THE AUSTRALASIAN

Radio World

1/6

Vol. 15 . . . No. 3 October 20, 1950

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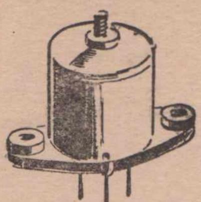
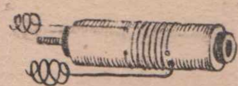
RE-PLACING ? RE-BUILDING ? *Here's why R.C.S Components will Improve Performance !*

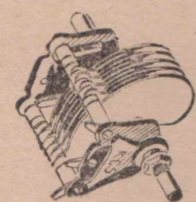


Dual-wave units.



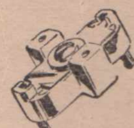
Short-wave Coil.

Trimming condenser.



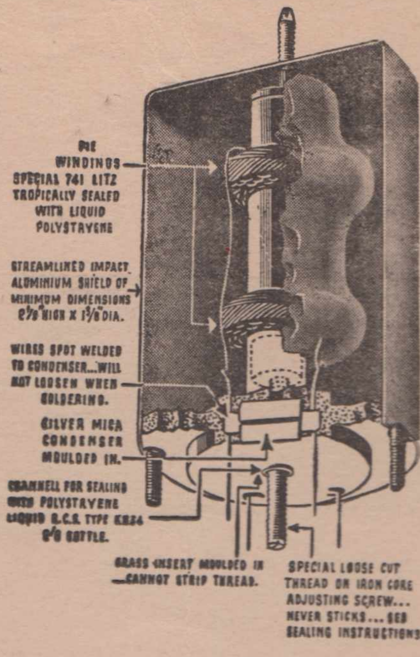
Midget variable condenser.

Resistors.



Padding condenser.

Standard broadcast coil.



The latest R.C.S. components offer radio technicians and and set assemblers the benefit of the very latest development in radio practice and the very latest in the new insulating materials. Outstanding is the latest R.C.S. Intermediate Transformer which has the condensers actually moulded into the Polystyrene base. The condenser is welded to the wirings and actually moulded to the Polystyrene base. This is a patented R.C.S. feature and places R.C.S. strides ahead in I.F. design; just as R.C.S. is strides ahead in radio component development. For the best results from your circuit, equip it with R.C.S. components.

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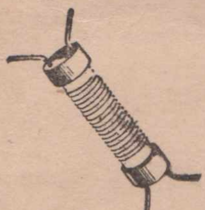

5 band coil.

Loop aerial coil.

Specify R.C.S. *Components*

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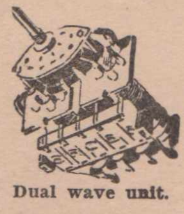
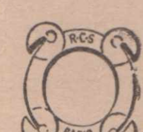
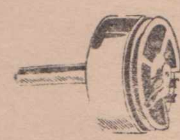


Dual wave unit.



Transposition block.



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Line filter coil.

Dial drive drum.

Radio frequency choke.

If you have difficulty in purchasing R.C.S. components locally, write us and we will advise you of the name of your nearest retailer from whom supplies can be obtained.

THE AUSTRALASIAN

RADIO WORLD

DEVOTED ENTIRELY TO TECHNICAL RADIO

and incorporating

ALL-WAVE ALL-WORLD DX NEWS

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A. G. HULL
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Short-wave Editor:
L. J. KEAST
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REPRESENTATIVES:

In Queensland: John Bristoe, Box 82, Maryborough, Q.

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OUR COVER PICTURE . .

Modern Permanent-Magnet Type Loudspeakers have reached their present stage of efficiency only as a result of extensive research by skilled metallurgists and physicists. Our cover picture shows Loudspeaker Magneto being measured in the Rola Laboratory with the aid of a search coil which simulates the magnetic circuit conditions under which the assembly unit will be called on to work.

CONTENTS

Personal . . .

A couple of years ago we ran a Special Data and Handbook Issue, complete with Buyers' Guide. This issue proved an outstanding success, as is often brought home to us by the blank space on the back numbers' shelves.

The compilation of such issues, however, calls for so much extra effort, so many more hours of time, that we haven't been able to get around to tackling another. As most readers understand, we have a heck of a job to get even ordinary issues out on time.

Things may be better in the near future, however, so here is a preliminary announcement of another special issue and with it an appeal for your co-operation. ... ...

Dealing first with the subject of data. How about dropping us a line if there is anything special you would like to see? Last time we ran the morse code, the international prefixes, the Q code, the broadcast station wavelengths, valve socket connections, circuit symbols, resistor colour codes, coil colour codes, and the frequency allocations. Can you suggest any more?

Then there is a big series of constructional articles set down for future issues; quite a technical development programme, in fact. We know to start with a five-valve general purpose set, then a four-valve midget, but what next? Have you any ideas for the plan? What type of circuits seem to have been neglected lately? How many people would build a high-fidelity F.M. set on the off chance that the experimental F.M. transmissions are to become permanent?

In fact, any suggestions you care to make will be doubly welcome at the moment, as big plans are being laid for the future.

—A. G. HULL

Home Truths about Amplifiers

NORMALLY, it is the policy of "Radio World" to be peaceful and quiet; to look on the happy side of life. But a case has arisen where someone has gone out of his way to look for trouble; he boasts that he wants to "buy an argument". It is a pleasure for us to do our little bit to oblige him.

DIRECT-COUPLED amplifiers and Parry cathamplifiers were declared sour grapes in a recent issue of "Radio and Hobbies."

Clue to the outburst was given in the article where the author mentioned that he had been upbraided by two trade identities because he had ignored certain amplifier circuits.

By A. G. HULL

With all the exaggeration and ballyhoo of the popular (?) style of journalism, the article claims that "technical twaddle" has been written about direct-coupled amplifiers, such as "rhapsodies about mysterious somethings." It would seem that the author has not been discriminating in his choice of technical literature when in search of inspiration. I am sure he has never read any such "technical twaddle" in "Radio World", which is recognized far and wide as a source of accurate information on amplifier circuits in general and direct-coupled circuits in particular.

There is no need for a defence of those circuits.

Direct - coupled amplifiers speak for themselves. Isn't it rather more than coincidence that the winner of the last Sydney Amplifier Championship used a direct-coupled circuit, that Charlie Mutton won the Victorian Championship with a direct-coupled amplifier, and that every time an audience is given a chance to judge the qualities of amplifiers, one after the other, it is usually the direct-coupled one which gets the acclaim?

Besides dealing with direct-coupled amplifiers the article goes on to try to prove that it is contradictory to ever remark that anything can be "theoretically right, yet wrong in practice."

It is quite true that theory and practice are complementary. But in real life, not only in radio, there is always the chance that theories are inaccurate, incomplete or incorrectly applied.

Going back to the article in question the author cites a case where someone said that they were giving up the Williamson circuit because another circuit (apparently cathamplifier) sounded "flatter and cleaner". The author then exclaims "What utter rot".

Probably the matter is not rot at all, but just another grand example of the need for intelligent appreciation of the relationships between theory and practice. More than ninety per cent. of the amplifiers built to the Williamson circuit, according to an authority on the subject, do not operate to perfection. The original Williamson amplifier circuit was designed for English valves, was amended to make it suitable for use with local valves, was fitted with twin triodes, had the resistance - capacity values changed and so on. Theoretically it may still be a good amplifier circuit, but as many have found to their horror after laying out big sums of money to buy the vast number of components necessary for this amplifier, it can suffer from microphonic and inter-element effects in the twin triodes, instability, parasitics, too much feedback resulting in serious phase displacement, and a dozen other unexpected "bugs", so that in practice its performance is not up to expectations.

If you are interested in the Parry "Cathamplifier" you will find further details in the issue for last June. For typical direct-coupled circuits of the type which have proved their superiority, we suggest the issues of April, 1948; November, 1948; February, 1949; March, 1949; June, 1949; October, 1949; and December, 1949. All these issues are available from our Back Dates Department.

AMPLIFIERS
(continued)

There need be nothing in the way of rot connected with a statement that some amplifier can sound better than one particular "Williamson", because that may be one of the many Williamsons which is not giving practical results up to theoretical expectations.

Anyone who has spent twenty-eight years in close contact with radio will know that there can be a big gap between theory and practice.

Once upon a time, a factory instituted a "quality control" system, so that each power transformer went out with a label attached to it, perforated along one edge (in the manner in which a tram conductor "punches" the ticket) to prove that it had been examined and tested at least six times in the course of its manufacture. Out of this very factory, shortly after the system was introduced, came a transformer which made its way into the hands of a certain technical editor who found that, in spite of the impressive "quality label", there were no internal connections to the terminal board! Theoretically the system was perfect, but in practice the human element beat it. Investigations showed that a lad with a punch got tired of checking, was in a hurry to get home to take his girl friend out to the pictures, so punched off a few dozen labels and tied them to a batch of transformers without actually testing them.

That particular case brings to mind another "real life" example of how a theory can be right, yet wrong. The scene of this little tragedy was a shop in which components were sold. By checking over the incoming invoices against the outgoing sales it was evident each stocktaking that there was a leakage somewhere, amounting to about £200 a year. The manager was so annoyed that he brought in an efficiency expert, who organized a card index system, introduced a docket system which made it necessary to put two extra men on the counter and two extra girls in the office.

After the system had been in operation for a year it proved beyond the slightest doubt that there was a leakage and that exactly £199/19/9 worth of parts vanished each year. Nice theory, but the trouble was that the total cost of the system was about £2,000 a year, so that in practice it was a losing proposition.

Theory is O.K. if you can be really sure that you have applied it correctly and given due consideration to every factor concerned, but so few of us are as clever as that. Most of us are human enough to make mistakes from time to time, so we feel so much more confident if we can confirm our theoretical findings by practical tests.

Getting back to radio again, let us consider valves and their characteristics. You can read the valve charts and gain the impression that certain valves are going to give you certain performance, but your ears may tell you differently. With all due respect to Mr. Parry and his cathamplifier, some people say that Mr. Parry was clever in his selection of the type EL35 output valves, as these are not beam power tubes like the 6V6, 6L6 and 807. In practical application they are less likely to give instability. They sound better, have plenty of power and are less likely to trap those who build amplifiers but do not have laboratory equipment for checking. Possibly this has a lot to do with the way in which so many amplifier builders are convinced that the cathamplifier sounds better than the Williamson. The Parry job is simple and goes together without being so liable to run into the troubles which sometimes mar the performance of more complicated circuits.

There is no need for any defence to be raised for the direct-coupled amplifiers as, although the article in question starts off as though it might be an attack on this type of circuit, it does not point out any drawback, fault or difficulty with circuits of this type. Apparently the worst feature of the direct-coupled amplifier is the way in which the builder raves about the performance he obtains from it.

NOTICE TO SUBSCRIBERS

Owing to pressure of work in connection with a reorganization plan, we have not been able to send out the usual renewal notices for those whose subscriptions have expired recently.

It will be appreciated if you will note that a cross in the margin alongside this notice indicates that your subscription has expired and if you wish to retain the continuity of issues you should remit cheque or postal notes at your earliest convenience. Please note address for all correspondence:—

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but watch out for a change-of-address notice soon.

FOR THE AMATEUR

Volume Compression

WITH LOW DISTORTION

TO reduce the nuisance of sideband splatter from A.M. phone transmitters, there are several devices which can be used, either separately or in conjunction with each other, to make the transmitter virtually incapable of overmodulation regardless of the incident sound-level to the microphone.

There is a simple high-level "clipper", using a diode

By PHIL EDWARDS

either at the hot or cold end of the modulation transformer secondary, and aided by the action of a low-pass filter; there is the low-level clipper, where early audio stages are handled in a similar way; and there is, finally, the true peak-limiter or volume compressor, as it is called in commercial practice. The last-named has one very marked advantage, in that it does not distort the WAVEFORM of the audio seriously, in the manner that any square - wave - producing style of clipping does. The V.C. merely limits the **dynamic RANGE** of the audio.

Let us therefore turn to the V.C. and see how a satisfactory circuit might be developed. Consider diagram No. 1. Here we have a relatively simple system using a variable-MU pentode, like the 58, 6K7, 6U7, and so on. The input signal to the control grid of the controlled stage is also fed simultaneously to the grid of a side-amplifier, a simple triode, which feeds a rectifier to develop the A.V.C. voltage. Note that the earthy end of the grid resistance of the controlled stage is not actually grounded, but returns to the negative end of the rectifier diode-load resistance, thence to ground through said resistance. Hence, the A.V.C. voltage will appear on the control grid of the 6K7 as a rectified and filtered D.C. potential which will increase as the input signal to the front end increases. The potentiometer at the grid of the side-amplifier controls what is called the COMPRESSION RATIO. When closed, no compression will take place, and we get an input-v.-output volts relationship as depicted in diagram 2. When we desire compression, we open this control up, and signal appears at the side-amp. grid, to be amplified and rectified, then used as A.V.C. after filtering in the R.C. chain.

