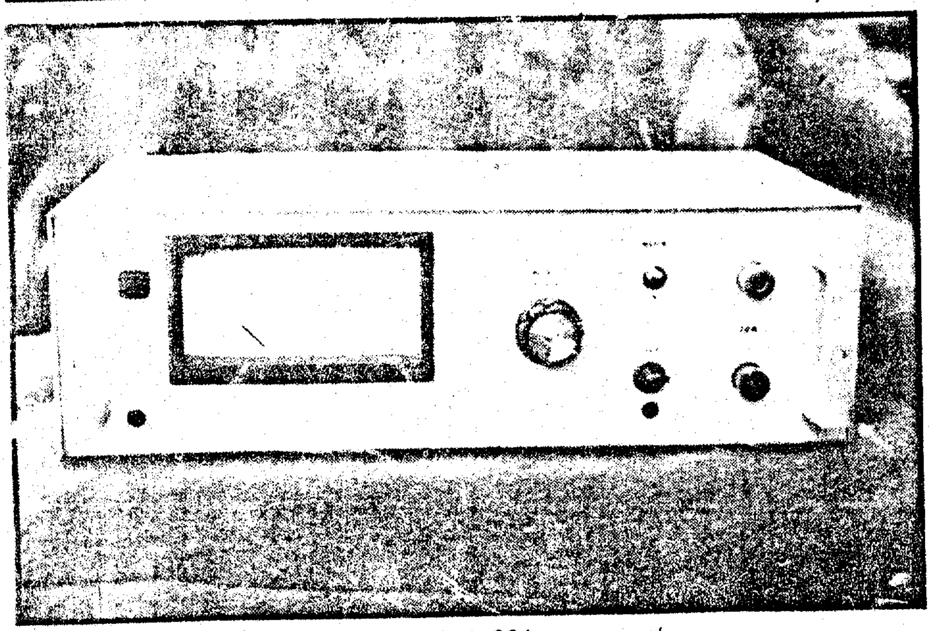
A VARIABLE 20A REGULATED POWER SUPPLY

By Arthur Forster VK2DKF



The author's variable 20A power supply.

The writer set out to design and construct a high current power supply to power a nominal 100W 13V HF transceiver. Many circuits of power supplies have been published for supplies of up to 6A. It becomes more difficult to find designs for 20A however. As the current requirements increase, it becomes difficult to purchase some specific components over the counter, hence the lack of constructional articles.

This design is one amateur's solution to the problems outlined above. It is presented to illustrate what can be done with a little ingenuity by the average amateur, utilising components available to him and adding additional features into the design at modest cost. Many of the major items such as power transformers and filter capacitors can be obtained from the amateur's 'junkbox' or by keeping an eye out for components offered through outlets retailing surplus goods. More about this later.

