PABESY!
Jan Poortman

OPERATING INSTRUCTIONS
No. EB 2002
for

MF/HF AM Signal Generator

TF 2002

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

C.P. 1.5c
5/68/E

EB 2002
1a - 1/66

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1 GENERAL INFORMATION

1.1 FEATURES

This all-transistorized signal generator gives high quality a.m. outputs from 10 kc/s to 72 Mc/s. It has very high frequency discrimination which, coupled with the good stability reached soon after switching on, makes it particularly suitable for setting up and adjusting crystal controlled receivers where the channel spacing is small and the i.f. pass band must have an accurate absolute setting. Another feature of note is the low leakage which will be found of advantage for tests on receivers that have an internal ferrite rod aerial.

The instrument is rugged yet compact in design, weighing only 50 lb and is available in bench or rack mounting versions.

Permeability tuning of the oscillator and output modules provides the low impedance required by the transistor circuitry and enables the complete range to be covered in only eight bands. The hand calibrated near-logarithmic tuning scale is displayed in a continuous zig-zag pattern, with scales running alternately left and right, which cuts out much of the tedium usually associated with tuning about the band-change frequencies. Above 100 kc/s carrier frequency, direct reading incremental tuning gives high discrimination. Carrier shifts can also be produced by externally applied d.c.

Crystal check points are available at intervals of 1 Mc/s, 100 kc/s or 10 kc/s. Subsidiary check points can be switched in at 1 kc/s relative to each of the main points. The dial of the incremental control can be standardized against the crystal check points by means of two independent trimmer controls. The whole system can provide a degree of scale expansion equivalent to a total scale length of over $2\frac{1}{2}$ miles.

Up to 2 V source e.m.f. can be obtained with 100% modulation over most of the range. Output is controlled by cam operated 20 dB and 1 dB step attenuators with voltage and dB calibration in terms of p.d. across a 50 Ω load or of source e.m.f.; interpol-

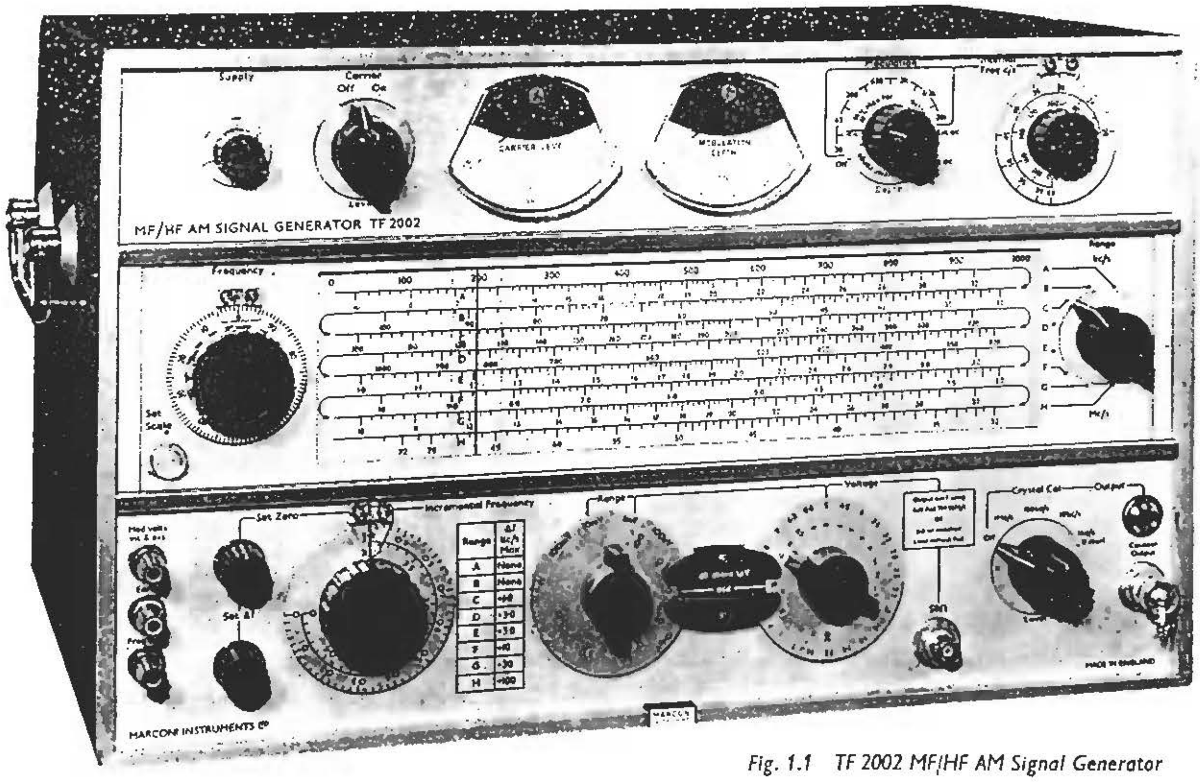


Fig. 1.1 TF 2002 MF/HF AM Signal Generator

ation between attenuator steps is provided by the carrier level control and meter. Automatic level control holds the output constant against frequency or range changing.

An auxiliary unmodulated output is available for such purposes as driving a counter to monitor the signal generator frequency.

Internal a.m. up to 100% is produced by a continuously tuned oscillator covering the audio band. This means that the generator can be used for comprehensive r.f., i.f. and a.f. response measurements on a receiver with no additional equipment other than a receiver output meter. The oscillator output is available for external use at a terminal to which an external modulating signal may alternatively be applied. Envelope negative feedback ensures good modulation quality up to at least 80%, and modulation depth is independent of both carrier tuning and carrier level.

The terminals used for frequency shift can also be used to apply external f.m. or phase modulation or, with the aid of a phase discriminator, to phase lock the carrier for maximum stability.

Emphasis has been placed on accessibility despite the compact structure and thorough screening. The instrument has three major horizontal sections; the centre one containing the oscillators and output circuits can be withdrawn and operated via an extension lead.

1.2 DATA SUMMARY

Frequency

Range : 10 kc/s to 72 Mc/s, in 8 bands :-

A	10 - 32 kc/s	E	1 - 3.2 Mc/s
B	32 - 100 kc/s	F	3.2 - 10 Mc/s
C	100 - 320 kc/s	G	10 - 32 Mc/s
D	320 - 1000 kc/s	H	32 - 72 Mc/s

Mechanical tuning discrimination : The frequency scales are near logarithmic and a 1000 division linear logging scale is provided.

Calibration accuracy : ±1%, with the scale in the index position. Provision is made for adjusting the scale position against the internal crystal calibrator.

Stability : At constant ambient temperature within the range 10°C to 35°C.

In the 15 minute period commencing 3 hours after switch-on, the frequency variation is typically 30 p.p.m. + 3 c/s, and will not exceed 90 p.p.m. + 3 c/s. During the period 10 minutes to 3 hours after switch-on, the maximum frequency variation per 15 minutes will not exceed three times the amounts stated above.

Following a 10°C change in the ambient temperature within the range 10°C to 35°C occurring after 15 minutes operation, the maximum frequency variation over the next 3 hours is typically 200 p.p.m. per 15 minutes.

Following a 10% change in the supply voltage, the maximum frequency variation is less than 20 p.p.m. +5 c/s.

Frequency (continued)

Electrical fine tuning :

Operative above 100 kc/s only.
Adjustable up to maxima of :-

+ 1.0 kc/s	for 100 - 320 kc/s	Band C
+ 3.0 kc/s	for 320 - 1000 kc/s	Band D
+ 3.0 kc/s	for 1 - 3.2 Mc/s	Band E
+ 10.0 kc/s	for 3.2 - 10 Mc/s	Band F
+ 30.0 kc/s	for 10 - 32 Mc/s	Band G
+100 kc/s	for 32 - 72 Mc/s	Band H

Incremental frequency accuracy is 5% of full scale when standardized at full scale against internal crystal calibrator.

Discrimination is better than 0.03% of carrier frequency.

For external frequency shift facilities, see under special modulation facilities.

Crystal calibrator :

Check points at 1 Mc/s, 100 kc/s and 10 kc/s intervals.
Accuracy : 0.01%, 10 - 35°C.
Check points at ± 1 kc/s ± 10 c/s about these points.

R.F. output

Level :

Maxima
10 kc/s - 32 Mc/s (c.w. or up to 100% modulation)
1 V e.m.f. using 6dB pad, or 1 V p.d. across a matched load.
32 Mc/s - 72 Mc/s
As above for c.w. Half the above with 100% modulation
10 kc/s - 72 Mc/s
If working into an open circuit without a 6 dB pad, 2 V e.m.f. is available using up to 30% modulation depth below 32 Mc/s, or using c.w. above 32 Mc/s.

Variable down to 0.1 µV at all frequencies.

(See also external d.c. modulation).

Attenuators :

Coarse - 120 dB in 20 dB steps.
Fine - 20 dB in 1 dB steps.
External 6 dB pad TM 5573/1.
Increments less than 1 dB obtainable by meter setting.

Total level accuracy :

(Above 1.0 µV with or without 6 dB pad, with meter at the appropriate reference mark)
Below 32 Mc/s ± 1 dB from 10°C to 35°C.
Above 32 Mc/s ± 2 dB, of which approximately ± 1 dB is caused by temperature effects over the range 10°C to 35°C.
A.L.C. maintains carrier level meter setting constant within 0.5 dB at all carrier frequencies.

R.F. output (continued)

Impedance :	Effectively 50 Ω at all level settings. V.S.W.R. 1.15 : 1 below 200 mV, with or without 6 dB pad.
Carrier harmonics :	Less than 3% individual harmonics at maximum output levels.
Leakage :	Negligible. Allows measurements to be made close to the signal generator.
Counter output :	Suitable for use with Counter TF 1417/2 and Converter TF 2400. Produces 10 mV into 50 Ω from high impedance source.

Modulation

Depth :	Continuously variable up to nominally 100%.
Monitor :	Reads equivalent average modulation and is virtually independent of carrier level reference.
Accuracy :	At 20°C up to 80% depth, ±5% modulation to 10 kc/s, and ±10% modulation to 20 kc/s, provided the maximum usable modulation frequencies shown in table 1.1. are not exceeded. The error with temperature may rise by an additional ±3% modulation at 10°C and 35°C.
Envelope distortion :	Using internal oscillator, less than 2% distortion factor at modulating frequency of 400 c/s for modulation depth up to 80% at carrier frequencies between 100 kc/s and 32 Mc/s (Bands C to G). The maximum usable modulation frequencies for up to 5% distortion at 80% depth over the whole carrier range are shown in table 1.1.

TABLE 1.1

Band	Carrier frequency	Maximum frequency for 80% modulation depth (5% distortion)
A	10 to 32 kc/s	100 c/s
B	32 to 100 kc/s	100 c/s
C	100 to 320 kc/s	1.5 kc/s
D	320 to 1000 kc/s	2 kc/s
E	1 to 3.2. Mc/s	20 kc/s
F	3.2 to 10 Mc/s	20 kc/s
G	10 to 32 Mc/s	20 kc/s
H	32 to 72 Mc/s	20 kc/s

Modulation (continued)

Internal oscillator :	Continuously variable 20 c/s to 20 kc/s in 6 ranges. Accuracy : 10%. Output : fixed sync signal available at modulation terminal approximately 1V from 10 kΩ with less than 1.5%. distortion.
External a.c. :	20 c/s to 20 kc/s; accuracy of modulation depth and frequency limitations as for internal modulation. Input : less than 1.5 V r.m.s. into approximately 1 kΩ for nominal 100% a.m. (Depth adjustable at panel).
External d.c. :	Carrier level may be varied by external d.c.
Spurious f.m. on a.m. :	For 30% a.m. up to 1 kc/s modulation frequency. Bands A-G: Deviation less than 100 c/s +10 p.p.m. of carrier frequency. Band H : Deviation less than 50 p.p.m. of carrier frequency.
Spurious f.m. on c.w. :	Less than ±1 p.p.m. ±5 c/s of carrier frequency using mains operation.
Spurious a.m. on c.w. :	-65 dB relative to 30% modulation, in a 3 dB bandwidth of 650 c/s at carrier frequencies below 100 kc/s, and in 20 kc/s bandwidth above 100 kc/s.
Special modulation facilities :	May be used for manual or automatic frequency control, frequency modulation, phase modulation or sweeping. Operation above 100 kc/s only; requires up to 15 V d.c. or peak to peak, varying with frequency range. Will provide frequency excursions to at least the maxima shown in the table under electrical fine tuning. Between 100 kc/s and 320 kc/s (Band C) up to 5 x the tabulated sweep widths are obtainable; and between 320 kc/s and 1 Mc/s (Band D), up to 10 x these widths. The f.m. deviation available is half the maximum frequency shift for the band.
Modulation frequency range :	D.C. to 4 kc/s for carrier below 1 Mc/s. D.C. to 20 kc/s above 1 Mc/s.

Power supply

Mains operation (absolute limits) :	95V to 130V a.c.) 45 to 500 c/s 190V to 264V a.c.) load 15 VA approximately.
Battery operation (absolute limits) :	19V to 32V d.c. positive earth. current 0.3A maximum.

Dimensions and weight

Height	Width	Depth	Weight
11 in	18 in	14 in	50 lb
(28 cm)	(46 cm)	(36 cm)	(23 kg)

1.3 ACCESSORIES

Accessories supplied

6 dB Pad, type TM 5573/1; BNC plug to BNC socket.

Output Lead, type TM 4969/3; BNC plug to BNC plug.

Telephone Jack Plug, M.I. code 23421-612. For crystal calibrator output socket.

Trimming tool.

Hexagon wrench for removing r.f. box cover.

Mains lead (TF 2002 only) M.I. code 43122-017.

Mains socket (TF 2002R only) M.I. code 23424-151.

Accessories available

Output Lead, type TM 4726/152; BNC plug to Belling-lee L788FP plug.

Matching Pad, type TM 5569; 50 to 75 Ω, BNC socket to Belling-Lee L734/P plug.

Matching Pad, type TM 6599; 50 to 75 Ω, BNC plug to Burndept PR4E plug.

Dummy Aerial & D.C. Isolating Unit, type TM 6123; Input, BNC plug on 3 ft lead; Output, spring loaded terminals. For general receiver testing or for use on circuits with d.c. potentials up to 350 V.

Matching Transformer, type TM 5955/5; 50 Ω unbalanced to 300 Ω balanced, BNC socket to 4 mm terminals. Voltage ratio 1 : 0.5 + 0.5.

Rack Mounting Kit, type TM 8269; consists of brackets and covers to convert bench mounting model TF 2002 for mounting on a 19 inch rack.

2 OPERATION

2.1 PREPARATION FOR USE

In common with other apparatus employing semiconductor devices, the performance of the instrument may be affected if it is subjected to excessive temperatures. Therefore completely remove the plastic cover, if one is supplied over the case, and avoid using the instrument standing on, or close to, other equipment that is hot.

A.C. power supply

Normally the instrument is supplied with the mains selector switch set for supply voltages within the range 190 to 264 V. For input voltages in the range 95 to 130 V the selector switch must be pressed to the left. Do this by removing the plate securing the switch button, pressing the switch to the correct position, reversing the plate and replacing it to hold the switch in the new position. The mains fuse need not be replaced when changing the voltage range.

Attach a suitable 3 pin plug to the mains lead. Note the wires are colour coded as follows :-

Earth (ground)	- Green/Yellow
Neutral	- Black
Line (phase)	- Blue

In addition the earth wire carries a yellow sleeve bearing a green earth symbol and the neutral wire has a sleeve marked N.

Before connecting the supply press the MAINS/BATTERY switch to MAINS.

D.C. power supply

A d.c. supply of between 19 and 32 V, positive earthed, may be used. The current drain is about 300 mA.

Press the MAINS/BATTERY switch to the position marked BATTERY and connect the supply by leads to the positive and negative terminals at the rear of the instrument.

Rack mounting

Before inserting TF 2002R into a rack, slides or runners should be fitted to the rack to give support to the rear of the instrument as the four retaining screws cannot be relied upon to bear its full weight.

Meter zeroing

Before turning the SUPPLY switch ON check that the pointers of the meters are at their extreme left hand calibration mark (zero scale deflection). If necessary adjust the set screw at the top of each meter to bring the pointer to this position.

2.2 CONTROLS—SUPPLY AND TUNING

(1) SUPPLY switch. Turn clockwise to switch on.

(2) MAIN TUNING SCALE. The scale is engraved in a continuous zig-zag from 10 kc/s to 72 Mc/s.

(3) RANGE switch. 8 positions, lettered to correspond to the frequency bands.

(4) MAIN FREQUENCY CONTROL. The knob skirt carries a logging scale that enables the main tuning scale to be divided into 1000 divisions.

(5) SET SCALE CONTROL. Mechanical adjustment of main tuning scale for frequency standardization. A positive index locates the nominal centre position.

(6) INCREMENTAL FREQUENCY CONTROL & SCALE. Provides calibrated frequency shifts up to the limits indicated alongside the control.

(7) SET ZERO CONTROL. Sets the frequency of the zero calibration mark of the INCREMENTAL FREQUENCY control (6).

(8) SET ΔF CONTROL. Sets the sensitivity of the INCREMENTAL FREQUENCY control by calibration against the crystal calibrator.

(9) CRYSTAL CALIBRATOR SELECTOR. Selects the intervals at which marker pips are provided (1 Mc/s, 100 kc/s, 10 kc/s). An additional switch position gives a sharp null separated 1 kc/s from each 10 kc/s marker.

(10) CRYSTAL CALIBRATOR LEVEL CONTROL. Adjusts the a.f. level of the markers.

(11) CRYSTAL CALIBRATOR OUTPUT SOCKET. Phones jack, the internal loudspeaker is disconnected when a plug is inserted.

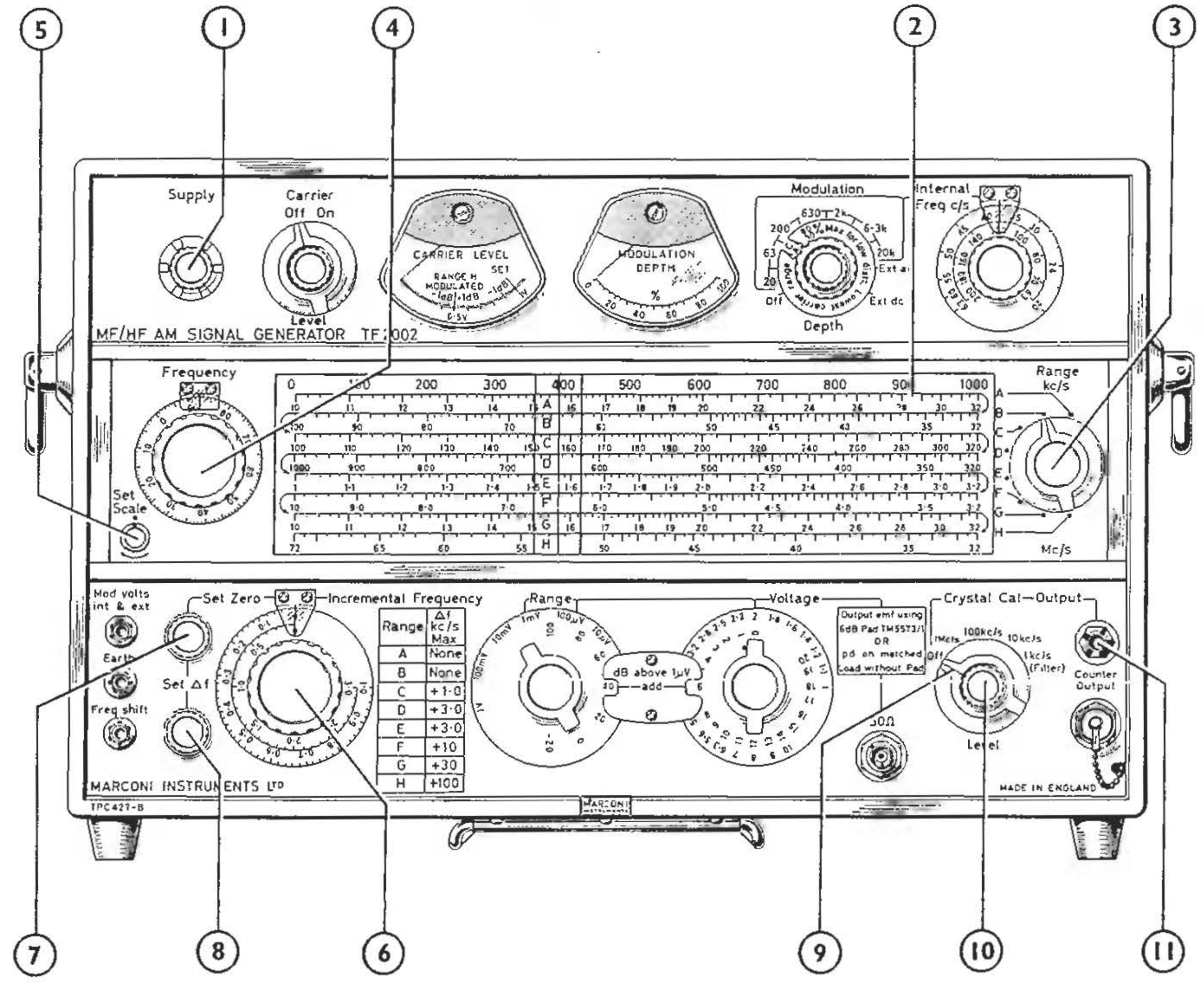


Fig. 2.1

2.3 CONTROLS—MODULATION AND OUTPUT

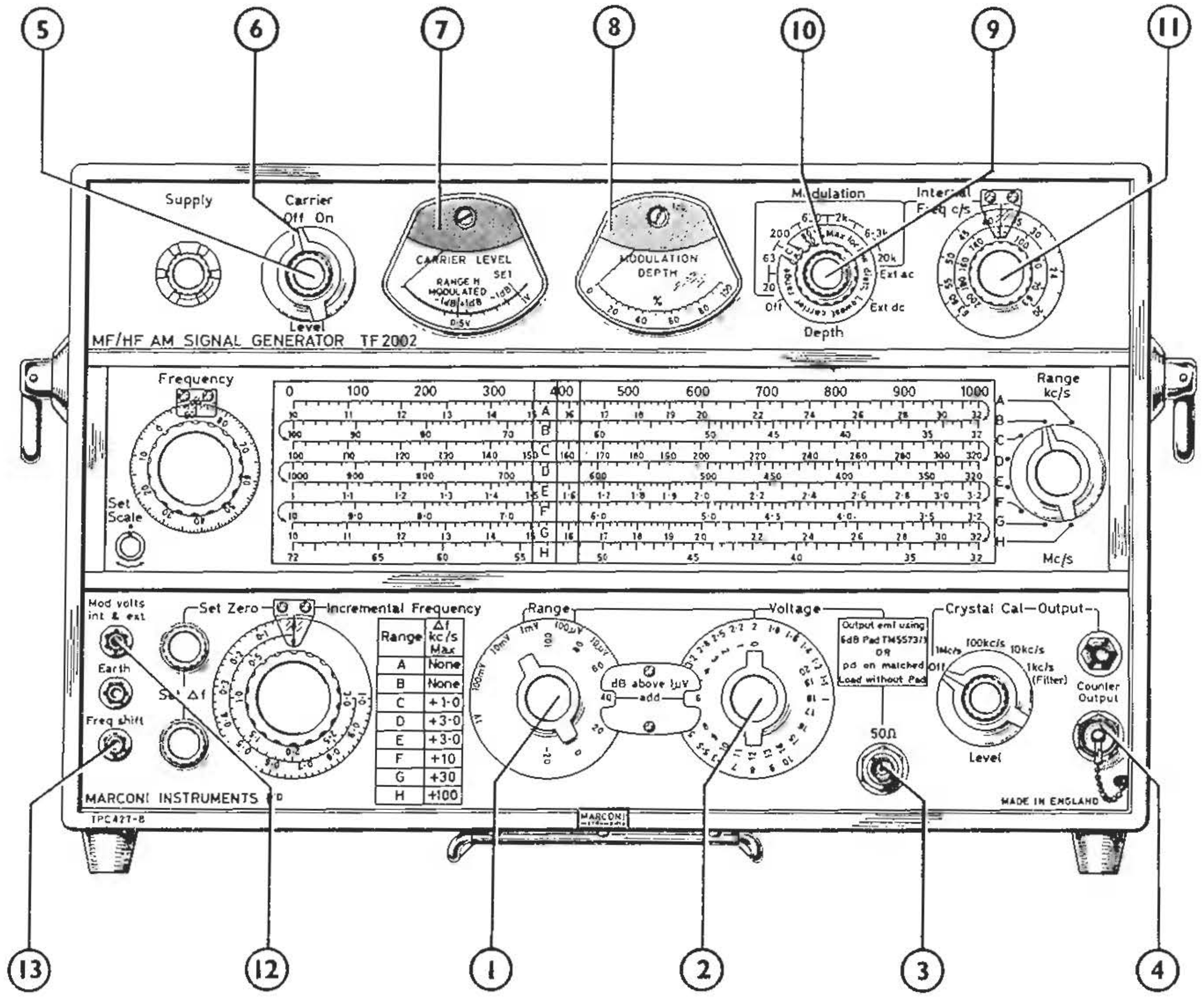


Fig. 2.2

(1) COARSE ATTENUATOR. Six 20dB steps.

(2) FINE ATTENUATOR. Twenty 1 dB steps.

(3) R.F. OUTPUT SOCKET. 50 Ω, BNC socket.

(4) COUNTER OUTPUT. 250 Ω source impedance BNC socket. Output is unmodulated and the level is not controlled; suitable for 50 Ω load.

(5) CARRIER LEVEL CONTROL. Sets carrier to standard level indicated by (7). May also be used to interpolate between attenuator steps.

(6) CARRIER SWITCH. For temporary interruptions of the carrier.

(7) CARRIER LEVEL METER. With the pointer at SET the attenuator dials are direct reading in dB above 1 μV. Meter also scaled in volts to assist interpolation.

(8) MODULATION METER. Scaled in percentage modulation depth. Readings are independent of setting of CARRIER LEVEL meter.

(9) MODULATION DEPTH CONTROL. Adjusts modulation depth of either internal or external modulating signals.

(10) MODULATION SELECTOR. Selects internal modulation frequency range or external modulation.

(11) MODULATION FREQUENCY CONTROL & SCALE. Continuously variable internal modulation frequency control.

(12) INTERNAL & EXTERNAL MODULATING SIGNAL TERMINAL. Acts as inlet for external modulating signals and output for internal modulating signals.

(13) FREQUENCY SHIFT TERMINAL. Inlet for controlling signal for frequency modulation or phase locking.

2.4 SETTING FREQUENCY

Turn the SUPPLY switch ON. Although the instrument operates within seconds of switching on, to obtain improved frequency stability allow a stabilizing period of ten minutes or more.

Using the RANGE switch, select the range that includes the desired carrier frequency. The ranges are :-

TABLE 2.1

A	10 - 32 kc/s	E	1 - 3.2 Mc/s
B	32 - 100 kc/s	F	3.2-10 Mc/s
C	100 - 320 kc/s	G	10 - 32 Mc/s
D	320 - 1000 kc/s	H	32 - 72 Mc/s

Turn the INCREMENTAL FREQUENCY control to zero and the SET SCALE control to its central index position. Adjust the main FREQUENCY control until the desired frequency is indicated on the main tuning scale.

Crystal calibrator

Marker points at 1 Mc/s, 100 kc/s or 10 kc/s intervals can be chosen by the CRYSTAL CALIBRATOR selector switch. The last position of the switch gives markers at 10 kc/s and brings into circuit a 1 kc/s rejection filter that gives a null 1 kc/s either side of each 10 kc/s point.

A loudspeaker is fitted to monitor the crystal calibrator markers, but if greater sensitivity is wanted or it is desired not to disturb other workers plug a pair of headphones into the CRYSTAL CALIBRATOR OUTPUT socket. Any headphones with an impedance in the range 50 Ω to 50 kΩ will be suitable. Switch the calibrator on by putting the CRYSTAL CALIBRATOR selector switch to a position that gives markers at convenient intervals. To avoid ambiguity due to the limitation of the main frequency scale use the following initial settings :-

TABLE 2.2

Frequency range	*Crystal calibrator selector setting*
A	10 kc/s
B	10 kc/s
C	10 kc/s
D	100 kc/s
E	100 kc/s
F	1 Mc/s
G	1 Mc/s
H	1 Mc/s

Tune the signal generator approximately to the marker frequency nearest to the desired carrier frequency and adjust the main FREQUENCY control for zero beat. Bring the beat note amplitude to a convenient level with the CRYSTAL CALIBRATOR LEVEL control (red knob).

If it is wished to standardize the scale, turn the SET SCALE control to bring the scale point corresponding to the crystal marker into coincidence with the cursor.

By switching the CRYSTAL CALIBRATOR selector switch in turn to 100 kc/s and 10 kc/s marker intervals, advancing the main FREQUENCY control and counting the marker pips as they are heard, it is possible to set the frequency of the signal generator to any 10 kc/s point.

Example : To tune the signal generator to a frequency of 4.23 Mc/s.

Switch to Range F (3.2-10 Mc/s), and with the main FREQUENCY control bring the cursor to 4 Mc/s on the main tuning scale. Plug in headphones and set the CRYSTAL CALIBRATOR selector to 1 Mc/s. Slightly adjust the main FREQUENCY control until a marker is heard. Reset the CRYSTAL CALIBRATOR selector to 100 kc/s and advance the main FREQUENCY control past the 4.0 Mc/s marker, then past the 4.1 Mc/s marker and stop at the 4.2 Mc/s marker. Reset the CRYSTAL CALIBRATOR selector to 10 kc/s and advance the main FREQUENCY control past the first two 10 kc/s markers (4.21 and 4.22 Mc/s) and stop at the zero beat point of the third.

Incremental tuning

Electrical fine tuning at frequencies above 100 kc/s can be obtained with the INCREMENTAL FREQUENCY control. This may be wanted, for example, for precise frequency setting or for accurate bandwidth measurements.

Tune the signal generator, with the aid of the crystal calibrator if necessary, to a frequency just lower than the range to be investigated. This frequency should be a multiple of 10 kc/s.

Two independent front panel preset controls are provided for setting up the INCREMENTAL FREQUENCY control; the SET ZERO control which gives a fine adjustment enabling the scale zero to be brought to a convenient point and the SET ΔF control which allows the control sensitivity to be set up against the crystal calibrator.

To adjust SET ZERO control. Set the CRYSTAL CALIBRATOR selector to 10 kc/s and either use the internal loudspeaker or plug headphones into the crystal calibrator OUTPUT socket. With the INCREMENTAL FREQUENCY dial at zero adjust the SET ZERO control for zero beat at the nearest 10 kc/s marker point.

To adjust the SET ΔF control: Turn the INCREMENTAL FREQUENCY control until the dial indicates the desired sensitivity and advance the SET ΔF control from its extreme counter-clockwise position (the control is a 5 turn potentiometer) until the wanted frequency shift, determined by the crystal calibrator, has been obtained. The principal settings are summarized in table 2.3.

TABLE 2.3

To set the INCREMENTAL FREQUENCY control for full-scale sensitivity of :

	1 kc/s	3 kc/s	10 kc/s	30 kc/s	100 kc/s
Set CRYSTAL CAL selector to :	1 kc/s (filter)	1 kc/s (filter)	10 kc/s	10 kc/s	100 kc/s
Set INCREMENTAL FREQUENCY dial to :	1.0 on scale 0-1	1.0 on scale 0-3	1.0 on scale 0-1	3.0 on scale 0-3	1.0 on scale 0-1
Advance SET ΔF control until	First 1 kc/s null point found	First 1 kc/s null point found	First 10 kc/s zero beat found	Third 10 kc/s zero beat found	First 100 kc/s zero beat found
Available on carrier ranges :	C, D, E, F, G, H	D, E, F, G, H	F, G, H	G, H	H

Whilst it is good practice to set the main FREQUENCY control before setting up the sensitivity of the INCREMENTAL FREQUENCY control, small subsequent adjustments of the main FREQUENCY control will not substantially affect the accuracy of frequency increments indicated on the INCREMENTAL FREQUENCY scale.

Example : To tune the signal generator to a frequency of 4.2352 Mc/s.

Tune to 4.23 Mc/s using the procedure described above. Set up the INCREMENTAL FREQUENCY control for full-scale sensitivity of 10 kc/s on the 0-1 scale. Turn the INCREMENTAL FREQUENCY control until the cursor is against the calibration mark 0.52 on the 0-1 scale.

Logging scale

For making incremental shifts on ranges A and B or for making greater shifts than available from the electrical fine tuning circuits on the other carrier ranges the logging scale may be used.

The 0-100 scale around the main FREQUENCY control relates to the top scale on the main tuning dial and thus allows each frequency range to be divided into nearly 1000 divisions.

Calibrate the logging scale over a convenient number of divisions corresponding to a frequency change of 10% or less, using the crystal calibrator. Although the frequency scale has a logarithmic type law, linear interpolation by means of the logging scale can be used for a first approximation.

External frequency shift

The FREQUENCY SHIFT terminal may be used to frequency modulate the Signal Generator, for making remote frequency shifts or for phase locking. There is a potential of -8.5V between the terminal and earth and the source impedance is 1 kΩ. The sense of operation is such that an increase of this potential (in the negative direction) increases the carrier frequency.

The limits of frequency shift that may be employed depend on the amount of non-linearity that is acceptable. In general, at the low frequency ends of the carrier ranges the maximum usable excursions are defined by the frequencies that are obtained when the INCREMENTAL FREQUENCY control is put at zero and at 10, with the SET ΔF control fully clockwise. This end-to-end range corresponds approximately to the table given on the instrument front panel and repeated in table 2.4.

