the second multiplier plate.

If the appropriate changes have been made in *L101*, the frequency range in position one of the *A* control should be approximately 1700 to 2100 kc. On position two of the *A* control the oscillator frequency range will be from 2000 to 2600 kc. We may now make a coarse calibration of the 1700 to 2100-kc range of the oscillator. First, tune a communications receiver to 1700 kc. Set the *A* control to position 1, the emission selector to *CW* and the power level switch to *Calibrate*.

When the low voltage is applied, somewhere between divisions 500 and 700 on the *B* control a signal should be heard in the receiver. The 1700-kc point on the *B* dial should be tabulated. Tune the communications receiver successively to 1800, 1900, 2000 and 2100 kc and at each spot frequency tabulate the setting of *B* when the transmitter signal is picked up. The 2100-kc position should be at approximately 1900 on the *B* control.

The same coarse check can now be made for the 2000 to 2600-kc oscillator range, except that the *A* control is now at position 2.

It is now possible to begin calibration of the *B* control. First set *A* to position 1 and set *B* to the approximate setting for 1700 kc. Plug a pair of headphones into the *Sidetone* jack and adjust the sidetone gain control for maximum signal in the headset. Rotate *B* control slowly for zero beat with the output of the 50-kc oscillator CFI-8Q. This zero beat point is now the correct 1700-kc calibration. The reading, however, should be very close to the approximate setting as determined in the coarse calibration. It is necessary to emphasize here that in addition to the 50-kc beat from the CFI unit there will also be a 25 and a 12.5-kc beat, which are much weaker, Therefore it is of utmost importance that the strongest beat be tuned and that the *B* control reading correspond fairly closely to the coarse readings. Once this primary point has been found, the *B* control is slowly rotated, zero-beating at every 50-kc point and carefully tabulating the control markings for each 50 kc in range.

The same procedure is followed in calibrating the 2000 to-2600-kc range, except the *A* control is moved to position 2. An actual calibration of a converted AN/ART/13 is shown in *Fig. 3*. This should be of assistance where the wiring and coil modifications have been followed as indicated in this article.

Adjusting the Multipliers

Peaking the multiplier circuits for operation in the amateur bands is accomplished by the adjustment of multiplier padder condensers, *C111* and *C115*. *C111* consists of six adjustable ceramic padder condensers associated with the first multiplier stage. *C115* consists of another six ceramic condensers, but associated with the second multi-

"A" CONT-ROL	OSCILLATOR FUNDAMENTAL (KC)	FIRST MULTIPLIER	SECOND MULTIPLIER	FINAL OUTPUT FREQ (MC)
1	1700-2050	DOUBLER		3.4 to 4.1
2	2050-2550	DOUBLER		4.1 to 5.1
3	1700-2050	TRIPLER		5.1 to 6.1
4	2050-2550	TRIPLER		6.1 to 7.6
5	1700-2050	QUADRUPLER		6.8 to 8.0
6	2050-2550	QUADRUPLER		8.0 to 10.2
7	1700-2050	DOUBLER	TRIPLER	10.2 to 12.3
8	2050-2550	DOUBLER	TRIPLER	12.3 to 15.3
9	1700-2050	TRIPLER	TRIPLER	15.3 to 18.4
10	2050-2550	TRIPLER	TRIPLER	18.4 to 22.8
11	1700-2050	QUADRUPLER	TRIPLER	20.4 to 24.0
12	2050-2550	QUADRUPLER	TRIPLER	24.0 to 30.6
13	Not used	Not used	Not used	

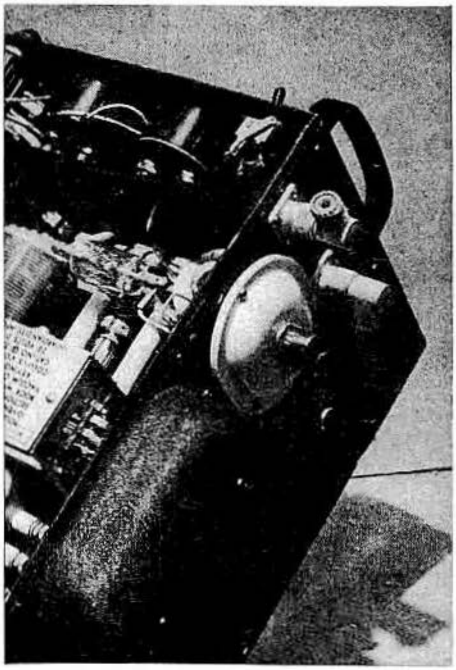
Fig. 2. Frequency range for the various positions of the "A" control on a converted Collins Autotune transmitter, showing fundamental oscillator range, multiplier function and final output frequency.

plier stage. With the transmitter placed bottom end up and the panel facing you, the first bank of condensers visible is the *C111* group. They are designated by letters from *A* to *F* and correspond to steps 1 to 6 on control *A*. The second band of condensers is the *C115* group, which, from left to right, are designated *A* to *F* inclusive and correspond to steps 7 to 12 on control *A*.

The multiplier stages are peaked in the following steps.

1. Set *A* to position 1 and *B* to the center of the 80-meter band.
2. Apply low voltage supply, place power level switch in the *Tune* position and the emission switch on *CW*.
3. Place the meter selector switch in the *Grid* position.
4. Use an insulated screwdriver and slowly rotate the small metal lip that protrudes from capacitor *C111A* and adjust for maximum grid reading.
5. Rotate *A* control to position 2, the 2 peak *C111B* for maximum grid reading. Repeat this for steps 1 to 6 on the *A* control, peaking the proper *C111* padder in each case.
6. Set the *A* control on position 7 and peak *C115A* for maximum grid reading. Repeat this procedure on position 8 and for *C115B* and each position to 12, peaking the proper *C115* padder as before.

To make fine adjustments for each band it is necessary on 40 meters to set the *A* control to position 4 and *B* to the center of the band. Then re-adjust *C111D* for maximum grid reading. For the 20-meter band set *A* to position 8 and *B* again to the center of the band. Then re-adjust *C115B* for maximum grid reading. Recheck ad-



End view, showing low frequency and high frequency antenna connections.

justment *C111B* for maximum grid reading.

On the 15-meter band, set *A* to position 11 and *B* to the approximate center of this band. Adjust *C115E* for maximum and then recheck *C111E* also for maximum grid current. In the 10-meter or 11-meter band set control *A* to position 12 and *B* to a frequency that will multiply to about 28.5 mc (2375 kc for example). Adjust *C115F* for maximum and then recheck *C111F*. It may be necessary to check the frequency with an absorption wavemeter, since the range of *C115F* is sufficient to make the second multiplier operate as a doubler in place of the usual tripler—its normal function.

After-Thoughts

The audio response of the ART/13 may be improved by the removal of *C205* (.001 μf) in the speech amplifier. This will raise the high frequency response about 2 db at 6000 cycles. By substituting a .03 μf for *C202* (20μf) the response will be substantially flat to about 10,000 cycles. *C205* need not be removed from the unit, since it is only necessary to clip off the lead on the plate side. Similarly, *C202* need not be removed from the unit.

Certain models of the ART/13 require an improved grounding of the 813 to prevent parasitic oscillation. This is accomplished by removing the 813 and the panel cover over the tube socket. It will be noted that three socket contacts are joined by a jumper and are soldered together. To connect these to the chassis ground, solder another short length of wire to them and tie the the free end under the hexagonal support post. Remove the bottom post screw, clean away paint and re-install.

There is some confusion about the various readings of the *Plate* meter. In the position labeled *Battery Voltage* the meter reads 54 volts full scale. In the *P. A. Grid* position it reads 17 ma full scale. In the *P. A. Plate* position it reads 300 ma. In the latter position each major division on the arbitrary scale is equal to 30 ma. The current reading here is taken by reading the voltage drop across a 13.4-ohm resistor. In the second position a voltage drop across *R111* of 235 ohms is read. Half scale in this position corresponds to 8.5 ma. Tuning readings of the final plate current should always be taken in the *CW* position. If the plate current readings are taken in the *Voice* position they will include the static modulator current of about 40 ma.

THE ART-13 ON SSB

The Collins Auto-tune aircraft transmitter, known more generally as the ART-13, has proven to be one of the better pieces of surplus radio gear. Like hundreds of hams, I was fortunate enough to lay my hands on one of these beauties and for the past several years I have thoroughly enjoyed using it on 80, 40, and 20 meters. As most all owners of the ART-13 already know, they pack a respectable wallop on both AM and CW and with a slight modification of the speech amplifier to permit the use of a crystal mike, the quality and punch is second to none.

Despite the fact that I had been enjoying all the contacts I could handle on both AM and CW, I nevertheless began listening to the guys on the high end of 80 with their "Duck Quacking" and was envious of the fact that they seemed to be having a regular ball for themselves. At first I was "agin" it, since I did not have the equipment and it looked like an expensive proposition. About that time a few of my friends began to give me the needle with such quips as, "You're behind the times," "It's the coming thing," etc., etc. It worked; I knew I had to get on SSB and now I had to figure *how*. I read all the ads and looked over all the available equipment on the market. An ad by *Barker & Williamson* describing their new *51SB Single Side Band Generator* struck a happy note since it appeared it could be used successfully with the good old ART-13. A short talk with the *B&W* engineers developed that the *51SB* was a natural for use with the ART-13. Here we already had a good stable VFO, frequency multipliers, and an ideal final tube. The job of converting appeared to be relatively simple.

After ten minutes of studying the circuit diagram of the ART-13 and taking a quick look at the actual location of the parts and space involved, it was clear that the conversion was going to be easy. Actually, the entire conversion required slightly less than three hours, not counting the time spent dressing up the works with a few decals. As a matter of fact, I was truthfully surprised at the ease with which this conversion was made and even more surprised with the marvelous reports and unexpected increase in power. The pictures of both front and rear of the ART-13 are pretty much self-explanatory, but for the hundreds of owners of ART-13's who might want to get on SSB the easy way here is how it's done.

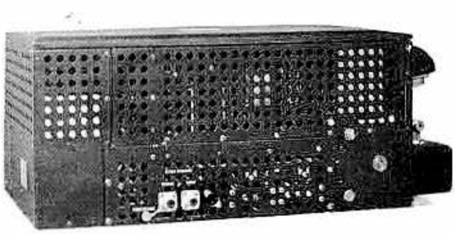
The 51SB plus eight small parts did the entire job. Required are: two *Amphenol* #83-1R fittings, two *Amphenol* #83-1SP fittings, one small 15 μμfd. 600 volt ceramic condenser, one 8-50 ceramic trimmer condenser, one *Jones* plug and thirty six inches of RG-65U. Since you will want to retain the AM-CW properties of the transmitter you will also need one DPDT toggle switch. This toggle switch is installed in the center of the blank panel which is used to replace the low frequency oscillator. The result is that with one switch on the 51SB and the newly installed AM-SSB switch on the transmitter we accomplish the change-over from SSB to AM or vice versa.

Figure 1 is the original circuit diagram of the grid and grid metering system. The resistor shown in dotted lines will be found in some models of the ART-13, while in others the circuit will be exactly as shown in hard lines. This is one of the few differences in the several models of the ART-13 which were produced for the Armed Services, but it has nothing whatever to do with our conversion. It has been shown merely to eliminate possible questions later on. Should your transmitter have such a resistor leave it alone. If it doesn't, just forget we even mentioned it.

Do It Yourself

Figure 2 is the circuit diagram of the entire modification. That is all there is to it. The toggle switch shown in this diagram is the one which we installed on the front panel as mentioned above. This could just as well be located on the rear apron if you are reluctant to alter the appearance of the front panel. A few decals will make the switch look very much a part of the panel layout.

Now, with the transmitter upside down on the bench and with the bottom cover removed, you will find the grid choke *L107* staring you in the face. It is mounted on a small terminal



Rear view of complete conversion

board which is bolted to the 813 socket. Don't remove any parts, merely snip the short piece of wire that runs from the grid choke to the coupling condenser *C116* in the multiplier stage. The next move is to mount the two *Amphenol* 83-1R fittings on the rear apron immediately adjacent to the 813 socket. The vent holes in the rear apron are just the right size for the screw in a *Greenlee* punch, so drilling is confined to the four small holes for the mounting screws in each fitting. We used the second row of holes up from the bottom since this placed the fittings in a position which gave us the very shortest possible leads.

Next, install the 8-50 trimmer in another of the vent holes right next to the appropriate coax fitting. Here again no drilling was necessary since the hole was just the right size for the twenty five cent variety trimmer which we used. Connecting the two coax fittings and the two small condensers as shown in *Fig. 2* is now a simple procedure.

Decisions, Decisions!

At this point you have to decide where the toggle switch will be mounted. Whether it is placed on the front panel or on the rear apron makes little difference since very low voltages

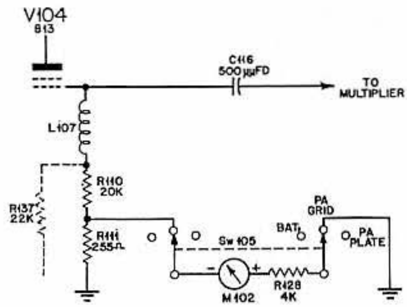
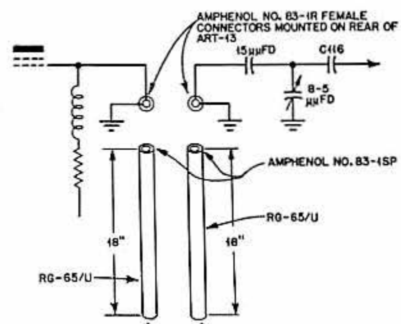


Fig. 1. Original grid diagram

are involved. Turn the transmitter right side up and alter the metering circuit as shown in *Figure 2*. This involves lifting the end of the grid metering resistor *R111* which is now grounded and also lifting from ground the corresponding terminal on the meter switch in the ART-13. Connect the newly installed AM-SSB toggle switch as shown. Note that it performs three functions: In the SSB position it applies the external bias to the grid of the 813 and at the same time shorts out the original bias resistor *R110*. In the AM position it returns the grid circuit to its original condition. Incidentally, it is necessary to short the original grid bias resistor for SSB operation in order to prevent the grid varying should you drive into the grid region under modulation peaks. The last step in converting our ART-13 is the installation of the *Jones* plug through which the bias voltage will be carried. Here again the job of drilling is at a minimum since the vent holes fit the two terminal *Jones* plugs very nicely.

In order to permit side by side installation of the 51SB and our ART-13 it was necessary to lengthen the RG-65U leads. Those which came with the 51SB were too short so we made up two new pieces each 18 inches long. We were concerned about this at first but found that adjustment of the 8-50 trimmer



Make up of new RF connector leads

installed on the rear apron made up very nicely for any difference that may have existed between our new longer leads and those supplied by *B&W*. It was also necessary to lengthen the control lead which comes from the front of the 51SB. Their original shielded lead would not quite reach the key jack on the transmitter so we merely replaced this lead with a piece of lamp cord and it worked just fine. Of course, shielded wire would be more proper, but none was handy.

Tune It

Tune up procedure is a very easy matter once the conversion and installation is completed. The instruction manual supplied with the 51SB is very explicit and should be studied carefully before any voltage is applied to either it or the transmitter. Most owners of ART-13s

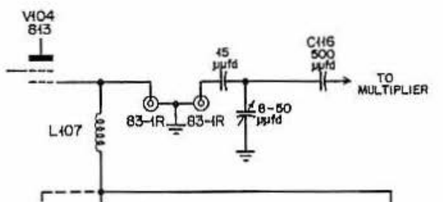


Fig. 2. Entire conversion for SSB

already know the tuning procedure for the transmitter, but for the record here's how we did it. The emission switch on the ART-13 was set on *CW*, the Tune-Operate switch set on *Tune* and our newly installed SSB-AM switch set on *AM*. The Balance-Unbalance switch on the 51-SB was set on *Unbalance*, the meter function switch was set on *Output* and the Band Selector of course set to the band on which we were tuning up. By the way, let me urge you to start out on 20 meters since it was my experience that once the trimming etc., was done on this band no further adjustments were necessary.

With all controls set in this manner and the filaments properly heated throw the high voltage on and dip the final amplifier. Then check the grid drive, making sure it is peaked by tuning both the *Driver* and *Balanced Modulator* tuning controls on the 51SB. At this point things will be running smoothly and you can now repeak the 8-50 trimmer installed on the rear of the transmitter for maximum grid drive. Also, it is now a good idea to repeak the output trimmer in the 51SB. This is identified by *B&W* as *C122* and is located on the r-f chassis near *V103*. When adjusting this trimmer for maximum grid drive be sure to rock the *Driver Tuning* control so that you will be sure of getting maximum output from your 51SB. You can always reduce the grid drive later on by backing off slightly on the *Driver Tuning* control. As a matter of fact, this will more than likely be necessary when operating on 80 meters and is a very nice feature not available with the ART-13 in its original state.

Assuming the transmitter is now tuned up and working nicely in the *AM* position, it is now time to adjust it for SSB operation. After turning off the high voltage, set the newly installed switch on the ART-13 to *SSB*. Push the Balance-Unbalance switch on the 51-SB to *Balance* and turn on the high voltage. It is assumed you will have connected bias voltage to the new Jones plug and it is suggested that you start with about 90 volts. Note the idling current on the plate meter of the transmitter and adjust the bias voltage to provide a resting plate current of between 35 to 40 ma. In my case, I run 1600 volts to the final tube and the bias is set to provide a resting current of exactly 40 ma. which seems to be just about optimum. Once this bias adjustment has been accomplished it is time to balance out the carrier in accordance with instructions given in the 51SB manual.

Up to this point you have adjusted your ART-13 in the usual fashion in the *CW* position, loaded to approximately 100 to 120 ma. Now comes the nice part, you can now throw your two switches back to the "carrier" or *AM* position and, leaving the Emission switch in the *CW* position, load on up to at least 190 or 200 ma. Don't for heavens' sake, leave it in that position too long with carrier, but once it is tuned to that amount of current you are all set to "knock em dead" with SSB. The 813 easily handles this kind of current on SSB and the quality of the signal will bring very flattering reports. You will find that under normal SSB operation the plate meter will appear to kick up to only about 150 ma. but this is only because the meter is damped and does not actually record the instantaneously reached peaks.

When returning to AM or CW operation it is obviously necessary that you either retune because of the excessive plate current or use another channel. The nice part of the ART-13 is having those other channels to use as well as the fact that we now can go from SSB to AM by merely flicking two toggle switches. Incidentally, it is neither necessary nor desirable to disconnect the 51SB when going back to either AM or CW. It gives you a perfect control of your grid drive and improves the entire operation. Personally, I am delighted with the performance of my newly improved ART-13.

THE BC-375E

THE RADIO AMATEUR purchasing the BC-375E or the BC-191F quickly realizes that he has a transmitter strictly not of "modern design." Those adventurous souls who have put them on the air "as is" using either a dynamotor or power pack, should have received the familiar pink ticket in short order. To balance the inherent weaknesses of design, according to present day standards, is the low initial purchase price, the solid construction and the clean-cut physical appearance.

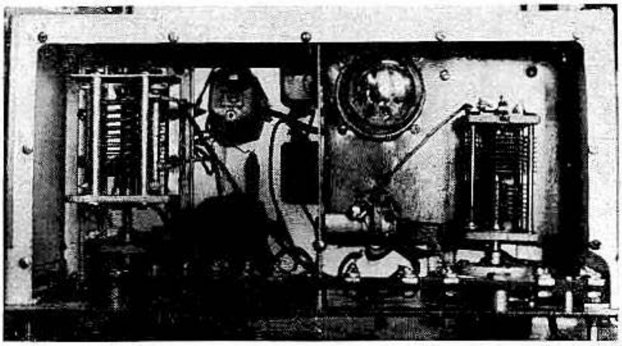
Naturally, the cost can be partially recovered by stripping the entire unit for component parts. A somewhat better idea, I have found, is to rewire the circuits, using as many of the original components as possible, while adding a little more surplus material. Specifically, I have removed most of the original circuitry, built and wired a low-voltage power supply into and behind the tube compartment, while re-designing each of the tuning drawers to cover one amateur band. The drawers are individual transmitters, consisting of the surplus tube combinations, 6L6 oscillator/ amplifier and 826 final amplifier. With minor changes the antenna loading and tuning unit remains completely useful.

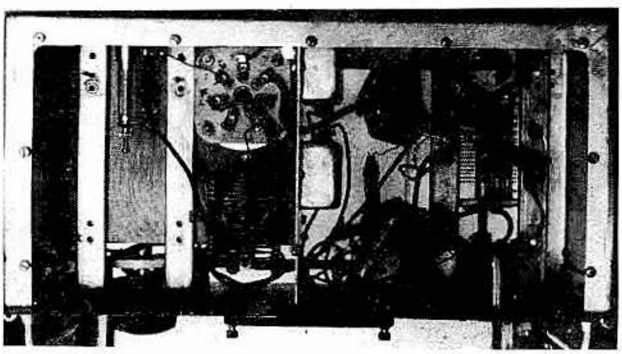
The Partial Dismantling

The second realization about these transmitters came when we found it necessary to use brute force with cold chisel and hacksaw to remove some of the well-anchored parts. However, this is not as bad as it sounds and with a little care exercised here and there, most of the parts can be used again.

First step is take off the back panel, slip out the tuning drawer, and remove all the wiring in the main body of the transmitter associated with the original circuit. Leave the wiring in the antenna tuning and loading compartment, although the antenna relay must be removed and the circuit slightly altered, as shown in the lower right corner of *Fig. 1*. For the sake of appearances, it might be best not to remove any of the controls from the front panel. Switches and meters will be used.

Dismantle the drawers, one for each band, by taking off the top and bottom plates and stripping out all the original wiring. Leave in each drawer the variable condenser marked "B." Remove the switch labelled "Ant. Coupling Switch D." The hole that this will leave in the panel serves as a spot to reach the neutralizing condenser with a long shank screwdriver.





Above: Top view of the 20-meter drawer. The base mounting brackets of the dual 100-$\mu\mu$f condenser determine the level of the copper sheet holding the 826 and plug-in coil sockets. Plug-in coils are used.

Left: Bottom view of the 20-meter drawer. The Millen neutralizing condenser can be seen in the lower right corner. It is directly opposite the hole in the panel left by removing switch "D". The 6L6 plate coil is taken from a GF-12 transmitter. The bathtub condensers are part of the key click filter.

Reconstruction

The low voltage plate supply for the 6L6 may be conveniently built into the vacated tube compartment of the transmitter frame. Any of the usual power supplies will do if they provide 300 volts at about 100-150 ma. The schematic in *Fig. 1* uses some old junk box parts and is shown merely to designate the socket connections to be made to the drawers and the power supply switching arrangements. The a-c line is well-filtered with inductances and condensers obtained from the surplus market. The high voltage supply for the final amplifier should be external. It is brought into the transmitter through a heavy-duty coax cable and the four-prong socket at the back.

A 45-volt battery is used for fixed bias on the 826 final amplifier. This may be mounted in the transmitter. It is connected between *pins 2* and *3* with the plus side going to *pin 2*. A connection from *pin 1* is brought out to a coax connector on the front panel. This provides a means of coupling the output of a v.f.o. directly into the grid of the 6L6.

In the antenna compartment, the inductance switch "P" is removed and a tuning condenser *C11* is mounted in its place. This condenser may be switched into the "counterpoise" side of the antenna tuner by switch *SW3*. The original antenna current meter will probably read too low, and to obtain more sensitivity it may be substituted with a meter from a GF 12 surplus unit. It will look approximately the same and with a little filing will fit the hole. The antenna inductance "M" is connected as shown in *Fig. 1* and is used for harmonic suppression. Tests show that it will easily improve harmonic attenuation appreciably.

Except for coil size, all drawers were constructed alike. The surplus twin-variable condenser, *C8*, should have mounting brackets. These will determine the level of the plywood backed copper sheet which is used for the mounting of the 826 tube

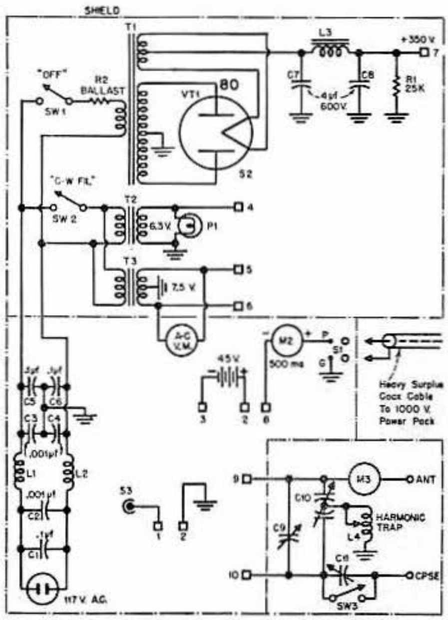


Fig. 1. The 375E after conversion. The 6L6 low voltage supply is mounted in the vacated tube compartment. The rewired antenna tuning and loading section is shown in the lower right-hand corner.

C1, C5, C6—0.1 µf, 400 v.
C2, C3, C4—.001 µf, mica.
C7, C8—4.0 µf, 600 v.
C9—in original circuit.
C10—dual 15 µµf, variable.
C11—in original circuit.
R1—25K, 10 w.
L1, L2—surplus inductances.
L3—surplus filter choke.
L4—rotary inductance in the original circuit.
T1—surplus power transformer.
T2—fil. trans., 6.3 v. T3—fil. trans., 7.5 v.

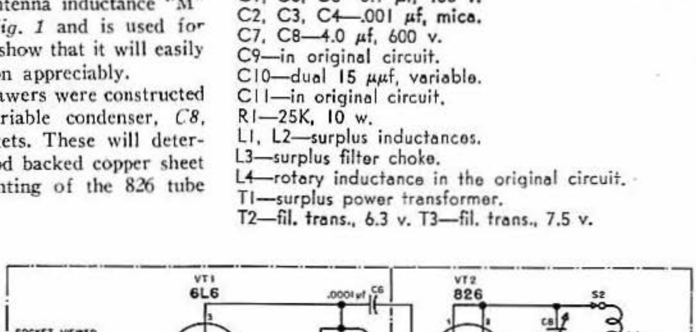


Fig. 2. Wiring schematic of the drawers for use with the converted 375E. Each drawer contains a separate transmitter.

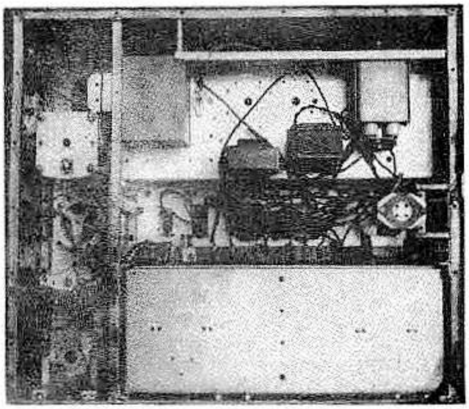
C1—0.5 µf, 600 v.
C2, C3, C4—.01 µf, mica.
C5—in original circuit.
C6—.0001 µf, mica.
C7—Millen 15001.
C8—dual 100 µµf, variable.
R1—100 ohms, 1 w.
R2—100K, 1/2 w.
R3—50K, 10 w.
R4—25K, 10 w.
R5—600 ohms, 10 w.
L2—2.5 mh.
L3—1.0 mh, in original circuit.
P1—60 ma pilot bulb.
L1—80 meters—26 turns on surplus form.
40 meters—17 turns on surplus form.
20 meters—11 turns on surplus form.

L4—80 meters—JVL 80.
40 meters—JVL 40.
20 meters—JVL 20.

socket and the plug-in coil socket. The octal socket for the 6L6 is mounted on the other side of the center shield and is supported by a bracket.

Wiring of the drawers is shown in *Fig. 2*. On 80 and 40 meters, the 6L6-826 combination works straight through, while on 20 meters, the 6L6 is used as a doubler from 40 meters. On 10 meters, a 14-mc crystal or v-f-o input is used with the 6L6 again doubling.

The 60-ma pilot light assembly, *P1*, in series with the crystal is mounted on the front panel of the drawer to the right of the tuning wheel "B." Directly underneath the tuning wheel is a ceramic octal socket. This is used to plug in crystals, or if v-f-o operation is desired an old octal male socket with *pins 3* and *4* shorted together is inserted,



Rear view of the converted 375E transmitter frame. All of the original wiring has been removed, except some of that in the antenna tuning and loading compartment at the left. The four prong socket is used to feed the external high voltage power supply into the transmitter.

thus coupling the grid of the 6L6 to the coax connector on the front panel of the transmitter frame. Underneath the ceramic socket is a phone jack for inserting the keying plug. The key click filter is mounted on the center shield wall. It will be found very convenient to have a grid current indication for the 826. This is provided by the 150-ma meter mounted on the panel of each drawer. This meter is in the circuit at all times.

Tuning up is straighforward and orthodox. The 826 is neutralized by adjusting *C7*, which is a Millen 15001. Together with the plug-in coils, these parts are the only ones purchased new. All others either came from the original transmitter, or are commonly available on the surplus market.

BC-459 VFO

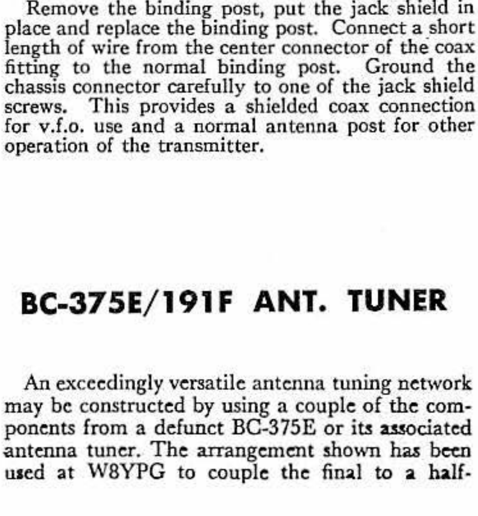
Owners of the BC-459 and similar series of transmitters may desire to use them both as v-f-o units and as complete transmitters for portable operation.

Without any change in the antenna tuning system, both coax and standard binding post connections may be made available if a JS-1 jack shield is placed around the antenna post, with a coax chassis-cable connector mounted in the side of the jack shield.

Remove the binding post, put the jack shield in place and replace the binding post. Connect a short length of wire from the center connector of the coax fitting to the normal binding post. Ground the chassis connector carefully to one of the jack shield screws. This provides a shielded coax connection for v.f.o. use and a normal antenna post for other operation of the transmitter.

BC-375E/191F ANT. TUNER

An exceedingly versatile antenna tuning network may be constructed by using a couple of the components from a defunct BC-375E or its associated antenna tuner. The arrangement shown has been used at W8YPG to couple the final to a half-



wave center fed antenna using 600-ohm feeders. The antenna has been used on 80, 40 and 20 meters with equally good results and can handle 250 watts with ease. There are no coils to change and by varying the L/C ratio the tuner will load up a piece of wire and possibly even the kitchen sink!

SURPLUS CRYSTALS

Below is a complete listing and relationship of the many different types of available surplus crystals.

A-54th harmonic
B-72nd harmonic

Channel	Harmonic	Channel —Mc.	Fundamental Frequency	Progressive Difference in Kcs.
0	A	20.0	370.370	
1	A	20.1	372.222	1.852
2	A	20.2	374.074	1.852
270	B	27.0	375.000	.926
3	A	20.3	375.925	.925
271	B	27.1	376.388	.463
4	A	20.4	377.777	1.389
272	B	27.2	377.777	0
273	B	27.3	379.166	1.389
5	A	20.5	379.629	.463
274	B	27.4	380.555	.926
6	A	20.6	381.481	.926
275	B	27.5	381.944	.463
7	A	20.7	383.333	1.389
276	B	27.6	383.333	0
277	B	27.7	384.722	1.389
8	A	20.8	385.185	.463
278	B	27.8	386.111	.926
9	A	20.9	387.037	.926
279	B	27.9	387.500	.463
10	A	21.0	388.888	1.388
280	B	28.0	388.888	0
281	B	28.1	390.277	1.389
11	A	21.1	390.740	.463
282	B	28.2	391.666	.926
12	A	21.2	392.592	.926
283	B	28.3	393.055	.463
13	A	21.3	394.444	1.389
284	B	28.4	394.444	0
285	B	28.5	395.833	1.389
14	A	21.4	396.296	.463
286	B	28.6	397.222	.926
15	A	21.5	398.148	.926
287	B	28.7	398.611	.463
288	B	28.8	400.000	1.389
16	A	21.6	400.000	0
289	B	28.9	401.389	1.389
17	A	21.7	401.851	.462
290	B	29.0	402.777	.926
18	A	21.8	403.703	.926
291	B	29.1	404.166	.463
19	A	21.9	405.555	1.389
292	B	29.2	405.555	0
293	B	29.3	406.944	1.389
20	A	22.0	407.407	.463
294	B	29.4	408.333	.926
21	A	22.1	409.259	.926
295	B	29.5	409.722	.463
22	A	22.2	411.111	1.389
296	B	29.6	411.111	0
297	B	29.7	412.500	1.389
23	A	22.3	412.963	.463
298	B	29.8	413.888	.925
24	A	22.4	414.814	.926
299	B	29.9	415.277	.463
25	A	22.5	416.666	1.389
300	B	30.0	416.666	0
301	B	30.1	418.055	1.389
26	A	22.6	418.518	.463
302	B	30.2	419.444	.926
27	A	22.7	420.370	.926
303	B	30.3	420.833	.463
28	A	22.8	422.222	1.389
304	B	30.4	422.222	0
305	B	30.5	423.611	1.389
29	A	22.9	424.074	.463
306	B	30.6	425.000	.926
30	A	23.0	425.926	.926
307	B	30.7	426 888	.462
31	A	23.1	427.777	1.389
308	B	30.8	427.777	0
309	B	30.9	429.166	1.389
32	A	23.2	429.629	.463
310	B	31.0	430.555	.926
33	A	23.3	431.481	.926
311	B	31.1	431.944	.463
34	A	23.4	433 333	1.389
312	B	31.2	433.333	0
313	B	31.3	434.722	1.389
35	A	23.5	435.185	.463
314	B	31.4	436.111	.926
36	A	23.6	437.037	.926
315	B	31.5	437.500	.463
37	A	23.7	438.888	1.388
316	B	31.6	438.888	0
317	B	31.7	440.277	1.389
38	A	23.8	440.740	.463
318	B	31.8	441.666	.926
39	A	23.9	442.592	.926
319	B	31.9	443.055	.463
40	A	24.0	444.444	1.389
320	B	32.0	444.444	0
321	B	32.1	445.833	1.389
41	A	24.1	446.296	.463
322	B	32.2	447.222	.926
42	A	24.2	448.148	.926
323	B	32.3	448.611	.463
43	A	24.3	450.000	1.389
324	B	32.4	450.000	0
325	B	32.5	451.389	1.389
44	A	24.4	451.852	.463
326	B	32.6	452.777	.925
45	A	24.5	453.703	.926
327	B	32.7	454.166	.463
46	A	24.6	455.555	1.389
328	B	32.8	455.555	0
329	B	32.9	456.944	1.389
47	A	24.7	457.407	.463
330	B	33.0	458.333	.926
48	A	24.8	459.259	.926
331	B	33.1	459.722	.463
49	A	24.9	461.111	1.389
332	B	33.2	461.111	0
333	B	33.3	462.500	1.389
50	A	25.0	462.962	.462
334	B	33.4	463.888	.926
51	A	25.1	464.814	.926
335	B	33.5	465.277	.463
52	A	25.2	466.666	1.389
336	B	33.6	466.666	0
337	B	33.7	468.055	1.389
53	A	25.3	468.518	.463
338	B	33.8	469.444	.926
54	A	25.4	470.370	.926
339	B	33.9	470.833	.463
55	A	25.5	472.222	1.389
340	B	34.0	472.222	0
341	B	34.1	473.611	1.389
56	A	25.6	474.074	.463
342	B	34.2	475.000	.926
57	A	25.7	475.925	.925
343	B	34.3	476.388	.463
58	A	25.8	477.777	1.389
344	B	34.4	477.777	0
345	B	34.5	479.166	1.389
59	A	25.9	479.629	.463
346	B	34.6	480.555	.926
60	A	26.0	481.481	.926
347	B	34.7	481.944	.463
61	A	26.1	483 333	1.389
348	B	34.8	483.333	0
349	B	34.9	484.722	1.389
62	A	26.2	485.185	.463
350	B	35.0	486.111	.926
63	A	26.3	487.037	.926
351	B	35.1	487.500	.463
64	A	26.4	488.888	1.388
352	B	35.2	488.888	0
353	B	35.3	490.277	1.390
65	A	26.5	490.740	.463
354	B	35.4	491.666	.926
66	A	26.6	492.592	.926
355	B	35.5	493.055	.463
67	A	26.7	494.444	1.389
356	B	35.6	494.444	0
357	B	35.7	495.833	1.389
68	A	26.8	496.296	.463
358	B	35.8	497.222	.926
69	A	26.9	498.148	.926
359	B	35.9	498.611	.463
70	A	27.0	500.000	1.389
360	B	36.0	500.000	0
361	B	36.1	501.388	1.388
71	A	27.1	501.851	.463
362	B	36.2	502.777	.926
72	A	27.2	503.703	.926
363	B	36.3	504.166	.463
73	A	27.3	505.555	1.389
364	B	36.4	505.555	0
365	B	36.5	506.944	1.389
74	A	27.4	507.407	.463
366	B	36.6	508.333	.926
75	A	27.5	509.259	.926
367	B	36.7	509.722	.463
76	A	27.6	511.111	1.389
368	B	36.8	511.111	0
369	B	36.9	512.500	1.389
77	A	27.7	512.962	.462
370	B	37.0	513.888	.926
78	A	27.8	514.814	.926
371	B	37.1	515.277	.463
79	A	27.9	516.666	1.389
372	B	37.2	516.666	0
373	B	37.3	518.055	1.389
374	B	37.4	519.444	1.389
375	B	37.5	520.833	1.389
376	B	37.6	522.222	1.389
377	B	37.7	523.611	1.389
378	B	37.8	524.999	1.388
379	B	37.9	526.388	1.389
380	B	38.0	527.777	1.389
381	B	38.1	529.166	1.389
382	B	38.2	530.555	1.389
383	B	38.3	531.944	1.389
384	B	38.4	533.333	1.389
385	B	38.5	534.722	1.389
386	B	38.6	536.111	1.389
387	B	38.7	537.499	1.388
388	B	38.8	538.888	1.389
389	B	38.9	540.277	1.389

HAVING USED THE ARC-5 SERIES OF VFOS for some time, I became thoroughly disgusted at the futility of getting them to key well on the higher bands—ten and twenty meters, while using full breakin.

There and then I decided to build a VFO of my own design that would have the following features:

1. T9x keying on all bands while using full breakin
2. Commercial appearance
3. Bandswitching—80, 40, 20, 15, 11–10 meters with enough output to drive my push-pull 807s.
4. A compact unit that would easily fit on top of the receiver.
5. Direct calibration in frequency with provision for easily resetting dial reading.
6. LOW COST

Looking over VFO designs, I found that the heterodyne type of frequency generator, which uses two oscillators and a mixer, was the best bet. This unit was designed similarly to the "T9-er" which was featured in the April, 1948, issue of *CQ*, with changes made to suit the particular application.

Upon searching the surplus market, I found the ideal unit to convert into this exciter. It is a T-20/ARC-5 transmitter which has a range of from 4 to 5.3 mc. The oscillator covered the desired range and the unit looked neat and matched the black crackle of my HRO receiver. Any other of the ARC-5 series or the SCR-274N series should work just as well, needing only a revision of the oscillator range.

The Circuit

The original oscillator is used as the VFO. The 1626 works quite well with six volts on the heater,

ALL BAND VFO

and eliminates the expense of a six-volt tube. The oscillator covers a range of from 4765 to 4290 kc, which, after being mixed with the crystal oscillator, beats to give output from 3375 to 3850 kc.

The fixed oscillator is crystal controlled on 8140 kc. A 6J5 works quite well in the conventional Pierce circuit. Using this range of frequencies no trouble should be experienced due to beat notes on the conventional communications receiver with an i.f. at or near 456 kc.

The two oscillator signals are fed into a 6SA7 mixer which extracts the difference frequency and sends it to the next stage. The 6SA7 is not used as an oscillator in itself so does not cause any chirp when it is keyed.

A 6AG7 is used as a buffer in the next stage. It is keyed along with the 6SA7 so as to keep the signal leakage at a minimum.

The next stage, a 6AG7, is used as either a quadrupler or a tripler, raising the frequency to either 10.5 or 14 mc. This stage may be switched either in or out by a switch on the side of the chassis, so as to allow excitation to the PA on 3.5 mc, whenever 80- or 40-meter output is desired.

A 2E26 is used either straight-through or as a doubler in the final stage. Considering the cost of turrets and the space available, I decided to use the ARC-5 antenna coil as my final coil. Although it may not be as efficient as a turret, the output is more than enough on all bands and the extra cost of a turret did not warrant its use. The silver plated wire makes it more efficient than it would seem.

Two band switches are used, one switching the final coil and the link, and the other switching the quadrupler in and out.

Special attention is called to the link output circuit. In order to get good output, a small link was needed for the higher bands and a big link for the lower bands. A two-turn link is used for 10-11, 15, and 20 meters, and one wire from that link plus one wire of a four turn link half way up the coil gives good output on 80 and 40 meters. The circuit is unorthodox but it works very well.

The 500-ohm resistors on the wire from the link of the VFO coil to the 6SA7 are used to cut down signal leakage with key up so as to be able to work full breakin. They also serve to keep a constant load on the oscillator which cuts down chirp.

Small size coax should be used in the wire from the link to the grid of the 6SA7 to insure against signal leakage.

A tune-up switch has been incorporated in the exciter since the pictures were taken. It is inserted in the hole in the front panel which originally housed the link control. It allows swishless zero beating and the VFO puts out a weak signal which does not overload the receiver. The switch cuts off screen voltage from the quadrupler-tripler and the 2E26.

Construction

There are a lot of parts that are unused in the ARC-5 that must be removed. Remove all tubes. Remove the 1625 sockets by slipping a screwdriver around the rim and prying the lip up. Disconnect the wires from these sockets and put them aside. Remove the neutralizing condenser and all parts of the amplifier and antenna coils and the tuning assembly for the antenna coil. Leave the mounting bracket on the antenna coil and put it aside for later use. Remove the r.f.c. and all the knobs on the front panel except the tuning knob and lock. Use a Bristol screwdriver for this purpose. If one is not available, take a six-inch screwdriver with a ¼ inch blade and file the blade on the edges so as to fit into the Bristol screw heads. Then jam it into the screws, with a hammer if necessary, and it will unscrew easily. This screwdriver will be of much use later on. Make sure to use a 6-inch one, for you will need the length.

Remove the p.a. padding condenser. Remove both relays and the plug in back of the unit. Cut the wires at the connection points to the parts, for they will be used to carry filament and plate voltages later on.

Remove the crystal and resonance indicator tube assembly and all connected parts. Remove all parts on tube sockets except the group on both #1 pins and the filament connection on the #2 pin of the resonance indicator socket. Follow the diagrams and make the necessary changes. Use as many parts from the original transmitter circuit as possible in wiring the new circuit.

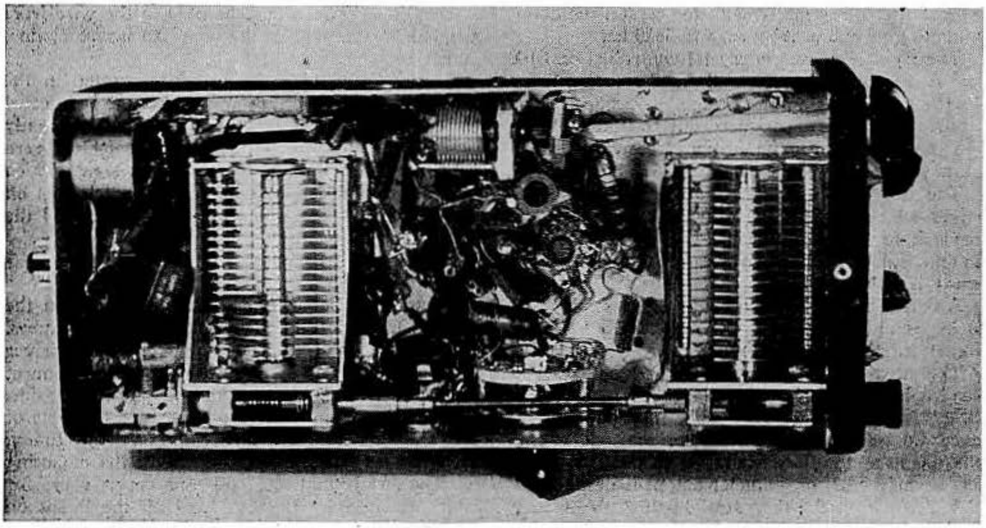
You should now have a clean chassis between the oscillator coil shield on top of the chassis and the front of the cabinet with the exception of the feed-through insulator. On the underside, all should be clean between the oscillator tuning condenser and the amplifier tuning condenser except for the relay wires which will be used for power wires later on.

The connector on the back is an 8-pin male plug. It may be bought commercially but it is very simple to make. Take a metal octal tube that has gone west and remove the octal plug from the bottom. Remove the wires from the plug and clean out the pins. File out the hole in the back of the chassis with a rattail file until the plug fits snugly. Then file two pips in the hole on the top and bottom. Place the plug in the hole and fasten it with two small screws through the pips. It makes an inexpensive substitute that works very well. If a commercial plug is used, the lock ring or screws should be put into place in the usual way.

Before assembling any parts on the chassis, the filaments should be wired. Use the original filament wires whenever possible. Remember, do not wire filament voltage to the coil socket! Allow these wires to go around the edge of the chassis so as not to interfere with the r.f. wiring.

The wiring should be done starting from the oscillators and finishing with the 2E26 stage.

The wiring is very crowded in the oscillator and mixer compartment. The 3×.05 condenser should be unscrewed and left hanging over the side to gain access to the sockets. The 6SA7 transformer should be installed last. The easiest way to assemble the crystal oscillator is to connect all the parts to be connected to the crystal socket first without soldering them. Solder the socket to pins #4 and #6 of the 6J5 socket after connecting pin #4 to pin #5 and the necessary connections to pin #6. If this is followed it will greatly simplify the job of assembly. The other wiring of the unit is routine stuff. The



Bottom view of the finished unit. The placement of major components should follow this model rather closely. The switch mounted on the side is the "multiplier in-out" control, SW_1.

The tube sockets should be punched next. The three sockets in the rear are ideal for the two oscillators and the mixer. The other sockets must be punched. The removal of the 1625 tube sockets leaves a problem because of the wide holes in the chassis. The 6AG7 sockets are mounted on the outer edge of these holes. They are made the right curve at the edge with a socket punch and the sockets are held by one screw which seems to be sufficient, for tube changing does not come often. The 6AG7 buffer coil socket is mounted in a hole punched exactly between the 1625 socket holes. Two screws should be used in this case.

The 2E26 socket is placed in the center of the chassis, being careful that the 2E26 tube, when inserted, will not interfere with its coil assembly. Follow the pictures in laying out the chassis as closely as possible.

3×.05 μf condenser is used as the 6SA7 cathode bypass, and the 105-volt bypass, and the 6SA7 screen bypass condenser.

The mixer plate transformer is made from a 456-kc cartwheel i.f. transformer that was lying idle in the junk box. This transformer may be easily obtained at any radio establishment. Both of the coils are removed and the transformer is built on one of the forms. The windings are wound with maximum coupling to get the widest bandpass without resorting to much resistor loading. Any small gauge cotton-covered, stranded, or solid wire may be used. The type that I used was stranded cotton-covered wire from an old i.f. coil of about a 34 gauge. The transformer consists of about 25 turns, closewound, on one of the forms. A piece of scotch tape should be inserted between the two windings of the transformer to take care of the difference in potential. The windings don't have to be wound in an orderly fashion and the specifications are not critical, for the wide range of the trimmers take care of any slight variations.

The transformer is mounted right below the 6SA7 tube on the right side of the cabinet. Two holes should be drilled in the side of the chassis to allow screwdriver adjustment of the trimmers.

The "quadrupler in-out" switch is located in the larger hole on the right side of the chassis. The cover for this hole and for the smaller hole is used to cover up the holes in front left by the removal of the knobs. The key jack is right next to the switch further back on the chassis.

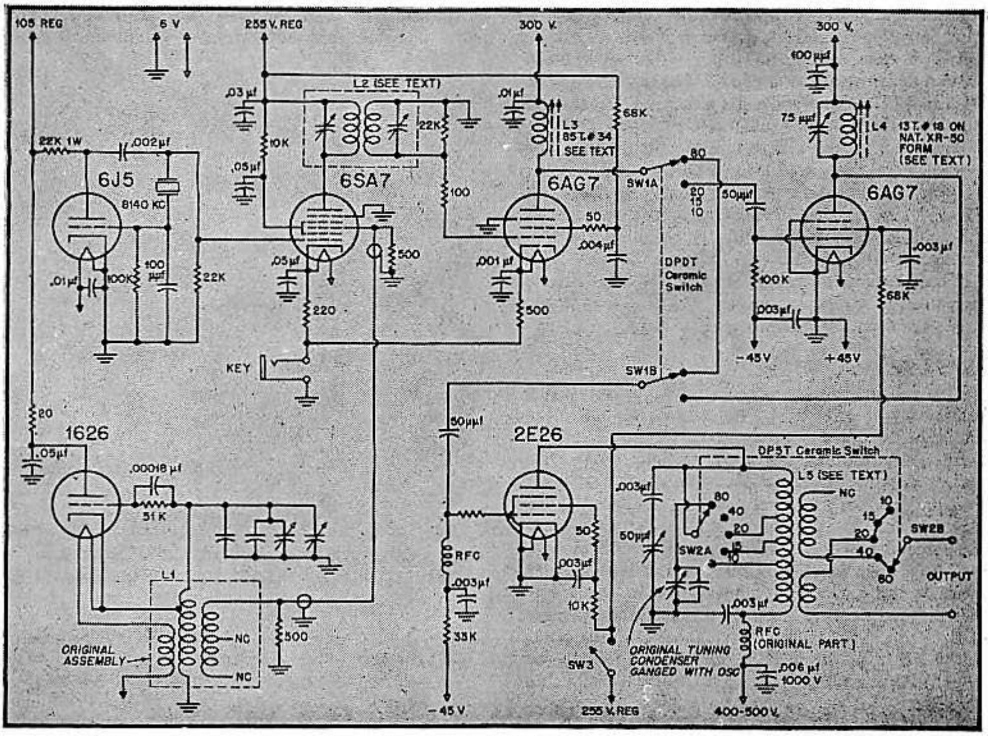
The quadrupler plate coil is located midway between the 6AG7 quadrupler and the 2E26. It is made up of 13 turns of 22 gauge enamelled wire spaced over the length of the XR-50 coil form. The 75 μμf variable condenser is mounted on a bracket made of copper sheeting. A lip is bent in the copper to allow it to be bolted to the side of the chassis and extend out at right angles.

Four holes should be drilled in the copper plate; one to hold it to the side of the chassis; two to hold the condenser to the plate; one for the rotor control that is large enough to prevent it from shorting to ground. The rotor is connected through a 1/4″ insulated flexible coupling to a 1/4″ rod extending through a bearing out the front of the cabinet to a knob. This circuit tunes either to 14.0 or 10.5 mc.

