

★
The finished amplifier, complete with cover and engraved front panel. Its facilities and power output make it suitable for almost any P.A. requirement.
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A 100 Watt Public Address Amplifier

Here is the most powerful public address amplifier ever to be described in these columns, capable of delivering 100 audio watts. It is ideal for handling the really big jobs in large halls, fair grounds and such like. Its general design is right up to the minute.

By Neville Williams and Brian Cleaves

THOUGH we have had requests in the past for some such design the difficulties of producing it and making it a marketable proposition have outweighed the limited demand. Our higher-powered designs in the public address field have, therefore, been limited to around the 40 watts, which was easily attainable with 807 type valves.

SPECIAL JOB

Just recently, however, the opportunity to tackle something larger occurred when a division of our parent company wanted a big amplifier for paging in a new large building. An examination of the proposition showed the possibility of building the amplifier required for the particular job as well as deriving from it an interesting article.

But why 100 watts? Is it because it's 10 times louder than 10 watts? Is it the largest anyone is ever likely to want? Is it the largest practical design?

The answer is no, no, and again no! Under practical listening conditions a 10 times increase in power does not produce a sensation of sound level being increased by that amount, because

of the "AVC action" of the ears, as indicated by operation of the decibel scale.

However, what is often more to the point, a 100-watt amplifier will operate 10 times as many speakers at a given sound level as a 10-watt amplifier.

Again, while almost any audio power can be obtained, given components of adequate capacity, 100 watts represents a very substantial "round figure" which can now be achieved using components and techniques which are within the orbit of servicemen and advanced hobbyists.

What a 100-watt amplifier will achieve in terms of coverage depends a great deal on the speakers used to disseminate the sound. Different types vary enormously in acoustic efficiency and directivity, as well as in frequency response, distortion and unit cost.

The choice of speakers is a question which is really best resolved with those who supply them but, in any case, cannot be further pursued here.

Coming back to the amplifier, its power is delivered, in the ultimate, from a pair of the relatively new KT88 valves. These are used in this circuit, in class B1 ultra-linear conditions, the actual circuit

being closely akin to one featured recently in the valve manufacturers' journal "Radiotronics."

Several points about this method of operation are worthy of explanation. Firstly, there is the matter of "class B1."

The traditional class B method of operation is, of course, well known. It involves applying a fixed bias to the output valves so that they operate from very close to cut-off. Each works into a relatively low value of load, as presented by the output transformer ratio half primary to full secondary.

Each is driven by the input signal well into the grid positive region, in order to secure high conduction through the valve and low voltage drop across it. Since the input grids are driven positive and draw current, the operating condition should rightly be referred to as class B2; the drive has to be supplied from a low-impedance push-pull source, normally involving a "power" driver stage and a special driver transformer of critical design.

NO GRID CURRENT

With valves like the KT88, it is possible to achieve the necessary conduction and low voltage drop without resorting to positive grid operation. Therefore, by operating the valves at near cut-off and carrying the grids to zero on signal peaks, a very large excursion of plate current is initiated through the load, which adds up to substantial power output.

And since the grids do not swing positive, the mode of operation is defined as class B1, and the need for a special low impedance signal source is eliminated.

100W FROM KT88s CLASS B U/L

Then there is the matter of ultra-linear (or divided load) operation.

It is debatable whether adequate conduction could be obtained through valves of simple triode structure, since the "incentive" to large electron flow disappears as the plate voltage falls during plate current peaks.

The field provided by the screen of a tetrode or pentode is necessary to sustain current flow with low plate voltage. Therefore, class B1 operation relates more naturally to tetrode or pentode rather than to triode operation.

DISTORTION PROBLEM

But this gives rise to the further difficulty that uncompensated pentodes or tetrodes, operating into reactive loads (viz. loudspeakers) are likely to produce excessive peak voltages on high-frequency signal components, as well as generating more than their share of distortion.

Negative feedback is not the complete answer to this problem since it is not very effective during those portions of the input cycle where the two output valves are each close to cut-off.

Neither is it completely satisfactory to connect an R/C filter across the load. The diversion of power into the filter can mean loss of treble response from the speakers, as well as presenting dissipative problems.

From published figures, and from our own results, it would appear that the ultra-linear arrangement provides a neat solution to the problem. While the screen "swings" with signal sufficiently to simulate triode behaviour, it does not digress sufficiently from the HT line to prevent it (in the DC sense) from sustaining high conduction at the minimum plate voltage swing.

As a result, the requisite high power is obtained at a modest distortion level and in keeping with the results normally expected of a public address system.

For the conditions under consideration, the KT88 valves require a power supply of 560 volts at current figures ranging to 325 mA., depending on the output signal level. As with all class-B amplifier systems, the real problem is to obtain adequate voltage regulation.