TABLE 2.4

Range	Maximum shift from zero on INCREMENTAL FREQUENCY control		Peak deviation from mid-scale on INCREMENTAL FREQUENCY control
	internal (kc/s)	external (kc/s)	(kc/s)
C	+1	±2.5	±2.5
D	+3	±15	±15
E	+3	+3	±1.5
F	+10	+10	±5
G	+30	+30	±15
H	+100	+100	±50

On carrier ranges C and D greater shifts than are available from the internal shift circuits can be obtained by increasing the applied voltage. The voltage at the terminal should not fall outside the limits of -2V and -13V if severe non-linearity is to be avoided.

(a) Frequency modulation

Turn the SET ΔF control fully clockwise and put the INCREMENTAL FREQUENCY control to mid-scale. Feed the input signal to the FREQUENCY SHIFT terminal through a blocking capacitor. The input level required is about 1V r.m.s.

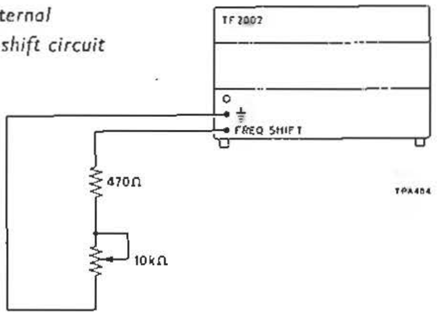
The available peak deviation for this input at the low frequency end of each carrier range is half the shift obtainable from the internal frequency shift circuits. Deviation increases with frequency and is 3.2 times greater at the high frequency end of each carrier range. On ranges C and D only it is permissible to increase the drive until up to five times (range C) or ten times (range D) the given peak deviation is obtained. An external deviation meter is required for monitoring.

(b) Frequency shift

Frequency shift may be achieved either by applying to the FREQUENCY SHIFT terminal a signal from a high impedance source or by shunting the terminal to earth with a resistor.

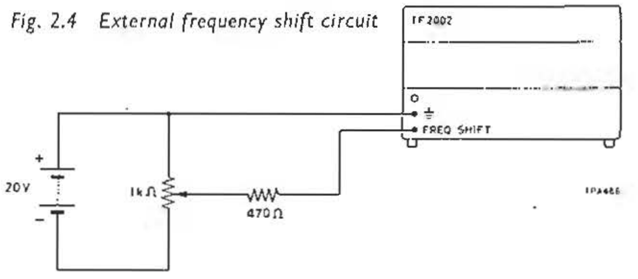
Using the passive method only downward shifts of frequency can be made. Turn both the SET ΔF and the INCREMENTAL FREQUENCY control fully clockwise. Connect a resistive network between the FREQUENCY SHIFT terminal and earth. About 3.5 kΩ will give the maximum shifts shown in the table engraved on the signal generator front panel.

Fig. 2.3 *Passive external frequency shift circuit*



Using an applied voltage, derived for example from a phase detector, shifts can be made in either direction. Turn the SET ΔF control fully clockwise. Put the INCREMENTAL FREQUENCY control to a position that will set the frequency to a convenient point within the available shift range, e.g. if it is wished to make upward and downward swings of frequency, up to the limit, the INCREMENTAL FREQUENCY control must be turned to mid-travel.

Fig. 2.4 *External frequency shift circuit*



Frequency shifts may be applied together with frequency modulation but take care to avoid over modulation. At the low frequency end of each carrier range the algebraic sum of the internally and externally applied shifts and the peak f.m. deviation must not take the frequency outside the limits given in table 2.4.

2.5 AMPLITUDE MODULATION

Internal

To obtain amplitude modulation by the internal oscillator :-

(1) Set the MODULATION selector to the position corresponding to the frequency range that includes the required modulating frequency. Each switch position that gives internal modulation falls between two figures, which indicate in c/s the frequency limits of the band obtained at that position.

(2) Turn the MODULATION FREQUENCY control so that the dial indicates the required frequency.

(3) Advance the MODULATION DEPTH control (red knob) until the MODULATION meter shows the required percentage modulation.

The maximum depth for low distortion modulation is limited when the modulation frequency exceeds a certain percentage of the carrier frequency. Thus the higher modulating frequency ranges are only usable at the higher carrier frequencies. Table 1.1, p. 7 gives the maximum modulating frequencies for 5% distortion at 80% modulation depth. The MODULATION selector knob also shows the lowest carrier ranges that can be used with low distortion for each modulating frequency range at 30% and 80% modulation depth.

The MODULATION selector also shows the lowest carrier ranges that can be used for each modulating frequency range at 30% and 80% modulation depth.

When switched to an internal modulation position the modulating signal is made available at the INTERNAL & EXTERNAL MODULATING SIGNAL terminal.

This may be used, for example, to synchronize an oscilloscope at the modulating frequency. The output level is about 1 V r.m.s. and the source impedance 10 kΩ.

External—capacitor coupled

Turn the MODULATION selector to EXT. A.C. Apply an a.c. modulating signal between the INTERNAL & EXTERNAL MODULATING SIGNAL terminal and earth. Set the MODULATION DEPTH control to give the required percentage modulation indicated on the MODULATION meter.

Note : The meter reading may be in error if non-sinusoidal modulating signals are used.

The input required is about 1 V r.m.s. into 1 kΩ for full modulation.

For high modulating frequencies the modulation depth limitations, given above for internal modulation, must be observed.

External—direct coupled

For low audio frequency modulation with very low phase shift, or sub-audio modulation, direct coupling to the modulating circuit is available. The facility may also be useful for remote level adjustment either manual or automatic.

Turn the MODULATION selector to EXT. D.C. In this position a standing potential of -2 V appears between the INTERNAL & EXTERNAL MODULATING SIGNAL terminal and earth. This may be used to control the carrier amplitude in two ways.

(1) By applying a direct or alternating potential from a high impedance source. The sensitivity is such that if the voltage is reduced from -2 V to -1 V the carrier level is reduced approximately to zero.

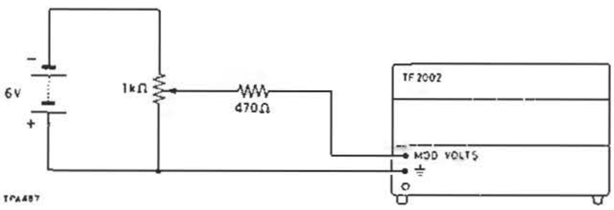


Fig. 2.5 External amplitude control circuit

(2) By shunting the terminals with a resistor, e.g., since the impedance between the terminals is 1 kΩ a 1 kΩ resistor in shunt will reduce the voltage to -1 V and so reduce the carrier level to zero.

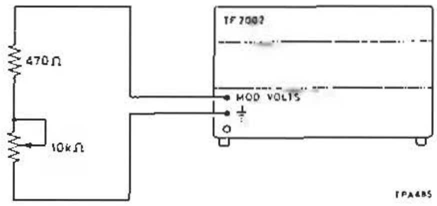


Fig. 2.6 Passive external amplitude control circuit

The MODULATION DEPTH control does not operate in this position but both CARRIER LEVEL and MODULATION meters are operative for slow changes and modulating frequencies above about 20 c/s, respectively.

CAUTION If an excessive drive voltage is applied to the INTERNAL & EXTERNAL MODULATING SIGNAL terminal the fuse 25 FS1, which is mounted on the wide band amplifier board, may blow.

For high modulating frequencies the modulation depth limitations, given above for internal modulation must be observed.

2.6 SETTING OUTPUT

Turn the CARRIER switch to ON and bring the pointer of the CARRIER LEVEL meter to the SET mark (1V) by adjusting the CARRIER LEVEL control.

Note: With a modulated carrier on range H the CARRIER LEVEL meter should be set to the RANGE H MODULATED mark (0.5V).

Adjustment of the CARRIER LEVEL control can be made without affecting the modulation depth. Turn the coarse and fine output attenuator controls until the desired output is indicated.

The output levels read from the attenuator dials are those which appear across a matching (50 Ω) load. The attenuators are also direct reading in terms of source e.m.f. when the output is fed through the 6 dB pad TM 5573/1. This pad is normally stowed at the rear of the instrument.

Expressed in dB referred to 1 μV

With the CARRIER LEVEL meter at SET, the output level is the sum of the readings of the dB scales of the coarse and fine attenuators. The fine attenuator allows level adjustment in 1 dB steps but intermediate outputs can be obtained by varying the setting of the CARRIER LEVEL control.

If the CARRIER LEVEL meter is at RANGE H MODULATED subtract 6 dB from the output indicated by the attenuator dials.

Expressed in volts

With the CARRIER LEVEL meter at 1 V the output voltage is indicated on the fine attenuator dial within the decade shown on the coarse attenuator dial. If the CARRIER LEVEL meter is at 0.5V the output is half that indicated by the attenuator dials.

Counter output

For applications such as operating a counter type frequency meter, an alternative output is provided. This output is unmodulated and the level is not affected by the CARRIER LEVEL control or the attenuators. The output e.m.f. is about 200mV and the source impedance 250Ω. It will satisfactorily operate equipment with a 50Ω input.

2.7 MISMATCHED LOADS

The r.f. output circuit of the signal generator should be regarded as a zero impedance voltage source in series with a resistance of 50 Ω. This is shown in Fig. 2.7 where :

E is the indicated source e.m.f.,

R_o is the source resistance,

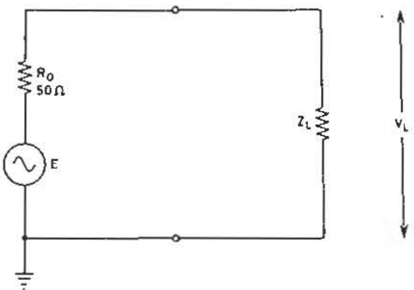


Fig. 2.7 Equivalent output circuit

Z_L is the external load impedance,

V_L, the voltage developed across the load is given by

$$V_L = E \frac{Z_L}{R_o + Z_L}$$

or, for purely resistive loads

$$V_L = E \frac{R_L}{R_o + R_L}$$

Table 2.5 shows the conversion factors for obtaining the load voltage from the indicated e.m.f. at different load impedances.

TABLE 2.5

	To find load voltage:		
Load ohms	*Multiply e.m.f. by*	*or*	*Subtract dB*
10	0.167		15.5
20	0.286		10.9
30	0.375		8.5
40	0.445		7.0
50	0.50		6.0
60	0.55		5.2
70	0.58		4.7
75	0.60		4.4
80	0.62		4.2
90	0.64		3.8
100	0.67		3.5
120	0.71		3.0
150	0.75		2.5
200	0.80		1.9
300	0.86		1.3
500	0.91		0.8
600	0.92		0.7
800	0.94		0.5
1000	0.95		0.4
2000	0.98		0.2
4000	0.99		0.1

When using a correctly matched, i.e., 50 Ω output lead its output end can be regarded as an extension to the output socket on the generator and wide variations of load impedance do not seriously affect the calculated load voltage obtained from table 2.5. Standing waves produced by the mismatched load can, for most purposes, be ignored.

For greatest accuracy - if the additional attenuation can be tolerated - use a 20 dB attenuator pad such as type TM 5573 between seriously mismatched loads and the output lead. This ensures that the lead is correctly terminated, and also attenuates any extraneous noise induced in the lead.

Matching to high impedance loads

To present a load that is greater than 50 Ω with a signal derived from a matched source, a resistor R_s is added in series with the generator output. The value of R_s is given by the difference between the load and the generator impedances, that is

$$R_s = R_L - R_o$$

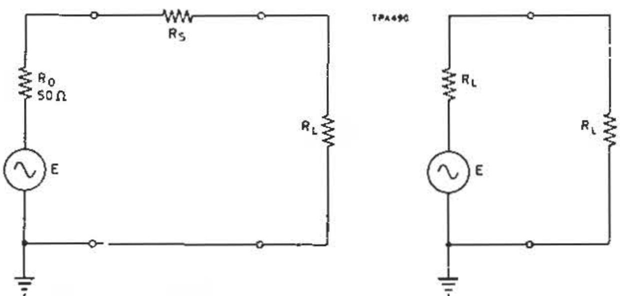


Fig. 2.8 High-impedance matching

The voltage across the load, V_L, is given by

$$V_L = \frac{E}{2}$$

For the special case of a 75 Ω load, matching pads types TM 5569 or TM 6599, are available as accessories and consist basically of a 25 Ω resistor with coaxial connectors for insertion in series with the output lead.

If the load impedance is substantially greater than 50Ω the maximum output may not be available with full modulation. See data summary p. 6.

Matching to low impedance loads

To present a load that is less than 50 Ω with a signal derived from a matched source, a resistor R_p is added in parallel with the generator output. The value of R_p is given by .

$$R_p = \frac{R_o R_L}{R_o - R_L}$$

The effective source e.m.f., is now different and is given by

$$E_1 = E \frac{R_p}{R_o + R_p}$$

and the voltage across the load, V_L, is given by

$$V_L = \frac{E_1}{2}$$

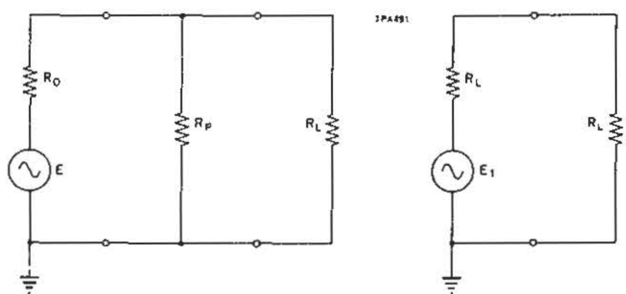


Fig. 2.9 Low-impedance matching

Matching to balanced loads

Equipment whose input circuit is in the form of a balanced winding can be fed from the generator by using two series resistors as shown in Fig. 2.10. This method makes use of the auto-transformer effect of the centre-tapped winding and is not suitable for resistive balanced loads.

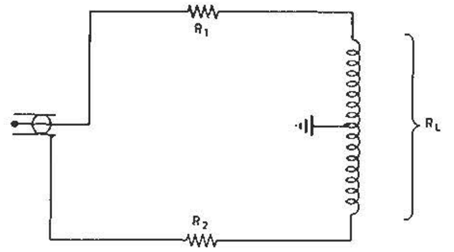


Fig. 2.10 Balanced load matching

The values of R_1 (for use in the centre conductor) and R_2 (for the earth lead) are given by

$$R_1 = \frac{R_L}{2} - 50$$

$$R_2 = \frac{R_L}{2}$$

For use with circuits that have a balanced impedance of 300 Ω a special matching unit is available as an accessory and may be ordered under the type number TM 5955/5. It incorporates a wide band transformer with a 1 : 4 impedance ratio and a resistive pad to give an overall ratio of 1 : 6. The voltage ratio is 1 : 0. 5 + 0. 5.

2.8 USE OF DUMMY AERIAL AND D.C. ISOLATOR

To use this dual-purpose unit as a dummy aerial connect the EMF/10 and E terminals to the receiver under test. The unit then simulates the impedance of a typical aerial for broadcast receivers in the l. f., m. f. and h. f. bands, and provides an out put voltage of one-tenth of that indicated by the attenuator dials.

To use it as a 350 V d. c. isolator connect the EMF/2 and E terminals to the equipment under test. This allows the signal generator output to be applied to circuits having a standing d. c. potential up to 350 V. The output voltage is half of that indicated by the attenuator dials.

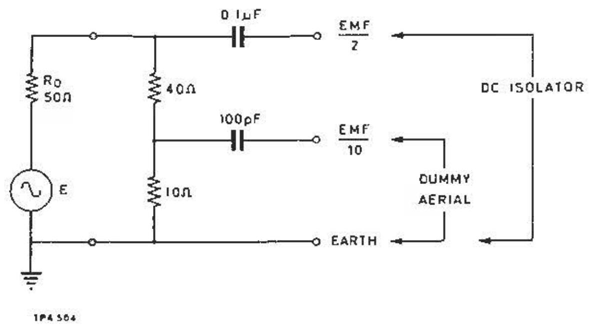


Fig. 2.11 Generator output using TM 6123

DECIBEL CONVERSION TABLE

Ratio Down			*Ratio Up*	
VOLTAGE	POWER	DECIBELS	VOLTAGE	POWER
1·0	1·0	**0**	1·0	1·0
·9886	·9772	**·1**	1·012	1·023
·9772	·9550	**·2**	1·023	1·047
·9661	·9333	**·3**	1·035	1·072
·9550	·9120	**·4**	1·047	1·096
·9441	·8913	**·5**	1·059	1·122
·9333	·8710	**·6**	1·072	1·148
·9226	·8511	**·7**	1·084	1·175
·9120	·8318	**·8**	1·096	1·202
·9016	·8128	**·9**	1·109	1·230
·8913	·7943	**1·0**	1·122	1·259
·8710	·7586	**1·2**	1·148	1·318
·8511	·7244	**1·4**	1·175	1·380
·8318	·6918	**1·6**	1·202	1·445
·8128	·6607	**1·8**	1·230	1·514
·7943	·6310	**2·0**	1·259	1·585
·7762	·6026	**2·2**	1·288	1·660
·7586	·5754	**2·4**	1·318	1·738
·7413	·5495	**2·6**	1·349	1·820
·7244	·5248	**2·8**	1·380	1·905
·7079	·5012	**3·0**	1·413	1·995
·6683	·4467	**3·5**	1·496	2·239
·6310	·3981	**4·0**	1·585	2·512
·5957	·3548	**4·5**	1·679	2·818
·5623	·3162	**5·0**	1·778	3·162
·5309	·2818	**5·5**	1·884	3·548
·5012	·2512	**6**	1·995	3·981
·4467	·1995	**7**	2·239	5·012
·3981	·1585	**8**	2·512	6·310
·3548	·1259	**9**	2·818	7·943
·3162	·1000	**10**	3·162	10·000
·2818	·07943	**11**	3·548	12·59
·2512	·06310	**12**	3·981	15·85
·2239	·05012	**13**	4·467	19·95
·1995	·03981	**14**	5·012	25·12
·1778	·03162	**15**	5·623	31·62

DECIBEL CONVERSION TABLE (continued)

Ratio Down			*Ratio Up*	
VOLTAGE	*POWER*	*DECIBELS*	*VOLTAGE*	*POWER*
·1585	·02512	**16**	6·310	39·81
·1413	·01995	**17**	7·079	50·12
·1259	·01585	**18**	7·943	63·10
·1122	·01259	**19**	8·913	79·43
·1000	·01000	**20**	10·000	100·00
·07943	$6{\cdot}310 \times 10^{-3}$	**22**	12·59	158·5
·06310	$3{\cdot}981 \times 10^{-3}$	**24**	15·85	251·2
·05012	$2{\cdot}512 \times 10^{-3}$	**26**	19·95	398·1
·03981	$1{\cdot}585 \times 10^{-3}$	**28**	25·12	631·0
·03162	$1{\cdot}000 \times 10^{-3}$	**30**	31·62	1,000
·02512	$6{\cdot}310 \times 10^{-4}$	**32**	39·81	$1{\cdot}585 \times 10^{3}$
·01995	$3{\cdot}981 \times 10^{-4}$	**34**	50·12	$2{\cdot}512 \times 10^{3}$
·01585	$2{\cdot}512 \times 10^{-4}$	**36**	63·10	$3{\cdot}981 \times 10^{3}$
·01259	$1{\cdot}585 \times 10^{-4}$	**38**	79·43	$6{\cdot}310 \times 10^{3}$
·01000	$1{\cdot}000 \times 10^{-4}$	**40**	100·00	$1{\cdot}000 \times 10^{4}$
$7{\cdot}943 \times 10^{-3}$	$6{\cdot}310 \times 10^{-5}$	**42**	125·9	$1{\cdot}585 \times 10^{4}$
$6{\cdot}310 \times 10^{-3}$	$3{\cdot}981 \times 10^{-5}$	**44**	158·5	$2{\cdot}512 \times 10^{4}$
$5{\cdot}012 \times 10^{-3}$	$2{\cdot}512 \times 10^{-5}$	**46**	199·5	$3{\cdot}981 \times 10^{4}$
$3{\cdot}981 \times 10^{-3}$	$1{\cdot}585 \times 10^{-5}$	**48**	251·2	$6{\cdot}310 \times 10^{4}$
$3{\cdot}162 \times 10^{-3}$	$1{\cdot}000 \times 10^{-5}$	**50**	316·2	$1{\cdot}000 \times 10^{5}$
$2{\cdot}512 \times 10^{-3}$	$6{\cdot}310 \times 10^{-6}$	**52**	398·1	$1{\cdot}585 \times 10^{5}$
$1{\cdot}995 \times 10^{-3}$	$3{\cdot}981 \times 10^{-6}$	**54**	501·2	$2{\cdot}512 \times 10^{5}$
$1{\cdot}585 \times 10^{-3}$	$2{\cdot}512 \times 10^{-6}$	**56**	631·0	$3{\cdot}981 \times 10^{5}$
$1{\cdot}259 \times 10^{-3}$	$1{\cdot}585 \times 10^{-6}$	**58**	794·3	$6{\cdot}310 \times 10^{5}$
$1{\cdot}000 \times 10^{-3}$	$1{\cdot}000 \times 10^{-6}$	**60**	1,000	$1{\cdot}000 \times 10^{6}$
$5{\cdot}623 \times 10^{-4}$	$3{\cdot}162 \times 10^{-7}$	**65**	$1{\cdot}778 \times 10^{3}$	$3{\cdot}162 \times 10^{6}$
$3{\cdot}162 \times 10^{-4}$	$1{\cdot}000 \times 10^{-7}$	**70**	$3{\cdot}162 \times 10^{3}$	$1{\cdot}000 \times 10^{7}$
$1{\cdot}778 \times 10^{-4}$	$3{\cdot}162 \times 10^{-8}$	**75**	$5{\cdot}623 \times 10^{3}$	$3{\cdot}162 \times 10^{7}$
$1{\cdot}000 \times 10^{-4}$	$1{\cdot}000 \times 10^{-8}$	**80**	$1{\cdot}000 \times 10^{4}$	$1{\cdot}000 \times 10^{8}$
$5{\cdot}623 \times 10^{-5}$	$3{\cdot}162 \times 10^{-9}$	**85**	$1{\cdot}778 \times 10^{4}$	$3{\cdot}162 \times 10^{8}$
$3{\cdot}162 \times 10^{-5}$	$1{\cdot}000 \times 10^{-9}$	**90**	$3{\cdot}162 \times 10^{4}$	$1{\cdot}000 \times 10^{9}$
$1{\cdot}000 \times 10^{-5}$	$1{\cdot}000 \times 10^{-10}$	**100**	$1{\cdot}000 \times 10^{5}$	$1{\cdot}000 \times 10^{10}$
$3{\cdot}162 \times 10^{-6}$	$1{\cdot}000 \times 10^{-11}$	**110**	$3{\cdot}162 \times 10^{5}$	$1{\cdot}000 \times 10^{11}$
$1{\cdot}000 \times 10^{-6}$	$1{\cdot}000 \times 10^{-12}$	**120**	$1{\cdot}000 \times 10^{6}$	$1{\cdot}000 \times 10^{12}$
$3{\cdot}162 \times 10^{-7}$	$1{\cdot}000 \times 10^{-13}$	**130**	$3{\cdot}162 \times 10^{6}$	$1{\cdot}000 \times 10^{13}$
$1{\cdot}000 \times 10^{-7}$	$1{\cdot}000 \times 10^{-14}$	**140**	$1{\cdot}000 \times 10^{7}$	$1{\cdot}000 \times 10^{14}$

3 TECHNICAL DESCRIPTION

Each of the printed boards and other sub assemblies in this instrument has been allocated a unit identification number in the sequence (1) to (29), which wherever practicable is marked upon it. The complete circuit reference for a component carries its unit number as a prefix, e.g., 6R15. Components that do not form part of any sub assembly carry the prefix 0, e.g., 0R6.

For convenience in this section and on the circuit diagrams, the circuit reference is abbreviated by dropping the prefix, except where there is risk of ambiguity.

3.1 CIRCUIT SUMMARY

Each carrier frequency range has completely separate oscillator and output filter circuits.

The oscillator and output filter circuits are tuned by ferrite cores moving inside the coil former. Each core derives the required linear motion from a tape attached to a drum. Alternate ranges are coupled to tapes wound in opposite way around the drum. The frequency of successive ranges thus alternately increases and decreases with one direction of rotation of the FRECUENCY control. This system which is illustrated in Fig. 3.1 allows a boustrophedon tuning scale to be used.

Range changing is carried out by the wafer switch SG. Power supplies to the oscillators are switched by SG4F and the low level oscillator output to the wide band amplifier by SG2F. SG7F and SG8F switch the wide band amplifier output to the output filter while SG6F switches the filtered signal to the attenuators.

All except the two lowest frequency oscillators have a voltage-controlled capacitive reactance. The controlling voltage is derived by a potential divider system from the 13.5 V regulated supply and is switched by SG3F.

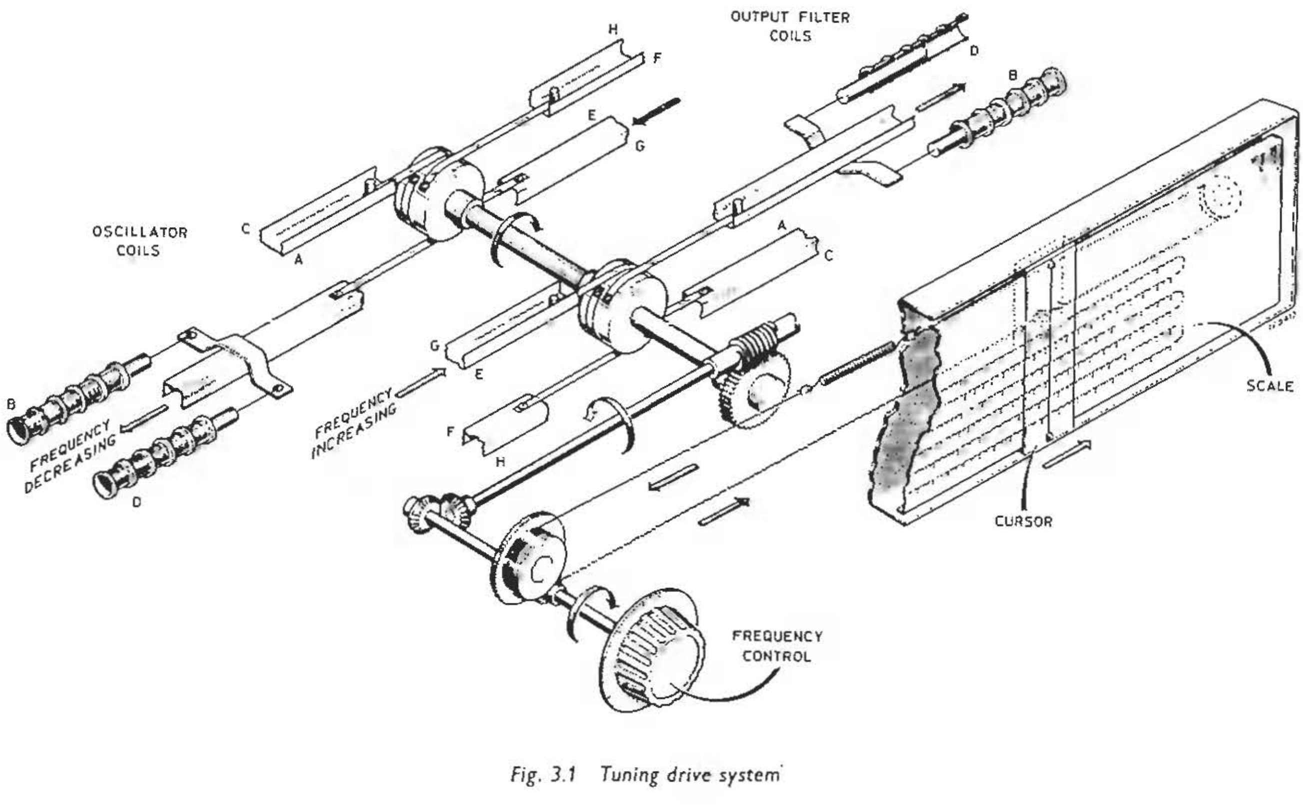


Fig. 3.1 Tuning drive system

Constant output level is maintained by sampling this level in the a.l.c. and envelope feedback circuit which produces an error signal to control the gain of the wide band amplifier. The modulating signal derived from the modulation oscillator, is effectively superimposed upon the error signal and modulates the r.f. signal in the wide band amplifier.

The crystal calibrator mixes the unmodulated r.f. signal with a pulse train derived from a 1 Mc/s crystal oscillator, giving audible marker points at closely spaced intervals.

3.2 R.F. OSCILLATORS

Circuit diagram - Fig. 5.2

All the oscillators are basically the same; a Colpitts circuit arranged to give a π output. In each instance tuning is carried out by variation of inductance. The

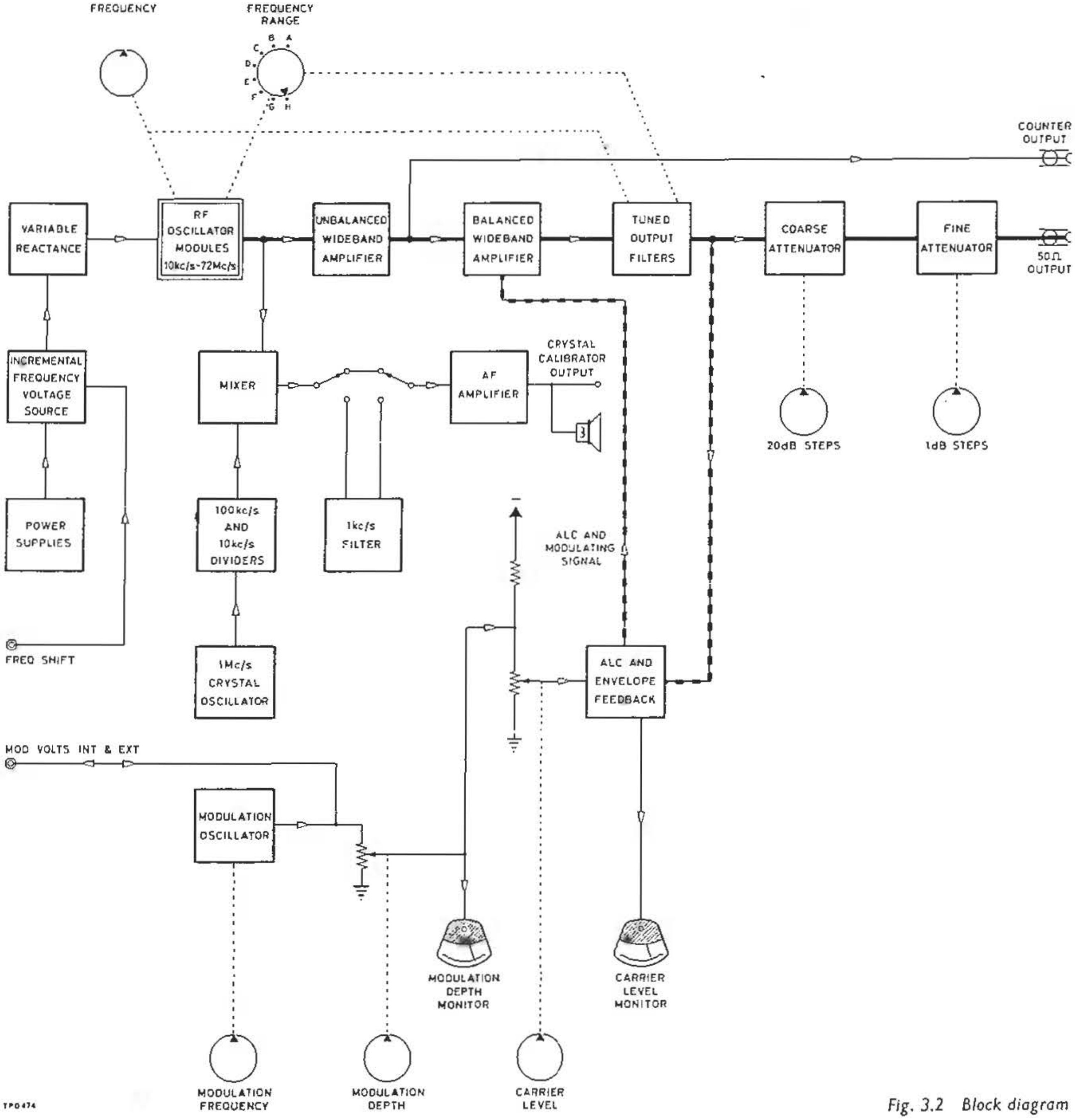


Fig. 3.2 Block diagram

principal inductor of each circuit has a ferrite core whose position in the coil is controlled by the main tuning drive. The series trimmer inductor sets the overall coverage of each range.

Considering the circuit for ranges A and B; a pnp transistor is used with the emitter tapped into the junction of C2 and C3; R5 serves as the collector return to supply whilst R3 shunts part of the tuned circuit to modify its Q.

Ranges C and D use a silicon npn transistor, VT2, as the oscillator. Its collector earth return has a resistance of approximately 50 Ω derived from the star terminating network; 25R1, 25R2, 25R3 at the input of the wide band amplifier. VT1 is a reactance transistor connected across the tuned circuit. As a result of the feedback components C2, R1 the transistor appears as a capacitive reactance whose value is controlled by the base voltage.

Ranges E and F are very similar to C and D the main difference being the use of a varactor, MR1, to obtain variable capacitive reactance for the incremental frequency facility.

For ranges G and H a buffer transistor VT2 is added. It is arranged in the common base configuration. Both VT1 and VT2 share the same base bias network; R2, R6, R3.