If the cathode of the rectifier is at ground potential, compression will take place, as it were, "from the ground up",

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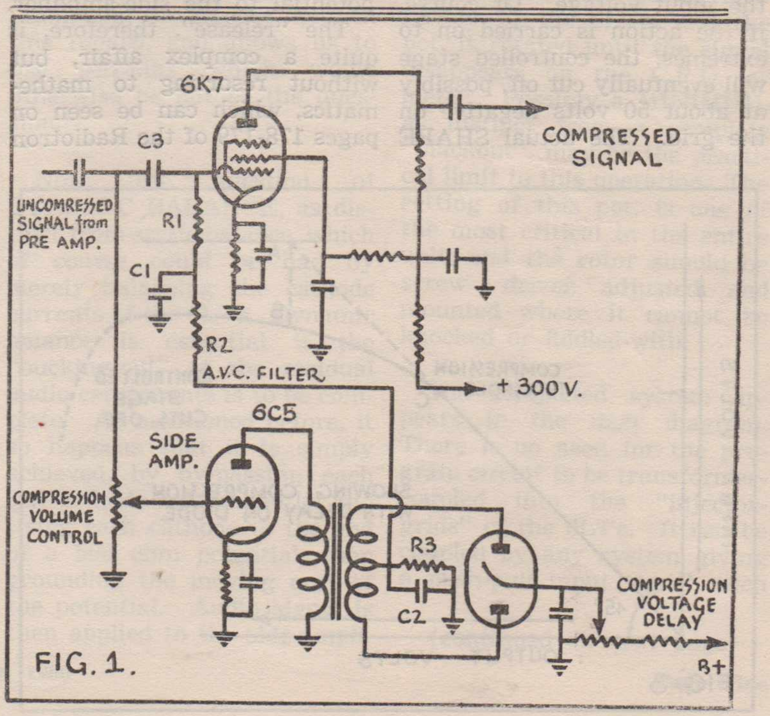


FIG. 1.

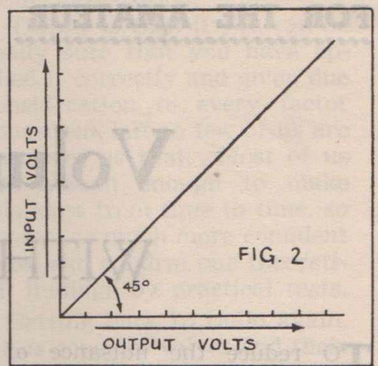
COMPRESSION
(continued)

i.e. at all levels, including the weakest signals, which is, of course, the action of any simple A.V.C. system without voltage delay. We can, however, "jack up" this cathode with a D.C. delay-potential to make the LEVEL at which compression occurs controllable. We might choose, say, 80% modulation, up to which level the signal will be linear, as in diagram 2; at this level compression will set in, and the input-versus-output voltage relationship will undergo a change as shown in the next diagram. It can be seen that, up to the arbitrary level, the controlled stage behaves just like any other normal stage, but when this threshold is crossed, the variable-MU characteristic takes charge, and the gain of the amplifier starts to drop, causing the output voltage to flatten out, despite a progressive increase in the input voltage. Of course, if the action is carried on to extremes, the controlled stage will eventually cut off, possibly at about 50 volts negative on the grid. The actual SHAPE of the compression characteristic shown in the diagram is not significant, but merely illustrates the general behaviour of the system.

The ratio of what the output voltage WOULD have been without compression, to what it IS with compression, is called the COMPRESSION RATIO, and its magnitude is seen in the line AB, which in the classical case would be the "height" side of a right-angled triangle, with the hypoteneuse represented by the side AC and the base by BC. In practice, of course, it is never so encountered, but can be approximated to a very useful degree.

Let us now return to our circuit. Note that the A.V.C. cannot "clamp" on an instantaneous peak of audio DUE TO THE TIME CONSTANT OF THE FILTER COMPONENTS R2, C1. The "release" time constant is even longer, and includes the effects of the components R1, C1, R2, R3 and C2, not to mention C3 and the potential to the side-amplifier.

The "release", therefore, is quite a complex affair, but without resorting to mathematics, which can be seen on pages 178-179 of the Radiotron



Designers' Handbook, we can immediately see that both the **release** and **attack** of compression voltage involves TIME delay. Since modulation peaks are virtually instantaneous, it can be appreciated how useless this simple circuit is, because it "shuts the stable door when the horse has bolted." The same statement applies to ALL common, single-ended compressed stages, regardless of whether the A.V.C. is applied to the suppressor, control, or injection grids of various tube types such as the 6J7, 6K7, and 6L7. Further, the intolerable time delay characteristic of such simple circuits **is accompained by a viscous** thump, click or surge when any significant compression ratio is attempted. Motorboating is another common occurrence with this system (due, of course, to insufficient audio filtering of the control voltage, as when the R.C. filter constants are reduced in an attempt to speed-up the compression time-lag). We may summarize by stating flatly that fast action and complete audio filtration are inconsistent with each other, and thus these simple systems are doomed from the outset. They have caused many bad tempers and temporarily-broken hearts in the past, because of an incomplete understanding on the part of the constructor. Avoid

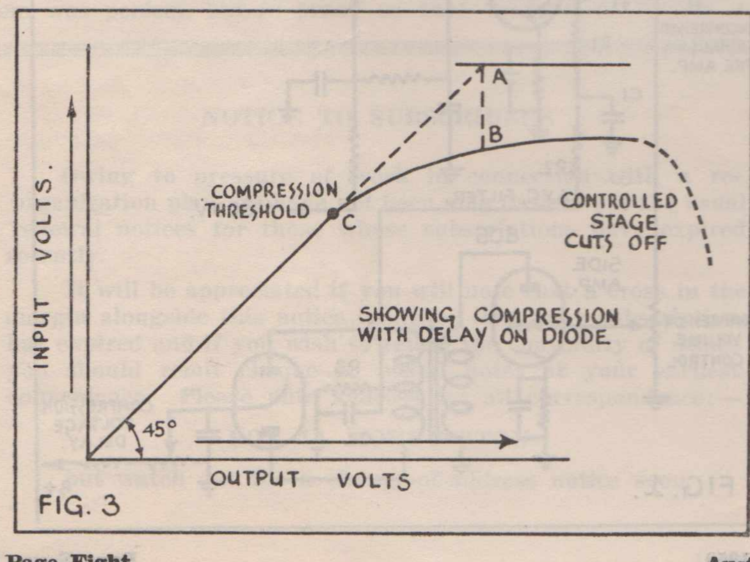


FIG. 3

them, therefore, scrupulously.

Let us now see if this A.V.C. voltage can be applied instantaneously or with very little time-delay, say a few microseconds, or, at worst, milliseconds.

If we used a push-pull stage with tubes like the 6L7 (which is chosen because the **program** and the **control can be applied** to two separate grids), and transformer - coupled the PLATE circuit, it would be possible to feed the controlled grids with a relatively UNFILTERED D.C. potential, because **if the two controlled grids are** tied in parallel, any audio component appearing in the plate circuit will be bucked-out in the push-pull plate winding of the output transformer. This, of course, assumes perfect dynamic balance, which, happily, is quite easy to get. You may recognize in this idea the basic "balanced modulator" system.

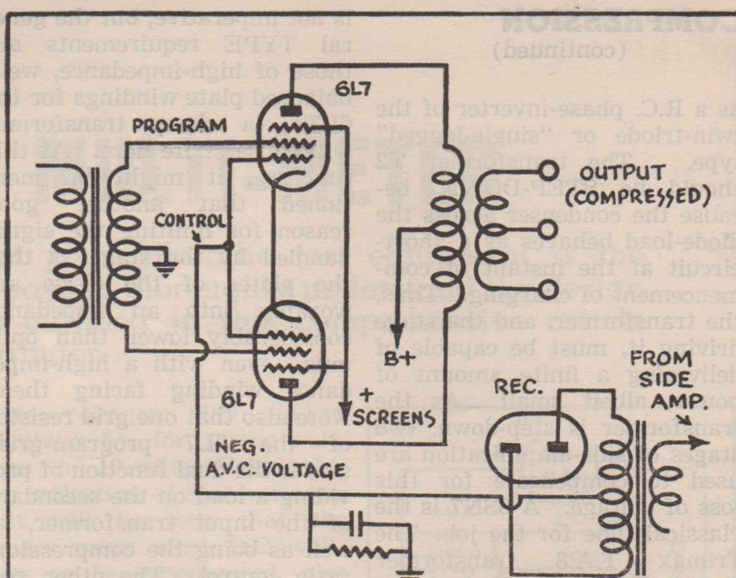


FIG. 4.

Athough the 6L7 has actually got five grids, only three are shown in the interests of simplicity. Reading from cathode to plate, they are:— Inner grid, top cap. Middle grid, "injector" grid. Third grid, screen. A skeleton circuit is shown, to keep the business simple at this juncture. Now here we have the basis of an idea which merely needs refining. Some comments are necessary. Firstly, the input voltage to the program grids on the 6L7's will have to be small, as the non-linearity of the tube's grid-volts-versus-plate-current curve will otherwise cause distortion. The even-harmonics can, of course, be suppressed by the push-pull output connection, but the third, and even fifth harmonics will be rich if the rate of curvature is abrupt. Which, at one part of said curve, is the case. Point number two is that we want to tie the **screens** down. A VR-105 lets us out of this in a hurry. We are not so concerned with getting a **high A.V.C. voltage,** as in receivers, but with **minimizing distortion** in this application. Stabilizing the screens helps in this regard, and allows us to use self-bias which would otherwise be out of the question.

Now, the question of DYNAMIC BALANCE, as distinct from static balance, which of course could be had by merely balancing the cathode currents of the 6L7's. Dynamic balance is essential if the "bucking-out" of the residual audio components is to be complete: As mentioned before, it so happens that it is simply achieved, by by-passing each 6L7 cathode independently, and tieing each cathode to the end of a 500 ohm potential, then grounding the moving arm of the potential. Audio signal is then applied to the **side-amplifier only,** with the program grids disconnected from the program input circuit, and given D.C. returns through a couple of 0.5 meg. resistances. An oscilloscope or V.T.V.M. is then connected across the secondary of the plate-transformer of the 6L7's, and the pot. is rotated until the signal disappears on the C.R.O. or meter. Possibly a MINIMUM, as distinct from a complete "blackout", may be the practical limit to this operation. The setting of this pot. is one of the most critical in the entire unit, and the rotor should be screw - driver adjusted and mounted where it cannot be knocked or fiddled-with.

The completed system appears in the next diagram. There is no need for the **program** circuit to be transformer-coupled into the "injector-grids" of the 6L7's. It can be coupled by any system giving a push-pull input signal, such

(continued on next page)

COMPRESSION
(continued)

as a R.C. phase-inverter of the twin-triode or "single-legged" type. The transformer T2 should be STEP-DOWN, because the condenser across the diode-load behaves as a short-circuit at the instant of commencement of charging. Thus, the transformer, and the stage driving it, must be capable of delivering a finite amount of power, albeit small. As the transformer is step-down, two stages of side-amplification are used to compensate for this loss of voltage. A 6SN7 is the classical tube for the job. The Trimax T.A.3 transformer nominated in the final circuit is not imperative, but the general TYPE requirements are those of high-impedance, well-balanced plate windings for the 6L7's; a cheap transformer will cause strife here. At this juncture, it might be mentioned that another good reason for limiting the signal handled by the stage, is that the plates of the 6L7's are working into an impedance considerably lower than optimum, even with a high-impedance winding facing them. Note also that one grid resistor of the 6L7 program-grids serves the dual function of providing a load on the secondary of the input transformer, as well as being the compression-ratio control. The other section of the resistive load on the input transformer is of course the upper 6L7 program-grid resistor. The COMPRESSION THRESHOLD control is a W.W. 15,000 ohm pot. in the diode cathode, which is in series with a 100,000 ohm resistance to the VR-105, giving a range of about zero to eight volts. Methods for increasing this D.C. bias range will suggest themselves immediately, should the suggested value be unsuitable for a particular transmitter or P.A. system.