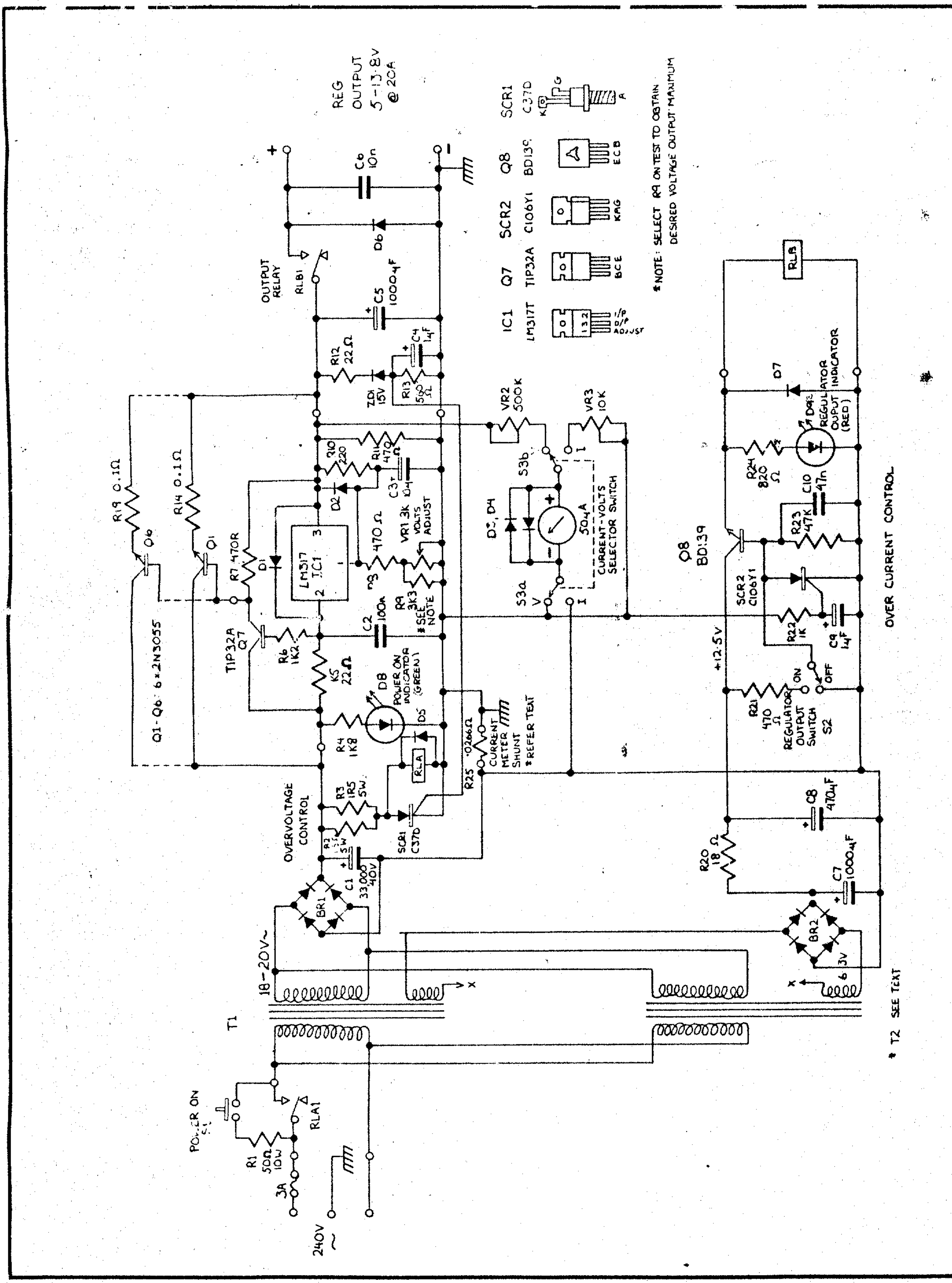
Many circuit designs for high current supplies leave a lot to be desired in relation to the protection circuitry used (if any). A current of 20A or so can do a lot of damage if not adequately protected. It is also desirable to protect the transceiver from high voltages in the event of a fault in the power supply unit. This design pays special attention to the means of over-voltage and over-current protection.

DESIGN FEATURES

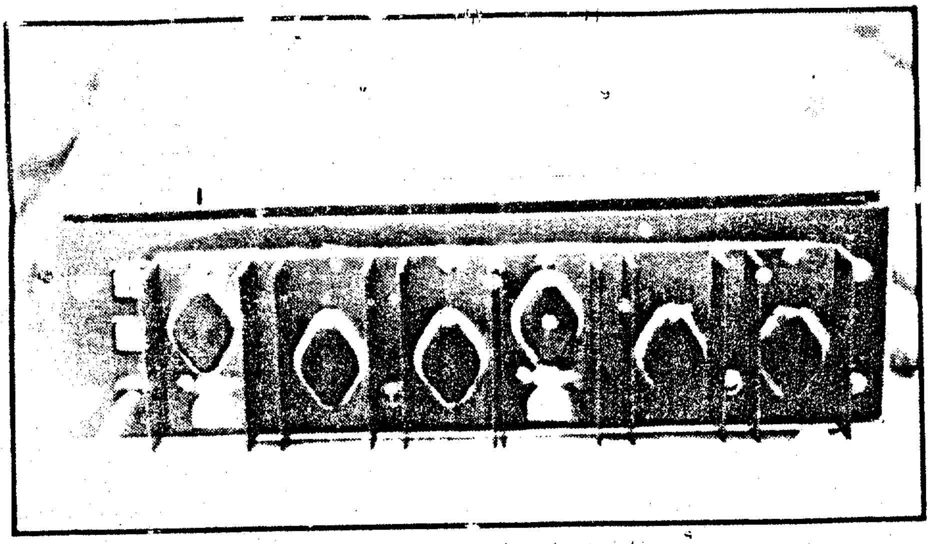
The following features were incorporated in the design of the supply: —