3.3 WIDE BAND AMPLIFIER

Circuit diagram - Fig. 5.3

Besides amplifying the signal from the low level delivered by the oscillators to the required output level, the wide band amplifier applies the modulating and level control signals.

The input signal from SG2F is applied to the star network R1, R2, R3 which acts as a splitter network passing part of the signal to the crystal calibrator and the remainder to the wide band amplifier, whilst providing a matching termination to both 50 Ω lines. VT1 and VT2 constitute a two stage unbalanced amplifier with negative feedback applied across R8 and the partially bypassed emitter resistor R6.

T1 acts as a phase splitter providing a balanced input to the bases of VT3 and VT4. To achieve the necessary bandwidth the transformer is wound bifilarly so that the winding represents constant impedance transmission line. The core is a toroid of ferrite material. Fig. 3.3 shows the transformer redrawn in transmission line form.

VT3 and VT4 form the first balanced amplifier stage and the output is coupled via the centre-tapped choke T2 into the second balanced stage VT5 and VT6. It is to this stage that the modulating drive signal, together with automatic level control, is applied. The modulating signal takes the form of a current drive applied to the emitter of VT5 and VT6 and results in a modulation depth of up to 55%.

The modulated signal is coupled to the output stage by T3 at low frequencies and by C12 and C13 at higher frequencies. Frequency compensated feedback is applied by R23 and R24 by using the inherent inductance of these wire wound resistors. No bias is applied to the output transistors VT7 and VT8 which for silicon transistors gives a quiescent condition beyond collector current cut-off. This class 'C' operation results in a transfer characteristic that has an initial region with no output (the cut-

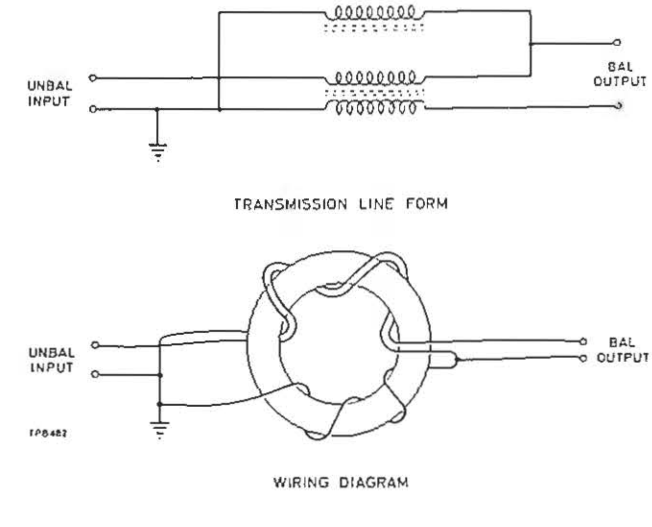


Fig. 3.3 25T1

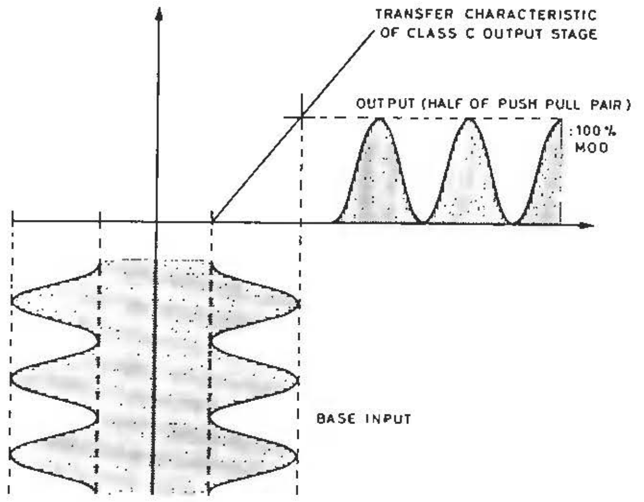


Fig. 3.4 Modulation deepening process

off condition) but is substantially linear for the remainder. The application of a modulated signal to a push-pull stage having this characteristic gives an effective increase

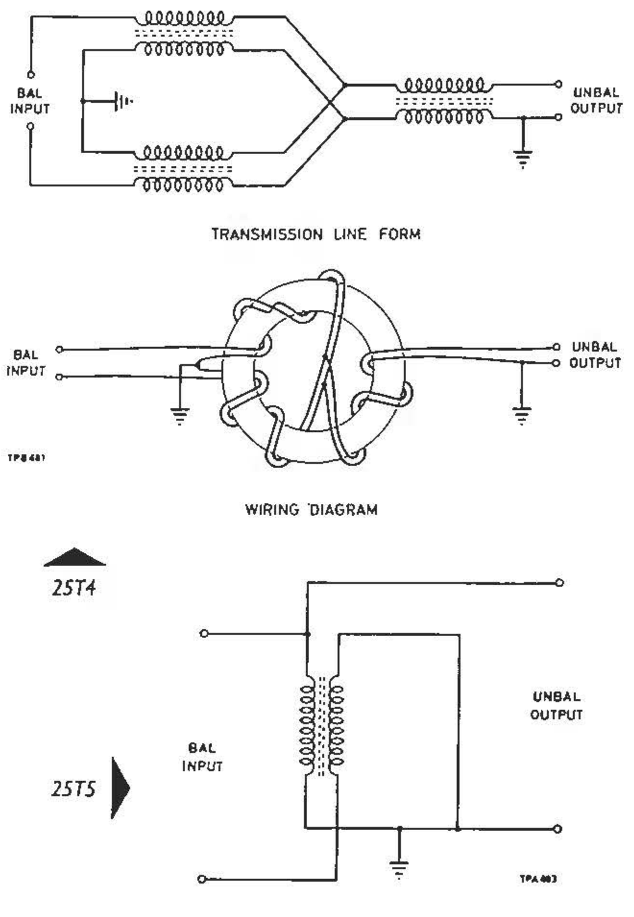


Fig. 3.5

of the modulation depth by a factor of approximately two. The process is shown in Fig. 3.4.

Two output transformers are used; T5 for ranges A to D and T4 for ranges E to H. Each has an impedance transformation of 1:4, balanced to unbalanced. Both transformers have bifilar windings which act as transmission lines, T5 being wound on a pot core and T4 on a ferrite toroid. Fig. 3.5 shows the transformers redrawn in transmission line form.

3.4 OUTPUT FILTERS

Circuit diagram - Fig. 5.4.

All the output filters are similar, consisting primarily of a π tuned circuit with a variable permeability inductor, coupled to the r.f. tuning drive.

Considering the range D circuit as typical, the π tuned filter is made up of the variable inductor L3 in series with the trimmer inductor L2, together with C1, C2 and C3. C4 and L1 constitute a high pass filter to reject the audio frequency modulation components that would otherwise pass the π output circuit.

3.5 A.L.C. AND ENVELOPE FEEDBACK

Circuit diagram - Fig. 5.5.

To maintain constant output level and to achieve minimum envelope distortion of a modulated carrier the circuit compares the output from the wide band amplifier with the modulating and carrier level control signals.

The audio drive plus the d.c. signal from the CARRIER LEVEL control form the instruction signal applied to VT1 which operates as a phase splitter giving balanced outputs to the emitter followers VT4 and VT5. R.F. derived from the output of the wide band amplifier is detected by the bridge, MR3, MR4, R30 and R31, which gives a balanced output with a d.c. component proportional to carrier level and an a.f. component proportional to the modulation depth. This is the reference signal.

These signals are added algebraically by the bridge R20, R22, R18 and R24 and the corresponding difference thus produced, is the composite d.c. + a.f. control signal that is used to modulate the wide band amplifier. The balanced control signal is applied between the bases of VT2 and VT6, which are connected as a long-tailed pair with VT3 acting as a constant current 'tail'. The unbalanced output from the long-tailed pair is fed to the high gain modulating amplifier consisting of VT7 and VT8 in a composite transistor circuit, whose collector currents are direct coupled to the emitter circuit of the modulating stage of the wide band amplifier, board (25). Localized feedback across VT7 and VT8 is provided by R36 in conjunction with C2 to C6 in order to modify the phase shift characteristics of the system and ensure stability.

A small forward bias current is applied to MR3 and MR4 which brings the diodes to the knee of their characteristic to ensure that minimum distortion is introduced into the modulated signal. These diodes are matched by corresponding diodes MR1 and MR2 on the opposite side of the comparator bridge so that the effect of any variation of diode characteristic with temperature is balanced out.

The CARRIER LEVEL meter is connected to the comparator bridge via two star networks; R12, R21, R23 and R13, R19, R25. This way it registers the difference between the control signal and the instruction signal, i.e., its reading corresponds to the reference signal and hence to the carrier level.

3.6 MODULATION OSCILLATOR AND DRIVE CIRCUITS

Circuit diagram - Fig. 5.6

Internal modulating signals from 20 c/s to 20 kc/s are provided by a Wien bridge oscillator with six switched frequency ranges.

Board (29) carries the Wien bridge capacitors C1 to C6 and C7 to C2 which are selected by SC1F and SC1B. The resistive arms of the bridge are provided principally by the ganged potentiometers 0RV1A and 0RV1B, the MODULATION FREQUENCY control.

The amplifier and amplitude stabilization components are carried on board (2). VT1 and VT2 are arranged in a high gain composite transistor circuit. This first stage is followed by VT4 acting as a conventional amplifier and by VT5 which is connected as an emitter follower to provide a low impedance output for driving the bridge. Positive feedback is taken from the junction of R16/R17 to the base of VT1 at a frequency that is determined by the Wien bridge.

Negative feedback from the emitter of VT5 is fed via R7 and RV1 to the emitter of VT2. The amount of feedback depends on the impedance of the network R4 and R5 shunted by the diodes MR1 and MR3. The output signal from the oscillator is fed to the peak detector VT3 which charges C4 to a potential proportional to the peak amplitude of the output signal. This potential controls the forward bias applied to MR3 and MR1, thus if the output signal increases, the impedance of the diodes increases, thereby increasing the feedback and maintaining the output level constant. The effective value of C4 is increased by shunting it by 29C13 on the three lower frequency ranges.

When the oscillator is not required, oscillation is stopped by shunting the output to earth by SC3F.

The modulating signal, either internal from the modulation oscillator or external, a.c. coupled, from TP3 is selected by SC2B and is applied to the MODULATION DEPTH control 0RV2. External, d.c. coupled, modulating signals bypass the MODULATION DEPTH control and are applied direct to the CARRIER LEVEL control. The CARRIER LEVEL control, 0RV3, determines both the amplitude of the modulating signal, and the level of the d.c. instruction signal and so the modulation depth does not vary with the setting of this control. Board (3) carries the modulation drive and monitoring circuits. VT1 acts as a current amplifier of the composite instruction signal which is applied to the a.l.c. and envelope feedback circuit.

Monitoring of the modulation depth is carried out by M2 which is fed by the diode bridge MR2, MR3, MR4 and MR5.

3.7 CRYSTAL CALIBRATOR

Circuit diagram - Fig. 5.7

The crystal calibrator circuitry is divided between two printed boards. Board ⑥ which is mounted inside the r.f. box carries all the circuits up to the mixer stage.

VT1 is arranged as a 1 Mc/s crystal oscillator in a Colpitts circuit. The output from VT1 follows two paths, to the pulse shaper and to the 100 kc/s storage counter. VT8 is operated in the class C mode and conducts for a part of the positive going half of the input sine wave. L1 resonates with stray capacitance at 50 Mc/s and tries to ring at that frequency whenever VT8 conducts. MR1 damps this oscillation so that only one negative going half cycle is produced. The output from VT8 consists of a train of 10 nsec pulses at a 1 Mc/s repetition rate which contains a spectrum of 1 Mc/s harmonics of approximately equal amplitude throughout the range of the signal generator.

When the CRYSTAL CAL switch is in the 100 kc/s position the 100 kc/s storage counter operates. The junction of C5 and RV1 is held at supply potential by the base-emitter diode action of VT8 and so VT2 conducts on the negative-going part of the waveform from the 1 Mc/s oscillator charging C6 in steps. VT3 and VT4 are cut off during the charging of C6, but after ten charging pulses have been received by C6, its potential has risen to a point sufficient to turn on VT3. A cumulative switching action through the regenerative coupling between VT3 and VT4 occurs, both transistors are rapidly turned on and C6 is discharged. When C6 is discharged a similar switching action turns both transistors off again. The counter produces an output pulse for every ten input pulses and so, for a 1 Mc/s input, gives a 100 kc/s pulse train output.

The 10 kc/s storage counter functions in an exactly similar manner with C9 being charged in steps through VT7, and VT5 and VT6 switching every ten steps.

A pulse shaper VT11 is included between the two counter circuits.

The r.f. carrier from the wideband amplifier is fed via VT10, acting as a buffer stage to the emitter of VT9. Mixing takes place in VT9 between the r.f. carrier and the 1 Mc/s, 100 kc/s and 10 kc/s pulse trains fed to the base. Audio frequency beat note signals are fed from the collector of VT9 via SA2 to the crystal calibrator amplifier which is carried on board ⑤.

In the 1 kc/s (filter) position of the CRYSTAL CAL switch, SA2 routes the a.f. signal via a 1 kc/s band-stop filter consisting of C9, C10 and L1. VT1, VT2 and VT3 are a conventional a.f. amplifier chain to bring the beat note up to a suitable level to drive headphones or the loudspeaker LS1. The frequency response of the crystal calibrator a.f. system is limited to 1.5 kc/s by the filters on boards ⑦ and ⑧ and by C6 in the collector circuit of VT2. The CRYSTAL CAL LEVEL control is a potentiometer 0RV8 interposed between VT1 and VT2. Its configuration has been chosen to ensure that VT2 is always fed from a high source impedance.

3.8 ATTENUATORS

Circuit diagram - Fig. 5.8.

Two stepped attenuators are fitted to the instrument, a coarse attenuator giving up to 120 dB loss in 20 dB steps and a fine attenuator giving up to 20 dB loss in 1 dB steps.

Both attenuators are of similar construction and operation. The pad sections consist of resistive π networks with a characteristic impedance of 50 Ω. The body is divided into compartments to achieve maximum shielding between pad sections. Pads are brought into circuit by microswitches housed inside the screened compartments and operated in pairs by leaf springs which are themselves actuated by cams on the control spindles.

The capacitors C1 to C5, in each attenuator, are fitted to compensate for the inductance of the micro switches when a pad is bypassed. If a pad is in circuit the capacitance of its components to the case is sufficient for this purpose.

The attenuators are fed via a coaxial line transformer 0T2 which at lower frequencies acts as a unity ratio current balancing transformer to ensure exactly equal currents through the inner and outer conductors of the cable from which it is wound. This avoids spurious voltages being developed as a result of current flowing in multiple earth paths. At higher frequencies the transformer acts as a normal coaxial line.

3.9 R.F. UNIT FILTERS

Circuit diagram - Fig. 5.9

All leads entering and leaving the r.f. unit are filtered by components carried on boards (7) and (8). These filters are all basically low-pass π-section types, with half sections on board (7) and full sections on board (8). Additional sections are switched into the modulation drive filter by SG11 and the incremental frequency drive filter by SG12 to give a lower cut-off frequency at the lower carrier frequency ranges.

3.10 POWER SUPPLIES

Circuit diagram - Fig. 5.10

Two stabilizer circuits are employed; the principal stabilizer comprising components mounted on and closely associated with board (1). The a.c. supply input is fed to 0T1, whose primary windings can be arranged in series or in parallel for supply voltages in the ranges 190-260 V or 95-130 V respectively. MR3 and MR4 constitute a full wave rectifier circuit.

If a d.c. supply is used it is fed to the input to the stabilizer via MR2, which gives protection from incorrect polarity.

0VT1 is the series control transistor and zener diode MR1 provides the reference voltage for comparison with the base voltage of VT2. Error signals from VT2 are amplified by VT1 and passed to the base of 0VT1.

For the oscillators, crystal calibrator buffer and incremental frequency drive circuits, an additional stabilizer is provided. The components are carried on board (4). Error signals developed between the base and emitter of VT5 are amplified by VT4 and fed to the base of the series control transistor VT3.

Also on board (4) is the incremental frequency drive circuit. This consists of a series of potential dividers which derive a voltage from the -13.5 V supply. The arrangement of controls is to ensure minimum interaction between them. 0RV9 is the tracking potentiometer, ganged to the tuning drive, and compensates for the variation of sensitivity with frequency of the oscillator reactor circuits. Switch sections SG1F and SG1B act as a reversing switch to take into account the reversal of direction that occurs at each end of the frequency scale.

0RV5 establishes the maximum positive excursions of the output voltage whilst 0RV7, in conjunction with 0RV9, establishes the maximum negative excursion. The final shift voltage is selected by 0RV6 and applied to the base of VT1. VT1 and VT2 are arranged as a composite transistor in the emitter follower configuration to present a high impedance to the drive circuit.

4 MAINTENANCE NOTES

This section is intended as a general guide to the servicing of the instrument. In case of difficulties, please contact our Service Division at the address on the back cover or your nearest Marconi Instruments representative.

This instrument uses semiconductor devices which, although having inherent long-term reliability and mechanical ruggedness, are susceptible to damage by overloading, reversed polarity, and excessive heat or radiation. Avoid hazards such as reversal of batteries, prolonged soldering, strong r.f. fields or other forms of radiation, use of insulation testers, or accidentally applied short circuits.

4.1 ACCESS TO COMPONENTS

To remove the outer case of the instrument extract the four coin-slotted 2 BA screws at the rear and slide the instrument forward out of the case. With the case off the following boards are accessible, (1), (2), (3), (4), (5), (29);. for the location of these boards and other components see Fig. 4.1 and Fig. 4.2.

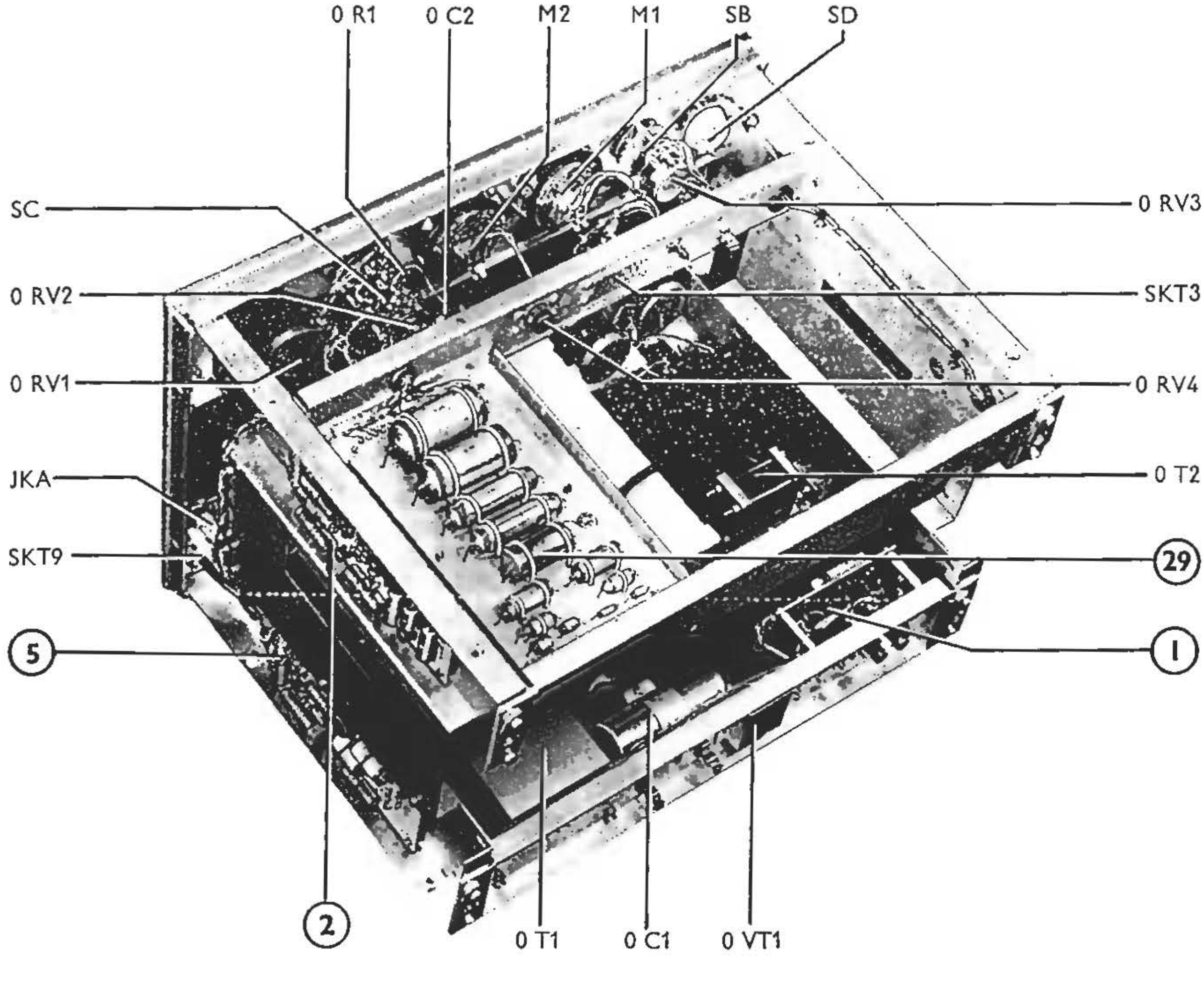


Fig. 4.1 Top view with r.f. unit removed

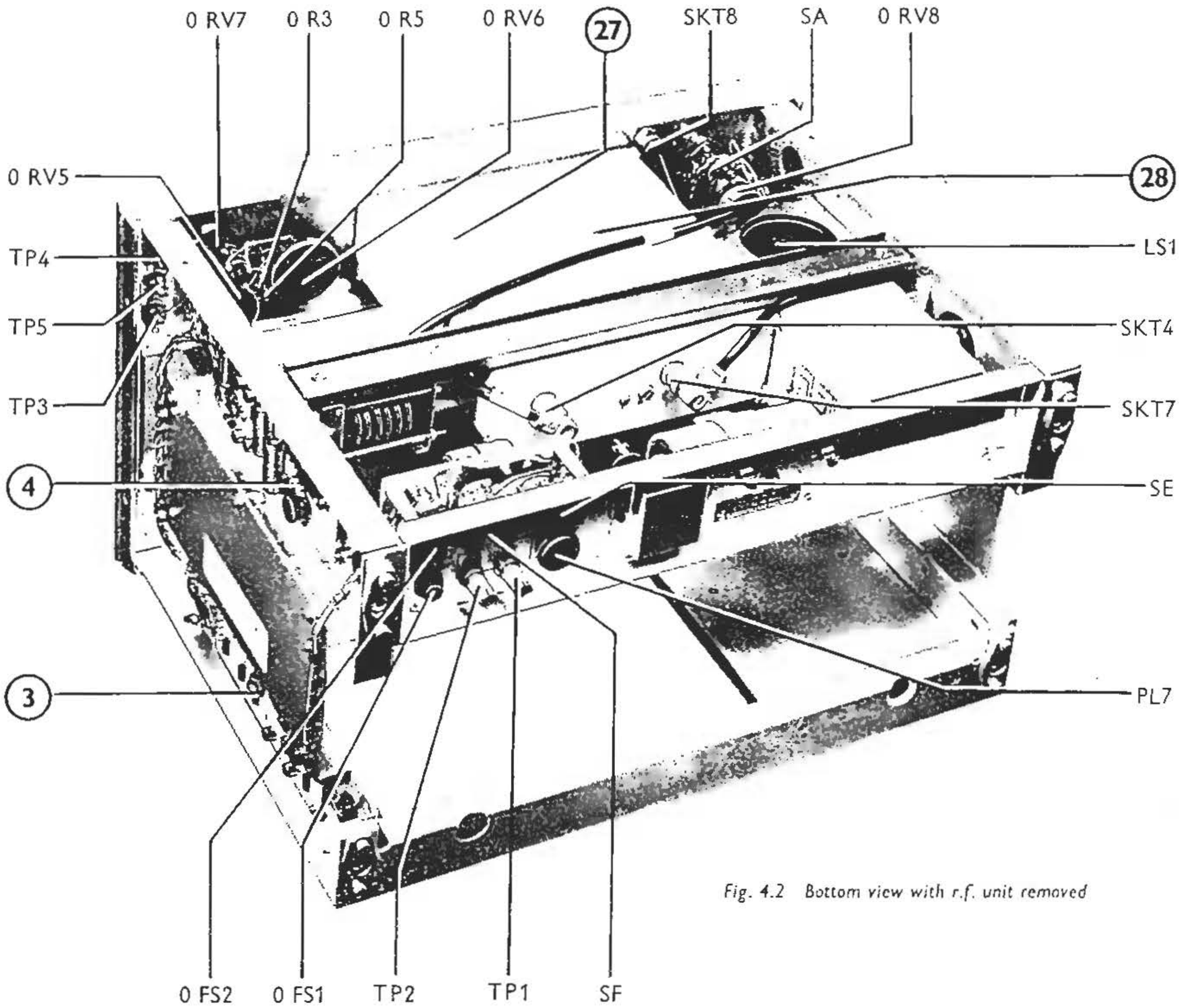


Fig. 4.2 Bottom view with r.f. unit removed

R.F. unit

Extract the eight 2 BA screws (four on each side) that secure the screening case of the r.f. unit to the side frames of the main chassis. Disconnect the 18-way plug and socket on the top cross member of the chassis, and disconnect the two BNC plugs and sockets on the front bulkhead of the r.f. unit.

Note : when reassembling, the lead from 0T2 connects with SKT10 and the lead from the COUNTER OUTPUT socket with SKT11. It will now be possible to slide the unit out through the rear of the instrument.

With the r.f. unit removed, switch wafer SG1 and the tracking potentiometer RV9 are accessible. If it is wanted, for test purposes, to operate the instrument with the r.f. unit removed and lying alongside the chassis, this is possible if the 18-way plug and socket are reconnected. The output can then be taken direct from SKT10.

To remove the r.f. unit cover, unscrew the two hexagon socket cap screws at the back of the unit and slide the cover off rearwards. A hexagon wrench to fit these screws is clipped to the top cross-rail of the chassis. When reassembling, to ensure a good r.f. seal, first

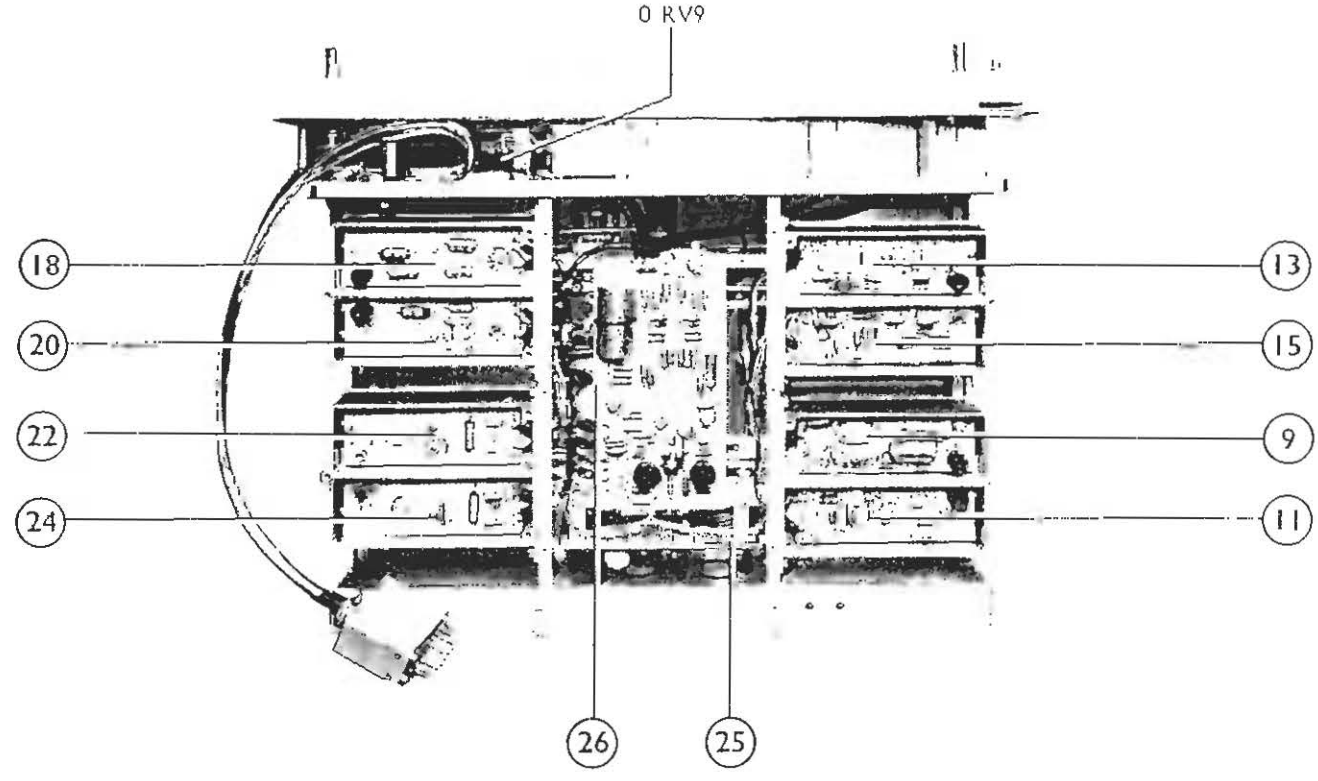


Fig. 4.3 R.F. unit with covers removed – top

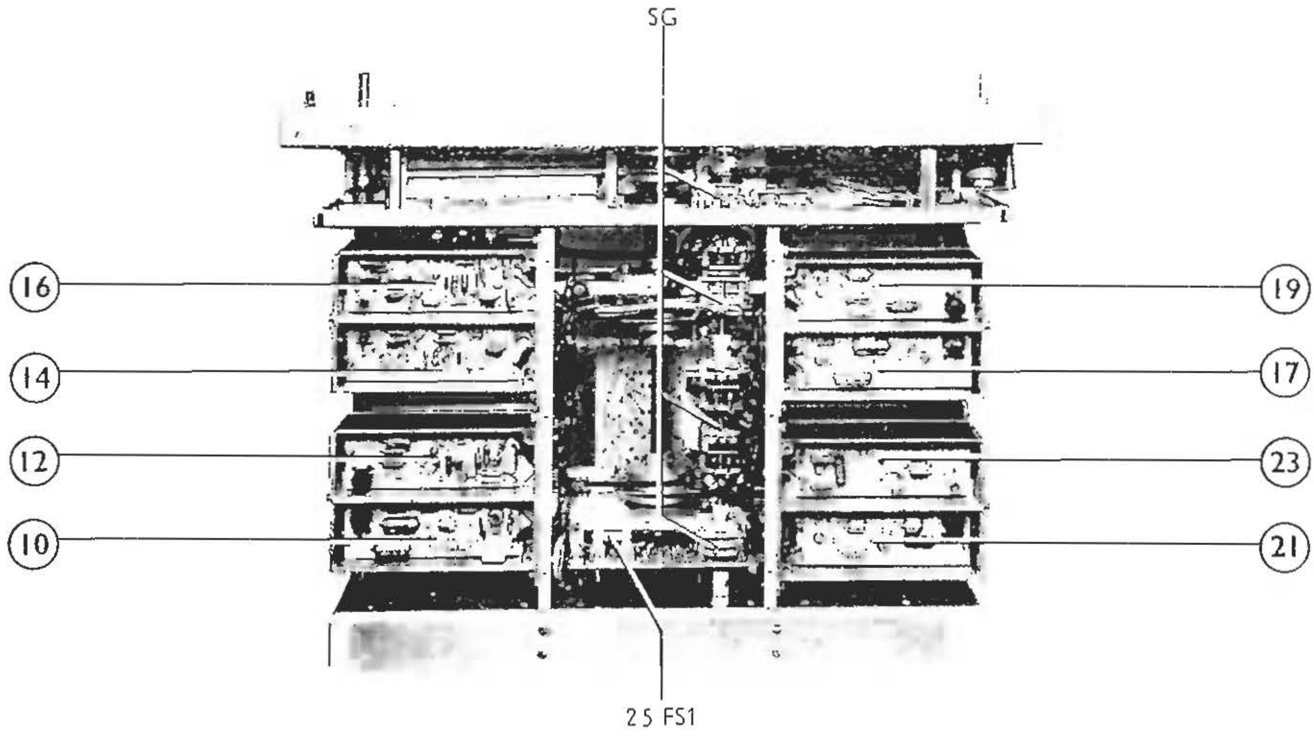


Fig. 4.4 R.F. unit with covers removed – bottom

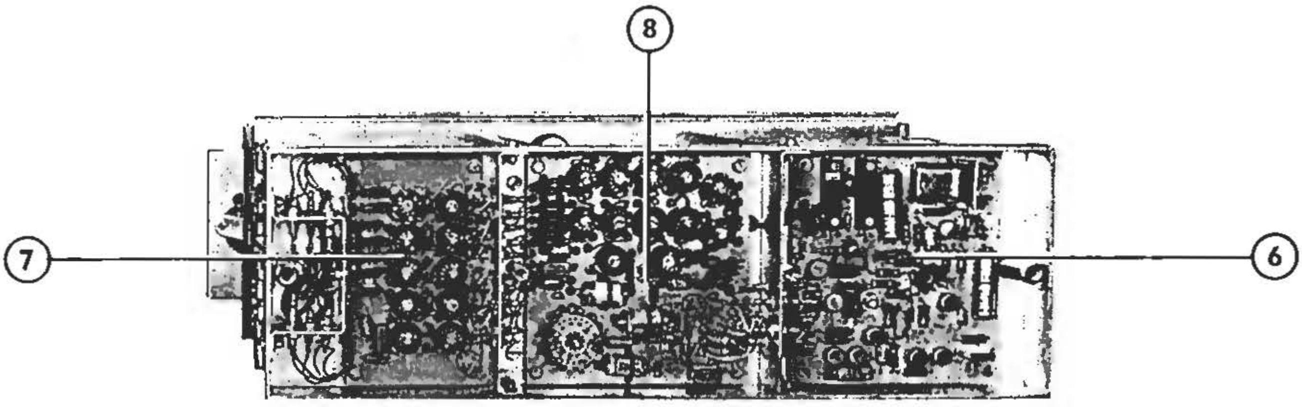


Fig. 4.5 R.F. unit with covers removed—rear

extract the sealing braid from the lip in the r.f. unit bulkhead and fit it to the r.f. unit cover before sliding the cover into place.