If the reader is a particularly keen experimenter, he will find some benefits to be derived from making the at-

(continued on page 30)

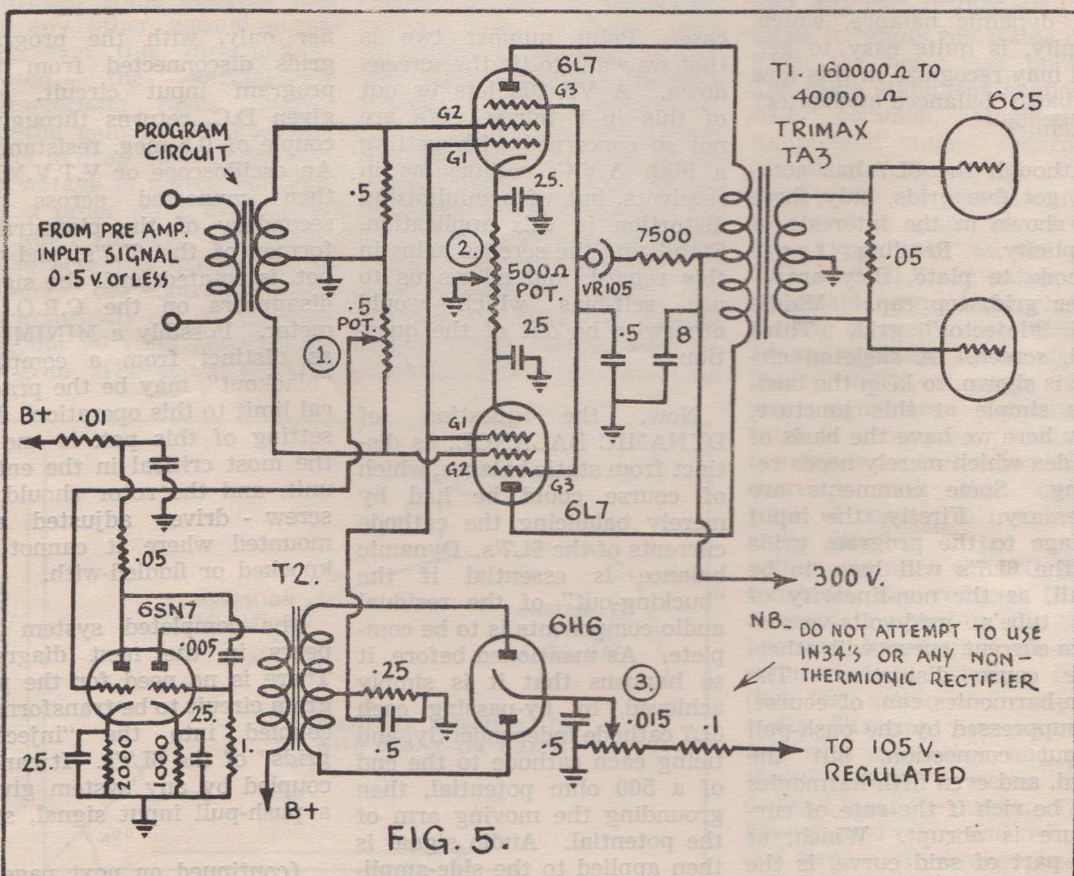


FIG. 5.

THE MULTI-METER

THE most important piece of radio test equipment is the multi-meter. It pays to thoroughly understand the design factors involved, as outlined in this comprehensive article from a popular contributor.

A MULTIMETER is an instrument designed to measure E. M. F., resistance and current flow in terms of volts, ohms and milliamperes, respectively.

We will analyse the multimeter, decide the ranges we require and proceed to design such an instrument, calculating as we go the values of

By
H. M. WATSON
89 Botting Street, Albert Park
South Australia

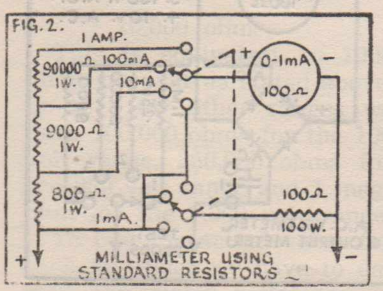
the multipliers for voltage and resistance measurements and the shunt resistor values for the current measurements.

As we will be using our instrument for radio work we must select our ranges accordingly. The following ranges are more or less standard practice, and cover all measurements an instrument of this type should cover:—

1000 volts, (Volts x 100) for B+ voltages higher than 250v.; 250 volts (Volts x 25), for plate voltages; 100 volts (Volts x 5), for screen voltages and 10 volts (Volts x 1), for indication of bias voltages.

It will be seen that the ranges cover most D.C. voltages to be encountered, also that higher ranges are multiples of the 10-volt range. This enables all D.C. voltage ranges to be read by calibrating the 10-volt range only and multiplying the reading obtained for other ranges by the figure shown above and corresponding to whichever range the instrument is switched.

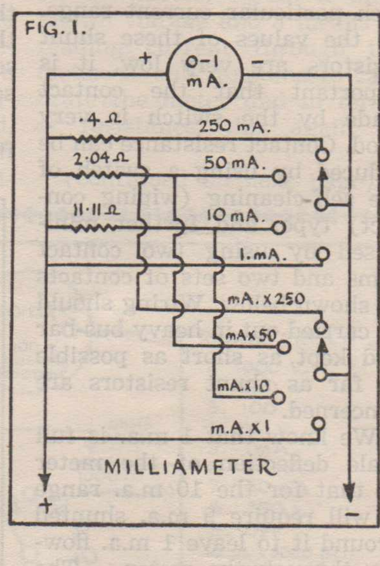
If we also include A.C. ranges we can use the high range for measuring the voltage across the high tension secondary of a power transformer and the low range for filament windings etc; whilst the 250 v. range will check line voltages.



Current Ranges

So much for the voltage ranges; for the current ranges we will select 250 m.a. for the total H.T. drain and 50, 10 and 1 m.a. ranges for plate and screen current measurements.

We cannot select a full-scale resistance reading for our ranges as this will be "infinity" in all cases. We can, however, select a half-scale reading for each of 15, 1500 and 45,000 ohms. Actually these ranges are mainly governed by the number of dry cells used, and as any dry cell has a voltage of 1.5 these ranges must be multiples of that figure, this will become evident later in the text.



The indicating device of the instrument is the meter; this is a moving coil type designed for a full scale deflection when 1 m.a. flows through it. The internal resistance of such a meter movement is usually in the vicinity of 80 to 100 ohms. For our examples we will take the internal resistance of the meter as 100 ohms and see how it can be made to indicate the various values of volts, ohms and milliamperes.

Milliammeter

The meter alone has a full

(continued on next page)

MULTI-METER

(continued)

scale deflection of 1 m.a. so can be used for measuring current values up to 1 m.a. For larger values of current, resistors have to be shunted across the meter by means of a range selector switch. The value of these shunt resistors must be such that the full scale deflection of 1 m.a. is maintained for each particular current range. As the values of these shunt resistors are very low, it is important that the contact made by the switch is very good. Contact resistance can be reduced by using a switch of the self-cleaning (wiping contact) type, and further minimised by using two contact arms and two sets of contacts as shown below. Wiring should be carried out in heavy bus-bar and kept as short as possible as far as shunt resistors are concerned.

We know that 1 m.a. is full scale deflection of the meter so that for the 10 m.a. range it will require 9 m.a. shunted around it to leave 1 m.a. flowing through the meter. The value of this shunt is found by a simple proportion sum:—

100 ohm passes 1 m.a.

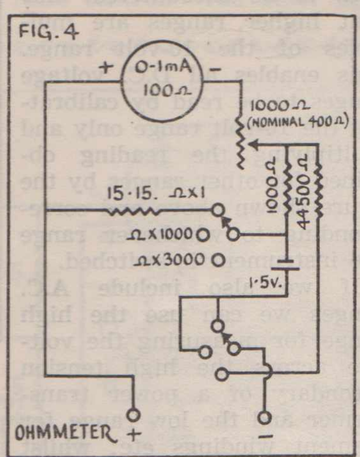
1 ohm passes 9 m.a. = $\frac{100}{9}$ or 11.11 ohms.

This amounts to dividing the meter resistance by the desired range, less 1. So that for the other current ranges we have $\frac{100}{50 - 1}$ for the 50 m.a. range = 2.04 ohms. and $\frac{100}{250 - 1}$ for the 250 m.a. range = .4 ohms.

The meter is always placed in series with the measured circuit for current readings and care should be taken that no more than 1 m.a. flows through the meter, as excessive current may ruin it. Always switch to the highest range first and switch down after.

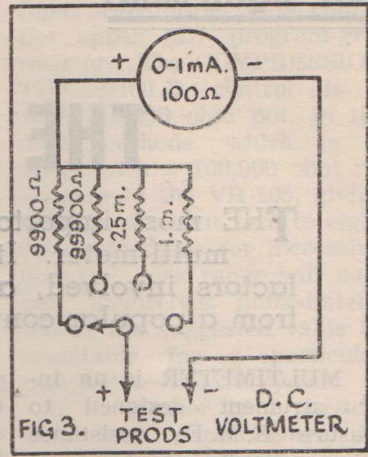
Some of us may desire to construct a milliammeter but find difficulty in obtaining the low values of shunt resistors required, some may have means of accurately measuring higher value resistors but no means of measuring low values. As with most other things there is a way out and the following circuit using a series-parallel circuit should solve the problem.

What has been said above regarding minimizing contact



resistance still has to be adhered to and, of course, all resistor values should be accurate. The 100 ohm resistor should have a rating of 100 watts if the 1 amp range is included (I^2R) = 100 watts.

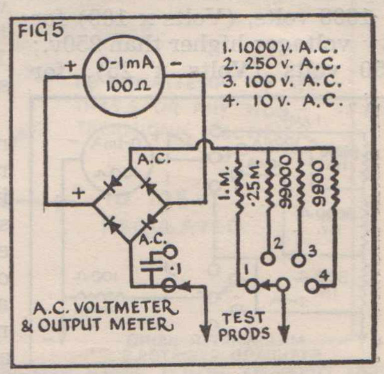
It will be seen that the 100 ohm shunt is switched across the meter and its series resistors for all ranges except the 1 m.a. range. On the 10 m.a. range we desire 9 m.a. to be shunted around the meter and its series resistor, the combined value of which is calculated thus:— 9 m.a. is passed by 100 ohm, then 1 m.a. would



be passed by 100 x 9 = 900 ohms. To find the value of the series resistor included in circuit for this range, we deduct the 100 ohm internal resistance of the meter which gives us 800 ohms. The two higher ranges are calibrated in a similar manner.

D.C. Voltmeter

For voltage measurements require resistors in series with our meter, these resistors are known as multipliers. Actually we are still measuring current flow through the meter; we know the total resistance in our meter circuit (100 ohms meter resistance plus the value of the multiplier), and we know the value of the current flowing through the meter circuit as this is indicated by the needle, so that with this same multiplier and same current reading the voltage will always



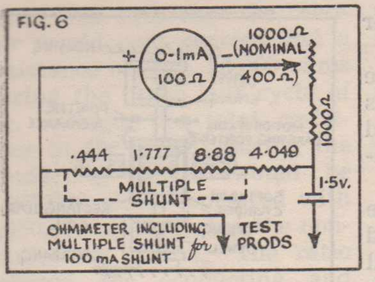


FIG. 6

be the same and can therefore be directly calibrated on the dial. This is just a matter of Ohms law (E = IR), or for those not conversant with these abbreviations, volts = amps x ohms, not forgetting that all our current values are in milliamps or 1/1000 of an amp.

As many of our voltage measurements will be taken across circuits of high resistance and uncapable of passingmore than a milliamp or two, it is important that the "ohms per volt" of the meter be kept reasonably high so that the meter will not draw current from the circuit under test, thus giving a false reading. Readings are not dead accuratein our case, but near enough for all practical purposes, our meter having a sensitivity of 1000 ohms per volt which is a good figure and common practice.

We desire full scale deflection when 10 volts are applied across the test prods, so the total resistance in the circuit must therefore be

$$R = \frac{E}{1} = \frac{10}{1} \times \frac{1000}{1}$$

$$= 10{,}000 \text{ ohms.}$$

This is equivalent to 1000 ohms per volt as stated above, so that for other ranges we have 100,000 ohms for the 100 volt range, 250,000 ohms for the 250 volt range and 1 megohm for the 1,000 volt range.

To find the actual value for each multipler we have to deduct the meter resistance of 100 ohms. This reduces the multipliers to 9900 ohms for the 10 volt range and 99,900 ohms for the 100 volt range. For the two higher ranges we can ignore the meter resistance, 100 ohms being negligible in 250,000 ohms and 1 megohm. The 100 ohms ignored in the case of the 1000 volt range would make a difference of only .1 of a volt in 1,000 volts.

Ohmmeter

Several ranges are required for the Ohmmeter as measurements have to be taken from a few ohms up to several megohms. If one scale were used, errors would occur at the high end of the scale due to crowding of the graduations on the meter scale and at the low end of the scale due to meter inaccuracy.

