THE AUSTRALASIAN

Radio World

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VOL. 14 . . . NO. 10

MARCH 15, 1949

CROWN

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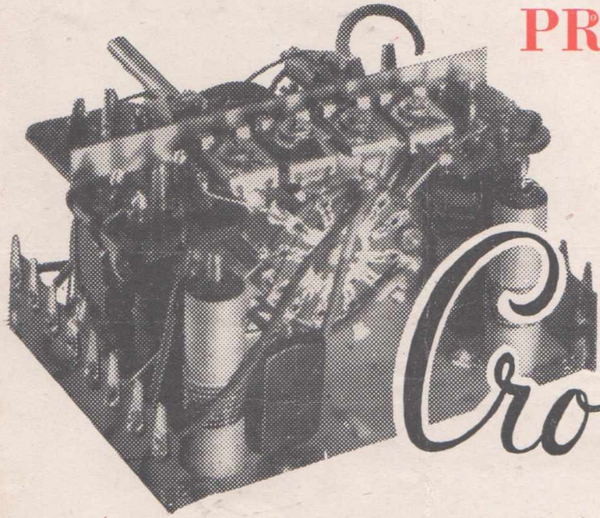

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CONTENTS

EDITORIAL

Tempora mutantur, et nos mutamur in illis.
(*The times are changed, and we are changed with them.*)

I can remember the days when the Ford car sold for £199/10/-. To-day the price is about £950. You will notice 1/6 on our front cover in place of the 1/- which has been there for the past thirteen years.

I have battled hard to avoid the increase, but find that it is unavoidable.

Strangely enough, the reason for the increase is the popularity of recent issues. Printing and production costs having risen a couple of hundred per cent., they finally reached the stage where the nett return from the sale of an issue was considerably less than its cost!

Advertising revenue offset this to a certain extent, but not enough.

The alternative was to give smaller issues with cheaper paper, as mentioned in last month's editorial, but the response to that editorial was emphatically the other way. Readers asked for better issues and cleaner paper for the better reproduction of intricate circuits, and were willing to pay the price.

So, here is a better-style issue.

I now have incentive to make it popular; will be able to hold my head up again and take pride in the job. I am sure you are going to find the issues well worth their price.

—A. G. HULL.

MID-WAY PORTABLE

During the past couple of years there have been many portable receivers designed and described. All of them have their limitations, but experience gives knowledge, and so it is noticed that the main problems are being effectively tackled. High running cost is one problem, long-range performance another, so let us see what can be done about solving them.

HERE is a design for an efficient and economical portable. The original set was deevloped by the engineers of R. W. Steane & Co. Pty Ltd. with a view to offering it as a kit-set. But the rapid growth of their Q-Plus coil business has made is necessary for them to concentrate on keeping pace with the demand for Q-Plus coils.. Rather than waste the time and effort which went into the production of this model we are giving the circuit and details of the set.

The dial and special cabinet, however, will not be available in the ordinary way of business, so a certain amount of individual effort will be required to build up the set if the original design is to be followed closely.

THE DESIGN

The main features of the design are, (1) the use of an r.f. stage ahead of the converter valve to ensure adequate sensitivity without undue noise level, even when the set is used in remote locations, (2) the series-parallel arrangement of the filament circuit to allow the use of a 3 volt cycle-lamp battery, thereby providing the most economical "A" battery supply, (3) bias for detector and output valves obtained from grid current in oscillator stage. This scheme was used in the set detailed in our August 1947 issue, with a lively discussion about its pros and cons in the November 1947 issue. It has the big advantage of allowing the full high tension voltage from the "B" batteries to be put to use to provide

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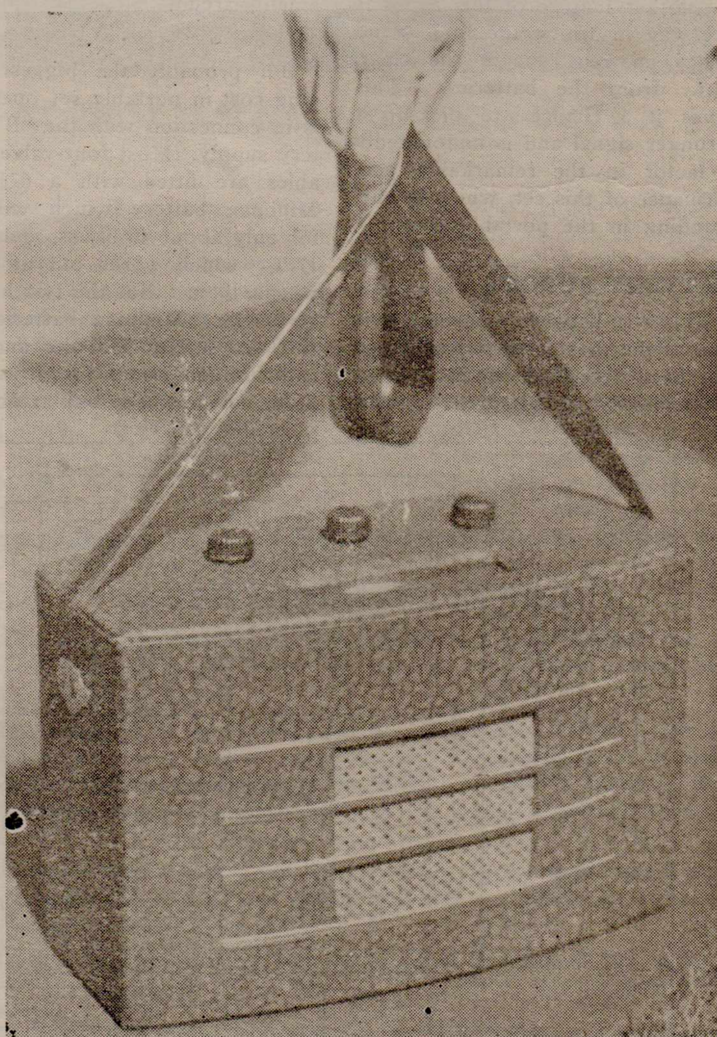


The Mid-way Portable.