The buffer coil consists of about 80 turns, close wound, of #30 or smaller wire. Any wire from an old r.f. or i.f. coil would work fine. The coil should be about 3/4 inches long, starting 1/2 inch down from the top of the form. Slight variations may be necessary in different coils. The turns can be easily removed, so I suggest that you start with about 85 or 90 turns and prune it down to size.

The 2E26 band switch and tuning condenser are placed on the front plastic window in holes drilled to fit. Make sure that your condenser is the right size and will not interfere with the coil directly behind it. The coil is the original antenna coil tapped for the different bands. It is screwed to the top of the chassis using the original brackets. The holes in the brackets are tapped so the screws, inserted from the bottom, need no nuts. The entire coil is used for 80 and 40 meters. It is tapped between the 15th and 16th turn for 20 meters, between the 10th and 11th turn for 15 meters, and between the 6th and 7th for 10–11 meters. The counting of the turns should be done from the high-voltage end of the coil. The taps are made by laying the tapping wire between the two turns and soldering them. These connections should not be made permanent until the unit is operating efficiently, for a bit of cut and try may be necessary to find the correct points for maximum output on the higher frequency bands.

The original p.a. condenser which is ganged with the oscillator condenser is used to provide a good



The circuit of the v.f.o. exciter. The original ARC-5 parts should be used wherever possible.

degree of gang tuning on 80 meters. A copper shield should be placed between this condenser and the 2E26 to insure stability. It is placed right over the side of the condenser, as seen in the pictures.

The parts layout in the pictures should be followed closely in order that all components be fitted into such a small space. The tolerances of the components are not close, and any makeshift parts will work, such as parallel or series resistors to reach a certain value.

Power Supply

Four plate voltages are necessary to operate the unit besides the six-volt filaments. You need 105 volts regulated, 255 volts regulated, 300 volts and 400–500 volts. Two supplies were used in our installation. One supply had an output of 105 volts, regulated, at about 30 ma for the oscillators. The other supply supplied all the other voltages by means of taps on the bleeder resistor. A 500-volt 200-ma transformer was used and seems to be bearing the load very nicely. Separate power supplies were necessary to take out the slight chirp that was introduced by the voltage shift if the same supply was used for the keyed stage and the oscillators. A VR-105 was used for the 105-volt supply and a VR-150 and a VR-105 were used in series for the 255-volt supply. Good filtering should be used throughout to insure a good clean note. A 45-volt "B" battery is used to supply bias. The one here has been in use for over 6 months and still going strong. It is placed on the power supply chassis.

Tuning up

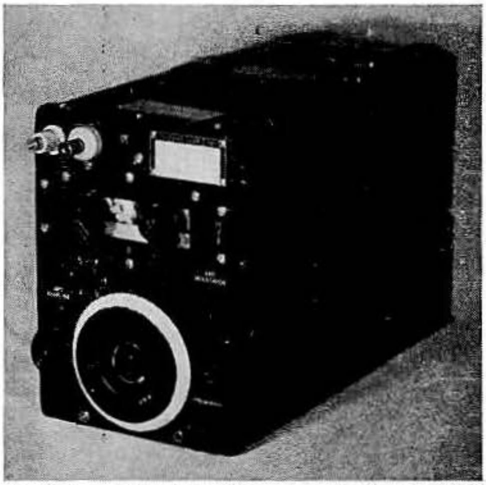
This job forms the nucleus of the unit, for if done incorrectly, it will give no end of trouble, but if done the right way, it will do wonders.

In this type of VFO circuit, as the oscillator frequency gets higher the output frequency gets lower, thus making the dial read "backwards." This condition was rectified by loosening the bristol screws on the rotor shaft of the oscillator condenser and rotating the condenser 180 degrees so that it moves into mesh as the dial reading is increased. Remove ten plates from this condenser, starting from the rear of the shaft, leaving the six remaining plates closest to the worm drive mechanism in place. This is done to get maximum bandspread. Make sure that you do not disturb the drive mechanism for it might introduce some backlash.

Remove the two 6AG7s and the 2E26 tubes and apply voltage to the unit. Tune your receiver to 3.6 mc. Adjust the oscillator tuning condenser so that it is a little less than half mesh, by turning the knob on the front panel. Short the key terminals and adjust the oscillator padder located in the shield on top of the chassis until you get a signal from the oscillator on the receiver. Make sure that you don't pick up an image instead of the fundamental. The oscillator padder is adjusted by unscrewing the locking screw through the hole on the side of the shield and pushing the adjusting arm toward the right with a screwdriver. The shield does not have to be removed for the arm only has to be moved about ½ inch. Move it slowly for it is very critical and a hair this way or that will get you off frequency. When you get the signal near 3.6 mc it may be adjusted by turning the top blue screw in or out, as the case may be. The original oscillator adjusting screw is used to reset calibration in this unit. It should be set at about half scale and all the fine adjusting should be done with the blue screw on the top during the original tuning up process.

Put a pencil mark on the dial at the 3.6 point for easy reference. Check the range of the unit by turning the VFO dial from one extreme to the other. It should cover from 3.375 to 3.85 mc. If this range cannot be covered, adjust the cut end plate on the condenser so that a lower frequency will be produced when it is out of mesh, and a higher frequency will be produced when it is in mesh. It should just cover the desired range.

Adjust the 6SA7 transformer to peak at 3.6 mc and insert the 6AG7 buffer. Adjust its coil for 3.6 peak. The output should be able to light up a neon bulb. Those of you who are anxious to get on the air might want to put a link around this coil and connect it to an 80-meter antenna or to your final grids, if using 807s or the like. You will really be thrilled by its performance.



Front view of the heterodyne v.f.o., showing the 2E26 tuning control and the band switch mounted on the plastic window.

Insert the 2E26 and, making sure that the band switches are in order, tune it to 3.6 mc with the tuning condenser. In order to obtain gang tuning over the 80-meter band, the original p.a. condenser is used to tune the 2E26. It was found that the range of the condenser was too much for the coil and padder combination to allow it to track perfectly over the range so the ganged condenser should be set at half mesh at 3.5 mc. This is an unorthodox condition but the front condenser dial only has to be touched three or four times during the whole range on 80 meters.

The 80-meter band should be set first before going to the higher frequency bands. The easiest way to tune the unit for uniform output over the range is to connect the output link to the grid circuit of the next stage in your rig and tune for uniform output, or grid current. The 6AG7 coil should be left at 3.6 mc and the 6SA7 transformer should be stagger-tuned until the correct range is covered. A little adjustment of the 6AG7 coil may be necessary in some installations. There will be more drive in the middle of the band, but that is to be expected from circuits not using elaborate loading resistors and the like. Your main consideration is getting enough excitation over the range, and if you get more than enough at some frequencies it will do no harm. Adjust this from 3.5 to 3.85. Do not worry about 3.4–3.5 output for this is not necessary on 80 meters.

Once you have it working on 80 meters the other bands are quite simple to get going except ten meters. You will find that you will get good output on 40, 20, and 15 meters with no trouble at all.

The 6AG7 quadrupler should work fb from the start. A wavemeter would come in quite handy to make sure that you have the right harmonics but you can get along ok without it. With the constants shown, the circuit should only tune the third and fourth harmonics of the 80-meter input. The circuit works quite efficiently on both tripling and quadrupling.

Ten meters may give you a bit of trouble in getting good output from the doubling 2E26. As the frequency gets higher, the taps on the 2E26 coil get more critical so that on ten meters you may have to adjust the tap a bit on the coil to get maximum output. The link should be coupled loosely to the coil to obtain good output. Experimentation with your particular application is the best condition under which to adjust the unit. Once the unit is adjusted correctly it will work with no trouble for a long period of time. The 2E26 tube plate should not get red under any condition if the unit is operating properly. Short overloads are permissable in tuning up, however.

The 6SA7 transformer may need a little adjustment when you are initially tuning for good output on the 11-meter band. By tuning it a little, a happy medium can be struck that will be good for both 80 and 11.

Calibration

To calibrate this unit so that it will be accurate in frequency readings, all that is necessary is a 100-c crystal oscillator and a receiver. If your particular installation does not require accurate calibration, you may calibrate it with the receiver alone if your receiver calibration is fairly accurate.

Since the original dial readings are discarded, a mask made from stiff paper was cut out to fit over the dial. Tune the receiver to 3.5 mc and tune the VFO to this spot. Make a mark on the new VFO dial at this spot. Now put the receiver on ten meters and find the harmonic on 28.0 mc. Keep the VFO tuned to 80 or 40 meters so as to get a weak harmonic to beat with the weak 100-kc harmonic at that frequency. Adjust the VFO trimmer to set the 3.5-mc point exactly at 28 mc, for any bit you were off on the adjustment on 3.5 mc will be multiplied 8 times on this band. After this is set, make a mark at every 100-kc point from 27 to 30 mc.

This procedure will make your unit a pretty good frequency meter, but remember, when using it near band edges, join it with a 100-kc crystal oscillator to make an unbeatable team. In time, the VFO will tend to get off calibration. An adjustment of the original oscillator trimmer will put it right on the beam.

Results

I have been using this exciter to drive pp 807s on all bands for about a year now and have found nothing lacking in its capability of T9x c.w. I have never gotten a report below T9.

Because I can now use breakin on the higher bands and still retain a good note, my scores in the DX and CD contests have been vastly improved.

I find that this exciter retains its calibration over long periods of time and is quite accurate as to band edges.

Although I spent quite some time taking the bugs out of this unit, it is repaid a millionfold when I can say during a QSO, "Exciter hr OM is a *home-made* bandswitching job and I am using Bk in," after receiving a T9x report.

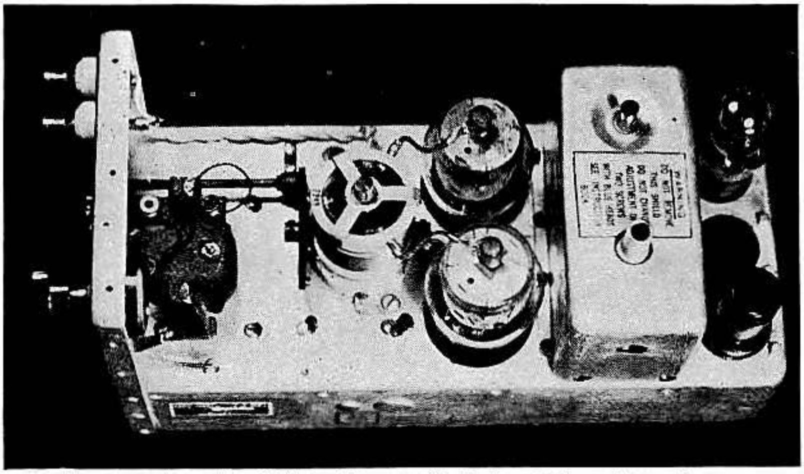
AN SCR-274N VFO FOR AM,FM

An increasing amount of surplus Army equipment is appearing on the civilian market. Among various items of interest to the radio amateur is the SCR-274-N, an aircraft unit that is very easily adapted to amateur use as a stable, variable-frequency oscillator (VFO), either for AM or FM operation. The SCR-274-N is the overall designation given the principal components of a multi-channel aircraft radio receiving and transmitting set-up used on thousands of planes and now "declassified." So that the reader may know what to look for, the army numbers of the equipment are as follows:

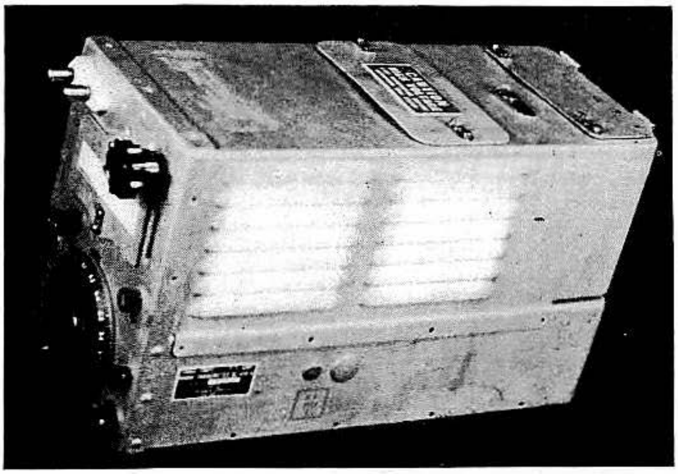
The receiving end consists of three separate units—the BC-453-A (190-550 kc), the BC-454-A (3.0 to 6.0 mc) and the BC-455-A (6.0 to 9.1 mc). These receivers operate from the airplane 24-28-volt storage battery and each contains a separate dynamotor for plate power. It is an easy matter to substitute 6-volt tubes for the 12-volt series type originally in the receiver, and rewire the filament string for parallel 6.3-volt operation from a standard filament transformer. (Alternatively, a 24-volt transformer may be used to energize the heater circuits with the receiver left as is.) Any light 250-volt receiver power supply will provide plate power for the sets, or a vibrapack may be used if mobile operation is contemplated. These receivers are very sensitive, incorporating an r-f stage, BFO for c.w. reception, and, all-in-all, make excellent receivers up to approximately 10 megacycles.

The Transmitters

Four separate transmitters are included in the sending unit. The BC-696-A covers 3 to 4 mc, the BC-457-A from 4 to 5.3 mc, the BC-458-A, 5.3 to 7 mc, while the BC-459-A tunes from 7.0 to 9.1 megacycles. Each transmitter consists of a master oscillator tube (1626 or 12J5) exciting a



Top view of completed VFO with cover off. At front is the audio transformer (500 ohms input) Next can be seen the power amplifier coil with the variable coupling to the link and the twisted pair to the output terminals. Tubes and master oscillator frequency control box next. At the rear are the master oscillator tube and the FM reactance tube. The center socket is not used.



View showing completed VFO. Upper left is the output. Upper right is the volume control when used for FM operation. Center is the dial which controls the frequency

pair of beam tetrodes in the power amplifier stage (1625's or twelve volt 807's). The tubes in the amplifier are connected in parallel. The master oscillator and r-f power amplifier tuning capacitors are gauged, and an excellent worm drive, with plenty of reduction, is incorporated in the dial system. Included in each transmitter is a piezo-electric crystal and an electronic resonance indicator for calibration. This may be removed to make way for additional FM features, to be described later, or left as is if only AM VFO operation is contemplated. The power output may be varied from a few watts to approximately 55 watts according to the power supply on hand. Thus, one of these little jobs may be used as a fixed variable-frequency transmitter or as a driver for a higher-power amplifier.

The components are of exceptionally high quality and the assembly rigidly constructed. By using standard aircraft shock mountings (which are attached), the mechanical stability is excellent; and with a stabilized 200-volt supply to power the master oscillator, the drift is very small. This equipment was designed to hold the frequency quite constant in aircraft under vibration and extreme temperature changes; so it can be understood that the frequency variation will be practically nil with the set mounted on the operating table, subject to little vibration and relatively constant temperature.

Modifications for Amateur Use

At W5AJG, we were interested in a VFO unit to work directly into the crystal oscillator tube—in fact, to work in place of the crystal itself. Since all the crystal stages started with either 6 or 7-mc crystals (6 mc for the 144-148-mc band as well as the 50-54- mc band) it was decided to purchase the BC-458-A transmitter unit which covers 5.3 to 7.0 megacycles. Actually, this unit will reach to about 7.5 mc and will replace any 7-mc crystal.

It was decided to add a simple reactance tube modulator circuit and have the choice of either AM VFO or narrow-band FM transmissions. This was accomplished by a simple modification, and the unit works on either frequency or amplitude modulation. Should the crystal stage of the regular station transmitter start with a 3.5-mc crystal instead of a 6 or 7-mc crystal, the BC-696-A, with its range of 3 to 4-mc, should be selected.

The changes necessary to do the job are as follows. Reference is made to the *original* schematic, *Fig. 1*, and to the *modified* diagram *Fig. 2*. To begin with, the 24-volt former airplant battery supply is replaced with a 110 to 24-volt transformer for the heaters. These transformers are surplus stock in any mail-order catalog and sell for around $1.25. This is cheaper and easier than replacing the oscillator tube and the two tetrode finals with 6-volt versions, and obviates wiring changes in the heater circuits.

Next, the unwanted components are removed from the chassis—namely the variable antenna loading inductor *L*52 (this will serve admirably as an antenna tuning coil elsewhere around the station), as well as the antenna change-over relay *K*54. Relay *K*53 is either tied down in the energized position or removed and the wiring circuits closed. This relay switches plate voltage to the master oscillator and shorts out resistor *R*75 which was used for c.w. work. An extra feed-through insulator is employed to bring out the low-impedance line coupling the output transformer, *T*54, to the crystal oscillator stage of the transmitter it drives (*Fig. 3*).

For AM VFO operation, the above changes are all that are necessary. Of course a power supply, preferably a regulated 220-volt unit, is used to power the master oscillator—while anything from 200 to 550 volts, unregulated, is suitable for the amplifier, depending on the desired power output.

The dial is very closely calibrated and a 4,600-kc crystal resonator is used to check the calibration. This is very simply observed by tuning for maximum indication on the electronic eye tube and then noting if the dial reads exactly 4,600 kilocycles. The transmitter is then calibrated over the rest of the dial. This crystal does not stabilize the frequency in any way—it is merely a built-in standard to check the master oscillator dial setting. A crystal of another frequency could be substituted—for instance one spotting a particular pet or net op-

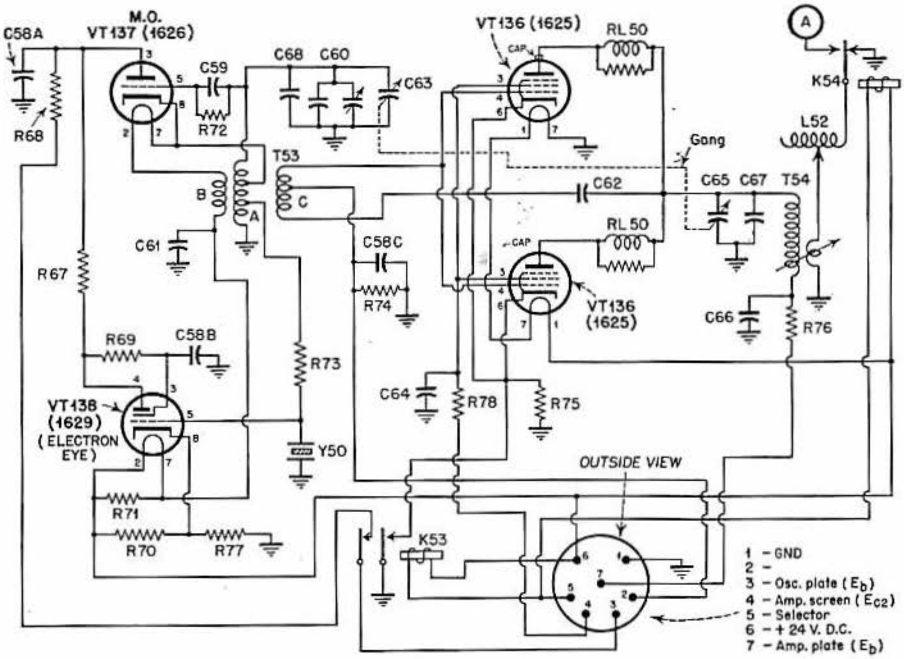


Fig. 1. Original schematic of the BC-458-A (5.3 to 7.0 megacycles with a bit of leeway). The following parts are identified:

C_{58}A, C_{58}B, C_{58}C—.05 μf
C_{59}—.00018 μf
C_{60}—master oscillator padding
C_{61}—.006 μf
C_{62}—fixed neutralizing
C_{63}—master oscillator tuning
C_{64}—.002 μf
C_{65}—power amplifier tuning
C_{66}—.01 μf
C_{67}—power amplifier padding
C_{68}—3.0 $\mu\mu$f
C_{69}—50 $\mu\mu$f
K_{53}—transmitter selector relay
K_{54}—transmitter output relay

L_{52}—antenna loading coil
R_{67}, R_{72}, R_{75}—51,000 ohms
R_{68}, R_{76}—20 ohms
R_{69}—1 megohm
R_{70}—1,000 ohms
R_{71}—126 ohms
R_{73}, R_{74}—15,000 ohms
R_{77}—390 ohms
R_{78}—51 ohms
RL_{50}—parasitic suppressors
T_{53}—oscillator coils
T_{54}—amplifier coils
Y_{50}—crystal unit
7-prong female plug, outside view

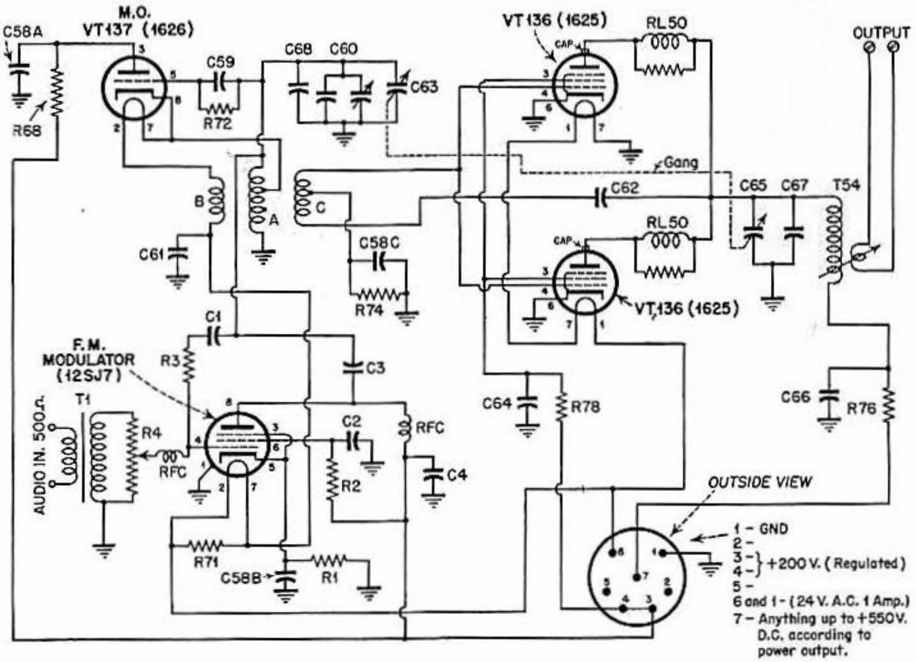


Fig. 2. Modified diagram of transmitter covering from 5.0 to 7.3 megacycles. Referring to Fig. 1., the following components were eliminated mainly from the electronic 'eye circuit: R_{67}, R_{69}, R_{70}, R_{73}, R_{77}, Y_{58}, K_{53}, K_{54} and L_{52}. Parts added for the FM reactance modulator comprise—

C_1—.00025 μf mica
C_2, C_4—.01 μf paper
C_3,—.0005 μf mica
R_1—1,000 ohms, ½, watt carbon
R_2, R_3—50,000 ohms, ½, watt carbon
R_4—500,000 ohms gain control
RFC—2.5 mh r-f chokes
T_1—line input audio transformer, 500 ohms to grid
12SJ7 metal or glass tube

eration frequency. This would enable the operator to place himself exactly on a particular frequency in the band.

Additional Modifications for FM

It is probable that the amateur will engage extensively in FM narrow-band operation in the near future as well as amplitude modulation. Advantages are claimed for FM in services closely paralleling amateur operation, such as mobile police and point-to-point communications. Not the least among these features is the very modest requirement in regard to modulating power. Also, existing superhets will do a good job of receiving FM transmissions. Later, of course, an FM channel will no doubt be standard equipment in all ham receivers.

By making a few more additional changes, the

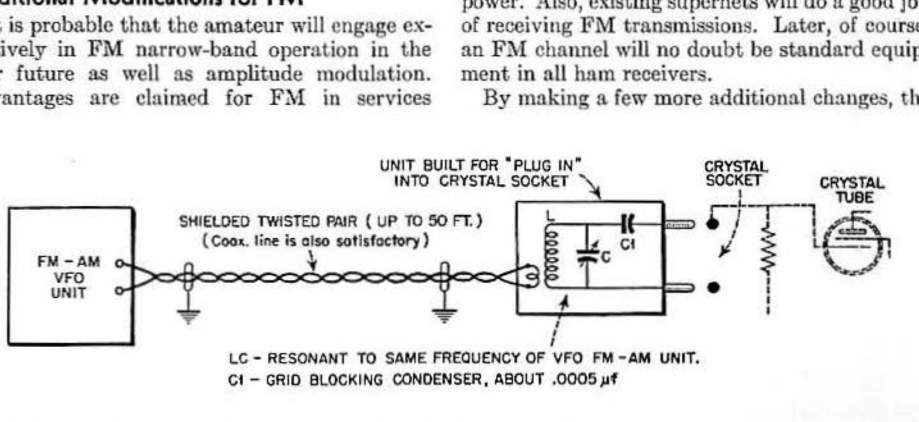
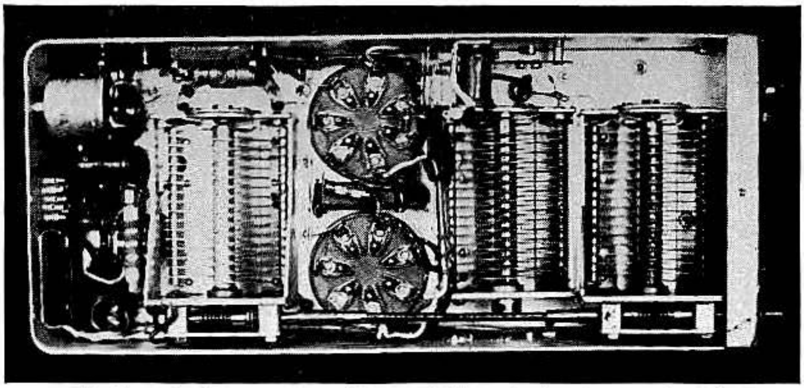


Fig. 3. Suggested arrangement for coupling the VFO to the regular station transmitter when high power is desired



This shows the bottom view and is practically as is when it comes from the ARMY. The reactance tube and components are mounted in the rear. The ganging of the Master oscillator and power amplifier condensers is clearly shown. Notice worm gears on the condensers.

already modified AM VFO can just as easily be converted to narrow-band FM operation. This is accomplished by adding a reactance modulator tube and shunting its output circuit directly across the master oscillator tube—thereby varying the frequency of the master oscillator in accordance with the audio applied to the reactance tube input circuit. Of course purely AM operation is still possible as above. The FM feature is additional.

Again referring to the original and modified schematics, the electronic eye (1629) is removed to make way for the substitute reactance modulator tube. This new addition will be a 12SJ7 type tube. Also the resonator crystal is dispensed with, and all wiring from these two sockets removed, with the exception of the heater leads to the 12SJ7 tube. Note that the original resistor $R71$ remains in the circuit across the heater terminals. The new wiring is simple and follows that in the modified schematic. A 500-ohm line to the grid transformer permits the output of the speech amplifier to modulate the reactance tube. Audio required is approximately zero db.

Should AM operation be desifed, it is merely necessary to turn off the reactance tube gain control, $R4$, and plate modulate the station transmitter in the usual way. With FM operation, the zero db audio track is fed into the 500-ohm input circuit and the gain control turned up sufficiently to produce the required swing of the carrier. Of course the mean frequency may be spotted anywhere in the band by using the calibrated dial in the usual way. Needless to say, it is necessary, when using FM, to stay within the confines of the FM portion of the band. A swing of a few kilocycles on the fundamental frequency of the VFO will be multiplied by the same ratio of frequency multiplication in the transmitter. Thus, if FM operation in the 144-148-mc band is desired with a VFO frequency of 6 megacycles, a swing of 1 kc at this point will be multiplied by 24, which is more than ample for narrow-band amateur FM work.

Coupling to Main Rig

The output of the FM-AM VFO unit can be coupled to the crystal tube of the regular station transmitter in a number of ways. At W5AJG, a shielded twisted pair runs from the operating desk, upon which the VFO is mounted, to the crystal stage of the transmitter proper across the room (*Fig. 3*). The crystal is removed and a separate tuned tank circuit substituted by plugging into the crystal holder. Should the ex-crystal tube be a harmonic type, this tuned tank can be of the same frequency as the crystal. In tri-tet crystal oscillators, the cathode coil should be shortened. With pentode type oscillator tubes, it is usually possible to work straight through without self-oscillation. However, should 7-mc operation be primarily desired, it is advisable to choose a VFO unit operating on 3.5 megacycles so that the former crystal-controlled tube will operate as a doubler. In any event, care should be taken to avoid shorting the grid bias of the ex-crystal tube by connecting a blocking capacitor in series with the high side of the oscillator tube.

It will be found that the SCR-274-N makes a very nice VFO unit with AM or FM operation optional at a very low cost. It is suggested that those interested in obtaining equipment of this type, contact firms that rebuild and reconvert government aircraft apparatus to civilian requirements. As used in Army service there is usually about three times the amount of equipment needed for civilian purposes, and the surplus gear is generally available at a very moderate cost.

A SURPLUS SSB EXCITER

Anyone who has tried to build a variable-frequency exciter that produces a T9 signal, keys well, and is stable enough to drive an SSB transmitter appreciates the difficulties involved. W6TZB, however, shows how to let someone else do most of the sweating.—Editor

While working on a single-sideband rig recently, the writer developed a simple method of converting 3 to 6-Mc and 6 to 9-Mc "Command" receivers (*BC-454* and *BC-455*) into heterodyne-type, variable-frequency exciters, covering the same frequency ranges. The stability of the converted units is outstanding, they key beautifully, and have sufficient output to drive a Class AB 807, a 6AG7, etc.

Heterodyne exciters have been described in the radio magazines for quite a few years; Their manifold virtues include good keying, excellent stability, and high reset accuracy. However, they are rather complicated and expensive to build. In addition, many are difficult to adjust and their output is full of "birdies." The conversion of a "Command" receiver into one, however, retains the advantages and eliminates the disadvantages. Besides the *surplus* receiver, a small handful of fixed condensers and resistors and an optional crystal are the only parts required. Unless you are unfortunate enough to possess nothing but thumbs, the entire job should take only an hour or two.

What Must Be Done

To accomplish our purpose, we change the receiver wiring around, so that, instead of high-frequency input to the antenna terminal being converted to intermediate-frequency output from the mixer plate, intermediate-frequency input to the mixer grid is converted to high-frequency output at the antenna terminal. *Figure 1* shows essentials of the high-frequency section of the receiver, where most of the simple, though necessary, changes are made. *Figure 2* shows the revised circuit.

Starting at the antenna terminal, change the present coupling condenser to 100 $\mu\mu$fd. and remove the small neon bulb. Disconnect *C3* and *R1* from the control grid (*pin No. 4*) of the 12SK7. Remove and save *R1*. Now, transfer the plate connection (*pin No. 8*) to the grid, and connect *C3* to the plate terminal. Feed plate voltage to the terminal through a 2.5 mh. r-f choke and a 200-ohm resistor in series, bypassing the resistor to ground through a 0.002-$\mu\mu$fd mica or ceramic condenser. Disconnect the bottom of *L2* from the *B* plus line, and ground. Believe me, this is important.

Proceeding to the 12K8 mixer stage, disconnect *L3* from the 12K8 grid cap. Also disconnect the wire between the 12K8 plate (*pin No. 3*) and the first i-f transformer. Then connect the plate term-

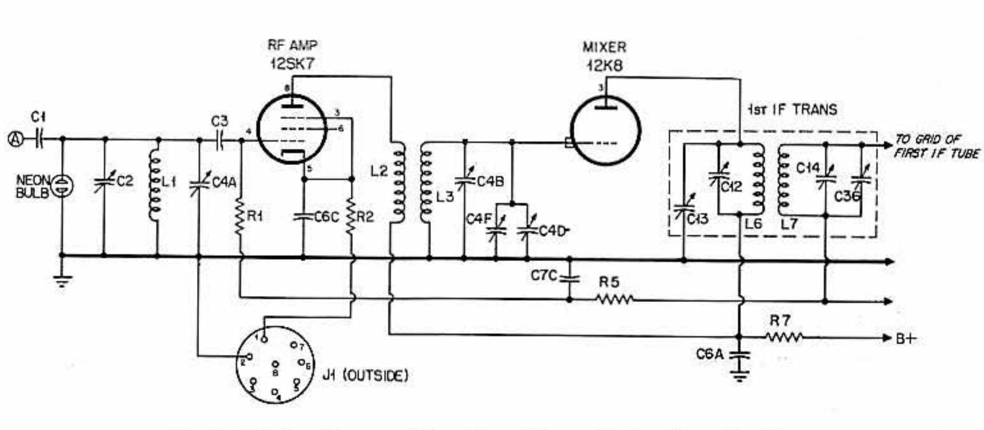


Fig. 1. Skeleton diagram of the r-f amplifier and mixer stages in either a BC-454 or BC-455, before modification to a variable frequency exciter.

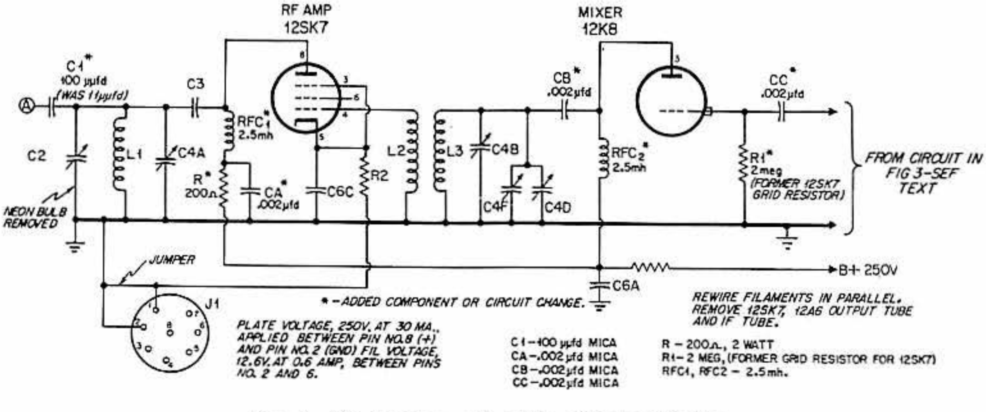


Fig. 2. The r-f stage and mixer, after modification.

inal through a 0.002-μfd midget mica or ceramic condenser. Feed plate voltage to the tube through another 2.5-mh, r-f choke. Connect the 2-megohm resistor (*R1*) salvaged from the r-f stage between grid and ground, and feed i-f energy into the grid through *Cc*, a 0.002-μfd midget mica condenser.

Obtaining Intermediate-Frequency Energy

In the first receiver (a BC-454) I converted, the input signal for the 12K8 control grid was provided by a single-sideband exciter ending up on 1415 kc. In the next one, the first i-f stage was changed into a crystal oscillator. (See *Fig. 3.*)

The grid lead of the first i-f tube was removed from the first i-f transformer, and the crystal connected between grid and ground. A 47,000-ohm resistor in series with a 2.5-mh, r-f choke across the crystal furnished operating bias. Output from the oscillator was obtained by disconnecting the secondary of the second i-f transformer from the grid of the second i-f tube and connecting it to *Cc* of *Fig. 2.* The double-tuned i-f transformer knocks out virtually all spurious "birdies" from the oscillator output. Incidentally, the crystal will not oscillate without the 10-μμfd condenser between grid and plate terminals of the 12SK7.

If a crystal of the proper frequency is not available, the receiver beat oscillator may be used instead. Referring to *Fig. 3,* disconnect the feedback condenser from the 12SK7 plate and use it to couple the beat oscillator to the 12SK7 control grid. To do so, connect the free end of the condenser to the control grid. (*pin No. 2*) of the 12SR7.

I have fed the output of the beat oscillator directly into the control grid of the 12K8. Results appeared satisfactory, however, the isolation provided by the 12SK7 stage is worth having, especially as it is already there, waiting to be used.

Two keying methods have been used. The first was screen keying of the 12K8 screen. No chirp was noticeable on either 3.5 or 7 Mc., but I was worried about the possible effect of the varying load on the oscillator section of the tube. Next I tried screen keying of the 12SK7 crystal oscillator (or isolation) tube. Keying was beautiful; so this system was retained.

Adjustment

As I said earlier, adjustment of the exciter is simple. First, get the low-frequency oscillator to work. Next, tune in the exciter output signal on a communications receiver. Then reduce the low-frequency output by decreasing the 12SK7 screen or plate voltage until the exciter output drops off a db. or two—a reduction barely noticeable to the ear or on the receiver *S*-meter.

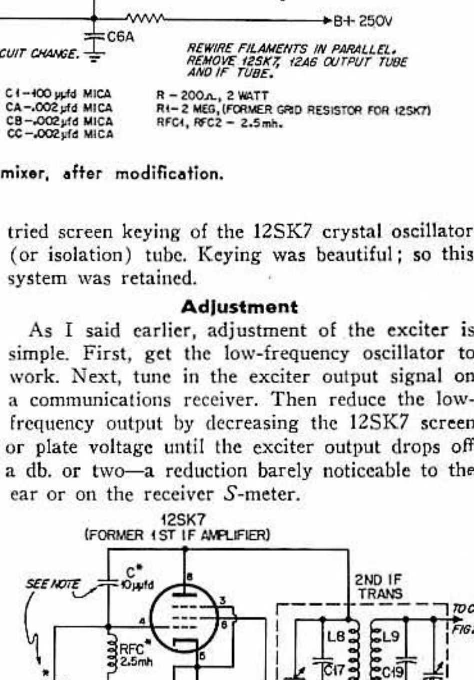


Fig. 3. This is how the first i-f stage is converted to a crystal controlled oscillator.

This adjustment produces maximum output at the desired frequency, commensurate with minimum spurious outputs.

After the low-frequency output is adjusted, adjust the padders across *L3* and the antenna trimmer for maximum output. If necessary, the padders on the high-frequency oscillator should also be adjusted for accurate dial calibration. This completes the conversion.

MOBILE WITH THE SCR-274N

THIS ARTICLE WILL DESCRIBE THE CONVERSION of war surplus SCR-274 transmitters for Mobile . These particular surplus units are very well suited for emergency use, first, because they are v.f.o., second, because they are available, and third, because they were originally designed for mobile use and may be used with their original shock units.

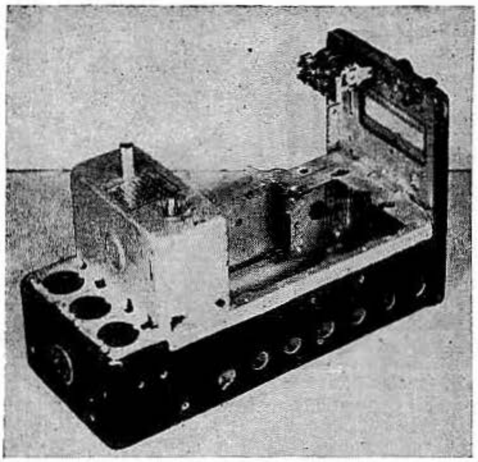
Circuit

With the above in mind, five of the popular SCR-274 command sets were converted for use as either fixed or mobile transmitters. These transmitters are so laid out that they may all be used with the same modulator and power supply by simply plugging the desired unit into the shock-mounted rack, and connecting the coax feed lines to the antenna and converter.

For mobile use on 28, 50 and 144 mc, instant heating filament type tubes are used, while for fixed stations, a heater type of tube such as a 6AQ5 and 2E26 may be used if preferred. There is a very great saving in storage battery life if the transmitter is off completely during standby. Therefore, the former is recommended.

The tubes are 2E30's and 5516's, manufactured by Hytron, although comparable types by other manufacturers could be used as well[2]. The v.f.o section uses a 2E30 connected as a triode, followed by 2E30 pentodes as frequency multipliers, with

[2] Comparable Tubes 2E30, 5618, 6AQ5, 5763, etc.
5516, 2E24, 2E26, etc.



The first step is to strip the chassis.

two 5516's in the final. The modulator unit is constructed on a similar chassis and consists of a 2E30 triode connected as a speech amplifier followed by a 5516 as a clamp tube[3] screen grid modulator. A PE-103 Dynamotor is used for mobile use.

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[3] For more information on clamp tube modulation see:
"Practical Screen Modulation," CQ, Dec. 1949, p. 24
"Screen Modulated Command Set," CQ, Sept. 1949, p. 35
"Clamp Tube Modulation," QST, Mar. 1950, p. 46
"High Output Grid Modulation," QST, Feb. 1951, p. 40

TABLE I

28 mc Coil Data for v. f. o. 4.666 mc to 5.000 mc using variable condensers C_1 and C_2 across coils.

Coil	Frequency Coverage	No Turns	Dia.	Length	Wire	Form	uh
L1	14 to 15 mc	28	1/2"	5/8"	#24	XR-50	5.0
L2	28 to 30 mc	14	1/2"	5/8"	#18	XR-50	1.4
L3 & L4	Links	2	1/2"		#16		
L5	28 to 30 mc	15	3/4"	1"	#16	Poly	1.8
L6	28 to 30 mc	14	1"	2"	#12	Air	1.8
L7	Ant. Link	3	1"		#16	Air	

Coil Table for 28 mc conversion.

28 mc Conversion

Referring to Fig. 1, the area within the dotted lines indicates that part of the original ARC-5 circuit is retained with minor changes in the three highest frequency units. The lead from the grid coil going to the magic eye tube has been removed, along with the tube and its resistors, as they are no longer needed. The crystal is also removed. The neutralizing condenser, which was formerly attached to the secondary of the v.f.o. coil, is discarded. For 6 volt heater operation a 6J5 may be used in place of the 1626 without change in socket connections. However, for the filament type 2E30, it is necessary to remove the octal socket and replace it with a 7-pin miniature. At this same time, all three octal sockets are removed and a small plate with two 7-pin miniature sockets is screwed on the rear edge of the chassis. The second socket is for an OA-2 voltage regulator tube. This is shown in the photographs.

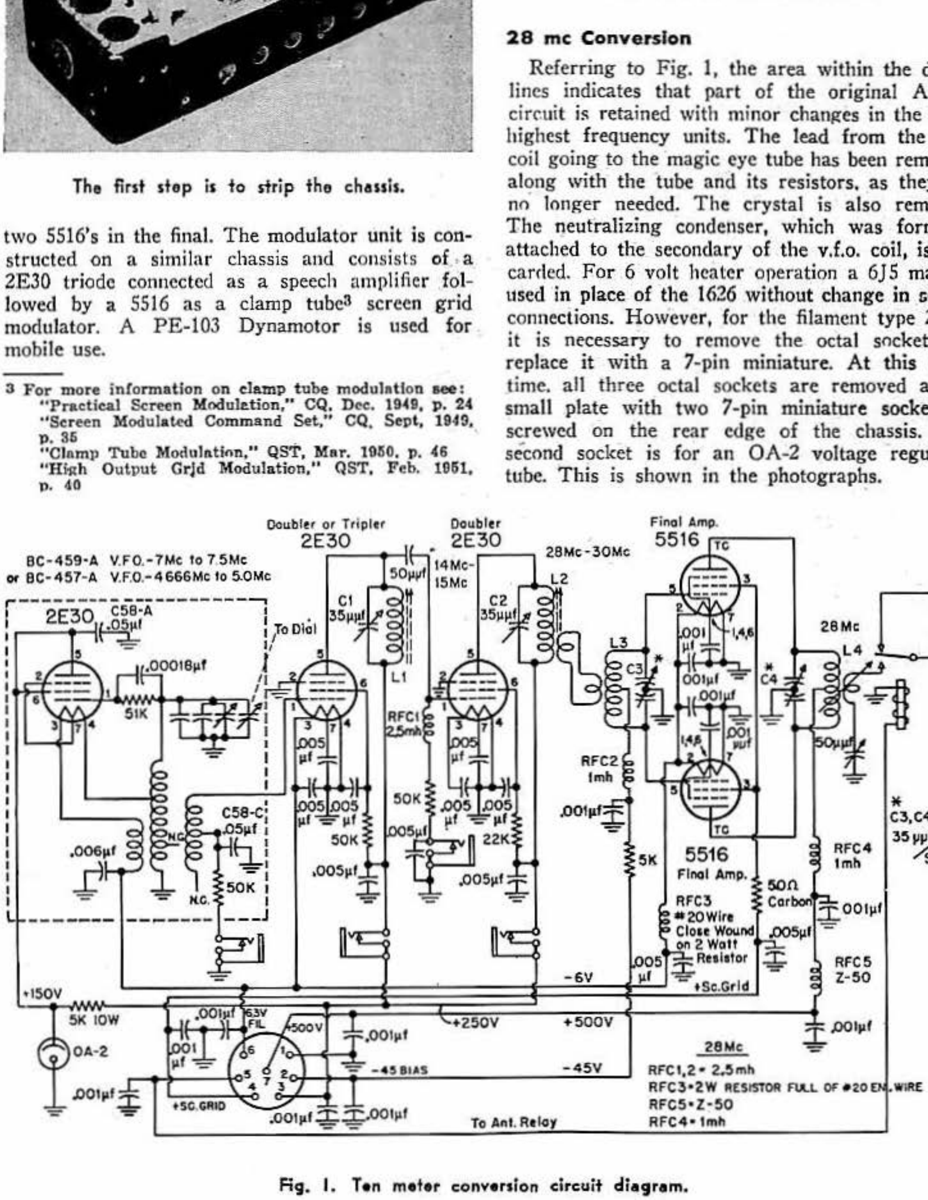


Fig. 1. Ten meter conversion circuit diagram.

A further study of the diagram reveals that the first frequency multiplier is inductively coupled to the oscillator, and capacity coupled to the second frequency multiplier. The output of this second stage could be capacity coupled to the final as far as output is concerned; however, we used inductive coupling in an effort to keep harmonics from feeding through to the antenna. The final amplifier may be either single ended or push-pull, using either 2E30's or 5516's[4], depending on the dynamotor available. In our case we chose push-pull 5516's for added power inasmuch as screen grid clamp tube modulation is not very efficient at best, due to the low average screen voltage. A send-receive antenna relay is mounted next to the antenna coax fittings on the front panel, and a low pass filter is used externally on the ten meter unit.

TABLE II

	GRID		PLATE		SCREEN	
	-Volts	MA	+ Volts	MA	+ Volts	MA
Osc. 2E30	30	1	150	5	---	--
1st Mult. 2E30	30	1	250	15	110	5
2nd Mult. 2E30	150	3	250	18	80	7
Final 2-5516	95	10	500	75	150	10
Sp. Amp. 2E30	10	-	250	10	---	--
5516 Clamp Mod.	25	-	150	25	---	--

Measurements made with V.T. voltmeter and milliammeter

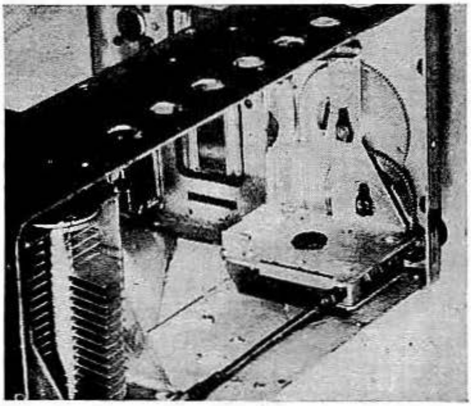
Operating voltages for 28 mc conversion. Transmitter and Modulator.

Construction

Or should we say destruction? Before starting to rewire these units, it is first advisable to remove all parts that will not be used in the final version, and this means everything above and below the chassis ahead of the master oscillator. Start with the coils, then the variable condensers, the 1625 tube sockets, and finally all the small parts, relays, etc. All this junk, of course, is saved for some future use. Take another look at the

Now, with a keyhole saw, cut a nice rectangular hole about 2 inches wide and the width of the chassis where the 1625's used to be. This hole will photos.
later be covered by an aluminum plate, 2½" x 5", upon which are mounted the two 2E30 multipliers, along with their tuning condensers, coils, resistors, etc.

The front variable condenser that holds the tuning dial and worm drive mechanism to the chassis, which you have already removed, must now be taken apart and cut with a hack saw so that all that remains of it is part of the frame—just enough to still hold the dial and worm drive.



This is the condenser frame after alterations.

This can now be replaced in the unit so that we will have a means of tuning the v.f.o. from the front panel, and yet will have enough space above and below the chassis to mount the 5516 sockets, grid coil and condenser. The two coax fittings and 6V antenna relay are now mounted on the rear of the front panel at the top.

A small bracket is bent up to hold the 35 uufd per section tank condenser high enough off the chassis so that a shaft extension can be brought out through the plastic window on the front, for tuning the final amplifier plate coil. The final amplifier grid is tuned through a clearance hole in the right hand side of the chassis.

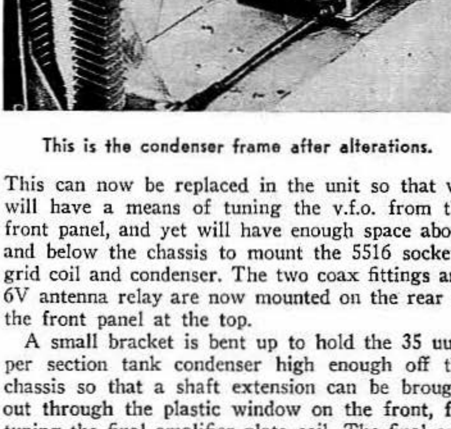


Fig. 2. V.F.O. coil connections.

Closed circuit jacks for metering the various stages are mounted along the side of the chassis and insulated from it with fibre washers. These jacks may seem unnecessary; however, they will save a lot of time in tuning up and trouble shooting later on.

These metering jacks were added after the photographs had been taken, and therefore do not show in the pictures.

[4] Screen resistor and clamp modulator changed accordingly.

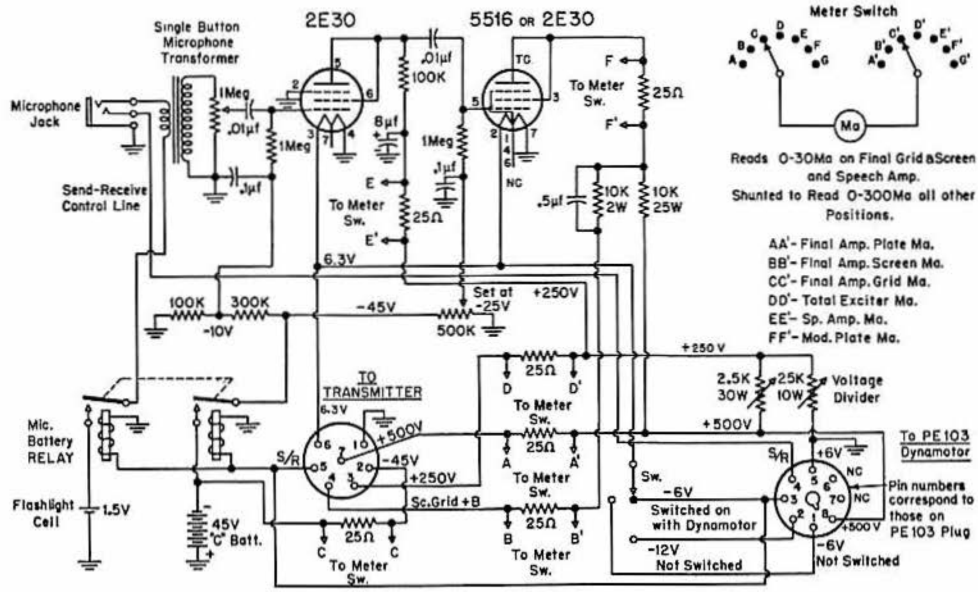


Fig. 3. Modulator circuit diagram.