As in the case of the voltmeter and milliammeter, we again measure the current through the meter. This time, however, it is the voltage and current that are known, the voltage being supplied by a dry cell (1.5 volts) and the current known by the reading shown on the meter. With a fixed known voltage and a means of reading current through the meter, it only remains to calibrate the meter dial in terms of resistance, this again by

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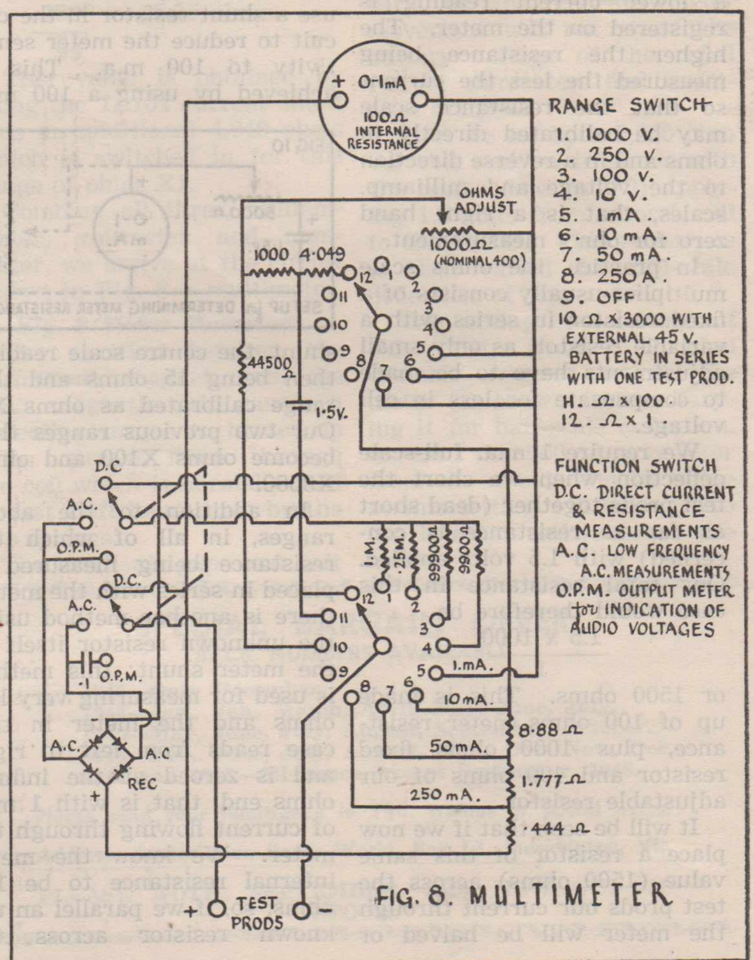


FIG. 8. MULTIMETER

MULTI-METER
(continued)

resorting to ohms law. The series resistor is selected so that when the test prods are shorted together, the meter gives a full scale deflection (zeho ohms). This series resistor is variable so that full-scale deflection can be obtained when the voltage of the cell drops below 1.5 volts with use and age.

When the prods are placed across a resistor, this extra resistance included in series with the meter circuit causes less current to flow through the meter due to the voltage drop across this resistor; hence a lower current reading is registered on the meter. The higher the resistance being measured the less the current so that the resistance scale may be calibrated directly in ohms and in a reverse direction to the voltage and milliamp. scales, that is a right hand zero for ohms measurement.

In practice, the ohms scale multiplier usually consists of a fixed resistor in series with a variable resistor, as only small adjustments have to be made to compensate for loss in cell voltage.

We require 1 m.a. full-scale deflection when we short the test prods together (dead short as far as resistance is concerned) with 1.5 volts applied. Our total resistance in this case would therefore be

$$\frac{1.5 \times 1000}{1}$$

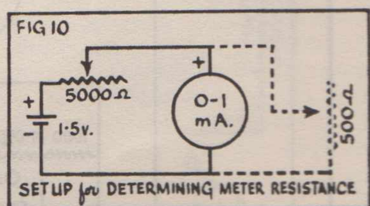
or 1500 ohms. This is made up of 100 ohms meter resistance, plus 1000 ohms fixed resistor and 400 ohms of our adjustable resistor.

It will be seen that if we now place a resistor of this same value (1500 ohms) across the test prods our current through the meter will be halved or dropped to ½ m.a., our meter reading ½ scale.

Full-scale deflection of the meter, as far as resistance is concerned, is to the left hand of the meter and has no definite value but "**infinity**".

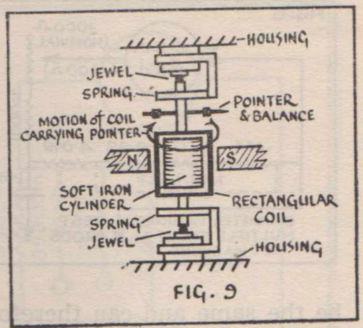
It is usual practice to include a multiplier that can be used in conjunction with an external 45-volt battery in series with one of the test prod leads. With this new range higher values of resistance can then be read accurately. For instance, if our multiplier for this purpose is 45,000 ohms, the centre scale would be 45,000 ohms, giving our previous range readings X10.

So that low ohms can be read accurately, it is usual to use a shunt resistor in the circuit to reduce the meter sensitivity to 100 m.a. This is achieved by using a 100 m.a.



shunt, the centre scale reading then being 15 ohms and this range calibrated as ohms X1. Our two previous ranges then become ohms X100 and ohms X3000.

In addition to the above ranges, in all of which the resistance being measured is placed in series with the meter, there is another method using the unknown resistor itself as the meter shunt; this method is used for measuring very low ohms and the meter in this case reads from left to right and is zeroed at the infinite ohms end, that is with 1 m.a. of current flowing through the meter. We know the meter internal resistance to be 100 ohms, so, if we parallel an unknown resistor across the



meter, the greater the value of this unknown resistor the less the current through it and consequently the more current through the meter.

We will not include this range in our completed multimeter as the additional switching required would not be warranted, particularly as we already have a range with a centre scale of 15 ohms. This low range is quite low enough for general usage.

The ohmmeter may be used for indication of short circuits (continuity tests) and open circuits as well as resistance measurements.

Adding A.C. Ranges

To measure A.C. voltages we naturally require a rectifier of some type or another. A copper oxide rectifier is used in a full-wave bridge circuit for this purpose, on account of its compactness, lightness and efficiency.

The full-wave bridge type keeps the efficiency high when voltage measurements ea r taken with a high resistance multiplier in the meter circuit. Suppose on the other hand we were to use a simple half-wave rectifier and that we were switched to the 1000 volt range in which case we would have the 1 megohm multiplier resistor in the circuit. Now, if the rectifier had a resistance of, say, 1000 ohms when polarity of the voltage being measured was such that the rectifier would pass current and a resistance of, say, 50,000 ohms during the other half cycle of a.c. voltage, the total resistance in the circuit during the conducting period would be 1,001,000 ohms compared with 1,050,000 ohms during the non-conducting period. The ratio between the conducting and non-conducting resistances has now been lowered from 50 to 1 without the multiplier in the circuit to as low as 1 to 1.04 with the multiplier included in the circuit.

The current at the output of the rectifier is pulsating d.c. so the meter reading is of the average value. As we require r.m.s. values we must multiply the d.c. volts calibrated on the scale of the meter by 1.11 or preferably draw a separate scale.

As an output meter is essentially an a.c. voltmeter, we may as well include one, the only additional requirements being provision for switching in a .1 blocking condenser. This condenser is necessary as a d.c. voltage is present across the primary winding of a speaker transformer in addition to the Audio voltage of which we desire an indication.

We have now analysed the individual volt, ohm and m.a. meter circuits, but before proceeding to combine these into a single instrument we will see how a multiple shunt may be used to simplify switching and how this shunt may also be used in conjunction with the ohm x 1 scale.

Referring to figure 7, it will be seen that the unused portions of the multiple shunts add to the series resistance of the circuit which explains the difference in value between these shunts and those shown in Fig. 1. For instance, when we are switched to the 250m.a. range the meter resistance plus the two sections of resistance in series wth it total 110.657 ohms. If this value of resistance passes 1 m.a. (full-scale deflection), then

$$\frac{110.657 \text{ ohms}}{249} = .444 \text{ ohms}$$

would shunt 249 m.a. around the meter to give a f.s.d. when 250 m.a. of curren is flowing.

Turning to figure 6, it will be noticed that we have made use of our multiple current shunt totalling 11,101 ohms in our ohmmeter. We know that 1500 ohms passes 1 m.a. with 1.5 volts applied, and wish to decrease the meter sensitivity to 100 m.a. which means that 99 m.a. have to be shunted around the meter. This requires a shunt of

$$\frac{1500}{99} = 15.15 \text{ ohms.}$$

This value is obtained by using the 11.101 current shunt plus an additional 4.049 ohms which is switched in for this range of ohms X1.

Combing all three, milliammeter, voltmeter and ohmmeter, we arrive at the circuit shown in Fig. 8 a multimeter.

Fig. 9 Meter Movement

The reaction between the permanent magnet and the coil's magnetic field causes a deflecting torque to be set up when current flows through the coil which is normally held at rest (left hand zero) by the two springs.

The small air gaps and soft iron cylinder keep the field uniform and concentrated so that a linear deflection of the pointer results.

Ascertaining Internal Resistance of 0-1 Milliammeter

In our discussion of the ohmmeter, it was seen that, provided the meter is correctly zeroed for full-scale deflection of 1 m.a. when the test prods are shorted, a resistor of equal value to the internal resistance of the meter when added to the circuit would cause a half-scale deflection of the meter.

It is this method that we adopt to determine the meter resistance, first finding an equal value of resistance to that of the meter and then measuring it. This is necessary as the delicate meter movement will not stand the battery voltage of the usual run of ohmmeters and resistance bridges.

First we set up a 5,000 ohm variable resistor in series with the meter (see fig. 10) applying 1.5 volts from a torch cell to the circuit. This resistance is then varied for full-scale deflection of the meter.

Maintaining the setting of this resistor shunt a 500 ohm variable resistor across the meter (as shown dotted) varying it for half-scale deflection. Remove the 500 ohm resistor from the circuit and its value at this setting will be equal to the internal resistance of the meter.

Audio Frequency Amplifiers

ONLY last week we heard someone exclaim "I wish I understood radio theory better". Stop wishing this way and get right into this theory course. It isn't dull or dry like some theory, but will give you a truly valuable grounding in the subject.

By
W. S. LONDEY
Barkly Street,
Sale, Victoria

In the sectional analysis of radio receivers we have discussed the receiver in general up to the stage where the signal from the radio transmitter has been converted from a modulated radio frequency signal to an audio frequency one by the detector.

This audio signal should have the same wave form as the original sound and should be free from any carrier or intermediate frequency.

The peak output of the detector varies somewhat but the average output from a biassed type detector may reach 20-30 volts while that from a diode type detector will be from 2 to 10 volts peak, the actual value depending on the signal at the aerial, the type and efficiency of the a.v.c., and various other factors.

This detected signal must be amplified, or more correctly, increased in power until it is capable of operating a speaker.

The actual power required depends on the circumstances and location in which the unit will be used. It would be useless to attempt to give satisfactory volume in a small hall full of people with a battery type amplifier having an output of about half a watt. On the other hand, a 50-watt amplifier would be wasted in a private home where the power required would be about a watt, or at the most four or five.

As most power amplifier valves require a fairly large audio input voltage it is usually necessary to have some form of audio frequency amplifier between the detector and the output or power valve. In the interests of quality and minimum distortion it is advisable, if possible, to select the driver valve so that it is capable of supplying about double the required peak voltage.

As most modern receivers use a single pentode or beam type power valve, these will be considered first.

The following table gives the power output and peak input for the principal types in use at present—

Valve Type	Power Output (Watts)	Peak a.f. Input (Volts)
1Q5	0.27	4.5
3V4	0.24	4.5
1L5	0.34	4.75
1L5	0.75	6.25
6F6	3.2	16.5
6V6	4.5	12.5
6V6	1.5	5.0
6L6	6.5	14.0
EL3	4.5	6.0
KT61	4.3	4.3

The first two types shown are battery types designed for use with dry batteries, the 1L5 is a 2-volt battery type

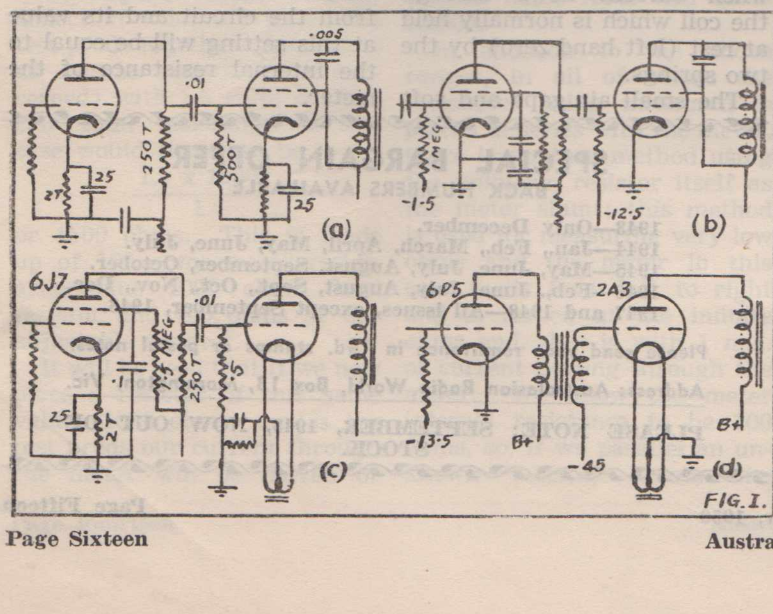


FIG. 1.

and two common operating conditions are shown, the first with 135 volts h.t. and the second with 180 volts (the usual condition for vibrator type sets). The remaining types are all 6.3 volt-heater type valves for a.c. type sets and the values shown are for 250 volts on plate and screen, except in the case marked, which is a special condition for the 6V6 which may be used where low power output and low plate current is preferred. (100v. screen, 250v. plate.)