PORTABLE

(Continued)

maximum power and performance, without making a bias battery necessary, (4) unconventional layout to make the set compact, yet allow room for the fitting of the large-size, type 482 Minimax batteries. Two are used to give 90 volts, which allows much greater power output and general performance than possible with the little 67½ volt supply often fitted to portables. The larger batteries are also more economical.

Another feature of the layout is the way in which the loop aerial has been kept out in the clear, away from the batteries. This gives it a chance to pick-up a stronger signal and is undoubtedly a factor in the remarkable performance of this set, which is outstanding in the portable class.

BATTERY BUDGET

This "In-between" portable is one of the most economical which has been described, for in spite of its five-valves and great power, the running cost is remarkably low.

Many portables use torch cells for the filament supply, sometimes singly, sometimes in parallel arrangements. But torch cells are built for intermittent use and do not take kindly to sustained load for long periods. Just as cheap, considering price to weight, as torch batteries are the 3-volt cycle lamp batteries. And they have been built to give long life on a steady load. Apparently most designers of portables have been scared off the cycle battery on account of its three-volt rating. But the Q-Plus engineers have put this to good purpose by their series-parallel filament circuit.

But probably the biggest running cost in portable set operation is in connection with the "B" battery supply. Most four-valve portables are fitted with a 67½ volt Minimax battery which will run for only about 40 hours, and costs 17/1, which works out at about 5d. per hour. But the two heavier (type 482) Minimax batteries in this set supply 90 volts and will run for 250 hours for a cost of 25/8, which works out at about a penny farthing per hour. Running cost of this five-valve model is about one quarter of the amount normal with most ordinary four-valve models!

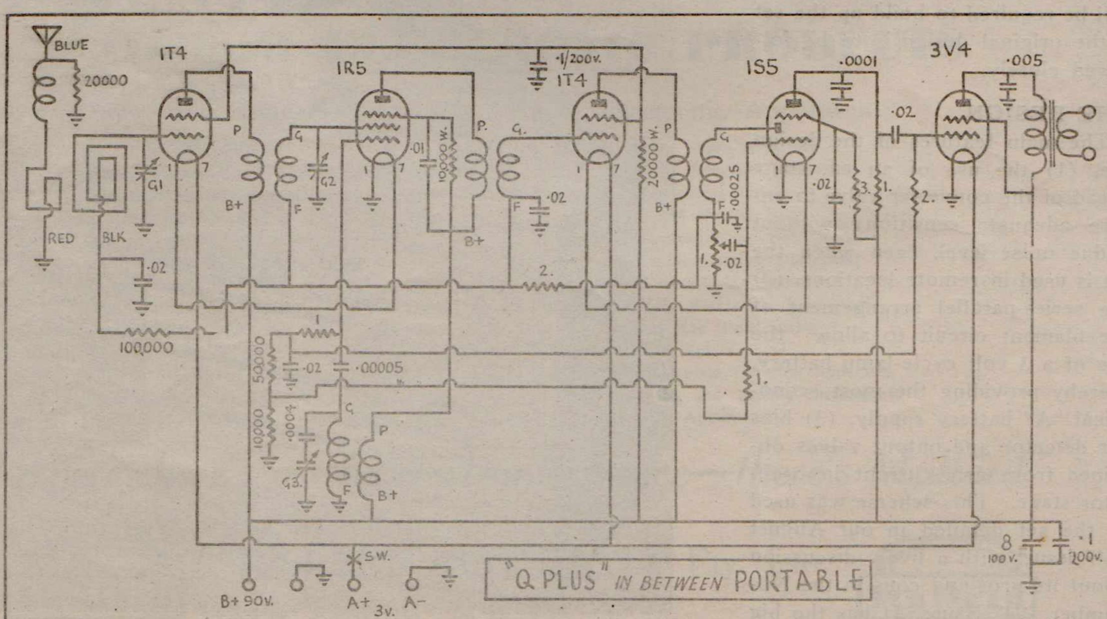
LAYOUT

As will be seen from the photograph, the layout is unconventional, having been worked out to suit the cabinet style and give the utmost in compactness. The loop aerial has been kept well away from the batteries in order to allow the most efficient pick-up.

The metal cases of the cells inside the battery make a form of screening which is to be avoided, if long-range results are required without valve hiss.

The actual chassis is a narrow strip of metal, 11½ inches long and two inches wide, which is folded with a one-inch step about four inches from one end. This makes a total width, after folding, of about 10½ inches.

The miniature three-gang condenser mounts vertically alongside the step in the middle of the chassis. The r.f. coil and r.f. valve are located up on the top step. The converter valve, oscillator coil and



i.f.'s run away from the gang towards the outside of the lower shelf. The dial mounts on top of the gang, with the volume control and switch. The speaker backs up to the gang, with the "B" batteries on either side of it. The filament battery lies on its side, directly under the gang and across to the bottom of the speaker.

When mounting the gang be sure to keep the trimmer adjustment screws facing to the back, so that they will be accessible when the set is finished.

The speaker in the original set is the Rola 5C, with a 10,000 ohm input transformer. This speaker is supplied with a mounting lug which fits neatly into this assembly.