Frequency Multipliers

The frequency multiplying strip is a small subassembly built up on a piece of aluminum large enough to cover the rectangular cut-out in the chassis where the 1625's used to be mounted. The parts are so laid out that the first 2E30 frequency multiplier grid is close to the tap on the secondary of the v.f.o. grid coil assembly. See Fig. 2 for v.f.o. coil connections. The plate coils and tuning condensers of the 2E30's are located near the edges of the aluminum strip with the two 2E30's in the middle, allowing room to pile up the necessary plate, filament, grid and screen grid by-pass condensers. This arrangement allows the operator to tune the condensers and coil slugs through the access door on top of the dust cover that was formerly used to get at the 1625's.

As shown in the photos, the 5516's are mounted on the left side of the final tank condenser, and the coil is mounted on the right side. The antenna coupling link is adjusted by hand by bending its pigtails and the loading is adjusted by varying the series antenna condenser which mounts on the front panel.

The link line between the last doubler plate coil and the final grid coil is a short length of receiving type 72 ohm twinlead, anchored at each end on tie points.

Coils

The 2E30 coils are wound on National XR-50 slug-tuned coil forms or equivalent, according to the coil table, and are mounted and preadjusted to resonance with a grid dip oscillator before mounting the aluminum strip in the main chassis. The grid coil of the final is wound on a plain ¾" diameter coil form, and after adjustment with the grid dipper is cemented with coil dope. The final plate coil is wound with #12 wire and soldered to the condenser terminals.

To cover from 28.5 mc to 29.7 mc, the v.f.o. frequency range will be 7.125 mc to 7.425 if a BC 459-A is used, requiring two doubler stages. If you are using a BC457-A, the frequency range will be 4.750 mc tò 4.950 mc, necessitating a tripler and a doubler. If you are using a BC 696-A, the frequency range is 3.166 mc to 3.300 mc, following with two triplers. Of course, a BC 458-A can be made to tune the 7.125 to 7.425 mc range by opening out the air padder that is in the shield next to the v.f.o coil, or to tune the 4.750 to 4.950 mc range by closing in the same air padder. The latter will give better band spread, and that is what the writer did. Rotor plates may be removed from the oscillator tuning condenser with a pair of pliers for increased band spread.

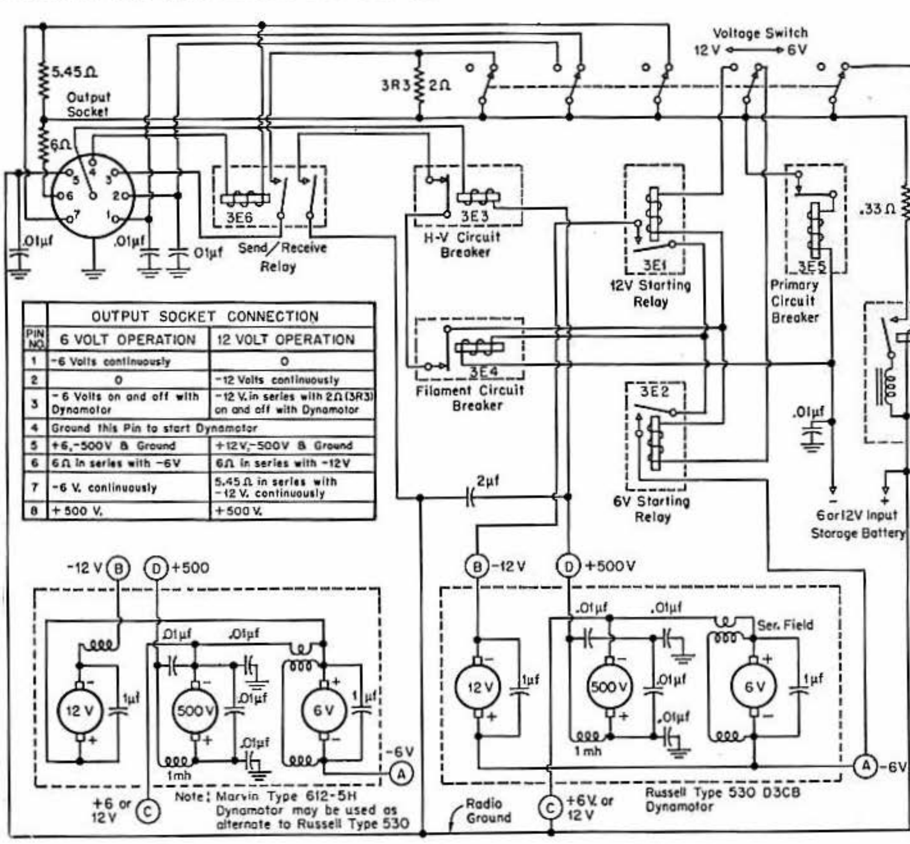
The writer ended up by removing 2/3 of the rotor plates. This gave considerably more band spread on the V.F.O. dial than is shown in the photos. Care must be exercised in twisting these plates and pulling them out with a pair of long-nosed pliers. The force should be exerted with a twisting motion by the pliers between the plates and the rotor shaft and not with a straight pull between the plates and the chassis, as there is danger of pulling the rear rotor shaft bearing out of its socket. (If this does happen, be sure to catch all the tiny ball bearings so that the condenser may be repaired. This is done by removing the condenser from the chassis and removing the rotor so that the ball bearings may be replaced. To do this, drive out one of the taper pins in the flexible shaft, remove the screws holding the condenser to the chassis, unsolder the connections to the coil and tube, remove the spring-loaded gears on the condenser shaft, and unscrew the bearing on the opposite end of the condenser shaft. The rotor now lifts out easily. Holding the condenser vertically with the shaft end down, drop the ball bearings into the race with a pair of tweezers and replace the rotor shaft. Holding the rotor shaft so that the balls cannot fall out, reverse the position of the condenser and replace the balls in the other bearing and then replace the screws. The condenser is now as good as new, and may be put back in the unit. If any balls are lost, they may be replaced from one of the two condensers that you have previously removed. You may even practice on one of these before trying to remove plates from the V.F.O. condenser if in doubt.)

Modulator

The speech amplifier-modulator unit is built on a SCR-274 transmitter chassis so that it may be plugged into a double shock-mounted transmitter rack alongside the transmitter. The circuit diagram is shown in Fig. 3, and consists of a 2E30 triode driving a 5516 clamp tube modulator. If desired, the reader can build up almost any type of modulator ; however, for the power involved and the overall battery drain, we decided in favor of the clamp tube[3], especially since no modulation transformer was needed. Since it is not feasible to use a cathode resistor with a filament type tube, a "C" battery is necessary to set the operating bias for the clamp tube. This same 45V battery supplies fixed bias for the RF units and in this way provides protection for the 5516 tubes in the case of excitation failure. A one megohm pot is connected across the battery as a convenient means of adjusting the clamp tube bias. One leg of this parallel resistor is broken by a relay during receive, so as not to run down the battery. This same relay also breaks the mike battery for the same purpose.

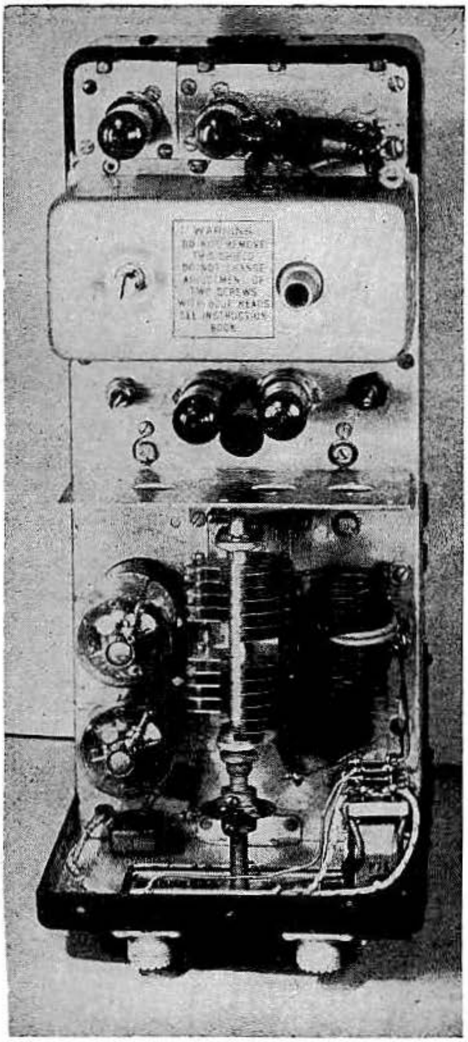
The Modulator unit carries an 0-30 ma meter with meter shunts[5] on the switch for reading the final plate, grid and screen grid in addition to

[5] Correct meter shunts for your particular meter may be calculated from the formula in the ARRL Handbook.



PIN NO.	OUTPUT SOCKET CONNECTION	
	6 VOLT OPERATION	12 VOLT OPERATION
1	-6 Volts continuously	0
2	0	-12 Volts continuously
3	-6 Volts on and off with Dynamotor	-12 V. in series with 2Ω (3R3) on and off with Dynamotor
4	Ground this Pin to start Dynamotor	
5	+6, -500V & Ground	+12V, -500V & Ground
6	6Ω in series with -6V	6Ω in series with -12V
7	-6 V. continuously	5.45Ω in series with -12 V. continuously
8	+500 V.	+500 V.

Fig. 4. PE-103 dynamotor plug connections and circuit diagrams.



Top view of the completed r.f. unit.

modulator plate current which is necessary when tuning up. The voltage divider for the exciter stages, as well as the final screen dropping resistor, are also included in the modulator unit.

Shock Mounting

A standard SCR-274 double transmitter shock-mounted rack is utilized to hold the two units in place either for mobile or fixed station use. A power connector plug is mounted on this rack or one of those already there may be used to make connections to additional racks. The PE-103 dynamotor connects to the modulator chassis. Fig. 4 gives the circuit and output plug connections for the PE-103.

Wire the plugs on the rack into which the transmitter and modulator plug in parallel; that is, pin 1 to pin 1, pin 2 to pin 2, etc. Now make suitable connections between them and the plug that goes to the other rack. See Fig. 5. At the dynamotor, the wiring must be arranged so that the filament voltage is switched on simultaneously with the primary to the dynamotor if other than a PE-103 is used. A switch at the modulator turns the filaments on continuously when using the low frequency units to be described later.

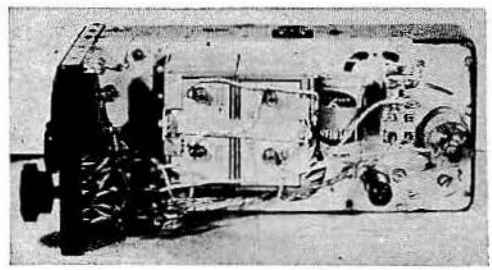
The switches shown in Figure 5 are mounted on the rear of the racks and are for breaking the filaments and plus 250V on the units that may be plugged into the additional racks, but which are not in use at the moment. This feature allows the operator to have up to three racks all connected in parallel, with five transmitters and a modulator plugged in. Any transmitter may be put in operation simply by turning filaments and plus 250V on. The others remain inoperative because their filaments are off. The plus 250V switch prevents all the unused OA-2 voltage regulators from igniting and drawing current.

PE-103 Dynamotor

Figure 4 gives the complete circuit diagram, copied out of the base of one of these units with some difficulty. It will be noted that the output power plug contains all the necessary voltages for operating the rig without any alterations. A S.P.D.T. toggle switch at the modulator selects pin #1 for 6 volt continuous heater operation for use with heater type tubes and pin #3 for 6 V intermittent filament operation for use with instant heating filament type tubes. Note that the + 6 volts is grounded while the −6 volts is above ground. Pin #3 is used to operate antenna relays because it is only energized when the send/receive relay #3E6 in the PE103 is operated.

The push to talk button on the mike, one side of which is grounded, connects to pin #4 to operate relay 3E6. The other contacts on relay #3E6 operate either the 6 volt or 12 volt dynamotor starting relays depending on the position of the 5PDT wafer switch at the top of the diagram. This circuit will be broken if either the H.V. or L.V. circuit breakers, #3E3 and #3E4, kick out due to an overload or short. #3E3, #3E4 and #3E5 are the three big switches behind the door on the side of the PE103 base, #3E5 is the primary circuit breaker.

For six volt operation, the S.P.D.T. wafer



The modulator. Batteries are for mike and bias.

switch, located under the cap on the top of the base next to the output connector, must be turned with a screw-driver to the six volt position. If it is desired to cut down on battery current, two six volt batteries may be used in the car; however, in this event, resistor 3R3, two ohms, must be shorted out and the filaments of all the tubes in the transmitters must be put in series-parallel for 12 volt operation. In addition, 12 volt antenna relays must be used. In the two low frequency conversions, the original 1625's and 1626's may be retained by wiring their heaters in parallel as they are 12 volt tubes. The PE103 wafer switch is now set for 12 volt operation. The filament/heater switch in the modulator unit referred to above is wired between pins #2 and #3 instead of #1 and #3.

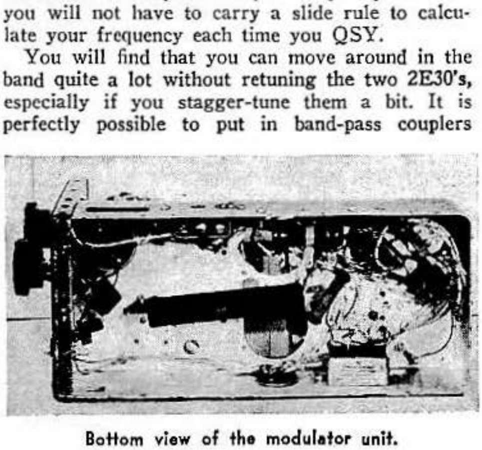
If trouble is experienced with the H.V. circuit breaker #3E3 kicking out too easily, it may be corrected by soldering a 10 ohm 1 watt resistor in parallel with the coil. This will increase its current handling ability, but will still allow it to kick out on a H.V. short circuit.

The two dynamotor diagrams at the bottom of Figure 4 are two different combinations that you may find in the PE103.

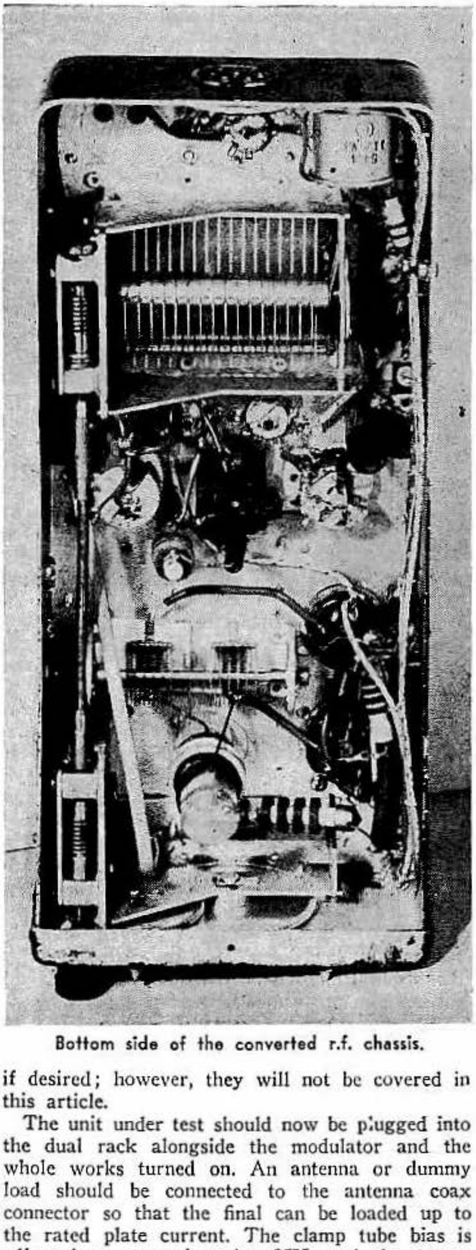
Tuning Up

The first step is to recalibrate the v.f.o. section. The dial is given a coat of Automobile Touch-up Black paint to cover the old calibrations and is then marked with a pencil and later the new calibrations are painted white with a fine pointed paint brush. The frequency lettering may be put on with "decals" if desired. With all the tubes removed except the oscillator, 250V is applied and the oscillator is adjusted until the frequency coverage is about right. Next, all the tubes are replaced in their sockets and the coils are tuned up with a grid dipper to their proper frequencies. Now, with the final plate and screen voltage temporarily disconnected, the plus 250 is again applied and the 2E30's are tuned for maximum final grid current. With the transmitter operating in this condition, the main v.f.o. dial should be calibrated directly in output frequency so that you will not have to carry a slide rule to calculate your frequency each time you QSY.

You will find that you can move around in the band quite a lot without retuning the two 2E30's, especially if you stagger-tune them a bit. It is perfectly possible to put in band-pass couplers



Bottom view of the modulator unit.



Bottom side of the converted r.f. chassis.

if desired; however, they will not be covered in this article.

The unit under test should now be plugged into the dual rack alongside the modulator and the whole works turned on. An antenna or dummy load should be connected to the antenna coax connector so that the final can be loaded up to the rated plate current. The clamp tube bias is adjusted to approximately -25V, and the screen dropping resistor is adjusted until the screen voltage on the 5516's is about 150 volts. When modulation is applied, this voltage will swing up and down at audio frequency. Adjust the antenna coupling or loading until a flashlight bulb coupled to the tank brightens up when modulation is applied. Table 2 gives operating voltages and currents for the transmitter.

Clamp tube modulation, if correctly set up and adjusted with a scope, does a good job and sounds fine. However, it is not something you just wire up with a handful of parts, connect to any screen grid final and get good-sounding 100 per cent modulation. The wave form shown on an oscilloscope can be about as awful as the writer has ever seen if the clamp tube bias, the final grid current, the final screen voltage, or the antenna loading are incorrectly adjusted. Without the screen dropping resistor, by-passed for audio, between the clamp tube plate and the final screen, it is difficult to get more than about 50 per cent modulation. If you try to increase the percentage by opening the gain, all you do is produce square waves with the resultant distortion. On the other hand, if you set the thing up right with a scope, it will sound fine and becomes a very economical means of modulation. Straight transformer type of screen grid modulation could be used if desired, by utilizing one of the modulation transformers, T52, out of the original SC274 modulator, BC-465-A. The plus B goes to terminal #1, the 5516 modulator plate to terminal #2, terminal #4 goes to the final screens, and terminal #3 goes to plus 150V for the final screen voltage. Terminals #6 and #7 are not used. See Figure 6.

In any form of screen grid modulation, the screen grid voltage must be run at about 1/2 of the normal plate modulated value with the resultant reduced output. The stage must also be run more like a class B linear amplifier with the decreased efficiency of such an amplifier.

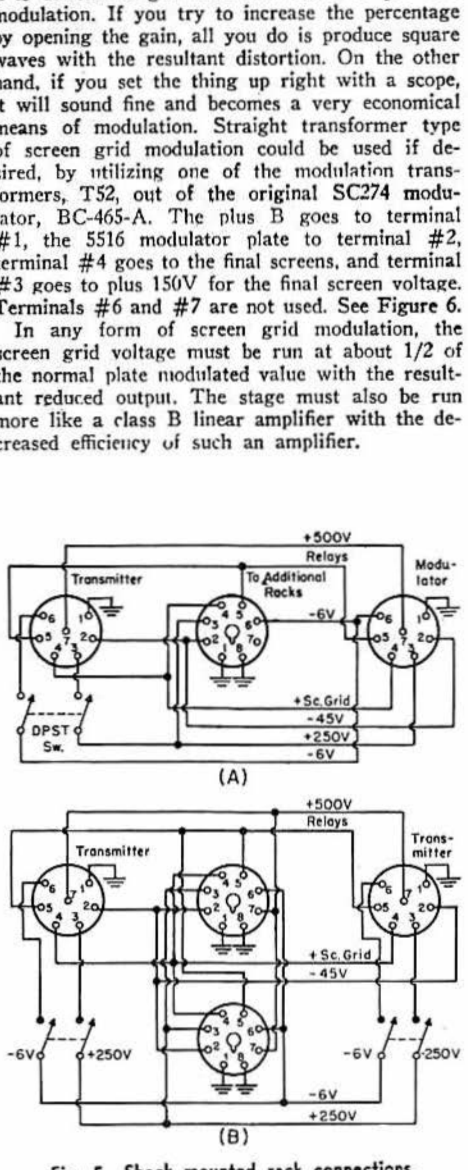


Fig. 5. Shock mounted rack connections.

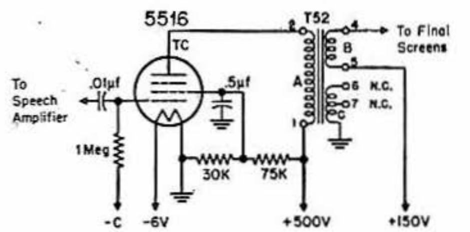


Fig. 6. Optional modulator, using transformer T-52

By far the most efficient form of modulation is narrow band frequency modulation. This is excellent for mobile use providing crystal control is used with a phase modulator. However, all the mobiles and net control stations should be equipped with FM receivers (NBFM adapters) which might not always be practical. V.F.O. could not be used because the vibration of the V.F.O. in mobile use would produce frequency modulation. With AM modulation the FM component is not objectionable because the signal is tuned "on the nose", and there the FM is the weakest.

The circuit diagram of the clamp tube modulator shown in Figure 3 calls for either a 5516 or a 2E30. Either may be used with slight difference in performance. The writer used a 5516 because one was available. For further information, on clamp tube operation, the reader is referred to the footnotes.

Neutralizing

The final amplifier should be checked for neutralization by observing whether or not the grid current changes when the plate circuit is tuned through resonance with both the plate and screen voltages of the final turned off. A grid current change indicates the need of neutralization. It was found necessary to neutralize the 5516's in our case, and this was done in the usual fashion by crossing over the grid leads and extending two pieces of stiff insulated wire about 2 inches long up beside each tube. These wires were bent towards or away from the glass envelopes while reading a crystal diode wavemeter, coupled to the final tank, for the lowest possible indication.

TVI and Antenna

This 10 meter transmitter incorporates the most essential TVI measures, such as filtering of the power leads, link coupling to the final and the use of a low pass filter in the 52 ohm coax feeding the whip. It is not 100 per cent TVI-proof but if the dust cover and bottom plate are screwed on well, it does not bother Channel 2 unless the car is parked right in front of the house containing the TV set.

Added TVI proofing can be accomplished by improving the shielding on the transmitter itself by covering the louvres, the rear corners and the plastic window on front with copper screening.

The standing wave ratio should be checked on the RG8-U line feeding the whip, with an "Antennascope," or resistance bridge, and the length of the whip adjusted for a minimum SWR at your operating frequency. This will insure that the Niagara low pass filter will work properly. In my case, the whip length turned out to be about nine feet long, to reflect 50 ohms at the transmitter. An eight foot whip looked like 15 ohms. The RG8-U in my installation was only two feet long. Signal strength reports were about the same with both whip lengths, however.

50—54 MC Unit

If you use a BC 458-A, the v.f.o. tuning range will be 5.555 to 6.000 mc followed by two triplers. If you use a BC 459-A, the v.f.o must cover from 8.333 to 9.000 mc and must be followed by one doubler and one tripler. Here, as in the case of the ten meter transmitter, other SCR 274 transmitters may be used by altering the coil and condenser in the v.f.o., so that they tune either of the above ranges.

The conversion to be described used a BC 458-A, and to get more band spread on the v.f.o. dial, the powdered iron slug was screwed all the way out of the coil, and the air padder was turned nearly all the way in. We ended up tuning 5.555 to 6 mc with considerably more band spread as shown in the photos. Plates may be removed from the oscillator condenser to obtain added bandspread if desired.

When substituting a 2E30 for a 1626, the frequency will be lowered slightly due to the higher grid-to-filament capacity in the 2E30, so if you intend to use the present dial calibrations, be sure to compensate for this by adjusting the padder.

Frequency Multiplier

Regardless of whether you double or triple in the first 2E30 multiplier, its plate coil must tune the range of 16.666 mc to 18.0 mc. The next 2E30 triples to 50 to 54 mc, and is link-coupled to the push-pull 5516 grid coil. This exciter strip is built up on a small 2½" x 5" aluminum plate, and is mounted over a cutout on the chassis exactly as was described in Part I for the 28 mc transmitter. In fact, the entire chassis conversion, removal of parts, mounting coax connectors, antenna changeover relay, etc., is identical on both the ten and six meter units and so will not be repeated here. The reader is referred to April 1951 CQ for details.

If desired, the builder may dispense with the small APC variable condensers shown tuning the 2E30 plate coils, and utilize the fixed input and output tube capacities of the 2E30 and tune with the powdered iron slug in the National XR-50

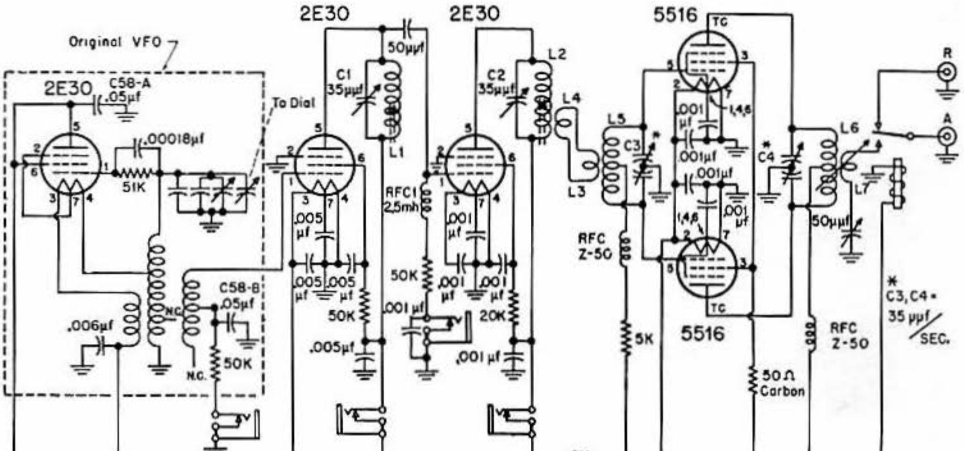
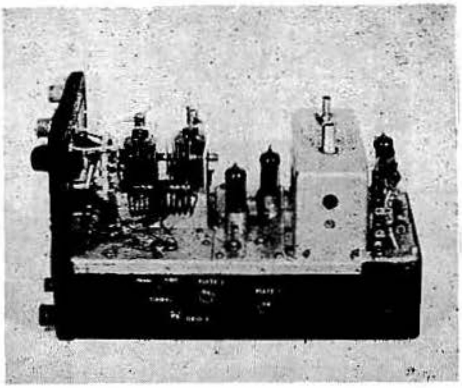


Fig. 7. The 50 mc conversion of either a BC-458-A or BC-459-A.

TABLE III
Coil Data for 50-54 mc Output

Coil	Frequency Coverage	No. Turns	Dia.	Length	Wire	Form	uh
L1	16.666-18.0mc	20	1/2"	5/8"	#22	XR-50	3.0
L2	50.0-54.0mc	6	1/2"	5/8"	#18	XR-50	.25
L3&L4		2	1/2"		#16		
L5	50.0-54.0mc	11	5/8"	11/2"	#14	Air	.75
L6	50.0-54.0mc	12	5/8"	2"	#12	Air	1.1
L7	Antenna Coil	3	5/8"		#16	Air	

See Text for coil dimensions if C_1 and C_2 are omitted.



Right hand view of the converted 50 mc transmitter. The remaining grid current jack is on the left hand side of the chassis.

coil form. Winding the coils is a little more critical as the tuning range with the slug is much more limited than with the variable condenser arrangement. Figure 7 shows the 50-54 mc circuit diagram. The first 2E30 multiplier plate coil tunes 16.6 to 18 mc and is shunted by 4.5 μμf, the plate-to-filament capacity, plus 10 μμf, the grid-to-filament capacity of the following 2E30, plus strays of about 5 μμf. This makes a total of around 20 μμf across the coil. The inductance necessary to cover the above range then becomes 3.8 μh to 4.5 μh. This can be made by winding 21 turns of 24 enamel wire on a National XR-50

The second 2E30 multiplier only has about 8 μμf across it, so it requires 1 μh to 1.2 μh to tune the range of 50 to 54 mc. This is a coil of 10 turns of #18 enamel wire wound on an XR-50 coil form. The link is 2 turns, wound on the cold end.

It is wise to check the ranges covered by the coils before applying the coil dope and mounting them permanently in the chassis. This is conveniently done by mounting them temporarily on the small sub-chassis together with the 2E30 sockets before the sub-chassis is mounted on the transmitter. The filament, screen grid, and other wiring is completed and the coils are temporarily soldered into the circuit. With both 2E30's in their sockets, the slugs are screwed from minimum to maximum while checking the resonant frequency with a grid dip oscillator. A turn or two is added or taken off from the coils as required, so that the slugs will tune the desired range with some leeway. The coils may now be "doped" and permanently mounted in place and the sub-chassis may be bolted to the main chassis. See Table III for coil

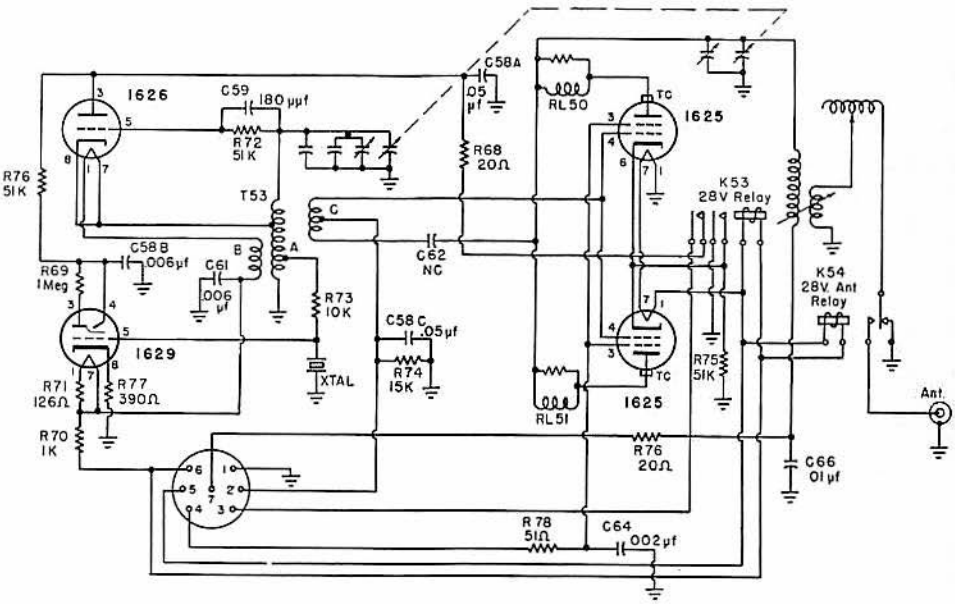


Fig. 8. The original circuit of the BC-696-A (and Navy CBY-52232).

winding data if parallel condensers are used to tune the coils.

Final Amplifier

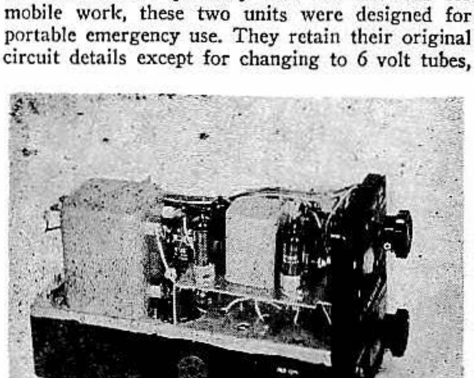
The components for the push-pull 5516 final amplifier are mounted in much the same fashion as for the 28 mc transmitter. The reader is referred to the photographs which show the general layout. The final tank condenser is raised off the chassis by means of a small aluminum bracket so that the plate leads will be short and so that the condenser shaft will protrude through a hole in the plastic window. The antenna loading condenser is mounted under the antenna change-over relay on the right hand side of the front panel. The grid tuning condenser is mounted for screw driver adjustment through a clearance hole in the right hand side of the chassis. Incidentally, to be sure to keep all your metering jacks and screw driver adjustments on the right hand side of the transmitters and all the switches, power plugs, etc., of the modulator on the left hand side, so that they will all be available when the two units are plugged in side by side in a double mounting rack with the modulator to the left and the transmitter to the right.

Tuning Up

The tuning up precedure for this 50 mc unit is similar to that of the 28 mc unit. First pretune all stages to the desired frequency with a grid dip oscillator so that they will be in approximate resonance when first turned on. Then with final screen and plate voltage off, peak the multipliers for maximum final grid current. Calibrate the v.f.o. dial in output frequency, marking the calibrations in white paint. Attach the antenna 52 ohm coax feed line and adjust the antenna coupling and loading for optimum output consistent with upward modulation as indicated by a flashlight bulb coupled to the final tank coil. See Table IV for operating voltages and currents.

1.75 to 2 mc and 3.5—4 mc Conversions

Inasmuch as these frequencies are proposed for communications between various disaster services and for some type of medium distance C.D. communications and probably will not be used for mobile work, these two units were designed for portable emergency use. They retain their original circuit details except for changing to 6 volt tubes,



The class B modulator; microphone and bias batteries are on the far side of the chassis.

TABLE IV
Voltage and Current Measurements 50-54 mc r.f. unit

	GRID		PLATE		SCREEN	
	Volts	MA	Volts	MA	Volts	MA
Osc. 2E30	-50	1.0	150		Triode Connected	
1st Mult. 2E30	-35	0.7	250	20	110	3
2nd Mult. 2E30	-100	2.0	250	20	110	3
Final 2-5516	-70	5.0	450 to 500	80-100	150	10

Class B Modulator

1st Sp. Amp. 2E30	-10	0	220	1.6	Triode Connected	
2nd Sp. Amp. 2E30	-22.5	0	220	25	220	5
Mod. 2-2E30's	0	0	450-500	5-80	Triode Connected	

Measurements made with V.T. Voltmeter and Milliameter.

a 6J5 and 2-807's,[9] and minor changes in wiring to enable them to be plugged into our shock-mounted rack for power and modulation. The units used are the 2.1 to 3.0 mc Navy Model CBY-52232, and the 3.0 to 4.0 mc Signal Corps BC-696-A. The conversion of these two units is identical except for changing the frequency of the v.f.o. in the Navy model. Figure 8 shows the original circuit diagram of these units before conversion and Figure 9 shows the circuit after conversion. Note that the relay under the chassis which originally broke the plus B for the oscillator and shorted the cathode of the 1625's has been removed. The plus B to the oscillator now runs directly to Pin #3 on the socket at the rear of the chassis, and the cathodes, and one side of the heaters of the 807's are now grounded. The antenna shorting relay on the inside of the front panel is removed and replaced by a s.p.d.t. 6 volt relay mounted on the outside of the front panel due to lack of space inside. This relay may be omitted if separate antennas are provided for the transmitter and receiver. The old grid leak of the final, mounted on spare pins #5 and #7 of the crystal socket, is simply clipped out of the circuit. A new 5000 ohm grid leak is put in the lead from Pin #5 on the crystal socket to Pin #2 on the power socket at the rear where it picks up minus 45 volts of battery bias. This is necessary to prevent the old resistor from shorting the bias battery.

The magic eye tube may be replaced with a 6E5, a six volt type, by changing the socket, or may be discarded along with the crystal. In either event the only circuit changes necessary are the rewiring of the heaters of the two tubes on the rear of the chassis in parallel instead of in series, and the removal of the resistor that parallels the magic eye tube heater.

In the event that you use a BC-696-A, it is of course all calibrated for the 3.5—4 mc range. However, you can use the BC-457-A, which covers 4—5.3 mc, just as easily by cranking in on the

9 "Mobile with the SCR-274N." George M. Brown, W2CVV, CQ, Jan. 1948, p. 22.

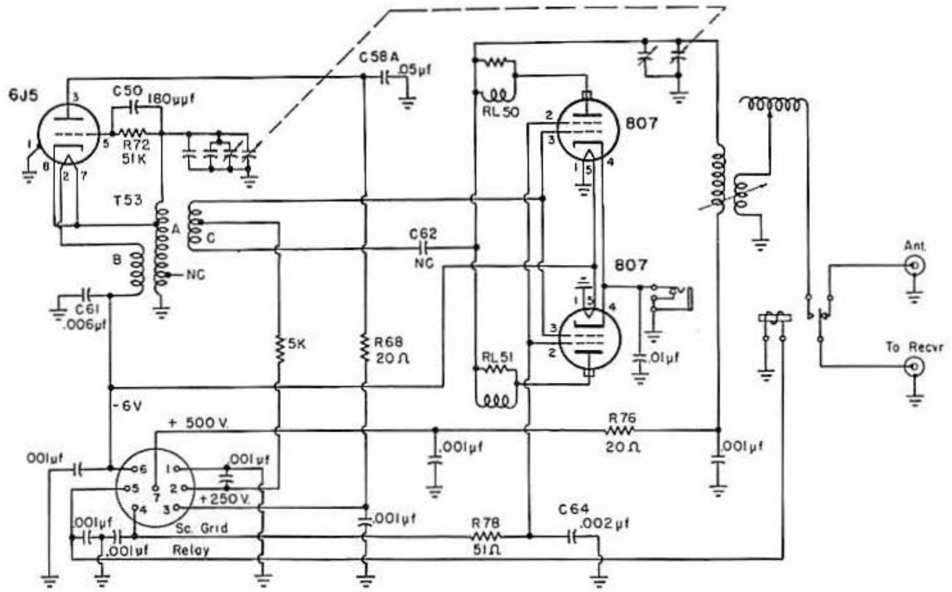


Fig. 9. W1DBM's 80 and 160-meter conversion from the circuit of Fig. 8.

two air padding condensers, one on the v.f.o. and the other on the final. (This is exactly what is now done on the Navy Model CBY-52232 to lower its frequency from 2.1—3 mc to 1.7 to 2.1 mc.) To do this, it is necessary to remove the cover from the v.f.o. and loosen the set screws on the shaft of the padding condenser. A 3/8" diameter hole is now drilled in the shield can so that the shaft of this condenser can be tuned with a screw driver after the can has been replaced. After the oscillator has been trimmed to cover the desired frequency range, the can is again removed and the set screws on the condenser shaft are tightened. Now replace the can and you are all set to recalibrate the dial in the same fashion as outlined for the other units Figure 10 shows my 160 meter calibration; yours should be similar.

Tuning Up on 160 and 80 meters

The voltage on the oscillators in the two low frequency units will run higher than in the 10 and 6 meter conversions, since there are no frequency multipliers pulling current through the voltage divider in the modulator unit. An auxiliary voltage divider may be built into each of these units if necessary, so that the correct voltage, +250, will be obtained. In tuning up these two low frequency units it is first necessary to couple a lamp load to the 807 tank coil and then switch the modulator to "filaments on all the time" position. Start the dynamotor and with a screw driver, "zero dip" the final padding condenser through the hole in the side of the chassis. This is the middle condenser under the chassis, and must have its set screws loosened first. After bringing the final to resonance, the set screws are tightened again, after which the final should track pretty well with the ganged-tuned v.f.o.

Antennas

It has been the author's experience that the 3-4 mc BC 696-A transmitters will feed voltage to a short antenna of from 10 to 30 feet in length, providing a 50 $\mu\mu$f condenser is connected from the antenna binding post to ground. They will also end feed an antenna approximately ½ wave long, between 100 and 150 feet. For other lengths it will be necessary to use a series condenser or a loading coil to shorten or lengthen the antenna electrically. With a little experimenting these units will feed a base loaded whip; however, the exact antenna will be left up to the reader. Probably the greatest C.D. use to which these low frequency units would be put would require the operator to drive to some favorable spot, park his car, string up a long wire to a tree and get a message through to some other city.

C. W.

If conditions require the use of c.w., this may be accomplished in a simple manner by inserting a key in the cathode jack of the 807's. This does not permit break-in operation; if much c.w. operation is anticipated, the reader is referred to one of the many articles dealing with improved break-in keying of these units.[10]

Plate Modulator

A good many hams will prefer to build a conventional push-pull Class B plate modulator on general principles, while others may wish to avoid some of the fussy adjustments necessary for the correct operation of screen grid modulation.

For the benefit of these who have some spare milliamperes left in their dynamotors and who would like to use regular plate modulation, the circuit shown in Figure 11 may be plugged into the rack interchangeably with the clamp tube modulator described in Part I. By so doing, you will gain: about half an "S" unit of signal strength, slightly higher percentage of modulation, oftentimes of better quality (no clipping), and greater ease of adjustment. Total cost: upwards of 100 ma more plate current drain at 500V, which

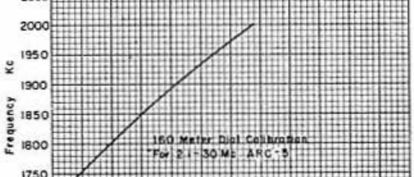


Figure 10.

equals 50 watts or more out of your storage battery while transmitting. At 6V this is another 10 amps.

Modulator Circuit

Referring to Figure 11, it will be seen that two 2E30's are used to drive another pair as modulators. The transformers shown in the photos are war surplus from the ART-13, which were used by the Signal Corps for 811's in Class B to modulate a single 813. They obviously will handle ten times the audio necessary in this case. However, they are cheaper and smaller than the usual 25 watt multimatch transformers which may be substituted of course. The r.f. load will be around 5000 to 6000 ohms, 500 volts at 80 to 100ma. This particular surplus modulation transformer has a primary to secondary impedance ratio of about 2 to 1 and, therefore, our r.f. load will reflect an impedance of ten to twelve thousand ohms in the primary. A pair of 2E30's in Class AB_2 requires 3800 ohm plate to plate load resistance, so we would have a pretty bad mismatch. We can correct this somewhat by putting both the r.f. plate and screen

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10 "Modification of the SCR-274N," E. B. McIntyre, W3KHJ, CQ, July 1948, p. 48.

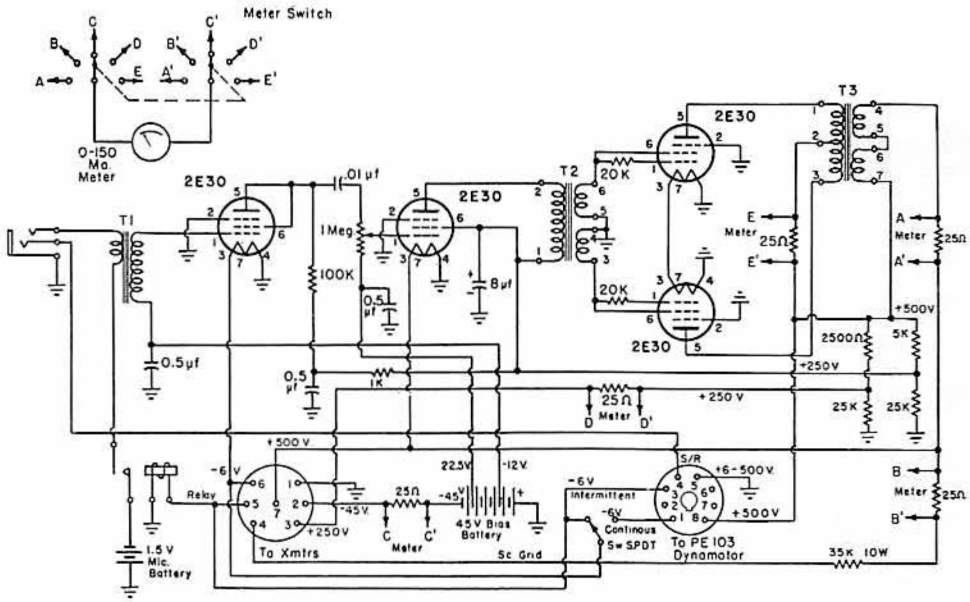


Fig. 11. The speech amplifier and class B modulator.

secondaries in series, assuming that an 813 screen winding will carry the 80 to 100ma without burning out. If the two windings are connected so as to add, we will get a 1.44 to 1 or a reflected impedance of between 8000 and 9000 ohms.

By using the 2E30's as triodes in Class B, we will save on the plate current drain from the dynamotor. One way is to tie the screens to the control grids so that zero bias may be used. A simple improvement on this method, which permits driving the screens to a higher potential than the control grids, uses dropping resistors in series with the control grids.[11] [12] For instant-heating filament tubes it is necessary to use transformer coupling. This requires a transformer, with a secondary that can handle the screen current of the modulator. In our case the surplus transformer used to drive the above mentioned 811's in Class B worked out satisfactorily. To get the required power to drive the modulator by this means, it was necessary to use two 2E30's from a single button mike, one triode and one pentode.

Additional information on suitable modulators can be found in the ARRL Handbook.

Construction

The chassis upon which the modulator was built was salvaged from a beat-up BC 457-A. All the parts were removed and a new front panel was bolted on over the old one. The four 2E30's were mounted on a small sub-chassis as shown in the photograph, with the driver transformer in the middle. The modulation transformer and relay are mounted on the rear of the chassis with the bias batteries along the right hand edge. Smaller batteries such as the hearing aid type may be used if available. All the voltage dividers, decoupling resistors, by-pass condensers and mike transformer are mounted at convenient spots under the chassis. The dynamotor plug and the filament switch are mounted on the left hand side, as in the clamp tube modulator previously described.[9] The meter switch, gain control and mike jack are on the front panel, together with the meter.

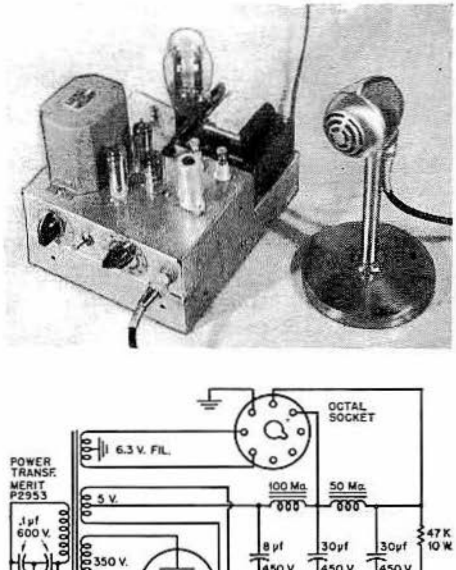
Tuning Up

The first thing to do in checking the modulator unit is to set the sliders on the variable resistors in the two voltage dividers so that around 250V is available under load. One of these dividers is for the exciter and the other feeds the modulator and speech amplifier.

The unit must of course be plugged into the dual transmitter rack with either the ten or six meter transmitter, while this adjustment is made. Once this has been done, the modulation of the transmitter can be tried out. If an oscilloscope is available, it should be hooked up to observe the modulation envelope and the gain control setting determined for 100% modulation. Be sure the antenna loading is the same as you will use in the car.

11 RCA "Ham Tips," Vol. VII, No. 2, May-June 1947.
12 "A High-Power Modulator for Mobile Operation," George M. Brown, W2CVV, CQ, Feb. 1950, p. 20.

SCREEN GRID MODULATING THE COMMAND RIGS



Complete modulator and power supply. Controls are, from left to right: Adjustable screen dropping resistor; c.w.-phone switch (to lower power input from 200 to 100 watts); mike input, and audio gain control.

THERE SEEMS to be no end to the uses that may be made of the popular command transmitters. But one obvious application seems to have been overlooked and that is operation of the BC-696 or converted BC-457 as a screen grid modulated phone.

Screen grid modulation can be accomplished with very low audio power and with a very simple modulation transformer. Furthermore, adjustment of the circuits is simple. Examination of the accompanying circuit diagrams will show that the components are small and relatively inexpensive and can be easily obtained. Any speech amplifier that will deliver two and one half watts or more of audio can be used and matched to the screens with a suitable transformer.

The modulator shown in the photographs is the one now in use at WØCRO. It has a 6AU6 input tube, a 12AU7 phase inverter feeding into a pair of Class A 6AQ5s. In the original setup a factory built PA amplifier was used which had an 8-ohm output. It was coupled to the transmitter with a universal output transformer and a load resistor

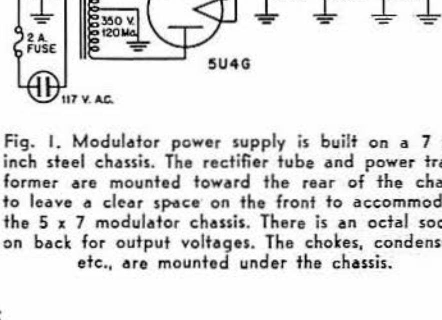


Fig. 1. Modulator power supply is built on a 7 x 9 inch steel chassis. The rectifier tube and power transformer are mounted toward the rear of the chassis to leave a clear space on the front to accommodate the 5 x 7 modulator chassis. There is an octal socket on back for output voltages. The chokes, condensers, etc., are mounted under the chassis.

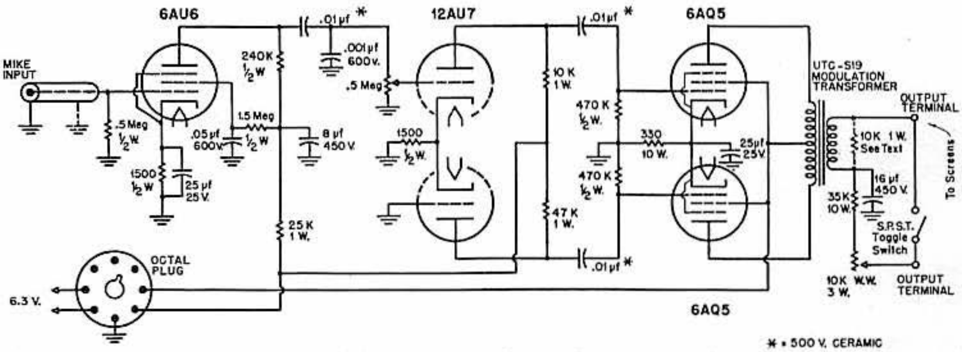


Fig. 2. The screen grid modulator is built on a 5 x 7 chassis which is mounted on the front of the power supply chassis. A cable with an octal plug comes out of the rear of the chassis and plugs into the octal socket on the back of the power supply. The audio output of the modulator, which is terminated with two feed-through insulators, is connected in series with the screen voltage feeding the transmitter.

placed across the 8-ohm line. In this modulator a small universal modulation transformer was used and matched with its highest ratio (10,000 ohm primary to 14,000 ohm secondary). This impedance is not critical.

Since we know a number of hams using the BC-696 for 100-watt phone rigs, modulating them with Class B modulators, conditions in this article have been set up to duplicate this performance.

Instead of the usual 400-volt power supply as used with the BC-696 when Class B modulated, a supply capable of delivering 800 volts under load was chosen. The supply must be capable of delivering 250 ma average power to the final, plus bleeder and screen current. The transformer in this particular installation has a rating of 1040 volts a.c. each side of center at 400 ma and is used with a 16-μf single-section filter. The screen voltage is obtained from this supply through a suitable dropping resistor to develop 450 volts of regulated supply across three VR150s in series. This 450 volts is used on c.w. and when tuning up on phone, but is further reduced in the modulator before modulation is applied. A separate oscillator supply delivering 300 volts is regulated by two VR150s in series. With 300 volts on the oscillator it will deliver the 7 ma of drive required.