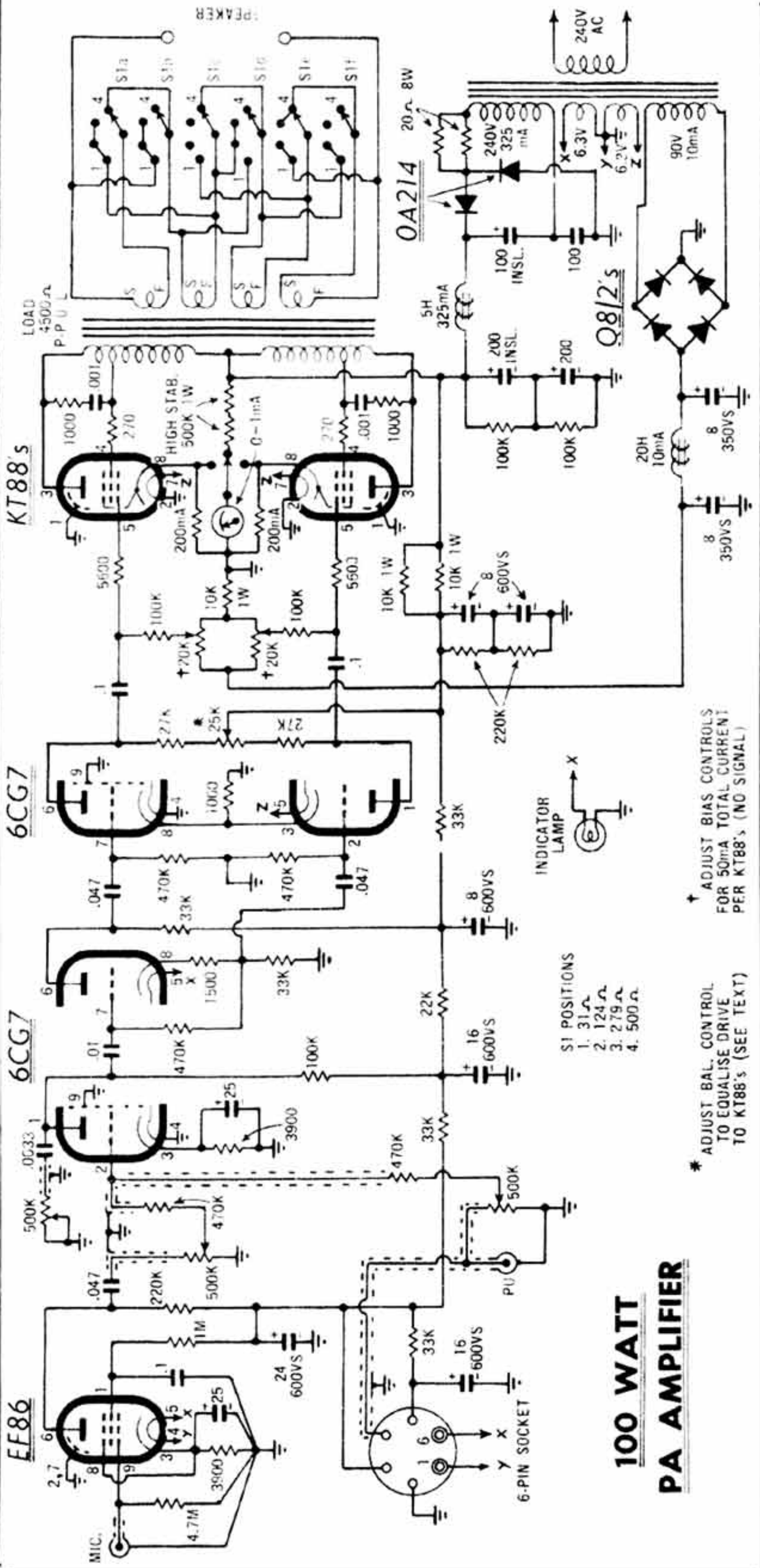
Much to our surprise, investigation showed that the voltage-doubling silicon rectifier type of supply, currently being used for television receivers, had better potential regulation than the traditional choke input filter, full-wave rectifier.

SPECIAL COMPONENTS

Before we could specify it, however, we had to be sure of the supply of silicon diodes with a specially high peak inverse rating. The ordinary 400-volt types will not do.

Then, also, we had to await the development of high voltage, high capacitance electrolytics for the doubler input position. These need to be special types, designed to operate with high ripple current. Again, ordinary types should not be used, even though their voltage ratings may appear to be adequate. One needs to have an insulating and protective type of mounting.