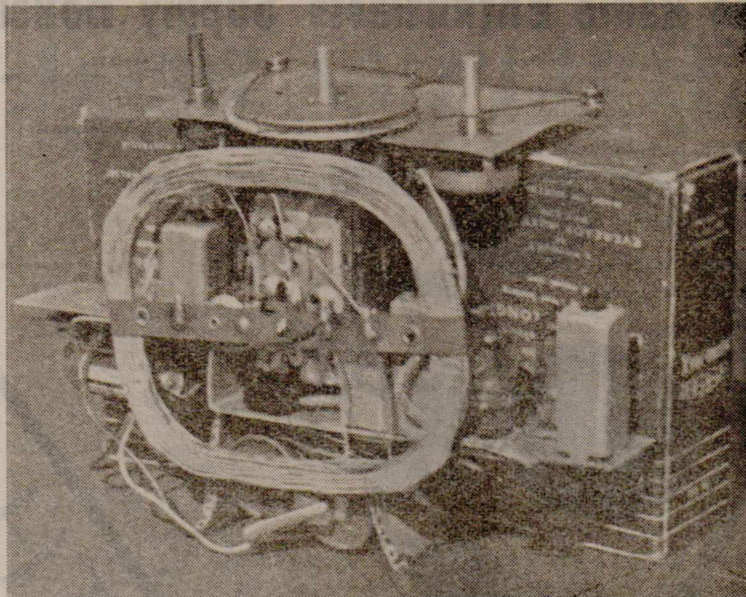
If a standard type of dial is used, it may be found necessary to mount it into a plate of aluminium, to mount on top of the gang and then carry the volume control and switch. A special dial for the job can be made up by cutting a piece of aluminium about 6 inches by 3, with small brass pulleys at the outside top corners and a drum on the gang spindle in the centre of the other side. Running a cord around the drum and across the two pulleys you can then mount a needle on the cord so that it will run across the aluminium plate. Of course, a dial scale will have to be drawn up and mounted on the piece of aluminium.

WIRING

After the bits have been assembled on the chassis the first step in the wiring job is the important one of earthing the centre (shield) terminals of the valve sockets. A bus-bar, run around the sockets, will make a handy mounting device for quite a few of the minor components.

Next carry out the filament wiring, which, on account of being the series-parallel arrangement, is most tricky. You know what happens to valves if you wire up their filaments so that they get three volts instead of 1½? So beware, take care. Make a double check against the circuit after you have finished the job. Then check again, against the following points; pin 1 must be kept negative to pin 7 in all cases, the No. 1 pins of both 1R5 and 1S5 are earthed to the chassis.

When doing the rest of the wiring a certain amount of juggling will be necessary to get everything fitted in. In some cases it may be found helpful to cut the valve socket terminals in half with your angle cutters, so that they will not stick out so far as to tend to cause short circuits. Use plenty of spaghetti to keep resistor and condenser leads from short circuiting.



A photograph of the chassis showing the unusual layout, with the loop aerial in the foreground. The layout is fully explained in the story about this set.

AMATEUR TRANSMITTING SECTION.

I am pleased to announce that arrangements have been completed for a new section devoted to the interests of operators and would-be operators of amateur transmitting stations.

The section will be conducted by Mr. R. H. Cunningham (VK3ML), one of Australia's best known amateur operators. Mr. Cunningham is at present President of the Victorian division of the Wireless Institute of Australia. He was for many years the Technical Editor of the Institute's journal "Amateur Radio."

Ambitious plans are being laid for the section, and it is hoped that it will prove of great help to those who want to have their own station, as well as to those who are already "on the air."

The first issue to contain the new section should be the April 15th edition.

—A.G.H.

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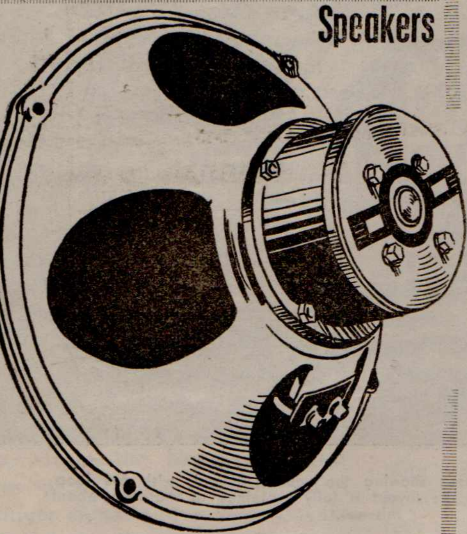

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IMPROVED 807 AMPLIFIER

By
WM. DARRAGH
(Dip. Radio Eng.)
129 Empress Avenue
Footscray W., Vic.

A great deal of publicity has of late been ascribed to an assortment of high-powered amplifiers, all reputed to possess, and no doubt they do, exceptional standards regarding fidelity.

Unfortunately, the great majority of these are beyond the means of the average enthusiast, not to mention those who are of opinion that high-powered amplifiers, of which most recent designs emulate, do not warrant the extra expense, when a watt or two is as much as can be tolerated in the average domicile.

The "Junior Feedback Amplifier" described in October's issue was admirably suited to fulfil this requisite, namely, a low-powered simple unit with excellent reproductive characteristics.

However, in view of the fact that there are undoubtedly a number of enthusiasts who would prefer an amplifier with slightly more output, such as would be suitable for both home duties and moderate outdoor requirements, the following design was instituted, which will be described in detail.

An examination of the circuit will disclose that only three tubes are employed. The circuit is the direct-coupled type, and feedback, is looped around both audio tubes, including the output transformer.

An 807 was the obvious choice for output duty. It is not only plentiful and cheap, but with the addition of a solid whack of negative feedback, is virtually distortionless, and very nearly equals a triode in performance, with the advantage of possessing higher sensitivity and double the output.

A 5V4, or its counterpart, an 83V, was chosen, mainly on account of its higher output voltage, not forgetting its indirectly-heated heater construction, a factor instrumental in preventing blown filter condensers and internal flashovers, which may occur in a circuit of this type if a directly heated rectifier is utilised.

The 6J7 is standard equipment, and requires little comment.