Modulation is accomplished by reducing the screen voltage to about one half of the value used on c.w. and then applying suitable audio voltage to swing the screen between zero and the 450 volts applied on the average peak c.w. condition.

Tuning Up

To accomplish the proper modulation of the carrier and to adjust the screen voltage to the proper portion of its operating curve a definite tuning up and adjusting procedure is used. Referring to the diagram of the modulator the control switch is closed for the initial tune up. The transmitter is then loaded up to 200 watts input or 800 volts at 250 mills which is an average carrier wattage whose instantaneous peak power is 400 watts. The switch is then opened and without changing anything else, the screen voltage is reduced so the plate current drops to one half, or 125 mills, which is 100 watts and is the phone carrier average power. Then apply enough modulation to cause the plate meter to move slightly; if the meter kicks upward it indicates the screen voltage is a little too low, if the meter kicks downward the screen voltage is a little too high. Attempt to adjust the screen voltage for minimum kick in either direction as a final adjustment. Just enough modulation to make the meter barely move is close to 100% modulation.

As an added refinement the d.c. was removed from the modulation transformer winding as shown in *Fig. 2* requiring the use of the choke and condenser, although the modulator works nicely without this modification.

With screen grid modulation and 100 watts power there has been no sign of BCI. An a.c.-d.c. midget can be operated right alongside the transmitter or within inches of my vertical antenna without any sign of blasting or signals beyond those characteristic points where a signal can be heard as a function of the receiver oscillator harmonics producing 455 kc i.f. beats.

A standard type 47 pilot lamp can be connected across about a foot of the antenna wire at a current point for a modulation indicator. Using this method of tuning and by making suitable changes there should be no reason why other rigs employing screen grid tubes cannot be similiarly modulated with excellent results.

AN ARC-5 MODULATOR

THE MOST COMMON FAULT with amateur mobile phone installations (and many home stations) is probably the lack of sufficient high-quality audio power for adequate modulation without overload. This is a perfectly understandable situation, since plate power is precious, and the desire to put as much of it as possible into the final, even at some sacrifice in modulation capability, is part of human nature, regardless of the effect it may have on the readability of the signal. The modulator to be described herein, and the complete high-

The modulation transformer fits nicely between the 807s and the meter and leaves plenty of room for the cover.

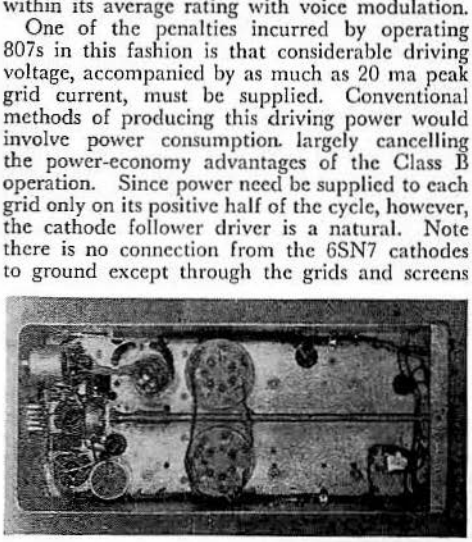
power mobile installation built around it, provides about the highest level of fully-modulated power that can be handled by a standard automobile battery and generator without excessive auxiliary charging. It is capable of as much as 60 watts input to the final, with 100% modulation, using a PE-103 for plate power and can be readily removed from the car for use as a fixed or portable station, using a rectifier power supply, and operated with as much as 120 watts input.

In spite of this high power capability, the modulator is economical for transmitters of as low as 30 or 40 watts input, since the static plate current is lower than that of a 6N7, with 10 watts rated output, and about one third the static plate and screen current of a pair of 6L6s, Class AB_1 with 24.5 watts rated output. Higher plate voltage is required, but in general this is obtained from a 450- to 600-volt dynamotor used for the r.f. also and is readily available.

The Driver

One of the most unique features of the modulator, *Fig. 1,* is the use of a push-pull cathode follower driver stage direct coupled to the grids of the 807 modulators. The 807s are operated with their "zero bias" Class B connection, in which their screens and control grids are both driven, the screens somewhat harder than the grids. With zero voltage on both grids and screens, the static plate current is reduced to a very low value, of the order of 5 or 10 ma. Actually, the direct-coupled cathode followers supply approximately 10 volts of positive bias with resultant total static plate current on the 807s of 30 ma. Of course, with tone modulation this plate current increases to 80 to 150 ma, depending on the output required, but on voice, although peaks of the same magnitude are present, the average is far lower. This means that a PE-103, rated at 160 ma at 500 volts, can be loaded to 120 ma into the p.a. and still be within its average rating with voice modulation.

One of the penalties incurred by operating 807s in this fashion is that considerable driving voltage, accompanied by as much as 20 ma peak grid current, must be supplied. Conventional methods of producing this driving power would involve power consumption largely cancelling the power-economy advantages of the Class B operation. Since power need be supplied to each grid only on its positive half of the cycle, however, the cathode follower driver is a natural. Note there is no connection from the 6SN7 cathodes to ground except through the grids and screens



The bottom view illustrates its simplicity.

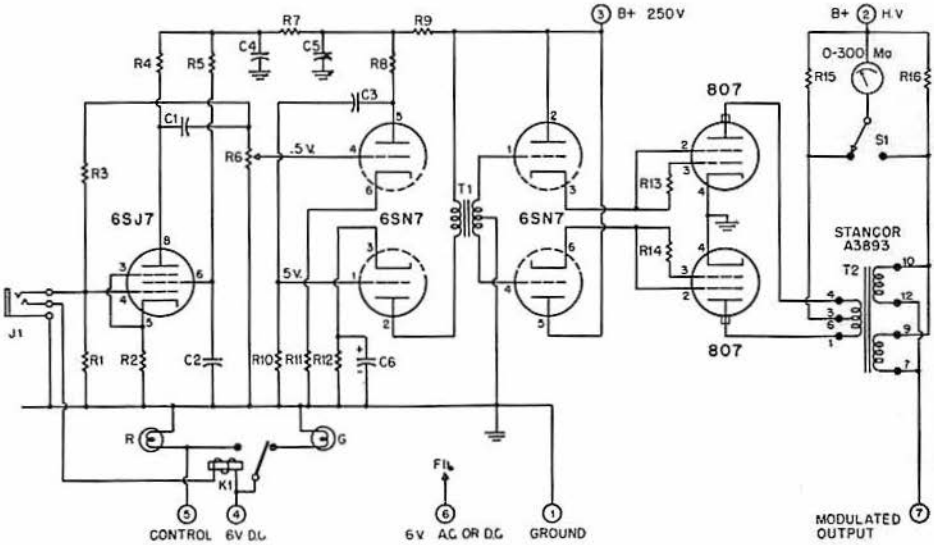


Fig. 1. The circuit diagram of the modulator.

C1, C3—.006 µf
C2, C4, C5—.05 µf
C6—5-µf audio bypass
R1—3 meg, ½w.
R2—1K, ½w.
R3—10 meg, ½w.
R4—220K, ½w.
R5, R10—1 meg, ½w.
R6—0.5-meg pot.
R7, R8—100 K, 1w.
R9—33K, 1w.
R11, R12—3.3K, 1w.
R13, R14—22K, ½w.
R15, R16—10 ohms, ½w.
T1—push-pull input transformer
T2—modulation transformer (Stancor A3893 or equivalent)
K1—push-to-talk relay, 6v. d.c. coil, s.p.d.t.

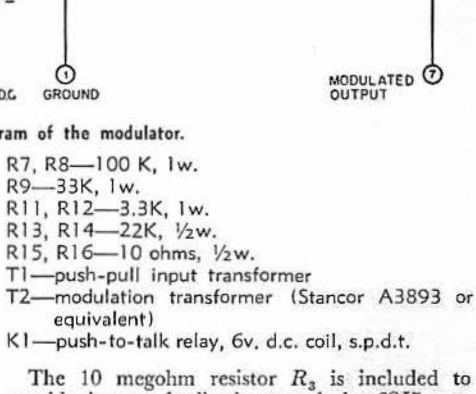
of the 807s. Thus the plate current flowing in the 6SN7s is equal to the grid and screen current of the 807s, and varies from less than 1 ma to peaks of 20 ma with voice modulation. Actually the total plate current consumption of the entire driver, up to the 807 grids, is less than 10 ma under static conditions. Since this driver section works on 200 to 250 volts, its plate power as well as that of the r.f. driver stages is obtained from the receiver plate supply to save all the output of the high-voltage dynamotor for the final and the modulator. The receiver plate power supply is switched from the receiver to the transmitter during transmitting periods.

Speech Amplifier

The early stages of the speech amplifier section are conventional in design. Transformer coupling is used to the grids of the cathode follower stage, using a conventional step-up interstage transformer, since they require higher voltage that can readily be obtained by resistance coupling. Of course the cathode follower draws no grid current, so the usual heavy-duty driver transformer and power stage are not required, but be sure the transformer is step-up, about 2 to 1 from primary to each grid. The type usually used between a 6J5 and a pair of 2A3s is okay.

The 10 megohm resistor R_3 is included to provide inverse feedback around the 6SJ7 preamplifier tube, since somewhat more gain than necessary was available. It may be omitted or increased if more gain is desired.

The optimum load on the modulator is ap-



The modulator sits on the right of the r.f. unit in the 274-N dual-transmitter rack. The whole assembly can be slipped out of the trunk for fixed-station operation.

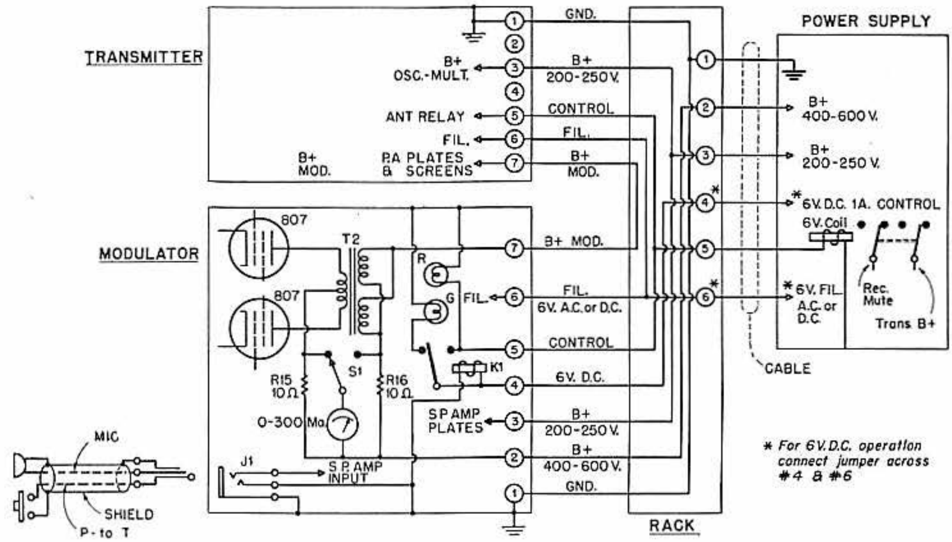
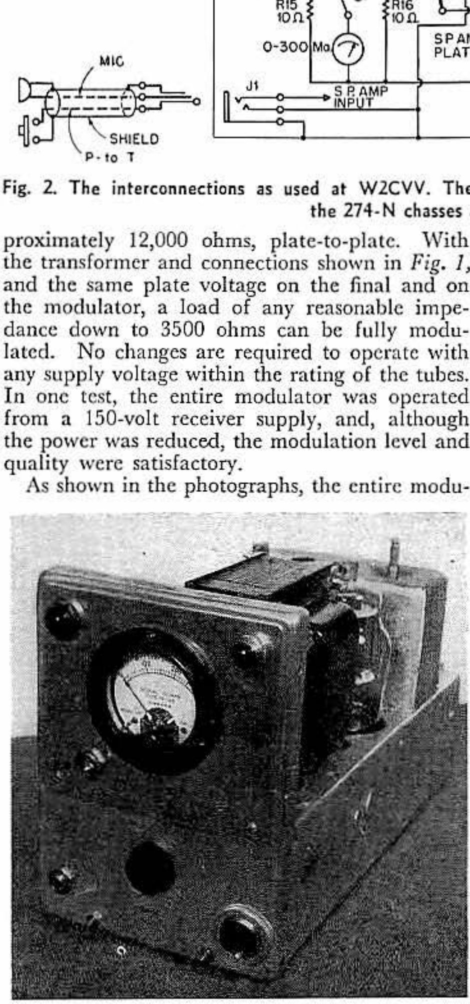


Fig. 2. The interconnections as used at W2CVV. The numbered connections correspond to the connectors on the 274-N chasses and the mounting rack.

proximately 12,000 ohms, plate-to-plate. With the transformer and connections shown in *Fig. 1,* and the same plate voltage on the final and on the modulator, a load of any reasonable impedance down to 3500 ohms can be fully modulated. No changes are required to operate with any supply voltage within the rating of the tubes. In one test, the entire modulator was operated from a 150-volt receiver supply, and, although the power was reduced, the modulation level and quality were satisfactory.

As shown in the photographs, the entire modu-



The meter may be connected, selectively, to the modulator or to the final at the flick of the panel switch.

lator was built into a stripped-down 274-N chassis. The 1625 sockets were filed to fit the 807s and the three other tubes are mounted in the three sockets on the rear of the chassis. The interstage transformer was mounted under the original VFO shield can, and the can used to cover both it and the large holes in that section of the chassis. One of the adjustment screws was left protruding from the shield can to form a rest when the unit is inverted on the bench.

A patch-plate was cut to cover the top portion of the front panel, and drilled for mounting the various components. The two receptacles in the lower corners are provided to permit the use of two different types of microphone plugs and are simply wired in parallel.

The metering circuit permits monitoring either the modulator plate current or the final plate and screen current by means of S_1. The two 10-ohm resistors, R_{15} and R_{16} are large enough so that they will not appreciably affect the calibration of the meter.

Note that the gain control R_8 is provided with a long extension shaft to permit keeping it near its associated components and still be accessible from the front panel. A tapered knob, protruding only a little way through the front panel, was selected in order that the gain would not be accidentally disturbed by the knob being bumped.

Choosing the Microphone

As originally built, the speech amplifier was intended to provide sufficient gain for a dynamic microphone, and a low-impedance microphone-to-grid transformer was incorporated. This transformer is shown in the photograph of the bottom of the chassis mounted near the tube sockets and is shielded by a section of iron pipe to reduce magnetic hum pickup. A crystal microphone would have eliminated the need for this transformer with its associated hum-pickup troubles, but the sensitivity of that type to temperature and humidity renders it unsuitable for mobile use. The recent availability of ceramic microphones, however, has changed this situation. They are essentially impervious to temperature and humidity conditions, and, having electrical characteristics similar to the crystal type, require no transformer. An Astatic CC1S, equipped with a ceramic cartridge, was modified to permit operating the push-to-talk relay, K_1 with the conventional microphone switch. The additional lead was obtained by replacing the single-conductor cord with a double-conductor one. The microphone transformer was removed and the microphone jack wired directly to the 6SJ7 grid as shown in *Fig. 2.*

Results with the ceramic microphone have been very gratifying. Reports from stations familiar with the previous dynamic unit (and it was a good one of standard make, not surplus) have invariably included reference to the greatly improved quality and intelligibility. A slight persistent vibrator hum, originally magnetically induced by the push-to-talk relay into the dynamic microphone transformer, has completely disappeared. A CC1S similarly modified and used by W2DZV has been equally successful.

A modulator such as this, on a 274-N chassis, mounted beside a converted 274-N transmitter on a dual transmitter rack as shown in the photographs, makes a very convenient installation for either fixed or mobile operation. All inter-unit connections may be made via the plugs on the rear of the chassis, with cross-connections made in the shielded compartment which comes on the rear of the rack. By means of a plug connector on the rack, the entire assembly may be plugged into either the mobile power supply cable or removed from the car and used with an a.c. power supply as a fixed or portable station. Perhaps even better, separate racks may be used for mobile and fixed operation, and the modulator and transmitter units only transferred.

The transmitter shown in the photographs is a 4- to 5.3-mc, BC 457, converted for 10 and 11 meters, essentially as described in January, 1948, *CQ.* The two grid current jacks are at the rear of the chassis, on the right, since they would not be accessible on the left as shown in that article. Note that the rack must have clearance holes to permit access to the jacks. No plate current jack is included since plate current may be read on the meter on the modulator. Because of the relatively high power level at which this installation is intended to run, two 807s in parallel are used in the final. The exciter shown in the January, 1948, article is capable of driving them.

By providing other 274-N transmitters, converted as necessary for the desired bands, bandchange can be reduced to the simple process of plugging in the proper transmitter and making such antenna modifications as are required. Since each can then be set on a preselected frequency, and completely pretuned, one to two minutes are all that are required for a complete band change, including adding or removing an antenna loading coil as may be required for lower frequency bands.

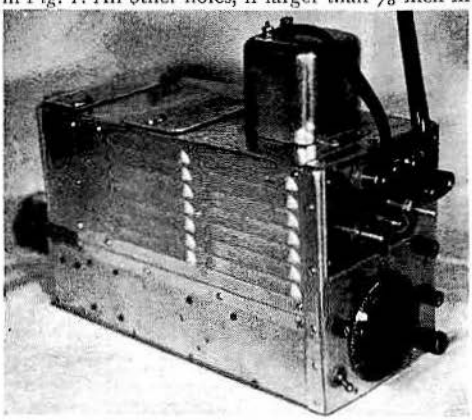
ENDING ARC-5 TVI

THE CHANCES ARE you're having trouble with TVI if you're using an SCR-274N Command-type transmitter. Not that this unit isn't a first-rate performer on the amateur bands. It is, but unfortunately its major component, the BC-457, unaltered and by itself is capable of producing a spectrum of harmonics so strong that television receivers, even a considerable distance from the 457, may be completely blanketed.

If you own an SCR-274N, here are the requirements.

1. Complete shielding.
2. Insert chokes and by-pass all power and other leads.
3. Feed the antenna with coax through a low-pass filter.

The cover of the BC-457, regardless of the louvres, must be made to function as a complete shield. This is done by using one layer of ordinary window screening, preferably copper, cut to size and installed over the louvres on the inner side of the cover and fastened down with 4–40 screws, as illustrated in *Fig. 1*. It is also necessary to cover the openings that are located in the back between the cover and the chassis with screening, as shown in *Fig. 1*. All other holes, if larger than 1/8 inch in



diameter, should be screened or filled in with blind machine screws. This is necessary to keep

Fig. 1

all the r.f. confined within the BC-457. To further the shielding, cut out two pieces of copper or aluminum (approximately 3 to 10 mils thick) that will fit neatly under the two small felt padded covers located on top of the large over-all cover.

Filtering the Power Leads

The next and most critical step is the fabrication and assembly of the r.f. chokes and their shields. It isn't necessary to purchase r.f. chokes if a stock of enamel wire is available. All chokes are wound with No. 20 enamel wire, close-wound on a 3/8-inch form to a coil of approximately 2 inches. The chokes are then fully covered with electrical tape (adhesive tape is satisfactory) to hold the coil firm and also to serve as an insulating medium between the shield and the coil. All the r.f. chokes are shielded individually in a 5/8-inch dia. (or larger) metal tube made of either copper, brass, or aluminum, as shown in *Fig. 2*. The choke coils had an inductance of 3.9 μh and a Q of 135; however, by covering the choke with tape and a tubular shield of 5/8-inch dia., the inductance dropped to 2.2 μh with a Q

of 60, which was still satisfactory. It is best to use chokes with the highest Q possible, but in this particular case, space was also an important factor, and since some sacrifice in inductance and Q could be tolerated, it was decided to make the assembly as small as possible and still get results. It is very important that every choke coil be shielded individually. The r.f. chokes mounted in their shields were arranged in a turret-like

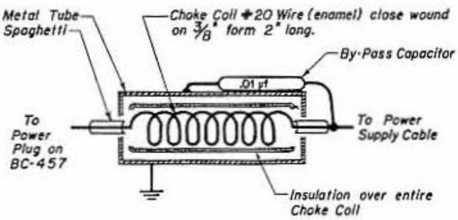


Fig. 2. Each of the individual power leads is filtered by its own LC network, as illustrated above. A "bundle" of these filter units fits into the rear doghouse.

manner, strapped together with tape and slid into a No. 8 tin can, thereby shielding the entire choke assembly. It is very important that this shield cover the entire choke and bypass assembly and be firmly bonded to the chassis of the BC-457. It was found necessary to strap the entire assembly to the chassis of the BC-457 with a heavy bracket.

All the coils are bypassed with .0033 and .01 µf capacitors. The power cable is shielded with heavy braid over its entire length, which, in this case, measured approximately three feet. The power supply need not be shielded; a breadboard supply is satisfactory.

The Antenna Filter

The low-pass filter used in the antenna circuit completes the isolation of all harmonics. The filter is similar to the Harmoniker described in the November issue of *Ham News*. The coils L are self-supporting and therefore need no form except for winding (*see Fig. 4*). The coils are close-wound on a ¾-inch form, 14 turns, with Nó. 14 enamel wire. It is best to wind a few extra turns because of the spring-back effect of the coiled wire when slid off the winding form. This will also increase the inside diameter of the coil from ¾ inch to approximately 13/16 inch diameter. Cut off all excessive wire except 14 turns and a sufficient amount of lead length. A large shield can should be used to house the filters. The coils should be mounted so that the distance between any part of the shield and coil should be not less than ¾ inch.

The capacitors C are 840 µµf; however, a value falling between 830 µµf and 840 µµf is satisfactory. A shield is located between the two filter sections. This shield is so placed as to prevent any opening between the two sections, as

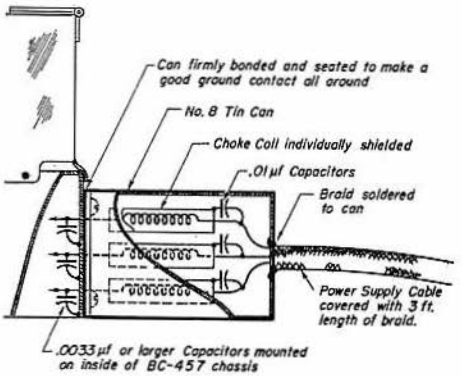


Fig. 3. A bundle of the Fig. 2 filter units is secured to the back of the transmitter and shielded as illustrated here. The .0033-µf condensers installed in the transmitter chassis as shown help out with the filtering job. A good electrical connection at each joint is essential.

shown in *Fig. 4*. The capacitors C are terminated as close to the molded portion of the capacitors as possible to minimize lead inductance. Silvered mica or silvered ceramic capacitors having a zero temperature coefficient and a 500-volt working voltage rating should be used. The filter as described here should be used only with transmitters operating between 3.5 mc and 4.0 mc. No. 8 tin cans were used very effectively as shields for the low-pass filter and the choke assembly. No circuit changes were made except to add .0033 capacitors on the inner side of the power plug, as shown in *Fig. 3*.

The BC-457 now shows no sign of TVI regardless of the operating frequency in the 3.5–4.0 mc band.

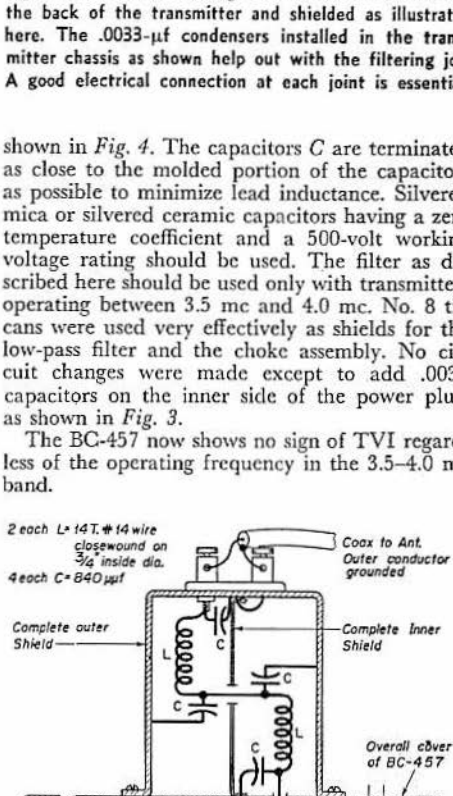


Fig. 4, showing what lives in the penthouse. The low-pass filter is a "must" for almost every 274N rig.

TVI'ING THE BC-459

THE THOUSANDS of "war surplus," Army 274-N transmitters (BC-459, BC-696, etc.), and the ARC-5 equivalents, used by amateurs speak highly for them. Unfortunately, as does most "surplus" equipment, they have their faults. Two of them are their propensity to cause television interference and their less-than-perfect keying characteristics. This article will outline methods for eliminating one and improving the other.

There is a good reason for discussing together such apparently unrelated subjects as television interference and keying. There is often an unsuspected relationship between the two. TVI is usually caused by harmonic or spurious-signal output from the offending transmitter in or near locally-assigned television channels, overloading of the input stages of the television receiver by the strength of the fundamental signal, or undesired signals bypassing the input stages to appear directly in the receiver i.f. channels, or keying transients or "clicks." Any of the above may be radiated directly from the transmitter or power supply, as well as by the antenna.

The 274-N series of transmitters have caused interference in every manner listed, although not every one does so. One does, and another does not, depending on the separation between transmitter and receiver, strength of the television signals, the design of the television receiver, and dozens of other variables.

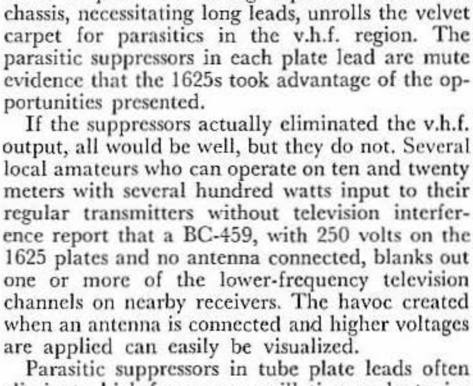
It is the variables that make the problem difficult, making it impossible to say, "Do this, and your TVI troubles are over." Instead, it is necessary to list remedies for as many of the probable causes as possible and offer the hope that only in the most severe cases will it be necessary to incorporate all of them. This is the procedure followed in this article, although all modifications can be made in a single evening. The modifications suggested refer specifically to the BC-459 (7 to 9.1 mc) unit, but apply to the other transmitters in the series as well.

The Original Layout

Looking at the original diagram, *Fig. 1,* and the physical layout of the BC-459, it is obvious that little effort was made to design a transmitter with low harmonic output. Tubes like 1625s generate parasitic oscillations at the slightest provocation, and putting a pair of them in parallel is a gilt-edged invitation for them to do so. Then to place the tuning capacitors below the chassis, necessitating long leads, unrolls the velvet carpet for parasitics in the v.h.f. region. The parasitic suppressors in each plate lead are mute evidence that the 1625s took advantage of the opportunities presented.

If the suppressors actually eliminated the v.h.f. output, all would be well, but they do not. Several local amateurs who can operate on ten and twenty meters with several hundred watts input to their regular transmitters without television interference report that a BC-459, with 250 volts on the 1625 plates and no antenna connected, blanks out one or more of the lower-frequency television channels on nearby receivers. The havoc created when an antenna is connected and higher voltages are applied can easily be visualized.

Parasitic suppressors in tube plate leads often eliminate high-frequency oscillations only to increase output at other equally-undesirable frequencies, which is what is apparently happening in the BC-459; therefore, we will remove the suppressors and attempt to eliminate the parasitics and harmonics through the methods shown in the



The placement of the vacuum condenser and the use of wide copper strap for plate circuit leads to achieve maximum attenuation of all but fundamental frequency output from the 1625s is clearly shown. Also visible is the piece of aluminum to cover the holes in the front panel. Output is from the "mike" connector in the upper corner of the panel.

photographs and the revised diagram (*Fig. 2*).

The most obvious difference between the two diagrams is the 50-$\mu\mu$f vacuum condenser in *Fig. 2.* Obtained from a BC-442 antenna unit, another part of the 274-N, and still available at "surplus" prices, its purpose is to bypass the plates of the 1625s directly to ground for frequencies in the television region. In order to mount it in the most effective spot, the unused antenna loading coil is removed and the amplifier plate coil moved forward.

The screws that fasten the coil to the chassis also support one side of a variable condenser below the chassis. By moving the center of the coil in line with the screws supporting the other side of the condenser, one of them will fasten one side of the coil in its new position. Rather than removing the condenser to drill a hole to fasten the other side, a small strip of metal clamps the coil bracket to the chassis with aid of a nearby screw.

Moving the coil forward requires a slight modification of the control for the variable link. With the antenna loading coil removed, it is no longer necessary to "offset" the link control; I therefore removed the gears and brought it to the front panel through an insulated coupling. Not having a spline wrench to remove the knob, I first sawed it with a hacksaw and then split it with a screw driver. A knob with a conventional set screw later replaced it.

Again, to avoid dismantling part of the transmitter to drill a hole, one end of the vacuum condenser is fastened to the chassis by bolting its mounting clip to the center of a three-quarter inch wide strip of stiff aluminum. Holes near the ends of the strip serve to fasten it to the chassis with the original coil-mounting screws. The head of the screw in the center of the strip is thus pressed firmly against the chassis, making a firm, low-resistance, electrical connection.

One-half inch wide strips of flexible copper strap connect the other side of the vacuum condenser to the 1625 plate caps. Another strip of the same material connects the condenser to the insulated stud, which is connected to the variable condensers under the chassis. A wire between the top of the coil and the vacuum condenser and another from the bottom of the coil to the stud, bringing the plate voltage through the chassis, completes this phase of the conversion.

Before these changes were made, the plate-circuit wiring, plus the parasitic suppressors, resonated in the low-frequency television channels. After they were completed, this secondary resonant frequency was raised beyond the range of my grid-dip meter.

Adding the 50-$\mu\mu$f capacity of the vacuum condenser to the plate tank circuit requires that the capacity of the amplifier padding condenser be reduced accordingly. Originally, it requires slightly less than half capacity on the padder to achieve resonance. With the vacuum condenser added, resonance is achieved with the padder condenser plates meshed about fifteen per cent.

For maximum harmonic attenuation, it would be better to remove the slug from the amplifier

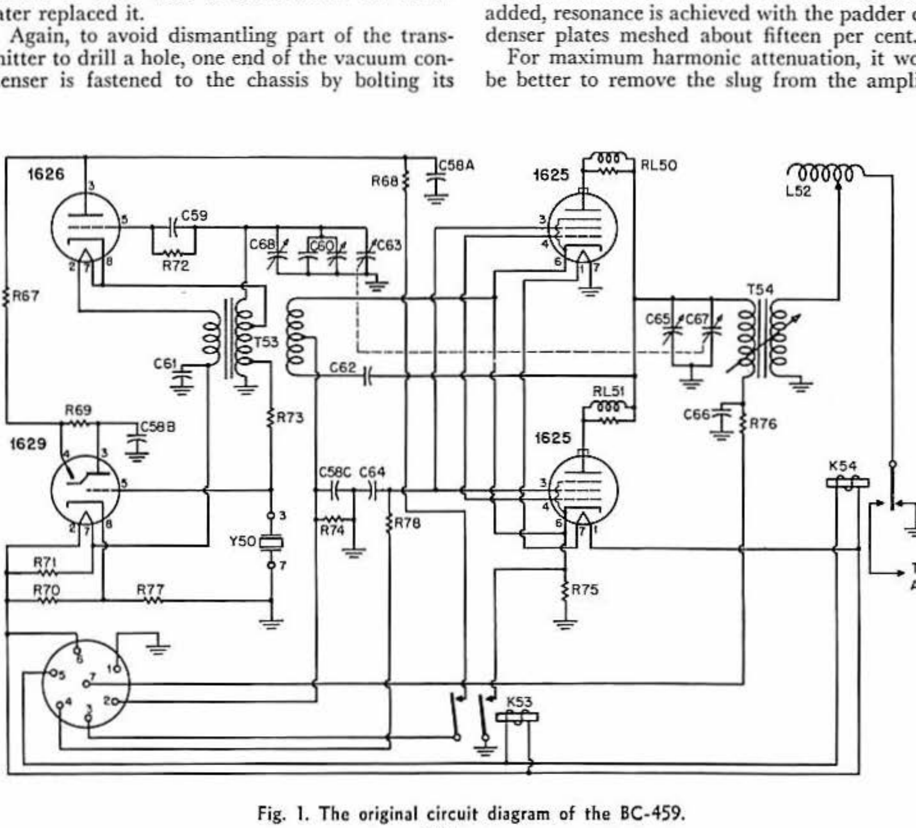


Fig. 1. The original circuit diagram of the BC-459.

coil and/or remove a turn or two from the coil so that the capacity required to achieve resonance is increased. Such a move may be desirable when it is suspected that third-harmonic (21 mc) energy is getting into the i.f. channels of nearby receivers. If either is done, it may be necessary to readjust the padder whenever the operating frequency is shifted appreciably. This should be done anyway in the interest of minimum harmonic output; therefore, it is not too much of a handicap.

Should the vacuum condenser be unavailable, either a mica or a ceramic condenser, with a d.c. voltage rating equal to four times the plate supply voltage, may be substituted with almost equal results if leads are kept short.

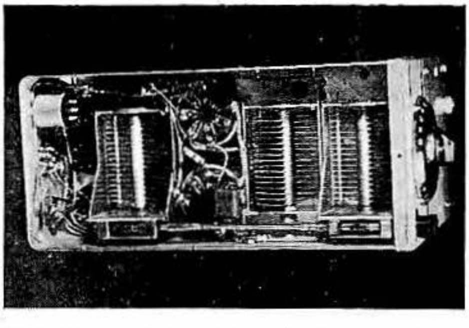
Below the Chassis

Below the chassis, the first thing noticed is that bypassing and grounding the 1625 cathodes and screens is done at one tube socket, with a jumper several inches long to the corresponding terminal on the other socket. Such construction leaves the second terminal floating for high frequencies. The photograph of the bottom clearly shows the placement of the added bypass condensers to bring them to zero r.f. potential. Also seen are the shielded wires replacing the jumpers between the cathode and screen terminals respectively, the shielded key lead, and those replacing the old leads between the power plug and the 1625 sockets. Each shield on these leads should be grounded at each end and wherever possible throughout its length. Although not necessary in this unit, it may be advisable to bypass each terminal of the power plug by 500-$\mu\mu$f condensers, and continue shielding of the power leads right to the power supply.

It would have been even better to ground the cathodes directly through wide copper strips, had it not been desired to key the cathodes. As said before, clicks can cause television interference, thereby nullifying efforts to remove other causes. Stabilizing the 1625s and shielding keying and power leads help in eliminating clicks, but whenever electrical circuits are suddenly broken, a power surge is developed which can cause a click independent of what is connected to the switch. (For example, turning on a nearby light often makes a click, causing a momentary loss of picture "sync.")

B-negative keying of the entire transmitter is particularly bad from this standpoint, and a filter sufficiently large to remove the click usually greatly accentuates the chirp accompanying this type of keying. Keying the B-plus supply for the oscillator plate and the amplifier screens is better, because the current and voltage keyed are less; however, the same difficulty with chirps is found. In addition, a keying relay is required to protect the operator.

Cathode keying of the amplifier permits using enough "lag" to eliminate clicks without increasing the chirp. The constantly running oscillator does prevent working "break-in;" therefore an alternate system permitting keying the amplifier alone, or with the oscillator by snapping a switch, is included in *Fig. 2*.



Shielded leads and the additional mica bypass condensers to stabilize the 1625s are clearly seen. Amplifier padding condenser (second from front) is still set at its original capacity. With the vacuum condenser in place, resonance is achieved with the padder near minimum capacity. The neutralizing condenser is mounted on the wall of chassis behind the padding condenser.

Shielding

Although the shielding of the BC-459 looks quite complete, there is much room for improvement. Lining the cover with copper screening makes it more nearly r.f.-proof than before, while still retaining ventilation. The fine-mesh screening designed for strainers, etc., is best, but ordinary copper (or bronze) window screening is satisfactory and much cheaper.

Bend a piece about twelve by fifteen inches into a long trough to fit against the sides and top. Then solder another piece across the open back of the trough. The screening should extend to the edges of the cover on all sides, and when the cover is screwed to the chassis, it is firmly clamped between the two.

Covering the openings in the top of the cover makes it necessary to remove it completely to change tubes. This is not much of a handicap, because tubes are changed so infrequently.

A small piece of aluminum, with a cutout at the bottom to accommodate the dial, covers the holes in the front panel. To remove the two "locks," drive out the pins fastening the knobs to the shafts with a small finishing nail.

Tuning

Tune up the transmitter in normal fashion and check the neutralization of the 1625s. The easiest way to do so is to connect a 50- or 100-volt, high-resistance voltmeter between the chassis and pin number 2 of the power plug to measure amplifier d.c. grid bias. Carefully tune the amplifier plate padding condenser slightly each side of resonance while observing amplifier plate current and grid voltage. If neutralizing is complete, minimum plate current and maximum grid voltage will occur at the same setting of the condenser. If this does not occur, attempt to reneutralize the 1625s by squeezing together or spreading apart the plates of the two-plate condenser mounted on the side of the chassis behind the amplifier padding condenser. (Caution! The condenser is "hot.")

If television interference persists after these changes have been made, your fundamental signal is probably overloading the input channels of the affected receivers. This very common receiver fault is a problem for the television receiver technician. Suggest to him that a pair of traps tuned to your operating frequency or a high-pass filter inserted in the television receiver feed line right at the receiver antenna terminals is an almost positive cure, *if the television receiver is in good operating condition.*

To be as pessimistic as possible, let us assume that one receiver still has interference, even with antenna traps installed. Substitute a dummy antenna for the transmitting antenna—an ordinary 115-volt bulb will do, preferably shielded—and load the 1625s to their normal input. If interference disappears, your greatly-reduced harmonic radiation is still sufficient to cause interference. An antenna tuner, if not already used, connected to the BC-459 through a shielded line, may be sufficient to eliminate the interference, or a low-pass filter or "harmoniker" in the feed line to the antenna or tuner may be necessary. If the interference persists, even with a dummy load on the transmitter, direct radiation or r.f. energy feeding back into the power lines is probably occurring. Sprague, 0.1-$\mu\mu$f, high-pass condensers in the 115-volt supply line at the power supply will eliminate the latter.

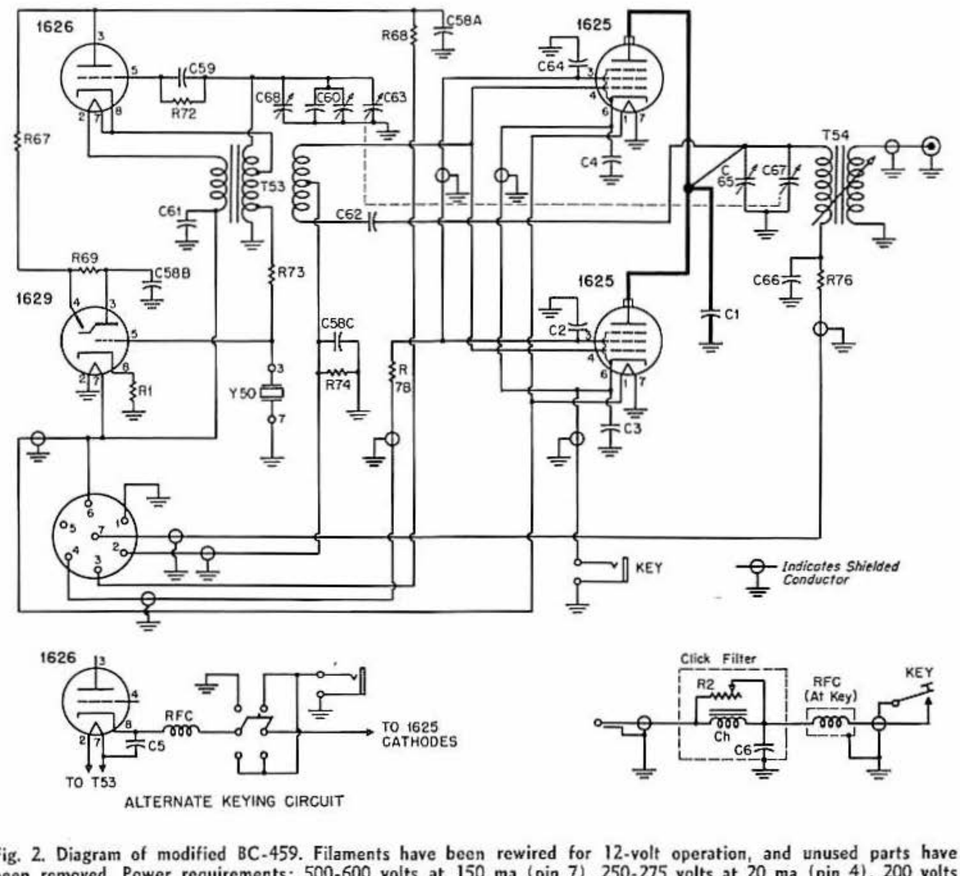


Fig. 2. Diagram of modified BC-459. Filaments have been rewired for 12-volt operation, and unused parts have been removed. Power requirements: 500-600 volts at 150 ma (pin 7), 250-275 volts at 20 ma (pin 4), 200 volts at 20 ma, regulated (pin 3), and 12 volts at 2 amp (pin 6).

C1—50-$\mu\mu$f vacuum condenser, see text.
C2-C5—.001 μf, mica.
C6—0.5 μf, 1,000 volts, paper.
R1—2.5K, ½ w.
R2—2K, 10 w., with slider.
RFC—2.5 mhy. r.f. choke.
Ch—150-ma filter choke (between 1 and 10 hy.)
Sw—D.p.d.t. toggle switch.
Other parts same as Fig. 1.

SCR 274N RECEIVERS

During the past few years the conscientious radio amateur has turned his attention more and more to the construction of portable-emergency equipment, which could be easily transported from one location to another at a moment's notice. Unfortunately, the attention given this type of equipment has been heavily lopsided in favor of the transmitter and those among us with a truly portable receiver are rare indeed. We are not entirely to blame; constructing a decent superhetrodyne receiver is by no means a simple job and since the manufacturers started building receivers with provisions for an external power source it has been easier to take along the home station receiver.

However, we can now all have a really portable job for a cost of from ten to twelve dollars. The "break" comes in the form of the BC-454-A and the BC-455-A government surplus receivers which form a part of the SCR-274N aircraft equipment. The two models available cover the tuning ranges of 3 to 6 mc and 6 to 9.1 mc respectively, and the circuits of both are nearly identical. The receivers are six-tube superheterodynes employing a 12SK7 t-r-f stage, a 12K8 mixer, two 12SK7s as i.f.s, a 12SR7 second detector and b.f.o. and a 12A6 audio amplifier. In the case of the 3 to 6-mc unit the i-f frequency is 1415 kc and in the higher-frequency model the i-f frequency is 2830 kc. The conversion data discussed can be applied to either unit without change, except for one item which will be described in detail further on in the article.

Built for the government, these receivers were designed to operate from a 24-volt d-c source which powered a small dynamotor mounted on the rear shelf of the chassis. The revamped job can be operated from either 110 volts a.c. or an external 6 or 12-volt a.c.-d.c. filament supply and 250-volt d-c plate supply. This is accomplished by means of a small a-c transformerless power supply and a six-pole two-position rotary switch. The power supply uses a 25Z5 in a conventional voltage doubler circuit but the whole secret to the receiver's versatility is centered around the aforementioned rotary switch. As

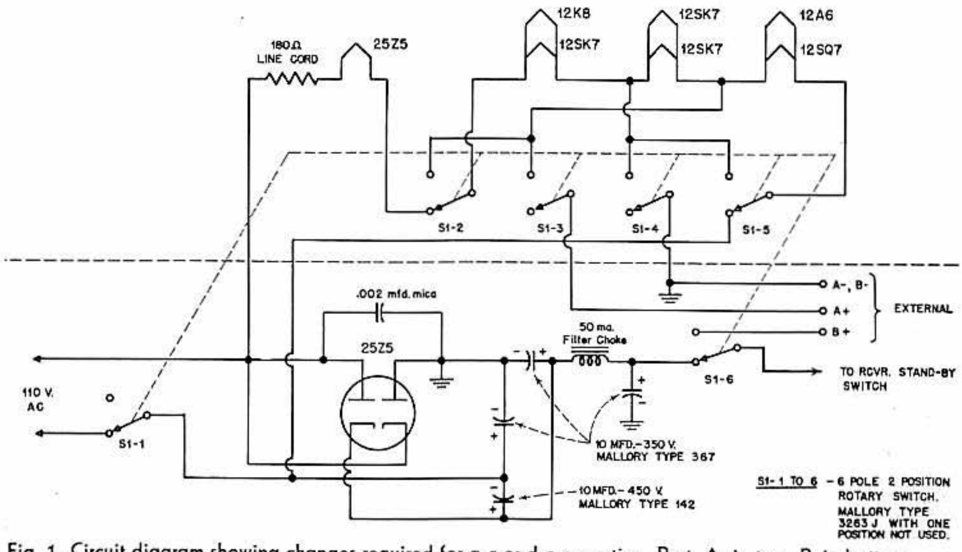
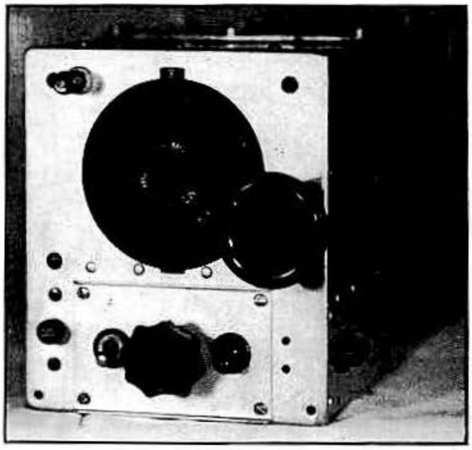


Fig. 1. Circuit diagram showing changes required for a-c or d-c operation. Part A is top, B is bottom.

will be seen from a study of the circuit diagram, this switch actually makes a complete change in the filament circuit. When it is in the position shown in the diagram the filaments are connected in a series-parallel circuit, with the 25Z5 voltage doubler cut in to supply power. It is necessary to have the tubes in the receiver proper wired so that two tubes will be in parallel in order to balance the filament current at .3 of an ampere. This seemed more desirable than using a .15 - ampere filament tube such as a 35Z5 in the power supply and having to sacrifice the extra voltage gained by using a voltage doubler.[1] When the switch is thrown to its second position the 25Z5 is completely removed from the circuit, all other filaments are connected in parallel and the leads for supplying filament and plate voltage are extended through to a set of terminals on the rear of the power supply shelf.

The first step in the modification is the preparation of the chassis for the addition of the power suply, plus the removal of the unnecessary parts. Remove the bottom cover plate and the large shield can which encloses the tubes and i-f transformers. Unscrew all of the metal-cased condensers, chokes, etc., from the sides of the chassis and remove the two screws holding the antenna, oscillator and mixer coils in place. With the exception of the square b-f-o transformer there is sufficient slack in the wiring to permit these units to be laid out over the sides of the chassis. The b-f-o transformer can be shifted far enough to be out of the way but care should be exercised to prevent breaking off the lugs to which its connections are made. The coils are of the plug-in type and may be entirely removed until the conversion is completed. The tubes and plug-in type i-f transformers should be taken out similarly and placed aside. Completely remove the metal-cased condenser mounted directly over the dynamotor connecting plug, the small mica condenser going from ground to one of the pins on the socket on the rear of the chassis and the dynamotor plug and its associated wires. Between the beat oscillator transformer and the 3 x .22-μf condenser across from it are two upright mounted black resistors. These were



Front view showing addition of tuning knob, gain control, stand-by switch, and b-f-o switch.

originally provided to furnish a dividing network for obtaining screen voltage. Since the power supply now being installed will give only about 210 volts this network is no longer required and the resistor nearest the b-f-o transformer is removed, leaving only a series resistor in the screen circuit and thereby giving an increased voltage. The four dynamotor mounting cushions are taken off by unscrewing the nut on the bottom of the chassis. All of the remaining leads going to the socket on the rear of the chassis are now completely removed and the socket itself is taken out. This completes the dismantling at the rear of the chassis and we can now begin to prepare the front end for the necessary revisions.

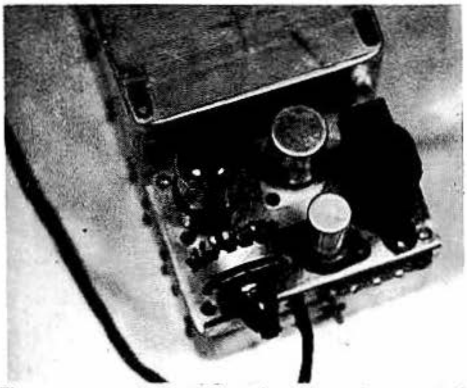
The first item to be removed is the 3-μf condenser fastened to the front panel alongside the remote control box. Remove the remote control box and the leads going to its socket with the exception of the black lead and the one remaining green lead, which should be cut only at the control box socket and left in place for further use.

Now that all of the "surplus" surplus has been removed we can go to work and put it together the way we want it. The first job of course is to rewire the filaments in accordance with the diagram shown in *Fig. 1.* The leads going from the tube sockets to the switch should be soldered in place at the socket end and fed through the left rear hole in the chassis which has been provided by the removal of the dynamotor mountings. These leads should preferably be color-coded so as to facilitate their later being connected to the six-pole two-position rotary switch. The next step is the installation of the controls on the front panel. These include a SPST toggle switch to be used as a stand-by switch, a 50,000-ohm potentiometer for a gain control and a second SPST toggle switch to control the beat oscillator. The controls are all mounted on the front plate of the remote control box which is completely dismantled for this purpose. The three holes left in the center of this plate, after the knob and socket supports

[1]It would, of course, be possible to construct a voltage doubler supply utilizing selenium rectifiers. Then the heaters could be connected in series and operated directly from the 117-volt a-c input if a 50L6 were substituted for the 12A6 (VT134). Screen voltage for the 50L6 would have to be limited to 110-volt d.c. requiring the addition of a screen dropping resistance, or bleeder and the inclusion of an audio bypass connected between screen and ground.

If a half-wave supply were used in place of the voltage doubler, no modification in screen wiring would be required in substituting the 50L6 for the 12A6. By the use of a half-wave supply, the receiver can be used on either 117 volts a.c. or d.c.

In either case, the substitution of the 50L6 for the 12A6 requires a 150-ohm cathode resistance in place of the 1500 ohms (*R21*) used with the 12A6. The substitution of a 50L6 in place of the 25Z5 permits full series operation of filaments and elimination of line cord filament dropping resistance.



The power supply fits in the place formerly occupied by the dynamotor. The rotary switch is S1.

have been removed, are used as the centers for mounting the three items. The green lead which previously went to the remote control socket goes to the gain control and the arm of the gain control goes to ground. The switch used for the b.f.o. has one connection going to ground and the other to the 3 x .05-μf condenser mounted alongside the b-f-o transformer. This lead connects to the terminal on the condenser to which is already fastened a 5100-ohm resistor. One of the stand-by switch leads goes to the terminal nearest the chassis of the remaining large black resistor and to the terminal on the rotary control switch shown in part *S1* of *Fig. 1*. The output jack is mounted on the side of the chassis next to the b-f-o switch and can be installed without insulating washers. The only connection necessary is the black lead previously removed from the remote control socket.