- Output capability of at least 20Amps.
- Ability to adjust output voltage from approximately 5V to 13.8V. This makes the supply very versatile as it can be used for other purposes besides powering a transceiver. Also, the ability to reduce the voltage below 13V is very useful when aligning PA stages.
- Metering for both voltage and current.
- Switching the output by means of a high current relay, thus eliminating the use of a bulky switch capable of carrying 20A.
- Instantaneous short circuit protection using a low cost SCR.
- Over-voltage protection using an SCR crowbar and primary relay to avoid destroying the power supply components in the event of activation!
- Switch-on surge protection in mains primary circuit.
- Use of two lower cost power transformers to supply the required current.
- Elimination of high current secondary fuse.

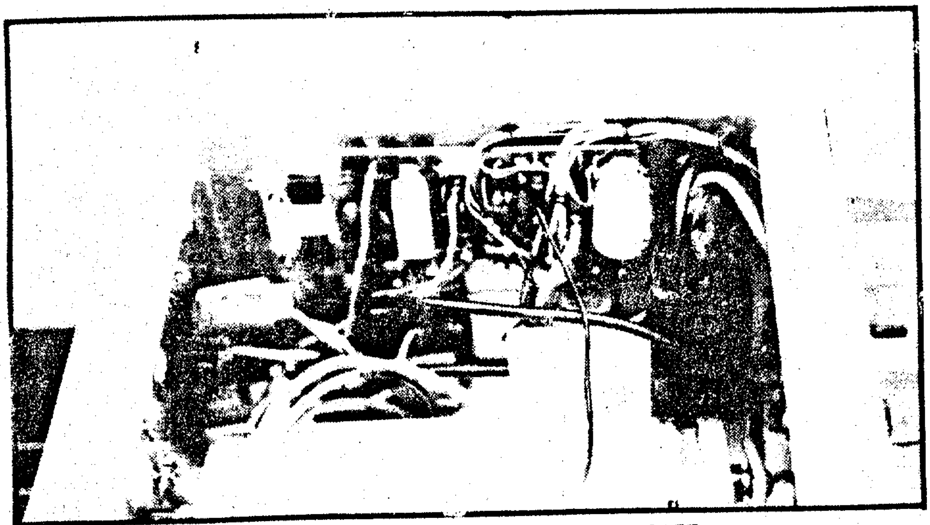
All of the above features were designed into the unit using simple circuitry and readily obtainable components. Here then is a design that can be built with options to suit the ideas of the constructor and the available materials on hand.



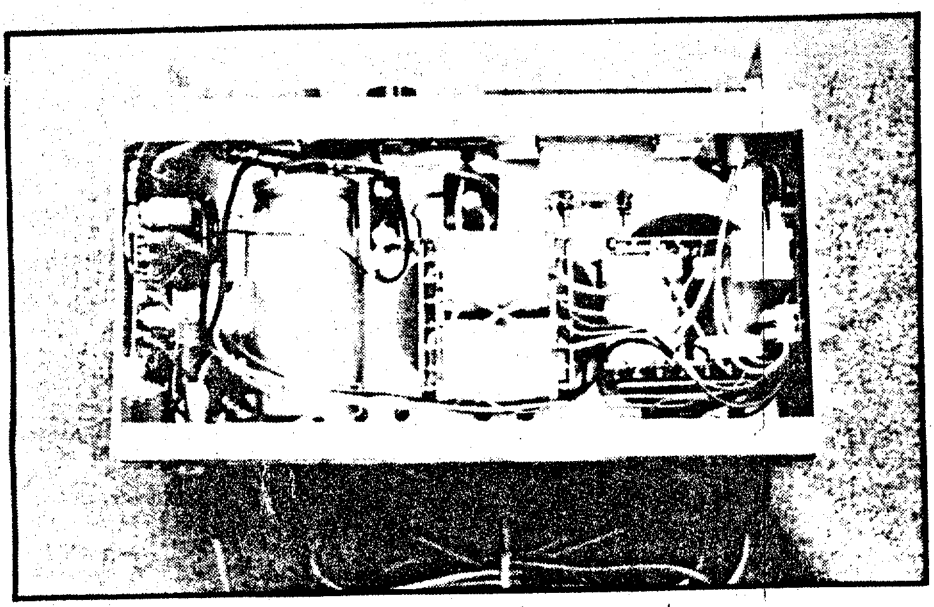
Circuit diagram for the 20A variable power supply.