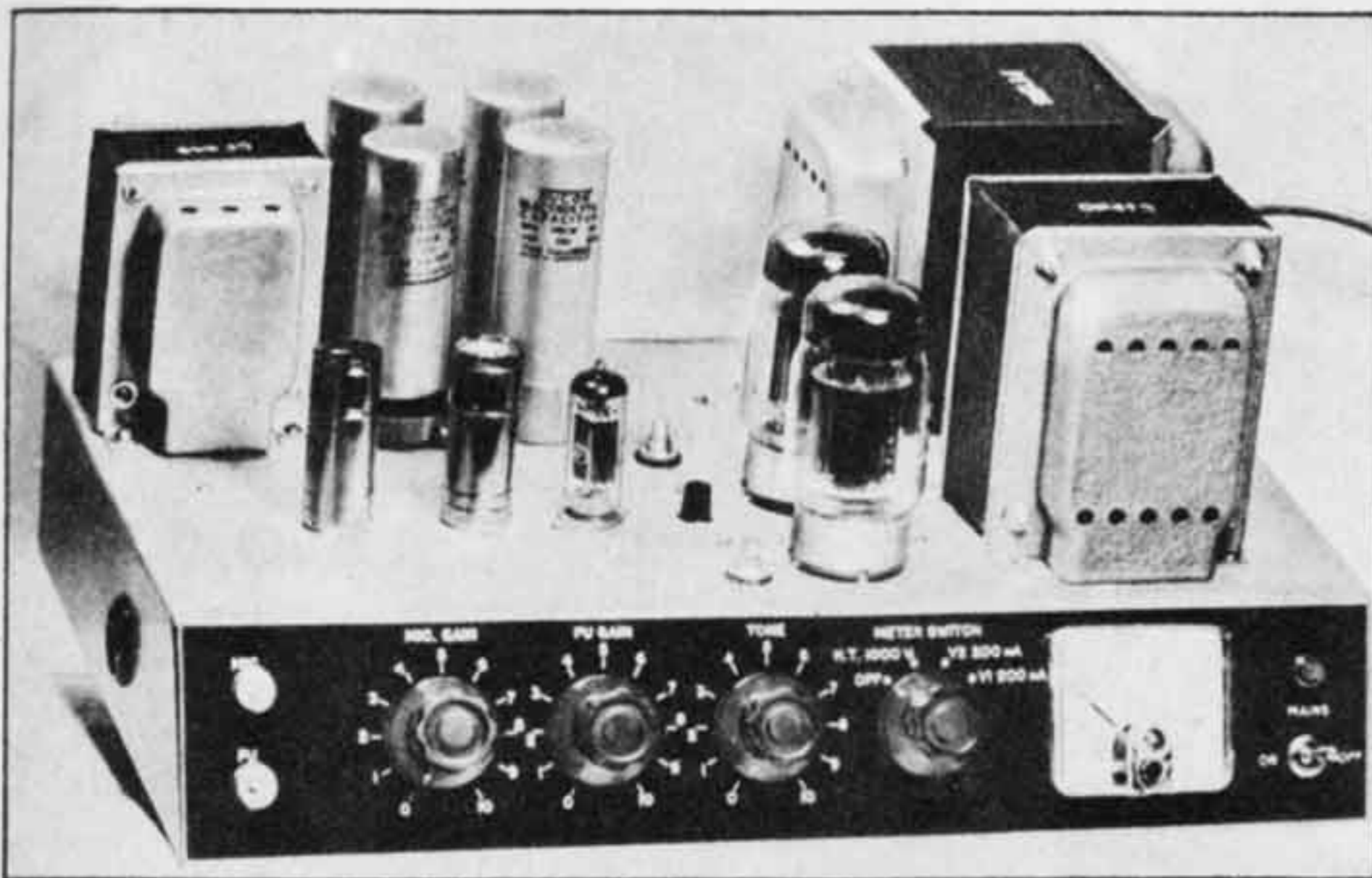
The H.T. filter is completed by a choke and two series-connected electrolytics, with 100K resistors across each to equalise the applied voltages. One of these needs also to be insulated and protected from accidental contact.



100 WATT PA AMPLIFIER

The circuit provides microphone and pickup inputs, with mixing facilities. In addition, it may be used with a separate mixer unit giving additional inputs and facilities. Note the special switching arrangement used to select the required output impedance.

LAYOUT OF MAJOR COMPONENTS



The two shielded valves on the left are the EF86 and 1st 6CG7 in that order, followed by the 2nd 6CG7 and the two KT88s. At left rear is the main filter choke, right rear the power transformer, and right front the output transformer. Note the meter used to monitor operating conditions.

A 10 ohm series resistor in the rectifier circuit is intended to minimise peak currents through the rectifiers, and the input filter capacitors. The series resistor is made up from two 20-ohm 8-watt resistors, connected in parallel.

A supplementary circuit in the power supply provides a fixed bias for the two grids. The supply is nominally rated at 90v. 5mA, but the actual bias used is subject to adjustment.

As indicated by the circuit, grid and screen "stoppers" are included to ensure stability, as well as a network between the plate and screen tapings on the output transformer.

Provision has also been included for setting up and metering the conditions for the output stage. Thus, separate 200 mA. shunts are provided in each cathode circuit, across which the meter can be switched as desired. By means of the bias adjustments, the cathode currents of each valve should be maintained at 50 mA. with no signal input.