The final job is the construction of the power supply, the circuit diagram for which is shown in part *B* of *Fig. 1*. This supply is built on an aluminum shelf measuring 3" x 4½" with a rear drop of 1". Once the power supply has been completed the receiver shield can may be reinstalled, the power supply bolted in place on the receiver proper using four 1" spacers, and the remaining filament and output connections soldered in place. When soldering these last leads in place it may be wise to leave a small amount of slack in the wires to provide for future servicing.

Installation of a Tuning Control

Two methods of installing a tuning knob may be used. One is to remove completely the threaded bushing over the geared shaft to give sufficient clearance for a ¼" solid coupling and the other is to use a short section of ¼" copper tubing adjusted to fit snugly on the geared shaft without removing the bushing. The author chose the first method, but only because the coupling was more readily available. The first system involves the complete removal of the tuning condenser and is therefore not recommended. If the first method is chosen the bushing should be removed before the power supply is bolted in place, since the receiver shield cans cannot be removed with the power supply securely fastened.

That about winds up the conversion of the receiver as far as necessary changes are concerned, but there is one thing more that can be done to make it still more adaptable for ham use. Like most equipment designed for military service, this unit is long on performance but short on bandspread. The particular unit the author converted was one that tuned from 6 to 9.1 mc and by removing all but two rotor plates from each section of the tuning condenser and adding small trimmer condensers to compensate for the loss of capacity, it was possible to spread out the 40-meter band to occupy a total of fifteen divisions on the dial, or 20 kc per division instead of the original 100 kc per division. No information is available on the number of plates to be removed from the 3 to 6-mc model, but this can be easily determined by removing the plates one at a time until the desired coverage is obtained. On the 6 to 9.1-mc model, trimmer condensers with a maximum capacity of 45 $\mu\mu$f were found to give excellent range since the maximum capacity of the original tuning condensers is 66 $\mu\mu$f. On the 3 to 6-mc model the maximum capacity of the tuning condensers is 147 $\mu\mu$f. This would indicate a trimmer condenser with a maximum capacity of about 125 $\mu\mu$f.

To operate the completed receiver merely throw the rotary switch to the desired position, either series or parallel and connect the proper supply voltage. With the switch thrown so that the filaments are all in parallel the operator can substitute 6-volt type tubes and run the whole works from a single storage battery with a vibropack furnishing the high voltage. When using 6-volt tubes a 6K6 should be used in place of the 12A6. If *only* earphone output is desired, a 12J5 can be plugged in place of the 12A6 (with 6-volt tubes, substitute a 6J5 or 6C5) with saving in power supply drain.

Considering its cost, this little unit leaves nothing to be desired and makes a useful adjunct to any station. W8AZ has even mounted a small 3" speaker on the top of his receiver and uses it as a monitor for his home rig when he is not operating in the field.

THE ARC-5

repackaged

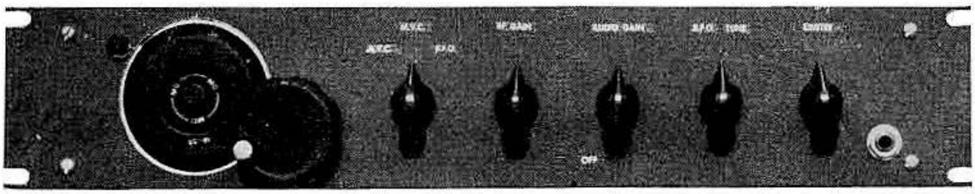


Fig. 1. The ***Commercial Look*** for inexpensive surplus receivers.

The ARC-5 receiver units are extremely handy around any ham shack. They are inexpensive, plentiful and require so little power for operation that they can be used as standby receivers, monitors for net channels, autocall service, and dozens of other purposes.

Most of us admire the neatness of commercial communications installations and their ability to stack a large quantity of the essential gear in "package" form by relay rack style of construction. More and more amateur stations are adopting this space-saving feature. The reworking of the popular ARC-5 series of receivers into the form shown here permits realization of that dream of all amateurs: a separate receiver, optimized for each band worked.

The ARC-5 units are, as originally packaged, fairly unhandy from many aspects: they clash with the decor of the shack, are difficult to hold in place while tuning, and require an external power supply. For many uses it is desirable to add another audio stage and a noise limiter. At any rate, the solution is one of repackaging.

The receiver repackaged in this case was the one which covers the .19-.55 Mc. band. Since it was to be used as a Q-5'er it was considered very desirable to add an additional audio stage and a noise limiter so that once the i-f signal was removed from the communications receiver it did not need to be returned for either audio amplification or noise limiting. These changes are useful even if the receiver is only used as a stand-by receiver.

If you do not have available a Handbook of Maintenance Instructions for the receiver it is strongly recommended that wiring diagrams be made of all the coil sockets before the old receiver is disassembled.

Fig. 1 is the front view of the repackaged ARC-5. It is mounted back of a 3½-inch rack panel. The components are mounted on a 4x17x3-inch chassis as shown in *Fig. 2*. A 5x17x3-inch chassis would have been preferable in some ways but no chassis of this size was available on the local market at the time the conversion was done so we just squeezed things up a little bit more. Even so, it did not turn out to be unduly crowded.

The components of the ARC-5 were removed from the original chassis and then the chassis was cut into parts which held the coil sockets and the mounting studs for the coils. The r-f, mixer and oscillator coil sockets were removed

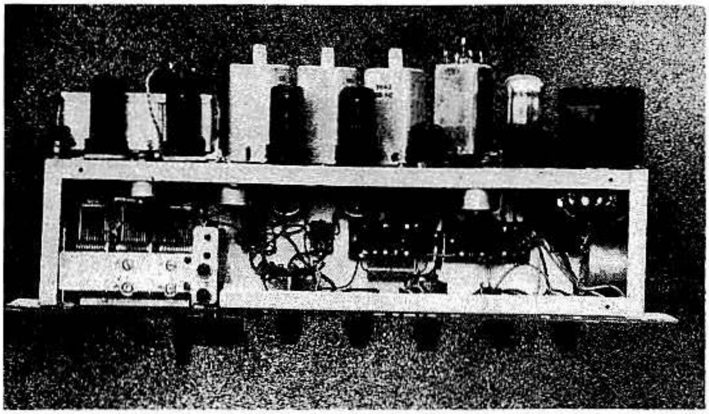


Fig. 2. Wiring under the chassis is kept simple if a parts layout like this is followed.

as a group of three and enough of the sides of the chassis was retained to allow the coils to be held by the screws, as was the case in the original instruction. Each of the i-f coil sockets was cut out along with enough of the chassis to hold the mounting studs and to permit the mounting of the socket to the chassis with four screws. An octal socket was placed next in line to hold the b-f-o coil which in the original receiver was not of plug-in construction. *Fig. 3* shows the back view of the new chassis with all the coil sockets mounted.

Fig. 4 shows the back of the chassis with all the coil installed. All the coils are from the original ARC-5 except the b-f-o coil which was missing from the receiver when it was purchased.

The circuit of the receiver was revised slightly to permit operation from a 120-volt d.c. plate supply. 6 volt tubes are used in this receiver since it had already been converted to 6-volt operation; however 12 volt tubes may be used if a power transformer with a 12-volt heater winding is installed or if a 6.3-volt filament transformer is connected in series with the heater winding of the type transformer used in this conversion. The revised circuit of the receiver is given in *Fig. 6*. The ARC-5 components which are re-used are not numbered on the diagram, making it a simple matter to distinguish the new parts needed. Since the second i-f amplifier operates at a fixed gain a 6SJ7 was substituted for the 6SF7 in order to save plate current. This made it necessary to get the a-v-c voltage from the second detector load resistor. This receiver was not designed for high-fidelity so there is no disadvantage to this change; however, after completing the conversion it was found that a reserve of plate current was available so the original second IF amplifier tube and the original AVC circuit could have been maintained.

The early stages of the receiver are little changed. In order to operate a 120-volt d.c. supply the screens and plates are fed from a single source, thus saving some decoupling resistors and associated by-pass capacitors. It was of course necessary to provide an RF gain control and it was also considered desirable to

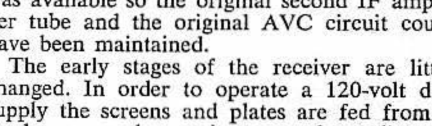
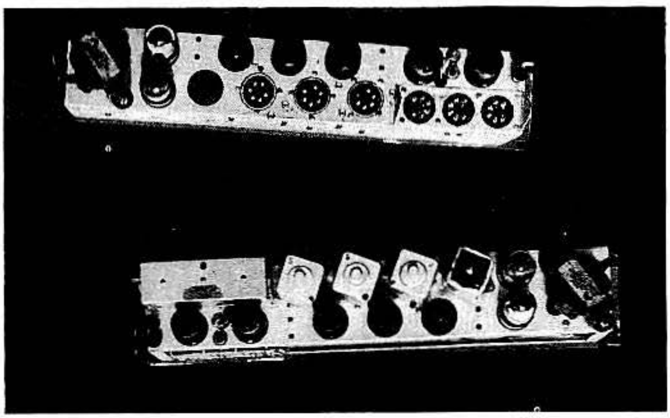


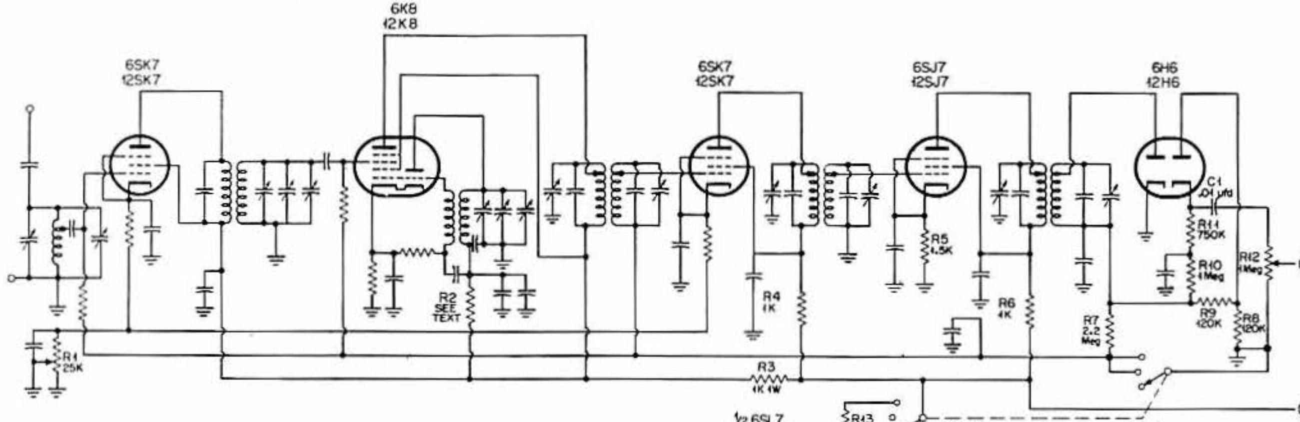
Fig. 5. Cross section of the recessed panel cut back to fit ARC-5 dial. Panel may be cut all the way through if you want to save some energy.

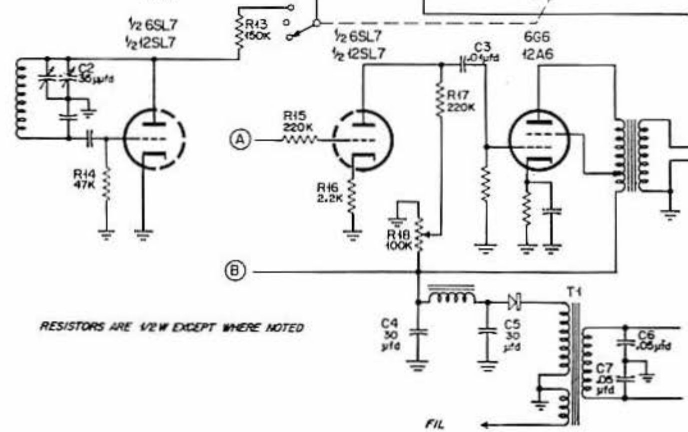
parallel the oscillator plate dropping resistor inside the coil shield with another one *(R2)* across the coil socket terminals. *R2* should be half the value of the resistor inside the coil shield.

One-half a 6H6 is used for the second detector and a-v-c rectifier and the other half is used for a series noise limiter diode. A 6SL7 is used as the first a-f amplifier and the b.f.o. The plate voltage of the audio section of the



Figs. 3 & 4. The position of the i-f and r-f plug-in strip sockets can be seen here.





All resistors ½ watt unless otherwise specified

R14—47,000 ohms.
R15—220,000 ohms.
R16—2200 ohms.
R17—220,000 ohms.
R18—100,000 ohm pot
T1—Merit P3045 or equiv. 117 v. at 50 ma., 6.3v, at 2 amps.
C1, C2—0.01 μfd., 400v.
C3—35 μμfd. variable.
C4, C5—30 μfd., 150v. electrolytic.
C6, C7—.05 μfd., 400v.
R1—25,000 ohm potentiometer.
R2—see text.
R3—1000 ohms 1 w.
R4, R6—1000 ohms.
R5—1500 ohms.
R7—2.2 megohms.
R8, R9—120,000 ohms.
R10—1 megohm.
R11—750,000 ohms.
R12—1 megohm potentiometer.
R13—150,000 ohms.

Fig. 6. Circuit diagram of the receiver. Unmarked parts are unchanged from original ARC-5 circuit.

6SL7 is made variable so that the tube may be operated as a saturated amplifier and thus act as an additional noise limiter. A 6G6 is used as a second audio amplifier. This tube was selected for its low heater current. A 6AK6 miniature output pentode could have been used or, if 12-volt tubes are used, the original 12A6 could be used. The screen of the 6G6 is fed from the tap on the primary of the output transformer to give some inverse feedback which reduces the output impedance of this stage and limits the voltage developed across the output transformer.

The power supply is a conventional half wave rectifier system employing a small transformer of the type used in audio pre-amplifiers or television boosters.

A few tricks were resorted to in order to use the 4-inch wide chassis instead of the 5-inch wide chassis for which the design was originally planned. It was originally planned to mount the tuning capacitor about ¾ inch behind the panel with the dial to be viewed through a window in the panel. Using the 4-inch chassis it was necessary to mount the capacitor right against the panel so the chassis flange had to be cut away as shown in *Fig. 2*. The panel had to be machined away to allow room for the dial as shown in *Fig. 5*. This machine work was done with a circle cutter the tool of which was ground to a slighter angle.[1] As may be seen from *Fig. 2*, the by-pass capacitor directly behind the tuning capacitor had to be mounted with its mounting studs sticking through the rear of the chassis. The antenna trimmer capacitor was mounted inside the first section of the tuning capacitor. The space there was a little crowded also so it was necessary to file off the bottom rear corners of the trimmer stator rods. Once these little mechanical details were arranged the project went forward at a good pace.

After the receiver was tuned up it was found to overload on strong stations when using avc and maximum r-f gain. An investigation showed that we were "fortunate" enough to have selected leaky 0.05 μfd sections for both of the avc line capacitors so they were replaced with a tubular capacitor alongside one of the terminal boards. Other constructors may profit by this easily avoided mistake and reserve the leakiest capacitors for the cathode by-pass function where a leakage resistance of 2 or 3 megohms is of no importance.

As stated previously, this conversion was planned to use the original ARC-5 parts wherever possible. A relaxation of this policy would have permitted further saving of space, for instance most of the bypass capacitors could have been located directly on the tube sockets and the remaining ones could have been terminal boarded. Miniature tubes could have been substituted for the metal tubes in which case the IF transformers could have been mounted square with the chassis and moved further to the left leaving more room for the power supply components at the right hand end of the chassis.

Regardless of whether the constructor wishes to follow exactly the instructions given in this article or wishes to give a more complete or less complete treatment to his receiver, the ARC-5 need not remain an ugly duckling. Repackage it!

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1. Editor's note: The use of an aluminum panel instead of steel should materially ease the job of recessing the dial into the panel. Some may consider it simpler to merely cut out a circular opening in the panel slightly larger than the dial itself.

BANDSPREADING ARC-5 RECEIVERS

Figure 1 illustrates how a dial scale may be added to the tuning knob of a "Command-Set" receiver *(BC-454, BC-455, etc.)* to provide a bandspread calibration for the amateur band it covers. The scale shown is a typical 7 to 7.3-Mc calibration for a *BC-455.*

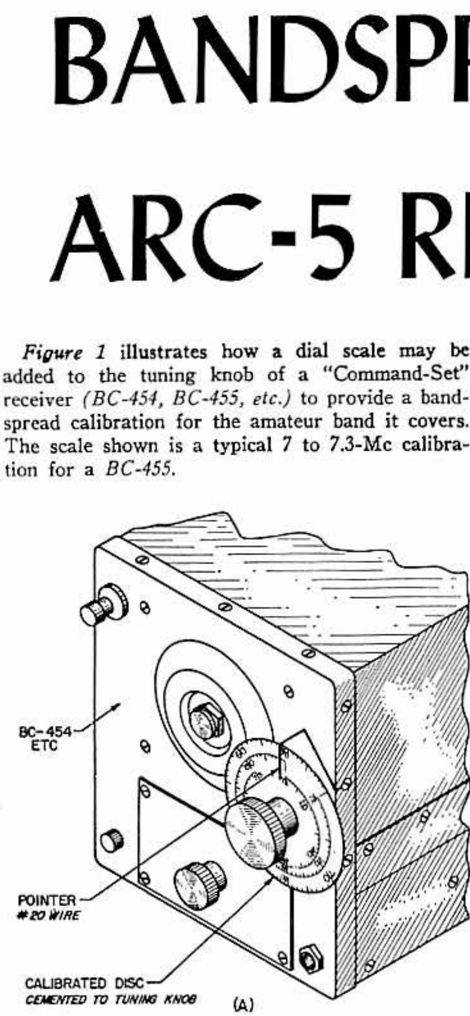


Fig. 1. Method of mounting bandspread scale.

To construct the scale, draw three concentric circles on a piece of stiff white cardboard. The first circle should be 2½ inches in diameter, and each of the others should be 3/16 inches smaller than the preceding one. Carefully cut out the disc around the outer circle, punch out a ¼-inch hole in its center, and cement it to the tuning knob.

Form a two-inch length of No. 20 tinned copper wire into a pointer. Fasten it by means of the screw on the side of the receiver nearest the knob. The pointer should extend vertically in front of the scale and about ¼ inch beyond the inner circle.

With the aid of a calibrated oscillator, set the main dial to exactly 7000 kc., and put a light pencil mark on the outer circle of the disc directly under the pointer. Tune the receiver to 7020 kc. and make another mark. Repeat every twenty kilocycles, until 7100 kc. is reached.

Mark the 7100 kc point and subsequent twenty kilocycle points on the second circle until 7200 kc is reached. Then drop to the inner circle and continue to 7300 kc.

Remove the disc from the knob and ink in the circles and calibration lines. Make the 100-kc lines slightly heavier and longer than the others. Next bisect the twenty kilocycle divisions with short lines. Finally, put four equally-spaced dots between each pair of marks.

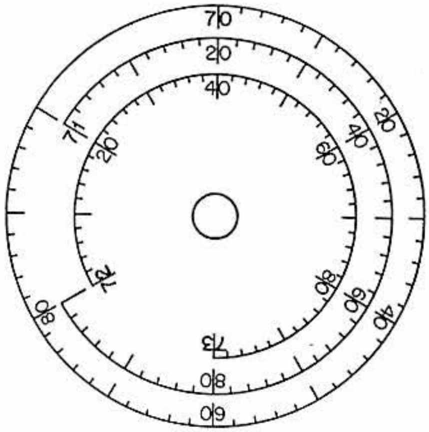


Fig. 2. Typical 40-meter band disc for the BC-455.

Identify the calibration points thusly: Number the 100 kc. points 7.0, 7.1, 7.2, 7.3. Then number the intermediate twenty kilocycle points 20, 40, 60, and 80. Re-cement the disc firmly to the tuning knob, taking care to see that the 7000 kc. points on it and the main dial correspond.

In operation, a glance at the main dial shows in which 100-kilocycle segment the receiver is tuned, and the auxillary scale indicates the exact frequency. If the work is done carefully, frequencies can be read to two kilocycles and estimated to one kilocycle with good accuracy.

The procedure for making a 3.5-to 4-Mc calibration disc for a *BC-454* is similar, except that the circles are required.

BANDSPREAD FOR BC-455'S

THE 6-9 mc receiver of the SCR-274N radio set is an inexpensive but efficient receiver for the 40-meter band. This article shows through a step-by-step process how the utility may be further enhanced by bandspreading the tuning range across the whole 7-mc band. This is done by removing portions of the main tuning condenser and substituting an adjustable padder and two negative coefficient condensers.

Step-by-Step Procedure

1. Remove the cabinet shield and all the tubes. It may also make it easier to work with the receiver if the i-f transformers are also removed. They should be clearly marked beforehand, as they cannot be interchanged. Remove the small shield from the front of the top chassis which houses the condenser gang assembly.
2. Turn the receiver right side up with the rear chassis wall facing you. Take a pair of diagonals and cut in two all the mica rotor stops on the ends of the three rotor sections. However, be sure to leave as much as possible of the stop on the last rotor plate on the right-hand side of each rotor.
3. Remove all rotor plates in each section starting from the left side with the exception of the last main rotor plate on the opposite end. Twist the rotor plates free, do not pull out. The shaft is floating on ball bearing which may be set free if caution is not exercised.
4. Remove the rotor phasing plates on each end of the rotor. These are the small plates with slots that are used to gang up or phase the main tuning condenser.
5. Mechanically line up the three remaining rotor plates, one in each section, if they have been bent while the other rotor plates were being removed.
6. Bend the right hand end stator plate about half way over towards the right side of the frame. This is done to further decrease the tuning capacity. Do not remove this plate, as it will be used to adjust the bandspread tuning range.
7. Solder a 50-$\mu\mu$f ceramic adjustable padder across the r-f tuning condenser section. This is done by mounting the padder as low as possible onto the top of the gang frame. Solder the adjusting screw lug to the frame. Then take a piece of #12 wire and run it directly between the top of the stator section and the other side of the padder. This wire should be heavy as it will also serve as the mechanical support for the padder. Drill a hole in the top of the gang shield can so that this padder may be adjusted with the shield in place.
8. Solder a 20-$\mu\mu$f CRL negative coefficient capacitor across the detector gang and another 20-$\mu\mu$f CRL negative coefficient capacitor across the oscillator gang. Both connections are made at the bottom of the gang on the top of the coil sockets. Do not attempt to use ceramic or bakelite adjustable padders across the oscillator or detector gangs as these will upset the stability of the receiver.
9. If the i-f transformers have been removed they should be carefully replaced and the receiver made ready to be brought back into the 40-meter band. With a known signal at either end of the band adjust the two midget air padders on the gang as well as the additional padder soldered across the r-f gang. Tune all three in the normal alignment procedure; no trouble should be experienced in tuning in the 40-meter band. By slightly bending each of the three stator plates, more or less bandspread may be obtained. Of course, after bending these plates the padders must be readjusted.

The entire band should extend from nearly one end of the dial to the other. As a matter of fact, it will probably be found necessary to use a spinner type knob, as the vernier and bandspread action are both so great as to make tuning a little slow.

BC-455 ON 10

MANY ARTICLES have been written on the conversion for amateur use of war surplus receivers and transmitters. To them should certainly be added the conversion of the BC-455B receiver for 27 to 30-mc operation. Very few additional components are needed and the antenna input may be adapted for either single-wire or doublet lead-in.

The parts required are a power supply furnishing either 6.3, 12.6, or 28 volts for the filaments and 250 volts for the plates. Also, a phone jack, plate switch, midget 25,000-ohm potentiometer, a five-prong socket with male plug to match power connections at the rear of the chassis, and several small resistors and condensers.

The first step is to take out the small can insert at the bottom front of the panel. This can contains male and female plugs which are clipped free of all wires close to the plug terminals. This will allow room for the controls which are mounted on the front plate. The midget potentiometer which is to serve as an r-f gain control is mounted in the center with the B − control switch on one side and the phone jack mounted on the other side.

The filament circuit is then rewired to match the new power supply. The BC-455B is initially designed for a 24–28 volt supply using 12.6-volt tubes. With a 12.6-volt supply the filaments will need to be rewired for parallel connections. 6-volt equivalents may be substituted while again rewiring for parallel operation.[1]

At this point the biggest job in the conversion is to reduce the capacity of the tuning condensers. This will be a much easier task if the condenser section is completely removed temporarily from the chassis. By heating the point of mounting of the plates, they can be readily removed. Care should be exercised to avoid bending or misaligning those plates which are to be left in the gang. Leave only one rotor plate and this one should be the middle one. Leave only two stator plates—the ones on either side of the single rotor plate. Also remove the front rotor sections of the trimmers on the mixer and oscillator variables, and all but three rotor plates of the remaining trimmers on the three sections. Do not touch the oscillator series padder condenser. Center the tuning plates by adjusting the centering screws on the sides of the condensers, remount the condenser and resolder the connecting wires.

The next step is to rewind the coils. The oscillator grid coil is changed to a double-spaced five-turn winding using the same wire and the same spacing for coupling to the adjacent winding. Take the mixer coil and remove the large winding of fine wire at the top of the form and replace it with four turns of No. 24 enamel wire. Change the grid winding to a double-spaced six-turn coil leaving a space of approximately one-eighth inch from the smaller one, being sure that both windings are in the same direction. Rewind the r-f form to duplicate the mixer grid winding and wind the two-turn antenna coupling coil of covered buss wire (No. 18) on top of the six-turn coil at its center. If a single-wire antenna is to be used, ground one end of this winding at the plug on the chassis, connect the other terminal to the antenna post, first removing the small condenser in series with the former antenna lead-in. Another antenna binding post may be mounted and both leads brought out for use with a doublet antenna.

Prior to starting the realignment process it is best to drill out the rivets in the coil shield cans.

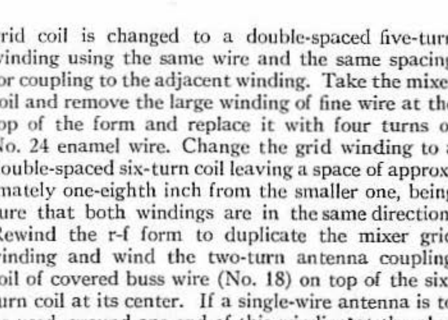


Fig. 1. Necessary changes for rewiring the BC-455B circuit for an additional audio stage and a.v.c.

C40, C42—100 µµf, midget mica.
C41—20 µµf midget mica or ceramic.
C43—25.0 µf, electrolytic.
C44—0.1 µf, paper.
R30, R38—470,000 ohms, ½ w.
R31, R32—100,000 ohms, ½ w.
R33—510,000 ohms (was R18 in original circuit).
R34—2200 ohms, 1 w.
R35—1.0 megohm, ½ w.
R36—220,000 ohm, ½ w.
R37—500,000 ohm, pot.

Enlarge the holes to one-quarter inch in both the can and the mounting bracket. This provides access to the slugs for alignment.

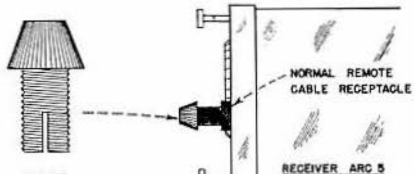
Preferably a signal generator feeding a 28-mc signal into the mixer grid should be used to start the realignment. Set the dial to 6.5 mc and adjust the oscillator trimmer and slug until a signal is heard. Next feed the 28-mc signal into the r-f stage through the antenna post and tune the mixer and r-f slugs for maximum signal output. An output meter should be used rather than tuning solely by ear. Now tune the signal generator to 30 mc and pick up the signal by rotating the receiver tuning dial. At this point tune the r-f and mixer trimmers for maximum signal output. Do not retune the slugs at the high end, nor the trimmers at the low end, as this will upset the tracking of the mixer and oscillator. Repeat the two settings until the tracking is accurate. Then remove the shield cans and replace the slug locking tabs. If care has been exercised in replacing the locking tabs the tuning should still be correct. Sometimes it may be advantageous to align the i-f transformers with the 28-mc input as the last step.

An a-v-c circuit has been added to our receiver and the detailed changes are shown in *Fig. 1*. The 25,000-ohm midget potentiometer is wired into the circuit to replace the external gain control of the BC-455B. The arm and one side of the potentiometer are grounded and the other side is connected to *pin 1* on *J-1*, or *pin 3* (outside view) on *J-3*.

TUNING DEVICE FOR ARC-5

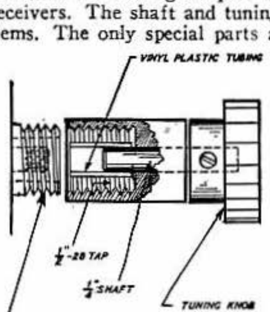
Probably a good many amateurs purchased SCR-274N receivers (ARC-5) without the tuning cables necessary for remote control. The mechanical construction of these receivers is such that they are difficult to tune locally without a key for the purpose.

This situation was solved at W2RAC by using the removable part of a fuse holder. The fuse holder is partially filled with Duco cement, and inserted in the receptacle for the tuning cable, making a convenient knob. The Duco cement must be allowed to dry overnight.



274N TUNING KNOB

This is a homemade tuning adaptor for the 274 N series receivers. The shaft and tuning knob are standard items. The only special parts are a piece



of vinyl plastic tubing, the inside of which should be slightly smaller than ¼ inch, and the adaptor fitting itself which is machined out of ordinary brass, or even aluminum. This adaptor is ¾ inch in diameter and ¾-inch long. One end is tapped to a depth of ⅜ inch with a ½ inch, No. 28 tap. A ¼-inch diameter hole is reamed on through to the other end. The length of the ¼-inch shaft should be such that the end of the shaft butts against the end of the splined shaft in the receiver tuning fitting and the plastic tubing fits evenly over both shafts when the adaptor is screwed onto the receiver fitting.

The plastic tubing retains its elasticity indefinitely and there is no noticeable backlash in tuning the receiver. For convenience a crank may be added to the tuning knob if desired.

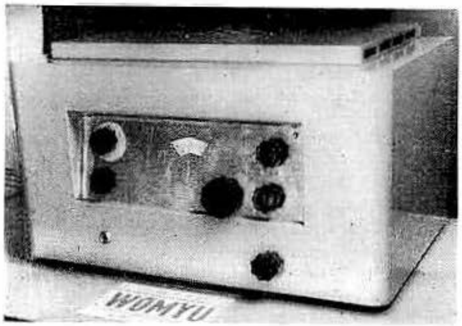


Fig. 1. The completely assembled double conversion receiver. Dial calibrations start at 0 above the line and 500 below the line. The 0 represents 7000 kc and 14,000 kc, while 500 represents 3500 kc. 50 kc is visible in the window. The BC-453 receiver is located in the center, tuned by the large knob. The r-f gain control and a-c switch is below the inset panel. The b-f-o switch is in the upper right corner.

BC-453 WITH DUAL CONVERSION

HERE is a relatively simple method of constructing a communications receiver, the performance of which is comparable to a far more expensive unit. Application of the fixed converter principle permits use of crystal-controlled high-frequency oscillators which provide stability that is unsurpassed. Combining fixed crystal-controlled converters with the BC-453 low frequency receiver results in exceptional stability and selectivity with an excellent degree of bandspread.

The circuit in *Fig. 2.* shows a converter which gives excellent results when used in conjunction with the BC-453 receiver. This converter uses a crystal oscillator which is 200 kilocycles lower in frequency than the low frequency end of the amateur band desired. Tuning is accomplished with the BC-453 functioning as a tunable intermediate frequency. The BC-453 tunes from 190 kilocycles to 550 kilocycles, a range which is sufficient to cover the 3.5 mc, 7 mc and 14-mc bands. The 3.85 to 4-mc phone band may be covered by plugging in another crystal which is 150 kc higher in frequency than the 3.5-mc band crystal.

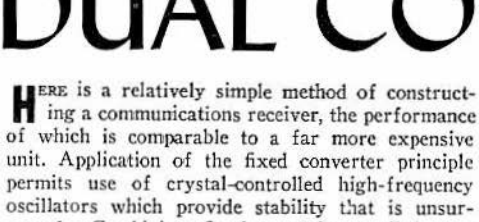


Fig. 2. Crystal controlled 3.5 and 7-mc converter.

C1, C7—50 μμf
C2—30 μμf
C3, C8—.01 μf
C4—.05 μf
C5—.005 μf
C6—.001 μf
R1—620 ohms
R2—150,000 ohms
R3—10 megohms
R4—25,000—50,000 ohms
R5—1000 ohms
RFC—2.5 mh
Coils—3.5 mc: L1, 8 turns; L2, 50 turns; 7 mc: L1, 5 turns; L2, 30 turns
Xtals—3.5-mc converter, 3300 kc. 7-mc converter, 6800 kc.

The converter tube, a 6AC7, gives excellent gain and signal-to-noise ratio. The oscillator is an untuned Pierce which adds to the simplicity. If plug-in coils were used, one converter could be used to cover the 3.5-mc, 7-mc and 14-mc bands. The crystals could be either switched or plugged in. The image ratio would be good on the two lower frequency bands and fair on the 14-mc band.[1] However, because of the low cost of the individual converters our receiver employs a separate unit for each band.

A Simple Super

Using these principles the author has developed a receiver which gives extraordinary performance considering the investment involved. The unit pictured in *Fig. 1* costs approximately $30.00 to assemble. It incorporates a converter for each of the three bands covered, 3.5 mc, 7 mc and 14 mc. The 7-mc and 3.5-mc units are identical except for the coils. The 14-mc converter uses a stage of tuned preselection and a converter tube which gives better selectivity than the 6AC7 in order to reduce the image response. This arrangement will give reasonable image rejection ratio on this band.

Bandswitching is accomplished by switching the output of each converter to the antenna circuit of the BC-453 receiver and simultaneously switching the positive plate voltage to the converter units. The addition of a new dial, calibrated from 0 to 350 above the center line and from 500 to 850 below the

1 The image ratio will be quite poor on all bands. It may be inferior to a conventional receiver with no r-f stage.

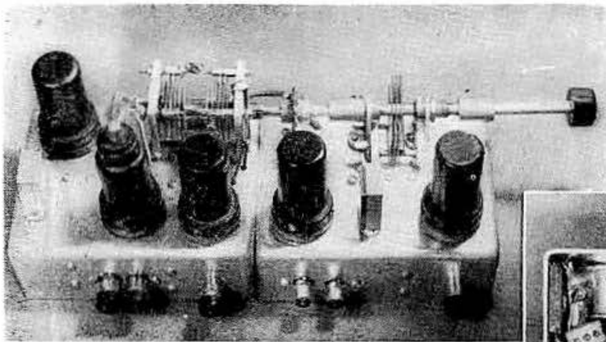


Fig. 3 (left). 7 and 14-mc converters. The tuning of both units is ganged to reduce the number of controls. The 7-mc converter with the trimmer condensers removed is on the right. The crystals are plug-in and different crystals may be used to cover other frequencies than the amateur bands. The individual chassis measures $3\frac{1}{2}$" by 5".

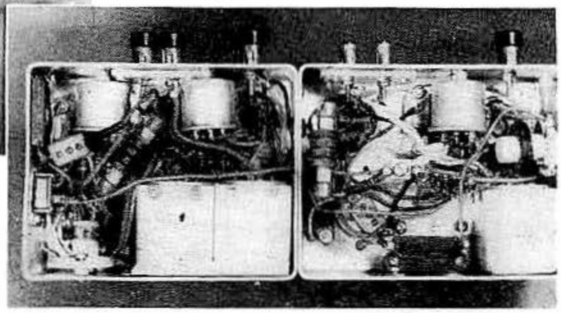


Fig. 4 (right). Under chassis view. The by-pass condensers, resistors, resistor holders and iron core coil forms, including shields, were obtained from surplus BC-453 receivers. A common power receptacle located on the extreme left supplies power to both units.

center line allows direct reading of frequency on all bands. Zero on the dial represents either 7,000 kc or 14,000 kc and 500 represents 3,500 kc. The dial is constructed by cutting an aluminum disk $3\frac{3}{8}$" in diameter. Draw the new scale on a good grade of writing paper so that "0" corresponds to 200 on the original dial and 50 corresponds to 250, etc. This will provide accurate calibration provided the crystals are carefully chosen for the proper frequencies. Crystals may be obtained for less than one dollar on the surplus market. But if surplus crystals are used, purchase frequencies somewhat lower than those desired and carefully grind the crystals to the exact frequencies.[2]

The type of construction used for the converters is patterned after the BC-453 and most of the parts were obtained largely from two of these receivers that were "cannibalized." These receivers can be purchased for around \$2.00 to \$3.00 less tubes. One caution—do not attempt to use the radio frequency chokes found in this type of receiver because their inductance is much too low for successful use in the converters.

The conversion of the BC-453 receiver is not difficult. The filaments are wired in parallel instead of series parallel as is required for 28-volt operation. A 50,000-ohm variable resistor is added between pins number *3* and *1* (see *Fig. 7*) on the rear power socket and serves as a gain control. An OFF-ON switch for 117-volt a.c. may be added to this control. A switch for b.f.o. is added between pins number *4* and *1*. The headphone jack is wired to pins number *2* and *1*. Filament voltage is connected to pins number *6* and *1*. The plate voltage is connected to pin number *7*. Loudspeaker operation is obtained by connecting an output transformer with an 8000-ohm impedance primary to pins number *2* and *1*. Make sure that number *2* is connected to lug number *3* on the output transformer of the BC-453, as this is the 8000-ohm tap. Power supply requirements are 250 to 300 volts at 60 ma, and either 6.3 volts or 12.6 volts for the filaments, depending on the tubes used.

Receiver Alignment

Adjustment of the receiver for initial operation is as simple as the modifications. With the bandswitch set for the band desired, turn up the gain control on the BC-453 and set the alignment tuning condenser on the converter at half scale. Next tune the associated trimmer condenser for a distinct increase in noise level. This will be either the frequency desired or, possibly, the image frequency. The image frequency can be easily checked because it falls outside of the amateur band.

2 Johnson, "Crystal Grinding Simplified," *CQ*, Jan. 1949.

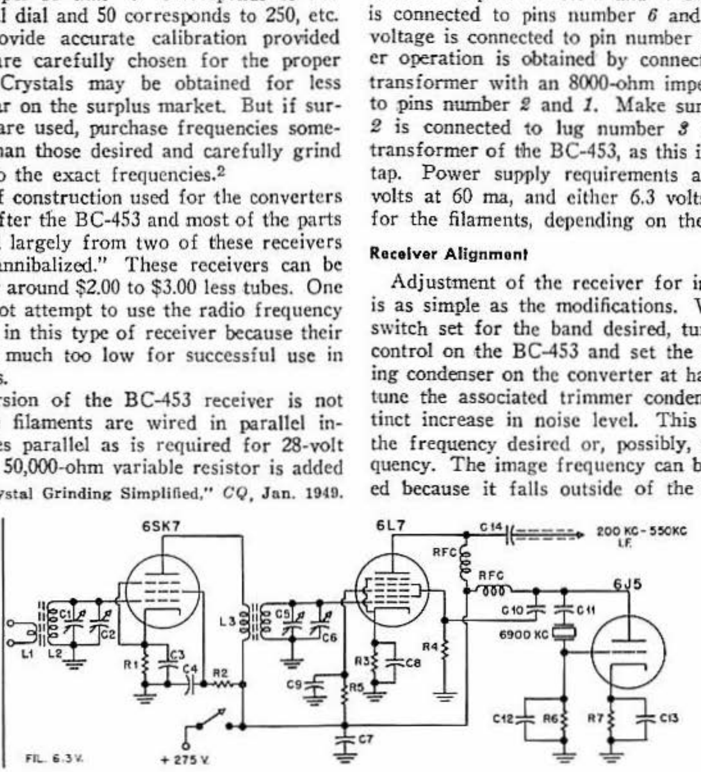


Fig. 5. Crystal controlled 14-mc converter for the BC-453.

C1, C5—15 μμf	C11—.001 μf	R5—15,000 ohms	L2—15 turns
C2, C6—40 μμf	C12—50 μμf	R6—25,000—50,000 ohms	L3—10 turns
C3, C8, C13—.01 μf	C14—.005 μf	R7—1000 ohms	L4—15 turns
C4, C7, C9—.05 μf	R1, R3—620 ohms	RFC—2.5 mh	
C10—30-50 μμf	R2, R4—50,000 ohms	L1—3 turns	

Now tune in a signal and adjust the trimmer for maximum signal strength. Once this setting is found it will need changing very little during complete band tuning. Repeat this process for each converter unit.

If the receiver does not operate check the appropriate crystal for oscillation. If it is oscillating sufficiently for adequate voltage injection to the converter the noise level will decrease noticeably when it is removed. Very little oscillator injection

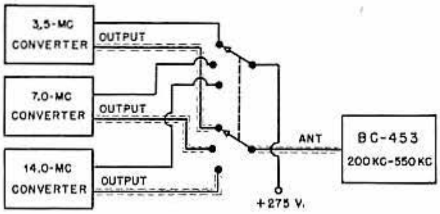


Fig. 6. Block diagram of receiver-converter arrangement.

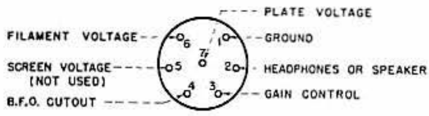
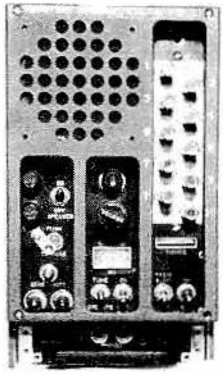


Fig. 7. Rear view of power receptacle connections.

voltage is actually required for the proper operation of the 6AC7 converters. For this reason the crystal oscillator plate voltage should be limited to 35 or 40 volts.

The over-all selectivity of this receiver is excellent. Single-signal reception is almost realized, one side of zero beat being very low. Additional selectivity would make intelligibility of phone signals poor. The substantial "skirt" selectivity offered in this receiver makes copying of weak signals possible right up to that kilowatt signal a few blocks away. As an interesting application of surplus and a good receiver at a modest investment this little super is a worthwhile shop project.

THE BC-603



Much of the equipment available in quantity still left over from WW-II has been converted. One obvious exception to this is the BC-603 receiver and the companion BC-604 transmitter. Probably this is due to the fact that FM has never really caught on and partly because of the frequency range of the BC-603. This receiver does cover the fifteen and eleven meter bands, but who is on FM on fifteen? Our job was to find out as much as possible about this receiver and make it into something. After a few weeks work we found the BC-603 well worth the few dollars we spent for it and it seems like this could be another ARC-5 in versatility. As a matter of fact we definitely feel that this little rig will open six meter for a lot of people and make it a real crowded band. Built like a you-know-what, it can take a lot of abuse and still stand up, probably due to the fact that it was designed for use in trucks and tanks rather than in aircraft.

The BC-603 is part of a tactical field communications system which also includes the BC-1335 and the BC-659 on the higher frequency end. Except for its frequency range it is identical with the BC-683. Operating in the region of 20-27.9mc. (the BC-683 covers 28-39mc), it is an FM receiver of high sensitivity. Various possibilities resulted in making this conversion cover two months instead of the usual single issue conversion we have been striving for. This month we will make the conversion to 6 meters FM and next month finish off the conversion to AM. No doubt there are many possibilities that could be examined, but we would rather do a complete good job than a half fast sloppy job.

One nice thing about the 603 is that it is not crystal controlled. The transmitter is but that isn't our problem right now. Tuning is accomplished by the conventional variable capacitor and the coils are slug tuned for adjustment with variable trimmer across them for minor adjustments. The push buttons may be reset to any setting you may desire and the dial is completely tunable, with good calibration.

The antenna is coupled to the receiver at the rear of the equipment by means of a coaxial connector in the power plug and also at the front by means of two terminals. The antenna is transformer coupled to the grid of the RF amplifier tube (V-1,6AC7) and the grid is tuned by one section of the variable capacitor. The plate circuit of V-1 is also tuned and coupled to the grid of the mixer (V-2, 6AC7) which is also tuned. This double tuning increases the selectivity of the front end of the receiver. The fourth section of the variable tunes the oscillator.

The 6AC7 mixer uses the suppressor for oscillator injection. The output frequency is 2.65mc which is the IF frequency. Three stages of IF and limiter stages precede the discriminator and there is a single stage of audio ahead of the 6V6 audio output stage. A CW oscillator is used for tuning the equipment and setting up the push buttons on a carrier, but may also be used for CW monitoring and copying. The loudspeaker is self contained in the front panel assembly and a half of a 6SL7 acts as a squelch tube.

The squelch is included but can be disabled from the front panel by means of a switch.

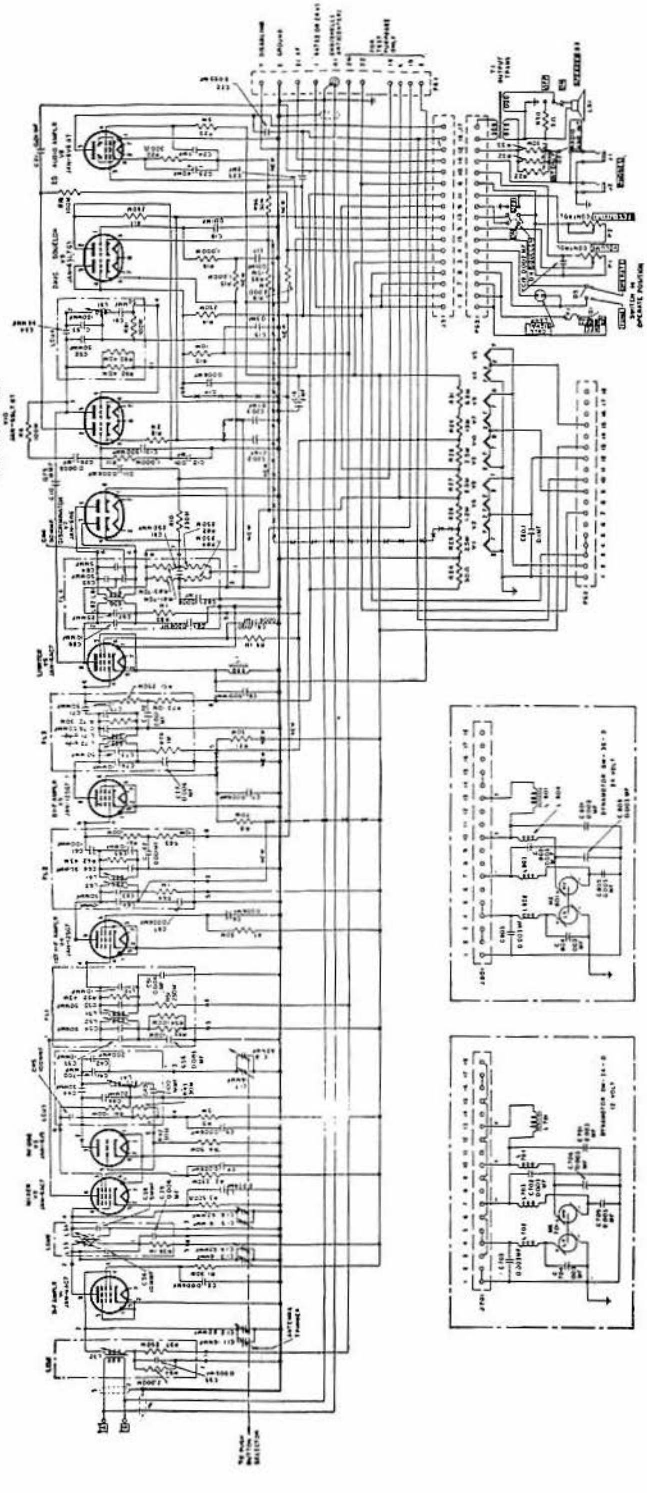


Fig. 1—BC-603 Radio Receiver

The level that the squelch operates at is determined by the setting of the SENSITIVITY control which is really the RF gain control. Other features not needed include the use of the equipment as part of an intercommunications system. Provision is made for the use of earphones by switching the loudspeaker out and when this is done the speaker transformer is terminated with a resistor so as not to cause the output tube to overload due to lead removal.

The basic power supply is shown in Fig 2, and may be used with the FM conversion this month or the AM conversion of next month. Basically they are the same except that the B minus is not returned to ground in the FM model. The original equipment was designed for 12 or 24 volts and used a dynamotor. Only two tubes are 12 volt filaments. These were replaced by their six volt equivalents, the 6SG7. The 6SK7 is very similar and could easy replace the 12SG7 type with little loss in gain. Using all six volt tubes greatly simplifies the power supply connections since all that was necessary was to rewire the filament string and add the high voltage supply. If you have a 12 volt filament transformer handy this won't be necessary.

The first thing to be done is the power supply construction. Concord Radio has one built on the same type of chassis the dynamotor mounts on. The power plug takes care of the filament switching in the original unit but we decided not to use that feature but rather to wire the filaments as we have already mentioned. With the connections shown the front panel switch will control the main power as well as the fusing of the equipment. Figure 1 is a full schematic of the BC-603 and another copy of this appears at the bottom of the equipment cabinet.

Converting the front end is about all that has to be done for the six meter band. This is a slightly ticklish job and some care will be necessary in order to make it work right. It is recommended that a grid-dip-oscillator be used so as to check yourself when wiring and winding the coils. For the six meter band, remove the RF and oscillator coils, one at a time from the chassis. They are held in position by four nuts two of which serve to hold the shield and two to hold the coil in position. Remove all but five turns from the RF coils and all but four turns on the oscillator coil. The other components inside the coil forms are removed as we will rewire them in from the outside. Connect the primary of each coil to the terminals 1 & 2 and the secondary to 3 & 4. Make sure that any of the grounds inside the coils are removed. There are several places where the screw stud also acts as a ground lug. When removing turns from the *Second* RF transformer note that there are two coil forms. The wire should be removed so that the spacing between coils is not altered at all. Put the coils back into the set in their proper position.

It will be necessary to solder the screen and plate resistors back into positions shown electrically in figure 2. The only remaining job left to do is to try and remove the unnecessary plates from the variable condenser. Do this by removing the front panel which is held in place by a multitude of screws. The front panel is also connected to the main chassis by means of a power plug. Care should be taken to prevent the power plug from breaking when the two parts are separated. The variable condenser should be visible now. We will remove all but one plate from the rotor and one plate from the stator. The two remaining plates should be adjacent to each other. The best way we found to remove the plates was to cut the web holding the plates in position with a pair of cutters and then rotate the shaft so we could pry and twist the plate free. Be careful not to damage the other plates as you do this. With one plate on the stator and one on the rotor you should be able to get good tracking over the entire six meter band. The dial will then cover slightly more than the entire six meter band.