Rear view shows transistor heat sinking.



Suggested method of heatsinking LM-317T.



Author's interior layout for power supply.

CIRCUIT DESCRIPTION

The regulator circuit itself is a straight forward conventional design using the **LM317T** variable voltage regulator with series pass transistors for current amplification.

For a power supply to power a transceiver, it is desirable to set the upper limit to 13.8V max. The range of control can be tailored to whatever the constructor wishes by varying the resistor combination **R8, R9, VR1.** The voltage control element of the regulator operates as follows: — (refer to fig. 2)

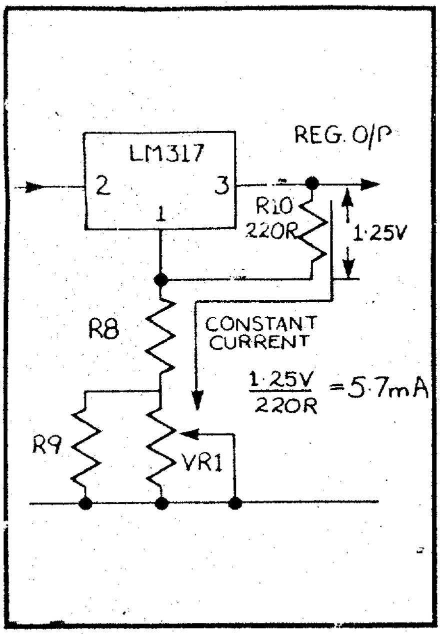
The internal circuitry of the regulator chip is such that it maintains a potential difference of 1.25V between its control pin and its regulated output pin. Therefore the current through **R10, R8, R9** and **VR1** will be constant and equal to 1.25V ÷ 220 ohms. As this is a constant current source it is possible to calculate the combination of resistors **R8, R9, VR1** to give a max. and a min. regulated output voltage. Diodes D1 and D2 are to prevent the capacitors on the regulated output from discharging through the regulator chip when the input is switched off. Capacitors **C2** and **C3** should be connected as close to the pins of the IC as practical to avoid instability.

Q7 connected across the regulator chip provides current drive to six **2N3055** series pass transistors with emitter balance resistors. Although it is possible to get away with less, six transistors were used to keep the power dissipation lower in each transistor. This avoids hot spots developing and spreads the heat dissipation more evenly throughout the heat sinks. The purpose of **C6** is to prevent any RF from the transceiver from entering the power supply and tripping the over-voltage protection circuitry. **C6** should be wired directly across the output terminals.