Boards (6), (7) and (8) : These boards are located at the rear of the r.f. unit; to reach them unscrew the two 6 BA screws that secure the rear cover plate and lift it off.

Boards (25) and (26) : These boards are, together with sections 2 to 10 of switch SG, mounted between the oscillators and the output filters. Extract the six 6 BA screws holding the upper central cover plate and remove it. Board (26) is then accessible. Remove the lower central cover plate in a similar manner to reveal sections 2 to 10 of switch SG and fuse FS1. To make measurements or tests on board (25) it must be removed. Do this as follows :-

(a) Turn the range switch to A.

(b) Slacken the 6 BA screws in the switch blade plastic coupling pieces on either side of switch sections SG9 and SG10 until the coupling pieces can be slid off the blade.

(c) With the r.f. unit right way up, extract the two 6 BA screws that secure the support brackets to the top edge of board (25)

(d) Withdraw the three 6 BA screws that secure the brackets on the bottom edge of board (25) to the main drive shaft rear support plate.

(e) The board may now be pulled out through the bottom of the r.f. unit. There is sufficient length of lead to allow the board to be pulled clear of the surrounding metalwork.

Oscillators and output filters; boards (9) to (24) : These boards are contained, in pairs, in cast boxes bolted on either side of the r.f. unit; oscillators on the left and output filters on the right. See Figs. 4.3 and 4.4. Access to the component side of each board may be obtained by removing the cover plate (secured by three 4 BA screws) on the outside face of the appropriate box. To get at the print side of a board remove the 6 BA screw and two 8 BA nuts that hold the board in position and swing it up and clear of the box.

Attenuator unit

To remove the attenuator unit :

(a) Remove the attenuator scale plate (held by two cruciform head screws).

(b) Slacken the hexagon socket set screws securing the attenuator knobs and pull them off.

(c) Unscrew the nut behind each attenuator knob.

(d) Disconnect the BNC plugs and sockets at the rear of the attenuator.

(e) If the r.f. unit has already been removed from the chassis, the attenuator unit will be freed by extracting the two 4 BA screws that secure it to the bottom cross rail of the chassis.

(f) If the r.f. unit has not been taken out the bottom cross rail of the chassis must be removed by removing the screws from the corners of boards (4) and (5), lifting them away and extracting the two 4 BA screws at each end that secure the bottom cross rail of the chassis.

To open the attenuator unit :

(a) Slacken the four 6 BA screws in slots at the rear of the sides of the attenuator unit.

(b) Withdraw the 2 BA and four 6 BA screws at the rear of the attenuator, and pull off the rear attenuator-cover.

(c) Remove the nuts securing the control spindles at the front of the attenuator unit and lift the coarse and fine attenuators out of the case.

(d) Access to the individual attenuator components can be obtained by removing the twenty two 8 BA screws that secure the L-shaped cover plate of each attenuator.

4.2 FUSES

Three fuses are fitted to the instrument; two, 0FS1 and 0FS2, protect the power supply circuits and are accessible at the rear of the instrument. The third, 25FS1, is to protect the output transistors of the wide band amplifier from the effects of excessive drive. It may blow, if, e.g., the CARRIER LEVEL meter is set above the -6 dB point, on range H with modulation present, or if excessive level of external d.c. modulation is applied.

All the fuses are standard 20 mm x 5 mm components. Suitable replacements are indicated in table 4.1.

TABLE 4.1

Fuse	Rating	Type
0FS1	160 mA, time-lag	Beswick TDC123/160 mA
0FS2	500 mA, time-lag	Beswick TDC123/500 mA
25FS1	100 mA, quick-acting	Beswick TDC13/100 mA or Bulgin F271

4.3 CIRCUIT VOLTAGES

The voltages given on the circuit diagrams are those which may be expected on a typical TF 2002, at a mains input of 240 V, using a 20 kΩ/V meter. All are negative with respect to the positive supply line.

The controls were set to the following positions :-

SUPPLY switch	ON
CARRIER switch	ON
RANGE switch	
boards (9) to (16)	the range corresponding to the board
board (25)	G
all other boards	A
FREQUENCY	500 on logging scale
CARRIER LEVEL	
all boards except (16)	SET
board (16)	RANGE H MODULATED
ATTENUATORS	90 dBμV
CRYSTAL CAL selector	10 kc/s
CRYSTAL CAL LEVEL control	fully counter-clockwise
INCREMENTAL FREQUENCY control	scale zero
SET ZERO control	mid travel
SET ΔF control	fully clockwise
MODULATION	100 c/s, internal, 80%

4.4 WAVEFORMS

The waveforms illustrated below were taken on a typical TF 2002 using a Marconi Instruments Oscilloscope type TF 2200. In each case the measurement was taken between the point indicated and earth.

Crystal calibrator—board (6)

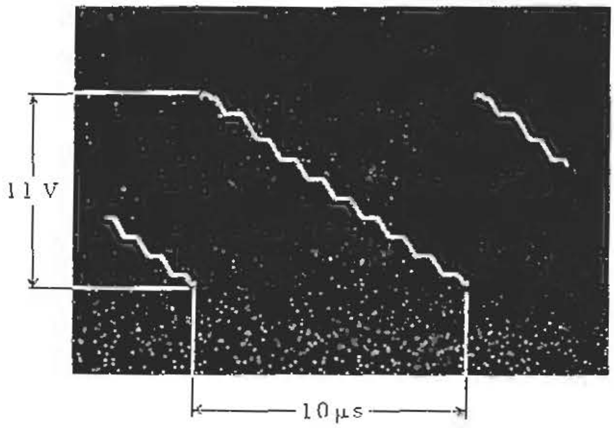


Fig. 4.6 Junction C6 and VT3 emitter, crystal calibrator selector at 10 kc/s

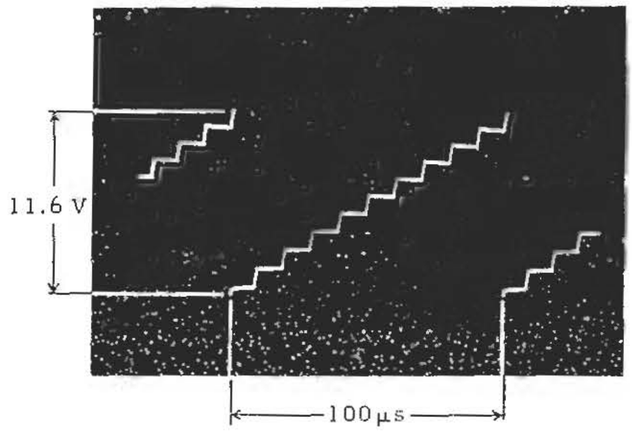


Fig. 4.7 Junction C9 and VT6 emitter, crystal calibrator selector at 10 kc/s

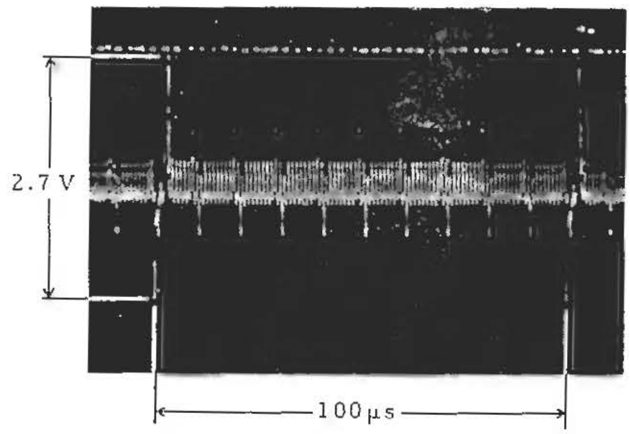


Fig. 4.8 VT9 base, crystal calibrator selector at 10 kc/s

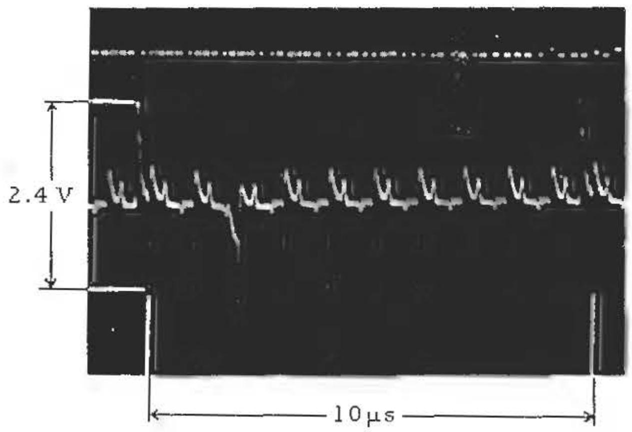


Fig. 4.9 VT9 base, crystal calibrator selector at 10 kc/s

Wide band amplifier—board (25)

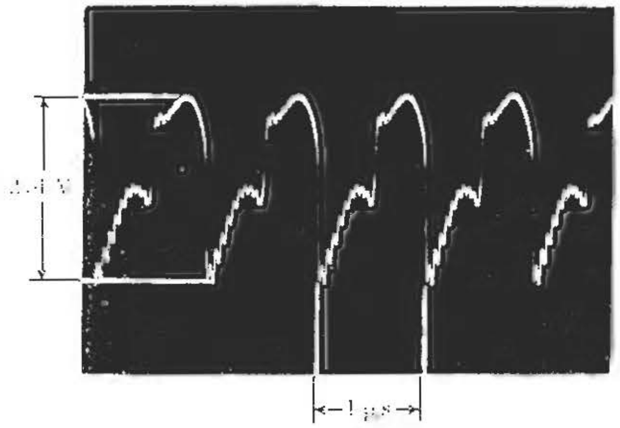


Fig. 4.10 VT7 base, carrier frequency 1 Mc s, no modulation

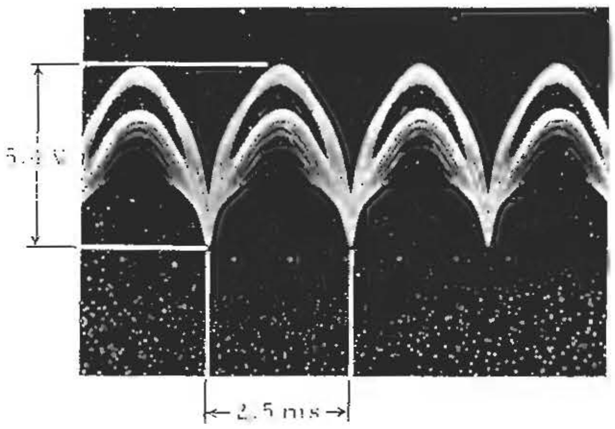


Fig. 4.11 VT7, base carrier frequency 1 Mc s, 100 % modulation at 400 c s

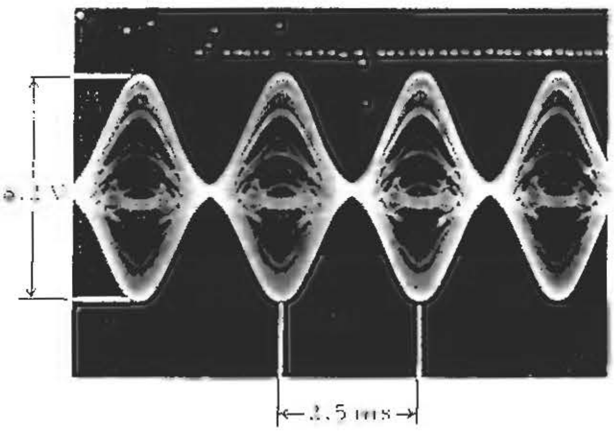


Fig. 4.12 VT7 collector, carrier frequency 1 Mc s

A.L.C. and envelope feedback—board (26)

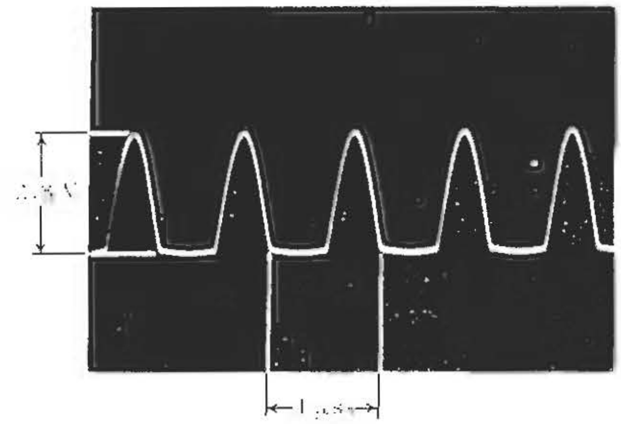


Fig. 4.13 Junction R30 and MR3, carrier frequency 1 Mc s, carrier level meter set to 0 dB

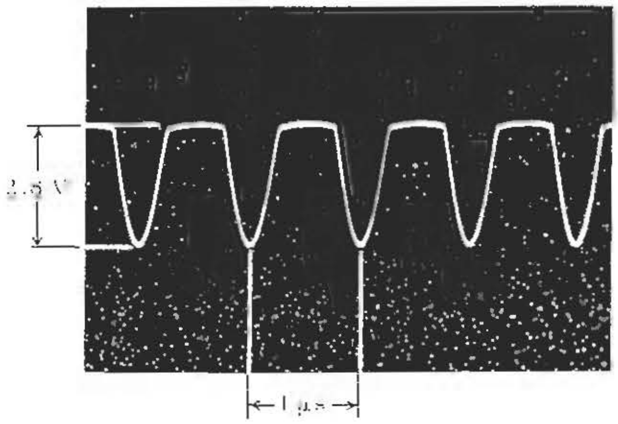


Fig. 4.14 Junction R31 and MR4, carrier frequency 1 Mc s, carrier level meter set to 0 dB

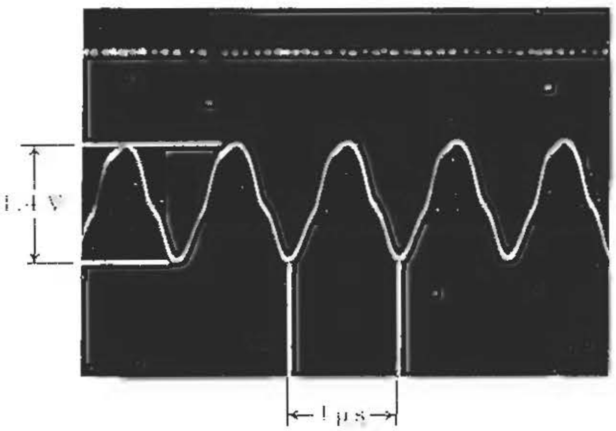


Fig. 4.15 VT3 collector, carrier frequency 1 Mc s, carrier level meter set to 0 JB

4.5 CLEANING ROTARY SWITCHES

If it is necessary to clean the contacts of any of the rotary switches, this should be done with benzine (not carbon tetrachloride), and the contacts should afterwards be wiped with a suitable lubricant, such as Electrolube No. 1, manufactured by Electrolube Ltd., Slough, Bucks., England.

4.6 PRESET CONTROLS

Power supplies

(a) Connect a voltmeter between tag 3 of board ① and earth, with positive to earth. Apply a 230 V a.c. input and adjust 1RV2 until the meter reads 15 V.

(b) Connect a differential voltmeter such as Marconi Instruments TF 1377 between tag 3 of board ① and earth. Apply the mains input via a rotary auto-transformer and swing the voltage from 190-260 V. Note the variation of the voltage at tag 3; if this exceeds 10 mV adjust 1RV1 and repeat the test until minimum variation is achieved.

Adjustment of 1RV1 has some interaction on the setting of 1RV2 and if a substantial alteration has been made recheck procedure (a), above.

(c) Connect a voltmeter between tag 9 of board ④ and earth, with positive to earth. Adjust 4RV1 until the voltmeter reads 13.5 V ±100 mV.

(d) Connect a differential voltmeter such as Marconi Instruments TF 1377 between tag 9 of board ④ and earth. Place the whole instrument in a constant temperature enclosure and raise its temperature from 20 to 55 °C. Note the voltage variation at tag 9 over this temperature range: if this exceeds 4 mV 4 RV2 must be adjusted.

Adjust 4RV2 with the instrument at 55 °C so as to slightly more than compensate for the voltage change that occurred during the temperature rise. Cool the instrument back to 20 °C and again note the voltage change. Repeat the procedure until a variation of 4 mV or less is obtained over the temperature range.

Finally check that the absolute value of the voltage is still 13.5 V ±100 mV.

R.F. oscillators

To check and adjust the frequency accuracy of the r.f. oscillators connect a frequency meter, preferably a counter such as Marconi Instruments type TF 2401 or TF 1417 series together with TF 2400 range extension unit, to the COUNTER OUTPUT socket. Tune the generator to the high frequency end of each range, in turn, and adjust the preset inductor of the appropriate oscillator to bring the oscillator frequency to the scale reading. After adjusting the high frequency end of a range, retune to the low frequency end, and check that the oscillator frequency is within 1% of the scale calibration. To adjust the scale coverage at this end alter the value of C5 on boards ⑨, ⑩, ⑬, ⑭ or C6 on boards ⑪, ⑫, ⑮, ⑯ by a small amount.

A.L.C. and envelope feedback circuit

For all the adjustments in this section tune the generator to 1 Mc/s on range E.

(a) To make a preliminary setting up of 26RV1 connect a voltmeter between TP6 and TP7. With the CARRIER LEVEL control fully counter clockwise adjust 26RV1 for zero reading on the voltmeter.

(b) Connect an oscilloscope, such as Marconi Instruments TF 2200 between tag 7 of board ㉖ and earth. The oscilloscope should be set to its most sensitive Y amplifier range (50 mV/cm). With the CARRIER LEVEL control fully counter clockwise adjust 26RV2 to the point, near to zero output, where the r.f. level changes value sharply. This corresponds to an r.f. output level across a 50 Ω load, of about 15 mV.

(c) Connect an accurate r.f. voltmeter across the r.f. output socket terminated with a 50 Ω load. Advance the CARRIER LEVEL control until the voltmeter reads 1 V. Adjust 0RV4 until the CARRIER LEVEL meter reads exactly 1 V.

(d) Set the generator up to give a signal modulated at 1 kc/s by the internal oscillator. View the modulated waveform on an oscilloscope, such as Marconi Instruments type TF 2200, connected to pin 7 of board (26) and earth. With the CARRIER LEVEL meter reading 1 V adjust the MODULATION DEPTH control until the waveform is seen to be modulated to 100%. Reduce the CARRIER LEVEL meter reading to 0.5 V by means of the CARRIER LEVEL control. If the modulation depth has changed restore it to 100% by adjusting 26RV1. Bring the carrier level to 1 V again and reset the modulation depth to 100%, if it has altered, using the modulation depth control. Repeat this procedure until there is no change of modulation depth between 1 V and 0.5 V carrier levels.

Modulation

(a) Turn the MODULATION FREQUENCY control fully clockwise. Adjust 2RV1 so that it is just sufficiently advanced for oscillation to start when the MODULATION selector is turned from the range 2 kc/s - 6.3 kc/s to the range 6.3 kc/s - 20 kc/s.

(b) Connect a frequency meter, such as Marconi Instruments counter type TF 2401 or TF 1417 series, to the output of the a.f. oscillator tag 9 of board (2). Set the MODULATION selector to the frequency range 200 c/s -630 c/s and adjust the MODULATION FREQUENCY control, 0RV1, until the frequency is 200 c/s. Slacken the set screws securing the scale to the spindle of 0RV1 and turn the scale until the cursor is at the 20 mark. Tighten the set screws and advance the MODULATION FREQUENCY control so that the dial reads 63. Adjust 2RV2 so that the frequency is 630 c/s. Recheck the setting of the scale at 200 c/s.

(c) Tune the signal generator to 1 Mc/s, range E and set the modulation controls to give internal modulation at 400 c/s. Connect an oscilloscope, such as Marconi Instruments type TF 2200 to the r.f. output socket and advance the MODULATION DEPTH control until the modulation depth, as measured on the oscilloscope, is 50%. Percentage modulation is given by the formula :

$$M\ (\%) = \frac{D\ max - D\ min}{D\ max + D\ min} \times 100,$$

where D max is the peak to peak amplitude and D min the trough to trough amplitude of the oscilloscope display. Finally adjust 3RV1 until the MODULATION DEPTH meter indicates 50%.

Note : If it is suspected that the a.l.c. and envelope feedback circuits are out of adjustment, complete the checks given in the preceding section before adjusting 3RV1.

Crystal calibrator

(a) To check and adjust the crystal oscillator connect a counter type frequency meter, such as Marconi Instruments type TF 2401 or TF 1417 series across 6R3 and turn the CRYSTAL CALIBRATOR selector to Mc/s. Adjust the trimmer capacitor 6C1 until the frequency indicated by the counter is exactly 1 Mc/s.

(b) It is possible to check the operation of the 100 kc/s and 10 kc/s storage counters without the aid of other test apparatus.

Tune the signal generator to 100 kc/s and turn the CRYSTAL CALIBRATOR selector to 100 kc/s. Using either headphones or the internal loudspeaker, slightly adjust the FREQUENCY control until a marker beat frequency is heard and brought to zero. If this occurs within 99 and 101 kc/s the counter is working correctly. If the marker point is substantially away from 100 kc/s, the counter is dividing by 9 or 11 and must be adjusted. Adjust 6RV1 so that it is in the centre of its range of travel over which the counter divides by 10. To find this centre of range, allowing for electrical backlash:

(1) Start with the storage counter dividing by 9 or 11 and begin counting the turns made by 6RV1 from the point where the circuit begins to divide by 10. Continue turning 6RV1 until the circuit stops dividing by 10. Note the number of turns made so far (n).

(2) Turn 6RV1 back until the counter again begins to divide by 10, noting the number of turns made in the reverse direction (m).

(3) Continue turning 6RV1 back for $\frac{n - m}{2}$ further turns.

A similar procedure is to be followed for setting up the 10 kc/s counter. In this instance the CRYSTAL CALIBRATOR selector is set to 10 kc/s and the signal generator tuned to approximately 10 kc/s. The preset control to be adjusted is 6RV2.

Both 6RV1 and 6RV2 are accessible through holes in the r.f. box cover at the top, rear, without removing the unit from the chassis.

To ensure reliable operation of the crystal calibrator make these tests with the instrument in an ambient temperature of 25°C or greater.

(c) Turn the CRYSTAL CALIBRATOR selector to 1 kc/s (filter). Connect an accurate (1%) a.f. oscillator, such as Marconi Instruments type TF 1101 or TF 2000 via a 47 kΩ series resistor between tags 5 and 11 of board (5). Connect a valve voltmeter between tags 8 and 11 of board (5). With the a.f. oscillator tuned to 1 kc/s, adjust 5L1 and 5RV1 for maximum rejection as indicated by the valve voltmeter.

To avoid overload do not allow the valve voltmeter reading to exceed 2 V with the CRYSTAL CALIBRATOR LEVEL control, 0RV8, at maximum.

The circuit can be set up almost as well using aural detection of the maximum rejection point.

5 REPLACEABLE PARTS and CIRCUIT DIAGRAMS

5.1 REPLACEABLE PARTS

Introduction

Each of the printed boards and other sub assemblies in this instrument has been allocated a unit identification number in the sequence (1) to (29), which wherever practicable is marked upon it. The complete circuit reference for a component carries its unit number as a prefix, e.g. 6R15. Components that do not form part of any sub assembly carry the prefix 0, e.g. 0R6, except those classes of component about which no confusion is possible.

For convenience in the text and on the circuit diagrams, the circuit reference is abbreviated by dropping the prefix, except where there is risk of ambiguity. When ordering spare parts or in any other correspondence, be sure to quote the complete circuit reference.

This section lists the components of each unit in alpha-numerical order of the complete circuit reference. The following abbreviations are used:-

C	:	capacitor
Cer	:	ceramic
Elec	:	electrolytic
FS	:	fuse
JK	:	jack
L	:	inductor
LS	:	loudspeaker
M	:	meter
Met	:	metal
Min	:	minimum
MR	:	semiconductor diode
PL	:	plug
R	:	resistor
RV	:	variable resistor
S	:	switch
SKT	:	socket
T	:	transformer
TE	:	total excursion
TH	:	thermistor
Var	:	variable
VT	:	transistor
WW	:	wirewound
X	:	crystal
ø	:	lead through
*	:	value selected during test; nominal value shown
**	:	resistor rating at 70°C
†	:	resistor rating at 40°C

All resistor ratings are referred to an ambient temperature of 55°C except those indicated ** or †.

Ordering

When ordering replacement parts, address the order to our Service Division (for address see rear cover) or nearest Agent. Specify the following information for each part required.

(1) Type and serial number of instrument.

(2) Complete circuit reference.

(3) Description.

(4) M.I. code number.

If a part is not listed, state its function, location and description when ordering.

Main chassis

When ordering, prefix circuit reference with 0

Circuit reference	Description	M.I. code
C1	Elec 1000µF +50% −20% 100V	26000-006
C2	Elec 100µF +50% −20% 6V	26417-154
C4	Cer ∅ 0.0047µF min 350V	26372-615
C5	Cer ∅ 0.0047µF min 350V	26372-615
C6	Cer ∅ 0.0047µF min 350V	26372-615
C7	Cer ∅ 0.0047µF min 350V	26372-615
C8	Cer ∅ 0.0047µF min 350V	26372-615
C9	Cer ∅ 0.0047µF min 350V	26372-615
C10	Cer ∅ 0.0047µF min 350V	26372-615
C11	Cer ∅ 0.0047µF min 350V	26372-615
C12	Cer ∅ 500pF ±20% 350V	26373-609
C13	Cer ∅ 500pF ±20% 350V	26373-609
C14	Cer ∅ 0.0047µF min 350V	26372-615
C15	Cer ∅ 0.0047µF min 350V	26372-615
C16	Cer ∅ 0.0047µF min 350V	26372-615
C17	Cer ∅ 0.0047µF min 350V	26372-615
C18	Cer ∅ 0.0047µF min 350V	26372-615
C19	Cer ∅ 0.0047µF min 350V	26372-615
C20	Cer ∅ 0.0047µF min 350V	26372-615
C21	Cer ∅ 0.0047µF min 350V	26372-615
C22	Cer ∅ 500pF ±20% 350V	26373-609
C23	Cer ∅ 500pF ±20% 350V	26373-609
C24	Cer ∅ 0.0047µF min 350V	26372-615
C25	Cer ∅ 0.0047µF min 350V	26372-615
C26	Cer ∅ 0.0047µF min 350V	26372-615
C27	Cer ∅ 0.0047µF min 350V	26372-615
C34	Cer ∅ 0.0047µF min 350V	26372-615
C35	Cer 0.01µF +80% −20% 100V	26383-055
C36	Cer 33pF ±5% 750V	26324-822
C37	Elec 100µF +100% −20% 25V	26417-158
FS1	160mA, time-lag	23411-054
FS2	500mA, time-lag	23411-056
JKA	Crystal cal output	23421-658

Circuit reference	Description	M.I. code
L1	Ferrite bead	44223-801
L2	Ferrite bead	44223-801
L3	Ferrite bead	44223-801
L4	Ferrite bead	44223-801
L5	Ferrite bead	44223-801
L6	Ferrite bead	44223-801
L7	Five ferrite beads	23635-833
LS1	80Ω	23646-103
M1	100µA	TM7080/7
M2	100µA	TM7080/8
PL1	18 way	23435-243
PL2	Elbow BNC 50Ω	23443-353
PL3	Elbow GP 50Ω	23444-053
PL4	Elbow GP 50Ω	23444-053
PL5	Elbow BNC 50Ω	23443-353
PL6	Elbow BNC 50Ω	23443-353
PL7	3 pin mains	23423-151
PL8	Elbow BNC 50Ω	23443-353
R1	Carbon 10kΩ ±10% ½W	24332-110
R3	Met oxide 10kΩ ±7% TE ⅜W	24552-110
R4	Met oxide 220Ω ±7% TE ⅜W	24552-058
R5	Carbon 33kΩ ±10% ½W	24342-122
R6	Carbon 10kΩ ±10% ½W	24332-110
RV1A	WW 16kΩ ±2% 3W †	25874-578 (RV1A and RV1B)
RV1B	WW 16kΩ ±2% 3W †	
RV2	2.5kΩ part of switch assy SC	
RV3	1kΩ part of switch assy SB	
RV4	Carbon 4.7kΩ ±20% ¼W	25611-209
RV5	WW 50kΩ ±10% 2W †	25814-391
RV6	WW 10kΩ ±10% 3W †	25814-345
RV7	WW 1kΩ ±10% 2W †	25885-066
RV8	100kΩ part of switch assy SA	
RV9	Multi-turn 1kΩ ±5% 1½W †	44371-007

For abbreviations, see introduction to this section

When ordering, prefix circuit reference with 0

Circuit reference	Description	M.I. code
SA	Crystal cal switch assy, includes ORV8	44324-216
SB	Carrier switch assy, includes ORV3	44321-127
SC	Modulation switch assy, includes ORV2	44325-804
SD	Supply	44321-406
SE	Supply voltage range	23467-119
SF	Mains/Battery	23467-115
SG	Range	
SG1	Wafer	44332-411
SG2	Wafer	44332-403
SG3	Wafer	44332-402
SG4	Wafer	44332-401
SG5	Wafer	44332-404
SG6	Wafer	44332-403
SG7	Wafer	44332-405
SG8	Wafer	44332-406
SG9	Wafer	44332-407
SG10	Wafer	44332-408
SG11	Wafer	44332-409
SG12	Wafer	44332-410
SG13	Microswitch	23483-131
SH	Microswitch	23483-128
SJ	Microswitch	23483-128
SK	Microswitch	23483-128
SL	Microswitch	23483-128
SM	Microswitch	23483-128
SN	Microswitch	23483-128
SP	Microswitch	23483-128
SQ	Microswitch	23483-128
SR	Microswitch	23483-128
SS	Microswitch	23483-128
ST	Microswitch	23483-128
SU	Microswitch	23483-128
SV	Microswitch	23483-128

Circuit reference	Description	M.I. code
SW	Microswitch	23483-128
SX	Microswitch	23483-128
SY	Microswitch	23483-128
SKT3	18 way	23435-293
SKT4	Panel jack BNC 50Ω	23443-443
SKT5	GP 50Ω	23444-193
SKT6	GP 50Ω	23444-193
SKT7	Panel jack BNC 50Ω	23443-443
SKT8	Bulkhead jack BNC 50Ω	23443-505
SKT9	Bulkhead jack BNC 50Ω	23443-505
SKT10	Panel jack BNC 50Ω	23443-443
SKT11	Panel jack BNC 50Ω	23443-443
T1	Mains	1 TM7266
T2	Current balancing	TM7616
VT1	2N 1534	28425-835
Knob	Supply	41142-208
Knob	Carrier switch	10-TM7267
Knob	Carrier level control	41141-503
Knob	Modulation selector	41142-201
Knob	Modulation depth control	41141-503
Knob	Modulation freq & scale assy	TM7022/5
	Cursor for above	18210-359
Knob	Freq & logging scale assy	TM7022/6
	Cursor for above	18210-359
Knob	Set scale control	14230-311
Knob	Range control	41145-206
Knob	Set zero control	TM6891/10
Knob	Set ΔF control	41141-202
Knob	Incremental freq & scale assy	TM7022/4
	Cursor for above	18210-359

For abbreviations, see introduction to this section

When ordering, prefix circuit reference with 0

Circuit reference	Description	M.I. code
Knob	Coarse attenuator & scale assy	TM7506/1
Knob	Fine attenuator & scale assy	TM7506
Knob	Crystal cal selector	TM6896/5
Knob	Crystal cal level	41141-503
	Fuse holder for 0FS1	23416-191
	Fuse holder for 0FS2	23416-191

Unit (1)—supply stabilizer, TM 7466

When ordering, prefix circuit reference with 1

Circuit reference	Description	M.I. code
C1	Elec 100μF +100% -20% 50V	26417-160
C2	Elec 100μF +100% -20% 25V	26417-158
C3	Elec 100μF +100% -20% 25V	26417-158
MR1	ZB7.5 Zener	28371-606
MR2	1N540	28357-044
MR3	1N540	28357-044
MR4	1N540	28357-044
R1	Carbon 2.2kΩ ±10% $\frac{1}{2}$W	24342-088
R2	WW 3.3Ω ±10% 1$\frac{1}{2}$W **	25133-008
R3	Carbon 220Ω ±10% $\frac{1}{2}$W	24342-058
R4	Carbon 6.8kΩ ±10% $\frac{1}{2}$W	24342-106
R5	Carbon 100Ω ±10% $\frac{1}{2}$W	24342-050
R6	Met oxide 3.9kΩ ±7% TE $\frac{3}{8}$W	24552-096
R7	Met oxide 2.7kΩ ±7% TE $\frac{3}{8}$W	24552-092
R8	Met oxide 75kΩ ±7% TE $\frac{3}{8}$W	24552-132
R9	Met oxide 2.7kΩ ±7% TE $\frac{3}{8}$W	24552-092
R10	Met oxide 2.7kΩ ±7% TE $\frac{3}{8}$W	24552-092