Study of the above figures will show that some form of audio amplifier is necessary between the detector and power valve in all cases which use a diode type detector — with the possible exception of the KT61, EL3, and low power 6V6, and even in these cases the set will not give maximum output except on local stations.

Biassed type detectors are quite capable of operating any of these output valves without an amplifier stage.

It is almost universal practice to use a single stage of audio amplification between the detector and power valve in a battery receiver, as the detector output is usually low and the set is usually operated with the output valve near full output.

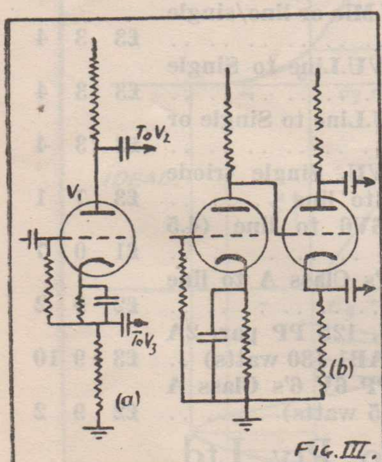


FIG. III.

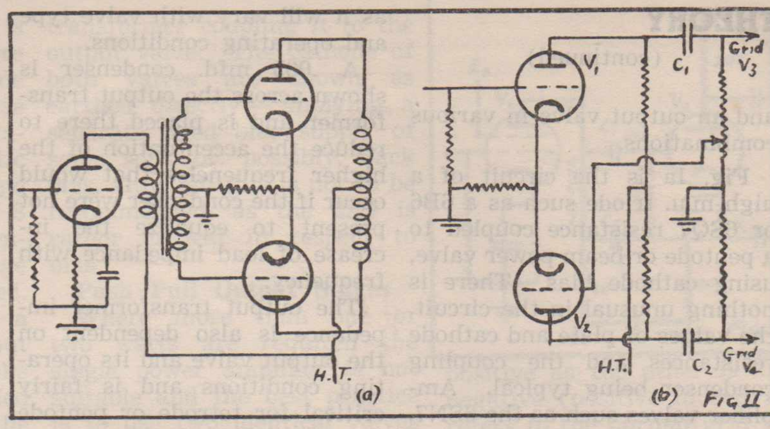


FIG. II

Audio Amplifiers

The type of voltage amplifier used depends to a large extent on the receiver, its output valve and the uses to which it will be put. The most common arrangement is to use a triode or a pentode as a resistance coupled amplifier; this arrangement giving ample gain for most cases and good quality.

A pentode, such as a 6J7, will give a stage gain of 80 to 150 and a peak output of 70 to 110 volts, while a high m.u. triode, such as a 6SQ7, will give a stage gain of 30 to 60 with a peak output of 30 to 60 volts. The triode has the advantage that it does not require a screen supply and therefore saves a few parts and connections (and service troubles as 1.5 meg. resistances have a habit of breaking down).

There is another arrangement used, particularly when a low grid circuit resistance is specified for the power valve. A low gain triode valve is used and it is transformer coupled to the grid of the power valve. With a transformer ratio of two or three to one it is possible to get a stage gain of 30 to 45 and almost unlimited peak output (150 to 250 volts peak at the transformer secondary). The transformer coupled arrangement is more expensive, particularly if an attempt is made to obtain reasonably high fidelity and wide frequency range. Transformer coupling has its advantages where push pull operation is desired—of which more later.

Triode Power Amplifiers

Triode valves have been made and are still available for use as power amplifiers, but are little used in home receivers as single amplifiers because they require a very large peak voltage at the grid and have a low output and efficiency. For example, the 2A3 gives 3.5 watts output for an input from the power supply of about 18 watts and requires a grid drive of 60 volts peak, while the 6V6 with 13 watts plate supply power and 12.5 volts at the grid can deliver 4.5 watts of output. On the other hand the triode has much less distortion than the pentode or tetrode and is less sensitive to variations in load impedance. Although a pentode type voltage amplifier is capable of satisfactorily driving a 2A3, a triode with transformer coupling is better as it allows the lower grid circuit resistance recommended.

Single Ended Driver and Output Circuits

Fig. I shows four circuits using a voltage amplifier valve

(continued on next page)

THEORY

(continued)

and an output valve in various combinations.

Fig. Ia is the circuit of a high m.u. triode such as a 6B6 or 6SQ7 resistance coupled to a pentode or beam power valve, using cathode bias. There is nothing unusual in the circuit, the values of plate and cathode resistances and the coupling condenser being typical. Amplifier valves such as the 6SN7, which have a lower gain and plate resistance than the 6B6 are usually used with a plate load of about 100,000 ohms. The cathode resistance of the output valve is not given as it will vary with valve type and operating conditions.

A .005 mfd. condenser is shown across the output transformer and is placed there to reduce the accentuation of the higher frequencies that would occur if the condenser were not present to equalize the increase of load impedance with frequency.

The output transformer impedance is also dependent on the output valve and its operating conditions and is fairly critical for tetrode or pentode valves.

Fig. Ib shows the circuit for a pentode driver and power output valve (6J7-6V6) using back bias. The cathodes of both valves are earthed and bias is obtained from a resistance "R" in the power transformer high tension centre tap lead. The value of this resistance depends on the total H.T. current of the receiver, but should be arranged to give a bias as specified for the valves under normal operating conditions (the current drawn by the r.f. and i.f. valves usually is reduced when tuned to a station and this must be taken into account).

Fig. Ic shows a pentode driver and a triode power amplifier valve. The only feature which is important is the method of obtaining bias for the 2A3. The filament winding which is connected to the 2A3 filament is centre tapped and the cathode bias resistance is connected between this centre tap and chassis. The cathode by-pass condenser in this case cannot be an ordinary low voltage high capacity electrolytic condenser as the bias voltage is 45 or so and an ordinary 8 or 16 mfd. electrolytic condenser having a working voltage of 100 to 300 must be used. This arrangement requires a high tension supply of about 300 volts from the filter choke because the bias must be added to the desired plate voltage, the cathode (filament) being positive this amount.

It will be noticed that there is a resistance-condenser filter shown in the h.t. supply to the a.f. amplifier valve in figs. Ia and Ib. This is good practice as this stage can tolerate much less h.t. ripple than the output or r.f. stages. In addition, this filter assists in preventing feed-back troubles from the output valve plate through the h.t. supply.

Fig. Id is the circuit of a triode driver stage with a transformer coupling it to the output valve. The cathode of both valves are shown as earthed directly — implying a separate fixed bias supply of some sort, or, possibly, back bias, although this is not to be recommended, as the 2A3 is rather critical in respect to bias.

Push Pull Output Stages

Where more than one or two watts are required the single power amplifier is not suitable and the best practice is to use two identical valves in push-pull as this gives more power than two valves in parallel and with less distortion. The reduction in distortion is due to the fact that all even harmonics (2nd, 4th, 6th, etc.) are cancelled by the push-pull arrangement.

There is, however, one important requirement of the driver stage for a push-pull output stage—it must supply to the grids of the output valves signals of equal amplitude, but opposite in phase, that is one grid must be driven positive as the other is made negative (positive in this case refers to the normal grid voltage and not necessarily to cathode). The output transformer must be centre tapped also, one output valve plate being connected to each end and the h.t. supply to the centre.

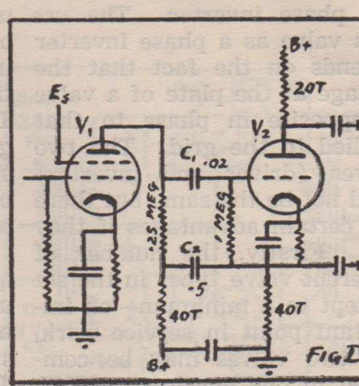


FIG IV.

The simplest means of obtaining the push-pull grid voltages is by using a transformer coupled driver and making the transformer secondary centre-tapped as shown in fig. IIa. In this case triodes are shown as the output valves but tetrodes or pentodes could be used, the only changes being the additional screen grid connections. It will be noted that the cathode resistance is not by-passed in the case of the output valves. A by-pass condenser is not necessary in this case (class "A" only) as there is no a.f. present in the cathode circuit as it cancels out. This system has the disadvantage of being rather expensive for anything better than average quality, as a good transformer then becomes a necessity.

It is possible to obtain the push-pull grid voltages without any transformers by introducing an extra valve between the input and one grid. This valve is termed a phase inverter as it serves to invert the phase of the voltage to the second output valve grid. Fig. IIb shows the usual circuit for a phase inverter stage. V_1 being the audio amplifier valve and V_2

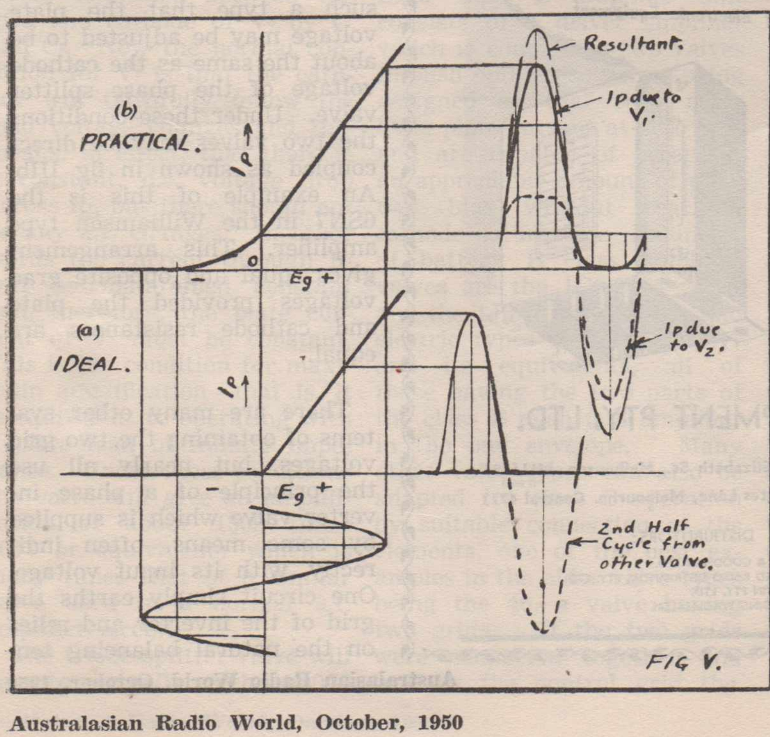


FIG V.

the phase inverter. The use of a valve as a phase inverter depends on the fact that the voltage at the plate of a valve is opposite in phase to that applied to the grid. The two valves (driver and inverter) need not be the same but there are certain advantages if they are. Firstly, the number of different valve types in the set is kept to a minimum—an important point in service work, the two valves may be combined in one envelope, (6SN7, 6C8), and similar valves allow the use of a common, unbypassed cathode bias resistance as shown, and this assists in ensuring that the two output voltages are equal and opposite.

The ideal phase inverter valve would have a gain of unity, but the same result can be achieved by supplying the inverter valve with a proportion only of the output of V_1. This is done by tapping the grid of V_2 down on the grid resistance of V_3 and for perfect balance, this tap should be made adjustable.

This arrangement gives quite good results and is often used, but the balance does not hold perfectly for all signal strengths and frequencies. This is so because the gain of any valve is not constant at all output voltages and the presence of an extra condenser (C_2) in one grid circuit only accounts for the variation with frequency.

Phase Splitter

A more accurate method of obtaining balanced grid voltages is to use a triode valve in the circuit shown in fig. IIIa. The valve, which is preferably a medium gain triode, has equal resistances in the plate and cathode circuits and is supplied with a signal in the normal way. Owing to the large un-by-passed resistance in the cathode circuit the valve will operate as a cathode follower so that a voltage equal to and in phase with the input signal will appear at the cathode. As a voltage variation at this point can only be obtained by a variation in plate current, an equal change in voltage must appear at the plate. This voltage will be opposite in phase to that at the cathode because the positive end of one resistance and the negative end of the other is at zero potential with respect to audio voltages. Bias is obtained by means of the usual cathode resistance and by-pass condenser, the grid resistance being returned to the junction of the bias resistance and cathode load resistance. Another method of coupling to the grid is by using a driver of such a type that the plate voltage may be adjusted to be about the same as the cathode voltage of the phase splitter valve. Under these conditions the two valves may be direct coupled as shown in fig IIIb. An example of this is the 6SN7 in the Williamson type amplifier. This arrangement gives equal and opposite grad voltages provided the plate and cathode resistances are equal.