It will be observed that a variable control is incorporated in the feedback line. Owing to the excellent bass response of this unit, and the necessity of employing a large amount of feedback to reduce the 807's rather high distortion content, oscillations of a low frequency may be experienced if a fixed amount of feedback were maintained on a number of similar amplifiers, employing output transformers of varying designs. This oscillation may only be observed

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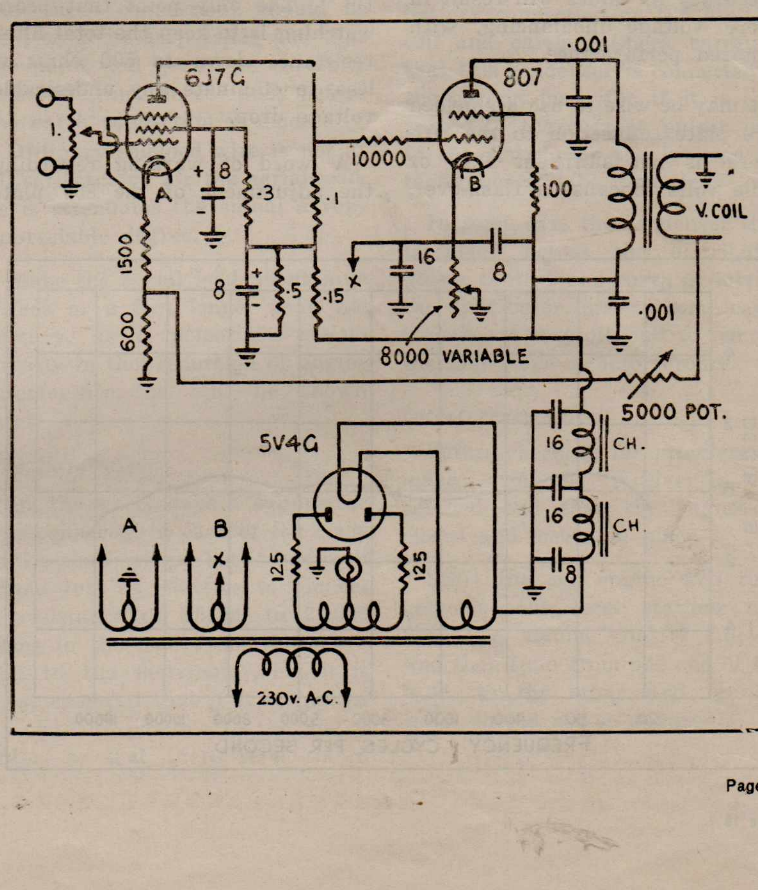

807 AMP.

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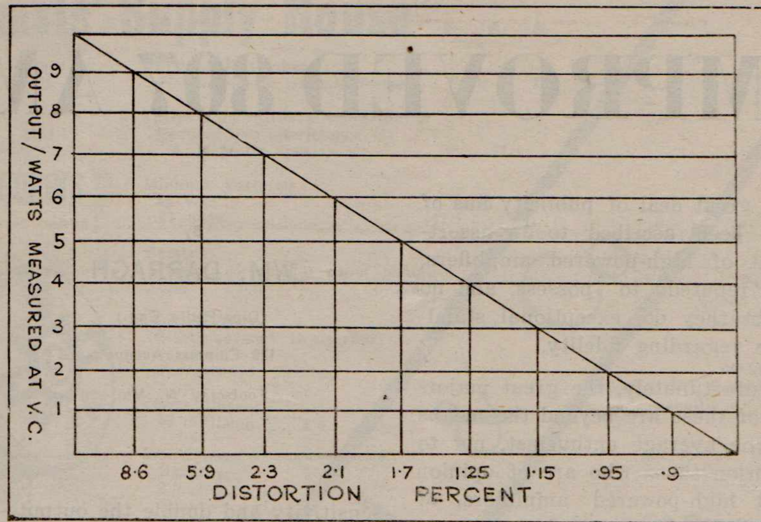
when the circuit is "shocked" by an input of a transient nature, the effect being a flutter of perhaps five-seconds duration, and of a very low frequency. The adjustment of this control will be explained later in this article.



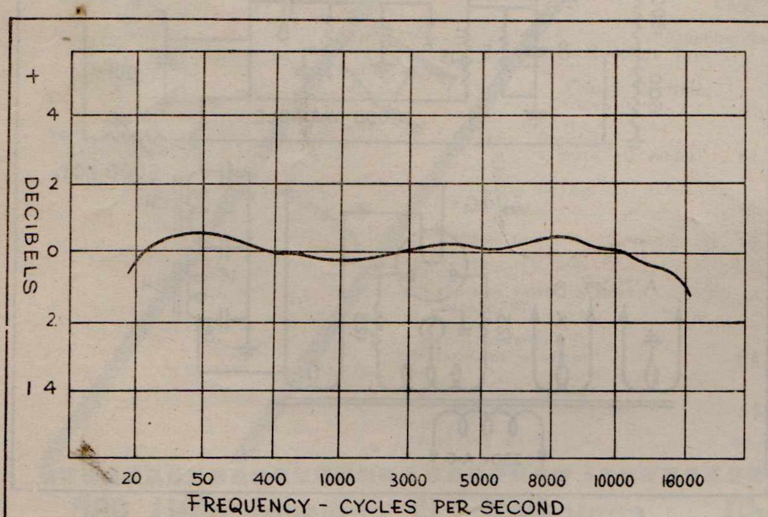
At this juncture it may be wise to mention that the linearity and distortion curves illustrated are based on a fixed value of 750 for this feedback resistor, used in conjunction with an 80 voice coil. This value was found eminently satisfactory in the original set-up.

Both sets of curves were plotted with the aid of sub-standard test equipment and are accurate within 2 per cent.

Particular attention should be paid to accuracy of component values, and make sure that the correct wattage is specified. Any inaccuracy in values will result in severe voltage unbalancing, with impaired performance.

It may be wise to use a shielded wire plate connection to the 807. There is not sufficient D.C. or audio volts to cause a flash-over, and shielding this lead will eliminate any tendency for positive feedback to occur. The two filter chokes, L1 and L2, are not particularly critical regarding inductance. The two original chokes were something of a relic, yet the measured hum level was down 50 Db. The only point that bears watching is to keep the total filter resistance down to 500 ohms or less, to eliminate any undesirable voltage drop.

A word of warning regarding the adjustment of the 807 plate current. On no account insert a meter in series with the plate cap and clip. Failure to heed this advice will almost certainly result in a damaged meter. The addition of a meter, and probably leads, in series with the hot side of the anode circuit, will cause violent oscillations to occur, coupled with a heavy increase in plate current. The correct method of adjustment is as follows:—



First ascertain that the amplifier is correctly wired and that speaker is in circuit. Set both R9 and R11 in the maximum resistance position, and insert a 0-100 MA meter, or higher, in series with the earth end of R9. Switch on, and adjust R9 until the meter shows a current of 80 MA. This meter may now be removed and the resister earthed. The voltage read between 807 plate and cathode should read very close to 250 V. now. If slightly higher don't worry about it, but if a voltage substantially lower is apparent a check on circuit values will probably reveal some outstanding inaccuracy.