When ordering, prefix circuit reference with 1

Circuit reference	Description	M.I. code
RV1	Carbon 220kΩ ±20% $\frac{1}{4}$W	25611-229
RV2	Carbon 470Ω ±20% $\frac{1}{4}$W	25611-246
VT1	ACY 17	28426-497
VT2	2G403	28424-728

Unit (2)—modulation oscillator, TM 7467

When ordering, prefix circuit reference with 2

Circuit reference	Description	M.I. code
C1	Elec 100μF +100% -20% 25V	26417-158
C2	Elec 5μF +100% -20% 70V	26417-118
C3	Elec 250μF +100% -20% 6V	26417-162
C4	Elec 100μF +100% -20% 25V	26417-158
C5	Elec 25μF +100% -20% 35V	26417-143
C6	Elec 50μF +100% -20% 35V	26417-153
C7	Elec 100μF +100% -20% 25V	26417-158
C8	Elec 100μF +100% -20% 25V	26417-158
MR1	HG1005	28323-035
MR2	ZB6.2 Zener	28371-486
MR3	HG1005	28323-035
R1	Met oxide 15kΩ ±7% TE $\frac{3}{8}$W	24552-114
R2	Met oxide 5.6kΩ ±7% TE $\frac{3}{8}$W	24552-103
R3	Carbon 8.2kΩ ±10% $\frac{1}{2}$W	24342-108
R4	Met oxide 1.2kΩ ±7% TE $\frac{3}{8}$W	24552-082
R5	Carbon 10kΩ ±10% $\frac{1}{2}$W	24342-110
R6	Carbon 1.5kΩ ±10% $\frac{1}{2}$W	24342-084
R7	Met oxide 2.4kΩ ±7% TE $\frac{3}{8}$W	24552-089
R8	Carbon 1kΩ ±10% $\frac{1}{2}$W	24342-080
R9	Carbon 10kΩ ±10% $\frac{1}{2}$W	24342-110
R10	Met oxide 120kΩ ±7% TE $\frac{3}{8}$W	24552-139

For abbreviations, see introduction to this section

When ordering, prefix circuit reference with 2

Circuit reference	Description	M.I. code
R11	Met oxide 10kΩ ±7% TE ⅜W	24552-110
R12	Carbon 33kΩ ±10% ½W	24342-122
R13	Carbon 2.2kΩ ±10% ½W	24342-088
R14	Carbon 220Ω ±10% ½W	24342-058
R15	Carbon 680Ω ±10% ½W	24342-076
R16	Met oxide 6.2kΩ ±7% TE ⅜W	24552-104
R17	Met oxide 6.8kΩ ±7% TE ⅜W	24552-106
R18	Carbon 47kΩ ±10% ½W	24342-126
RV1	Carbon 2.2kΩ ±20% ¼W	25611-206
RV2	Carbon 1kΩ ±20% ¼W	25611-204
VT1	2G401	28422-718
VT2	2G401	28422-718
VT3	2N404	28423-508
VT4	HT101	28432-735
VT5	2N404	28423-508

Unit (3)—modulation drive and monitor, TM 7207

When ordering, prefix circuit reference with 3

C1	Elec 5μF +100% -20% 50V	26414-114
C2	Paper 0.001μF * ±10% 500V	26174-125
MR2	HG5004	28332-465
MR3	HG5004	28332-465
MR4	HG5004	28332-465
MR5	HG5004	28332-465

When ordering, prefix circuit reference with 3

Circuit reference	Description	M.I. code
R1	Met oxide 9.1kΩ ±7% TE ⅜W	24552-109
R2	Met oxide 220Ω ±7% TE ⅜W	24552-058
R3	Met oxide 3.6kΩ ±7% TE ⅜W	24552-095
R4	Met oxide 4.3kΩ ±7% TE ⅜W	24552-097
R5	Met oxide 22kΩ ±7% TE ⅜W	24552-118
R6	Met oxide 4.7kΩ 7% TE ⅜W	24552-100
R7	Met oxide 270Ω ±7% TE ⅜W	24552-061
RV1	Carbon 4.7kΩ ±20% ¼W	25611-259
TH1	CZ3 1.5kΩ	25683-644
TH1	CZ3 1.5kΩ	25683-644
VT1	2S302	28433-458
VT2	2S302	28433-458

Unit (4)—oscillator supply stabilizer, TM 7297

When ordering, prefix circuit reference with 4

C1	Elec 100μF +100% -20% 25V	26417-158
C2	Elec 100μF +100% -20% 25V	26417-158
C3	Elec 25μF +100% -20% 35V	26417-143
MR1	ZB7.5 Zener	28371-606
R1	Met oxide 470Ω ±7% TE ⅜W	24552-069
R2	Met oxide 220Ω ±7% TE ⅜W	24552-058
R3	Met oxide 910Ω ±7% TE ⅜W	24552-079
R4	Met oxide 2.2kΩ ±7% TE ⅜W	24552-088
R5	Met oxide 470Ω ±7% TE ⅜W	24552-069

For abbreviations, see introduction to this section

When ordering, prefix circuit reference with 4

Circuit reference	Description	M.I. code
R6	Met oxide 4.7kΩ ±7% TE $\frac{3}{8}$W	24552-100
R7	Met oxide 2.2kΩ ±7% TE $\frac{3}{8}$W	24552-088
R8	Met oxide 820Ω ±7% TE $\frac{3}{8}$W	24552-078
R9	Met oxide 330Ω ±7% TE $\frac{3}{8}$W	24552-063
R10	Met oxide 330Ω ±7% TE $\frac{3}{8}$W	24552-063
R11	Met oxide 910Ω ±7% TE $\frac{3}{8}$W	24552-079
R12	Carbon 2.2MΩ* ±10% $\frac{1}{2}$W	24342-174
RV1	Carbon 500Ω ±10% $\frac{1}{2}$W **	25886-717
RV2	Carbon 1kΩ ±20% $\frac{1}{4}$W	25611-204
TH1	CZ 3 1.5kΩ	25683-644
VT1	2S304	28432-268
VT2	BCY34	28434-227
VT3	ACY20	28424-747
VT4	2S701	28453-488
VT5	2S304	28432-268

When ordering, prefix circuit reference with 5

Circuit reference	Description	M.I. code
R1	Carbon 47kΩ ±10% $\frac{1}{2}$W	24342-126
R2	Carbon 47kΩ ±10% $\frac{1}{2}$W	24342-126
R3	Carbon 10kΩ ±10% $\frac{1}{2}$W	24342-110
R4	Carbon 10kΩ ±10% $\frac{1}{2}$W	24342-110
R5	Carbon 3.3kΩ ±10% $\frac{1}{2}$W	24342-094
R6	Carbon 1kΩ ±10% $\frac{1}{2}$W	24342-080
R7	Carbon 4.7kΩ ±10% $\frac{1}{2}$W	24342-110
R8	Carbon 470kΩ ±10% $\frac{1}{2}$W	24342-152
R9	Carbon 1kΩ ±10% $\frac{1}{2}$W	24342-080
R10	Carbon 470Ω ±10% $\frac{1}{2}$W	24342-069
R11	Carbon 22kΩ ±10% $\frac{1}{2}$W	24342-118
R12	Met oxide 330Ω ±7% TE $\frac{3}{8}$W	24552-063
RV1	Carbon 4.7kΩ ±20% $\frac{1}{4}$W	25611-209
VT1	ACY20	28424-747
VT2	2S701	28453-488
VT3	ACY20	28424-747

Unit (5)—crystal calibrator amplifier, TM 7190

When ordering, prefix circuit reference with 5

C1	Elec 5µF +100% -20% 70V	26417-118
C2	Elec 50µF +100% -20% 6V	26412-245
C3	Elec 1µF +100% -20% 50V	26414-106
C4	Elec 100µF +100% -20% 25V	26417-158
C5	Elec 1µF +100% -20% 50V	26414-106
C6	Plastic 0.1µF ±10% 200V	26582-208
C7	Elec 250µF +100% -20% 6V	26417-162
C8	Elec 25µF +100% -20% 35V	26417-143
C9	Plastic 0.047µF ±1% 125V	26516-821
C10	Plastic 0.047µF ±1% 125V	26516-821
L1	285mH	TM7559/4

Unit (6)—crystal calibrator, TM 7082

When ordering, prefix circuit reference with 6

C1	Var air 3-12pF	26817-238
C2	Cer 15pF ±5% 750V	26324-807
C3	Plastic 0.0022µF ±2% 125V	26516-564
C4	Plastic 510pF ±2% 125V	26516-416
C5	Cer 0.01µF +80% -20% 350V	26383-392
C6	Plastic 330pF ±2% 125V	26516-369
C7	Paper 0.03µF ±10% 200V	26174-155
C8	Elec 10µF +100% -20% 35V	26414-121
C9	Plastic 0.0022µF ±2% 125V	26516-564
C10	Elec 100µF +100% -20% 25V	26417-158
C11	Cer 33pF ±5% 750V	26324-822
C12	Paper 220pF ±20% 600V	26174-118

For abbreviations, see introduction to this section

When ordering, prefix circuit reference with 6

Circuit reference	Description	M.I. code
C13	Cer 33pF ±5% 750V	26324-822
C14	Cer 0.1μF +50% -25% 25V	26383-031
C15	Cer 0.47μF +50% -25% 3V	26383-037
C16	Cer 0.47μF +50% -25% 3V	26383-037
C17	Elec 100μF +100% -20% 25V	26417-158
C18	Plastic 100pF ±2% 125V	26516-241
L1	Choke	TM7380/6
L2	Choke	TM7380/7
MR1	CG 91H	28321-311
MR2	ZB 4.7 Zener	28371-376
R1	Met oxide 22kΩ ±7% TE $\frac{3}{8}$W	24552-118
R2	Met oxide 15kΩ ±7% TE $\frac{3}{8}$W	24552-114
R3	Met oxide 1.5kΩ ±7% TE $\frac{3}{8}$W	24552-084
R4	Met oxide 2.2kΩ ±7% TE $\frac{3}{8}$W	24552-088
R5	Met oxide 3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
R6	Met oxide 430Ω* ±7% TE $\frac{3}{8}$W	24552-067
R7	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R8	Met oxide 750Ω ±7% TE $\frac{3}{8}$W	24552-077
R9	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R10	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R11	Met oxide 3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
R12	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R13	Carbon 10Ω ±10% $\frac{1}{2}$W	24342-020
R14	Carbon 470Ω ±10% $\frac{1}{2}$W	24342-069
R15	Carbon 47Ω ±10% $\frac{1}{2}$W	24342-037
R16	Carbon 12kΩ ±10% $\frac{1}{2}$W	24342-112
R17	Carbon 3.3kΩ ±10% $\frac{1}{2}$W	24342-094
R18	Carbon 1kΩ ±10% $\frac{1}{2}$W	24342-080
R19	Carbon 1kΩ ±10% 1/10W **	24341-280
R20	Carbon 33Ω ±10% 1/10W **	24341-280
R21	Met oxide 330Ω ±7% TE $\frac{3}{8}$W	24552-063
RV1	Carbon 5kΩ ±10% $\frac{1}{2}$W **	25886-730
RV2	Carbon 1kΩ ±10% $\frac{1}{2}$W **	25886-720

Circuit reference	Description	M.I. code
VT1	2G403	28424-728
VT2	2S701	28453-488
VT3	2N1304	28443-528
VT4	2G403	28424-728
VT5	2S701	28453-488
VT6	2N404	28423-508
VT7	2S303	28433-468
VT8	BFY 18	28453-533
VT9	MDS39	28421-428
VT10	2G403	28424-728
VT11	2N404	28423-508
X1	1000 kc/s	28311-702

Unit (7)—filters, TM 7355

When ordering, prefix circuit reference with 7

C1	Cer 0.1μF +50% -25% 25V	26383-031
C2	Cer 0.1μF +50% -25% 25V	26383-031
C3	Cer 0.1μF +50% -25% 25V	26383-031
C4	Plastic 0.047μF ±10% 200V	26582-206
C5	Cer 0.1μF +50% -25% 25V	26383-031
C6	Cer 0.1μF +50% -25% 25V	26383-031
C7	Cer 0.1μF +50% -25% 25V	26383-031
C8	Cer 0.1μF +50% -25% 25V	26383-031
C9	Plastic 0.0021μF* ±2% 125V	26516-559
C10	Plastic 0.00114μF ±2% 125V	26516-499
L1	120mH ±25%	44267-601
L2	120mH ±25%	44267-601
L3	120mH ±25%	44267-601
L4	340mH ±25%	44271-602
L5	1mH ±25%	44251-003
L6	1mH ±25%	44251-003
L7	120mH ±25%	44267-601
L8	120mH ±25%	44267-601
L9	45.5mH ±1%	TM7387/3
L10	48mH ±5%	TM7387/4

For abbreviations, see introduction to this section

Unit (8)—filters, TM 7356

When ordering, prefix circuit reference with 8

Circuit reference	Description	M.I. code
C1	Cer 0.1μF +50% -25% 25V	26383-031
C2	Cer 0.1μF +50% -25% 25V	26383-031
C3	Cer 0.1μF +50% -25% 25V	26383-031
C4	Cer 0.1μF ±10% 200V	26582-208
C5	Cer 0.1μF +50% -25% 25V	26383-031
C6	Cer 0.1μF +50% -25% 25V	26383-031
C7	Cer 0.1μF +50% -25% 25V	26383-031
C8	Cer 0.1μF +50% -25% 25V	26383-031
C9	Plastic 0.0026μF* ±2% 125V	26516-587
C10	Plastic 0.0027μF ±2% 125V	26516-589
C11	Plastic 0.0200μF ±2% 125V	26516-797
C12	Plastic 0.0180μF ±2% 125V	26516-786
C13	Paper 0.001μF ±20% 600V	26174-125
C14	Cer 0.1μF +50% -25% 25V	26383-031
C15	Cer 0.1μF +50% -25% 25V	26383-031
C16	Cer 0.1μF +50% -25% 25V	26383-031
C17	Plastic 0.1μF ±10% 200V	26582-208
C18	Cer 0.1μF +50% -25% 25V	26383-031
C19	Cer 0.1μF +50% -25% 25V	26383-031
C20	Cer 0.1μF +50% -25% 25V	26383-031
C21	Cer 0.1μF +50% -25% 25V	26383-031
C22	Plastic 0.0118μF ±2% 125V	26516-722
C23	Plastic 0.0047μF ±2% 125V	26516-646
C24	Plastic 820pF* ±2% 125V	26516-462
C26	Plastic 640pF ±2% 125V	26516-438
L1	120mH ±25%	44267-601
L2	120mH ±25%	44267-601
L3	120mH ±25%	44267-601
L4	340mH ±25%	44271-602
L5	1mH ±25%	44251-003
L6	1mH ±25%	44251-003
L7	120mH ±25%	44267-601
L8	120mH ±25%	44267-601
L9	37.5mH ±1%	TM7387/5
L10	44mH ±5%	TM7387/6
L11	330mH ±25%	TM7387/7
L12	300mH ±25%	TM7387/8
R1	Met oxide 10kΩ ±7% TE 3/8W	24552-110
R2	Met oxide 4.7kΩ ±7% 3/8W	24552-100
R3	Met oxide 100kΩ* ±7% TE 3/8W	24552-135
R4	Met oxide 150kΩ* ±7% TE 3/8W	24552-139

Unit (9)—range A oscillator, TM 7561

When ordering, prefix circuit reference with 9

C1	Cer 0.1μF +50% -25% 25V	26383-031
C2	Plastic 0.11μF ±2% 125V	26518-293
C3	Plastic 1μF ±5% 125V	26511-382
C5	Plastic 0.022μF* ±5% 125V	26511-324
C6	Plastic 1μF ±5% 125V	26511-382
C7	Cer 0.1μF +50% -25% 25V	26383-031
L1	Tuning coil	44267-001
L2	Trimmer	44264-705
R1	Met oxide 3.3kΩ ±7% TE 3/8W	24552-094
R2	Met oxide 1kΩ ±7% TE 3/8W	24552-080
R3	Met oxide 1kΩ ±7% TE 3/8W	24552-080
R4	Met oxide 1kΩ ±7% TE 3/8W	24552-080
R5	Met oxide 100Ω ±7% TE 3/8W	24552-050
VT1	ACY20	28424-747

For abbreviations, see introduction to this section

Unit (10)—range B oscillator, TM 7562

When ordering, prefix circuit reference with 10

Circuit reference	Description	M.I. code
C1	Cer 0.1µF +50% -25% 25V	26383-031
C2	Plastic 0.01µF ±2% 50V	26518-053
C3	Plastic 0.33µF ±5% 125V	26511-367
C5	Plastic 0.001µF* ±2% 125V	26516-481
C6	Plastic 0.33µF ±5% 125V	26511-367
C7	Plastic 0.1µF ±10% 200V	26582-208
L1	Tuning coil	TM7664/10
L2	Trimmer	44264-205
R1	Met oxide 3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
R2	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R3	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R4	Met oxide 820Ω ±7% TE $\frac{3}{8}$W	24552-078
R5	Met oxide 100Ω ±7% TE $\frac{3}{8}$W	24552-050
VT1	ACY20	28424-747

Unit (11)—range C oscillator, TM 7563

When ordering, prefix circuit reference with 11

Circuit reference	Description	M.I. code
C1	Plastic 0.01µF ±10% 200V	26582-202
C2	Plastic 100pF ±2pF 125V	26516-241
C3	Plastic 0.01µF ±10% 200V	26582-202
C4	Plastic 0.003µF ±2% 125V	26516-597
C5	Cer 0.1µF +50% -25% 25V	26383-031
C6	Plastic 300pF* ±2% 125V	26516-358
C7	Plastic 0.033µF ±5% 125V	26511-330
C8	Plastic 0.1µF ±5% 125V	26511-349
L1	Tuning coil	TM7664/5
L2	Trimmer	TM7722/6

When ordering, prefix circuit reference with 11

Circuit reference	Description	M.I. code
R1	Met oxide 4.7kΩ ±7% TE $\frac{3}{8}$W	24552-100
R2	Met oxide 6.8kΩ ±7% TE $\frac{3}{8}$W	24552-106
R3	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R4	Met oxide 3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
R5	Met oxide 1.5kΩ ±7% TE $\frac{3}{8}$W	24552-084
R6	Met oxide 1.5kΩ ±7% TE $\frac{3}{8}$W	24552-084
VT1	2S701	28453-488
VT2	2S701	28453-488

Unit (12)—range D oscillator, TM 7564

When ordering, prefix circuit reference with 12

C1	Plastic 0.01µF ±10% 200V	26582-202
C2	Plastic 100pF ±2% 125V	26516-241
C3	Plastic 0.01µF ±10% 200V	26582-202
C4	Plastic 0.001µF ±2% 125V	26516-481
C5	Cer 0.1µF +50% -25% 25V	26383-031
C6	Plastic 100pF* ±2pF 125V	26516-241
C7	Plastic 0.01µF 5% 125V	26511-313
C8	Plastic 0.033µF ±5% 125V	26511-330
L1	Tuning coil	TM7664/6
L2	Trimmer	TM7722/7
R1	Met oxide 470Ω ±7% TE $\frac{3}{8}$W	24552-069
R2	Met oxide 10kΩ ±7% TE $\frac{3}{8}$W	24552-110
R3	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R4	Met oxide 3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
R5	Met oxide 2.0kΩ ±7% TE $\frac{3}{8}$W	24552-087
R6	Met oxide 1.5kΩ ±7% TE $\frac{3}{8}$W	24552-084
VT1	2N706	28433-356
VT2	2N706	28433-356

For abbreviations, see introduction to this section

Unit (13)—range E oscillator, TM 7565

When ordering, prefix circuit reference with 13

Circuit reference	Description	M.I. code
C1	Paper 500pF ±20% 600V	26174-122
C2	Paper 500pF ±20% 600V	26174-122
C3	Cer 0.1µF +50% -25% 25V	26383-031
C4	Mica 215pF ±2% 350V	26268-332
C5	Cer 33pF* ±5% 750V	26324-822
C6	Plastic 0.0033µF ±2% 125V	26516-609
C7	Cer 0.1µF +50% -25% 25V	26383-031
C8	Plastic 0.0033µF ±2% 125V	26516-609
L1	Filter	44255-204
L2	Tuning coil	TM7664/8
L3	Trimmer	TM7722/4
MR1	BA 112	28381-281
R1	Met oxide 10kΩ ±7% TE $\frac{3}{8}$W	24552-110
R2	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R3	Met oxide 3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
VT1	2N706	28433-356

Unit (14)—range F oscillator, TM 7566

When ordering, prefix circuit reference with 14

Circuit reference	Description	M.I. code
C1	Paper 500pF ±20% 600V	26174-122
C2	Paper 500pF ±20% 600V	26174-122
C3	Cer 0.1µF +50% -25% 25V	26383-031
C4	Mica 365pF ±2% 350V	26268-393
C5	Cer 33pF* ±5% 750V	26324-822
C6	Plastic 0.0033µF ±2% 125V	26516-609
C7	Cer 0.1µF +50% -25% 25V	26383-031
C8	Plastic 0.0033µF ±2% 125V	26516-609
L1	Filter	TM7665/3
L2	Tuning coil	44237-603
L3	Trimmer	44223-201
MR1	BA 112	28381-281
R1	Met oxide 4.7kΩ ±7% TE $\frac{3}{8}$W	24552-100
R2	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R3	Met oxide 3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
VT1	2N706	28433-356

Unit (15)—range G oscillator, TM 7567

When ordering, prefix circuit reference with 15

Circuit reference	Description	M.I. code
C1	Cer 0.01µF +80% -20% 350V	26383-392
C2	Paper 0.001µF ±20% 500V	26174-126
C3	Cer 0.01µF +80% -20% 350V	26383-392
C4	Cer 68pF ±2% 750V	26324-868
C5	Mica 68pF ±1% 350V	26268-317
C6	Cer 10pF* ±0.5pF 750V	26324-085
C7	Mica 500pF ±5% 350V	26258-392
C8	Cer 0.01µF +80% -20% 350V	26383-392
C9	Mica 0.001µF ±1% 350V	26268-350
C10	Mica 100pF ±5% 350V	26268-325
C11	Cer 0.01µF +80% -20% 350V	26383-392
L1	Filter	44221-803
L3	Tuning coil	44133-901
L4	Trimmer	44223-201
MR1	BA 111	28381-201

For abbreviations, see introduction to this section

When ordering, prefix circuit reference with 15

Circuit reference	Description		M.I. code
R1	Met oxide	3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
R2	Met oxide	1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R3	Met oxide	3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
R4	Met oxide	100Ω ±7% TE $\frac{3}{8}$W	24552-050
R5	Met oxide	330Ω ±7% TE $\frac{3}{8}$W	24552-063
R6	Met oxide	470Ω ±7% TE $\frac{3}{8}$W	24552-069
R7	Met oxide	4.7kΩ ±7% TE $\frac{3}{8}$W	24552-100
VT1	BSY 28		28451-713
VT2	BFY 18		28453-533

Unit (16)—range H oscillator, TM 7568

When ordering, prefix circuit reference with 16

C1	Cer	0.01µF +80% -20% 350V	26383-392
C2	Paper	0.001µF ±20% 500V	26174-125
C3	Cer	0.01µF +80% -20% 350V	26383-392
C4	Cer	15pF ±5% 750V	26324-795
C5	Cer	1pF ±0.5pF 750V	26324-020
C6	Var air	3 - 12pF	26817-238
C7	Mica	100pF ±5% 350V	26268-325
C8	Cer	0.01µF +80% -20% 350V	26383-392
C9	Mica	100pF ±5% 350V	26268-325
C10	Mica	33pF ±5% 350V	26268-308
C11	Cer	0.1µF +50% -20% 25V	26383-031
C12	Cer	33pF ±5% 750V	26324-822
L1	Filter		44221-803
L3	Tuning coil		44227-901
L4	Trimmer		44223-202
MR1	BA 111		28381-201

When ordering, prefix circuit reference with 16

Circuit reference	Description		M.I. code
R1	Met oxide	1.5kΩ ±7% TE $\frac{3}{8}$W	24552-084
R2	Met oxide	1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R3	Met oxide	3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
R4	Met oxide	100Ω ±7% TE $\frac{3}{8}$W	24552-050
R5	Met oxide	330Ω ±7% TE $\frac{3}{8}$W	24552-063
R6	Met oxide	470Ω ±7% TE $\frac{3}{8}$W	24552-069
R7	Met oxide	4.7kΩ ±7% TE $\frac{3}{8}$W	24552-100
VT1	BSY 28		28451-713
VT2	BSY 28		28451-713

Unit (17)—range A output filter, TM 7571

When ordering, prefix circuit reference with 17

C1	Plastic	0.068µF* ±5% 125V	26511-343
C2	Plastic	0.22µF ±1% 125V	26511-360
C3	Plastic	0.33µF ±5% 125V	26511-367
L1	Trimmer		TM7722
L2	Tuning coil		TM7664/1
R1	Carbon	330Ω ±10% $\frac{1}{2}$W	24342-063

Unit (18)—range B output filter, TM 7572

When ordering, prefix circuit reference with 18

C1	Plastic	0.01µF* ±5% 125V	26511-313
C2	Plastic	0.068µF ±5% 125V	26511-343
C3	Plastic	0.1µF ±5% 125V	26511-349
C4	Plastic	0.15µF ±5% 125V	26511-356
L1	A.F. filter		TM7380
L2	Trimmer		TM7722/1
L3	Tuning coil		TM7664/3

For abbreviations, see introduction to this section

Unit (19)—range C output filter, TM 7573

When ordering, prefix circuit reference with 19

Circuit reference	Description	M.I. code
C1	Plastic 0.0047µF* ±5% 125V	26511-149
C2	Plastic 0.022µF ±5% 125V	26511-324
C3	Plastic 0.033µF ±5% 125V	26511-330
C4	Plastic 0.047µF ±5% 125V	26511-337
L1	A.F. filter	TM7380/2
L2	Trimmer	TM7722/2
L3	Tuning coil	TM7664/4

Unit (20)—range D output filter, TM 7574

When ordering, prefix circuit reference with 20

Circuit reference	Description	M.I. code
C1	Plastic 0.001µF* ±2% 125V	26516-481
C2	Plastic 0.068µF ±5% 125V	26511-164
C3	Plastic 0.01µF ±5% 125V	26511-313
C4	Plastic 0.015µF ±5% 125V	26511-319
L1	A.F. filter	TM7380/3
L2	Trimmer	TM7722/3
L3	Tuning coil	TM7664/7

Unit (21)—range E output filter, TM 7575

When ordering, prefix circuit reference with 21

Circuit reference	Description	M.I. code
C1	Plastic 330pF* ±2% 125V	26516-369
C2	Plastic 0.0022µF ±2% 125V	26516-564
C3	Plastic 0.0022µF ±2% 125V	26516-564
C4	Plastic 0.005µF ±2% 125V	26516-652
L1	A.F. filter	TM7380/4
L2	Trimmer	TM7722/8
L3	Tuning coil	TM7664/10

Unit (22)—range F output filter, TM 7576

When ordering, prefix circuit reference with 22

Circuit reference	Description	M.I. code
C1	Plastic 0.001µF ±2% 125V	26516-481
C2	Plastic 680pF ±2% 125V	26516-444
C3	Plastic 220pF* ±2% 125V	26516-327
C4	Plastic 0.001µF ±2% 125V	26516-481
L1	A.F. filter	44257-210
L2	Trimmer	44223-201
L3	Tuning coil	44237-003

Unit (23)—range G output filter, TM 7577

When ordering, prefix circuit reference with 23

Circuit reference	Description	M.I. code
C1	Mica 330pF ±5% 350V	26268-391
C2	Mica 100pF ±5% 350V	26268-325
C3	Cer 33pF* ±5% 750V	26324-822
C4	Mica 330pF ±5% 350V	26268-391
L1	A.F. filter	44257-210
L2	Trimmer	44223-201
L3	Tuning coil	44233-901

Unit (24)—range H output filter, TM 7578

When ordering, prefix circuit reference with 24

Circuit reference	Description	M.I. code
C1	Mica 100pF ±5% 350V	26268-325
C2	Mica 15pF ±1pF 350V	26268-302
C3	Var air 3-12pF	26817-238
C4	Mica 100pF ±5% 350V	26268-325
L1	A.F. filter	44257-210
L2	Trimmer	44223-202
L3	Tuning coil	44227-901

For abbreviations, see introduction to this section

Unit (25)—wide band amplifier, TM 7189

When ordering, prefix circuit reference with 25

Circuit reference	Description	M.I. code
C1	Cer 0.1μF +50% -25% 25V	26383-031
C2	Elec 10μF +100% -20% 35V	26414-121
C3	Cer 33pF ±5% 750V	26324-822
C4	Elec 10μF +100% -20% 35V	26414-121
C5	Elec 5μF +100% -20% 15V	26414-113
C6	Elec 5μF +100% -20% 15V	26414-113
C7	Elec 10μF +100% -20% 35V	26414-121
C8	Cer 0.47μF +50% -25% 3V	26383-037
C9	Cer 0.47μF +50% -25% 3V	26383-037
C10	Cer 0.47μF +50% -25% 3V	26383-037
C11	Cer 0.47μF +50% -25% 3V	26383-037
C12	Cer 0.01μF +80% -20% 100V	26383-055
C13	Cer 0.01μF +80% -20% 100V	26383-055
C15	Cer 0.1μF +50% -25% 25V	26383-031
FS1	100mA, quick acting	23411-002
L1	Filter	44255-204
L2	Ferrite bead	44223-801
L3	Ferrite bead	44223-801
MR1	ZB5.6 Zener	28371-436
MR2	ZB4.3 Zener	28371-316
R1	Carbon 33Ω ±10% ½W	24342-033
R2	Carbon 33Ω ±10% ½W	24342-033
R3	Carbon 33Ω ±10% ½W	24342-033
R4	Carbon 1kΩ ±10% ½W	24342-080
R5	Carbon 3.9kΩ ±10% ½W	24342-096
R6	Met oxide 240Ω ±7% TE ⅜W	24552-060
R7	Carbon 1kΩ ±10% ½W	24342-080
R8	Met oxide 2kΩ ±7% TE ⅜W	24552-087
R9	Carbon 820Ω ±10% ½W	24342-078
R10	Met oxide 240Ω ±7% TE ⅜W	24552-060
R11	Carbon 470Ω ±10% ½W	24342-069
R12	Carbon 1kΩ ±10% ½W	24342-080
R13	WW 47Ω ±5% 1½W **	25123-037
R14	WW 47Ω ±5% 1½W **	25123-037
R15	Carbon 100Ω ±10% ½W	24342-050
R16	Carbon 100Ω ±10% ½W	24342-050
R17	WW 47Ω ±5% 1½W **	25123-037
R18	WW 47Ω ±5% 1½W **	25123-037
R19	Carbon 220Ω ±10% ½W	24342-058
R20	Carbon 220Ω ±10% ½W	24342-058
R21	Carbon 220Ω ±10% ½W	24342-058
R22	Carbon 220Ω ±10% ½W	24342-058
R23	WW 2.2kΩ ±5% 1½W **	25123-088
R24	WW 2.2kΩ ±5% 1½W **	25123-088
T1	1:1 unbal to bal	TM7817/1
T2	Driver	TM7823/1
T3	Driver	TM7823/2
T4	2:1 bal to unbal	TM7817
T5	2:1 bal to unbal	TM7823
VT1	BSY 28	28451-713
VT2	BSY 28	28451-713
VT3	BSY 28 } matched pair	44522-031
VT4	BSY 28 } matched pair	
VT5	BSY 28 } matched pair	44522-032
VT6	BSY 28 } matched pair	
VT7	2N 743 } matched pair	44522-033
VT8	2N 743 } matched pair	
	Fuse holder for 25FS1	43281-003