There are many other systems of obtaining the two grid voltages, but nearly all use the principle of a phase inverter valve which is supplied by some means, often indirectly, with its input voltage. One circuit simply earths the grid of the inverter and relies on the natural balancing tendency of the common cathode resistance, which is un-by-passed and may be higher than usual, to obtain the balanced voltages. Another ingenious idea is to place a resistance of suitable value in the screen circuit of one of the output valves and to drive the second valve with the a.f. voltage appearing at the screen. I would not like to say that this arrangement would give the balance or freedom from distortion that is expected from a good inverter stage but it does save one valve.

A system suggested in an English radio publication is very interesting from the point of view of getting the most out of the valves used, which are a pentode driver and a triode splitter, the circuit being as shown in fig. IV. At first sight it appears to be normal except that the phase splitter cathode resistance is twice the resistance of the plate load. However, the plate load resistance of the driver is effectively connected between the grid and cathode of V_2 by C_1 and C_2. Now the normal condition for V_2 is that the cathode will faithfully follow the grid voltage changes and this means, in effect, that there is a constant, d.c. voltage drop across R_1, but there should not be any a.f. changes. In other words the current through R_1 will be maintained constant and, therefore, the plate current of V_1 must be constant. This is the condition for maximum amplification—that is, it is equivalent to operating with a plate load of infinite impedance. Under these conditions the valve will give an amplification of about 1500 times (6J7 or equivalent) which is many times that of a similar valve used in a normal a.f. amplifier circuit.

The triode splitter valve will operate normally as the 40,000 ohm resistance in the plate feed circuit is in parallel with the cathode resistance, making the impedance 20,000 ohms, the same as the plate load resistance.

The advantage claimed for the circuit is that it gives a gain of about 10 times that of a single stage so that the second valve, although not contributing anything to the gain by its own amplification, is used to increase the gain of the previous tube to make up for its own lack. I do not know how the arrangement will meaure up from the quality point of view, but it appears that it would not tolerate any capacity in the plate circuit wiring.

Class "B" Amplifiers

The class B amplifier is most commonly encountered in battery type receivers where economy of high tension current is important and comparatively high output power is required, or in high power public address systems and modulators. The ideal class B amplifier unit consists of a driver amplifier which is coupled to two valves in push pull, these valves being designed so that they draw little plate current at zero bias and are capable of accepting an appreciable amount of positive bias without reaching cathode saturation. Examples of battery B class amplifier valves are the 1G6 (1.4 volt), and the 1J6 or 19 (2 volt) and electric types include the 6N7 and its equivalents, all of these having the two parts of the class B push pull amplifier in the one envelope. Many other valve types can also be adapted for class B operation by suitable connection of the elements, one of the best examples in the older valve types being the 46, a valve having two grids. If the two grids were connected together and used as the control grid the

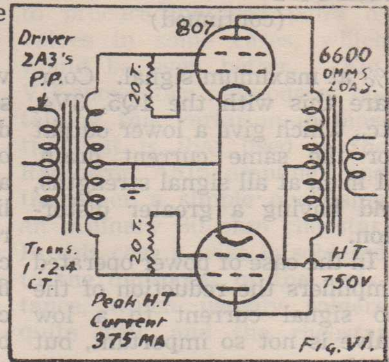


Fig. VI.

valves could be used as the push-pull class B output valves, but if the second grid was connected to the plate the valve operates as a normal amplifier and requires about 30 volts of bias and gives an output of about 1.25 watts. With this connection the valve is capable of satisfactorily driving a pair of 46 valves as class B amplifiers to give an output of 16 to 20 watts. The 59, a valve type which has virtually disappeared in the last few years was another valve which could be used with several different connections, one of which was as zero bias class B amplifier. Some battery type valves such as the 1H4 may be used as a biassed type class B amplifier (battery bias only).

The advantage of the class B amplifier lies in the fact that the plate current under no signal conditions is low and that it increases as the applied signal increases. This means that the power supply is called on only for sufficient power to give the desired audio output —in theory at least. The advantage of this in practice is shown by considering the 1G6, a 1.4 volt class B amplifier which is capable of an output of 350 milliwatts for a current of 11 milliamps, but with a no signal current of only 2 milliamps, and a distortion of only

(continued on next page)

THEORY
(continued)

4% at maximum signal. Compare this with the 1Q5, 3V4, etc., which give a lower output for the same current drain, 11 m.a., at all signal strengths, and having a greater distortion.

In the case of power operated amplifiers the reduction of the no signal current to a low valve is not so important, but the lower average current with a class B amplifier allows the use of a somewhat smaller power supply, particularly for speech work where the power is varying all the time. If class A amplifiers are used the power supply must be capable of supplying the full output all the time.

Push Pull Necessary

The use of push-pull output valves in class B stages is essential because the valves are designed to be very near cut-off under zero bias conditions and any negative signal has little effect on the plate current. The ideal input-output characteristic is as shown in fig. Va, which shows a sharp change in slope at the zero bias point. This curve will give an output signal which contains only the positive half cycle of the input signal, but if two valves are used in push pull the output will then contain both half cycles, one from each valve and the distortion, which would be nearly all even harmonics (2nd, 4th, etc.) would be reduced to a very low value as a push-pull connection causes even harmonics to cancel out.

In practice, the valve has a curved characteristic and some distortion is inevitable, but the principal cause of the distortion is the fact that all zero bias amplifiers must not only have a varying plate current, but, in addition there must be some grid current during the positive half cycles. This makes transformer coupling a necessity and as the transformer has some resistance and leakage reactance, the grid circuit impedance cannot be zero which would be the ideal. This impedance, together with the power supply regulation (variation of voltage with current) reduces the maximum possible power output slightly as well as increasing the distortion.

Because the driver stage has to supply the power consumed by the grids of the class B stage it must be capable of a fairly large power output (comparatively) and, because of the transformer coupling, must generally be a triode.

One recent example of a modern class B amplifier is the use of two type 807 valves in a zero bias circuit as shown in fig VI, in which an output of about 120 watts is obtained from an input of 5 or so watts to the grids and a plate supply of 750 volts.

Class AB1, AB2

As most valves cannot be operated under zero bias conditions and their characteristics do not lend themselves to class B operation, it is common practice to operate push-pull amplifiers in a slightly overbiassed condition to reduce the no signal plate current slightly. As a consequence, the plate current increases slightly from no signal to maximum signal. This is usually done because the high tension supply voltage is often increased for push pull stages to obtain higher power output and the bias must be increased to keep the plate dissipation below the maximum rated value.

If the peak grid voltage is less than the standing bias, no grid current will flow during any part of the cycle and the valves are said to be operating class AB1. Increasing the peak grid voltage so that grid current flows during part of the cycle gives class AB2 operation. In the latter case the grids must be supplied by transformer coupling although either transformer or resistance-capacity coupling may be used for AB1.

As an example of the above the operating conditions for the 6L6 may be taken as typical.

	Neg. Bias Volts	Plate Volts	Screen Volts	Grid Volts Peak	Plate Current No. Sig.	Plate Current Max. Sig.
Class A single valve 6.5 watts ..	14	250	250	14	72	79
Class AB1 P-P 18 watts	22.5	360	270	22.5	44	66
Class AB2 P-P 47 watts	22.5 (Low impedance)	360	270	36	44	102.5

The currents for the push pull examples are given for one valve only so that double the current would be required. In the last example the maximum plate current would only reach 205 m.a. on peaks, so a power supply capable of about 175 m.a. would be satisfactory in most cases.

The rated maximum plate dissipation is 19 watts and the no signed dissipation for the cases listed is 18 for the first and 15.8 for the others. The actual plate dissipation under maximum signal conditions is not Ep x Ip, but is less by the power supplied to the load, so will be less than the no signal dissipation.

Nearly all push-pull amplifiers are operated on class AB1 conditions because of the plate dissipation limitation.

Except where valves are not critical with respect to bias, it is good practice to provide some means of adjusting the bias for each valve separately so that the plate currents may be made equal. It is possible to procure matched pairs of valves in some cases, which would be even better. Fig. VII shows two methods of obtaining this variation in bias, the first is that used in the Radiotron A515 amplifier and the other a simple one using an ordinary 30 ohm rheostat. In this case a wire is soldered to the mid-point of the resistance, which usually solders quite well, and the rheostat connected as a potentiometer as shown.

Where back bias or a separate bias supply is used it is a simple matter to arrange a variable tap for one valve bias supply. In the case of class AB2 amplifiers the bias supply must have low resistance and be well by-passed, otherwise the bias may vary with the grid current instead of remaining constant.

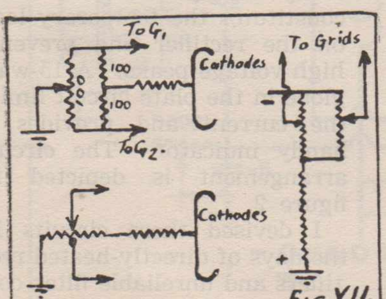


FIG VII.

Peak Protection Devices

I PAY tribute to the ingenuity of G. B. Wolfe in his time-delay switch for protecting filter condensers during the "warm-up" period, as described in the August number of A.R.W. In some of the recent high voltage amplifiers there is a renewed need to look after the peak voltages which are developed by a directly-heated rectifier before the load comes on. It may be of interest to readers that this can be accomplished by simpler methods on the dummy load principle, the first of which to be described has worked for several years in one amplifier without the slightest trouble or failure.

In figure 1, the fixed contact on an ordinary motor-car cut-out has been remounted so as to provide a "break" when current flows through the relay instead of a "make". The low resistance coil is not used, but the high resistance coil is inserted in the high tension lead of the power unit between the rectifier and first filter condenser. The fixed contact of cut-out is connected to the H.T. line on the rectifier side and the moving contact to a voltage divider tapped at approximately 10,000 ohms, the other end of which is earthed. In some cut-outs insulation will have to be provided between chassis and cut-out.

When the equipment is switched on, a by-pass bleed circuit is provided across the output of the power unit, thus holding the voltage within rateable limits, but when the valves have warmed up and start to pass current through the relay coil, the contacts open and isolate the bleed circuit. A little adjustment may be necessary in the tension of the armature to obtain the final crossover condition.

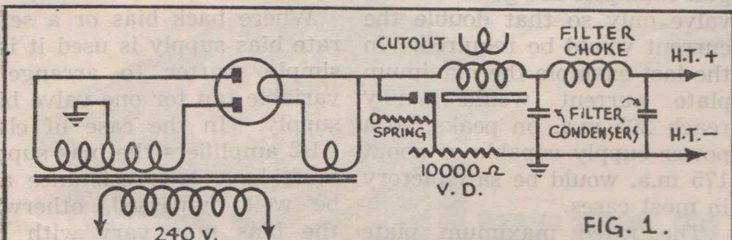


FIG. 1.

A more scientific method, but one which involves a spare 2.5v. heater winding and a discarded 2A3, is applicable where a speaker field is to be energized. The field is placed in the negative lead of the power unit and the normal voltage drop across it is used to over-bias the 2A3 so that practically no plate current passes through it when the equipment is working normally. During the warm-up period, however, there is no voltage drop across the field, the grid is at zero bias, and the 2A3 draws a comparatively heavy current which constitutes the temporary load on the rectifier and prevents high voltage peaks. A 15-watt globe in the plate circuit limits the current and provides a handy indicator. The circuit arrangement is depicted in figure 2.

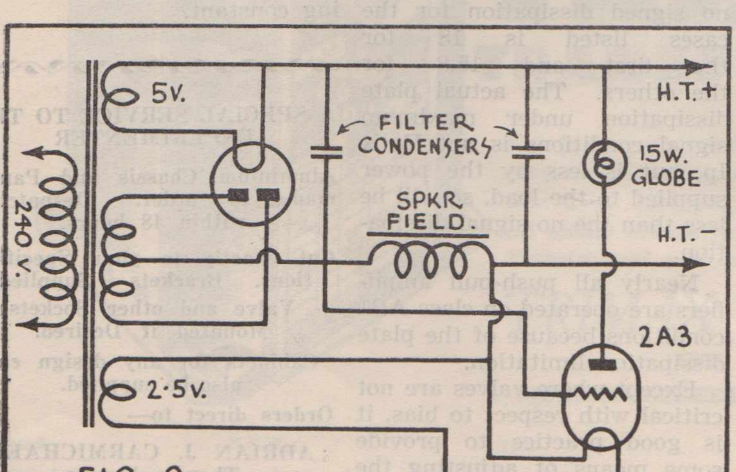


FIG. 2

I devised these circuits in the days of directly-heated rectifiers and unreliable filter con-

(continued on page 34)

TOPS IN TUNERS

THE mail bag continues to overflow with interesting letters from our many readers, near and far. Many of them contain items of really practical value, direct from enthusiasts who have similar interests to your own.

FROM Mr. C. W. McIntyre, of 8 Macalister Street, Ipswich, Queensland, comes a claim that the t.r.f. tuner which he is now using "is the tops." Mr. McIntyre has been working on tuners for some time past, first from a circuit we published a short time ago, then from the circuit which was given in our issue of May, 1941.