VOLTAGE RANGE

A further position of the switch connects the meter in series with a 1-meg. resistor across the HT supply, so that it reads the HT voltage on a 1,000-volt scale. The resistor should be a 1-watt high-stability type, with a voltage co-efficient rating comfortably in excess of the 560 volts which it will need to withstand.

If there is any doubt on this point, it would be preferable to use two series-connected 0.5 meg. high stability resistors.

In any case, close tolerance resistors should be used to ensure an accurate reading of voltage.

Although the metering allows the no-signal plate currents of the output valves to be balanced, it does not ensure balance on output peaks, which is a function of drive and of valve transconductance.

In this case, optimum balance can be achieved by varying the setting of a 25K pot. in the plate circuit of one driver valve.

Balance can be checked by comparing the output on a CRO developed across each of the cathode shunts. A better method is to set up the amplifier with an optimum resistive load, turn

up the input to the point where clipping just begins and adjust the drive pot. for equal clipping on both peaks.

Both methods assume, of course, that the input waveform is itself pure.

It is a good idea to insulate the balance potentiometer from chassis to obviate any risk of a HT short. Similar precautions should be taken with the bias pot., not in this case because of the voltage, but because failure of the bias supply to the output valves would be quite tragic.

Special consideration had to be given to the matter of the output transformer secondary, with a view to obtaining a reasonable range of impedances without sacrificing efficiency.

FOUR WINDINGS

The arrangement finally adopted was to provide four separate secondary windings, each for a nominal impedance of 31 ohms. The requirement is that all windings be used simultaneously, in order to avoid "idle" copper and window space.

Thus the four windings may be connected in parallel to provide for a 31-ohm load. The four in series match to a 500-ohm load.

The four in series-parallel match to 124 ohms, while two in parallel, connecting in series with the other two, provide for 279 ohms.

Naturally, in effecting these connections, correct phasing is vital, for which reason the coding relating to the start

(Continued on Page 35)

PARTS LIST

- 1 Chassis to suit, see text.
- 1 Power transformer 240v. 325 mA. 6.3V 4A. 6.3V 4A. 90V. 10mA. PF1546 or similar.
- 1 Output transformer Prim. U L 4.5K plate-plate Sec. 500 ohms tapped. Op413 or similar.
- 1 Filter choke 5H 325 mA. CF448 or similar.
- 1 Filter choke 20H 10mA. CF447 or similar.
- 1 Switch 6 pole 4 pos. 250V 10A. (See text).
- 1 Switch 2 pole 4 pos.
- 1 Meter 1mA. (small).
- 2 Silicon diodes OA214.
- 4 Selenium rectifiers type Q8/2 or similar.

VALVES

- 2 KT88
- 2 6CG7
- 1 EF86

SOCKETS

- 2 Octal mica filled
- 2 Miniature 9 pin with shield, one to be tinfoil, Philips type B8700/55. (See text).
- 1 Miniature 9 pin plain.
- 1 3 pin recessed plug and socket
- 1 6 pin
- 2 Single contact mic. plugs and sockets C/1/02m or similar.

CAPACITORS

- 1 100mfd 350VW electrolytic voltage doub. EMG1584
- 1 100mfd 350VW electrolytic insul. voltage doub. EMG1585S
- 1 200mfd 350VW electrolytic EMG2035.
- 1 200mfd. 350VW electrolytic EMG2035 (Insulated type)

- 3 8mfd. 600VS electrolytics.
- 2 8mfd. 350VW electrolytics.
- 2 16mfd. 600VS electrolytics.
- 1 24mfd. 600VS electrolytic.
- 2 25mfd. 40VP electrolytics
- 3 .1mfd. 600V paper.
- 2 .047mfd 600V paper.
- 1 .047mfd. 400V paper
- 1 .0033mfd. 600V paper
- 1 .01mfd. 600V paper
- 2 .001mfd. mica.