For abbreviations, see introduction to this section

Unit (26)—a.l.c. and envelope feedback, TM 7186

When ordering, prefix circuit reference with 26

Circuit reference	Description	M.I. code
C1	Elec 500μF +100% −20% 25V	26417-175
C2	Plastic 150pF ±2% 125V	26516-287
C3	Plastic 0.001μF ±2% 125V	26516-481
C4	Cer 0.01μF +80% −20% 350V	26383-392
C5	Cer 0.22μF +50% −25% 6V	26383-034
C6	Cer 0.22μF +50% −25% 6V	26383-034
C7	Elec 1μF +100% −20% 50V	26414-106
C8	Elec 1μF +100% −20% 50V	26414-106
C9	Cer 0.01μF +80% −20% 350V	26383-392
C10	Elec 50μF +100% −20% 6V	26412-245
C12	Paper 300pF ±20% 500V	26174-119
C13	Cer 1.0pF* ±$\frac{1}{4}$pF 750V	26324-020
C14	Cer 1.0pF* ±$\frac{1}{4}$pF 750V	26324-020
C16	Cer 0.01μF +80% −20% 100V	26383-055
MR1	HG 5004	28332-465
MR2	HG 5004	28332-465
MR3	CG91H	28321-311
MR4	CG91H	28321-311
R1	Met oxide 6.8kΩ ±7% TE $\frac{3}{8}$W	24552-106
R2	Met oxide 9.1kΩ ±7% TE $\frac{3}{8}$W	24552-109
R3	Met oxide 12kΩ ±7% TE $\frac{3}{8}$W	24552-112
R4	Met oxide 1.2kΩ ±7% TE $\frac{3}{8}$W	24552-082
R5	Met oxide 2.2kΩ ±7% TE $\frac{3}{8}$W	24552-088
R6	Met oxide 2.2kΩ ±7% TE $\frac{3}{8}$W	24552-088
R7	Met oxide 1.5kΩ ±7% TE $\frac{3}{8}$W	24552-084
R8	Met oxide 3.3kΩ ±7% TE $\frac{3}{8}$W	24552-094
R10	Met oxide 10kΩ ±7% TE $\frac{3}{8}$W	24552-110
R12	Met oxide 5.1kΩ ±7% TE $\frac{3}{8}$W	24552-101
R13	Met oxide 5.1kΩ ±7% TE $\frac{3}{8}$W	24552-101
R14	Carbon 2.2kΩ ±10% 1/10W **	24341-288
R15	Met oxide 33kΩ ±7% TE $\frac{3}{8}$W	24552-122
R16	Met oxide 4.7kΩ ±7% TE $\frac{3}{8}$W	24552-100
R17	Met oxide 33kΩ ±7% TE $\frac{3}{8}$W	24552-122
R18	Met oxide 10kΩ ±7% TE $\frac{3}{8}$W	24552-110
R19	Met oxide 4.7kΩ ±7% TE $\frac{3}{8}$W	24552-100
R20	Met oxide 10kΩ ±7% TE $\frac{3}{8}$W	24552-110
R21	Met oxide 4.7kΩ ±7% TE $\frac{3}{8}$W	24552-100
R22	Met oxide 10kΩ ±7% TE $\frac{3}{8}$W	24552-110
R23	Met oxide 4.7kΩ ±7% TE $\frac{3}{8}$W	24552-100
R24	Met oxide 10kΩ ±7% TE $\frac{3}{8}$W	24552-110
R25	Met oxide 4.7kΩ ±7% TE $\frac{3}{8}$W	24552-100
R29	Met oxide 33kΩ ±7% TE $\frac{3}{8}$W	24552-122
R30	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R31	Met oxide 1kΩ ±7% TE $\frac{3}{8}$W	24552-080
R32	Met oxide 33kΩ ±7% TE $\frac{3}{8}$W	24552-122
R33	Carbon 50Ω ±1% 1/8W **	24112-500
R34	Carbon 1kΩ ±10% 1/10W **	24341-280
R35	Met oxide 2.2kΩ ±7% TE $\frac{3}{8}$W	24552-088
R36	Met oxide 100Ω ±7% TE $\frac{3}{8}$W	24552-050
R37	Carbon 1.8kΩ ±10% 1/10W **	24341-286
R38	Carbon 10Ω ±10% $\frac{1}{2}$W	24342-020
RV1	Carbon 1kΩ ±20% $\frac{1}{4}$W	25611-014
RV2	Carbon 1kΩ ±20% $\frac{1}{4}$W	25611-014
VT1	BCY34 } matched trio	44522-025
VT4	BCY34 } matched trio	
VT5	2S703 } matched trio	
VT2	HT101 } matched pair	44522-026
VT6	HT101 } matched pair	
VT3	HT101	28432-735
VT7	ST53	28451-728
VT8	ST53	28451-728

For abbreviations, see introduction to this section

Unit (27) —coarse attenuator, TM 7351

When ordering, prefix circuit reference with 27

Circuit reference	Description	M.I. code
C1	Cer 2.2pF ±0.5pF 750V	26324-042
C2	Cer 2.2pF ±0.5pF 750V	26324-042
C3	Cer 3.3pF ±0.5pF 750V	26324-048
C4	Cer 2.2pF ±0.5pF 750V	26324-042
C5	Cer 2.2pF ±0.5pF 750V	26324-042
R1	Met film 53.3Ω ±0.5% $\frac{1}{4}$W **	24634-356
R2	Met film 26.6Ω ±0.5% $\frac{1}{4}$W **	24634-230
R3	Met film 53.3Ω ±0.5% $\frac{1}{4}$W **	24634-356
R4	Met film 61.1Ω ±0.5% $\frac{1}{4}$W **	24634-357
R5	Met film 61.1Ω ±0.5% $\frac{1}{4}$W **	24634-357
R6	Met film 61.1Ω ±0.5% $\frac{1}{4}$W **	24634-357
R7	Met film 30.5Ω ±0.5% $\frac{1}{4}$W **	24634-231
R8	Met film 61.1Ω ±0.5% $\frac{1}{4}$W **	24634-357
R9	Met film 790Ω ±0.5% $\frac{1}{4}$W **	24634-806
R10	Met film 790Ω ±0.5% $\frac{1}{4}$W **	24634-806
R11	Met film 247Ω ±0.5% $\frac{1}{4}$W **	24634-609
R12	Met film 247Ω ±0.5% $\frac{1}{4}$W **	24634-609
R13	Met film 247Ω ±0.5% $\frac{1}{4}$W **	24634-609

Unit (28) —fine attenuator, TM 7350

When ordering, prefix circuit reference with 28

Circuit reference	Description	M.I. code
C1	Cer 2.2pF ±0.5pF 750V	26324-042
C2	Cer 3.3pF ±0.5pF 750V	26324-048
C3	Cer 2.2pF ±0.5pF 750V	26324-042
C4	Cer 3.3pF ±0.5pF 750V	26324-048
C5	Cer 2.2pF ±0.5pF 750V	26324-042

When ordering, prefix circuit reference with 28

Circuit reference	Description	M.I. code
R1	Met film 292Ω ±1% $\frac{1}{4}$W **	24636-714
R2	Met film 292Ω ±1% $\frac{1}{4}$W **	24636-714
R3	Met film 870Ω ±1% $\frac{1}{4}$W **	24636-906
R4	Met film 870Ω ±1% $\frac{1}{4}$W **	24636-906
R5	Met film 436Ω ±1% $\frac{1}{4}$W **	24636-713
R6	Met film 436Ω ±1% $\frac{1}{4}$W **	24636-713
R7	Met film 150Ω ±1% $\frac{1}{4}$W **	24636-615
R8	Met film 150Ω ±1% $\frac{1}{4}$W **	14636-615
R9	Met film 96.3Ω ±0.5% $\frac{1}{4}$W **	24634-481
R10	Met film 96.3Ω ±0.5% $\frac{1}{4}$W **	24634-481
R11	Met film 17.6Ω ±1% $\frac{1}{4}$W **	24636-116
R12	Met film 5.77Ω ±0.05Ω $\frac{1}{4}$W **	24634-052
R13	Met film 11.6Ω ±1% $\frac{1}{4}$W **	24636-115
R14	Met film 37.3Ω ±1% $\frac{1}{4}$W **	24636-235
R15	Met film 71.2Ω ±0.5% $\frac{1}{4}$W **	24634-355

Unit (29) —capacitor board, TM 7595

When ordering, prefix circuit reference with 29

Circuit reference	Description	M.I. code
C1	Plastic 0.372µF ±$\frac{1}{2}$% 125V	26516-879
C2	Plastic 0.118µF ±$\frac{1}{2}$% 125V	26516-856
C3	Plastic 0.0372µF ±$\frac{1}{2}$% 125V	26516-815
C4	Plastic 0.0118µF ±$\frac{1}{2}$% 125V	26516-721
C5	Plastic 0.00372µF ±1% 125V	26516-623
C6	Plastic 0.0011µF ±2% 125V	26516-509
C7	Plastic 0.372µF ±$\frac{1}{2}$% 125V	26516-879
C8	Plastic 0.118µF ±$\frac{1}{2}$% 125V	26516-856
C9	Plastic 0.0372µF ±$\frac{1}{2}$% 125V	26516-815
C10	Plastic 0.0118µF ±$\frac{1}{2}$% 125V	26516-721
C11	Plastic 0.00372µF ±1% 125V	26516-623
C12	Plastic 0.0011µF ±2% 125V	26516-509
C13	Elec 1000µF +50% -20% 12V	26417-403

For abbreviations, see introduction to this section

5.2 CIRCUIT DIAGRAMS

Circuit notes

1. COMPONENT VALUES

   Resistors : No suffix = ohms, k = kilohms, M = megohms.
   Capacitors : No suffix = microfarads, p = picofarads.
   * value selected during test, nominal value shown.

2. VOLTAGES

   Shown in italics adjacent to the point to which the measurement refers. See section 4.3 for conditions.

3. SYMBOLS

   arrow indicates clockwise rotation of knob.
   RANGE etc., external front or rear panel marking.
   tag on printed board.
   other tag.
   preset control.
   (27) unit identification number.

   A point marked with this symbol is connected to and receives power from : A point marked with this symbol

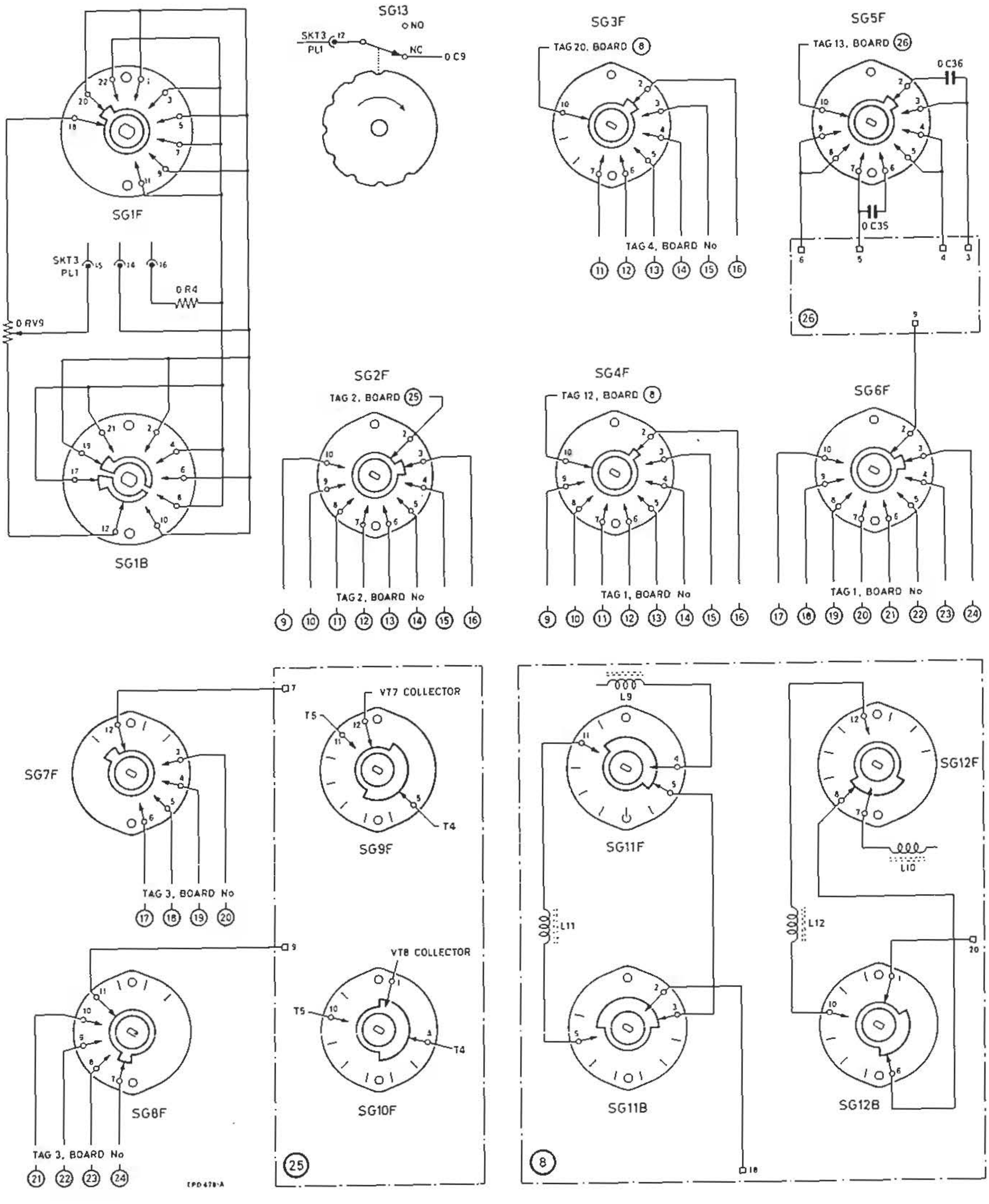
   These symbols are used to identify branches of the power supply circuitry but have no particular physical reality on the printed boards.

4. CIRCUIT REFERENCES

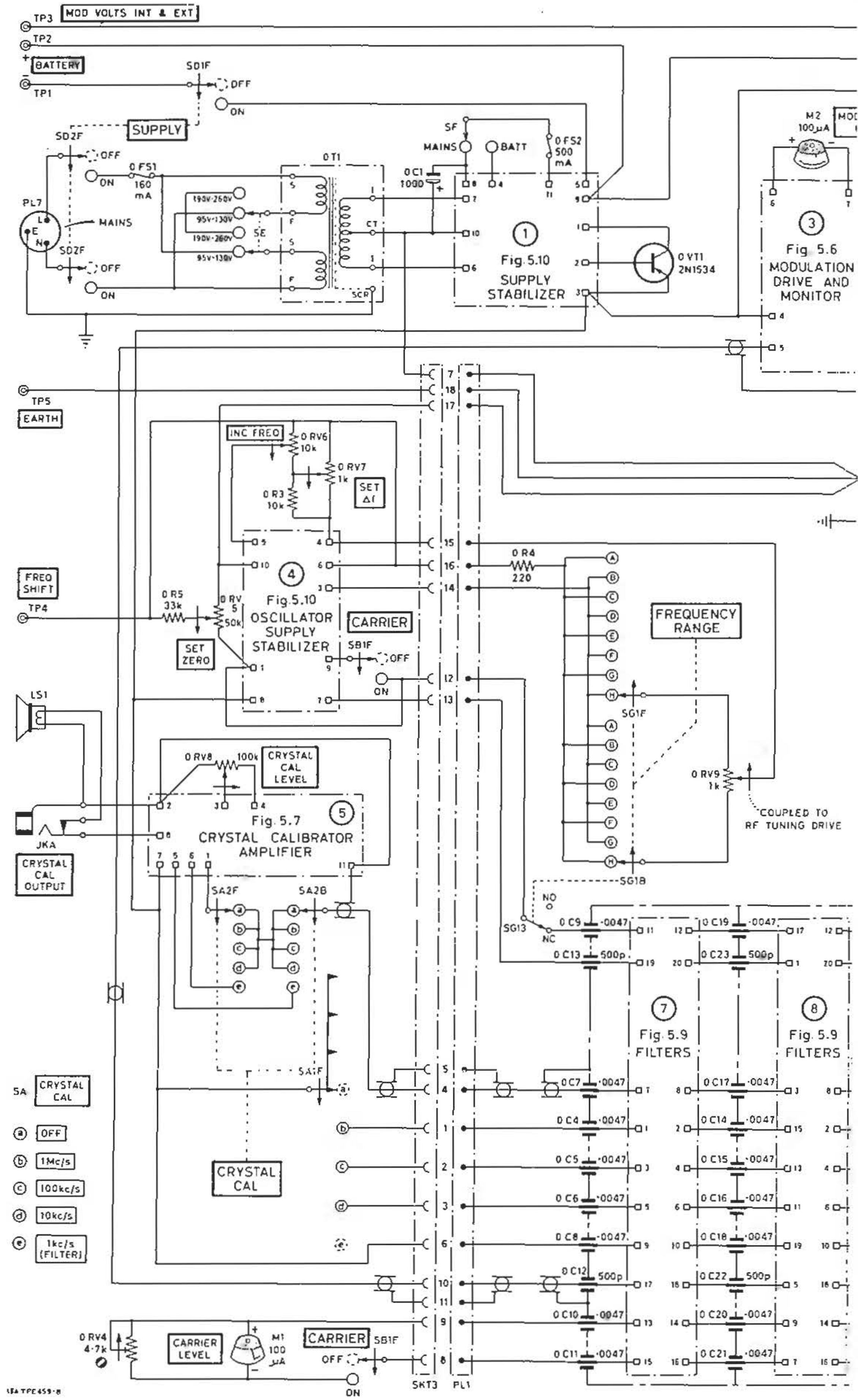
   These are, in general, given in abbreviated form.
   See also introduction to section 5.1, page 41.

5. SWITCHES

   Rotary switches are drawn schematically.
   Letters indicate control knob settings.
   1F = 1st section (front panel), front
   1B = 1st section, back
   2F = 2nd section, front
   etc.



SG—plan of sections viewed from knob end with switch in fully counter-clockwise position



MOD VOLTS INT & EXT
TP3
TP2
BATTERY
TP1
SD1F
OFF
ON
SUPPLY
SD2F
FS1
160 mA
PL7
MAINS
OT1
190V-260V
95V-130V
SE
SCR
SF
MAINS
BATT
FS2
500 mA
C1
1000
VT1
2N1534
Fig. 5.10
SUPPLY STABILIZER
M2
100μA
Fig. 5.6
MODULATION DRIVE AND MONITOR
TP5
EARTH
INC FREQ
RV6
10k
RV7
1k
SET Δf
R3
10k
R4
220
FREQ SHIFT
R5
33k
RV5
50k
TP4
SET ZERO
Fig. 5.10
OSCILLATOR SUPPLY STABILIZER
CARRIER
SB1F
FREQUENCY RANGE
SG1F
RV9
1k
COUPLED TO RF TUNING DRIVE
LS1
RV8
100k
CRYSTAL CAL LEVEL
Fig. 5.7
CRYSTAL CALIBRATOR AMPLIFIER
JKA
CRYSTAL CAL OUTPUT
SA2F
SA2B
SG1B
SG13
NO
NC
C9 ·0047
C13 500p
C19 ·0047
C23 500p
Fig. 5.9
FILTERS
Fig. 5.9
FILTERS
SA1F
SA CRYSTAL CAL
(a) OFF
(b) 1Mc/s
(c) 100kc/s
(d) 10kc/s
(e) 1kc/s (FILTER)
CRYSTAL CAL
C7 ·0047
C4 ·0047
C5 ·0047
C6 ·0047
C8 ·0047
C12 500p
C10 ·0047
C11 ·0047
C17 ·0047
C14 ·0047
C15 ·0047
C16 ·0047
C18 ·0047
C22 500p
C20 ·0047
C21 ·0047
RV4
4·7k
CARRIER LEVEL
M1
100 μA
CARRIER
SB1F
OFF
ON
SKT3
PL1
SA TPC459-8

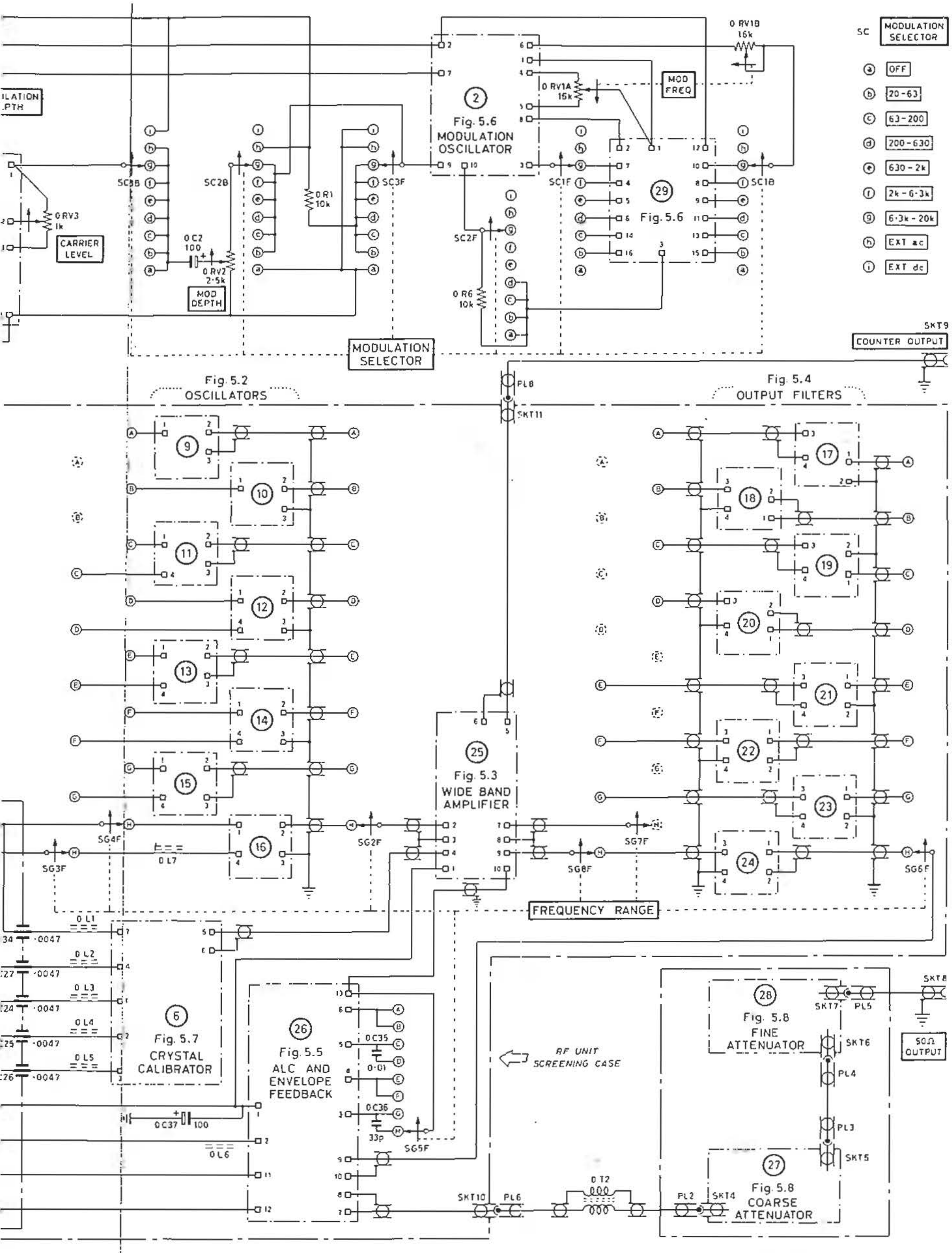
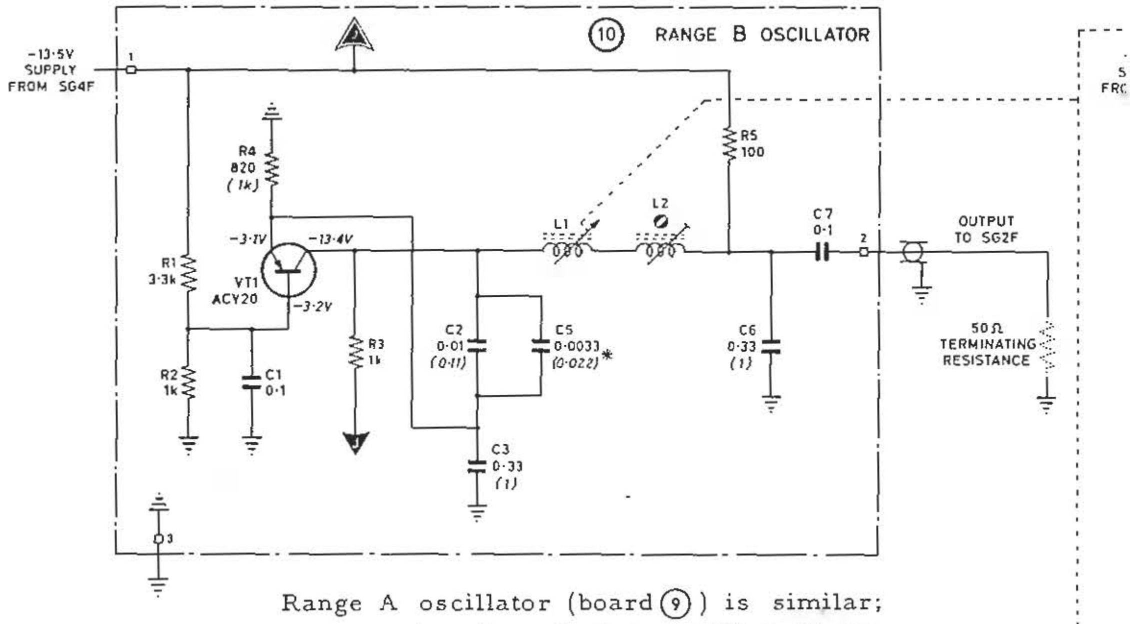
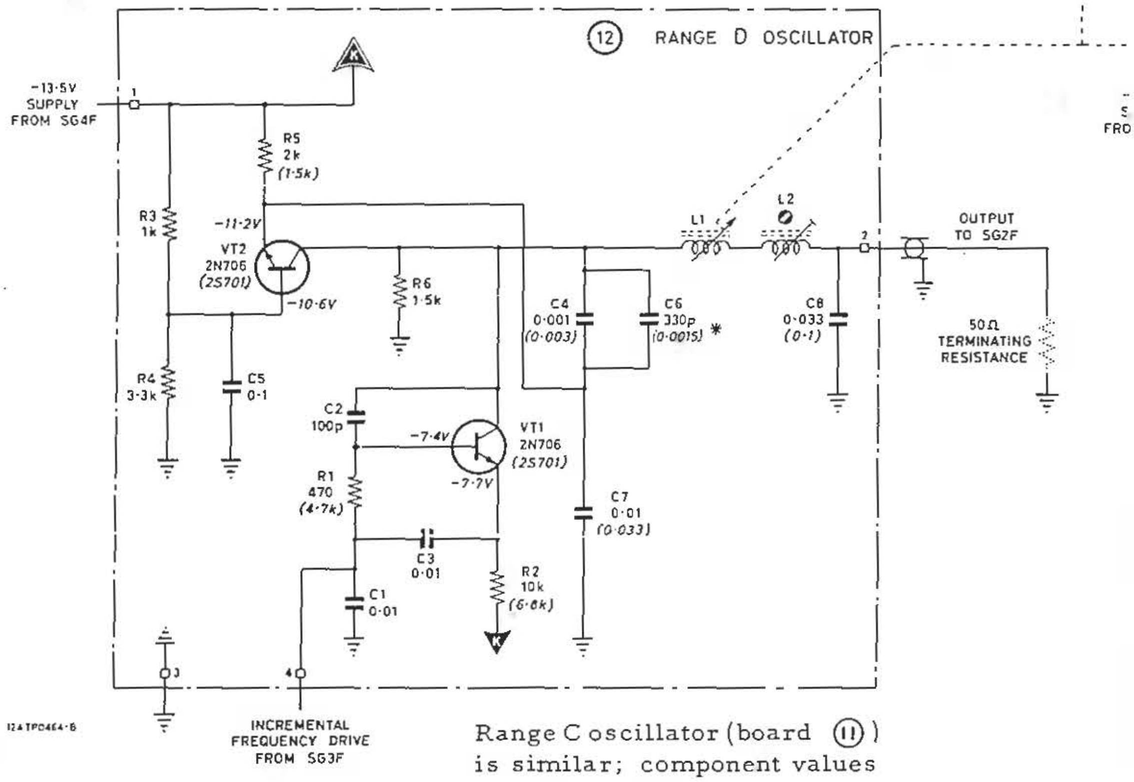


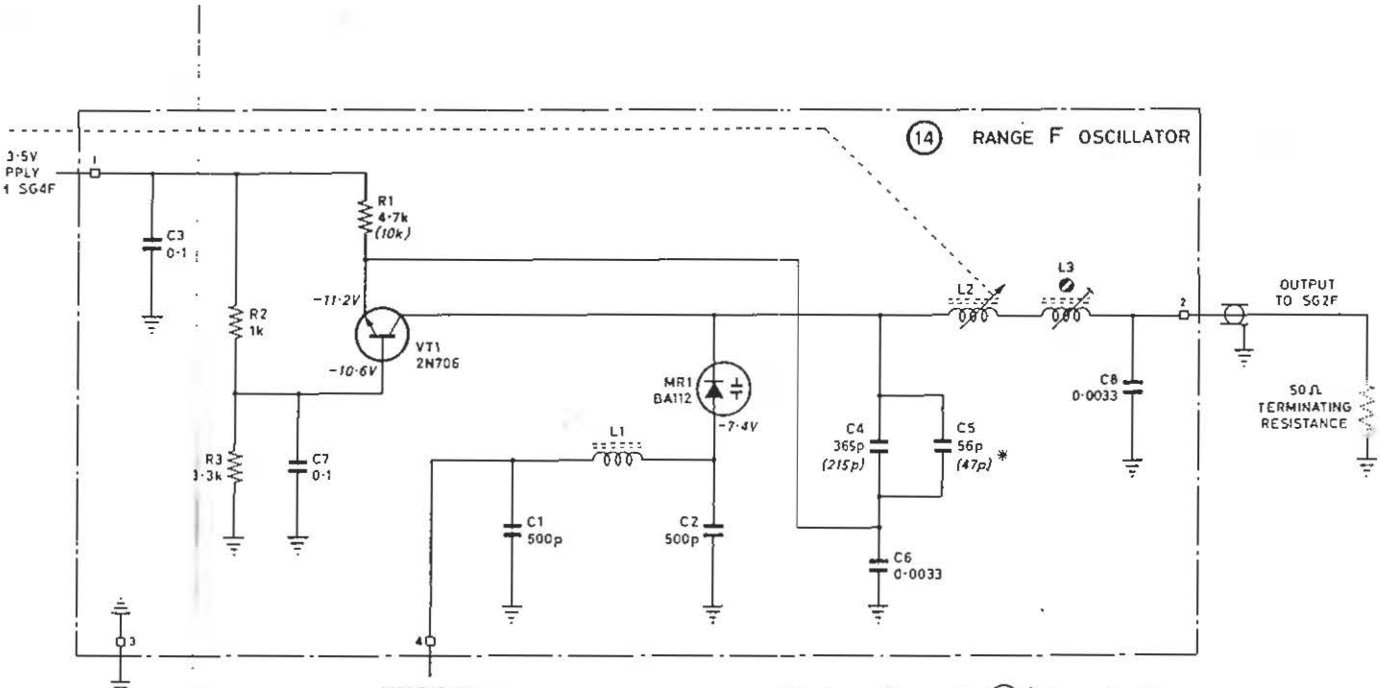
Fig. 5.1 Interconnection diagram



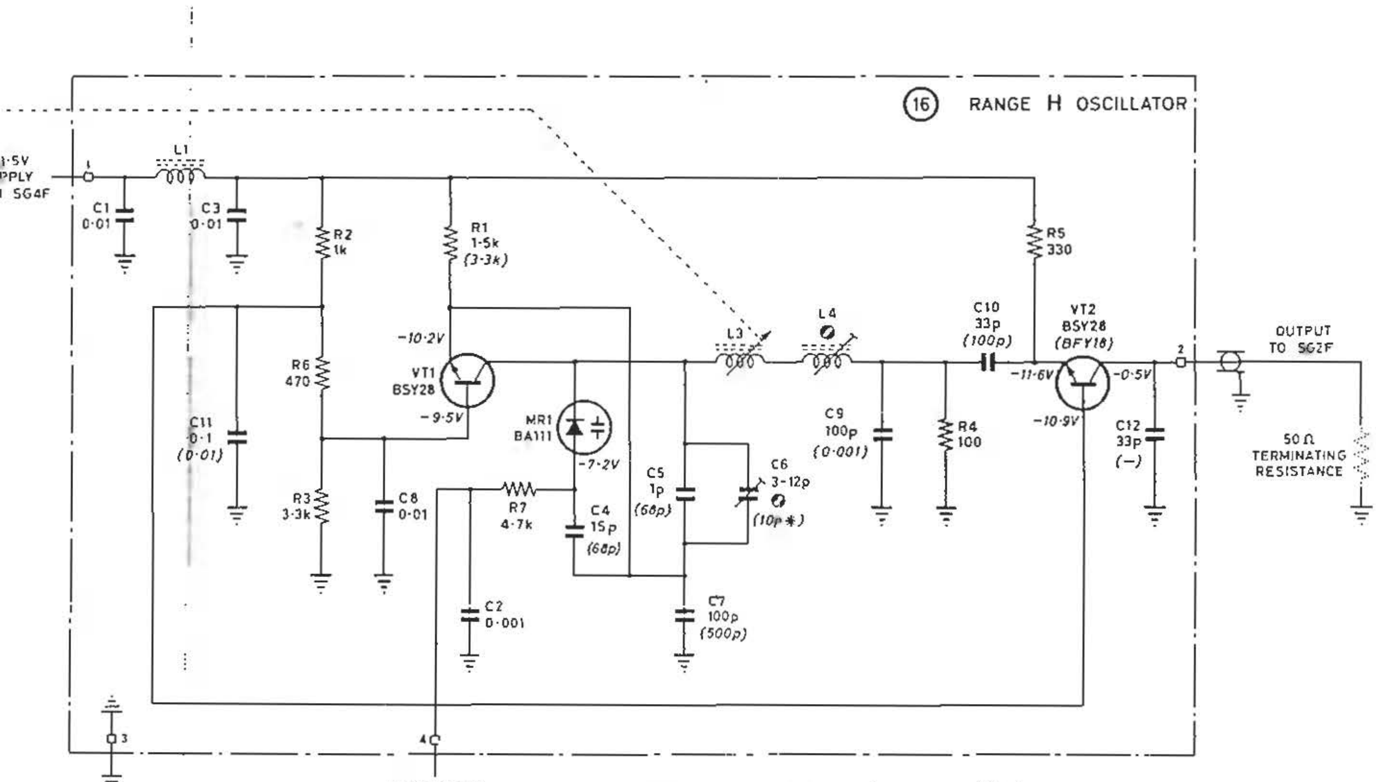
Range A oscillator (board 9) is similar; component values that are different are shown in brackets.



Range C oscillator (board 11) is similar; component values that are different are shown in brackets.