The next step is the adjustment

(Continued on page 46)

Car Radio Installation

The installation and interference suppression of car radios is truly a specialised business, as can be judged from the few radio firms who will take them on, and the number that do a first-class

By
C. ASTON
25 George Street
Marrickville, N.S.W.

job are fewer still.

The installation is more of a mechanical problem, and each make and model of car requiring individual treatment. The main points to remember are to put the set in a position where it will not interfere with any of the car controls and not unduly cramp the leg room. Before drilling the receiver mounting holes check where the drill will come out. It is quite easy to do a lot of damage.

The Aerial

There are several types of car aerials, the most successful being the side aerial, having a pleasant appearance, and may be obtained to a size of nine feet when fully extended. This length is not necessary for city work. Three feet should be ample.

Another advantage of the side aerial is that it is relatively easy to instal. First remove the side leatherette covering near the driver and examine the situation. Most American cars have the outside body plate next, and it is only necessary to make certain the mounting holes will not come out behind any obstacles. With the English built car it is more often than not a different tale, and it may be necessary to cut through one or two shells with a cold chisel and hammer before the aerial can be mounted. Make certain that the angle of the aerial harmonises with the lines of the car before drilling the holes.

The Aerial Lead

The aerial lead is of the low loss type, and co-ax. cable is very suitable. The outside braid should be earthed at *both* the aerial and receiver ends; at the receiver the braid may be earthed to the metal cabinet, while at the aerial end the braid should be earthed to the car body. It is most essential that the earth connections should be kept as short as possible and that the paint and grease is carefully removed from the car body before the earth connection is made.

Ordinary shielded wire is not at all satisfactory for the aerial lead, as it attenuates the signal a very appreciable degree.

Make the aerial lead about nine inches or a foot longer than necessary, as it sometimes assists greatly in the reduction of engine interference, as will be shown later.

The Suppressor

In the early days a suppressor was connected in each of the leads to the spark plugs, but it has been found just as effective to connect a resistance of 15,000 to 20,000 ohms in the lead from the spark coil to the distributor, but it is most essential that it is connected as close as possible to the distributor, so that there is no more than about two inches of wire between the suppressor and distributor.

Condensers

It is standard practice to fit two condensers, as well as a suppressor on all installations.

In American cars the six-volt receiver lead is connected to any suitable connection under the dash, while English cars should have the battery lead connected to "A2" on the terminal strip. It is at this point a condenser of .5 mfd. should be connected directly to earth, care being exercised to ensure a good connection.

The other .5 mfd. condenser should be connected between the battery connection on the ignition coil and earth. Check carefully that this condenser is connected to the correct lead, for if it is connected to the current pulser lead to the distributor the ignition interference will be increased.

In some cars the condenser that is fitted across the distributor pulser contact and earth is outside the distributor, and in some cases it makes it very difficult to remove the last trace of interference.

Interference Check

Before checking for interference make sure the receiver is well earthed and that the bonnet is closed and locked in place.

Start the car engine and tune between the local stations and turn the volume control full on and then tune from one end of the band to the other and ignition noise should not be apparent. In

(Continued on page 12)

CAR RADIO

(Continued)

due interference the installation is then usually passed OK.

If there is any ignition noise then the first step is to find if it is via the aerial or battery lead, so the aerial is disconnected at the set, and if the interference disappears then the noise is being picked up in the aerial circuit.

If the noise is still apparent with the aerial disconnected first check the earth connections to the braid on any external connections, such as the dial light, and particularly the tone control, and it will be found that the interference will disappear when this is correctly earthed.

In most Australian made sets there is sufficient filtering in the six-volt input to the receiver, and the battery input is therefore seldom a source of interference.

Aerial Pick-up

When it is obvious that the interference is being picked up in the aerial circuit it is then the spare foot of aerial lead-in is used, for by varying its position behind or below the dash the interference will sometimes completely vanish, this position is very critical, and an inch one way or the other may spoil the effect. This effect is due to the lead-in picking up an interfering voltage 180 degrees out of phase with that induced in the aerial.

Bonnet Earthed

By earthing the bonnet at a certain point interference can be overcome. This can first be checked with the aid of a screw driver or file forced between the bonnet and the body to ensure that there is a low resistance connection. If a point is found where the interference is reduced a piece of copper braid about two inches long should be screwed on the body at this point with a couple of self-tapping screws and the paint scraped from underneath the bonnet at this point, assuring a good connection between the bonnet and body at this point.

If all the above procedure does not remove the interference it would be as well to check all the points again before proceeding to bond.

Bonding

Firstly, make sure that the motor blocks are well bonded to the bulkhead. Then connect the shielding of any wires passing through the bulkhead and copper tubes to earth with heavy copper braid.

Bond the ignition coil to its bracket by sweating them together with solder.

If after all the above precautions have been taken there should be no interference from the ignition system, and I personally have not done an installation that could not be cured with the above precautions. However, if it should be found that these methods will not eliminate the interference I suggest completely shielding the spark plugs and connecting wires with proper earthing.

Generator Noise

Another common source of interference is generator hash and should not be confused with ignition noise. It sounds more like interference produced when an electric motor is operated near a domestic set and is simply cured by connecting a .5 mfd. condenser from the voltage output connection to earth.

Instrument Interference

Another source of interference that is of a crackling nature is that produced by the electrical instruments such as the temperature and petrol gauges, which may also be cured by connecting a .5 mfd. from the offending device and earth. If this is not possible connect it to the instrument and earth behind the dash.

Speedy Query Service

Replies by Mail Again Available

As from March 1st, we are re-opening our reply-by-mail query service. During the war and ever since we have been so short of staff that we have not been able to handle individual queries in this manner, but the position is now easing.