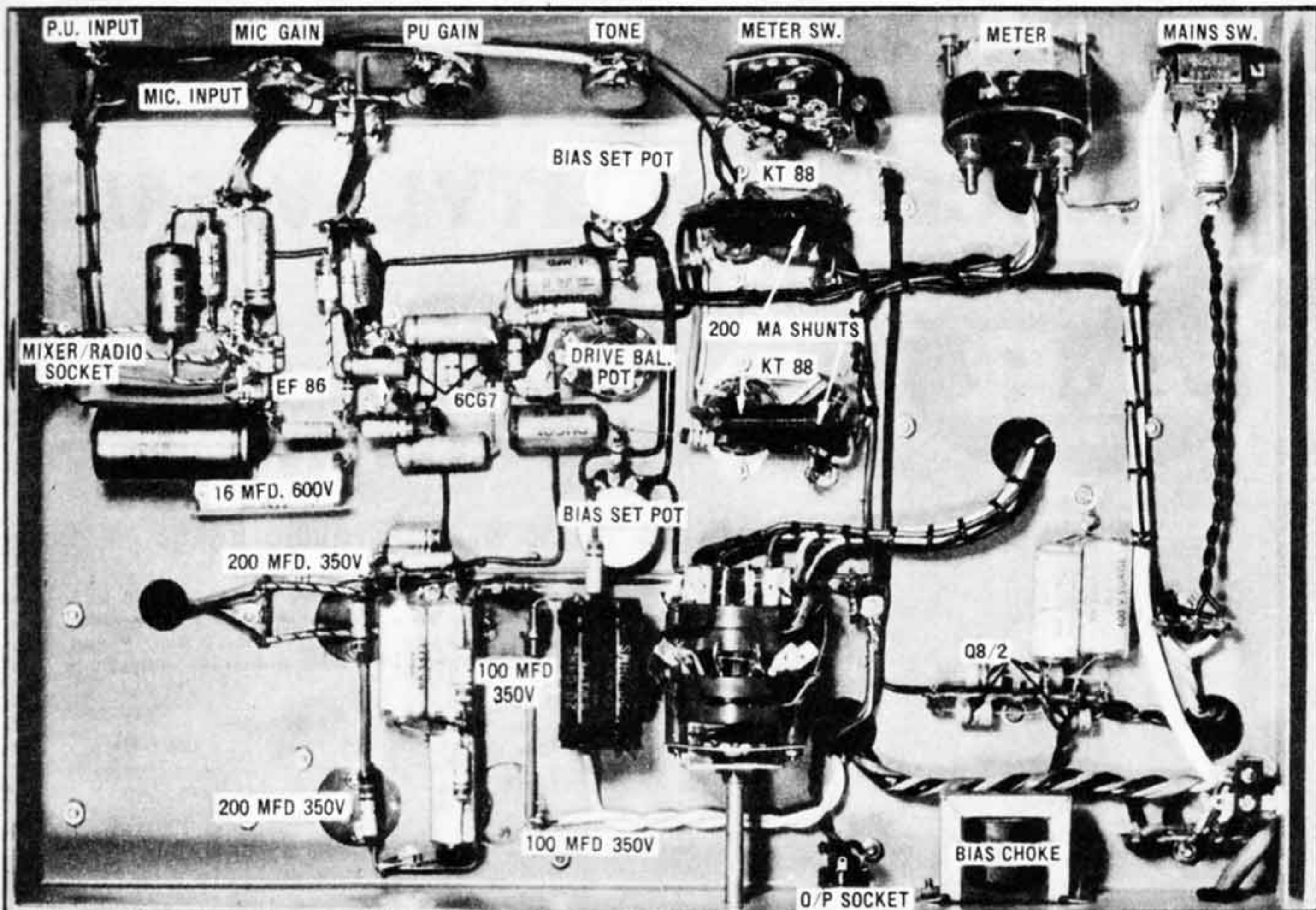
RESISTORS

- | | |
|-----------------------|------------------------|
| 2 270 ohm 1/2W | 2 1K 1/2W |
| 1 1K 1W | 1 1.5K 1/2W |
| 3 10K 1W | 2 27K 1/2W |
| 1 22K 1W | 2 5.6K 1/2W |
| 2 3.9K 1W | 2 100K 1W |
| 3 100K 1/2W | 1 220K 1/2W |
| 2 220K 1W | 2 500K 1W |
| 2 500K 1W | 1 1meg. 1/2W |
| hi-stab. | 5 33K 1W |
| 1 4.7meg 1/2W | 2 20 ohm 8W |
| 5 470K 1/2W | 2 20K potentiometers |
| 3 500K potentiometers | 2 200mA. meter shunts. |
| 1 25K potentiometer | |

SUNDRIES

- 1 Mains on-off switch
- 1 Pilot lamp assy.
- 7 2 tag terminal strips
- 2 4 tag terminal strips
- 1 7 tag terminal strips
- 2 5 tag terminal strips
- 1 6 tag terminal strips
- 2 stand off ceramic insulators.
- 1 Yd. PT9M Coaxial cable
- 4 Clamps for electrolytic capacitors.
- Hookup wire, power flex, grommets, nuts and bolts, solder lugs, etc.

UNDER CHASSIS VIEW SHOWS WIRING DETAILS



A good idea of the underchassis wiring and placement of minor components can be obtained from this picture. The two KT88 sockets are towards the top of the picture, almost central, immediately above the impedance selector switch. The EF86 socket is at extreme left of the picture.

and finish of windings should be strictly observed.

In this case we have avoided the use of open connectors for the various secondaries, for two very good reasons. Firstly, they can be confusing and lead to error. Secondly, the voltages produced across the secondary circuit may be every bit as lethal as the power mains.

SPECIAL SWITCH

In our prototype amplifier we installed a special rotary switch, produced by Paton Electric Pty. Ltd. This effects the necessary interconnection as it is rotated and makes the desired impedance available at the turn of a knob.