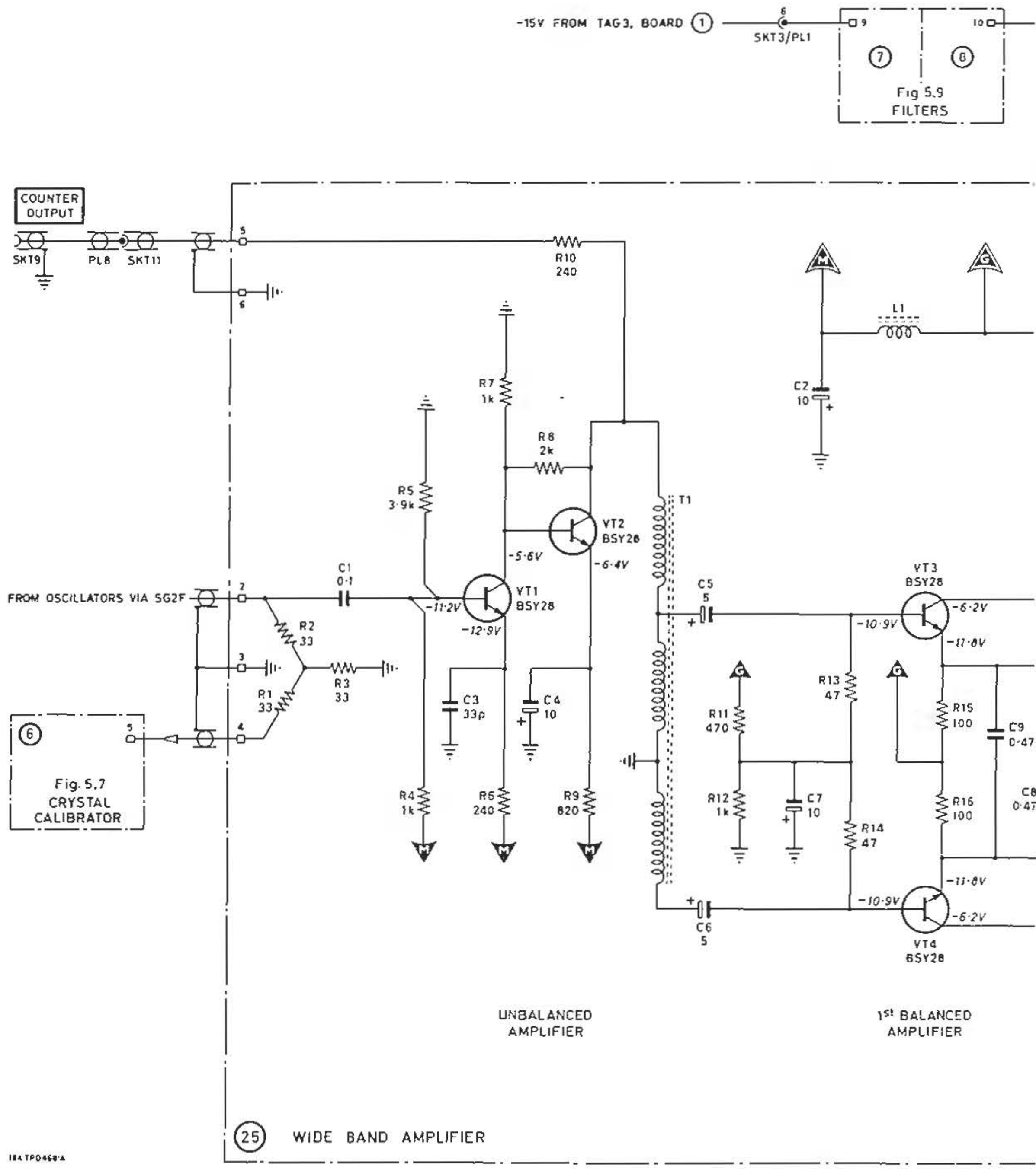


Range E oscillator (board (13)) is similar; component values that are different are shown in brackets.



Range G oscillator (board (15)) is similar; component values that are different are shown in brackets. C6 is a fixed capacitor and C12 is not fitted.

Fig. 5.2 Circuit diagram—oscillators


-15V FROM TAG3, BOARD 1
SKT3/PL1
Fig 5.9
FILTERS
COUNTER OUTPUT
SKT9
PL8
SKT11
R10
240
R7
1k
R8
2k
R5
3·9k
VT2
BSY28
-5·6V
-6·4V
T1
C1
0·1
FROM OSCILLATORS VIA SG2F
VT1
BSY28
-11·2V
-12·9V
R2
33
R3
33
R1
33
C3
33p
C4
10
Fig. 5.7
CRYSTAL
CALIBRATOR
R4
1k
R6
240
R9
820
L1
C2
10
C5
5
VT3
BSY28
-6·2V
-10·9V
-11·8V
R13
47
R11
470
R15
100
C9
0·47
R12
1k
C7
10
R14
47
R16
100
C6
5
VT4
BSY28
UNBALANCED
AMPLIFIER
1st BALANCED
AMPLIFIER
25 WIDE BAND AMPLIFIER

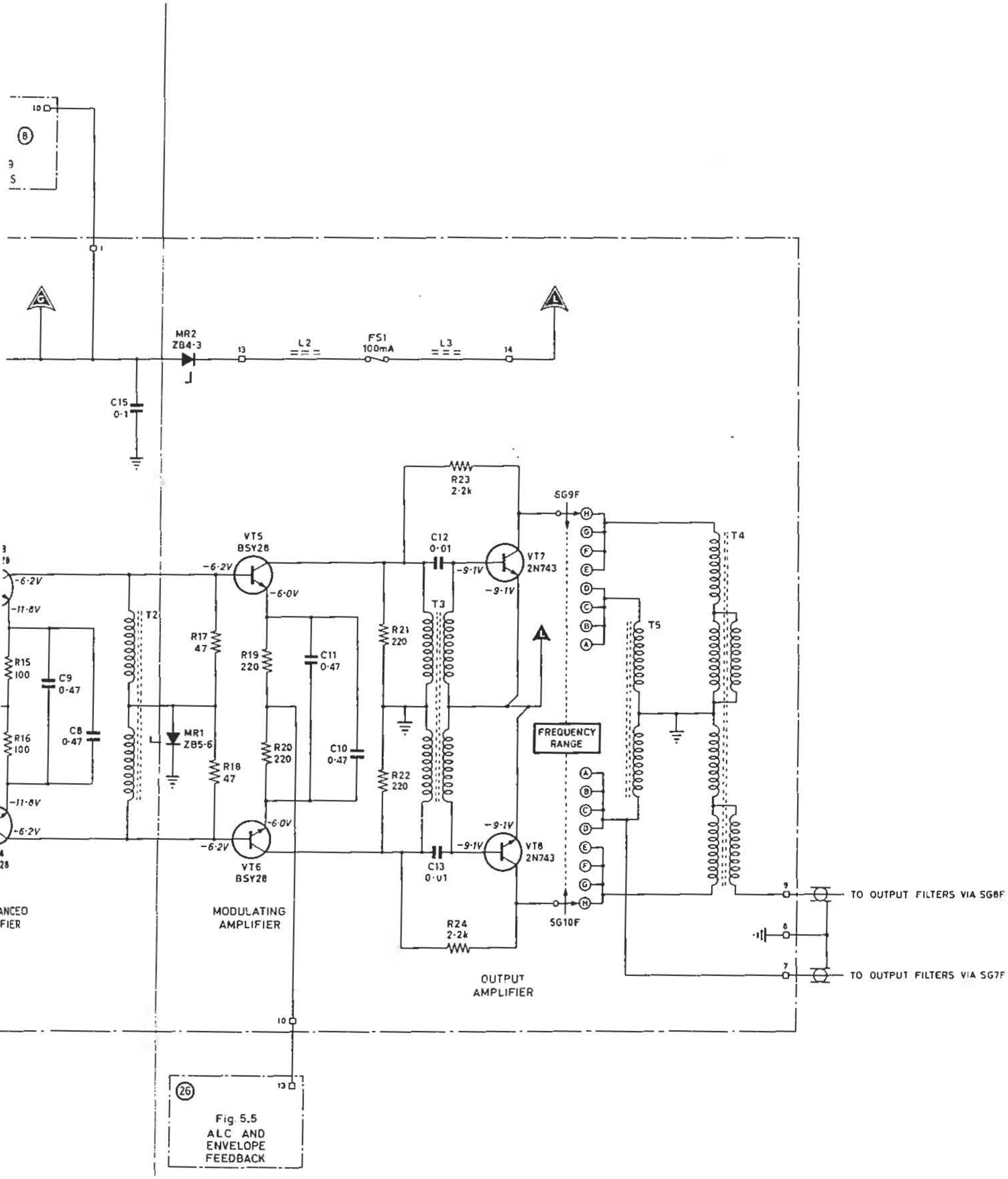
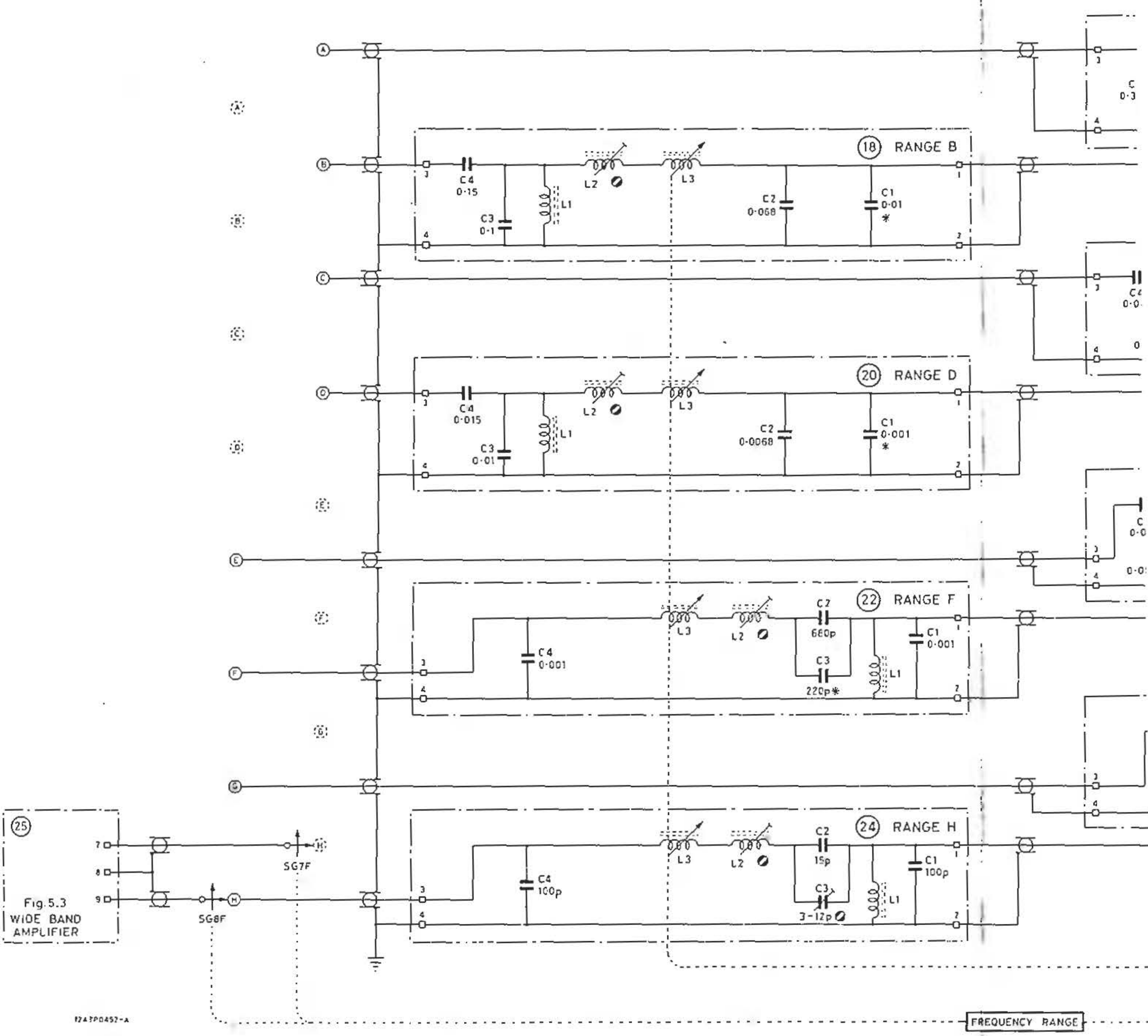


Fig. 5.3 Circuit diagram—wide band amplifier



18 RANGE B
C4 0·15
C3 0·1
L1
L2
L3
C2 0·068
C1 0·01 *
20 RANGE D
C4 0·015
C3 0·01
C2 0·0068
C1 0·001 *
22 RANGE F
C4 0·001
C2 680p
C3 220p*
C1 0·001
24 RANGE H
C4 100p
C2 15p
C3 3-12p
C1 100p
25
Fig.5.3 WIDE BAND AMPLIFIER
SG7F
SG8F
FREQUENCY RANGE

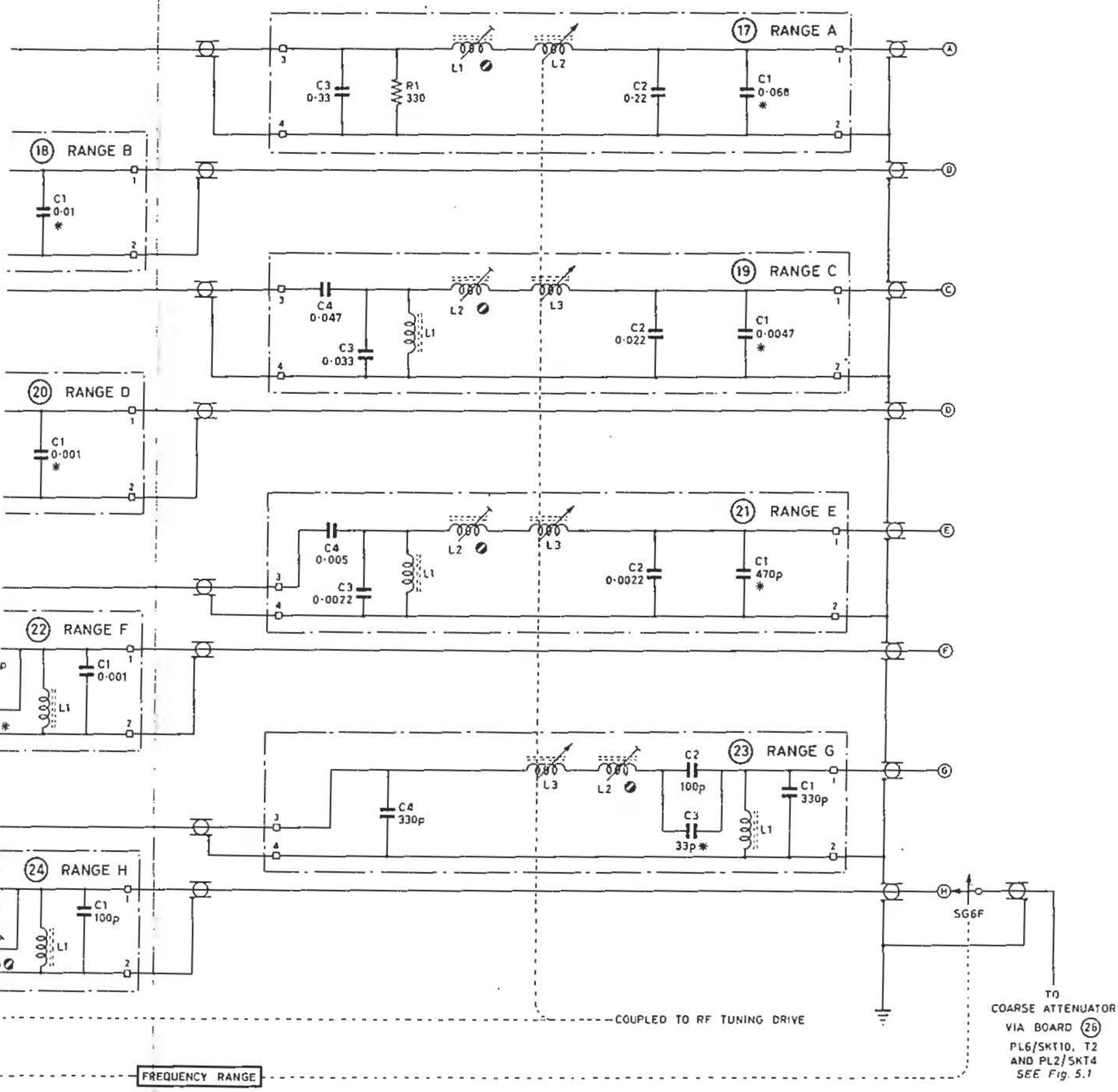
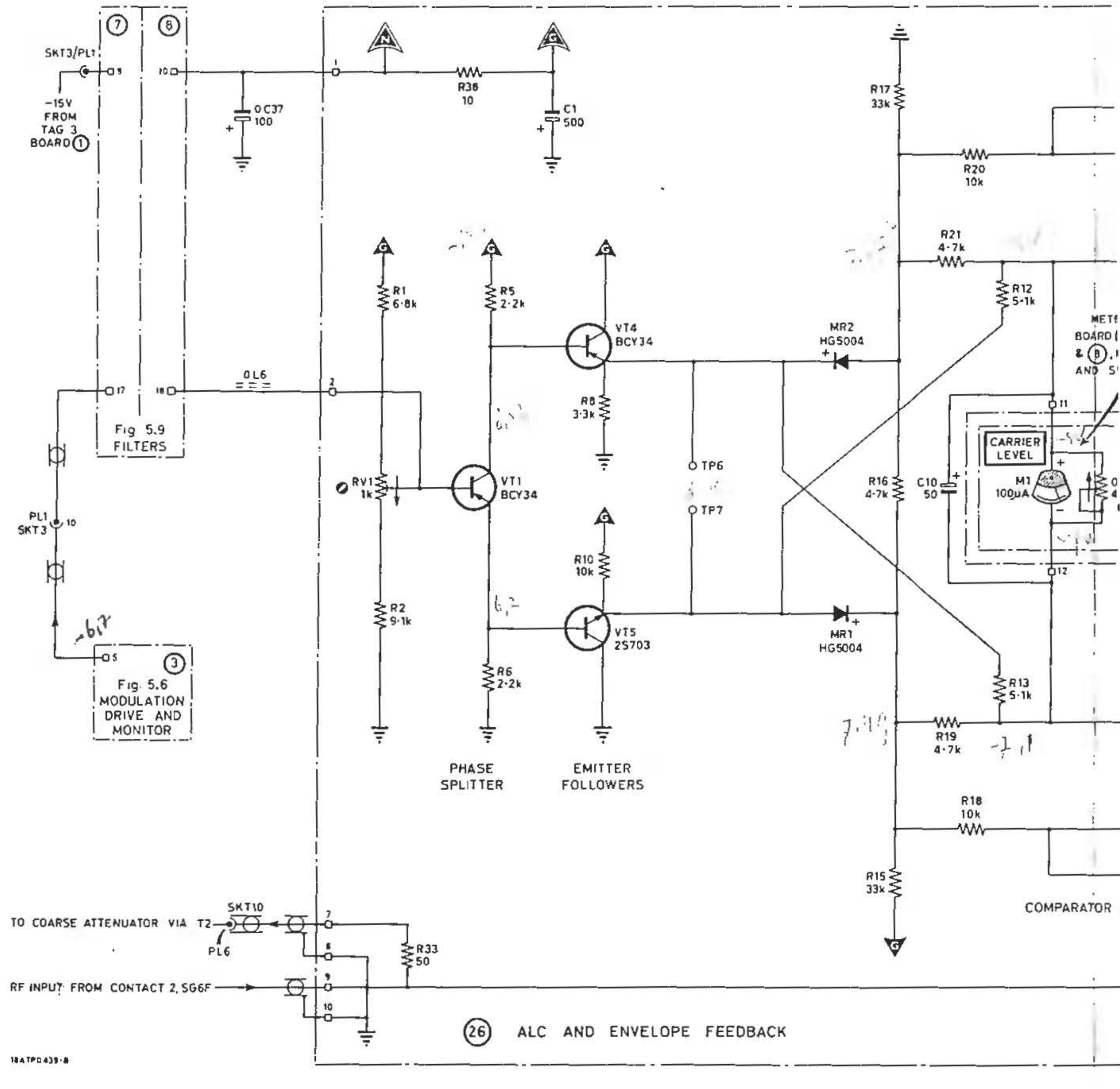


Fig. 5.4 Circuit diagram—output filters


SKT3/PL1
-15V FROM TAG 3 BOARD 1
C37 100
R38 10
C1 500
R17 33k
R20 10k
R21 4·7k
R12 5·1k
R1 6·8k
R5 2·2k
VT4 BCY34
MR2 HG5004
R8 3·3k
OL6
Fig 5.9 FILTERS
TP6
TP7
CARRIER LEVEL
M1 100μA
RV1 1k
VT1 BCY34
R16 4·7k
C10 50
PL1 SKT3
R10 10k
R2 9·1k
VT5 2S703
MR1 HG5004
Fig. 5.6 MODULATION DRIVE AND MONITOR
R6 2·2k
R13 5·1k
R19 4·7k
PHASE SPLITTER
EMITTER FOLLOWERS
R18 10k
R15 33k
COMPARATOR
TO COARSE ATTENUATOR VIA T2
SKT10
PL6
R33 50
RF INPUT FROM CONTACT 2, SG6F
26 ALC AND ENVELOPE FEEDBACK
18ATPD439·8

2002 (1a)

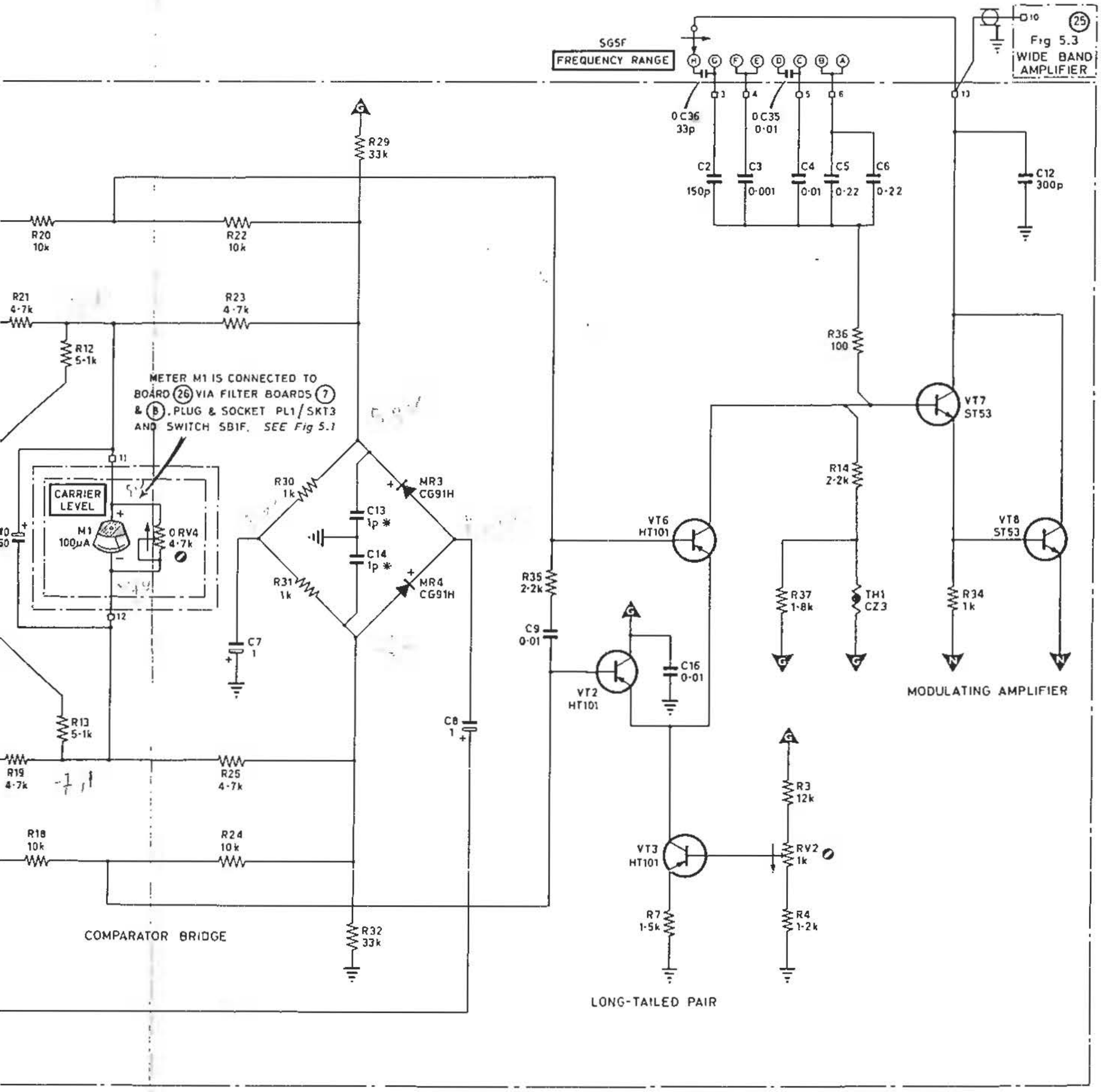
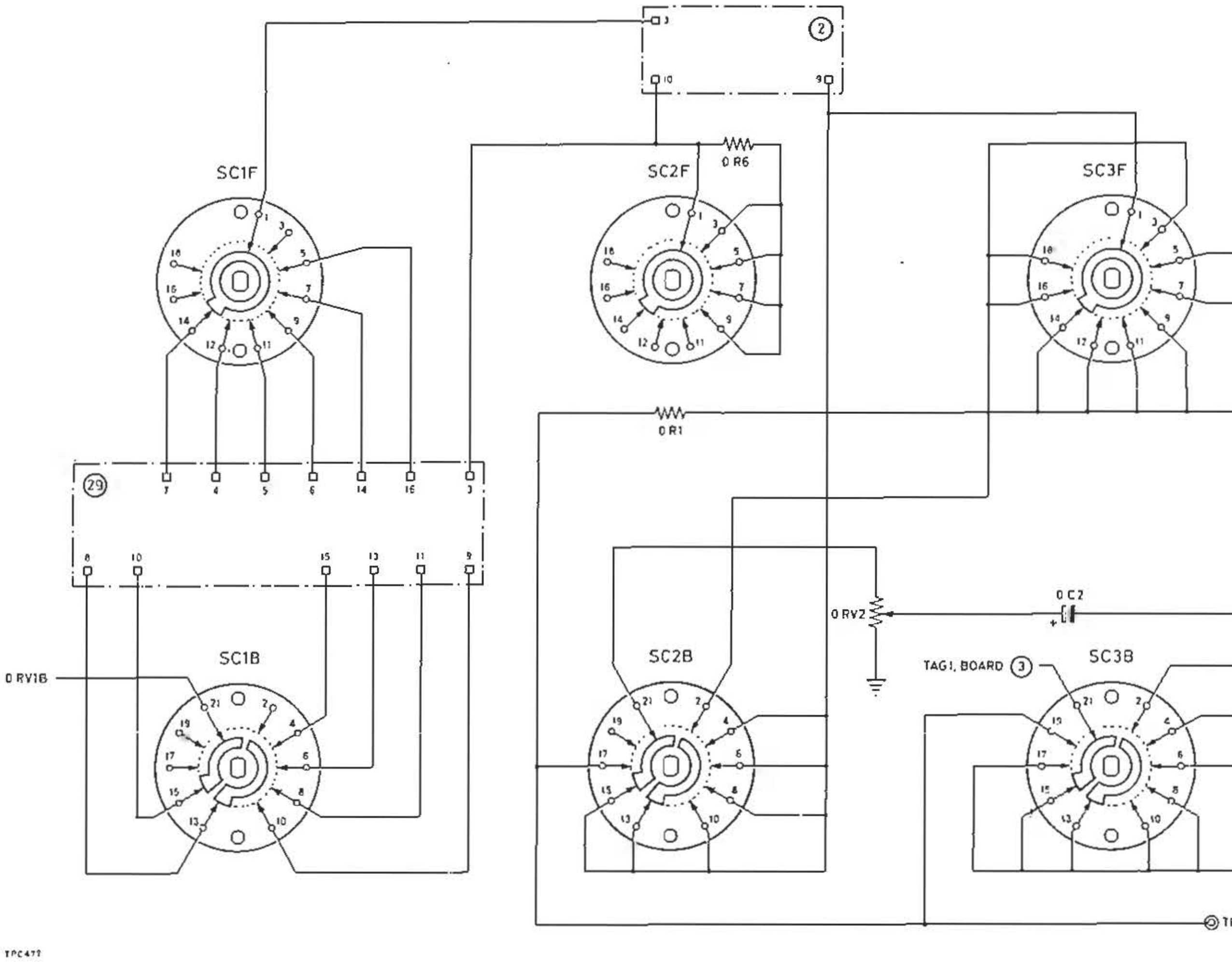
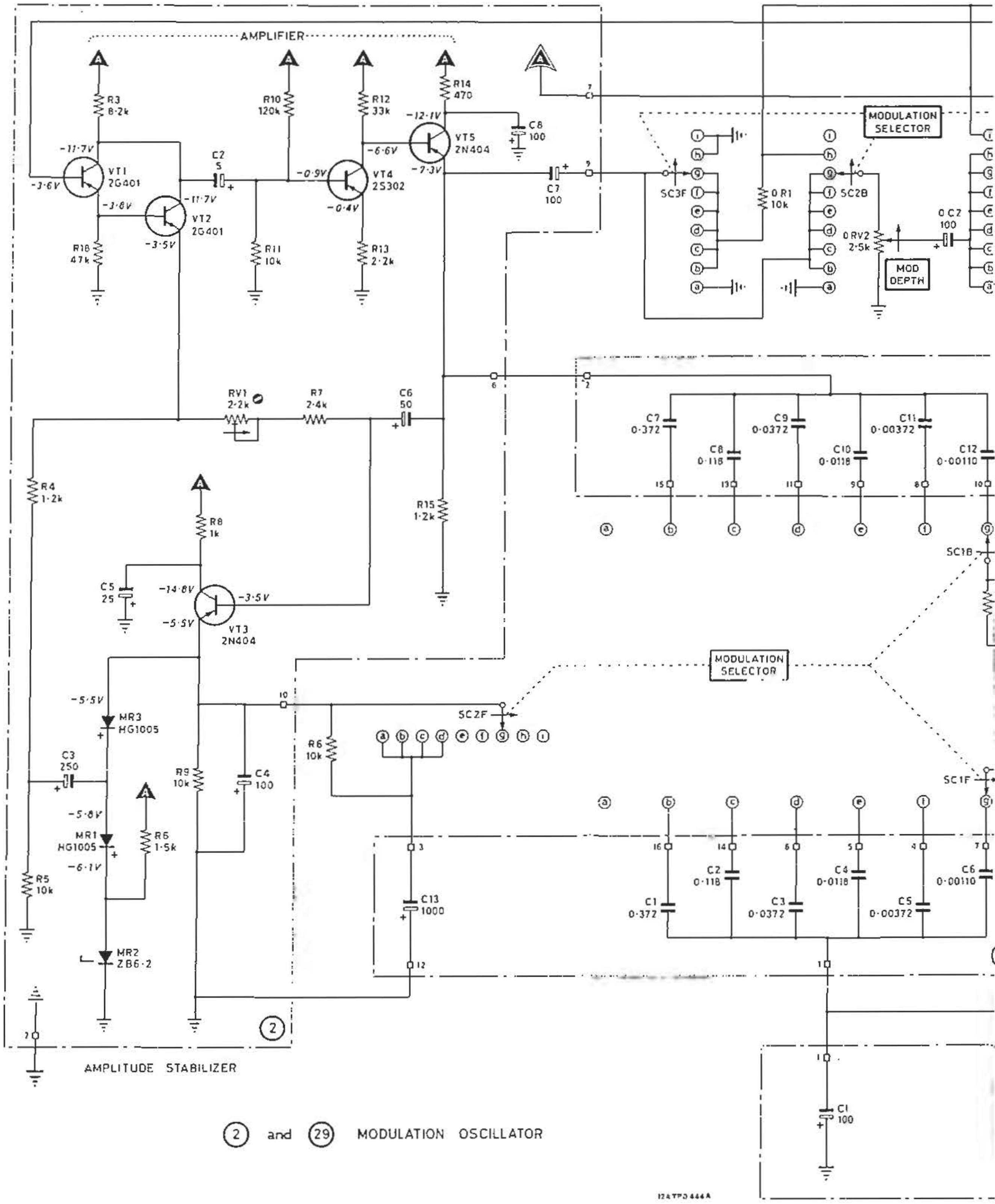