Using the grid dipper you should find that the coils will be just about right for the band. Tune the coil slug to about 49.9 mc at the point with the condenser fully closed. Then open the condenser and adjust the trimmer to get the band edge at about 54. Repeat the adjustments until the tuned circuits all tune up the same way. The oscillator may give a little trouble. It was necessary to tap the cathode of the oscillator up by only one turn and spread the windings until we got exactly what we wanted. The oscillator should be set so that it is always 2.65 mc below the frequency the RF is tuned for so as to minimize TVI (Interference from TV). That means that the oscillator should tune from 47.25 to 51.35 mc. When a signal is heard on the air you can peak the coils to that, or you can use the second harmonic of a signal generator should you find that there are no signals around. The dial strip can be calibrated by using the channel numbers as the logging scale and checking against known frequencies such as crystal oscillators etc. The dial strip can then be removed and the true frequencies be put on the dial by means of gummed tape. Return the dial to its position after calibrating it.

By now you should have a pretty good FM set for the six meter band. You can realign the IF stages and even make them sharper by cutting out a few of the shunting resistors that load down the IFs to broaden them slightly. Unbalancing the discriminator will allow a little AM reception and rewiring the limiter stage will be an asset in allowing AM to get to the detector in the first place.

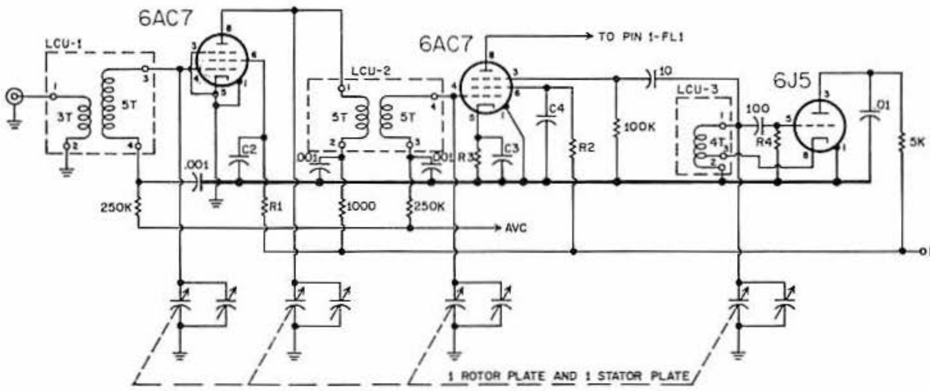


Fig. 2 Modified RF stages of BC-603 to 6 meters.

Disconnect wires from 1, 2, 7, 8 of front panel plug. Connect A to pin 1. Connect B to pin 2. Connect C to pin 6. Connect D to pin 16.

Just about everyone who dabbles in surplus converting has been interested in doing a job of the BC-603. And well they might, for this unit is available for under fifteen dollars just about everywhere and is usually in pretty good shape.

If you are interested in a wide band FM receiver then you are all set to go by just powering the thing. But chances are that you will be wanting to change the original tuning range of 20-28 mc to the 50 mc band and modify it for AM reception. Last month we went into the six meter conversion and ac power supply for it. This month we cover the de-FMing of it, a much more formidable task. You see, once you start looking closely into the bowels of the 603 you find, much to your dismay, that all of the wiring has been made into a harness and is stuck together permanently with goo. This means that you have to perform major surgery for even minor conversion attacks.

Because FM is wide in bandwidth due to the sideband distribution, the FM receiver must be equally as wide in order to pass the necessary intelligence. It is common to "load" circuits in order to increase the bandwidth by adding resistors across the tuned circuits to decrease the Q of the circuit. This is what was done in the BC-603. Therefore the first part of the conversion is to remove the loading resistors and sharpen the receiver selectively.

The actual process of removing the components used to broaden the receiver is accomplished by removing one i-f transformer at a time by unsoldering the leads going to its terminals and removing the shield and transformer mounting hardware. When the shield is removed, the components will be visible. Unsolder all resistors and those capacitors used for by-passing and save them for future use. The by-pass capacitors are square postage stamp type mica capacitors and usually have one lead connected to the screw stud used for mounting. The four rods (one in each corner) are all of the connections we will make use of. All other connections at the base are not used and may serve as tie-points later on. Note that the ends of each coil are terminated at these four rods, and that the resonating condenser is mounted between two of these rods. Each resonating condenser is about 50 mmfd. in value. With all unused components removed we will have a conventional i-f transformer with a resonant frequency of 2.65 mc or a little higher. Check the resonant frequency of each coil with a grid dip oscillator. Don't forget that there is an additional capacity due to wiring and tube capacity yet to be put across each coil, therefore the coils will probably resonate a little higher in frequency . . . say 2.8 mc. Reconnect the transformer after remounting it, using only the plate and grid connections. The AVC and B-plus conections will be added later.

The only i-f transformer that may give you trouble is the final one, FL-4, originally used as a discriminator transformer. On this one again remove all components including the resonating capacitors, but leave the coils alone for the time being. Clean up all excess solder and then carefully remove the bottom section of the output coil, leaving two identical coils one on each ceramic form. The leads of these coils should be connected to the corner rods as in the original transformers. A 56 mmfd is all that we should have to use in order to resonate each coil, but use a grid dip oscillator to check this to be on the safe side

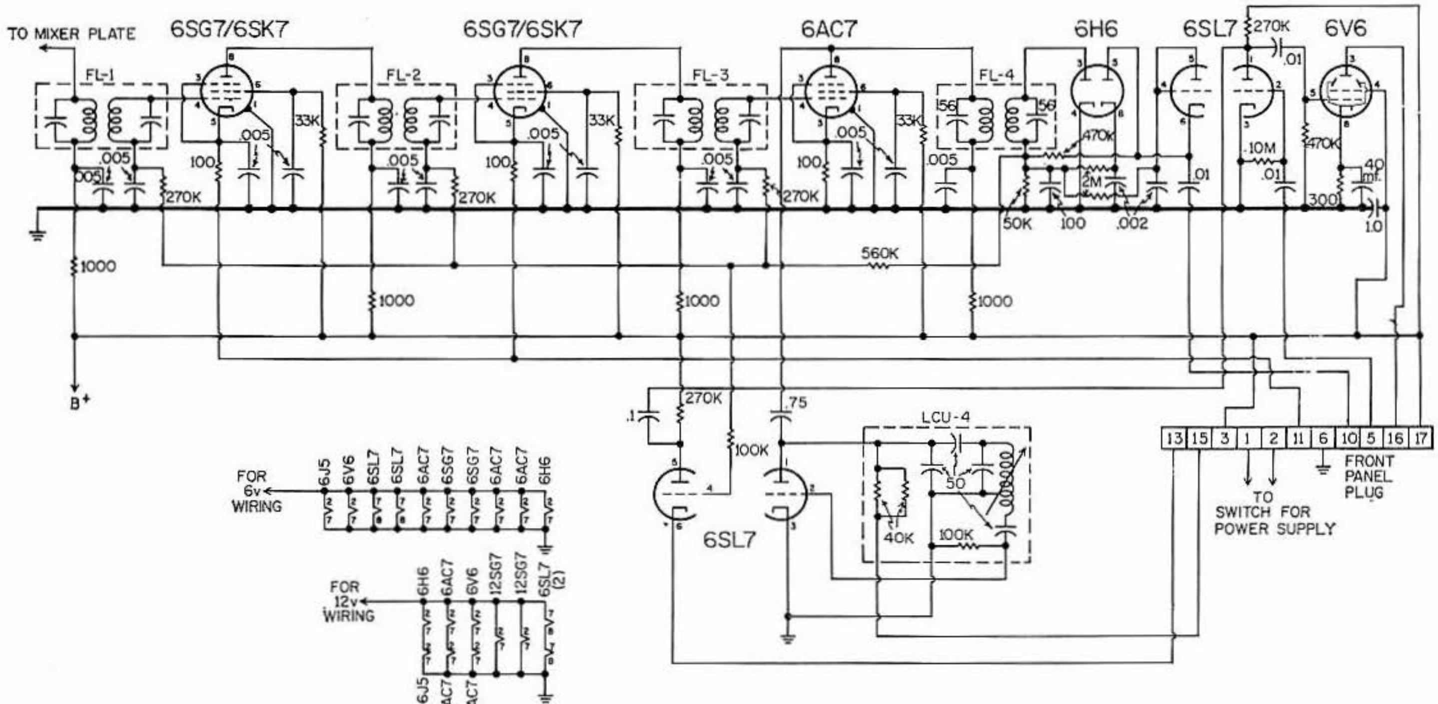


Fig. 1—Circuit of the modified i-f, detector, noise limiter, and audio of the BC 603.

once you install the condensers. It may be necessary on all of the transformers to adjust the slug screws in order to get to the exact frequency we want, and we will definitely have to do this later when we align the set.

The next step is the hardest (the hardest to get yourself to do). Completely remove all terminal boards, the main harness, and clean up all the terminals going to the front panel plug and all of the unused (so far) terminals on the tube sockets. That should sound like a big job—well it is. First a word of reason is in order. We found that a very complicated delayed avc circuit, a squelch circuit, a sensitivity control and an operator's alarm circuit were giving us a real headache. As a matter of fact this one part held us up for a full month. Next, the conversion can be speeded up by not relying upon the tracing of leads covered with that moisture and fungus paint that always gets in your way, and third why leave a lot of useless components hanging around especially since they aren't being used. Once you reconcile yourself to the facts it isn't too bad at all.

Rewire the filaments. It is up to you to decide what voltage you are going to use here. For mobile use six or twelve. For ac operation use 6 volts. When this is completed, wire in the plate and screen supply voltages, and then the avc voltages also known as the grid return. The detector and the noise limiter, audio and audio output stages and the bfo if you have removed anything from it are all that has to be done to complete the receiver. That is a big job, though and the circuit is shown in figure 1. Remember that the bypass capacitors should be wired with leads as short as possible. It may take a bit of hunting for it, so we'll give you the clue that the 6V6 cathode bias resistor is located near the two bath-tub condensers on top of the wiring side of the tuning condenser. Remember that the values shown on the diagram, with the exception of the i-f tuning capacitors are relatively not critical. Any value within 20% of the value shown should work with little change in performance.

Naturally a noise limiter is needed and we added one of a very simple nature (source: Radiotron Designers Handbook), together with a diode detector to provide avc. We left the bfo alone and it is still operated by the TUNE switch on the front panel. No modifications were made on the front panel wiring, and all connections to the front panel were made using the panel plug. Note that the volume control is on the front panel, so make sure that the leads going to the volume control are short and away from the leads going to the output transformer which is also located on the front panel. Getting back to the noise limiter, we found that two diodes were needed. Having only one left over from the other half of the 6H6 detector, we made use of the other half of the 6SL7 used for the audio amplifier by making the triode into a diode merely by connecting the plate to the grid. The other 6SL7 is used for the bfo and the squelch. The original squelch circuit of the BC-603 used a very complicated network and was fairly effective. We can't say the same for the one we used, except that it is simple and fairly effective. One more thing to remove is the inductor in the cathode of the limiter. This was used in the process of limiting and will find no use in an AM set, therefore take it out and add it to your junk box.

Alignment

The alignment of the set is probably going to be the most tedious part of the conversion. The i-f transformers should all be about the same frequency without any further adjustments, so apply power and first check to see if the bfo is working. This can be done by using a grid dip oscillator as an absorption wave meter, or by actually measuring the grid bias of the oscillator tube. It will be on 2.65 mc providing nothing was touched inside the can. Using the bfo you can beat the signal provided by the grid dip oscillator to get an audio tone to tune in on. Of course a signal generator should be used if one is available. Start by connecting the signal generator (set 2.65 mc and modulated) at the grid of the last i-f amplifier and adjust the slugs of the output transformer. When they have been peaked, go to the grid of the previous tube and peak this. Keep this procedure up until you get to the grid of the mixer. Here you should pull the oscillator tube (6J5) out and peak all of the i-f transformers for a clean tone. Any sudden change in tone should be checked and if in doubt, turn the signal generator off for a second. Should the tone continue with the signal generator off, you have an oscillation, and this will require detuning or anyone of a dozen procedures to eliminate. If you have followed the directions carefully you will find that the set may oscillate while you are aligning it, but that the backing off of the slug adjustments will eliminate the oscillations. In severe cases you will have to increase the size of the plate decoupling resistor (that's the 1000 ohms resistor at the bottom end of the i-f return for B-plus) and also increase the size of the by-pass condenser associated with the resistor. Front end alignment was described last month, so we won't go into that except to say that the rf gets aligned at the low end of the band with the slugs and at the high end of the band by means of the trimmer condensers.

It is a usual practice to disable the avc when aligning a set by shorting it, but since this is not always advisable especially when the i-f gets a large portion of its bias from the avc line, we found that the alignment can be accomplished by the monitoring of the avc voltage (about 8 to 10 volts) with a vtvm.

A SUPER "SUPER PRO"

This article has been prepared and dedicated to the many amateurs in the United States and other countries throughout the world who still own and use, or have access to, that grand old behemoth of receivers, the Super Pro. Even though it is many years old, this receiver has all of the basic prerequisites of a modern receiver. The battleship construction lends itself admirably to rigidity and stability and the major components are of a superb quality found only in the most expensive present day receivers. The desire of most radio amateurs to design, create and to strive constantly to improve their equipment has contributed to most of the present day advancements in h.f., v.h.f. and u.h.f. communication developments. My desire to do something constructive was brought about not only by the two articles by L. E. Geisler,[1] and Comdr. Paul H. Lee, but also due to the theft of a newly completed Mohawk RX 1 receiver from my (locked) automobile one very rainy night. However through the offices of a very good friend, I was able to obtain a BC-779 in mint condition.

In planning for a major modification of this receiver, hours of drawing and redrawing sketches, and rereading the previous articles on this unit, were required. I had already completed an earlier modification on one Pro receiver patterned after the two articles, combining the best features of each, plus some ideas of my own. Armed with the experience gained and many new ideas, I was ready to begin planning for the final modification.

[1]Geisler, L. E., "Souping The Super-Pro", *CQ*, Dec., 1957, p. 30

In the following modification it should be pointed out that the changes are equally applicable to the other models of the Super Pro. such as BC-779, BC-1004, R-129/U, SP-200, SP-210, SP-400 and others of this series. And with a bit of planning and ingenuity these changes can be used with slight variations for the modernization of the HQ-120, HQ-129X and other similar superheterodyne receivers. It is therefore suggested that the following changes be accomplished one at a time in the order given.

1—The construction of a new audio system and squelch system plus a self contained power supply using the new silicon power diodes, all contributing to the conservation of space, a tremendous reduction of radiated heat and a long trouble free life.

2—An improved product detector and beat frequency oscillator which is voltage regulated.

3—The rebuilding of the entire r.f. section, incorporation of a new cascode 1st r.f. amplifier, grounded grid 2nd r.f. amplifier and twin triode tubes in the mixer and oscillator stages, with voltage regulation.

4—An antenna trimmer capacitor, i.f. gain control and crystal calibrator switch installation.

5—Infinite impedance second detector, audio and noise limiter stages.

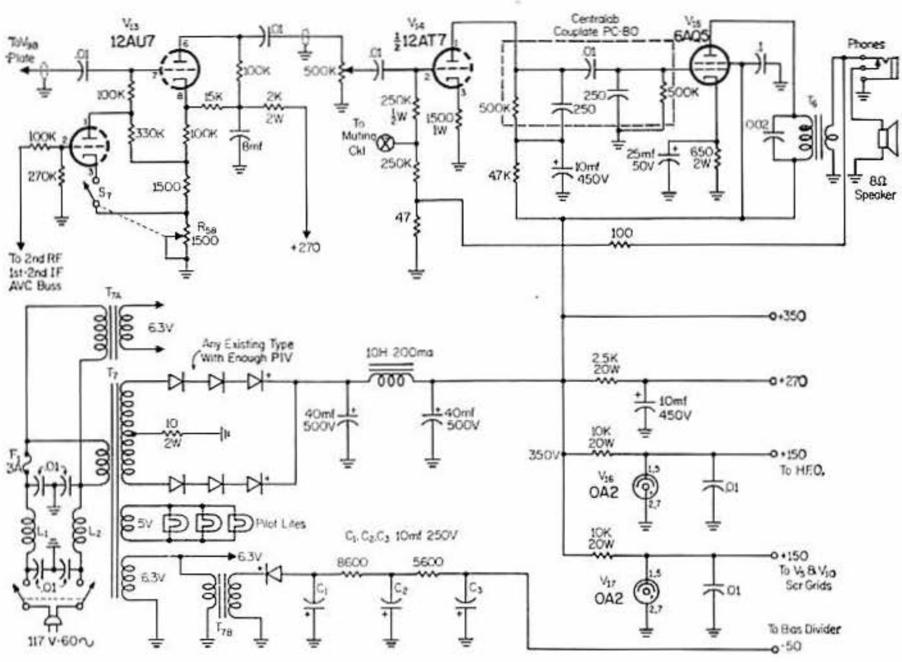
6—A 100 kilocycle crystal calibrator.

7—A "T" notch filter.

8—A crystal controlled converter for the series of receivers which do not cover the 10 and 15 meter bands.

9—Other minor items include the installation of an antenna coaxial chassis connection, auxiliary a.c. outlet and fuse holder.

The manner in which the modifications are



T_6—Universal Output transformer 8,500 ohms to 8 ohms, 5W

T_7—Power transformer—See text

T_{7B}—117v to 6.3 v.a.c. @ 6 amperes—See text

T_{7L}—117v to 6.3 v.a.c.—See text

L_1-L_2—20t, #18E, ¼ diam. close wound.

Fig. 1—Power supply, audio amplifier and squelch circuit. Regulated outputs are provided for the h.f.o. and i.f. screen grids. The 10 ohm resistor in the hv winding center tap is for surge limiting.

made will naturally be left to the discretion of the owner. However, the steps listed here facilitate those steps deemed most desirable. For example, the completion of the power and bias supply, and the audio system and associated circuitry in order to have an operating receiver before beginning other modifications. Precautions must be taken in the wiring of the new r.f., oscillator and mixer stages. Careful orientation of the new 9 pin miniature tube sockets at the time of their installation is important. The other stages were rewired in accordance with good wiring procedures; leads rigid, short and as direct as possible. Use a wiring harness for the major portion of those leads carrying the miscellaneous d.c. voltages. All power leads, as well as all audio leads, were run in shielded wire. The new filament transformer, located in the center rear, was covered with a heavy copper hysteresis shield to prevent 60 cycle hum from being introduced into the antenna circuit.

Suggestions

It is recommended that the newcomer or the inexperienced amateur proceed slowly.

Study each circuit and modification before going ahead.

Do only one modification at a time and tag leads which will be used later. This method will save you many hours of trouble shooting to find mistakes that are inevitable, should you attempt to make all the changes at once.

In order to fully understand all that is to take place, it is highly recommended that the original schematic diagram be on hand and it should be checked frequently. The two previously mentioned articles should be read and their contents thoroughly digested. All of these recommendations will be used with some modifications in order to improve our receiver, and it is extremely necessary that they be followed and completely understood.

When completed, the receiver is self contained, including the new, miniature power supply. It has all of the modifications deemed necessary for present day band conditions. It will do an admirable job of receiving a.m., c.w. and s.s.b. in the crowded amateur bands and can be surpassed only by receivers costing many times more than the cost of this modification.

Power Supply and Sub Chassis Construction

The first step is without a doubt the most difficult, in as much as the new audio system *and* power supply components have to fit into the same space the audio system alone had previously occupied. The new circuit is shown in fig. 1.

To accomplish our first major objective we begin by removing the entire audio system, in-

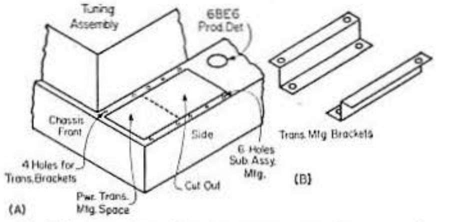


Fig. 2A—Location of new power transformer and audio sub-chassis. (B)—Transformer mounting brackets. Dimensions are determined by the transformer used as explained in the text.

cluding the two audio transformers. Unsolder all leads and remove all components connected to the 6F6 sockets as well as those to the 6C5 socket. Lift the terminal strips fastened to the chassis and tie them up out of the way. Remember; study the original schematic as well as the new one, and if you aren't certain which wires can be removed from the harness, trace out the original schematic and tag those which will remain. Before you start removing the two transformers and the 4 tube sockets, carefully remove the tuning shaft from the b.f.o. transformer, T_5, and lay it aside. Then remove the transformers and sockets, etc. Now that we have plenty of room under our chassis, remove the old volume control and associated wiring and also the ON-OFF, SEND-RECEIVE switch SW_3. In place of the C.W.-PHONE switch we will install our new miniature 3 pole 2 position rotary switch. This is necessary for switching the outputs of our a.m. and s.s.b. detectors to our common audio input. Also install the new 500K volume control with its d.p.s.t. on-off switch. This is easy now, but would be quite difficult later, as the power transformer will be in the way and will complicate wiring. Now is also a good time to install the shielded leads on both of the switches and the volume control. Make them plenty long and tie them back out of the way, temporarily. You can cut them to proper length later.

The next step is to cut out a portion of the chassis in order to install our power transformer, and new sub chassis. Mark the top of the chassis ¼" from the edge, on all four sides, (up to the b.f.o. transformer) and cut out. (Refer to fig. 2 and the appropriate photos.) This can be done by using a 1" square chassis punch on each of the corners, a small hack saw, and a lot of elbow grease. After removing the cut-out portion, smooth and round off all four edges with a small file and emery cloth. The mounting of the transformer is next and how it is done will depend upon which transformer you have selected. It must be sunk below the chassis just enough to clear the tuning shaft of the beat frequency oscillator by ¼ inch and yet no deeper than absolutely necessary, because we must mount our filter choke, capacitors, power diodes and output transformer directly beneath the power transformer. The brackets for mounting our transformer, (see fig. 2), were made of #18 gauge sheet aluminum. Dimensions will again depend upon make and type of transformer used.

Selecting a Power Transformer

The power transformer used in the conversion was a surplus unit that fortunately contained the necessary 100 volt bias winding. Since there is no way of identifying it, a standard commercial transformer must be used. Suitable units are made by Merrit, Stancor and Triad but none have the required bias winding. This is provided for by connecting a 117 to 6.3 volt filament transformer (T_{7_b} in fig. 1) to the 6.3 volt line and stepping it up to 117 volts. The current rating may be very small, 1 ampere or less.

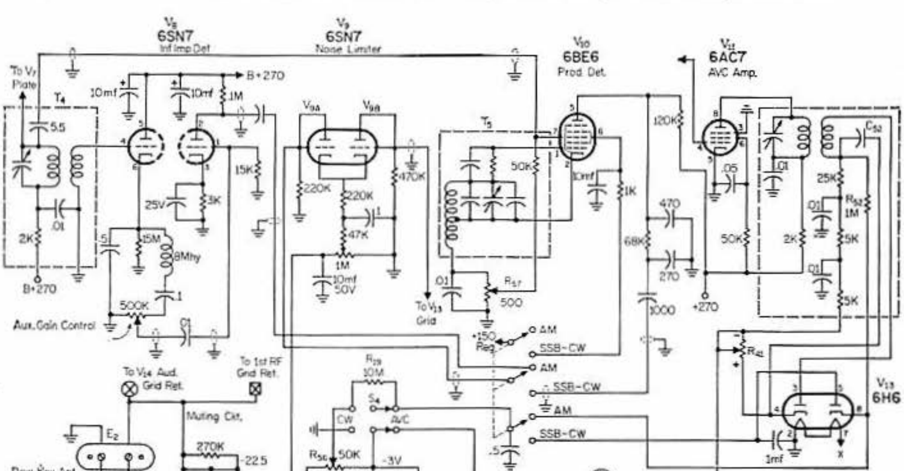


Fig. 3—Modified diagram of the infinite impedance 2nd detector, 1st audio amplifier, noise limiter, product detector, A.M.—S.S.B.—C.W. switch and a.v.c. circuit.

The filament windings on the replacements are not adequate and must be supplemented by a separate filament transformer (T_{7a}) with a rating of 6 amperes. This is the transformer shown in the rear of the underside view of the chassis. It has been wrapped in copper to help reduce the possible 60 cycle radiation into the antenna circuit.

Now select a sheet of aluminum large enough to cover the remaining hole in the chassis. This will be the sub chassis containing six miniature sockets, three 9 pin and three 7 pin miniatures. These are for the two audio stages, squelch stage, 2 voltage regulator tubes (0A2) and 1 spare 9 pin miniature for possible future use. Drill the necessary holes for mounting all of the sockets and tie point terminals and wire up all of the audio, squelch and the voltage regulator stages before securing the sub chassis to the regular chassis. Allow plenty of lead length for connecting of grounds, filament and B plus voltages, as they can be cut to the desired length later. The sub chassis is then secured to the main chassis by six #6 quarter-inch long self-tapping sheet metal screws.

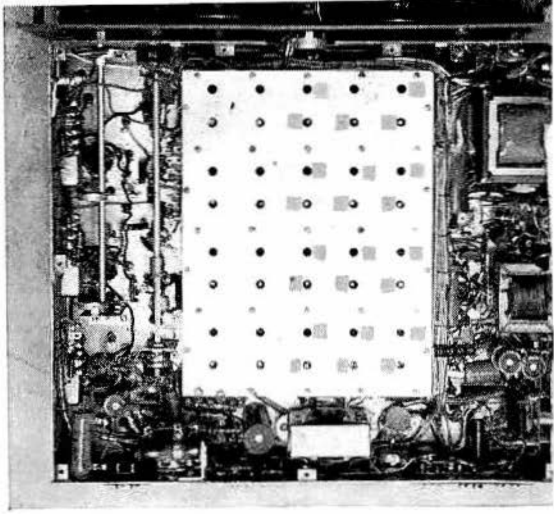
We can now mount our filter choke on the inside edge of our main chassis. The dual section 40 mf filter capacitor can also be mounted securely to the side of the chassis. The power diodes are mounted on a small piece of micalex or other good insulating material, and the whole assembly is mounted on stand-off bushings on the side of the chassis. Wire up the rectifiers, power transformer and filter circuit and install the line filters and fuse holder. Now wire in the new power on-off switch and the power supply may be tested. Voltage will be quite high without a load, so I suggest a 15K 20 watt resistor be connected across the output filter during the voltage measurements.

We are now ready to complete the wiring of the audio section. Finish wiring the two 0A2 voltage regulators. The 10K 20 watt resistors can be mounted conveniently above the back of the main chassis. The squelch circuit can also be wired at this time, if desired.

The squelch control potentiometer and its on-off switch are now mounted in place of the old SEND-RECEIVE SWITCH. Here, again, to avoid any possible chance of hum pick up, all audio leads are run in shielded wire. You are now ready to check out the receiver with the new audio system and the new power supply. If you haven't goofed somewhere it should take off and operate as before.

Product Detector

The next step is to install the product detector and modify T_5. Remove the 6SJ7 b.f.o. tube and its octal socket. Unsolder the leads from the socket as they aren't long enough to begin with. Substitution of a 7 pin miniature tube socket in place of the octal socket is accomplished by using either a small square sheet of aluminum or one of the Mallory metal mounting wafers used for



The bottom view shows the location of the auxiliary filament transformer in the rear center of the chassis. To the left are the 2 ten watt resistors used in conjunction with 0A2 regulators and to the extreme right is the line filter mounted on standoffs. On the right hand lip of the chassis is the output transformer and towards the front, the filter choke.

their can type electrolytic capacitors. They come in three sizes and are very well suited for adapting small sockets to large holes formerly occupied by octal sockets. The MP-4 will accommodate both 7 and 9 pin miniature tube sockets by merely using a ½" or ¾" socket punch to enlarge the existing hole. The socket can be soldered directly to the wafer *after* it has been correctly oriented for minimum lead length. This not only applies to the product detector tube, but to all other stages, particularly the new front end of the receiver. In most cases the original mounting holes in the chassis can be re-used if you position correctly before soldering.

The shield can on T_5 can now be removed in order to gain access to C_{49}, the original plate voltage blocking capacitor, and to remove it entirely from the circuit in order to provide a d.c. return for the cathode of the 6BE6 product detector. However, this connection does not go directly to ground. Remove this lead from its lug on the terminal board of the transformer and add a new lead about 12" long. This lead will connect to the top of R_{57} 500 ohm pot which we can now mount conveniently on a clear space on the rear lip of the chassis. Re-assemble the transformer, taking care not to allow any internal shorts to exist. Refer to the schematic of V_{10} in fig. 3 and wire this stage.

R.F. and Oscillator Section

The r.f. section of the receiver has been modernized to accommodate modern miniature tubes. The high frequency oscillator and its cathode follower (V_3 in fig. 4) are fed from the voltage regulated 150 volt line of V_{16}.

A 3 mmf negative temperature coefficient capacitor is placed across the oscillator tank cir-

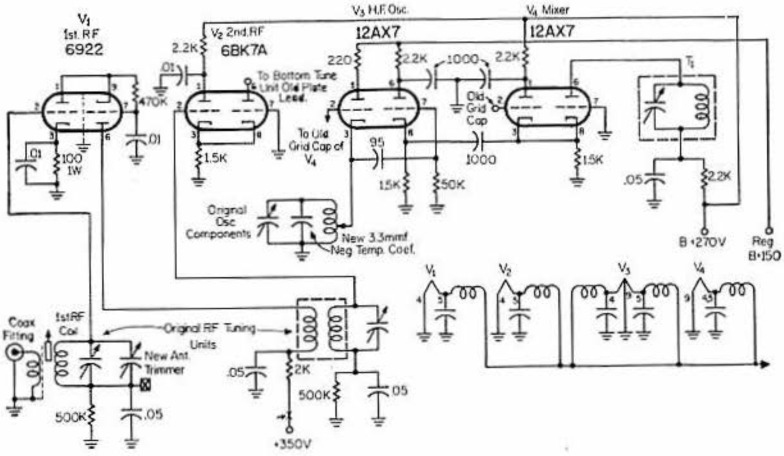


Fig. 4—Modified diagram of the 1st and 2nd r.f. amplifier, high frequency oscillator and mixer circuit. Chokes in the filament circuits improve the operation on the high end and stability is improved by voltage regulating the oscillator and use of a temperature compensated capacitor in the oscillator tank circuit.

cuit but is not done until the next step when the tuning unit cover has to be removed.

The second r.f. amplifier uses a 6BK7 and remains a grounded grid stage. The first r.f. stage, however, has been changed to a cascode amplifier which supplies increased gain with considerably less noise. This circuit follows the S-9er circuit[3]. Amperex has developed a new tube, the 6922 dual triode especially for this type of circuit and it works exceptionally well in ours. This tube must be operated in accordance with the manufacturer's specifications in order to achieve maximum gain and uniform operation. It is rated at 1½ watts plate dissipation, and the voltage on each plate and the maximum current should be followed closely. Maximum current can be checked by breaking the plate voltage lead to this stage at point "X" in fig. 4, the schematic of the modified r.f. section, and inserting a 0 to 50 milliameter. The reading should not exceed 23 milliamperes. If the current is too high or too low the 2K resistor in the plate voltage line must be changed until a satisfactory reading is obtained. The oscillator and mixer stages are now completed. The original 95 mmf capacitor coupling the oscillator to the mixer is used again in our modification, so use care in removing and resoldering it. Keep the heat away from the capacitor by allowing the long nose pliers to dissipate it.

The filament chokes and bypass capacitors are installed. The chokes are made of #18 enamel covered wire, close wound on a 3⁄16" diameter form, 20 turns per coil. These help somewhat in increasing the high frequency performance of the receiver at the high frequency end of the dial. Realignment of the new r.f. section will be necessary and will be covered later.

[3]Kyle, J., "More On The S-9er, Mark II", *CQ*, Dec., 1959, p. 38

Antenna Trimmer, IF Gain, Crystal Calibrate Switch

The installation of the antenna trimmer is next on the agenda and we begin by removing the front panel. Remove all dials and pointer knobs, screws and brackets holding the panel. Carefully remove the S meter. While the panel is off, drill new holes for the antenna trimmer shaft bushing and the 100 *kc* crystal calibrator switch, SW_6. Also remove the old on-off power switch and its wiring, and in its place install a new 5000 ohm pot. This is our new i.f. gain control. Connect three long color coded wires to the terminals before installing and wire them later as shown in fig. 6.

Center the hole for the antenna trimmer above the main tuning dial escutcheon plate, midway from the top of the panel. Center punch and drill a ⅜" diameter hole. The hole for the 100 kc crystal calibrate switch, SW_6 can be located and drilled at this time. It should clear the dials and the front edge of the chassis by at least ¼". Drill a ⅜" diameter hole approximately 1⅛" above the center line of the hole formerly occupied by the old A.C. ON-OFF switch. Solder two lengths of hookup wire to the switch before mounting. Leads should be approximately 24" long after twisting together. They can then be extended up behind the panel along the top left edge of the tuning unit. They are held in place along the edge of the tuning unit by small plastic cable clamps secured by the four cover plate mounting screws and small washers.

We next remove the top cover plate on the left side of the tuning unit. Install the 3 mmf zero temperature coefficient capacitor across the main oscillator tuning capacitor as shown in fig. 4. Now solder a short piece of hookup wire to the stator connection of the large tuning capacitor of the 1st r.f. stage. Replace the cover tempo-

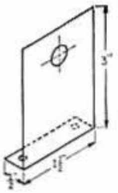


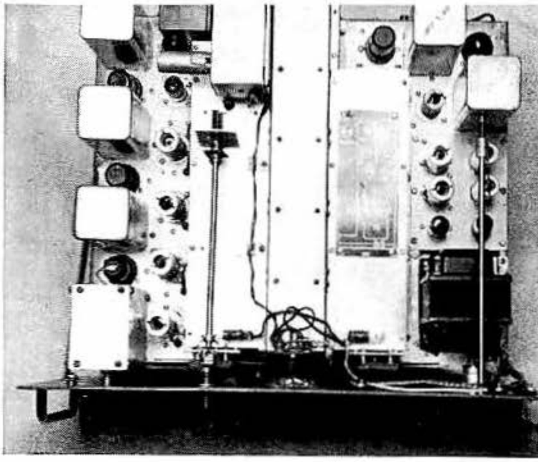
Fig. 5—Mounting bracket for the antenna trimmer.

rarily and make a pencil mark directly over the connection. Drill a ¼" hole and insert a small rubber grommet. Make a right angle bracket as shown in fig. 5. Use a piece of scrap aluminum, 3" x 1½" x ½". Drill two holes for mounting, using a number 31 drill. Drill one ⅜" hole for mounting the variable 35mmf antenna tuning capacitor. Mount the bracket on the cover, using ¼" 4-40 machine screws, nuts and lock washers. Make sure the top surface of the tuning unit has been scraped clean of the coating of moisture fungus proofing. Now mount the variable on the bracket and replace cover and all of the screws removed. You can now replace the front panel after everything has been assembled. Install a flexible coupling between the antenna trimmer and the ¼" brass tuning shaft. Install the panel bushing and the second short piece of ¼" brass shaft. Connect the two brass rods with a ¼" universal coupling. A second coupling may be used as a stop and mounted directly behind the panel. Install the knob and you have an antenna tuning capacitor. The 1st r.f. coils must be modified to accommodate this new capacitor but we will leave this to be done in a later step.

Infinite Impedance 2nd Detector, Audio and Noise Limiter

Our next operation is the rewiring of the old 6H6 diode 2nd detector and noise limiter circuit to an infinite impedance detector and first audio. Remove the late i.f. transformer (T_4) from the chassis and take off the shield can. Remove all of the components on the mounting board except the small 5.5 mmf capacitor, the variable capacitor and the i.f. coil. Connect as indicated in fig. 3. You will now have five leads coming from the i.f. unit. If the original leads are too short this is a good time to install longer ones. Replace the 6H6 detector with a 6SN7 or 12AU7, and wire as shown. One triode section is our new infinite impedance 2nd detector, and the other half the new first audio amplifier. Install the auxiliary volume control in the rear of the chassis along side, or near to, the 500 ohm pot. At the same time remove the meter zeroing pot, R_{41}, and install it on the rear lip near the other two. These controls, once set, need not be touched again.

We also use a 6SN7 or 12AU7 in the noise limiter in place of the 6N7. Wire the socket as shown in fig. 3. This *must* be done prior to installing the 1 megohm variable threshold pot and the on-off switch. Next, remove the old ANL switch and shaft. Replace it with the 1 meg pot. Install a ¼" shaft coupling on the arm of the pot. Cut off enough of the old shaft so that the pointer knob will clear the panel by ⅛".



Top view showing the new miniature tubes in the front end to the left of the tuning unit. They are from front to back, 12AX7, h.f. oscillator, 12AX7 mixer, 6BK7 2nd r.f., 6922 1st r.f., 12AU7 a.n.l. To the rear of the 12AU7 is the old 6H6, V_8. The 6H6 is replaced by a 12AU7 or 6SN7 and is the new a.m. detector and first audio. This modification was not yet made when the photos were taken. The power transformer may be seen at the lower right mounted low enough to clear the b.f.o. shaft. Behind the power transformer is the audio sub-chassis with the left row of tubes (from front to rear) being, 12AU7 audio, 12AX7 squelch and spare socket. The right row is 6AQ5 output, 0A2 and 0A2. To the rear of the sub-chassis is the new product detector V_{10}, 6BE6. The new antenna trimmer may be seen mounted on the left side of the tuning unit. To the rear of the capacitor is the crystal calibrator.

We now have a new noise limiter which really works, plus a new infinite impedance 2nd detector. This circuit will have to be realigned, and after completion it will be found that the i.f. selectivity has been improved considerably because the detector does not load the secondary winding of the last i.f. transformer, T_4. We no longer need a diode detector; it is a mystery why one was ever used.

We use a diode, V_{12}, to provide our a.v.c. voltage. Make sure the a.v.c. switch is rewired correctly. Replace R_{19}, (a 1 or 2 megohm resistor) with a 10 megohm resistor. Check and make sure your bias voltages are correct, *i.e.*, —3 volts and —50 volts. Be sure and ground the unused contact on the AVC ON-OFF switch.

A 6AC7 is substituted for V_{11}, a 6SK7, providing additional gain in the a.v.c. amplifier stage. No other modifications are made at this socket.

100 KC Crystal Calibrator

You can next assemble, build or buy, one of the many crystal calibrator units now sold by several manufacturers. It can be placed conveniently close to the antenna trimmer capacitor by mounting the unit on a small sheet of aluminum slightly longer than the calibrator base. The aluminum bracket is drilled so that the holes

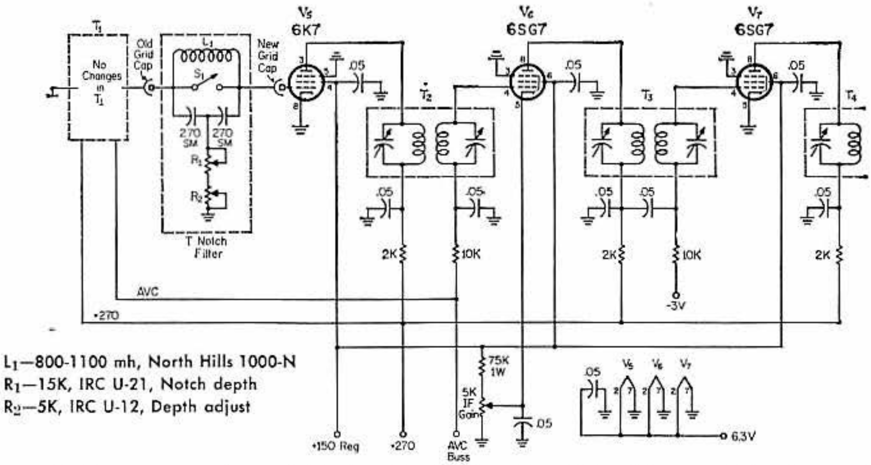


Fig. 6—There are no changes in the i.f. section other than the addition of the new 5K i.f. gain control. The "T Notch" filter shown between T_1 and V_5 is optional and may be installed if desired. Increased gain may be had by substituting 6SG7's for the 6SK7's V_6 and V_7.

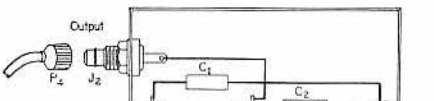


Fig. 7—Pictorial of the "T Notch" filter layout and wiring.

match those of the two holes on the left rear of the r.f. tuning unit. The two 4-40 binder head screws should hold the unit securely in place. A small socket is installed in the hole formerly used by the tuning meter pot. The hole may be enlarged to accommodate the miniature socket, if necessary. The one used in our case was an Amphenol miniature hexagon, series 126, 4 pin, cat. no. 28J740. It requires a ¾" diameter hole. Connect B plus, B— and 6.3 v.a.c. to the socket. B plus 150 to 250 volts is wired through the CALIBRATOR ON-OFF SWITCH SW_6. A small three conductor cable made of hookup wire and a matching 4 connector plug is connected to the calibrator unit. This switch now applies B plus to the calibrator unit. The calibrator output wire is capacity coupled to the antenna trimmer by wrapping 2 turns around the lead coming through the grommet.

"T" Notch Filter

The "T" notch filter was installed after the photographs were taken, however, it is presented for those who desire to build and install one in their receiver. The entire unit is assembled in a small aluminum midget chassis, 2⅝" x 2¾" x 1¼" and mounted directly behind the panel, centered midway between the top of T_1 and the top of the panel. The circuit is shown in fig. 6 and layout in fig. 7. It is held in place by the 5000 ohm notch depth pot and two 8-32 machine screws. All of the components will mount inside of the chassis. The s.p.s.t. switch is also mounted on the notch depth pot. The variable inductance is a North Hills 1000-N. The capacitors are 270 mmf silver mica type. The small Switchcraft phono plug and jacks were used for connecting the unit in the circuit. The coil can be peaked with a signal generator once the set is functioning.

Converter Stage

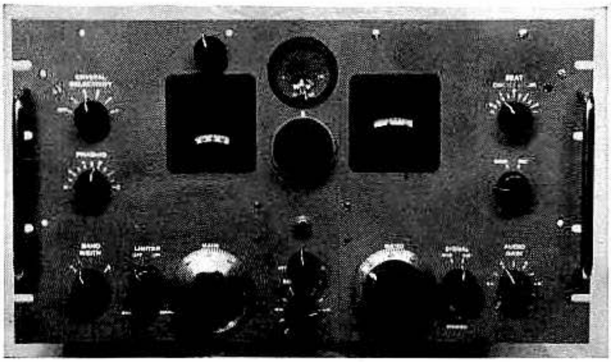
After all of the modifications were completed and the set was realigned and checked out, it was our desire to increase the frequency range of the receiver so that we could also enjoy the 10 and 15 meter bands. The h.f. converter was patterned, circuit wise, after the "Bonus 10-15 meter Converter," described in *QST*[4]. It was built with slight modifications, such as an r.f. gain control in the cathode of the r.f. amplifier, and an antenna transfer switch for switching the unit in or out of the antenna circuit when not in use.

RF and IF Alignment

The i.f. transformer T_4 will require realignment because of the modifications to the 2nd detector stage. The secondary is not loaded nearly as much as before. The alignment can be accomplished quite easily, by using a signal generator tuned to the center of our i.f. frequency, 465 kc, or by tuning in a strong, steady carrier such as a local broadcast station and adjusting

[4]McCoy, L. G., "The 'Bonus' 21-Mc. Converter", *QST*, Oct., 1958, p. 33

The front view shows few changes. The control functions to the left of the main tuning dial are unchanged. Above the tuning dial is the antenna trimmer. Below the bandswitch is the 100 kc calibrator switch, the new i.f. gain control and the sensitivity control. The switch to the right of the bandspread knob is now the A.M.-S.S.B. mode selector while above the audio gain knob is the new squelch control. The notch filter, added after this photo was taken is located above the crystal selectivity switch.



the tuning capacitor for maximum reading on the S-meter. An attempt to realign the entire i.f. section is not advisable unless you have the instruction book, access to a f.m. or TV alignment generator and oscilloscope. However, if you are a purist and must try, follow the procedure as outlined by L. E. Geisler, in the December 1957 issue of *CQ*, on page 32.

1st RF Stage Coil Modification

After the set has been checked over and given its smoke test, all the mistakes and omissions corrected, and signals are pounding in very well, you are ready to proceed with the alignment of the r.f. section of the receiver. All that is necessary is a signal generator which can be tuned to 2.5 *mc*. Turn on the signal generator or frequency meter and let it warm up for several hours. This also applies to the receiver. While this is going on, there is still work to be done. Turn the receiver over on its left side, (uggghh). Remove the bottom plate from the r.f. coil housing assembly. Now locate the three h.f. 1st r.f. coils. They are along the rear wall. Remove the 6-32 machine screws holding the antenna coils. Pull the antenna coil away. The Faraday screen will also come away with the antenna coil exposing the 1st r.f. grid coil. Do one modification at a time. Starting with the 2.5 *mc*. coil, unsolder the wire which runs from the top of the coil, the end facing you. Pull the loose end through the two holes in the coil form. Remove three turns of wire from the coil and push the wire back through the two holes, pull tight, clean the enamel from the end of the wire and resolder. Apply some coil dope to the coil and reassemble the tuning unit. Proceed to the 5-10 mc r.f. coil assembly. Repeat the procedure, only this time remove only two turns. Then proceed to the 10-20 mc coil; this time remove only one turn but do not cut it off. Excess wire is now formed on the inside of the coil form in the shape of a circular loop as large as the inside diameter of the coil form. Poke the end of the remaining length of wire through one of the holes and resolder the wire to the original connection. You now have a circular turn of wire, which can be rotated, inside of this coil form. By rotating the turn of wire, you will be able to tune the 1st r.f. stage to resonance when the antenna trimmer capacitor is set at mid range. Cement the coil in place and reassemble the r.f. unit. You will now have an antenna trimmer capacitor which will really peak each signal right on the nose. The capacitor will peak at mid range on all three bands.

If you have checked the performance of the receiver before making this modification, try it again and you will be amazed at the overall improvement. Before making this change, a signal from the signal generator was used as a reference signal. The generator frequency was set to the center of each of the three amateur bands, e.g., 75 meters: Set the receiver band switch to the 2.5 mc-5 mc band. Adjust the output frequency of the generator to 3.8 mc. Tune in the signal on the receiver and adjust the generator output or coupling so that the receiver signal as indicated by the S Meter reads S5. The modifications were then made, and after completing, the receiver was again tuned to the generator frequency. An increase of 3 to 4 S units was noted on all three bands. This has been the average improvement on all of the conversions which have been made. It certainly is a worthwhile improvement, well worth the short time required to make it.

RF and Oscillator Alignment

In order to complete the alignment of the oscillator and the r.f. stages, it is suggested that the procedure outlined by L. E. Geisler be followed without deviation. Also it is imperative that the signal generator output frequency of 2.5 *mc* be rechecked against WWV each time, before proceeding to the next high band. We might add, that in our case, both the receiver and signal generator were left on overnight, before starting the calibration of the r.f. stages. If this procedure is followed, the receiver calibration will be as accurate as it is humanly possible to read the calibration of the dials. NOTE. It is especially important to set the newly installed antenna trimmer capacitor to its mid position before the final alignment of the first r.f. stages. Make sure all of the tube shields are in place.

S Meter Circuit

The completed modifications on the a.v.c. detector V_{12} changes the circuit slightly, and now

R_{41} acts as a sensitivity control across the meter. If a signal generator with a calibrated output is available, the meter adjustment can be set to correspond to the calibrations of the meter. Or if a suitable generator is not available, one may use a strong signal, such as a broadcast station or short wave station, to calibrate the meter; e.g., adjust the pot R_{41} until the meter just pins on an extremely strong signal. The meter will read 0 with no signal in.

T_5 Tuning

After modifying the b.f.o. transformer T_5, it will be necessary to retune the transformer to the i.f. frequency. The modification on the coil connection changes the frequency slightly. It will be necessary to center the b.f.o. tuning capacitor and make sure the pointer is also in mid position. With an insulated screw driver adjust the variable padder capacitor C_{48} to exact zero beat with an incoming signal. Once this adjustment has been made it will be possible to receive c.w. and s.s.b. signals. All that remains for s.s.b. reception at its best is the proper setting of R_{57}. Tune in a good strong s.s.b. signal, free of interference, and slowly rotate the arm of R_{57} until the received signal reaches maximum volume and minimum distortion at the same setting or time.

Muting Circuit

The muting ciruit is extremely simple and quite adequate, utilizing the —22.5 volts for bias on the 1st r.f. stage and the 2nd audio amplifier stages. The applied increase in bias cuts off the plate current of the 1st r.f. amplifier, and 2nd audio stages. The relay terminals E_2 were used and rewired for proper connection to our coaxial antenna Dow relay.

The complete modification took many evenings, and lots of hours of work, plus a couple of long week ends at the home of W2CLG. Most of the work was accomplished, however, on a small kitchen table in a Brooklyn apartment. Therefore, anyone having a good work bench, plus the normal amount of hand tools and necessary equipment, will find the project much easier. The entire cost of the receiver modification, including the h.f. converter, was just under $100.00 and all can be accomplished for considerably less if there is a good supply of parts already on hand. Only the best of components were used. All disc type capacitors were the 600 volt rating. Other capacitors, such as filter capacitors and the large bypass capacitors, were either the molded type, or metal can type, with the highest possible working voltage. Multi-section filter capacitors were used wherever possible to conserve space.

This modification has been one of the most interesting, constructive and challenging projects undertaken, and once completed, you too will have a receiver which will stack up alongside the best of them. It is now a pleasure to operate on c.w.-a.m. or s.s.b. and the stability is excellent. Too, with the addition of the h.f. converter, we are now able to cover the high frequency bands. The addition of a crystal controlled converter further adds to the stability of the h.f. bands. The signal to noise level has been greatly improved. On the 75 meter phone band, on a Sunday afternoon, we can now copy an S-1 signal Q-5. In addition to covering all the h.f. Amateur bands, we can also cover all of the commercial frequencies as well as the MARS frequencies. We hope you will enjoy your newly rejuvenated receiver for many years.

While you are working on your receiver, perhaps other improvements and modifications will come to mind. The front panel appearance has been changed very little. The main difference is the addition of the new controls. A new band set dial and band spread dial were added. These were the 2½" Crowe instrument dials calibrated 0-100 in 360°. They add to the appearance and help calibration. Duplicate pointer knobs were available on the surplus market.

Credits

I would like to offer profound thanks to all those who have helped with suggestions and encouragement. Special thanks to Mr. Carol Freed for his very kind and able assistance and advice in the use of the 6922 Amperex tube used in the 1st r.f. stage, and suggestions which helped us in our simplified muting circuit. A special kind of thanks to Lew for his splendid critical comments, encouragement and suggestions, and for the use of the many pieces of test equipment and bench facilities required in the final completion, alignment and testing of the completed receiver (and also for the many cold bottles of nourishment during the day, and the hot coffee during the late hours).

To those of you I may have tempted, I offer you the best of luck. Many long hours of good listening and good hunting. May all of you make DXCC. See you all from Greenland!

SSB'ING THE SUPER PRO

As a sequel to our experiences in Venezuela[1] modernizing RCA CR-88A receivers, we decided to tackle our BC-794 Super-Pro and see what could be done to bring it up to date. While in the process of thinking about it and planning these receiver changes, we had the opportunity to snap up a good bargain in the form of a kilowatt single sideband transmitter. This made modernization of the BC-794, or purchase of a new receiver, a necessity. We chose the first course of action for economic reasons, as well as for the satisfaction of doing the job ourselves and experiencing the pride of workmanship.