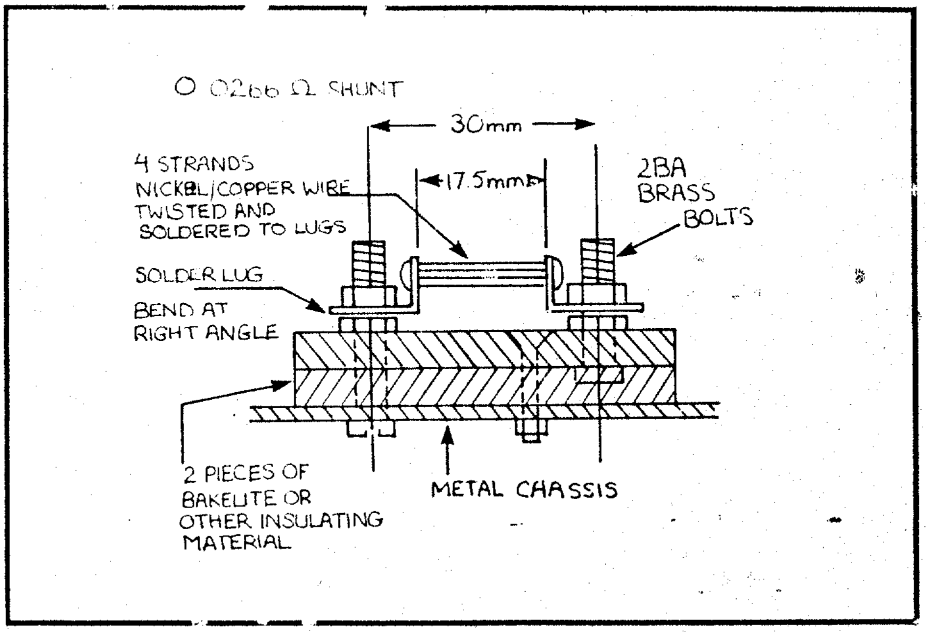
PROTECTION CIRCUITS

Any system that relies upon taking out a fuse in the low voltage-high current circuit will not work reliably and safely under fault conditions with the currents involved. A 20 amp fuse requires at least 3 times its rated current to rupture quickly.

The system used here is a form of circuit breaker which removes the mains supply via relay **RLA** as well as rapidly discharging the filter capacitor under over-voltage fault conditions. A SCR with its gate connected to the zener diode sensing circuit at the output of the regulator, is connected to the unregulated d.c. supply, via current limiting resistors **R2, R3** such that it short circuits the main filter capacitor and the mains relay coil under fault conditions. To start the supply, it is necessary to bypass the contacts of **RLA** by pressing the push-to-start switch **S1.** The low value resistor **R1 in series with S1** limits the mains current to a level which



Regulator arrangement — see text.



Current shunt construction — see text.

allows the mains fuse to be of the quick blow type rather than having to withstand the high current surge during switch on. This also benefits the rectifier and filter capacitor.

The supply to the output terminals is switched using a high current relay to avoid using a large and expensive switch capable of carrying the required current. The relay is an automotive type, used to switch accessory driving lamps and is available at a modest price from auto accessory stores.

The use of a relay in the output circuit lends itself to a very simple, reliable and cost effective method of providing over current protection. The relay **RLB** is controlled by a transistor switch **Q8.** The overcurrent sensing voltage is developed across the current meter shunt **R25** in the return circuit to the bridge rectifier **BR1.** The resistance of the shunt is such that when the output current exceeds 26 amps, approx 0.665V is developed across it. This voltage fires the SCR in the base circuit of **Q8,** switching off the transistor and tripping the relay, thus isolating the output terminals. The output indicator L.E.D. **D9** indicates when the output is switched on.

As a separate 6.3V winding was on the transformers used, a separate low current supply was arranged to drive the control circuit.