A fee of 2/- is charged for each letter to cover cost of time, stationery and postage, and this will cover more than one query, so long as it is possible for the answers to be prepared in a total time not exceeding a quarter of an hour.

Designs for elaborate equipment, transformers for special purposes, chokes for filter networks, and such elaborate problems are beyond the scope of the service.

We can, however, give socket connections and basic characteristics for all types of valves, including disposals and ex-army types. Data is also available for most cathode ray tubes, but we cannot undertake to design special oscilloscope circuits to suit any particular gear you may have on hand.

In most cases it is hoped that replies will be made by return mail unless any special data has to be collected. If a 3d. stamp is enclosed the reply will be sent by air mail.

Address all queries to *Radio World*, Box 13, Mornington, Vic.

A. C. Power From Batteries

Here is a mighty handy gadget for the radio serviceman who does not have a.c. power, yet is called upon to work on a.c.-operated receivers. It takes 12 volts d.c. from a couple of car batteries and supplies 240 volts a.c. with which to operate any ordinary a.c.-operated receiver.

Following are details of a successful unit used by myself for some months to provide a 240 volt A.C. supply from a 12 volt battery.

By
E. C. Jamieson
FORRESTON,
S.A.

The unit consists briefly of a 12 volt synchronous vibrator wired as a non-synchronous vibrator, feeding into a 12-volt centre-tapped vibrator transformer, the secondary of which is not centre-tapped in the usual manner. The two ends of the windings, plus the nine intermediate voltage tappings, form the secondary. The required output voltage is selected by an ordinary ten position wafer switch, and the output going to two outlets. One a special five-pin socket (detailed further on), and the other to a standard three-pin power socket.

Critics will argue that very little increase in the surface area of the contact points of the vibrator will result from the non-synchronous connection. However, the type of vibrator I am using, the P.M.804, was made for the Air Force receiver, AR7, during the war years, and I understand that these vibrators have both sets of points adjusted so that they open

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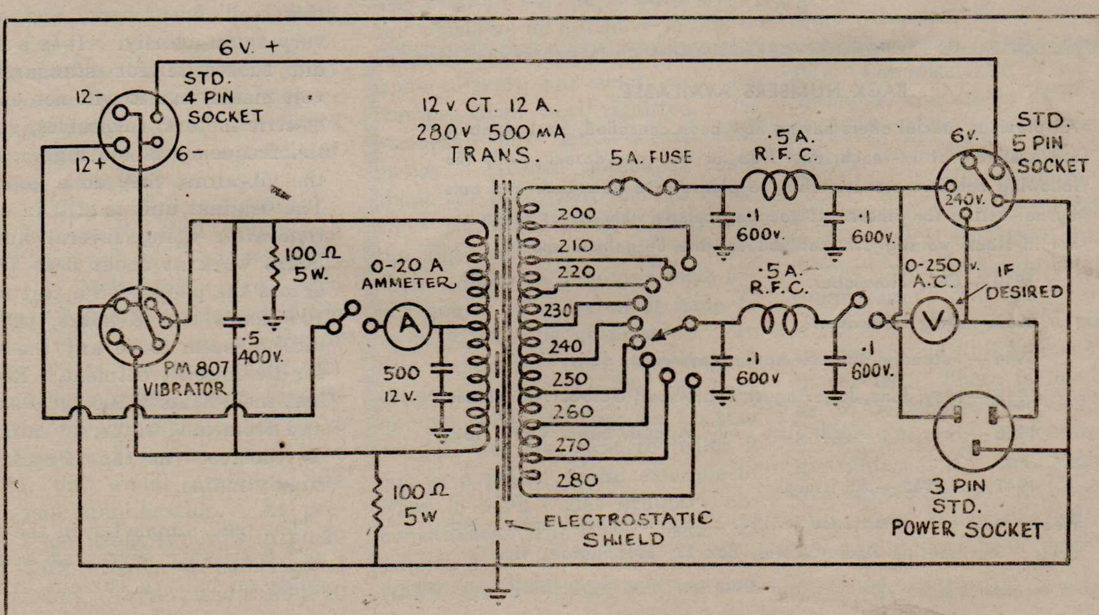

POWER UNIT

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and close together, thereby doubling the surface area. These vibrators are plentiful now and are cheap for brand new units. I have not regretted buying a dozen of them for spares.

The transformer is a specially made, highly efficient job, having a 12-volt centre-tapped primary, at 12 amps, and a 280-volt secondary at half an ampere, tapped every 10 volts from 200 volts. This allows a wide adjustment of voltages to suit all equipment, and to compensate when the batteries get low. An electrostatic shield is an essential feature if hash is to be eliminated. The transformer must be specially wound for 100 cycle vibrator operation, and anyone likely to build this unit is advised to get a good quality transformer, the best that can be had. Otherwise, severe losses may result.

The common output lead is completed through a fuse and filter circuit, consisting of a five-amp fuse and an R.F. choke and two .1 mfd. 600-volt condensers. Two Eddystone R.F. chokes of the transmitting type, in parallel, will stand the half-amp output. The by-pass condensers are critical. Small departures from the above values were found to increase the hash content of the output.

The "hot" side of the output connects through the selector switch, thence through the filter, then through an ordinary Alpha two-way switch to the outlets. This switch is handy for a quick cut off of the power, though it still leaves the vibrator in operation.

Now the following are special points about the operation of the unit. Firstly, there will always be a small amount of hash in the output when a receiver is coupled to the unit for the following reason. When the 240-volt 100 cycle supply is connected the output at the rectifier will be of the order of 200 cycles, a rather high pitched buzz when compared with the 100 cycle output of standard 50 cycle supply. However, removal of hash from the high tension is very complete after passing through the receivers filter system. The main trouble is caused by the heater circuit, where no filtering is done in the receiver. However, effectively earthing the receiver does away with all but about 10 per cent. of noise, and then the A.V.C. of the receiver can take care of this small amount. Short-wave reception is somewhat noisy, but not bad enough to prevent effective alignment of receivers.