Modifying this circuit to use the single-ended valves type 6SJ7 and 6SK7, and using Aegis coils, with an iron-cored coil for the aerial stage and air-cored coils for the r.f. transformers, Mr. McIntrye finds that it gives excellent quality when hitched up to his direct-coupled amplifier driving a Rola 8/42 speaker in a 5¼ cubic foot vented enclosure.

Radio is strictly a hobby with Mr. McIntyre. He makes his units upon separate bases, connecting them up with miniature plugs and sockets. For the chassis he uses the aluminium cake cans which he can obtain cheaply from Woolworths. These measure 10 x 3 x 1⅞.

Mr. McIntyre offers a cordial invitation to anyone interested in radio to call on him when visiting Ipswich, and he would also like to start up correspondence with anyone having similar tastes, so as to compare notes, etc.

"Herewith please find cheque for my subscription, which ran out some months ago. I had sworn off radio for keeps—for about the third time — but somehow I always fall again. I am interested in hi-fi from records and radio, if any. The set-up I am using is some 14 years old, has been re-vamped several times but is still essentially the same, with t.r.f. tuner, push-pull amplifier with 6J7, 42 as a triode, transformer coupled to a pair of 42's as triodes, Connoisseur moving iron pick-up, pre amp with bass boost to Connoisseur circuit. I use two speakers, a Jensen A12 for the bass, and a high note unit built up from a Tannoy magnet and voice coil from disposals, with horn loading and a dividing network with 12 db./octave cut-off. I have learned much from your journal in the past; may I wish you the best in the future." — **L. B. Cullen, Chartered Engineer, 5 Highbury Street, North Balwyn, Victoria.**

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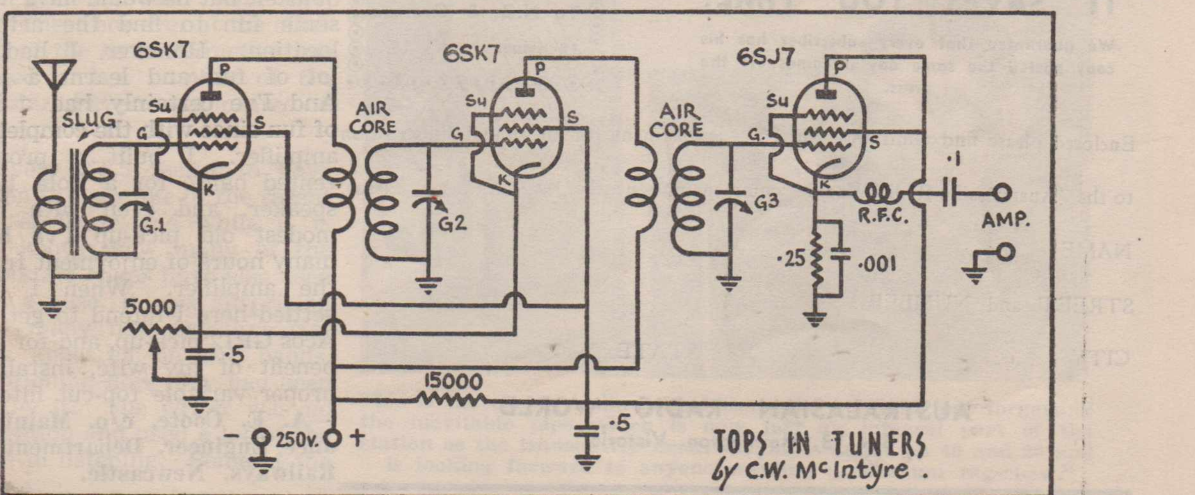

OUR READERS

(continued)

"I am a commercial operator, and also a ham; have been interested in radio for a few years now. Am particularly interested in receivers, test gear as applied to both the ham world and the service bench, and medium-fi reproduction. Amplifier in use is p/p 2A3's with a Connoisseur pick-up, twin speakers with change-over network, in heavy cabinets. Here's wishing A.R.W. continued success." —

C. A. Hyatt, 30 View Street, Alphington, Victoria.

"Please find postal notes enclosed for renewal of subscription. This will make me a seven-yearer; that is praise enough for your excellent magazine."—**L. J. Boyle, 120 Fernberg Road, Rosalie, Q'ld.**

"I feel that I must accompany my cheque with a note to let you know that your journal is appreciated in this part of the world. I look forward to its arrival each month and am not disappointed, as it is certainly not deteriorating at all. One shortcoming, and perhaps hard to do anything about, is lack of details in the advertisements, prices, types, varieties, etc. Your last six or seven issues are badly dog-eared and battered as I have read and re-read the articles on direct-coupling and am at present surrounded by large slabs of cedar from which I am fashioning a vented baffle. The A. & R. transformer arrived several days ago, so you see I am having a busy time building the d.c. amplifier. I have no doubt that it will be a success; if it isn't my wife will take a lot of living with."—**J. M. Reid, Box 51, Tenterfield, N.S.W.**

"I look forward to Radio World each month. It is easily the best monthly publication on the market at present. You might remember I wrote you some months ago in a terrific hurry, about the hum in your direct-coupled amplifier circuit which I made up. You kindly replied promptly, but to date I have not had the decency to tell you the results. Still, I suppose I am one of many hundreds who don't do this, so you have probably forgotten. I was completely baffled. Did no good until I started to pull it to pieces and then found one single strand from the metal braiding which was causing a short circuit. A more experienced man might have found the short much quicker, but he would have had some fun to find the actual location. However, I had a lot of fun and learnt a lot. And I've certainly had a lot of fun since with the completed amplifier. I built a proper vented baffle for a Rola 12-0 speaker, and even with my modest old pick-up I've had many hours of enjoyment from the amplifier. When I get settled here I intend to get an Acos GP12 pick-up, and for the benefit of my wife, install a proper variable top-cut filter." —**A. E. Coote, c/o. Maintenance Engineer, Department of Railways, Newcastle.**

(continued on page 33)

TRANSMITTING

Amateurs' Activities

Conducted by J. A. HAMPEL (VA5BJ)

WITH the Remembrance Day Contest and the VK-ZL Contest now past memories, the bands are back to the general state of inactivity brought about by the present sun spot conditions. As the sun cycle reaches its rock bottom around January next year the bands could get worse—if that is possible! Many and varied have been the comments on the present ionospheric conditions and apparently some stations have not yet realized this approaching null which occurs every eleven years. The shut-down during World War II covered the last one and it is really amusing at times to hear the theories on the subject advanced by some "natterers." While all the grumbling has been going on, some chaps have been lucky enough to share in the DX which the peculiar conditions have caused. 'Phone DX has popped up on 40 metres some nights; 20, although not near its usual form, has still provided some new rare ones; however at the other end of the scale 10 metres has closed and a number of the regulars have now appeared on 20.

Every VK5 seems to have fallen in the wake of the recent 'flu epidemic and while it is not known how many of the interstate chaps have also used this excuse, it was surprising how many new day-time signals appeared on the bands, mentioning how they had been hit by it. The writer was no exception and used a lot of the time in listening. Some of the signals heard were frightful, some good and a great number mediocre; with a crowded spectrum allocation it is up to us to use our bands sensibly. After a few hours of tuning around, however, I started to wonder what the casual listener who happens on the Amateur Bands on his dual-waver must think. No matter what the big-hearted public think about the Amateur's status in the community in time of emergency, they are the first to condemn him again for the slightest reason. Reformists have been urging a clean-up of our bands for some time now, but apparently to no avail; so that the conditions to-day have seemingly worsened and are no advertisement when it is realized that the two main bands for the dispensing of "drivel", unnecessary transmissions and mis-placed remarks are 20 and 40—right in the middle of the domestic short-wave ranges. Stations still persist in QRMing nets and the W.I.A. broadcasts, whilst listening on one's own frequency before transmitting is almost now unknown. This job of straightening up our bands is up to no-one but ourselves and the sooner everyone starts in his own little way, the better. As we have been told on this subject before: "United we stand, divided we fall." The commercials are after our channels as their premature presence already shows; they want our bands but are we going to give them cause to be in a position to make a claim? Once again, it's up to YOU.

VK5WM is a Happy Ham

This is the cheery smile behind the mike at 5WM, not forgetting the inevitable pipe which is now just an integral part of the station as the transmitter itself. Wyke is active on 40 and 20 and is looking forward to anyone wanting a "dinkum rag-chew."

News from the Shacks

5DR, isolated at Cape Cowedie, on Kangaroo Island, recently thought he had seen the end of the rig when the bank of batteries he was charging blew up in his face when about to remove them from the generator. Suffering only a minor injury as the plugs sped upwards, Bert has now installed a system of switching to control the charging from a distance .—.—. Kevin, 3AKG, had a meeting with exploding kerosene about the same time and was the first to sympathize with Bert while in QSO .—.—. 3AGD could not keep away from the bug while on holidays in the snow country of VK3, and kept skeds. with 3AJI on 2 metres. During this period the two Johns conducted a number of tests with antennae, but no results are known .—.—. 5RR missed out while on holidays as the ship on which he travelled only had 110 volt D.C. mains, so Reg's hopes of mobile operation were brought to a halt. It was the only voltage the Type III's power pack could not handle, despite its versatility to work from a wide range of voltages. Reg is now negotiating for his next holiday resort to be supplied with 240v. A.C.! .—.—.

As far as antennae go, the main topic at the moment seems to be the modified version of the old Windorn type which has always borne with it the stigma of BC1 — plus! However, this latest one to filter out from W land uses 300 ohm ribbon as the feeders against the old idea of a single wire feed. Several chaps who have tried it have quickly pulled it down again and the whole idea has lost its popularity generally. It may be unfair to judge any antenna with conditions as they are at present, but this sudden appearance of new antennae or new "re-hashes" of old ideas has been going on for a score of years and I, personally, take little notice of the chap who advises to "pull down your old wire there and try this one I have here." Sometimes it works out but lots of factors, such as height, type of terrain and location have to be taken into consideration; factors which usually upset all our pet theories as past experience has shown. Every "new" antenna can be traced back to the original ancestor which may be a quarter - of - a - centruy old! .—.—. 3AHK is very dormant and little has been heard of the Eastern Zone. The Sale Radio Club is under way and the organizers are reminded of the offer to publish Club news in this section for Amateurs .—.—. All Amateurs, particularly those residing in VK2, were recently called upon by Professor Bailey of the C.S.I.R.O. Radio Division, to give their aid by conducting listening tests on the broadcast band. The Professor has been experimenting with the modulation effects appearing on a Queensland station and once again Amateurs were able to help when requested to do so by VK2WI .—.—. 5LA, whilst rebuilding, is seriously thinking along high-frequency lines after recent acquaintance with VHF gear. Bob's interest up there so far lies in the F.M. band, but before long there should be another convert on 144 m.c. .—.—. 2BN has no trouble in knocking them over the hard way; Reg recently worked XE1AC and YN1HB on 40 metre 'phone whilst many others were bemoaning the poor conditions of the band.

Most nights on 40 will provide a few DX CW contacts as well as the occasional appearance of PK1's on 'phone near 7050 k.c. .—.—. 4TU, ex-5BW,

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FOR those who are certificate minded, the Moorabbin (Vic.) Radio Club has brought into effect a new award which is in the form of a handsome certificate worthy of any shack. This award also marks honorary membership in the Club when the recipient has shown proof of 15 contacts with transmitting members of the Club. As there are 50 members it should not be hard to establish QSO's with the 15 required. Stations intending to apply for the award should ask VK3 contacts near the Moorabbin area if they are members of the Club; if so, then a full exchange of details must be made so that both the VK3 and the other station may compile their lists for submission. Each member will be forwarding check logs so that this information is necessary to produce proof of the contact. The idea is certainly a commendable one as the Club has provided an excellent means of keeping themselves in the limelight, while the members won't be short of contacts if the idea catches on .—.—.

is still catching up with the QSL situation with being changed from station to station with the Air Force, so that you can still expect Bill's card — in time .—.—. 5BC knocked off to carry bricks when he went on leave from the broadcasting station where he is chief technician, just recently. Hugh took a portable 40 metre rig with him to Victor Harbour, a south coast resort where they have thoughtfully provided 240 volts A.C. for the holiday shacks—home away from home for portable operation .—.—.

(What about dropping a line to VK5BJ at Box 1589M, G.P.O., Adelaide, and setting out details of YOUR station. Your co-operation would be welcomed. J.A.H.)

(continued on page 34)

ALMOST A VK3

WITH his QTH almost on the Vic.-S.A. border at Pine Hill, 5CC almost got a VK3 call in the hand-out. Being on a farm, he is heard popping up on 40 metres at odd times, regulated by the work in hand. Since receiving the ticket a year ago Gordon has been very active, using only simple gear which has proved more than reliable. The first rig was an FS6 modified to use cathode modulation from a separate speech amplifier instead of the hopelessly inefficient grid modulation used originally. The present transmitter is the old favourite, the Jones regenerator oscillator, a one-tube rig with about 20 watts input feeding a coupling network into a Windom antenna. Soon after coming on the air Gordon found it necessary, like every other ham has at sometime, to move into a separate shack away from the QRM and is now able to boast a very neat layout, all wired with 32 volts throughout, as there is no A.C. available.