Fig. 5.5 Circuit diagram—a.l.c. and envelope feedback



SC—plan of sections viewed from knob end with switch in 6.3 k—20 k positions



(2) and (29) MODULATION OSCILLATOR

12ATPD444A

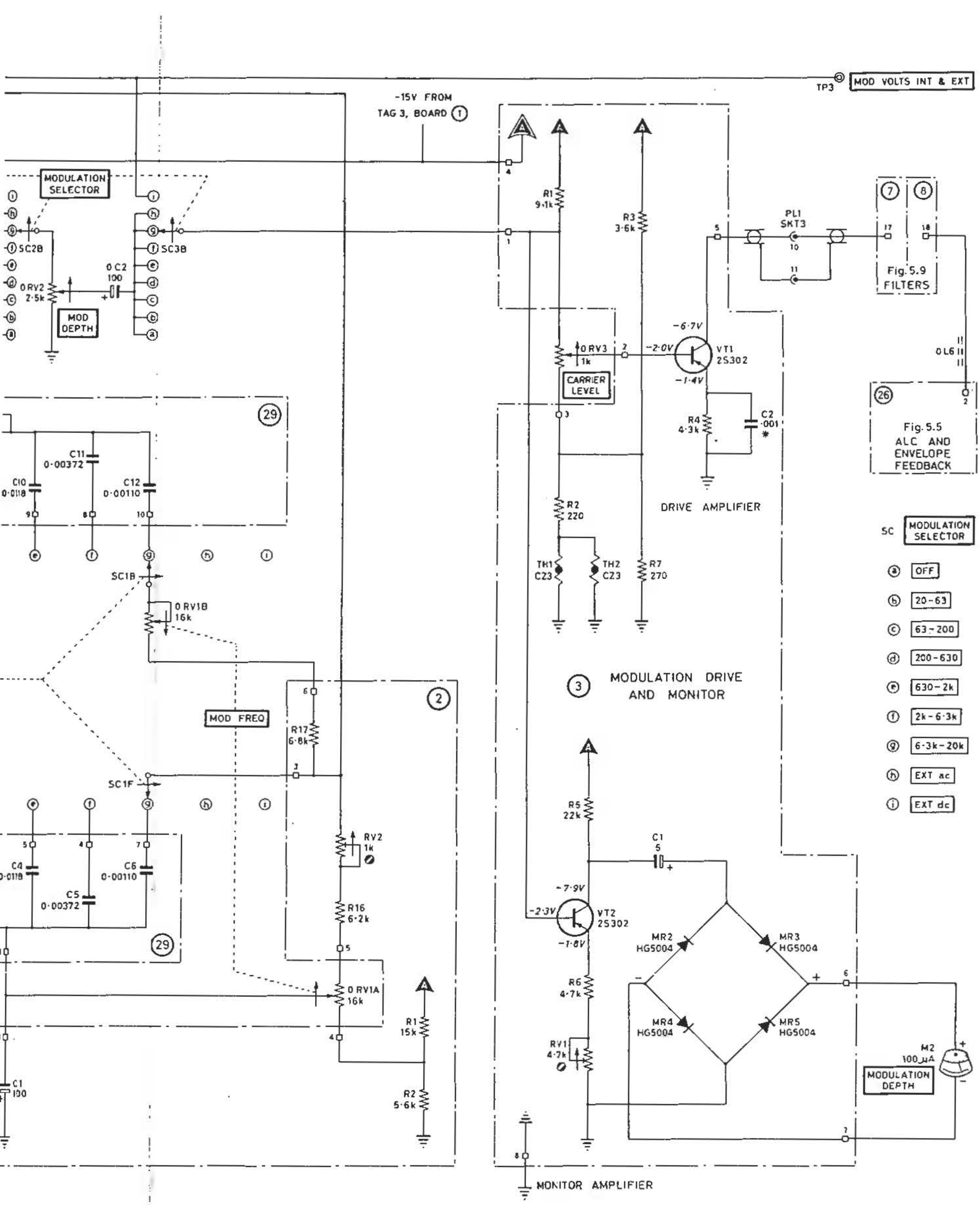
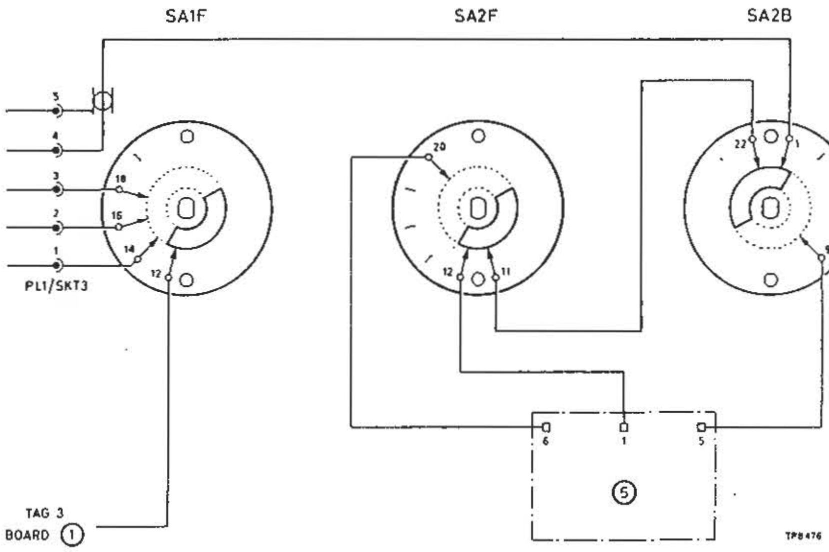
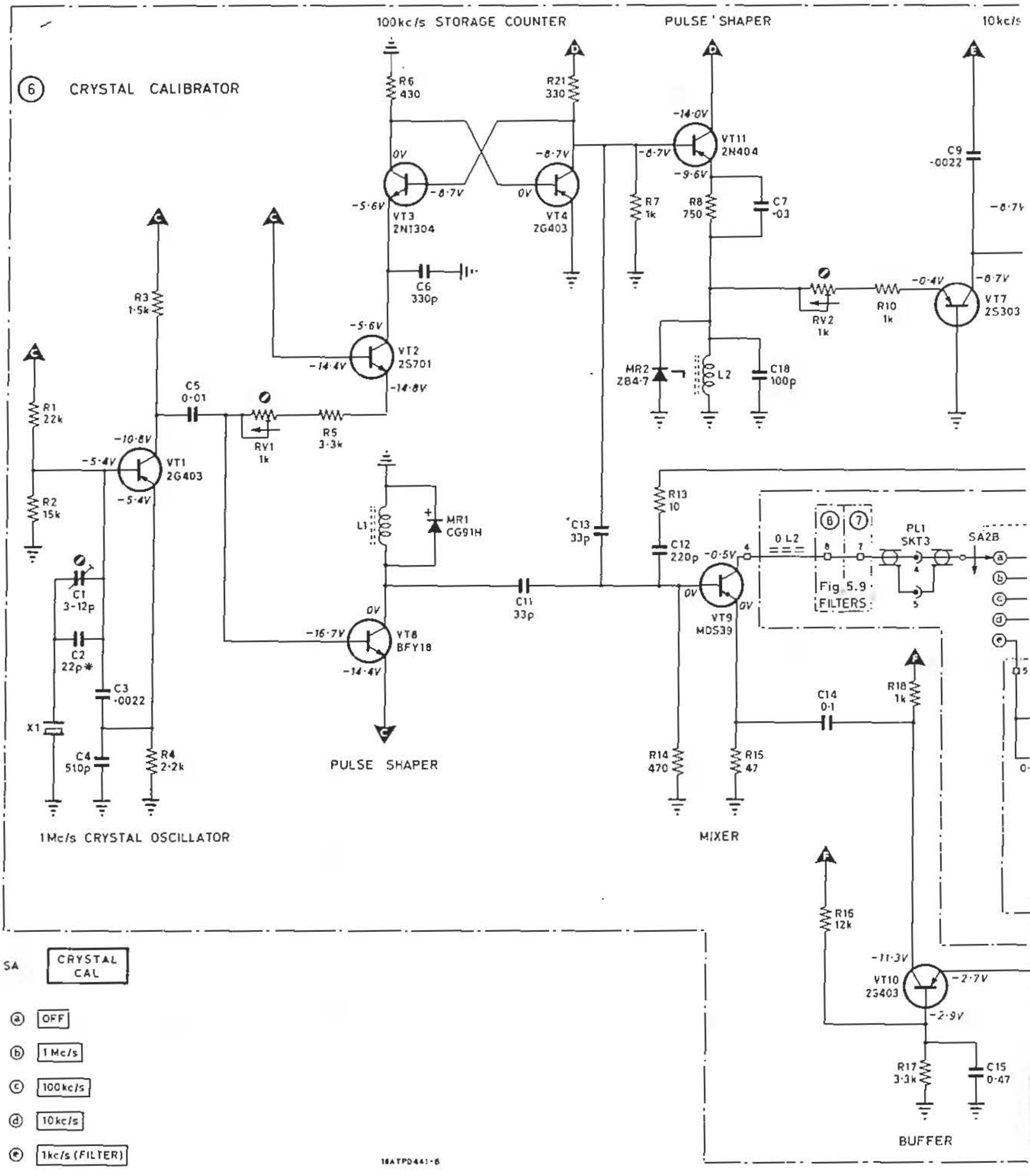


Fig. 5.6 Circuit diagram—modulation oscillator and drive .



SA—plan of sections viewed from knob end with switch in fully counter-clockwise position



6 CRYSTAL CALIBRATOR
100kc/s STORAGE COUNTER
PULSE SHAPER
10kc/s
1Mc/s CRYSTAL OSCILLATOR
PULSE SHAPER
MIXER
BUFFER
VT1 2G403
VT2 2S701
VT3 2N1304
VT4 2G403
VT7 2S303
VT8 BFY18
VT9 MDS39
VT10 2S403
VT11 2N404
R1 22k
R2 15k
R3 1·5k
R4 2·2k
R5 3·3k
R6 430
R7 1k
R8 750
R10 1k
R13 10
R14 470
R15 47
R16 12k
R17 3·3k
R18 1k
R21 330
RV1 1k
RV2 1k
C1 3-12p
C2 22p*
C3 ·0022
C4 510p
C5 0·01
C6 330p
C7 ·03
C9 ·0022
C11 33p
C12 220p
C13 33p
C14 0·1
C15 0·47
C18 100p
X1
L1
L2
MR1 CG91H
MR2 Z84·7
PL1 SKT3
SA2B
Fig 5.9 FILTERS
SA
CRYSTAL CAL
a OFF
b 1Mc/s
c 100kc/s
d 10kc/s
e 1kc/s (FILTER)
18ATPD441-6

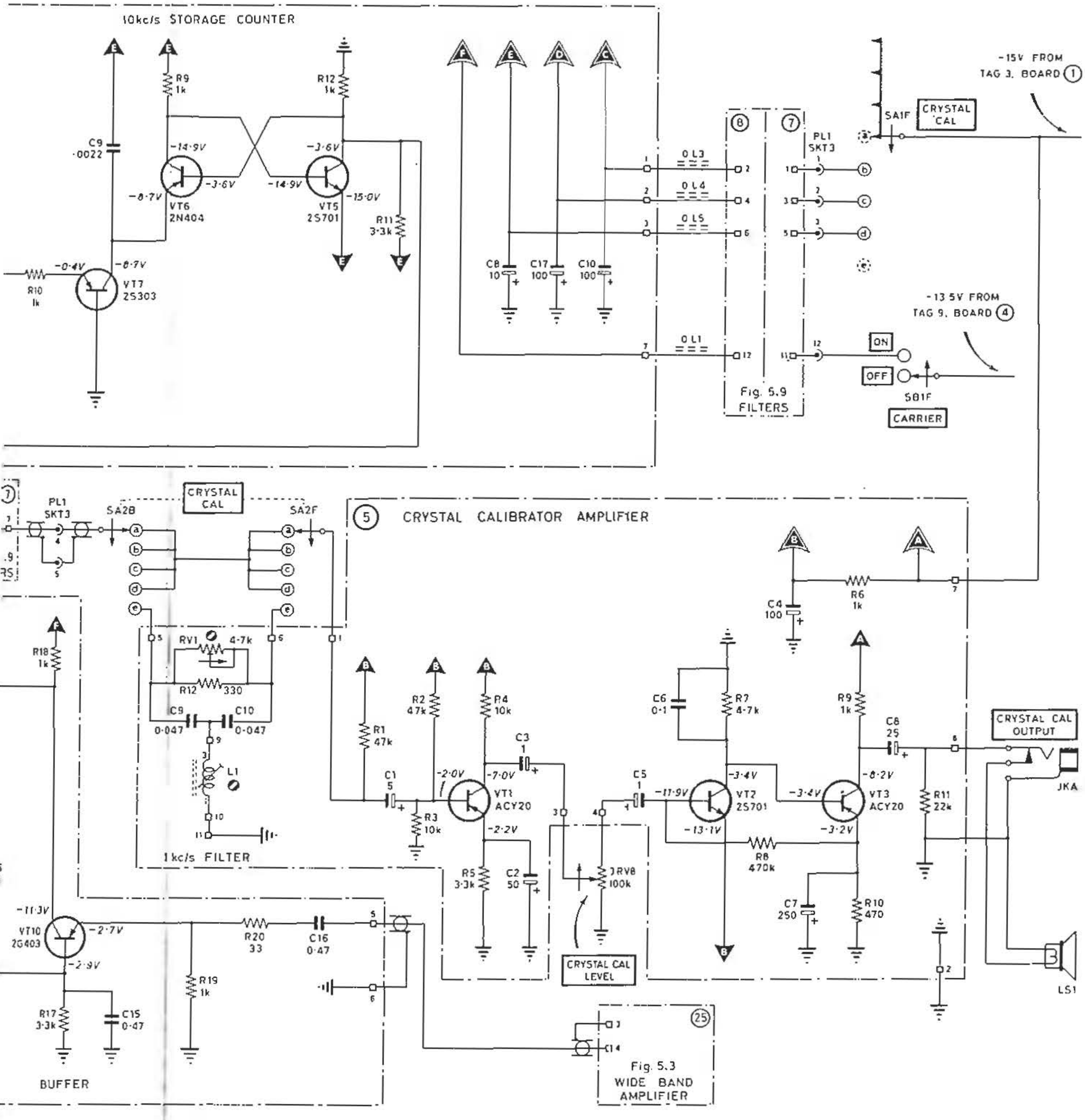
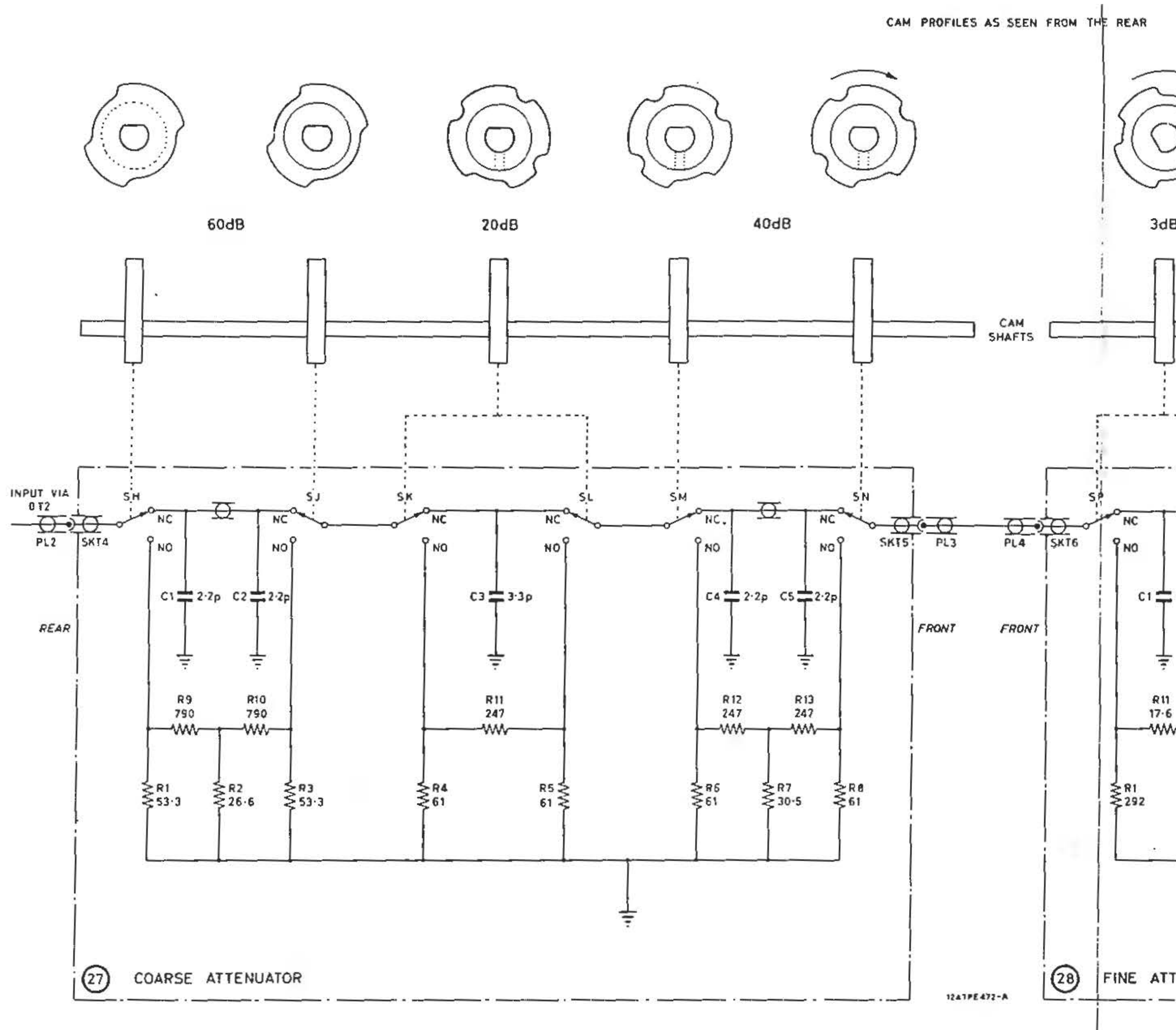
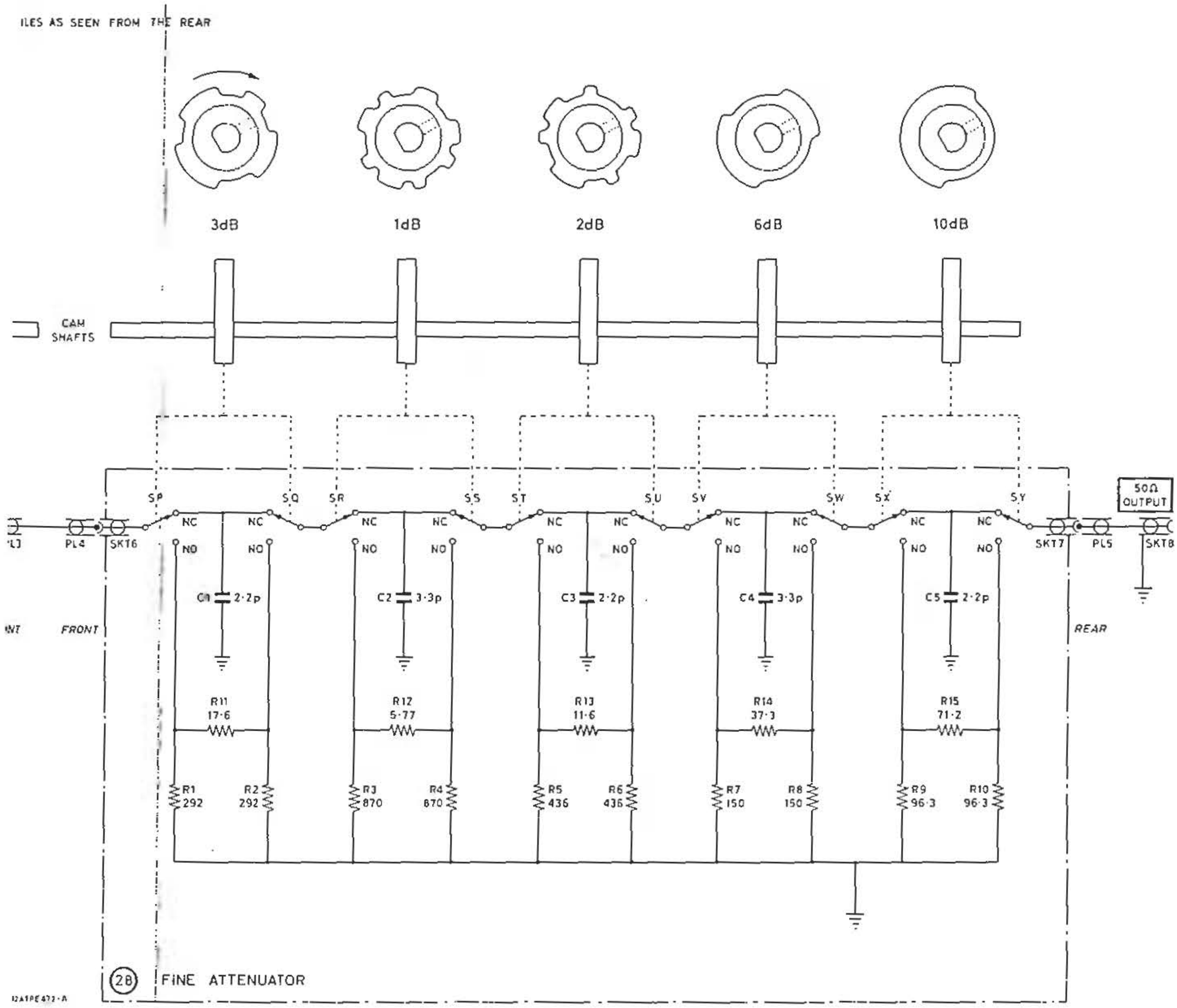


Fig. 5.7 Circuit diagram—crystal calibrator



100	80	60	40	20	0	-20	dB ABOVE 1µV —ADD—			0	1	2
0	20	40	60	80	100	120	ATTENUATION dB			20	19	18
							PAD SECTIONS IN CIRCUIT					
							dB		dB			
—	π	—	π	π	—	π	20		1	π	—	—
—	—	π	π	—	π	π	40		2	—	—	π
—	—	—	—	π	π	π	60		3	π	π	—
									6	π	π	π
									10	π	π	π



B ABOVE 1µV —ADD—		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
TENUATION dB		20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
AD SECTIONS IN CIRCUIT																						
	dB																					
	1	Π	—	—	Π	Π	—	Π	—	—	Π	Π	—	—	Π	Π	—	Π	—	—	Π	—
	2	—	—	Π	—	Π	Π	—	—	Π	—	—	—	Π	—	Π	Π	—	—	Π	—	—
	3	Π	Π	—	—	Π	Π	Π	Π	—	—	Π	Π	—	—	Π	Π	Π	Π	—	—	—
	6	Π	Π	Π	Π	—	—	—	—	—	—	Π	Π	Π	Π	—	—	—	—	—	—	—
	10	Π	Π	Π	Π	Π	Π	Π	Π	Π	Π	—	—	—	—	—	—	—	—	—	—	—

Fig. 5.8 Circuit diagram—attenuators

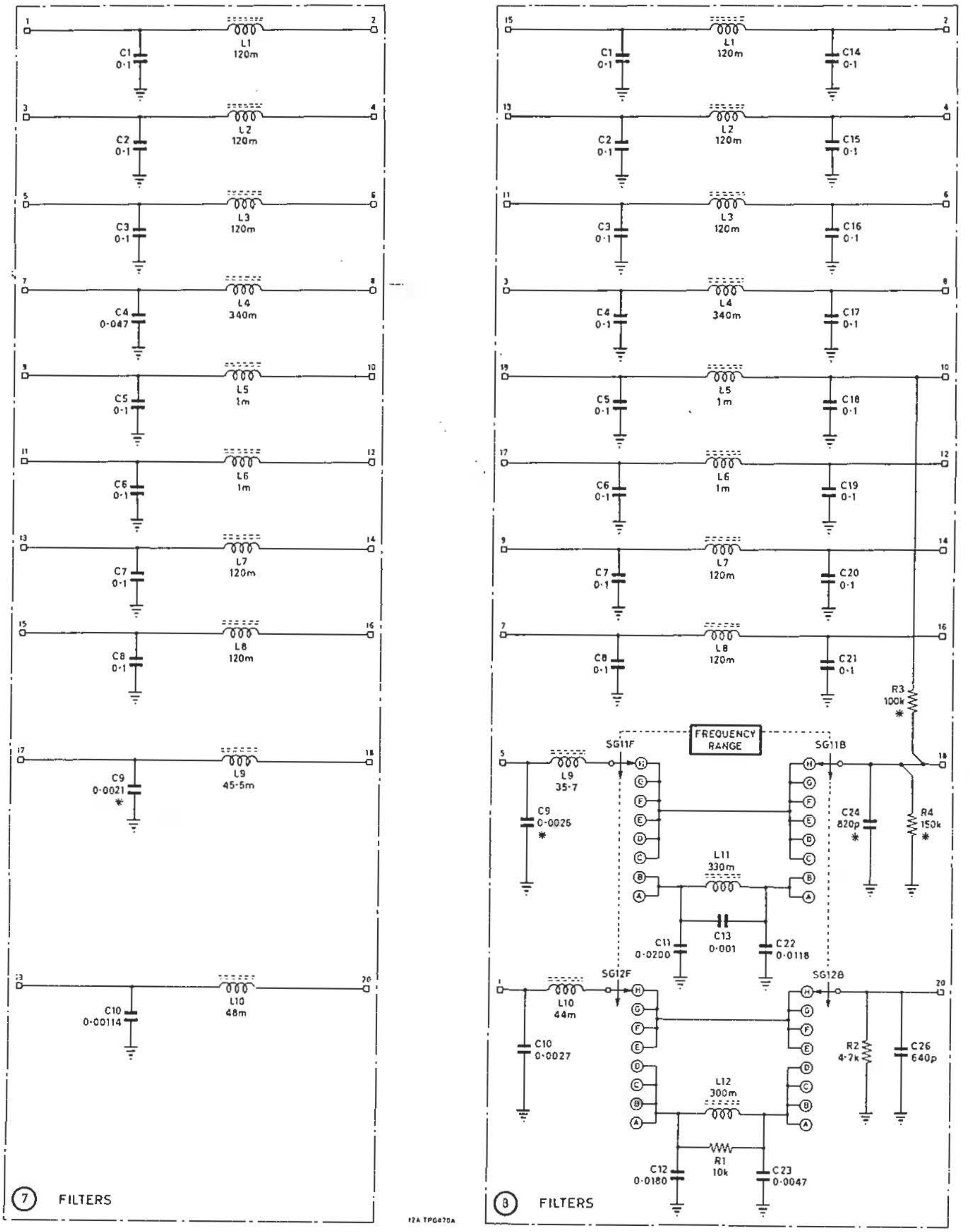
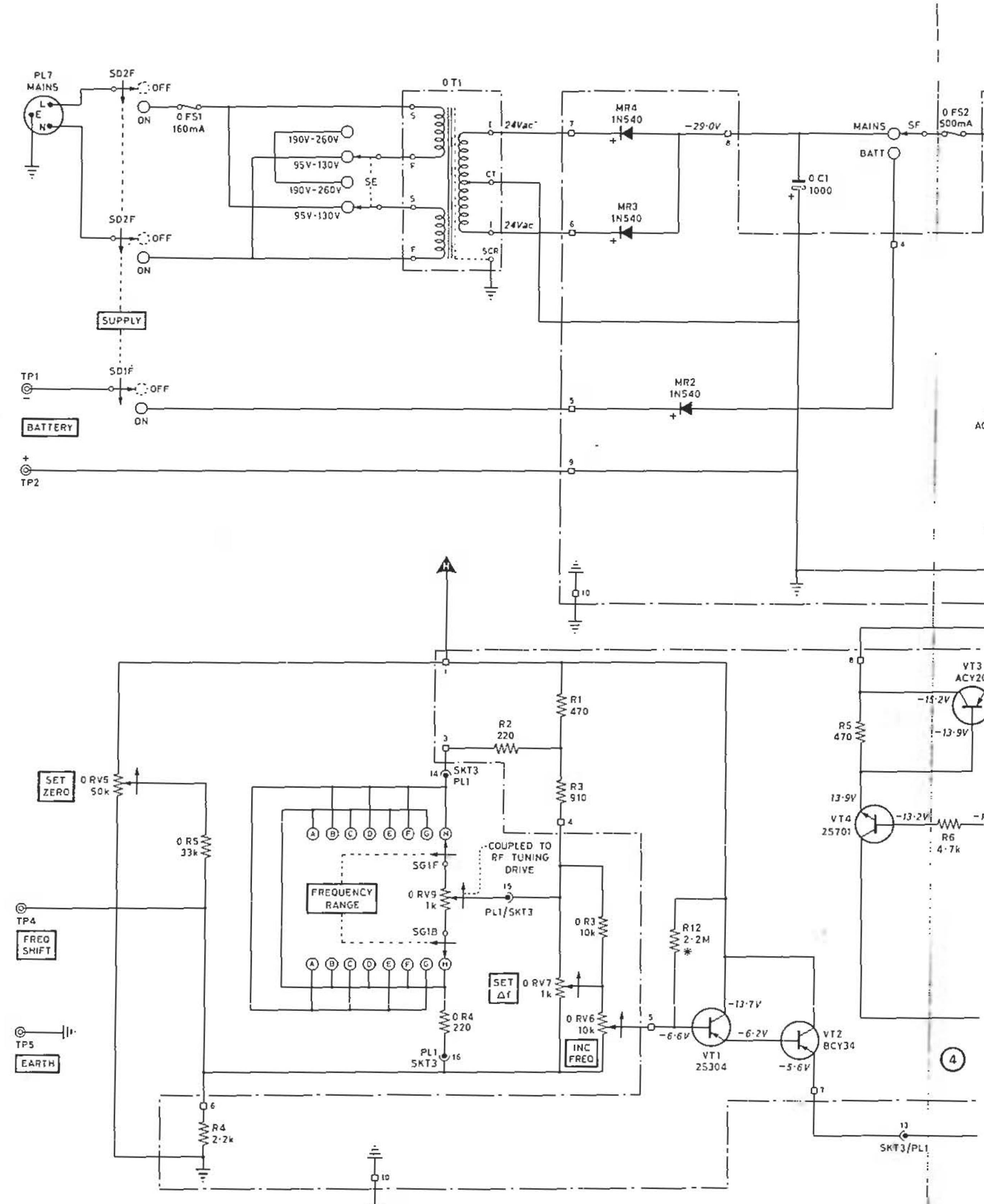


Fig. 5.9 Circuit diagram—r.f. unit filters



INCREMENTAL FREQUENCY DRIVER

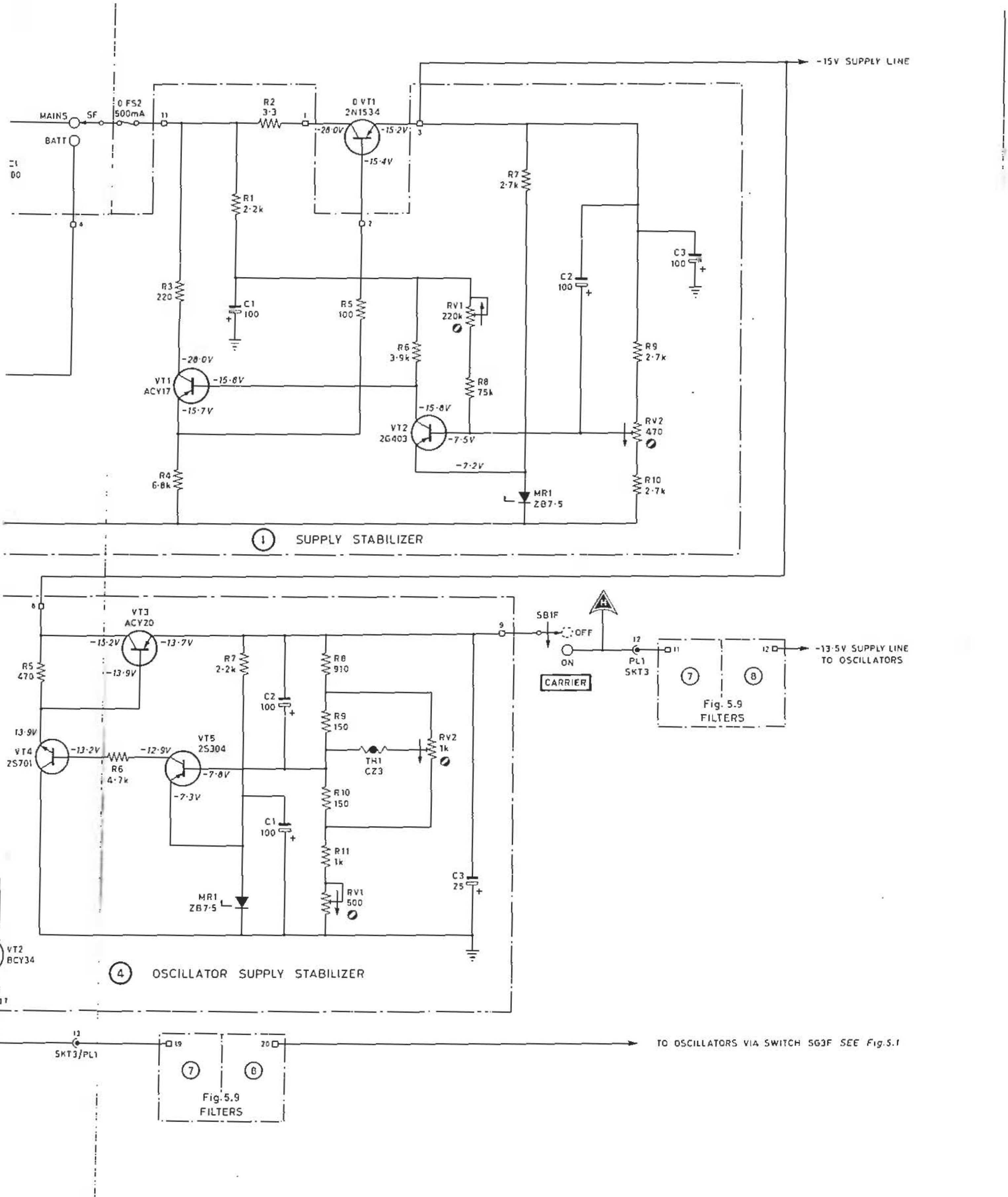


Fig. 5.10 Circuit diagram—power supplies