About this time there appeared in "CQ" an article by Geisler[2]. Careful digestion of the meat of this article gave us several good points to consider. However, we were not completely swayed by the author's very exuberant enthusiasm, nor did we "buy" all of his changes as being necessary or desirable. Several points in his wiring diagrams as published were not clear. Furthermore, we had to carry matters further and come up with something good for SSB reception in order to keep up with the trend in modern point-to-point communications techniques.

One of the first requisites for SSB reception is a good product detector. Another one is frequency stability in the hf oscillator. A third is proper AVC action for SSB to permit running the set with the rf gain wide open. Still another is a 3 kc i-f bandpass curve. With these points uppermost in mind as design criteria we planned and made the changes in our BC-794 which are described here.

It should be pointed out that these changes are equally applicable to the other models of the Super-Pro series, such as BC-779, BC-1004, R-129/U, SP-200, SP-210, and SP-400. These changes may also be used as a design basis for modification of any similar type of superheterodyne receiver, if the reader uses a bit of ingenuity in adapting them to his own particular set. This is a real modernization, not merely the substitution of other types of obsolescent tubes in an old set.

(1) Feb. 1957 CQ, "Worthwhile Improvements for that Old Receiver."
(2) Dec. 1957 CQ, "Souping The Super-Pro."

Our first and most logical point of attack on the BC-794 is the installation of a product detector. Removal of the 6SJ7 BFO tube and its octal socket is easily done. Be sure not to cut the leads from the BFO transformer T5 too short in the process. Substitution of a 7-pin miniature socket mounted on a small square of sheet aluminum to fill the old hole is easily accomplished. A 6BE6 tube is used, with its oscillator section acting both as BFO for CW and as a local oscillator for SSB reception. The circuit should be rewired as shown in fig. 1.

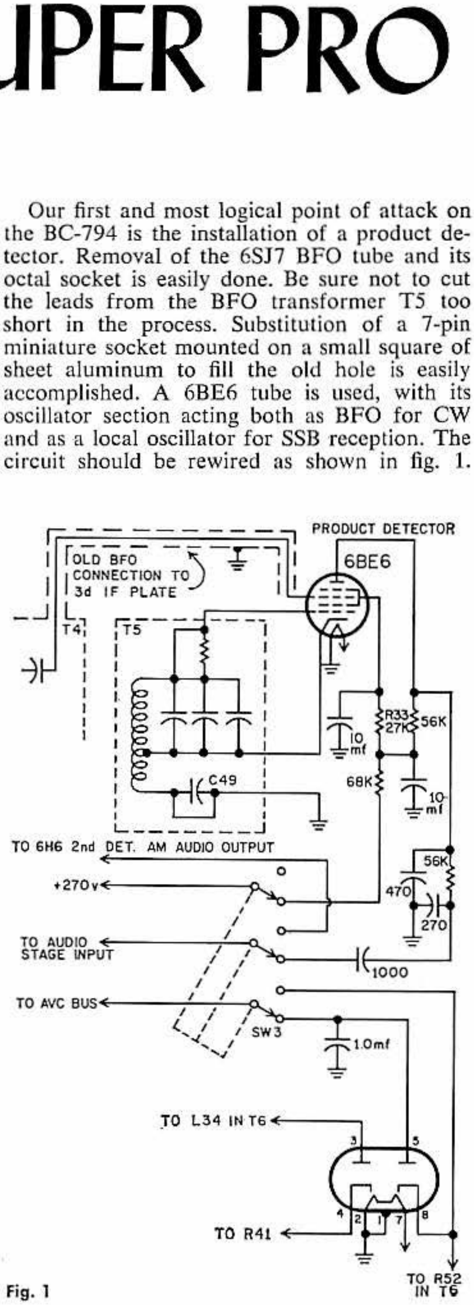


Fig. 1

The value of the screen dropping resistor R33 was found to be quite critical. A strong local oscillator signal is an absolute necessity to avoid the overloading of the detector by strong SSB signals which would produce distortion. R33 was experimentally adjusted in value until all traces of distortion disappeared, and concurrently for the greatest audio output from the detector. It is necessary to remove the shield can from transformer T5 to gain access to C49, the old plate voltage blocking capacitor, and to short out C49 in order to provide a dc return for the cathode of the 6BE6. This is not a difficult operation, but is time-consuming and requires care. In re-assembling the transformer into the can, be sure that there are no internal shorts to the can.

Concurrently with the above, switch SW3 should be replaced with a small 3-pole 2-position rotary switch.

This is necessary to provide an added pole for switching the audio input from the output of the 6H6 AM detector to the output of the 6BE6 SSB detector. Getting the new switch into place is a bit of a squeeze play. We used a Centralab PA-1007. A little bending of an interfering chassis bracket was necessary to make the fit. The new switch SW3 is wired as shown in fig. 1. One pole turns on the 6BE6 plate and screen voltage, another pole throws the audio from the AM to the SSB detector, and the third pole cuts in the special SSB "hanging" avc circuit to be described.

One half of the 6H6 avc diode rectifier, V12, comprising pins 5 and 8, formerly connected in parallel with the other half, is cut free and wired as shown in fig. 1. This section is reverse-connected so that the 1 mfd capacitor which we added to the avc circuit can charge up through the diode, but cannot discharge back through the diode. The 2 megohm avc resistor R19, which is mounted on the back of the AVC-MANUAL switch SW4, should be changed to 10 megohms to provide a slow discharge rate for the 1 mfd capacitor. This provides a fast attack-slow release avc action which permits the avc to ride along on the peaks of the SSB signal. It releases and restores receiver gain quickly enough, however, so that a weak signal in a round table contact is not missed.

The 3-volt bias should be removed from R41 and the 6H6 avc rectifier by moving the two bias lines from terminal 9 of strip E-24 to a convenient ground lug[2]. The avc lines to the 1st rf stage and the mixer should be removed from their terminals on strip E-24 and grounded also, allowing these two stages to operate "wide open"[2].

The product detector is coupled to the 3rd i-f plate transformer T4 by means of the old bfo connection, which is the shielded lead. No change is made here, and this connection works fine.

This is a good point at which to stop work and turn on the receiver and check out all that has been done so far. The local oscillator portion of the 6BE6 may be roughly retuned at this time. Now tune in an SSB signal and try out the new product detector and avc circuit. Run the rf gain wide open, and see how neatly the receiver handles the signals. Gone is the old four-way struggle of rf gain vs. audio gain vs bfo setting vs. tuning. Just sit back and listen to that smooth SSB operation!

While gloating over your work thus far, you will still be dismayed by the frequency drift inherent in all of the Super-Pro series. Well, let's do something about that. Let's do the best we can with what we have and make a practical approach to the problem. Admittedly, we cannot satisfy the "ivory tower" perfectionist and build a long-term stability of one part in ten million into this set and still make it tunable. This is not needed for day to day amateur operations anyway. What we do need and what we can do is to obtain a short-term stability such that during SSB contacts, the other fellow's voice does not grow higher and higher in pitch like an excited Donald Duck and gradually drift out of the i-f passband. The signals will really "stay put", after the changes to be described here.

Following an excellent lead previously published[2], we replaced the hf oscillator and mixer stages with 12AX7 dual high-mu triodes, wired as shown in fig. 2. The octal sockets are removed, and replaced with noval miniature sockets mounted on small sheet aluminum plates. The noval sockets should be oriented so that short, direct rf leads are obtained. Tube shields are used, and should be in place before any subsequent re-alignment is attempted. Next, remove the top cover of the main tuning capacitor, and connect a 3.3 mmfd type N750 negative co-efficient capacitor across the oscillator tuning capacitor. The former 6L7 and 6J7 grid leads should be extended and run through holes in the chassis drilled adjacent to the grid pins. Rubber grommets should be used in the holes. We chose miniature tubes for this modification in the interests of modernization.

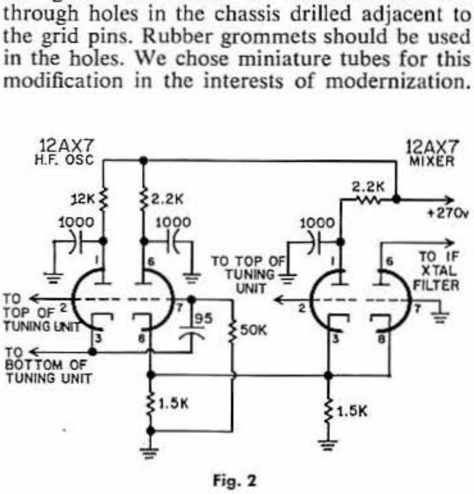


Fig. 2

The important thing is the result of the modification, which is an excellent short-term frequency stability. This is due to the isolation between the oscillator triode section and the remainder of the set afforded by the cathode coupling scheme used.

The next improvement to be made is in the rf stages. We removed the old 6K7's and their octal sockets, and replaced them with 7-pin miniature sockets and 6BA6 tubes. This change greatly increased rf gain and sensitivity. No changes in circuit or components were made, and therefore no diagram is shown here for this change. Here again the grid leads are extended through grommetted holes in the chassis. Tubes are shielded, and the tube shields should be in place before any re-alignment is done. A word of caution is necessary here. If oscillation of either 6BA6 stage is noted in the 20 to 40 mc range, the grounding of the filament, cathode and suppressor pins is not effective. Do not rely on connecting all those pins together and running one common ground lead to the nearest ground lug. Drill a new hole in the chassis adjacent to each pin, and ground each pin separately by a very short connection. We experienced this trouble at the high frequency end of this band, and it took us some time to find the source and apply the cure.

We might say in passing that we tried several other tube types in the 1st rf stage. We tried a 6BZ6, a 6CB6, and a 6DC6, but each of these produced overloading and cross-modulation from strong local signals on the high frequency end of the broadcast band, even with the avc re-applied to the stage. The same was true of the 6BK7A, 6BQ7A, and 6BZ7 dual triodes which we naturally tried as a result of our previous work with the CR-88A[1].

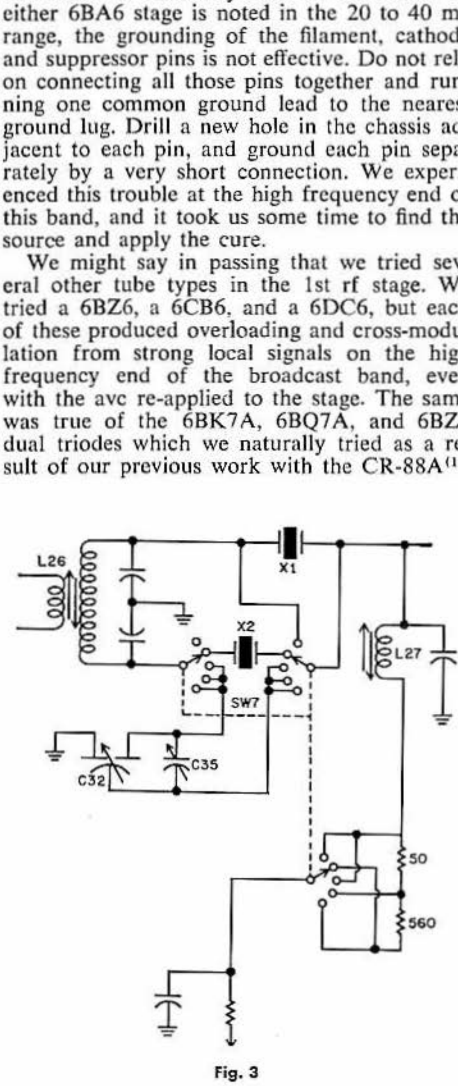


Fig. 3

Reasoning that a strong local amateur signal would cause the same effects, we chose the remote cut-off 6BA6, and there is no trouble from overloading nor cross-modulation even from 50 kw WTOP nearby, and with the 6BA6 1st rf. stage running "wide open."

After re-alignment of the rf portion of the set, we then proceeded to the installation of a 3 kc band-pass crystal filter, whose complete circuit is shown in fig. 3. We wished to do this without destroying the usefulness of the receiver for short-wave listening or cw reception, and if possible, without spoiling the front panel appearance. A half-lattice crystal filter was chosen as being the most practical type from the standpoint of available space and a minimum of circuit changes.

First it is necessary to remove the top and side covers of the existing crystal filter. Access to the side is facilitated by temporary removal of the chassis support bracket. The 465 kc crystal and the old 6-position switch should be removed and added to your junk box. The switch can be removed without taking off the front panel by using a thin open-end wrench to turn the locking nut behind the panel. A new switch with 3 poles and 5 positions on a single wafer was installed. Getting the old one out and installing the new one is a tight fit, but it can be done. A small, thin switch with but a single wafer is a necessity to fit in the small space. We used a Centralab type PA-2007. The switch should be lined up so that its five positions correspond to the OFF-1-2-3-4 markings on the front panel. The last figure, 5, is not used. The new crystal filter switch positions are:

OFF-OFF
1—3 kc Bandpass
2—Broad CW
3—Medium CW
4—Sharp CW

A half-lattice filter has the simplified schematic and response curve shown in fig. 4. Crystal X1 is a surplus type FT-241-A for channel 334, whose fundamental frequency is 463.88 kc. Crystal X2 is a companion unit for channel 336, whose fundamental frequency is 466.66 kc. These are the 72nd harmonic crystals which are readily available from surplus crystal suppliers at a cost of about 55¢ each. The separation between this pair is 2.78 kc, which is just about right for a nominal 3 kc filter. Following through the circuit in fig. 3 will show that X1 is used for both cw and SSB, but that X2 is in the circuit only for SSB. Neither crystal is in the circuit when the switch is in the OFF position. On cw positions 2, 3, and 4 the crystal phasing capacitor is connected in the circuit to provide for moving the rejection notch from one side of the received signal to the other for phasing out heterodynes. For SSB, a small (1 or 2 mmfd) capacitor may be added in parallel with X2, to cause rejection notches to appear in the skirts of the passband, if desired.

The values of the secondary loading resistors are changed to 50 and 560 ohms. We chose 560 ohms experimentally because it seemed to give a sharp enough filter without too much of the characteristic crystal "ringing" effect which we found could become objectionable when using the 3 kc position on voice. If the reader wishes to increase the value of this resistor above 560 ohms, it may be done if the "ringing" effect is not considered objectionable.

Crystals X1 and X2 were placed in the space formerly occupied by the old 465 kc crystal, and were connected by merely soldering the leads to the tips of the holder pins. This must be done very quickly and carefully, without excess heat. The pin should be firmly grasped with pliers near the holder while soldering, to minimize the heat travelling back up the pin and causing damage to the crystal and its very delicate connecting wires.

At this point in the operation, replace the 6SK7 avc amplifier and the 6SK7 2nd i-f tube with 6SG7's, and substitute a 6AC7 for the 3rd i-f 6SK7. Then it is wise to thoroughly check over all that has been done to date, to make sure there are no omissions nor errors in wiring. Replace the crystal filter shield covers.

The only stages now being supplied with avc voltage are the 2nd rf and the 1st and 2nd i-f. The 1st rf and the mixer are running with no avc, and the 3 volts bias is still being applied to the 6SG7 avc amplifier. Re-connection of the 6AC7 to the 3 volts bias is necessary, and it is done by disconnecting the old bias lead from the end of R22 (10,000 ohms), and running a new lead from R22 to terminal 9 of strip E24. No 1500 ohm resistor from R22 to ground is used here. [2]

The modifications are now completed. With the crystal switch in the OFF position, and the bandwidth control at 3, the i-f stages should be realigned to 465.27 kc, which is the mid-frequency of the 3 kc passband. This alignment was done with the help of our LM frequency meter as a signal generator. An accurate signal generator is a necessity for plotting the response curves of the filter in the SSB and cw positions. L26 should be peaked up on the mid-frequency also. Now turn the crystal switch to position 3 or 4 and perform the adjustments of L27 and trimmer C35 to obtain the proper rejection curves for the right and left positions of the phasing capacitor C32. The shapes of these rejection curves are shown in fig. 5. These adjustments can best be made with the use of a sweeping oscillator and an oscilloscope so that one can actually see the changes in shape as adjustments are varied, but we used our LM, and a VTVM on the output of the avc amplifier, and used the longer method of plotting results and then making changes.

The shape of the response curve of the 3 kc filter should also be checked. The bandwidth control should be set at 6 or higher for this. Any inequality in the two peaks at the frequencies of X1 and X2 can be evened out by shifting an i-f transformer slightly to one side or the other of the center frequency. There will be a slight dip in the center of the curve, possibly as much as 16%. This is satisfactory and normal, so don't worry about it.

The receiver has enough gain to compensate for the insertion loss of the 3 kc filter when receiving on position 1. It also has sufficient gain to make up for the fact that the cw crystal frequency, 463.88 kc, is 1.39 kc off from the i-f alignment frequency of 465.27 kc. It will be noted that as you swing the crystal switch from position 2 to position 4, a drop in S-meter reading and in gain occurs. This is due to the slight mis-alignment for cw just mentioned. It is not serious, however, and it does not handicap cw reception at all. After all, we have designed for the SSB requirement as our primary objective, and we should not handicap our 3 kc filter by an off-center frequency alignment for the i-f stages.

Now a word about operation of the receiver is in order. For reception of am or cw, the single crystal filter of positions 2, 3, and 4 may be used, and the phasing control adjusted for reduction of heterodyne interference exactly as before. Or, for short-wave broadcast reception, the switch may be left in the OFF position, and the bandwidth control adjusted to suit the listener's tastes.

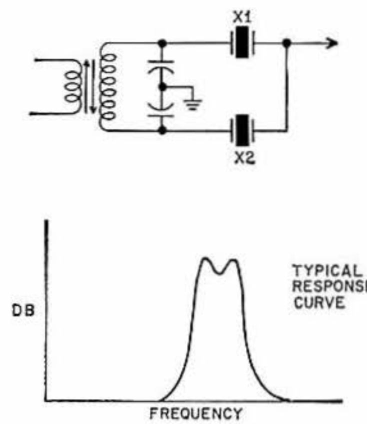


Fig. 4

For SSB reception, we first adjust the local oscillator transformer T5 for zero beat at 465.27 kc, with the bfo knob at zero center. It will then be found that the local oscillator will be at zero beat at 463.88 kc with the knob at about 1.0 on one side of center, and at zero beat on 466.66 kc at about 1.0 on the other side of center. Which side it is, is immaterial. Thus one is able to set the local oscillator to one side or the other of the crystal filter passband, to demodulate whichever sideband is in use by the transmitting station. The actual setting of the local oscillator should be about 250 to 300 cycles out beyond the crystal filter frequencies, for increased rejection of unwanted sideband products and for most efficient use of the crystal filter passband. This is shown graphically in fig. 6, which shows the relationships of local oscillator settings, crystal frequencies, and overall passband. A picture at this point is worth more than a thousand words. For 3 kc

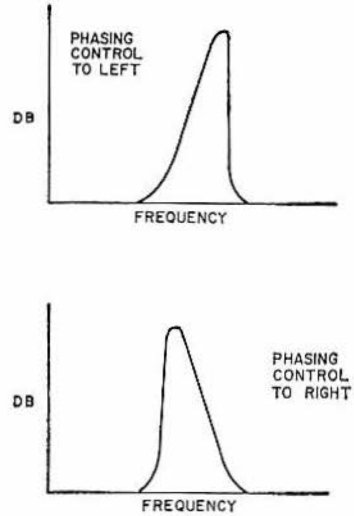


Fig. 5

filter SSB reception, the bandwidth control should be set at 6 or higher, inasmuch as the variable selectivity i-f transformers are after the crystal filter in the i-f chain, and the filter is the controlling factor in bandwidth. We do not wish to compress the filter response curve by setting the bandwidth control at a narrow selectivity position. Nor did we wish to eliminate the bandwidth control entirely, as it does have its value, for certain uses. SSB may also be received with the crystal switch in the OFF position, and best results are then obtained with the bandwidth control set from 4 to 6 depending on interference conditions.

The 3 kc filter can be very useful for AM reception as well as for SSB. If one tunes the AM signal right on the nose, it will be noted that the audio sounds very bass with the high frequency sidebands on both sides cut off. Tuning to one sideband or the other, depending on interference conditions, and thus making good use of the 3 kc passband of the filter, is a great help in reducing interference in AM reception. By experimentally tuning across an AM signal which is not fading, and watching the S-meter, one can get a very good mental picture of what the 3 kc filter does for AM reception as well as for SSB. Refer again to fig. 5 to see the relationship of passband and crystal frequencies.

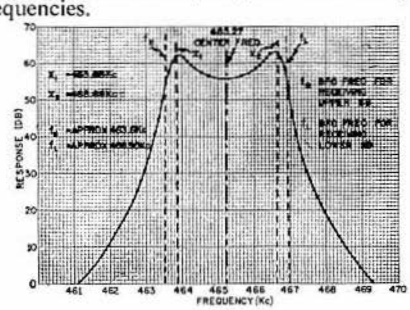


Fig. 6

Operation of this receiver on SSB, our primary objective, is now very simple and straightforward. There is no more fussing with rf and audio gain controls. Just set the rf gain at maximum, the audio gain at a comfortable level, and turn on the product detector and sit back and tune in the SSB signals. The avc does the work—it takes care of the strong ones, and there is plenty of gain for the weak ones "down in the mud." If the going gets rough due to overpopulation of the band, cut in the 3 kc filter. And with the new hf oscillator and mixer the signals stay in tune during contacts. To switch to receive the other sideband, just rotate the old bfo control to a bit over 1.0 on the other side, and there you are—it's as simple as that. Your old Super-Pro has been lifted out of the trade-in class, and you don't have to hand out the cash for a new receiver. SSB reception is now a pleasure instead of a headache! See you on SSB, fellows!

THE BC-348 ET AL

The BC-348 is essentially an aircraft receiver. It has bandswitching and covers from 200 *kc* to 18 *mc*. The receiver *if* is 912 *kc* and since it lies in what is our broadcast band, that band, from 500 *kc* to 1500 *kc*, is omitted. The receiver is relatively broad although a crystal filter is used to sharpen things up a bit. It's difficult to tune a receiver very close in a vibrating aircraft when wearing heavy gloves, so this is probably the reason. The *if*'s can be sharpened up a bit, although we are making it sound very much worse than it is. Power was 24 volts, supplied by a dynamotor, but we'll go into the BC-348 power supply next month. The BC-312 is similar to the BC-348 except it covers 1.5 *mc* to 18 *mc* and operates directly on 12 volts. (A 110 *vac* model was known as the BC-342.) A suitable power supply can be built up either on the original dynamotor chassis (if you are lucky, an RA-20 power supply can be obtained for a direct replacement) or you can build up a separate power supply. If you run this mobile on 12 volts, no changes are required at all, except to check that the negative and positive leads of dynamotor agree with your car battery polarity and ground. Having removed the receiver from its case, swing the dynamotor on its hinges to gain access to the 9 pin terminal board. For a self contained power supply, remove the dynamotor power supply components, add a suitable sub-chassis for your transformer and choke and then wire it up as shown in fig. 1. Of course it is possible to build the entire power supply on a separate chassis external to the receiver. It will be necessary to add a power switch (S-1 fig. 1) or re-wire the switch on the BC-312. We feel it should be added to the front panel by choosing an appropriate place for the toggle switch and drilling a ½ inch hole. The fuse can be a fused plug instead of a standard panel fuse, although the front panel fuses of the 312 can be used for the power supply if you desire. If you're really enterprising, you can re-wire the filaments to six volts to eliminate the need for the second transformer (T-2) used to make the filament line 12.6 V. Make sure the filament windings

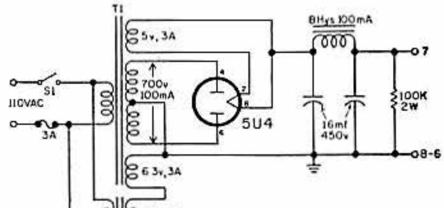


Fig. 1—Power supply for the BC 312, BC 348. (Fig. 5 page 76)

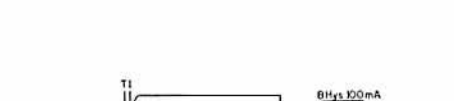


Fig. 2—Audio voltage amplifier for the BC 312 or 348, shown in fig. 5.

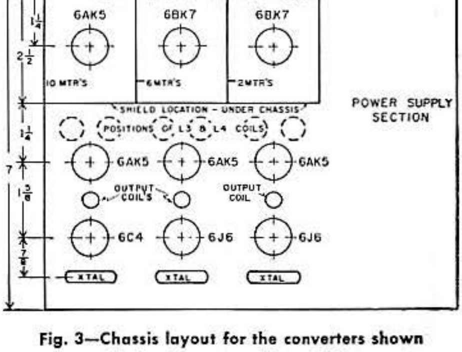
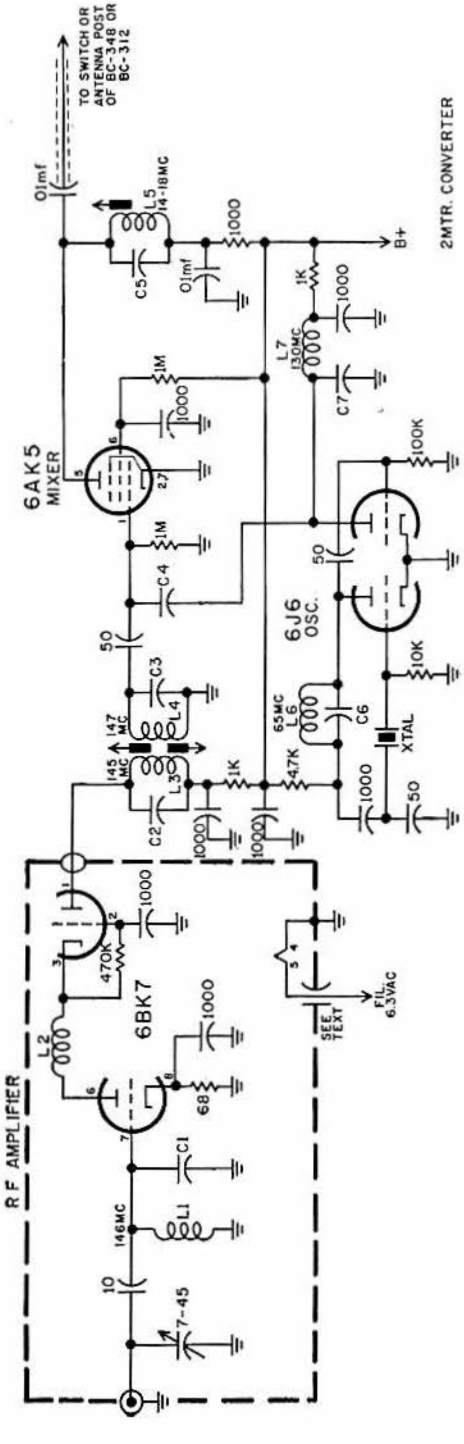
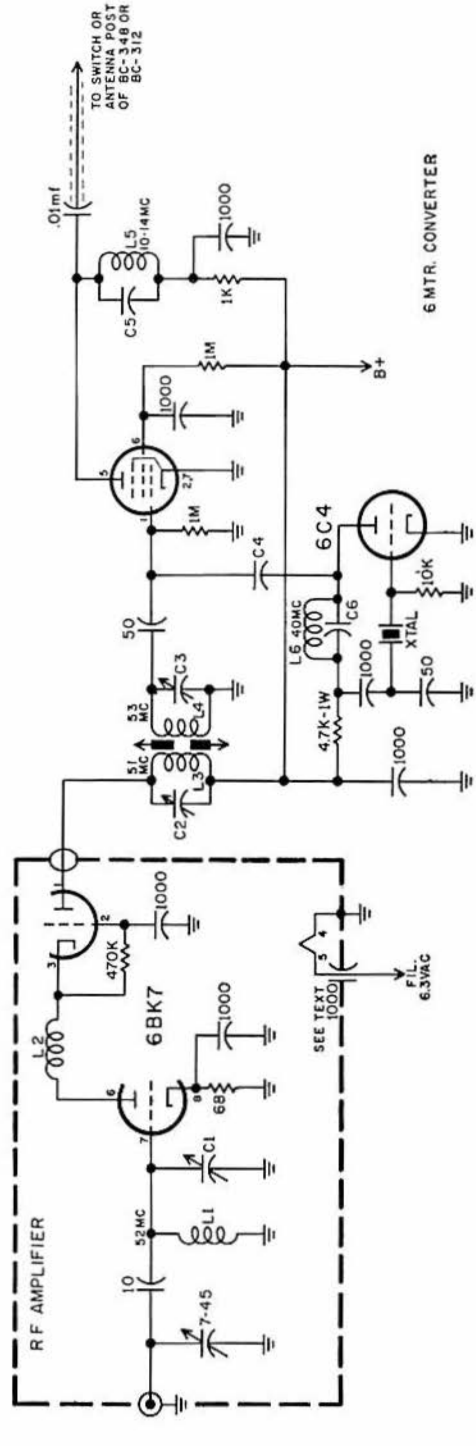


Fig. 3—Chassis layout for the converters shown in fig. 4 on pages 74 and 75.



R F AMPLIFIER
6BK7
6AK5
MIXER
6J6
OSC.
TO SWITCH OR ANTENNA POST OF BC-348 OR BC-312
L5 14-18MC
L7 130MC
L6 65MC
145 MC
147 MC
146MC
XTAL
SEE TEXT
FIL. 6.3VAC
B+
2MTR. CONVERTER



R F AMPLIFIER
6BK7
6C4
TO SWITCH OR ANTENNA POST OF BC-348 OR BC-312
L5 10-14MC
L6 40MC
51 MC
53 MC
52MC
4.7K-1W
XTAL
SEE TEXT
FIL. 6.3VAC
B+
6 MTR. CONVERTER

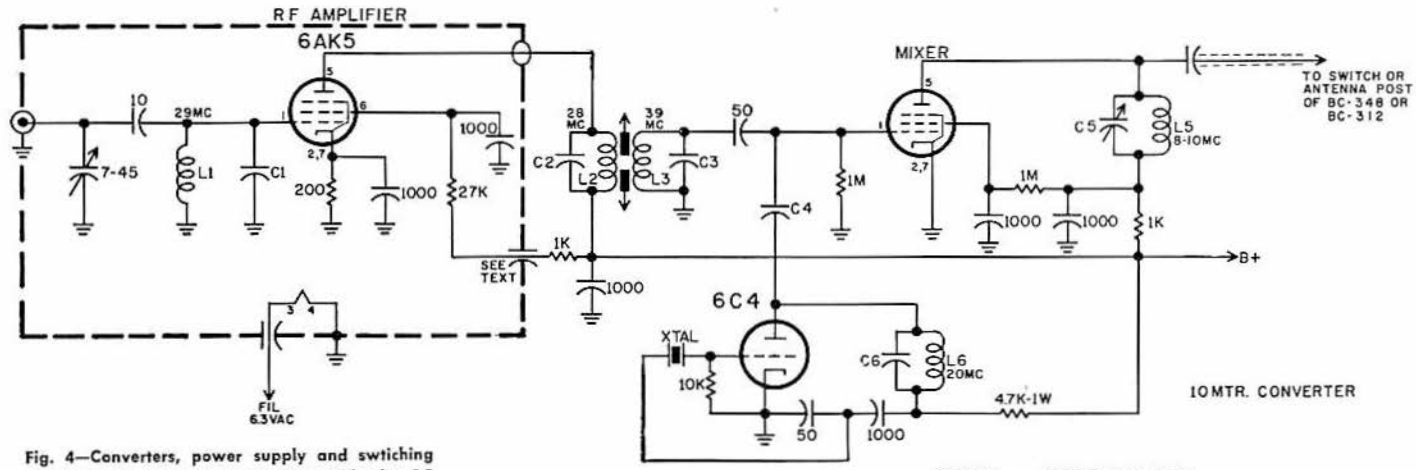
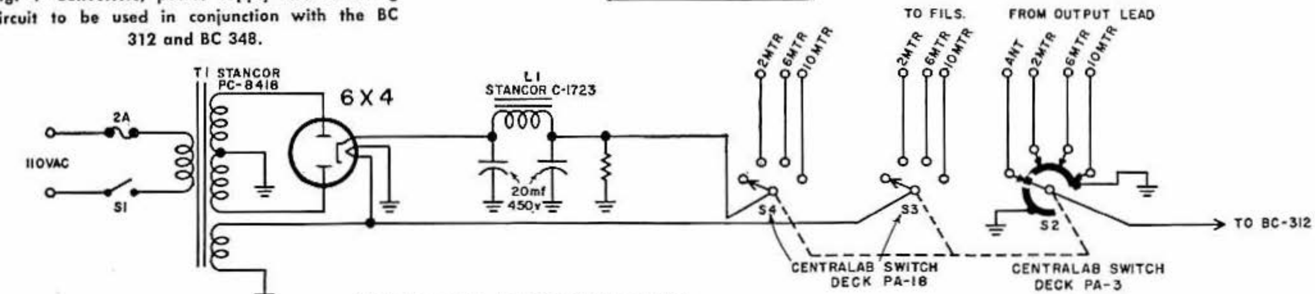


Fig. 4—Converters, power supply and swtiching circuit to be used in conjunction with the BC 312 and BC 348.



Converter Coil And Condenser Values

	2 Meters	6 Meters	10 Meters
C-1, 2, 3	3-12 mmf trimmer	4-30 mmf trimmer	7-45 mmf trimmer
C-4	2 mmf	5 mmf	5 mmf
C-5	7-45 mmf trimmer	7-45 mmf trimmer	6-45 mmf trimmer
C-6	3-12 mmf trimmer	7-45 mmf trimmer	7-45 mmf trimmer
C-7	3-12 mmf trimmer	not used	not used

L-1	4 turns #16 ¼" dia spaced 1"	7 turns B and W #3003	2-3 μh coil North Hills #120A
L-2	5 turns #22 ¼" dia spaced close	7 turns #22 ¼" dia spaced close	not used
L-3, 4	4 turns #20 ⅜" dia 5/16 long	7 turns B and W #3003	2-3 μh coil North Hills #120A
L-5	9-18 μh coil	9-18 μh coil	9-18 μh coil

L-6	North Hills #120D 9 turns B and W #3003	North Hills #120D 8 turns B and W #3003	North Hills #120D 3-5 μh coil North Hills #120B
L-7	4 turns #16 5/16" dia ¾" long	not used	not used
XTAL	6.500 mc	8.000 mc	6.666 mc

Note: B&W #3003-Air Dux 416T ½" Dia, 16 Turns per inch.

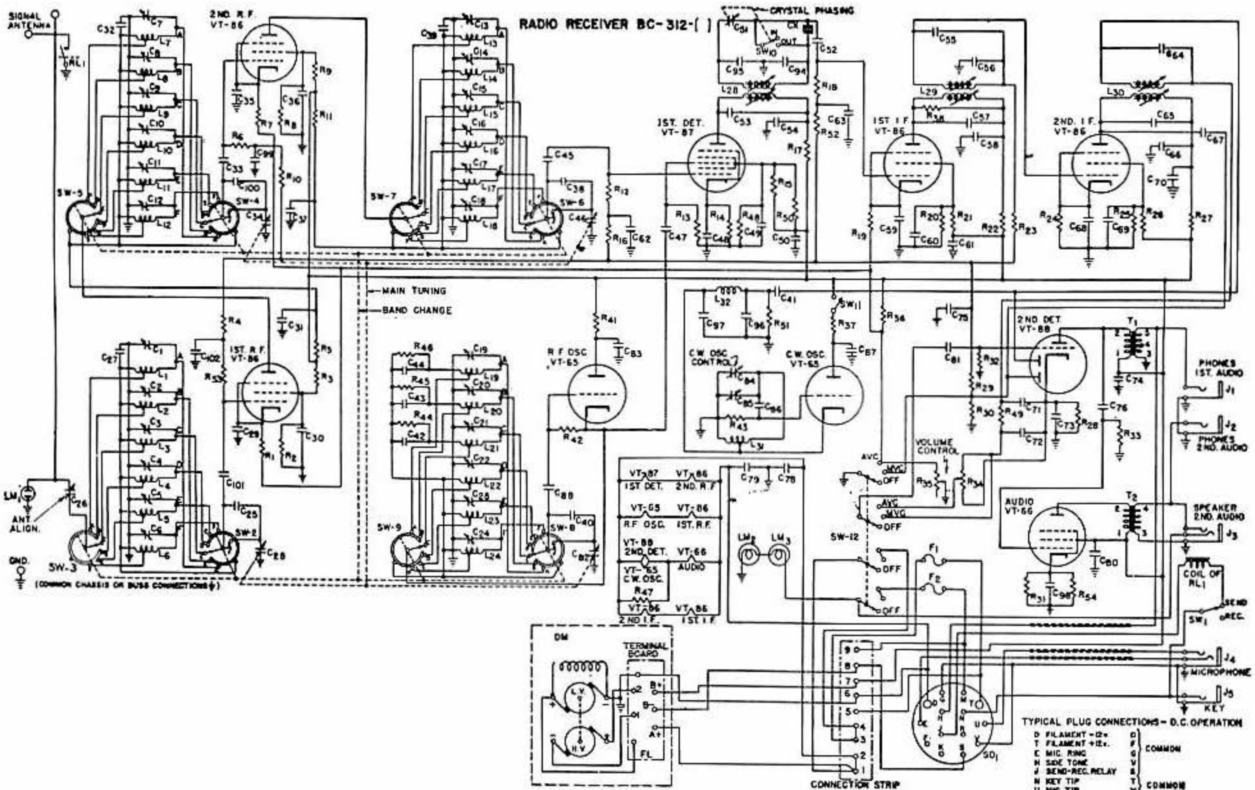


Fig. 5—Radio receivers BC 312-D, E, F, and G schematic

are wired so the voltages add and do not cancel, if you use the second transformer.

The BC-312 was designed for the use of headsets only. A speaker may be added by using a matching transformer of about 2000 ohms to speaker between the output phone jack and the speaker itself. Since there will barely be enough audio, an additional stage of audio should be added. This is done by adding a 12AT6 triode amplifier as shown in fig. 2. The tube can be located on a small bracket under the chassis near the 6V6. It is connected by breaking the lead going to the grid of the 6V6 and connecting it to the 12AT6. The output from the 12AT6 is connected to the 6V6 grid. This provides more than enough gain.

Some difficulty will be experienced trying to obtain a correct *rf* plug for the antenna. We solved this problem by changing the plug and socket to the more conventional SO-239 socket (*uhf* type). This allows everyday coax fittings to be used.

The converters are fairly simple to build. Being crystal controlled they operate by using the receiver to tune in the desired station and since the receiver has good bandspread, so will the converter, when used. Since the receiver tunes 8 to 10 *mc* for ten meters, merely add a 2 in front of the receiver frequency and you have the correct 10 meter frequency. Likewise add 40 to 10 to 14 *mc* and you have your six meter band of 50 to 54 *mc*. Two meters covers 14 to 18 *mc* on the dial and you read it as 144 to 148 *mc*. Although no dimensions are given for specific parts, the layout shown in fig. 3 will show the correct parts positions. The entire power supply for the converters, and the converters themselves, are built on a 9″ x 7″ x 2″ steel (cadmium plated) chassis. While aluminum can be used, it is far easier to solder the grounds and shields to steel.

The first thing to do is make the holes for the tubes, coaxial sockets and the other components. The shield is soldered into place, and is made from steel or even a piece of tin. One piece is "L" shaped and is 8½″ x 1⅞″ plus a ¼″ lip on each end. It is bent to form a 6″ x 2½″ "L." Two smaller pieces 2½″ (plus a ¼″ lip on each end) x 1⅞″ divide the chassis into three shielded *rf* compartments. Three holes (about ⅛″) provide clearance for output and power leads from each *rf* compartment. Input *rf* is from the coaxial socket on the back of the chassis in line with the *rf* tube. Since L-3 and L-4 are placed very close to each other, and are parallel, they should be mounted on terminals across which the tuning capacitors are connected (C-2 and C-3). Actually all of the B&W coils are mounted on suitable terminals. Keep all leads short and all power leads very close to the chassis. Use shield type of sockets and don't be afraid to make good solder joints to ground using a big enough soldering iron.

We've shown the converters as being three separate units. Well that is exactly how they were wired. Each one is on only when in use. The output leads of those not in use are grounded to prevent any possible stray pickup.

Adjustments are first made using the grid dip oscillator. Set the grid dipper to the frequency given on the schematic for the particular tuned circuit and adjust the coil or the condenser or both till a dip is obtained. Make sure no spurious dips are caused by nearby circuits. When all circuits are preadjusted by this technique apply power and adjust the tuned circuits for the best signal to noise ratio obtainable on the receiver, as the receiver is tuned through its range. Special care should be taken when adjusting C-2, L-3 and C-3, L-4 since the coils must be moved to obtain the best coupling, and the capacitors must be readjusted for minor changes in loading. These circuits directly affect the bandpass of the converter and warrant as much adjustment as you see fit to obtain the desired results.

The mixer should develop about 3 v maximum from the oscillator at the grid of the 6AK5. If the coupling value given for C-4 causes too much oscillator injection decrease its value. You may find that stray capacity is all you need. Make this measurement with a *vtvm*.

Note that the plate coil of the *rf* stage is outside of the shield. This is to prevent oscillations from occurring as well as to prevent stray pickup. For additional improvement, bypass all filaments (hot lead) to ground with .001 disc capacitors using very short leads. The input capacitor is used to increase the signal to noise ratio and should be adjusted for maximum sensitivity of the converter. The entire set of converters are housed in a small metal cabinet. A rotary switch selects the band while a toggle switch controls main power and a pilot light dresses up the panel and serves as a power on indicator.

MORE ABOUT 348 & FAMILY

These receivers offer a lot for the money, especially when you consider the quality of the components, the receiver stability and workmanship. Although the receiver range is limited, the use of converters similar to those shown last month should take care of any problems along these lines. However, one complaint heard from CW operators is that the selectivity, even with the crystal filter in, leaves something to be desired. Well, W2HHZ came up with one simple solution to increase the selectivity, and at no additional expense. Assuming the *if's* to be completely aligned (as we later describe), try adjusting the neutralizing capacitor for best results. This is only a couple of turns of wire around a coil and the value is extremely small (about two micromicrofarads). A distinct narrow band effect will be noticed with the neutralization adjusted properly. W2HHZ has found that the crystal is actually imbedded in a small plastic mount. This plastic acts like a capacitor dielectric and increases the stray crystal capacity. Carefully remove some of the plastic, leaving just enough to hold the crystal assembly together. The selectivity, after making this modification and re-neutralizing, dropped 800 cycles, which isn't bad at all. It may seem like a lot of work, but if you are a CW man, it is going to prove worthwhile.

Much of the correspondence about the BC-348 is in reference to a suitable noise limiter. Having tried just about every type, from the simple diode to the Lamb noise silencer, I'm convinced that the TNS offers more than any of them. Of course you may say that you don't need a noise limiter. If so, don't use one. But, just in case, the circuit and the correct connections are shown in fig. 2. The TNS and an additional stage of audio were mounted on a small strip type chassis in the space under the *if* wiring. The original volume control was ganged to the *rf* gain control and is not used in our conversion. Instead, a half-meg potentiometer with a SPST switch was mounted on the front panel access plate for audio volume control, while a second half-meg pot was mounted along-side for the TNS control. The switch is used for a power control since we didn't trust the original power switch at 117 volts ac.

While you still have your soldering iron out, make sure that the output tap is set at 4000 ohms on the output transformer-filter choke combination. This will allow you to connect a loudspeaker directly to the set by means of a standard four or five thousand ohm to voice coil transformer. Table I gives you the correct pin connections for the power plug and the output connection (pins 1 and 5) can be made by means of these pins or by means of the earphone jacks which are in parallel with these pins.

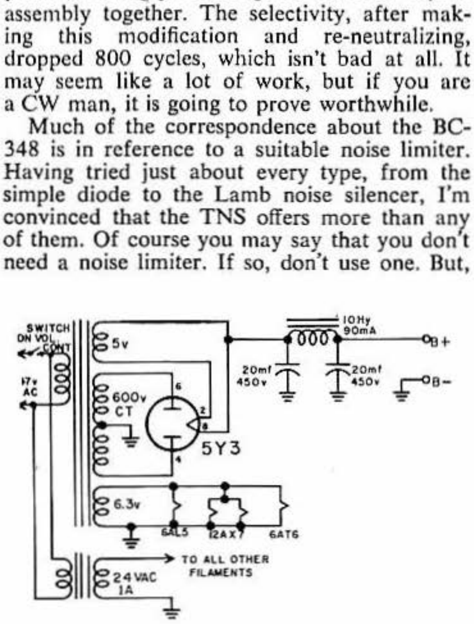


Fig. 1—Power supply for the BC-348.

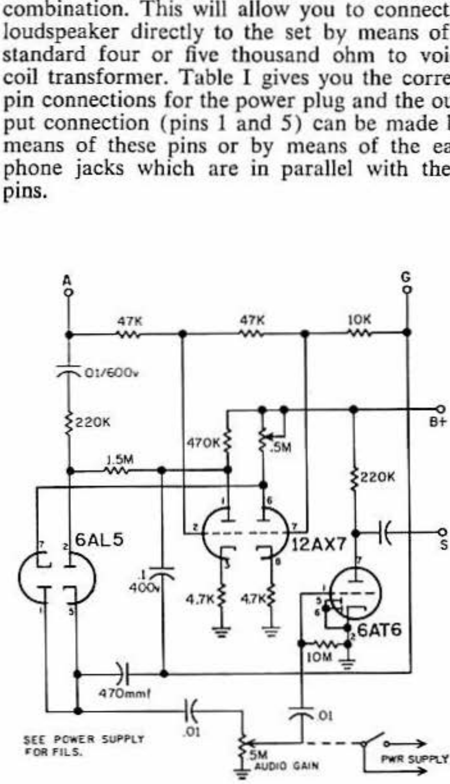


Fig. 2—TNS and audio amplifier.

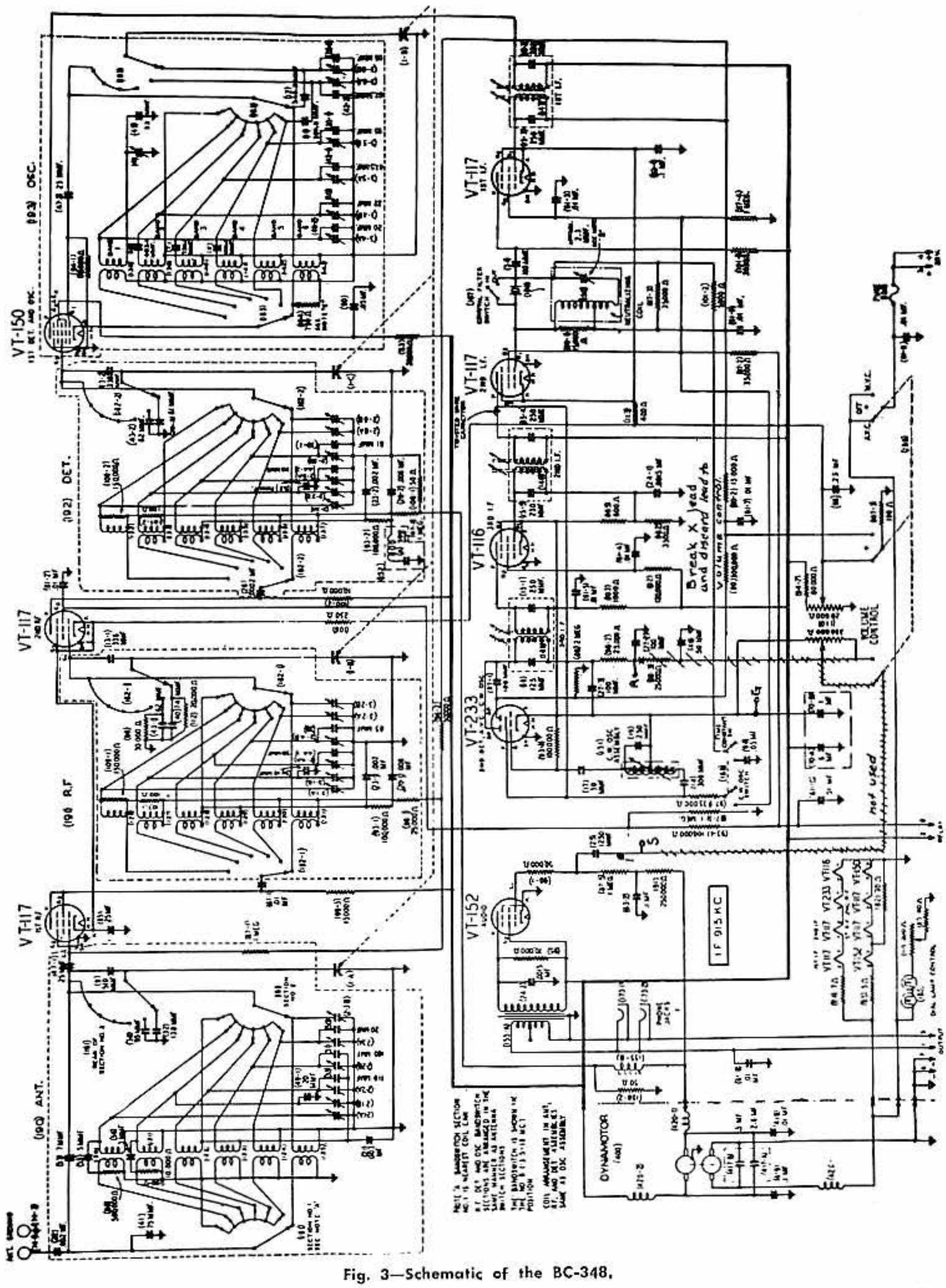


Fig. 3—Schematic of the BC-348.

Table I

1 Output
2 Relay (short to 6 for receive)
3 Plus 24V DC
4 Plus 24V DC
5 Output (may be grounded)
6 Relay (short to 2 for receive)
7 Ground—24V DC
8 Ground—24V DC

Several "S" meter circuits were tried, but with the lack of a calibrated meter and the effort needed in properly calibrating such a meter, we decided against putting one in. Actually, unless you have such a meter, it would prove only to be a rather expensive tuning meter, and probably useless. If you feel that it is worth it, you can refer to the handbooks that are available for suitable circuits.

The original BC-348 that we had used a set of binding post type of terminals for the antenna input. We found that the use of a coaxial connector was more compatible with our equipment and we removed the one marked "Antenna" and enlarged the hole to ⅝ inch for a standard coaxial connector. The results were surprising, especially the reduction in noise pick up from the fluorescent desk lamp.

Alignment

Now comes the alignment job. Set the receiver to *mvc* reception, with the *bfo* off. Beg, borrow or even buy a signal generator and connect the hot lead to pin 1 of VT-116 (6SJ7) and the ground lead to ground. Set the signal generator to 915 *kc* modulated AM, and make sure the receiver crystal filter is off. Connect a *vtvm* type *dc* meter (or a 20,000 ohm per volt unit) across R-86 (2 megohm) or connect an *ac* voltmeter across the receiver output (phone jack). Turn the signal generator up and adjust the range of the meter until a mid-scale reading is obtained. Adjust the 3rd *if* transformer for maximum reading on the meter by adjusting the top and bottom threaded adjustments. When you have reached the maximum meter reading, disconnect the hot lead and reconnect it to pin 1 of VT-117 (6SK7), the second *if* amplifier.