For a permanent installation, it would probably be sufficient to interconnect the windings as required, without provision for switching.

The remainder of the amplifier ahead of the output valves is fairly straightforward, but the general features are worthy of some comment.

As already explained, the class B1 output valves do not require a specially low impedance input. The grids are, therefore, fed from a pair of conventional triodes, operating in push-pull, and with fairly low values of plate load.

A 6CG7 twin triode makes an excellent pair of drivers and, in the circuit shown, provides ample swing for the KT88 grids.

Ahead of this is another 6CG7, one triode serving as a conventional phase

splitter, and the other half as a voltage amplifier feeding the phase splitter.

The phase splitter uses 33K resistors in the anode and cathode circuits, and it is suggested that these be matched to within five per cent to ensure balanced output to the push-pull driver stage. The triode amplifier has a voltage gain of about 16, which brings the sensitivity to a level appropriate for volume control, and to receive the input from a crystal pickup, radio tuner or microphone preamplifier.

A simple top-cut tone control is provided in the anode circuit of this same triode amplifier, the constants chosen giving an adequate degree of control.

In practice, such a control is often handy to "round off" unpleasant voices or unduly shrill music, while it can also minimise feedback where this involves peaks in the treble register.

SIMPLE MIXER

A simple mixer network is incorporated in the triode grid circuit, using two volume controls and two isolating resistors. One section connects to the pickup input, and the other to the output of the microphone pre-amplifier stage.

Something under 400 mV of signal is required at the pickup terminals to drive the amplifier to full output. There should be no difficulty in obtaining this from a standard mono crystal pickup.

To have provided for a magnetic

pickup would have involved at least one extra valve giving the requisite compensation and gain.

The pre-amplifier is a pentode-connected EF86 or Z729. The low noise and rigid construction of such valves shows to good advantage in this application. There is no problem with noise or microphony, and no need to resort to shock mounting of the socket.

HUM

However, it is necessary to take all the usual precautions to avoid hum pickup. As implied by the circuit, the entire input network should follow the now well-established practice of single point earthing. A solder lug firmly secured under a socket mounting bolt, and making good contact with a cleaned area of the chassis will make a good earth point.

To this is returned the 4.7M grid resistor, the cathode bias network, the screen by-pass, the central shield of the socket, and the shielding braid of the co-ax cable running to the microphone input socket. This latter should be insulated from the chassis by means of the insulating washers supplied, the braid connecting to the "earthy" side of socket, but not to the chassis.

Another precaution concerns the heater line. This is shown earthed on one side, rather than centre tapped, and this seems to be quite satisfactory in itself. However, while a single heater line

(Continued on Page 71)

100W. AMPLIFIER

(Continued from Page 35)

and a chassis return is quite satisfactory (and a good deal easier) for the remainder of the valves, this is not advisable for the first stage.

The best arrangement appears to be a twisted pair running from the transformer terminals to the heater pins, the chassis connection being made near the power transformer, rather than at the EF86 socket.

The only remaining source of hum

In considering the mixing facilities which should be provided in an amplifier of this kind we decided to repeat the arrangement used in the 35 watt P.A. amplifier of April 1958. This provides for one microphone and one pickup input circuit, at appropriate levels, and a simple mixer network, whereby these may be adjusted separately for any desired balance.

Such an arrangement has the advantage of simplicity, both as regards the circuit and the number and function of controls (P.A. systems often have to be

100W. AMPLIFIER

(Continued from Page 71)

Our prototype amplifier was produced on a 16-gauge steel chassis, measuring 17in long by 10½in wide by 3in deep. A front panel is provided by sloping the front side of the chassis, and this can be embellished, if desired, by the addition of a lettered panel.

In the normal way, a chassis blueprint will be made available showing the details of holes and cutouts.

In service, a plate covers the complete underneath of the chassis while a cover fashioned from perforated metal goes over the valves and transformers.

The layout of major components is quite straightforward, and is shown clearly in the photograph on page 31.

The placement of minor components and general wiring details can be seen in the under chassis picture on page 35. When mounting the valve sockets it is advisable to follow our orientation, in order to duplicate the original layout.

The KT88s have the spigot keys facing the front of the chassis, while the 6CG7 driver has the space between pins 1 and 9 facing toward the microphone and pickup sockets. Both the first 6CG7 and the EF86 face the rear of the chassis.

Otherwise the construction should be perfectly straightforward, and well within the scope of any serviceman or reasonably experienced home builder.

However, it is suggested that care be exercised in bringing the amplifier into operation for the first time. There is a lot of power available both in the power supply, and as audio power in the output stages. A fault due to careless wiring or checking could cause a lot of damage.

Check all wiring most carefully beforehand, and monitor the HT voltage carefully for the first few minutes of operation. Since it is unlikely that speakers will be available immediately to take the full output, the power should be fed into a dummy load, and the power output measured by means of an accurate AC voltmeter and appropriate calculation.