During the summer months, VK5CC joins the ranks of scores of other country amateurs when everything is placed in readiness for portable bushfire operation.

COMPRESSION

(continued from page 10)

tack and release time-constants variable, to cope with individual voice characteristics. This is done as shown in the diagram. The values shown are not significant. Beware of introducing more than a few milliseconds of FORWARD time delay. The release delay can be the subject of more experiment—if the overall action is too rapid, it will start to follow individual cycles of the audio, rather than the desired effect of "clamping" on the peaks of a whole train or group. Remember that it is possible to get this "balanced-modulator" style of unit rather TOO "hot", and discretion must be exercised accordingly.

About 10 to 15 DB. of compression is considered to be a very good figure. You will not get more than this, without cascaded compression stages, which get to be really intricate. Some of the ABC's short-wave broadcasts incorporate about 6 DB of compression, which gives an idea of commercial restraint in connection with such work.

It has been said that compression does not sound natural. This is true, but at the same time, it does not sound nearly so rough as the relatively crude "clipping" action which produces filtered square-waves, in the case of "Clipter" systems. Again, it is a matter for discretion. The operator must realise that Compression is not a panacea, but a system with clearly defined limitations, like all other equipment. The writer's unit can be heard in action currently, on the 20 and 40 meter bands, where further discussion relative to the foregoing material may be had. Questions in letter form will, of course, also be forwarded by the Editor, and will be handled as promptly as possible.

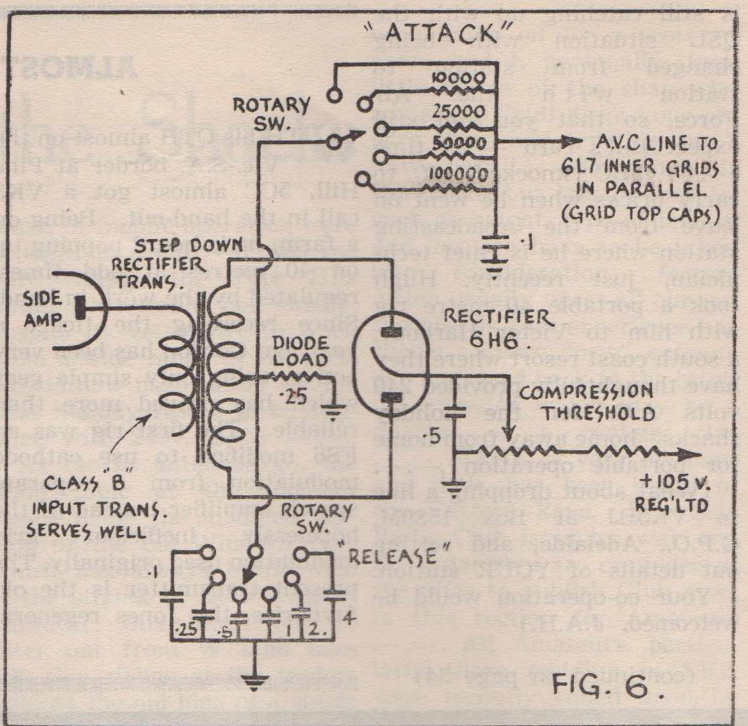

FIG. 6.

OUR READERS

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"I am most interested in aerial installations for receiving, as I reside in an area which gives poor reception due to interference from high tension power wires. I recently installed an aerial system using shielded co-axial cable and matching transformers which gave excellent results. When using an ordinary unshielded aerial, reception was impossible. Why I read your publication—I am a part-time radio serviceman and projectionist at St. Helen's cinema, therefore I like to keep up with any technical data. Hoping to be reading many more interesting articles in future issues as I have done in the past."—

K. E. Chapple, St. Helens, Tasmania.

"I am interested in direct-coupled amplifiers, and have built the single-ended direct coupler described in the March, 1949, issue. I wish to let you know that it certainly performs up to your claims and gives splendid transient response. I have also built one for a friend, and he is more than satisfied with the high degree of realism and clear-cut bass. We use it in our Dance Studio and the quality of the instruments and voices of the vocalists has often been commented upon. I found it necessary to include a .5 mfd. condenser, shunted with a 1 megohm potentiometer, in series with the feed-back resistor to give a bit more lift to the bass for some records. This control is seldom used when the amplifier is not in a hall."—**F. H. Wright, 24 Inverness Avenue, Penshurst, N.S.W.**

Sapphires Hard on Records

WITH this discourse on record reproduction the writer fully expects to raise some comment and perhaps introduce some argument as to the factors which are involved, but this can only be regarded as fortunate, as any information uncovered by others will be of assistance to anyone dealing with records.

By J. A. HAMPEL

A FEW months ago, a broadcasting station colleague and the writer decided to do some research into the field of needles — a subject on which very little has been written, and to say the least, is very much to the point! Over a period of using various types of needles, we both came to the conclusion that different needles gave differing responses, all other things remaining unchanged. To the ear the change of needles was only approximate and, of course, the output variation from the pick-up could only be roughly estimated and then solely over the whole complex audio range represented by the average record.

So it was that proper equipment was brought together to ascertain the output at spot frequencies in the audio range. In order to test the needles under the right conditions, each type was played with a broadcast transcription type "Audioscribe" pick-up, the response of which was already known and checked with our subsequent findings when using one particular type of needle. Other gear used included a Weston output meter and the set of standard frequency records made by the HMV company. When dealing with a certain make of needle, a number of that make were tried in turn, and, surprisingly enough, it was found that nine out of every ten selected were in a comparable class — the tenth only varying somewhere in the range. With this in mind, it can be safely assumed the same performance may be realized from other batches of the same brand needles.

(To further satisfy ourselves that the needles would be of different origins, they were purchased from three different distributors and therefore a ratio of one, in those ten, being then of negligible difference can be taken as a good average).

Even though it will be obvious from the figures finally compiled that different needles possess widely varying characteristics, it cannot be said that any one needle is better than its counterpart unless the application of that needle is taken into consideration. Each of the makes and types has been specially developed in most cases for a particular make or weight of pick-up, or, as is often the case, to suit individual listening tastes! An example of application would be a radio station using ordinary steel needles on its discs with the delicate "acetate" surface However, for the serious record enthusiast who is looking around the counters wondering what type of needle he should use, this will serve to illustrate to him the merits of the types found on sale to-day.

For these tests the writer's amplifier was used. This amplifier is flat, really flat, from 20 to 14000 cycles and, as the AWA Laboratory Audio Generator only extends that far, it probably goes along a straight "curve" even higher into the audio frequencies. Once again accurate laboratory instruments were used to check the amplifier and any chance of a discrepancy having been introduced by the amplifier itself can be ruled out. While conducting these experiments it was regretted that no projection equipment was available as it would have proved interesting to compare the point shapes, because although output from most needles hardly varied for one make, a much different story can be told of the point shapes, even when examined with the naked eye. In one tin alone three needles were found to have flats in-

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RECORDS

(continued)

stead of points, whilst another two were of uneven taper. Naturally, any departure from the standard can be expected to not only impair reproduction but have an abrasive effect on the record material.

When we came to sapphires, about which both of us had many misgivings due to past experiences with them, the first thing evident was that no sapphire would play records which had previously been played by a steel needle. Since the frequency records were on loan, no level comparisons could be made due to this tearing action. Noticing this result, various records were then tried with the following results: As stated, no sapphire would play a track already played by a steel needle; the same sapphire would play new pressings, both local and imported, only if they had not previously been played with a steel needle and that a sapphire reproducer would not fit the groove shape of records released up till about three years ago. Included in this group was a local pressing of a symphonic work some three years old and not previously played. The same thing is found on trying to play new local pressings of any re-issues made from the masters of ten to twelve years ago. Apparently the groove shapes have varied greatly over that period of transition to the "Hi-Fi"—this latter term to be taken as a lot of bunk, more than a serious name for present day record responses! Anyone who thinks that the present-day practice of the record companies in re-issuing the same old masters on the new base material will give him a better frequency response is sadly mistaken. The fact remains that only the genuine "ffrr" recordings are any different, but it is also a notable point that as soon as the high frequency response is raised in the upper limit, the scratch will come up in output, too. After playing some hundreds of these new records I'm more than ever convinced that the scratch frequencies are more objectionable now than with the older records of say three years ago.

To further test the sapphire as the "perfect reproducer" that we would be lead to believe, a new imported pressing was played continuously with the same sapphire till the reproduction was no longer enjoyable or bearable. After the thirty-eighth playing our nerves were on edge with the noise and so it is inconceivable that a collector would preserve a worthwhile library of discs after they had been played more than thirty-five times. Two acetate type discs, as used by Broadcast stations, were available to be played by the sapphires; at the first playing the sapphire ground the surface into a fine powder and after two playings, the modulation on the grooves had been destroyed in parts so that further playing would have been impossible. It has always been the writer's opinion that in the one big chain involved in record reproduction, something must eventually wear. With the steel needle it is the needle which wears and, of course, it can be discarded as soon as necessary, whereas, with a sapphire it remains a polished and perfectly shaped point so that the disc must, and does, wear.

So, can we expect in the future to have a sapphire reproducer and throw away the records instead? To say the least, it is a frightening thought with records at their present-time high price!

INDEX TO VOLUME 14

Speedy Query Service

Conducted under the personal supervision of A. G. HULL

R.J. (Ballarat enquires about magazine prices.

(A): The price which is charged for any periodical or daily paper has little relationship to the printing cost. In fact, for example, one of the typical Saturday papers will contain more than 6d. worth of bare paper, yet sells for 3d. The cost of production, profit and incidentals is borne by the advertisers. Revenue from advertising is sometimes several hundred pounds per page. Advertisers are often like sheep. Where one goes the others follow. Once a paper or magazine appears to be popular the advertisers flock to get into it, thereby providing the publisher with plenty of funds so that he can disregard such trifles as the extra cost of colour printing.

W.A. (Cabramatta) has a low-output pick-up, and is having hum trouble.

(A): We heard recently from a chap who found that his pick-up gave hum trouble if he used the shield braiding as the earth return. By connecting two separate leads to the pick-up, then enclosing them in braid, with the braid earthed to the metal chassis, but not to the negative side of the pick-up leads, he found that he cured his hum trouble. It might help in your case and is well worth trying.

C.H. (Colac) asks about the EL35.

(A): Yes, this is a valve with great possibilities and we hope to do quite a bit with it in the near future. It is possible to get plenty of power from a single valve, with only 250 volts high tension. There seem to be no worries about it at all, and it definitely sounds good in practice. It should be a simple matter for you to try it out in your set if the power transformer has a 100 m.a. rating.

B.H.W. (Horsham) is displeased with the scratch level in his new hi-fi amplifier.

(A): Scratch is just one great big problem and there is no easy way out of it. If you want the brilliance you have to take a fair bit of scratch with it. Some records are better than others, needles have a slight effect, and the proper alignment of the arm is important, too. But even with everything at its best you are still likely to have plenty of scratch. The tuned filters which were hoped for as a panacea for all scratch troubles have not come up to expectations in practice.

"I find little time for radio work, but recently put together the "Local Tone Four" which you featured in 1940. It was unusual in that it had no i.f. amplifier valve. I must say that I was highly delighted at the low noise level and good tonal quality. At present I am interested in putting together something with two or three valves for dry battery operation, capable of operating a small speaker, for an old couple living in the hills, where reception should be reasonably good. Perhaps someone can recommend a good circuit of this kind." — **B. Lorenz, 100 Denmark Street, Kew, Victoria.**

PROTECTION

(continued from page 24)

densers, and both devices worked like a charm. Whilst these hazards have disappeared largely with indirect heating of rectifier cathodes and lower power pack potentials, there are still circuit arrangements, large vibrator packs in particular, in which all the capacitors in a set are subject to terrific punishment whilst valves are heating up, and some protective elaboration will commend itself to thoughtful amateurs.

AMATEURS

(continued from page 29)

Superfluous transmissions aren't helping an already overflowing band, so what will it be like when the cut is introduced at the same time as the opening of the 15 metre band? Such efforts as the station who recently held an unmodulated signal on 40 for over a quarter-of-an-hour and then quickly signed off, aren't helping either. This chap was quite surprised when called, and expressed great wonder that his little test was causing QRM to a QSO already being conducted on the frequency. No mention was made of the necessity to provide intelligible modulation on a carrier, but the climax was the offending station's closing remarks: "Now I come to think of it, I didn't listen up on this frequency first."

Let's hope that conditions will lift a few more times, as has been happening lately, to provide some chances of DX working until that blemish on "Ole Sol" clears up next year .—.—.

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