For use in high-gain audio amplifiers trouble may be encountered in the heater circuit, but here again there is a solution. As most amplifiers draw a fairly substantial heater current it is rather a waste of vibrator power to draw these amps through the unit. So why not connect straight to the battery, a separate battery preferably, and so remove the hash, and also remove undue strain on the vibrator. The 4-pin inlet socket is wired for four leads, two at 12-volt and two at 6-volt. The 5-pin output socket carries 6 volts to the amplifier heaters, and 240 volts to the power supply for high tension.

Each individual unit constructed will probably require its own hash treatment to a certain extent, but the main essential is to thoroughly earth the receiver drawing supply from the unit, earthing of the unit itself does not seem to matter.

In conclusion, I want to say that this unit does work, and works very satisfactorily. It is a splendid substitute for standard 240-volt mains, but it will not operate electric motors, turntables, etc., as the frequency is too high. As to the vibrators, they do a good job. The original unit is still in operation after doing several hundred hours work at about 6 to 7 amp. across the points; on a test run at 10.5 amps. for 8 hours, the unit did not seem to be any the worse for its rough treatment. Remember, though, its a 100 cycle supply, and from a vibrator, so cannot be as perfect as the 50-cycle A.C. supply mains.

The 0-20 ampmeter in the primary centre-tap serves as a useful guide on battery current drain.

ANSWERS IN FULL

The first of a new series, here is an article which makes an attempt to cover every angle to a problem asked by a reader in a letter to our Query Service. In this first article we deal with the checking of an amplifier to make sure that it is in first-class operating condition.

From what I have heard it would seem that most-read columns of all are the couple which are devoted each month to answering queries. But most of the replies are in brief; sometimes quite misleading to those who don't know the full text of the question. Thinking about this matter brought forth the brain wave scheme of starting a new section—"Answers in Full."

The idea will be to take two or three letters each month, publish the questions in full, and then answer them in finest detail. I think it is likely to unearth some interesting stuff, and will prove a great help to me by collectively answering, in advance, the hundreds of questions which take so much of my time from day to day.

So here is the first example, a letter received on January 12th, from a Melbourne man, who writes: "I should be pleased if you would (1) send me a copy of *Radio World* for May, 1946; (2) let me have your opinion regarding the following matter: I have purchased a Ferrotune unit, type KFT1, but would prefer to use push-pull amplification. At present I am using two 45's in push-pull, with an Abac transformer. I use a 56 as a driver, and a Rola 10 inch speaker. The results on gramophone records are good, but, I think, could be better. I thought first of using 6A3's in push-pull, but a friend suggested using 6V6's, and it was on this matter I should like your opinion. Could you also give me a suitable hook-up for the valves you recommend?"

Now, to answer the first part of your letter is not easy, as I like to keep everything on a nice friendly basis. Yet I am positively exasperated by the number of people who send in 6d. for a back number which we do not have in stock. In such cases it is necessary to write a reply and send back the stamps which were remitted. In business such matters cost real money. Headed notepaper costs about 1d. per sheet, printed envelopes ½d. each, stamps 2½d.; but the biggest cost of all is time. Even a builders' labourer costs 5/- per hour. The value of time to write a letter is at least 6d. In this particular case it costs nothing extra to mention the back number when writing on another subject, but we want to bring it out as a point; as an example of what it costs under ordinary circumstances. In every issue we publish a list of the back numbers which are available, yet we average at least two letters a day asking for back numbers which we cannot supply. It costs us 10d. to send back your remittance, and, of course, it costs you your paper, envelope and stamp, too.

To return to the happier things of technical radio; a fair-sized book could be written in reply to your second query, and a mighty interesting book at that.

Dealing first with the Ferrotune unit; these units seem pretty good buying at the cut prices at which they are sometimes available. Of course, the poor Ferrotune has become an orphan. Fate, the Income Tax Commissioner, the Bank Manager, and others seem to have brought about that sad state of affairs when the makers of the Ferrotune units had to call a meeting of creditors to tell them the sorrowful tale that they were "broke" and going into voluntary liquidation. So it is doubtful what the future has in store for the Ferrotune unit which plays up in service. There is much doubt as to servicing facilities, expert adjustment, or attention under guarantee. Not that such things are expected to be prominent. Our own experience with Ferrotune units has been quite happy,

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ANSWERS

(Continued)

and reports from readers about them have been at least 95 per cent. bright and cheerful.

The Ferrotune unit is quite OK for use with push-pull amplifiers, and the obvious suggestion is to build up a tuner with the Ferrotune unit and simply add it on to the present amplifier.

Possibly the biggest problem here will be the matter of heater voltage, as your amplifier uses valves taking 2½ volts on the heaters, whereas the KFT1 unit is specially designed to operate with the 6J8G converter valve. It might work with a 2A7, but there would be an element of doubt about it. There would be no trouble in using a 58 as an i.f. amplifier and a 55 or 2A6 as detector.

However, the first thing to do is to get the amplifier working properly. A very real truth was expressed by a fellow who wrote us the other day, mentioning that he had been taking *Radio World* so long that he now knows that it isn't the circuit that counts, but the way you get it operating. Now, if an amplifier, consisting of a 56 driving a pair of 45's through an Abac transformer, is operating properly it gives mighty fine quality. Forgetting for a moment the fairy tales you hear about the value of high-fidelity reproduction, you will find that it is possible to get pleasing reproduction from any amplifier which can deliver a fair amount of distortion-free power, even if the frequency range is much more restricted than is likely to be found with even a cheap Abac transformer. It is not disclosed just what type of Abac transformer is being used, but if it is the popular type TA3 it is well within even the high-fidelity limits, provided always that it is used correctly. Most high-fidelity audio transformers do not take kindly to a heavy plate current in the primary, so the safest way is to eliminate it entirely by arranging a shunt-feeding scheme. This is done by feeding the plate of the driver valve through a suitable resistor, and then coupling the plate to the primary of the transformer through a condenser. Little loss of gain is noticed, in fact, lows are strengthened on account of the increased effective primary inductance when no current is in it to detract from the flux of the core. The value of the plate feed resistor and the coupling condenser are fairly critical if you want to get the finest possible high-note response. For good "highs" the plate load must be kept fairly low, say about 50,000 ohms for the feed resistor. With such a low value of plate load the coupling condenser will need to be fairly large to allow full reproduction of the "lows," so one of .5 mfds. capacity should be used.