This has been covered in previous articles (see November 1959) and we cannot deal with it here in detail. However, using a suitable load across the output transformer primary, it should be possible to measure the full 100 watts, using a 1,000 cps sine wave input.

And that's a lot of audio power in any application.

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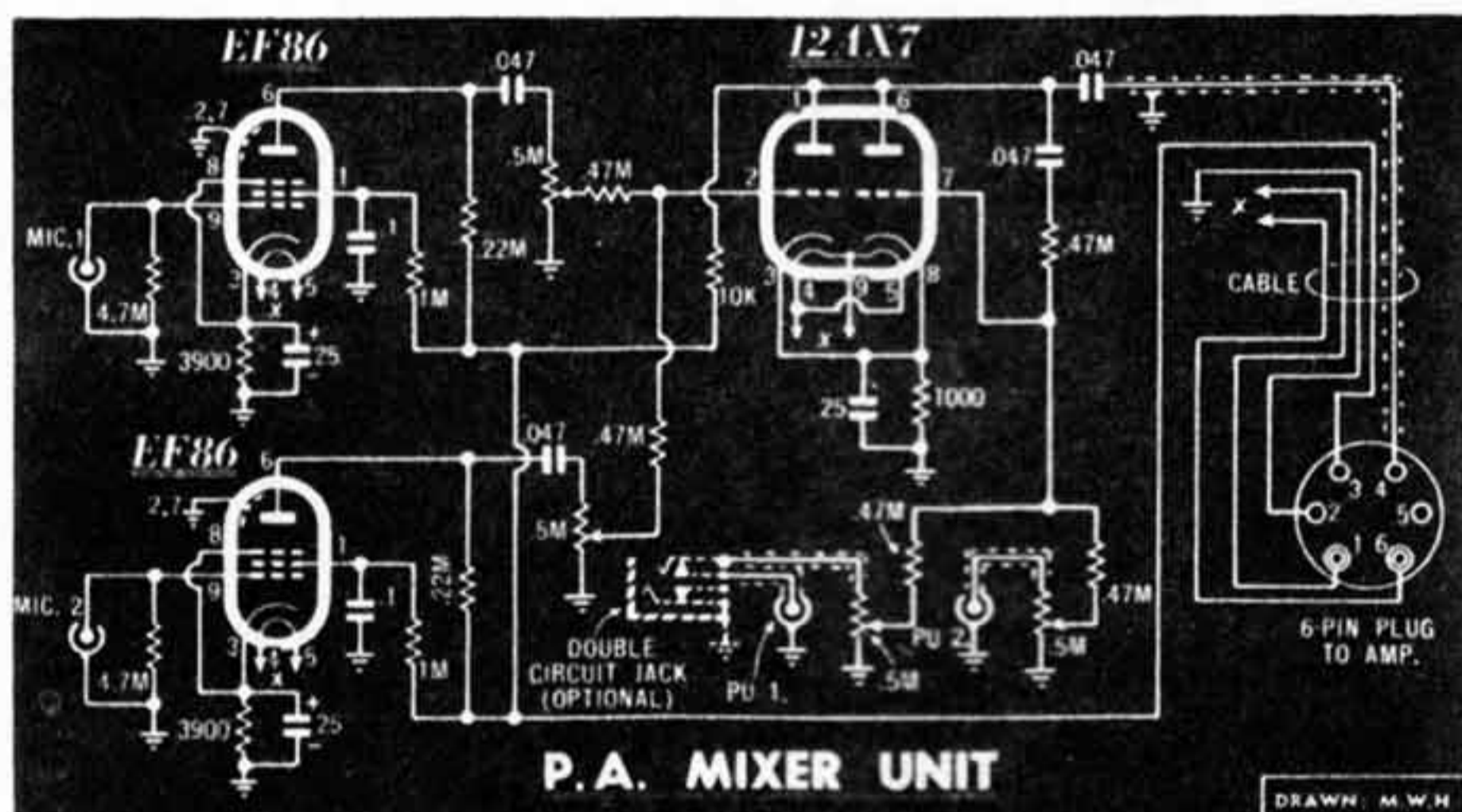
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Circuit of the P.A. Mixer Unit, which may be used if required to provide more elaborate mixing facilities than available in the main amplifier. By its use, three microphones and two pickup channels are provided.