Adjust the second *if* transformer the same way that you did the third, but decrease the output from the signal generator in order to keep the meter on scale. When you have reached a maximum as before, disconnect the signal generator and connect it to the signal grid of the converter tube, pin 8, 6SA7. Make sure that the crystal switch is in the OUT position. Adjust the first *if* transformer for maximum output as before, again readjusting the output of the signal generator so as not to overload the meter. Note that we by-passed the adjustment of the crystal filter. This is a rather tedious job involving the realignment of the *if* amplifiers, but with the crystal in the circuit and the signal generator carefully adjusted to the exact frequency of the crystal. We will be going over receiver alignment techniques soon in another article and will completely discuss this technique then.

The next thing to align is the *rf* and oscillator stages. The oscillator should always tune to a frequency 915 *kc* above the incoming signal, meaning that the variable capacitor should cause the oscillator to tune this difference regardless of where the dial is set. Minor variations will not permit this to occur exactly, but with the aid of trimmers and padder type variable capacitors we can make the error very slight. The technique of receiver alignment is to first adjust the oscillator. Set the receiver to the high end of one band, say 18 *mc* on the high frequency band. Adjust the trimmer for maximum output from the signal as read by the meter. The signal generator supplying the test signal should be set at 18 *mc* and should be connected to the signal grid of the converter tube (6SA7). Since there are no other adjustments for the oscillator on this band, check and see if the calibration is correct at the low end of the band (13.5 *mc*). It should be OK, but if it is off a little find out how much. You can check the calibration by merely setting the signal generator at the frequency you wish to check. If it is practically on, you may merely have a signal generator that is not calibrated very well. You may have to use a frequency meter and check both the sig-gen and the receiver to see which is off if there is a big error. Notice that the trimmer is adjusted at the high end of the band in all cases, so when you adjust the other bands follow the same procedure.

On the low frequency bands, in the case of these receivers, you will find that we also have a padder. This is used to further correct the *rf* alignment, and is adjusted after the trimmer. The padder capacitor has most of an effect with the tuning capacitor fully meshed and therefore must be adjusted at the low end of the band. The procedure is simple enough. Just feed in a signal to the converter grid from the sig-gen at the high end of the band, adjust the trimmer for maximum output on the meter. Then turn the sig-gen to the low end of the band and set the receiver dial to the same frequency. Adjust the padder for maximum output and you have the oscillator adjusted.

The *rf* stages are a little simpler, since they only have trimmers. Reconnect the sig-gen to the signal grid of the second *rf* amplifier (pin 1, 6SK7) and tune the high end of the dial. Adjust the appropriate trimmer for the band you are on, by getting maximum on the meter. Now, go to the next band and do the same, but don't forget to set the sig-gen to the correct frequency. Again, go to the next band and do the same, until all bands are fully adjusted. Now, reconnect the sig-gen to pin 1, 6SK7, of the first *rf* amplifier and repeat this all over for each band, adjusting the *rf* coils. Once more, reconnect the sig-gen to the antenna connector and adjust the antenna coils on all bands.

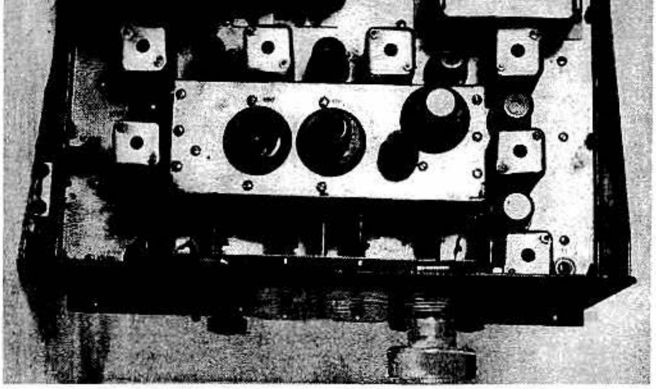
THE 1068A ON 2

THE PLEASURE OF SAYING, "We've a superhet here, OM," when operating in the 2-meter band is rapidly becoming a very low cost proposition. The basis for this statement is the influx of BC-1068-A radar receivers in the war surplus market places. Since the original tuning range is somewhat higher in frequency than the 144-mc band, the problem of converting the r-f end is greatly simplified. A converted model shown in the accompanying photographs has been in use at W3GQS for the past eight months and we feel that our DX contacts, many of which are over 200 miles, speak for themselves and the receiver.

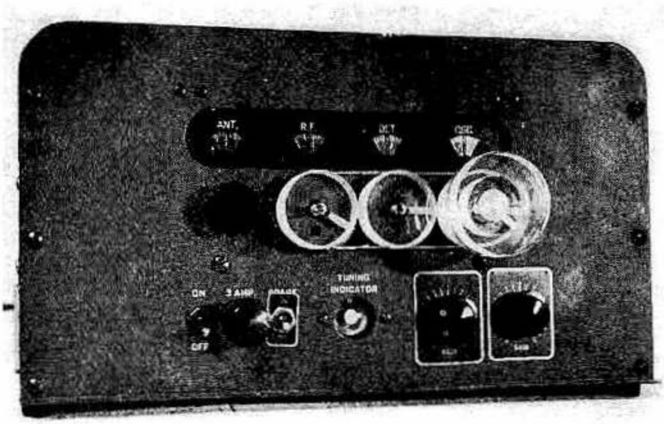
Mechanical Conversion Points

The first step in the conversion of the BC-1068-A is the rearrangement of the back panel connectors. This is accomplished by removing the top receiver cover, the shock mounting (if it has one) and the bottom plate. Using glyptol solvent, loosen the nuts holding the three *Amphenol* weatherproof sockets to the rear of the chassis. Remove the connectors. Prepare to cover the openings with a sheet of lucite, or for the phone jack, a piece of aluminum or bakelite. Mount a phone jack in one of the connector openings and ground the outside sheath and connect the center terminal to point marked *C*. Over the antenna opening use lucite insulation with a later type antenna connector or binding posts. Resolder the two antenna leads coming from the silver-plated tube. Connect a new a-c cord to points *A* and *B* of the a-c input.

Turning to the front panel, remove the spare fuse holder and mount in its place an SPST toggle switch for "standby" operation. The best method appears to be the removal of the ground wire from terminal #4 on the power transformer and running a new length of wire from this terminal to the switch and grounding on the other. This opens the high voltage circuit. The next step is to remove the DPST switch on the right hand side of the receiver. Solder the three 6-volt dial lamp leads together and insulate. Solder



Top view of the converted 1068-A. The r-f section appears in the right hand center. The bottom tube is the 6AK5 with the octal adapter arrangement described in the text.



Front panel view of the two-meter receiver at W3GQS. A volume control, an i-f gain control and a standby switch have been installed. The r-f detector and oscillator tuning controls are ganged with specially cut lucite knobs. Substituting the 6AK5 in the first r-f stage reduces the band-spread on the antenna tuning control.

the $B+$leads for the magic eye together and insulate. Enlarge this hole and install a 5000-ohm wire-wound potentiometer. Ground the arm of this control and connect one side to *15-4 spark plate*. This is now the i-f gain control. A 0.5-megohm volume control is then installed as shown in *Fig. 1.*

Tube Substitution

Replacing the 6SH7 r-f stage with a 6AK5 will greatly improve the sensitivity of the receiver. Although the socket assembly may be completely replaced, with a little careful soldering it is possible to use the octal base of an old glass tube with a miniature 6AK5 socket as an adapter. The wiring arragement of the pins is then:

6SH7		6AK7
2		3
7		4
5		2
3	200 ohm resistor	7
6		6
8		5
4		1

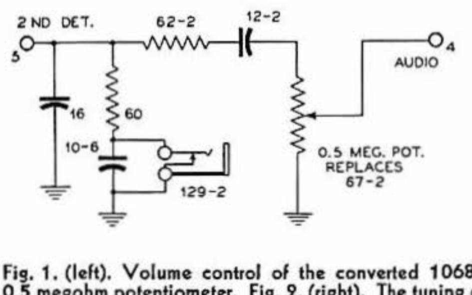
1 metal base of miniature socket

In some installations the 6AK5 will have a tendency to oscillate, but this may be cured by correcting the value of the screen resistor. Substituting a 0.1 megohm resistor for the 22,000 ohm *74-1* is generally sufficient.

Some improvement in the tone of the receiver will result if either a .005 μf or 0.01 μf paper condenser is connected from the plate of the *video amplifier* to ground. If the receiver does not motorboat after alignment the selectivity may be improved by replacing the grid resistors of the first three i-f transformers. 100,000 ohms across the i-f transformer secondary will sharpen selectivity considerably, but will prevent increasing the i-f gain to full. A simple solution is to place another potentiometer of about 4000 ohms in series with the i-f gain control. Locate this control under the chassis and adjust the value until i-f oscillation stops with the panel i-f control full up.

Aligning the Receiver

After making the conversion outlined above the receiver is ready for re-alignment. Stand the receiver on end with the power transformer down. Plug earphones or a PM speaker into the output jack. Do not connect an antenna. Turn on the power switch and tune all four dials to read approximately *1*. Leave the *OSC* dial set



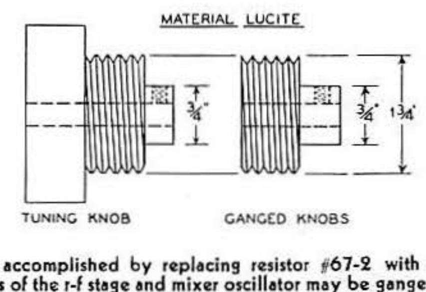


Fig. 1. (left). Volume control of the converted 1068-A is accomplished by replacing resistor #67-2 with a 0.5 megohm potentiometer. Fig. 2. (right). The tuning controls of the r-f stage and mixer oscillator may be ganged after conversion by turning on a lathe two knobs pictured on the right view and one knob as pictured in the left hand view. Cord is used to gang the knobs and is loaded with small springs.

at *1* and tune the *ANT*, *R.F.* and *DET* for maximum rush level in the speaker and maximum closing of the magic eye. Loosen the i-f transformer adjusting screws with glyptol solvent and back out the #3 tuning slug until the magic eye shows the maximum gain. Repeat procedure with #5 tuning slug. These transformers are now tuned to about 13.0 mc.

After removing the cover plate of the r-f section, tune in a signal about 146.0 mc. It should appear at about *3* to *4* on the *OSC* dial. Spread the oscillator coil until the 146-mc signal is received at dial setting *1*. Spread or squeeze the antenna (r-f stage) and detector (mixer) coils to make all dials read approximately the same as the *OSC* dial setting. If the antenna coil or the detector coil will not resonate near point *1* on the dials it may be necessary to add a small padder condenser across each coil. When the r-f section has been adjusted for maximum gain, peak the i-f transformers starting with the #2 transformer. It is not necessary to retune i-f transformer #1.

For convenience at W3GQS the *R.F.*, *DET* and *OSC* have been ganged. This has been accomplished by cutting on a lathe three lucite knobs as illustrated in *Fig. 2* and installed as shown in the accompanying photographs.

THE BC-453 ON BC

The following coil information was obtained experimentally from a regular BC-946, and comparisons on an inductance bridge with the stripped down BC-453 coils. The nomenclature is the same as that appearing on the original BC-453 circuit diagrams.

L1—Remove 132 turns below the tap and then add 25 turns after the tap.

L2, L3—The top coil on this form is left alone

After recently buying a new car and finding that a factory model BC radio for the same would set me back an additional $90, I decided to call war surplus to the rescue. So we converted a BC-453 to do the job. The selectivity is very good and the sensitivity adequate. The audio quality is somewhat down, but can be modified to suit individual tastes.

The i.f. transformers should now tune very close to 239 kc, which is the frequency used in the BC-946 models. I would suggest removing the b.f.o. and reconnecting as the first audio stage. Let the r.f. end run wide open, and wire a volume control into the grid of the first audio tube.

(i.e., the coil farthest from the base). The lower coil should have 195 turns removed.

L4, L5—Remove 147 turns from the top coil and remove 38 turns from the bottom coil.

1st i.f.—Remove 800 turns from both coils.

2nd i.f.—Use the existing tap for the outside end of the coil, making sure to reconnect the tap to the end of the coil. No tap connection was used.

3rd i.f.—Same as the 2nd i.f.

BANDSPREADING THE 274'S

A bandspread of 42 kc per division instead of the normal 100 kc may be obtained (on the 3–6 mc receiver) by removing five of the eight rotor plates on the tuning gang. Additional padding condensers must be added across the r-f and oscillator portions of the circuit. I found 33-$\mu\mu$f NPO Ceramicons did the job.

Another 274 trick is to lift the opposite end of the 620-ohm resistor connected to pin 5 of the r-f amplifier tube and ground this resistor, thus removing the r-f amplifier from the gain control line. This will improve the signal-to-noise ratio. The diagram shows the modification required to obtain this increased performance.

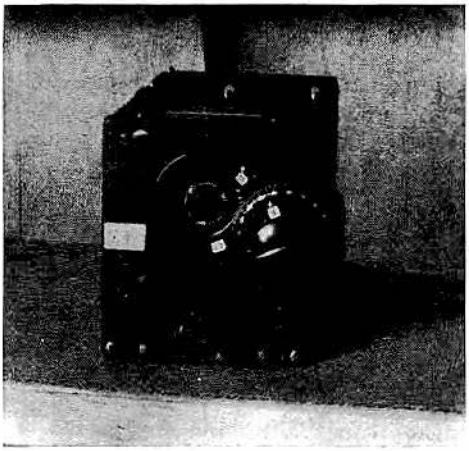


Fig. 1. Showing the tuning dial.

274N DUAL CONVERSION

With good prospects ahead for the higher frequency bands, and as more hams get on 10 and 15, we hear the boys speaking, not, as the Walrus said, about cabbages and kings, but about beams and receivers.

For many years past, amateurs generally have depended on the manufacturers to furnish them with receivers instead of making their own, and it must be said that the various companies have done a pretty good job. Performance on the low frequencies has been good, even on the low priced models. Above 14 mc however, most of these receivers are lacking in sensitivity and image rejection, so that it has been necessary to use converters or preselectors ahead of them.

In the high-priced newer model receivers double conversion is used, which practically eliminates images and at the same time increases the sensitivity on the higher frequency bands. However, when the Walrus mentioned cabbage, maybe he was thinking about the price of these new double conversion jobs, and the kings who could afford to buy them. Many of us simply cannot do so, and balance the budget. We *do* have our old model receivers, hot upstairs, but not so hot downstairs, and they have continuous coverage from 550 kc to 30 mc or thereabouts. If you are in that class, brother, read on:

The 274N Receiver

Most hams are familiar with the little "Command" receivers, the 274N Series, which are so plentiful on the surplus market. One of them, and only one, the BC 455, has an intermediate frequency of 2830 kc. With a small power supply, capable of giving 24 volts a.c. for the heaters, and 250 volts d.c. or thereabouts for the plates, they may be used without modification on 40 meters, and they make good stand-by or portable rigs.

By rewinding the r-f section they may be used as high up as 28 mc with a surprising amount of sensitivity if the job of rewinding is properly done and the rig is realigned to peak the various stages. Used as a converter, with the 2830 kc output taken directly to a communications type receiver, images are eliminated in the first conversion, while the old receiver takes care of the jobs of amplification, noise limiting, beat frequency production for c-w operation, and audio control.

Tuning

Tuning is done with the BC 455. Band spread and logging dials may be added, concentric with the tuning shaft as shown in the photograph *fig. 1*. The method used here may be explained as follows: To the threaded sleeve which holds the splined tuning shaft in place is fastened a dial scale from a BC 375 tuning unit. This scale has a hole that just fits the knurled outer diameter of the threaded sleeve. The sleeve is first drawn up tight, the original tuning knob removed, and the BC 375 dial forced onto the sleeve with its number 50 pointing directly upward. A skirted knob is then installed on the tuning shaft. The skirt of this knob just comes out to the bottom of the dial scale. Indicating arrows, numbered 1 to 4, are placed 90 degrees apart on the outer edge of the skirt. By making use of the main dial markings, together with the numbered arrows and the auxiliary dial, stations may be accurately logged at any place on the tuning system.

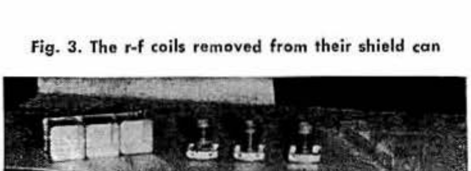
The BC 455 Command receiver was designed to cover a range of from 6 to 9 mc. It may be

Fig. 2. Underchassis view the r-f coils to the left.

converted to cover higher frequencies, at least up to and including all of the "ten meter" amateur band, by simply rewinding the r-f coils with fewer turns. No circuit modification is necessary, nor is it necessary to remove condenser plates.

Fig 2 shows one of these receivers with the bottom plate removed. The oblong strip near the left end holds the r-f coil assembly which consists of the three coils mounted on their respective sockets, and three square metal shield cans, as shown in *fig 3*. A complete assembly is shown at the left of the receiver in *fig 2*. By removing two small screws the assembly may be lifted off the small banana plugs which make the connections to the coils. Properly assembled it cannot be plugged in wrong. However, the location and position of the separate coils in the shield cans is very important. To help keep track of these things small dabs of brightly colored paint, known as "witness marks" are located in their proper positions on the shields and coil sockets. I spoke of three coils. Actually, there are five coils, wound on three forms. Two of the coils have resistors attached to one end, and running to another plug on the coil socket. These resistors are left as they are. The coils are designated *L1*, *L2*, *L3*, *L4* and *L5*, and are shown with their respective terminals in the sketch *fig 4*. The coil forms are fastened to their metal socket bases, and they are best left there while they are being rewound. This way, each

Fig. 3. The r-f coils removed from their shield can



coil may be plugged into position separately and tested with a grid dip meter if one is available. The coil shields seem to have little effect on the frequency, any difference may be compensated for by the trimmers and the slugs may also be used to peak the coils. Starting with *L1*, remove all but six turns, spacing these turns over about half of the coil form so that the slug will have an effect on the inductance when moved in or out. The inductance of this coil should be such that the little antenna trimmer knob on the front of the BC 455 will be effective at the desired frequency. If it is not, it may be necessary to adjust the turn spacing a bit.

L2 is the r-f mixer coil. It originally has a "honey-comb" winding. Unwind all of it, but be sure to leave the wire long enough so that you will have ten turns to wind back on. These ten turns will later be interlaced in between the turns on coil *L3* so as to provide very close coupling for greater sensitivity.

L3, also a mixer coil, is rewound with six turns, which may later have to be reduced to five if necessary. Space the turns the full length of the coil form, plug it into position in the receiver and test for resonance with a grid dip meter. The tuning dial should be set at the place where you want the band to come. Adjust turn spacing and slug position until the inductance is correct. Tuning the main dial should dip the meter. In this way you can locate where the band edges will come on the dial.

L4. It is not necessary to modify this coil at all.

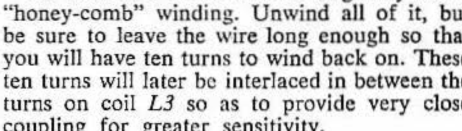
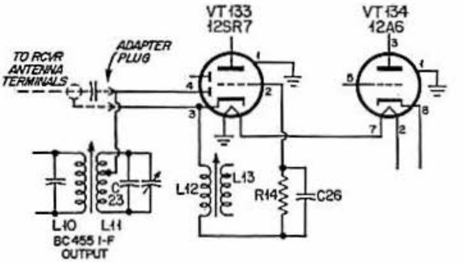


Fig. 4.

L5 should be very nearly a duplicate of *L3*. Start with six turns, spaced fairly close, about ⅛ inch from *L4*. With some adjusting of the slug and turn spacing it can be made to match the frequency of *L3* without much trouble. When re-assembling the coils for trial, use just enough of the little screws to serve the purpose, as it is very likely that you will have them out and in several times. This can be done quite rapidly once you get the hang of it. If a signal generator is available, or can be borrowed, it will help the trimming process. The i-f coil train in the BC 455 should first be aligned for best output. In fact, the receiver should be first tested for correct performance on 40 meters before any changes are made.

A small amount of trimmer adjustment may be necessary to make the receiver work as it should on 40. The i-f transformers need to be aligned but once, but the r-f end will of course have to be re-aligned after re-winding the coils. Trimmer condensers for this purpose will be found at the front of the receiver, top side. Some units have holes in the covering shield



Schematic of adaptor plug.

to allow for their adjustment. If they are not there, better make them. The first two at the left, as you face the receiver dial, are in parallel. One is set either all in, half way in, or all out, and the trimming done with the mate. These tune the mixer coils. A little farther to the right there are two more, also in parallel. These tune the oscillator coil *L5*. At the extreme right there is a single trimmer. This one trims the coil *L4*, and is best adjusted when moved in conjunction with the tuning dial for best overall receiver output.

Operation

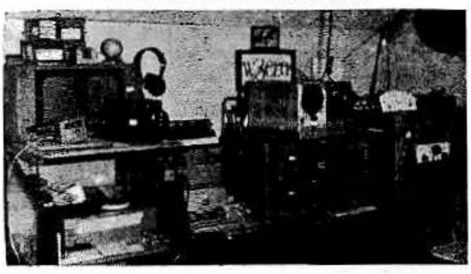
With everything trimmed up properly the receiver should work very well as a straight ten meter receiver on fairly strong signals while using headphones. When this has been accomplished we can take up the job of making a converter out of it. This is easily done. All you have to do is to remove the second detector tube, *VT 133*, 12SR7, and make up an adapter plug to put in its place using but two of the pins, *No. 3* and *No. 4*. It is not necessary to remove the audio output tube 12A6, since its heater is disconnected when the 12SR7 is removed. The adapter should be made long, for two reasons; A short adapter would be very difficult to plug into the socket. Also the adapter should contain a small condenser in the lead to pin *No. 4*. An old coil form, large enough to take a plug at one end, and about three inches long would be ideal. The condenser, .001 μfd. could be inside the tubing, with one lead running to pin *No. 4* on the plug. The other condenser lead should go to the inner conductor of a piece of small co/ax cable. Pin *No. 5* on the plug should be connected to the shield of the cable. This cable runs directly to the antenna terminals on the Communications Type Receiver with which the converter is to be used. Set the dial of the second receiver to 2830 kc, fire up both receivers, and you should be in business. You will need a volume control on the BC 455. The b.f.o. won't operate, as you have pulled the tube. Probably the volume control on the second receiver will have to be set pretty low. CW is received by throwing in the b.f.o. in the second receiver. You may find that the noise limiter in the second receiver works much better than it ever did. The "S" meter will read a lot higher. Crystal selectivity filters or "Q" Multipliers will work in a normal fashion. Images will be absent, and the signal strength, as compared to that of the old receiver alone, will be very gratifying.

Caution

It might be well to add a word of caution here; Be sure that the input circuit to the old receiver is not open. These input coils are sometimes wound with a few turns of very fine wire, so small that a good heavy dose of static will open them up. It has occurred, in several cases. Surprisingly enough, the receiver will work to a certain extent even with the input coil open.

The foregoing winding data is given with the assumption that the BC 455 is to be used mostly for ten meters. It is possible to squeeze the 10, 11, and 15 meter bands into one set of coils but it will take very careful adjustment of turn spacing and trimming to get the proper tracking, because the ten meter segment will be at one extreme dial reading and the fifteen meter portion will be at the other extreme end. It is much easier to convert two units, one for use with 10 and 11, and the other one for use on 15 and 20 meters. In the latter case, start with double the number of turns given for the various coils and trim down until the band segments are at the desired places on the main dial.

The receiver in the author's shack.



THE R28 VHF RECEIVER

This unit was designed by the Western Electric Co. for operation on 24-28 volts. It fits into an FT 220-A mounting rack. The line-up is a 717A in the r-f stage, 717A as a mixer, 12SH7 oscillator and two more 717A's as multipliers, two i-f stages with 12SH7's, two 12SL7's in the detector, a.v.c., squelch and 1st audio stages and a 12A6 2nd audio output. Motor tuning to set the receiver on four channels is provided.

The first step in the conversion process is to replace the 12-volt tubes with their 6-volt equivalents (a 6V6 will replace the 12A6). Then remove the side and end plates of the receiver, and separate the receiver housing from the front end containing the motor. Remove the motor, but be sure to save all the gears. Leave the motor drive shaft in place. Note that two pieces of pressed iron constitute the frame that held the motor. As you take these apart notice that on the front of the larger piece is a raised portion that must be flattened out—otherwise it will interfere with the dial drive mechanism that is to be mounted.

Vernier tuning can be obtained through the use of the discarded parts from the motor drive mechanism. Remove the bronze gear and one worm gear from the shaft that has two worm gears. Be careful not to bend or spring this shaft. Enlarge the hole in this gear to ¼ inch and then drill and pin it about 11/16 inch from the bottom plate on the main drive shaft for the gear train. Make a bushing for the new dial drive (see photo) by forcing the 3/16-inch shaft into a short length of ¼-inch O.D. tubing and then trim the whole shaft to about 2-3/16 inches. Put the worm gear on this shaft and mount it at right angles to the bronze gear (again see photo) by making up an end bearing. The latter can be cut from a piece of square bar (or equivalent) that is 1 inch long and 5/16 or ⅜ inch on a side. Drill and tap one end for an 8-32 thread to mount it to the bottom plate (see photo). About ¼ inch from the tapped end drill a 3/16-inch hole for the worm gear shaft. Drill additional holes in the ¼-inch main drive shaft and put in pins to hold it in place.

From the aluminum cabinet, remove the door by drilling out the rivets in the hinges. Remove the two steel pins by twisting them out with pliers. Bolt a piece of aluminum (4⅝ x 4⅜ inches) to the front of the unit and cut out a 2¼-inch hole for the dial drive (centered about 2⅜ inches from the left side and 2½ inches from the bottom). Bolt the dial unit in place.

Remove all of the crystal sockets and relays. In opening up the bundle of wire going over the top of the unit be careful not to disturb the two wires going to the squelch and the one wire to the r-f stage.

Convert the oscillator stage by removing the grid by-pass condenser (*C163*) from *pin 4* of *V108*. Add a 0.0001 μfd. from *pin 4* of *V108* to the cold side of *L111* at the junction of *R152* (1000 ohms). The 6SH7 should now take off on its own and be tuneable.

Remove coupling resistor *R136* (1.0 megohm) and coupling condenser *C149* (0.006 μfd.) from *pin 1* of the 6SL7 *(V106)* squelch amplifier. Replace with a single 0.01 μfd. Now remove *R143* (1.0 megohm) and coupling condenser *C154* (0.006 μfd.) from *pin 5* of the 6V6. Replace with a single 0.01 μfd. Remove the 47,000-ohm grid resistor *(R144)* from *pin 5* of the 6V6 and replace with a suitably connected volume control (450,000 ohms with switch). For more audio remove *C157* and *R168* across the audio output transformer primary (*terminals 1* and *2*).

The impedance of the output can be changed from 600 to 8000 ohms by switching the connection from *terminal 6* to *terminal 3*.

Receptacle *J102* on the rear of the receiver should have *pins 3* and *4* connected to ground *(pin 1)*. Since the original squelch control has a short slotted shaft, use the control 6488 Type J from either a control box BC-496-A or from a C-25/ARC-4. A new speaker output jack was mounted in the front of the unit.

8 Power

D.C. FROM THE PE-73

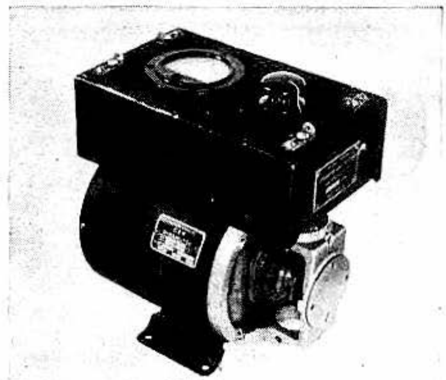
HAVE you been looking for an application for those useless 28 volt dynamotors? Can you use a low voltage power supply for field day, a battery eliminator for servicing mobile gear, or a battery charger? Then here is an easy and inexpensive way to fill your needs.

The conversion consists of eliminating the high voltage function of the dynamotor, driving the converted unit with some sort of motor, and extracting the low voltage from the dynamotor input. The conversion was done on several 28 volt PE-73s, but there is no reason why any dynamotor with suitable mechanical construction cannot be converted similarly.

The converted unit may be run with a ½ to 1 hp gas engine or electric motor, and easily turns out 28 volts at 20 amps, or 6 volts at 50 amps. The output voltage is continuously variable from 0-28 volts by the pot in the field circuit. Alternately, if you have lots of 28 volt d.c. around, the converted unit may be used as an electric motor, delivering about ½ hp at 5000 r.p.m.

The original dynamotor consists essentially of a compound wound d.c. motor driving a d.c. generator. A common armature and field windings are utilized to conserve space. Since a d.c. machine may be used either as a motor or a generator, we will use the motor (low voltage) portion of the dynamotor as a generator in the converted unit.

Our aim in this conversion is to attach a V-belt pulley to the dynamotor so it can be turned with a motor. We also wish to provide a means of varying the generator output voltage. These objectives are easily accomplished and the conversion can readily be done in an evening.



View of the converted PE-73 dynamotor. Note that the end support has been shifted 90° to clear a horizontal drive belt. The field rheostat in the junction box permits voltage output control from 0-28 volts.

Pre-Testing

The dynamotor to be converted should be tested on 28 volts d.c. before beginning the conversion to make sure it runs. High voltage output isn't necessary since we won't use that anyway. Sad experience showed that a few minutes at this point would have saved considerable frustration when one of the converted units didn't work. If you don't have 28 volts available, use 12 volts since most of these 28 volt dynamotors will run, at least slowly, on 12 volts. Also when testing the unit, note the direction of rotation of the armature and mark it on the frame.

Conversion

Remove all of the wiring from the junction box on top of the dynamotor. Take off both end covers and remove the four brushes. Remove the high voltage end framework which supports the armature bearings, and take the armature out of the dynamotor. Remove the brush holders

View of the finished armature with the V-belt pulley and bearings mounted.

from the high voltage end. This completes the disassembly and brings us up to the mechanical conversion.

The armature revision requires the use of a metal turning lathe. However, it is not a job requiring precision machine work, and may be completed in about an hour. To protect the bearings, remove them from the armature shaft with a press or a bearing puller. Mount the armature in the lathe and cut away the entire high voltage commutator, down to the ¾" steel shaft that passes through the entire armature, as shown in fig. 1.

After the entire commutator has been turned down, apply some varnish or shellac to the exposed insulation on the end of the armature to seal it against moisture penetration. Install a 1½" diameter V-belt pulley in the space formerly occupied by the high voltage commutator. Press the bearings back on the armature shaft carefully. Install the armature into the dynamotor frame with the pulley at the high voltage end. Install a suitable V-belt on the pulley and put the high voltage end framework back onto the unit, but rotated 90° from its original position (heavy rib vertical). This permits the V-belt to be brought out to the side of the unit without interference from the bearing support.

Wiring

Now look at the wires connected to the low voltage brushes. There is a heavy wire on each one, which is the generator output. Also there is a smaller wire attached to each of the brushes, at least to one of them, depending on the unit you are working with. These are the shunt field wires, and *one* of them should be removed. Splice a 12" piece of wire onto the shunt field wire that was just removed, and attach another 12" piece of wire to the brush holder that the shunt field wire was removed from. Pass the

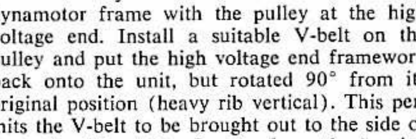


Fig. 1—Drawing of the armature showing the removal of the high voltage commutator which is cut away on a lathe.

wires carefully up into the junction box on top of the unit, making sure they clear the rotating armature. A rheostat connected between these two wires will provide the output voltage adjustment.

The junction box on top provides a convenient place to mount the voltage control and the generator output terminals, as well as any metering desired.

An old car ammeter provides a cheap and helpful monitor of what the unit is doing. Also, a 30 amp fuse is put in the output to protect the armature in case the output is accidentally shorted.

Wire up the generator as shown in fig. 2.

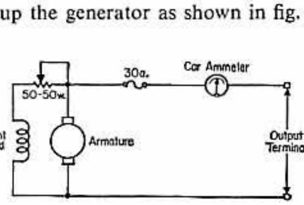


Fig. 2—Wiring diagram for the converted PE-73 dynamotor. Output voltage can be varied from 0-28 volts by the 50 ohm field control.

Testing

Well, there's your low voltage generator! Hook the V-belt to a motor (about ½ hp) with a large enough pulley to turn the dynamotor about 4000-5000 r.p.m. in the *same direction* as the unit ran when it was hooked to the d.c. source in the initial checks.

The generator is now ready for your use. If it is to be used in a dirty location, the low voltage end cover may be partially cut away to provide clearance for the V-belt, and then put back in place.

If you desire a low voltage output from the generator, you may find that it is not obtainable when there is no load on the generator. This is normal, and the voltage will drop as soon as some load is applied to the generator.

The voltage regulation of the unit is quite good due to the compound winding of the dynamotor. As the load current increases, the series field produces a stronger magnetic field. This boosts the generated voltage to compensate for the increased drop in the armature, thereby tending to hold the output voltage constant.

The converted unit makes a nice battery charger for extra batteries used for mobile servicing, by running it with an electric motor. Another real handy use is for field day—the unit can be attached to a gas engine and used to charge six, twelve, or twenty-four volt batteries just by adjusting the voltage control.

This generator provides a cheap supply of d.c. at high current, in addition to providing a use for one of those 28 volt dynamotors you've got kicking around. Next time you need lots of amps of low voltage d.c., think of this and take a few hours off to build yourself this handy generator.

D.C. Machine Theory

For those who would like to improve their understanding of the operation and conversion of this generator, presented here is a review of some basic d.c. machine theory.

We are only concerned with the low voltage part of the dynamotor, so let us consider this portion alone from a linear equivalent circuit point of view. The d.c. motor may then be represented as shown in fig. 3:

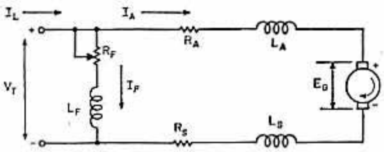


Fig. 3—Equivalent circuit of the motor.

where V_T is the applied voltage, I_L is the current drawn from the line, R_F is the shunt field resistance, L_F is the shunt field inductance, I_F is the shunt field current, I_A is the armature current, R_A and L_A are the armature resistance and inductance, R_S and L_S are the series field resistance and inductance, and E_G is the back voltage generated by the moving armature. The only element requiring further comment is E_G, which represents the armature reaction. This is an opposing voltage generated by the armature windings moving thru the magnetic field produced by the field coils. The E_G accounts for the bulk of the voltage drop within the motor, and is only slightly less than V_T. This generated voltage is proportional to the motor speed N, the shunt field current I_F, and the armature current I_A, related by the constants K_1 and K_2.

We shall now analyze the circuit to see the motor speed dependence on the circuit paramenters.

Since we are working with d.c. and are only concerned with steady state behavior, the inductances do not enter the calculations. From the circuit we see that:

$$I_L = I_F + I_A$$

$$I_F = \frac{V_T}{R_F}$$

$$V_T = E_G + I_A\,(R_A + R_S)$$

$$E_G = K_1 N\,[I_F + K_2 I_A]$$

Combining these equations we obtain:

$$N = \frac{V_T - I_A\,(R_A + R_S)}{K_1\,[I_F + K_2 I_A]} = \frac{V_T - I_A\,(R_A + R_S)}{K_1\left[\frac{V_T}{R_F} + K_2 I_A\right]}$$

From a look at this equation we see that the motor speed, N, may be easily controlled by changing R_F; increasing R_F increases the motor speed. We will see this to be exactly opposite of the voltage output control exercised by R_F in d.c. generator operation.

If we now turn the armature in the same direction by some external means, our d.c. machine becomes a generator. The same equivalent circuit holds except for the form of the input and output powers, and the current directions. In motor operation we put in electrical power and derive mechanical power; in generator operation the powers are reversed. Also, for generator operation, the direction of the line current I_L and the armature current I_A reverse.

The equivalent circuit is now as shown in fig. 4.

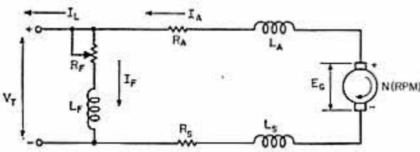


Fig. 4—Equivalent circuit of the generator.

Following a similar analysis and solving for the electrical output of the generator, we see that:

$$V_T = K_1\,N\,I_F + I_A\,[K_1 K_2\,N - (R_A + R_S)]$$

and
$$I_F = \frac{V_T}{R_F}$$

These equations say that, for constant driving speed N, the output voltage may be varied by changing the field current I_F, which is varied by changing R_F. We also see that the output voltage is inversely proportional to R_F; just the opposite of the motor speed control by R_F. Another observation from these equations is that if $(R_A + R_S)$ is appreciable, then the output voltage will drop as increasing load current (I_L) is drawn. However, if $(K_1 K_2 N) = (R_A + R_S)$, then the output voltage is independent of the load current drawn. This condition represents what is known as "flat compounding"; when the action of the series field compensates for the voltage drop within the generator to maintain the output voltage constant.

Now that we understand the operation of the d.c. machine from a circuit standpoint, we are in a better position to appreciate the operation of the PE-73.

POWER THAT 274N

HIGH ON THE popularity list of surplus equipment are the command set receivers. Few changes are necessary for conversion to amateur requirements and their cost per unit is but a fraction of the original contract price.

Unfortunately, a power supply is not included and the purchaser is confronted with the problem of designing his own. Inasmuch as there are several methods whereby one can obtain the necessary heater and plate voltages this is often a problem. Conversion to a.c.-d.c. operation was described by W8OZA in an early issue of *CQ*.[1]

The selenium power supply described is designed especially to keep these receivers as compact as possible. Ease of construction, low cost and efficent operation characterize this midget plug-in unit.

Selenium Rectifiers

Contrary to popular belief, selenium rectifiers have been in use for many years. Until recently, however, their general use has been prohibited by high cost and physical size. Seleniums are now available to the amateur at prices comparable to rectifier tubes and sockets which they replace. Their small size, low voltage drop and nominal cost class as the logical solution to a trouble-free power source.

Figure 1 shows a standard half-wave circuit with a 100-ma selenium rectifier replacing the usual half-wave rectifier tube. Capacitor C_1 across the input acts as a small filter absorbing any stray line "hash." A limiting resistor, R_1, protects the rectifier from peak voltages. Capacitors C_2 and C_3, together with resistor R_2, comprise an effective resistance/capacity output filter. Two small replacement type filament transformers, rated at 6.3 volts, 2.0 amperes, furnish heater current to the 12.6-volt tubes.

Assuming 117 volts a.c. input with values approximating those shown, the resultant d.c. output will be 100 volts. The values shown represent the best compromise between d.c. output voltage and a.c. ripple. Inasmuch as condensers C_2 and C_3 are not subjected to large peak voltages, a rated working voltage of 150 d.c. is safe. No appreciable improvement will be realized by using capacitors in excess of 40 μf.

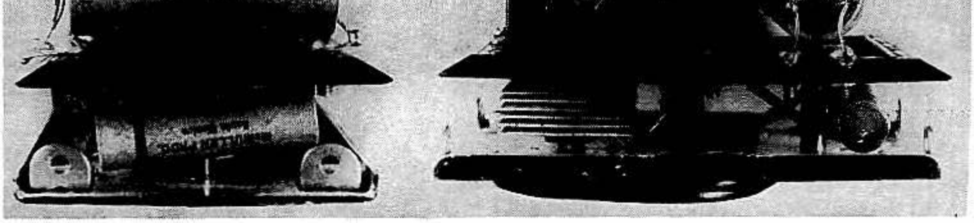
Construction

As may be seen from the photographs, the unit's foundation is the plug-in base removed from the dynamotor which originally powered the command set receiver. These bases (model D-32) may be purchased separately at some surplus outlets. If not procurable locally, one may fabricate a base plate from sheet aluminum and a modified wafer socket.

The top deck consists of an ordinary bakelite wall switch plate, obtainable at most "dime" stores. It so happens that these plates are the exact size of the dynamotor base plate which measures 2¾" wide by 4½" long.

All components are midget sized and leads consequently are short. A 6-32 machine screw through the rectifier eyelet serves to support the top

[1] Sievert, "Converting the SCR-274N Receiver," *CQ*, Nov. 1947.



Top and bottom view of the complete selenium rectifier power supply. Note the "sandwich" type construction permitting compact design. This supply uses a single filament transformer, the receiver filaments operating at half voltage.

deck at one end, while the remaining edge is supported by small bushings. The a.c. lead is brought through a rubber grommet mounted on the bottom front of the base plate. An on-off line cord switch is connected in series with one side of the a.c. line before its entry into the base plate.

Guide holes are drilled in both plates and all wiring is completed before the "sandwich" is assembled. Filter condenser and transformer leads should be readied with soldering lugs and guided into place after assembly. Parts placement and wiring is not critical. A good portion of those components at ground potential are easily taken care of by connections to the metal base plate.

For those contemplating a higher voltage utilizing standard voltage doubling circuits, several precautions should be considered. In any voltage doubling circuit, two selenium rectifiers will be required in addition to an extra filter condenser. This condenser must withstand the sum of the voltages across the doubling condensers and therefore should be rated at least 250 volts, d.c. working.

Where space is at a premium, these added components present a difficult problem. Furthermore, the total cost of a voltage doubling power supply employing selenium rectifiers, is almost twice that of a half-wave circuit. For headphone reception,

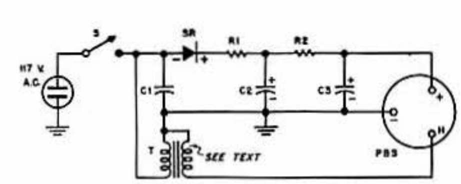


Fig. 1. Circuit diagram of 100-volt 100-ma supply.

C1—.02 μf paper tubular condenser, 400 volts d.c. working (Aerovox.)
C2, C3—Double 40 μf electrolytic condenser, 150 volts d.c. working, (Pyramid).
PBS—Plug-in base, Type D-32.
R1—30-ohm ½-watt resistor. (IRC).
R2—1,000-ohm 1-watt resistor. (IRC).
SR—Federal selenium rectifier, 100 ma.
S—SPST switch.
T—Replacement type filament transformer, 6.3 v., 2.0 amp.
1—Wall switch plate (bakelite or composition).
1—Rubber grommet.
Miscellaneous: Pushback Wire, Spaghetti Tubing, 6-32 Hardware, A.C. Line Cord.

of command receivers, the increase in signal strength at higher plate voltages is very little above that at normal rectified line voltages.

STAY OUT OF JAIL

Of the many conversions and adaptations to which the 274-N command receivers have been put, we believe our conversion of a BC-454-B as a station monitor to be one of the easiest, most useful, and economical. Every amateur phone station should be monitored by its operator when first going on the air, and, at least periodically, during an evening of QSOs. Even the most experienced code operator likes to monitor his sending at times, while the beginning c.w. man will probably want to, or at least should, monitor continually. The BC-454-B is a natural for this purpose. About two hours of your time and the price of the receiver, plus the cost of one open circuit jack, one 20,000-ohm pot (with switch), one s.p.s.t. (BFO) switch, and one d.p.d.t. (B+) switch, are all that's required. It was found that by tuning the receiver to a transmitter sub-harmonic, it could be used on 80 through 10. It will usually be found unnecessary to use any antenna on the monitor. When using the BC-454 on the 80-meter band, the antenna post may be tied directly to the chassis to reduce pickup.

Conversion Procedure

Remove all hardware from the adapter panel and mount the pot, phone jack, and BFO switch,

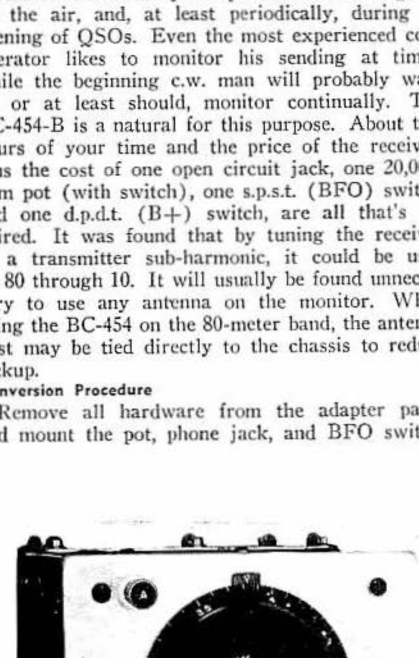


Fig. 1. From the front it looks like any other SCR-274N conversion.

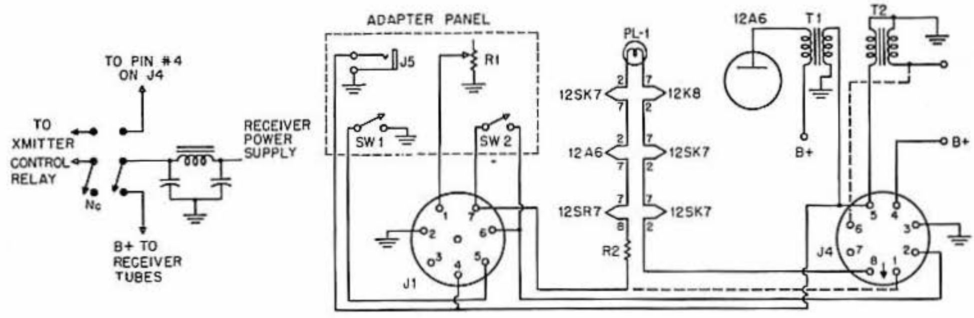
as shown in *Fig.* 1. Ground one side of the pot to the panel and connect the center tap to *pin 1* on J_1. Use stranded wire about 4 inches long for these panel connections. Wire the phone jack to *pin 4* on J_1. Ground one side of the BFO switch and connect the other side to *pin 5* on J_1. These connections may be soldered directly to the pin tips on J_1. Solder two wires to the switch on the volume control pot and connect to *pins 6* and *7* on J_1. This completes the front-end changes, and the adapter panel may now be replaced on the front panel.

Next, remove the bottom cover. Remove the two side screws that hold the coil assembly in place. Pulling out the coil assembly is necessary in order to permit working on the rear side of J_1. Unsolder the two white wires attached to *pins 6* and *7* on the rear side of J_1, and remove completely from the set. Remove the small r.f. choke L_{14} and the audio choke L_{15}. A couple of tie-points are bolted to the chassis for mounting the filament-dropping resistor in the space vacated by L_{15}. As we were unable to secure any male plugs to fit J_3, it was decided to remove it and replace with a standard Amphenol 86-PM8. Slight reaming of the hole with a pocket knife is necessary to admit the Amphenol plug. All leads unsoldered from J_3 may be removed to their nearest point of contact except the long red lead from *pin 4* on J_3. This lead is clipped just long enough to reach the point where the short red lead is removed. This is the point where the 5100-ohm resistor is tied to C15-C. As may be seen on the diagram *Fig. 2*, the audio output is brought to *pin 5* on J_4, the B+ to *pin 4* on J_4, and *pin 3* is grounded to the chassis.

The next step is to rewire the filaments, as shown on the diagram, *Fig. 2.* In rewiring the filaments it will be found easiest to start with *pin 7* on the 12SR7 and proceed around the circuit as shown. In this manner the original filament wires may be used to the best advantage. The a.c. wires running to the filament switch should be a shielded twisted pair with the shield grounded to prevent possible hum induction to the receiver.

Use as a C.W. Monitor

When the receiver is being used to monitor c.w., the output may be connected to a small speaker by placing a 4000-ohm-to-voice coil transformer between the speaker output on *pin 5* and the voice coil, as shown on the diagram. A switch must be added in series with the transformer to kill the speaker when monitoring with the phones. This speaker transformer may be mounted on the dynamotor deck or at the speaker.



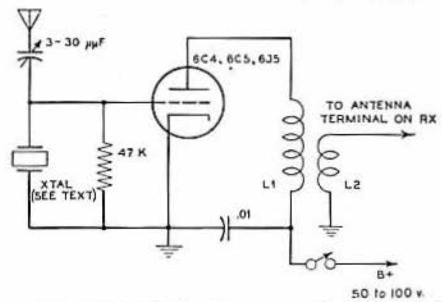
J4—Amphenol 86-PM8.
J5—open ckt. jack for phones.
PL1—6 v., 250-ma series pilot light.
R1—20K volume control.
R2—250 ohms, 10 w.
SW1—b.f.o. control switch.
SW2—filament switch (on R1).
SW3—d.p.d.t. monitor B+ switch (see text).
T1—output transformer in monitor.
T2—speaker trans. (50L6-to v.c. trans.)

To prevent leaving the filaments turned on by mistake when using the monitor, a pilot light must be added. The small 3-μfd. condenser mounted on the front panel may be moved far enough up to make room for a small pilot light. If the pilot light is wired in series with the filaments as shown on the diagram, a 250-mil 6-volt bulb should be used. The 150-mil bulbs will not stand the current surge which occurs when the filaments are first turned on. The 250-mil bulbs will last many months and give plenty of light for the purpose. Some may prefer to use a 110-volt neon pilot light instead.

As the writer has several of the 274-N receivers around the shack used in various manners, the output plugs were standardized with the Amphenol 8-pin plugs. The wires shown by the dotted lines were incorporated to permit turning on the receiver B supply with the filament switch when individual power supplies are used on the various receivers. It was shown here with the thought in mind that some operators might prefer to use a small power supply for the monitor, or it may be utilized to control the transmitter filament relay from the operating desk, as we are using it here.

The B+ for the monitor is taken from the station communications receiver B supply, as shown by the diagram. The other half of the d.p.d.t. switch is used to control the transmitter high voltage relay. Thus the station receiver is killed and the monitor and transmitter are turned on with one switch. This switch may be located at any spot handy to the operating position.

BC ON MILITARY SETS



Although a 6C4 is shown, any triode or triode-connected tube will function as well. The converter operates by mixing the incoming signals with a crystal-oscillator frequency, thus producing a high frequency resultant in the plate circuit which is fed into the antenna terminals of the receiver. Instead of using a fixed i-f system, and tuning with the local oscillator and mixer grid circuits as is normally done, this converter frequency is fixed and the intermediate frequency is shifted. It was found that the broadcast signals, being relatively strong, required no tuned circuits to produce the desired results, thus offering an arrangement having no adjustable controls. All tuning is accomplished with the receiver's own tuning controls.

The system operates as follows: Suppose the desired broadcast-band station is operating on 1000 kc, and that a 3500 kc crystal is available. The receiver should then be tuned to 1000 plus 3500 or 4500 *kc;* or, it could be tuned to 3500 minus 1000 or 2500 *kc:* or, using the *second harmonic* of the crystal the receiver could be tuned to 2000 plus 3500 or 5500 *kc.*

Reliable broadcast-band reception is possible up into the 20-meter band with 80-meter crystals in the converter.

Wide variations from the specified values can be introduced with little noticeable difference, as long as the converter is maintained in oscillation.

The coil shown as $L1$ and $L2$ may be an r-f choke with a secondary of about 20 turns between two of the pies, or an old i-f transformer can be used with the tuning condensers removed. Almost any type of coil seemed to work as long as the crystal will oscillate.

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