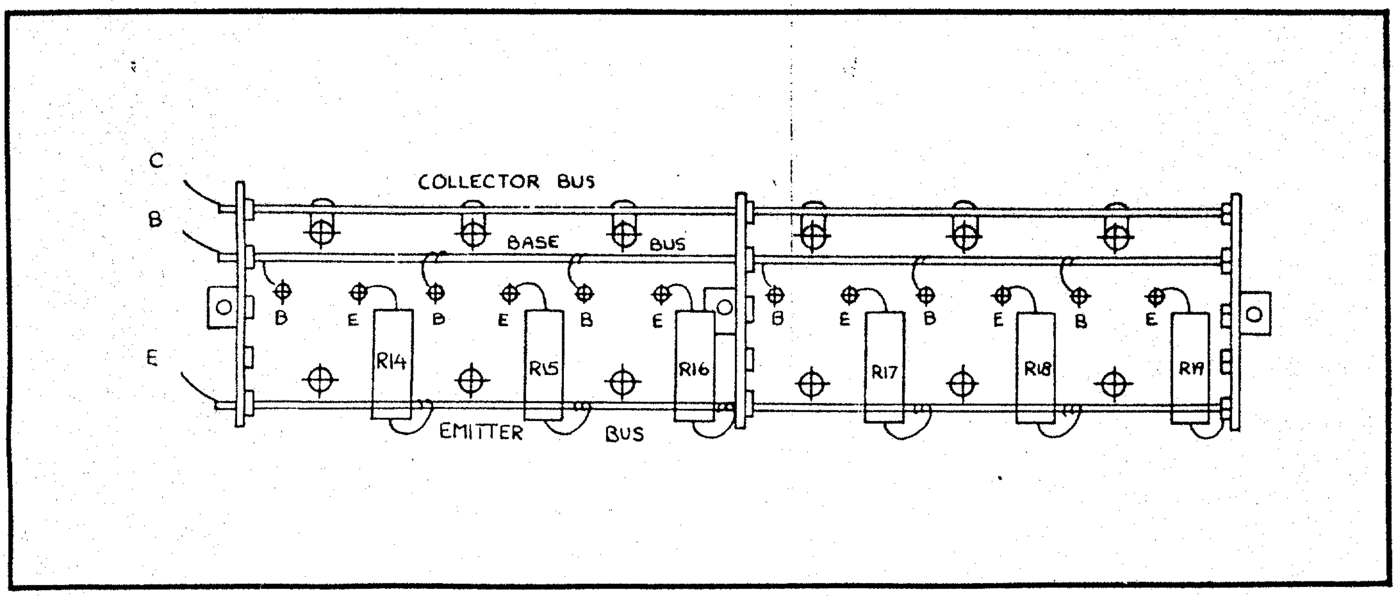
However a twelve volt supply could be arranged by using a 12V regulator chip or a series pass transistor from the main 20V supply at the high current filter capacitor terminals. Note that the earth return of **RLB** control circuit must be connected to the rectifier side of the current shunt **R25.**

This approach to protection, whilst appearing complicated, is in fact the most cost effective way.

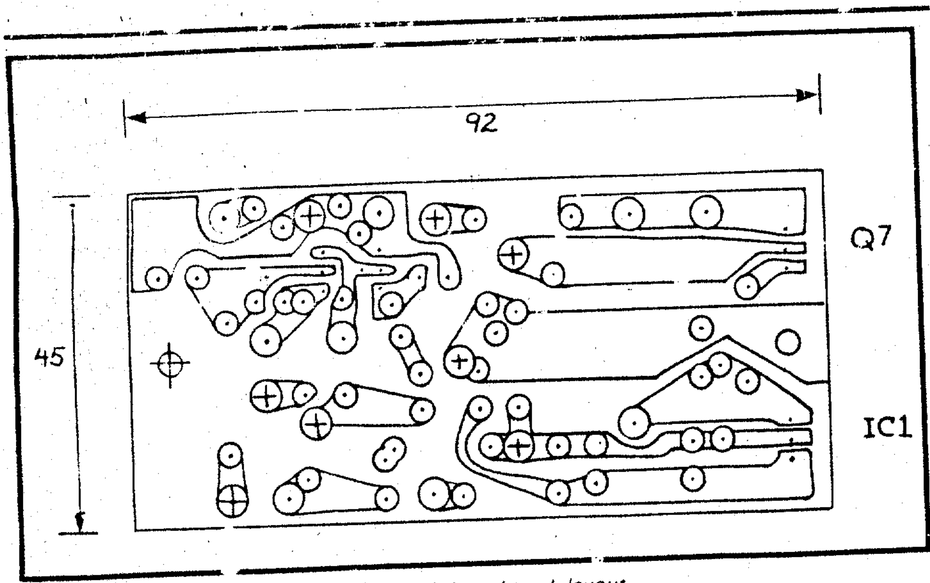
COMPONENTS

Now some notes on the components used. The power transformer is not available to supply the max. current required, it is practical to connect two similar transformers with the same secondary voltage in parallel as has been done in the writer's case.