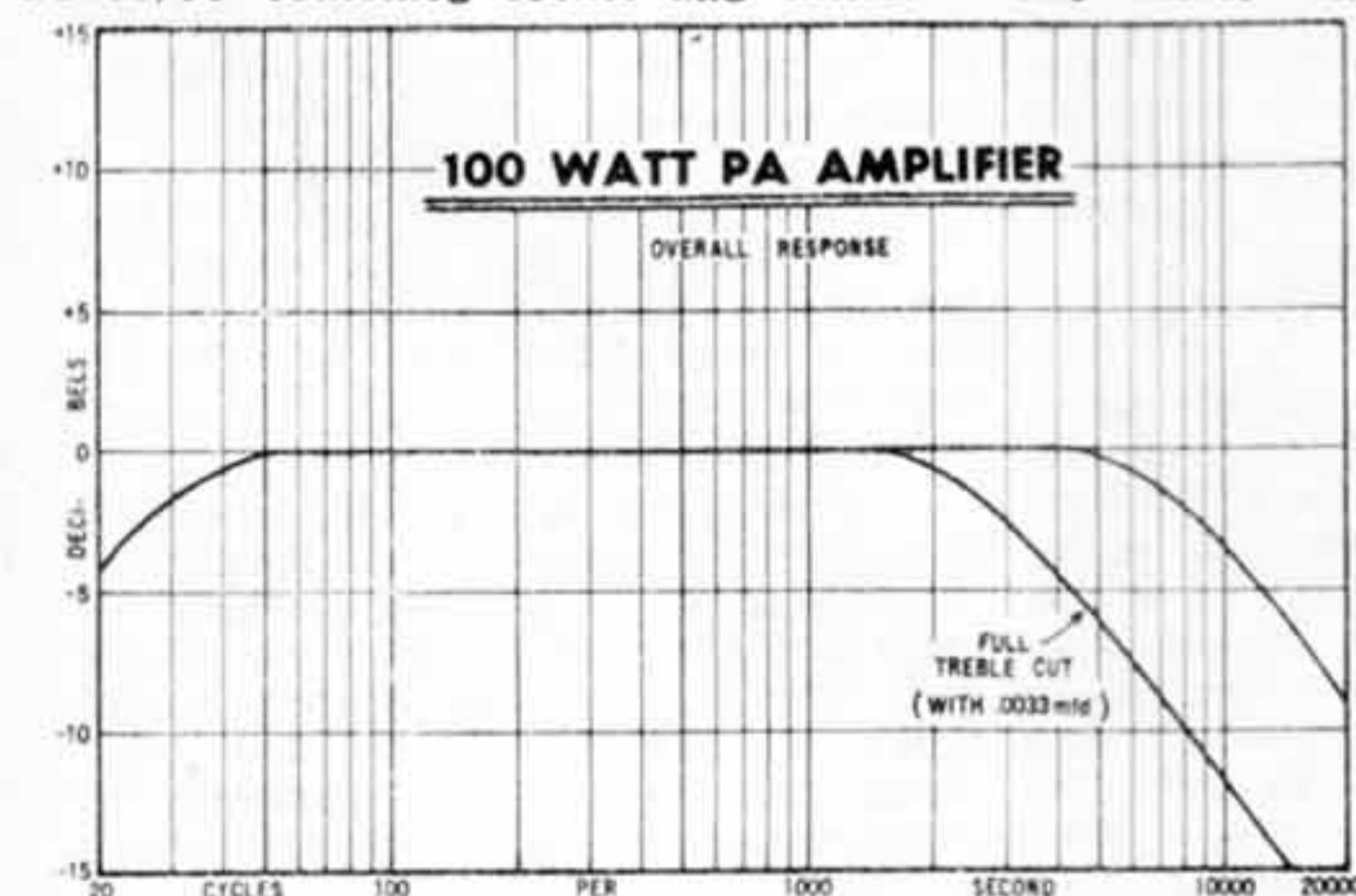
is a small amount of magnetic coupling between the power transformer and the EF86; always a possibility where we seek the convenience of a high gain amplifier on a single chassis. The amount of hum thus introduced is quite small, and is unlikely to be a problem except where low output microphones are used. In any case the cure is relatively simple.

The magnetic field is so weak that it may be effectively "shielded" by nothing more pretentious than a steel (tinplate) valve shield. This is available in at least one brand, the Philips type B8700/55 combined socket and shield.

operated by relatively unskilled personnel), yet is adequate for almost all the normal jobs where a P.A. system is required. Thus, in most cases, the amplifier may be used as a completely self-contained unit.

However, for those occasions when something more elaborate is required, as when the local amateur dramatic society needs a system with "everything that opens and shuts," provision is made to fit a separate mixer unit which, with the mixing facilities already in the amplifier makes a very versatile combination.

The mixer unit provides for two



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Frequency response is dependent mainly on the output transformer. That shown should be more than adequate for any P.A. requirement.
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The "55" indicates the tinplate shield, but this point can be checked with a magnet. We suggest that this type of shield be fitted as a matter of course.

Input to the microphone channel for full output is of the order of 5mV, so that a fairly wide choice of microphone is possible. The better it is, in terms of frequency response, the less will be the troubles experienced with acoustic feedback.

microphone and two pickup channels, all independently controlled. The output of the mixer unit feeds into the pickup circuit of the main amplifier, the associated control now becoming a master control, which is a useful feature in itself. In addition, the original microphone channel in the main amplifier may still be used, making three microphone channels in all.

(Continued on Page 109)