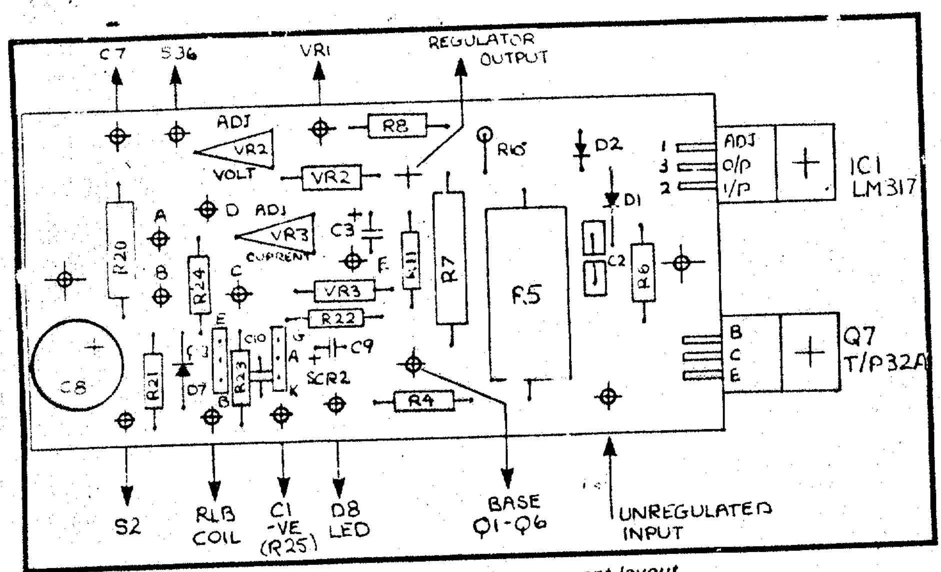
A ready source of transformers is available



Series pass transistor wiring diagram.



Printed circuit board track layout.



Printed circuit board component layout.

in the form of discarded TV sets, and in particular the early model colour TV's. These usually have secondary windings to give approx 18 to 20v output. The transformers used in this unit came from early model Pye colour TV's.

If the constructor must wind his own secondary winding on a transformer on hand, it is necessary to measure the existing secondary voltage, and remove and count the turns to arrive at the turns ratio. Most TV transformers have a turns ratio of 3 turns per volt so it would be necessary to wind say 57 turns to give an output of 19VAC.

A transformer rated at 18V at 10 amps is available at a reasonable cost through at least one component supplier (see components list). Two of these would be suitable for this project.

The filter capacitor used was a computer type rated at 40v. The voltage rating is important. There are many of these capacitors being offered at low cost through firms that retail surplus stock.

The current shunt can be manufactured from a thin strip of brass but the writer solved the problem in an easier manner. Nickel/copper resistance wire with a resistance of 1.852 ohms/ft is available from the Dick Smith organisation. By calculation, four strands of this wire connected in parallel and exactly 17.5 mm long will give the required resistance. See fig 3 for details of the construction of the current shunt. All other components are readily obtainable.

CONSTRUCTION

The construction of the case is left to the individual ideas of the builder and depends to some extent on the size of the transformers used. The writer used a standard computer card frame. This was shortened in width and an aluminium panel added to the front and the rear. A cover was then bent up to fit over the top of the case.

Most of the regulator control circuitry, including the LM317T, transistors Q7, Q8 and SCR2 are mounted on a printed circuit card 90mm x 45mm which is situated on one side of the case. The regulator chip and Q7 were bent horizontal and mounted to a short length of aluminium bar, using mica insulating washers. This bar was bolted to the side of the case to form a heatsink. The mains relay RLA and resistor R1 were mounted on a separate P.C.B. and attached to the opposite side of the case. The overvoltage SCR1 and its associated components R12, R13, ZD1 were mounted on another small P.C.B. A small aluminium heatsink plate measuring 25mm x 35mm was used to heat sink the SCR although it is not really necessary. Note that capacitor C4 should be mounted directly on the gate electrode.

The six current pass transistors Q1-Q6 are mounted to two heatsinks (three to each). The heatsinks were in turn bolted to a 3mm aluminium panel mounted to the back of the case. A method of wiring the transistors and the associated emitter resistors is illustrated i., fig. 4. Tag strips were mounted along the length of the rear panel using countersunk screws. Three parallel lengths of large diameter tinned copper wire were inserted through the eyelet holes in the tag strips and form the emitter, base and collector bus for the transistors. The emitter resistors are mounted on the back panel between the transistor pins and the emitter resistors are mounted on the back panel between the transistor pins and the emitter bus wire.

It should be emphasised that all high current wiring as shown in heavy lines on the circuit diagram should be wired in as large a diameter cable as possible, paying care to cable terminations. Lugs were crimped to cables and bolted together where practical. The heavy current wiring between the transformer, rectifier bridge and filter capacitor should be as short as possible and should be connected directly to these components. There should be no direct connection to ground at this point so as to prevent large ripple currents from flowing in the chassis, and to permit the current sensing function to operate.

The metering circuit can be tailored to the constructor's requirement. The writer chose to use a single meter which was at hand to perform both functions. A lower sensitivity meter than the one specified could be used and the meter series resistance adjusted accordingly.

CONCLUSION

This unit was designed to be flexible and can be adapted to the requirements of the constructor. It illustrates what can be accomplished with materials that may be on hand. It will provide a very convenient and reliable power supply for the radio amateur who likes to experiment with equipment as well as fulfilling the requirements of others that may only want to operate their HF mobile rig from the mains.

COMPONENT LIST

Resistors

R1	50 ohm	10W wire wound
R2,3	1.5 ohm	5W wire wound
R5	22 ohm	5W wire wound
R14-19	0.1 ohm	5W wire wound
R7,11	470 ohm	1W 5% carbon film
R20	18 ohm	1W 5% carbon film
R4	1k8 ohm	¼W 5% carbon film
R6	1k2 ohm	¼W 5% carbon film
R8,21	470 ohm	¼W 5% carbon film
R9	3k3 ohm	¼W 5% carbon film
R10	220 ohm	¼W 5% carbon film
R12	22 ohm	¼W 5% carbon film
R13	560 ohm	¼W 5% carbon film
R22	1k ohm	¼W 5% carbon film
R23	47k ohm	¼W 5% carbon film
R24	820 ohm	¼W 5% carbon film
R25	0.0266 ohm	current shunt
VR1	3k ohm	linear pot
VR2	500k ohm	trim pot
VR3	10k ohm	trim pot

Switches

S1	240V 3A	momentary action[3]
S2	SPDT	toggle switch
S3	DPDT	mini toggle

Capacitors

C1	33,000 uF	40VW electrolytic[1]
C2	100 nF	ceramic
C3	10 uF	25V tantalum
C4, C9	1 uF	35V tantalum
C5, C7	1000 uF	25V electrolytic
C6	10nF	ceramic
C8	470 uF	16V electrolytic
C10	47 nF	ceramic

Semiconductors

ICI	LM317T	regulator
Q1-6	2N3055	NPN transistor
Q7	TIP 32A	PNP transistor
Q8	BD 139	NPN transistor
SCR1	C37D 30A	(see note 2)
SCR2	C106 Y1	30V at 4A

Diodes

BR1	MDA 3504	35A bridge
BR2	WO2	1A bridge
D3, D4	1N914	
D1, D2	1N4001	
D5-D7	1N4001	
D8	green LED	
D9	red LED	
ZD1	1N4744	15V Zener

Miscellaneous

RLA	24V coil	contacts 240V/2.5A
RLB	12V coil	contacts 12V/30A
METER	50 uA	calibrated 0-20V/0-20A

Transformer MM 2000, 18VAC at 10A, 2 required[4]
Resistance wire, Nickel/Copper 1.852 ohms/ft[5]
Heat sinks, tag strips, tinned copper wire, bolts, nuts, case and hardware.

Notes

1 — Or six 5,600 uF 40VW.
2 — C164D 16A could be used if R2/R3 increased.
3 — Dick Smith Cat. S-1199.
4 — Available from Jay Car, Sydney.
5 — Dick Smith Cat. W-3200.