The use of a plate feed resister of up to .25 megs. will allow a smaller capacity coupling condenser to be used, but the highs will be lost to quite a noticeable extent. Sometimes, incidentally, it is desired to lose a few highs. In such a case you can use a quarter-meg resistor and a .1 mfd. condenser.

The secondary of the audio transformer will require proper loading, too, if you want to watch the finer points. A couple of .1 megohm resistors across from each grid to centre-tap will do nicely and level out any tendency to peaked highs.

So much for the transformer and the attention which must be paid to it to ensure proper operation, but there are also the usual factors to be watched to make sure the amplifier is operating right.

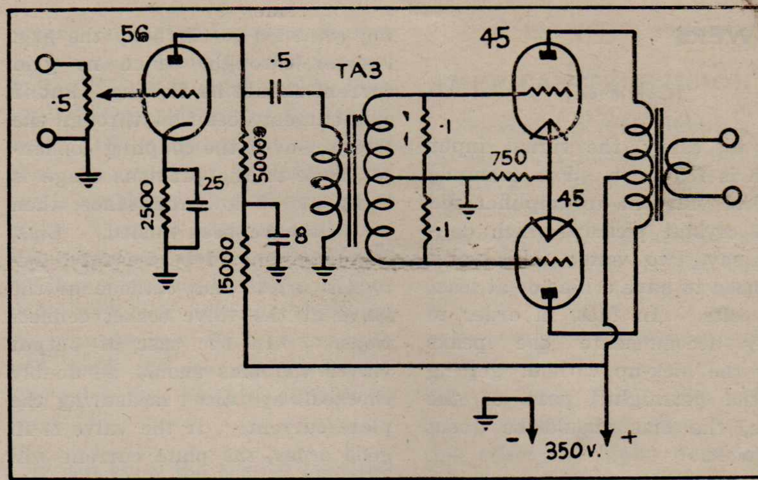
For a start the record has to be a good one. There is a tremendous difference between one recording and another. Some are definitely bad and never will reproduce properly. Others are not actually bad, but have been recorded with characteristics which do not line up with the characteristics of the pick-up.

Now to deal with the pick-up. Our friend gives no clue as to what type or brand of pick-up he is using, and there are gulfs of difference between pick-ups. Maybe it is one of those magnetic types which came on the market towards the end of the war. They can be classed as useless for anyone with an ear for correct reproduction or a care for what happens to the record after the needle has scraped over it a few times. There is only one cure for them. Give them away to somebody else.

But it must be about a three to one chance that the pick-up will be a crystal type, which is a much brighter picture. Not all crystal pick-ups are all that can be desired, but most of them will give reasonably good results, so long as the arm is mechanically sound, and free from rattles. Go over its bearings and mountings to make sure it is free, but firm; has up and down freeness at the head, is not too heavy on the record. Insert a needle and test for the elasticity of the rubber mounting of the needle holder. All such points are more or less a matter of careful inspection, but possibly the biggest factor is the unseen one, the circuit loading considerations.

Crystal pick-ups must be fed into the right electrical loading. Most crystal pick-ups like to feed into a load of from a quarter to half a megohm. Normally the load can be considered as consisting solely of the volume control across the pick-up's output, but the trap is when shielded wires are used. Often enough the makers fit their pick-up with a shielded cable about two or three feet long. Removing this cable and fitting a pair of ordinary leads of hook-up wire sometimes improves the performance quite noticeably. Crystal pick-ups usually have a volt or two of output, so hum trouble should not be a problem, even without shielded leads. This high output voltage also makes it undesirable to have too much gain in the amplifier. It is seldom necessary to have more than two stages of amplification. Operating with a volume control retarded almost to zero is not good practice. This large voltage output from the crystal pick-up also makes it highly desirable to feed it into a valve with a bias of four or five volts.

Next consideration in the chain whose weakest link will ruin reproduction, is the turntable. It must turn the record at the correct speed, with ample tow to drag the needle through the widest grooves, without mechanical rattle or vibration. Speed of the turntable, 78 revolutions per minute, must be checked with the pick-up needle on the record, not when the turntable is running free. Turntable must be flat and level. Needle must contact the record at the proper "rake," but transversely at right angles to the surface of the record. Records themselves must be flat and not warped.



Here is the proper circuit arrangement for using a push-pull transformer to drive a pair of 45 type triodes. If the transformer is a high-quality one, such as the Trimax TA3 or Red Line AM2 or AM3, high-fidelity results can be obtained.

METER CHECKING

To make sure that an amplifier is working perfectly is almost an impossibility without a meter of some sort. Even a fairly cheap multimeter will do the job. Absolute accuracy is not essential, as there are wide tolerances permissible. Yet, nothing can compare with a milliammeter, showing the plate current of the output valve, when it comes to making sure that there are no parasitics, no unexpected distortion.

With a meter the first check is to make sure that all heater and filament voltages are correct, at the sockets. This becomes especially important in the case in question, where the heaters run at 2.5 volts. The current drawn is fairly heavy, and even a voltage drop of half a volt in the filament wiring is going to have a serious effect on the amplifier's performance. With 6.3 volt valves the current drain is less, and voltage drop can be half a volt without spoiling results completely. But for maximum performance with any valves the heater and filament voltages should be within 5 per cent. of the makers' recommendations. After a few years' experience you get to know when a heater is glowing properly, but as different valves appear brighter than others, according to the type and the inside coating on the glass, the only sure way is to check with a meter, right at the valve socket.

The high tension voltages should be checked to make sure they are within the makers' ratings. Plate voltage should be measured between plate and cathode, or filament centre-tap in the case of directly-heated valves.

Most valves take only 250 volts here, but it is possible to overrun some valves without seriously affecting their expectancy of life. Increased plate voltage means much better power output and general performance. The type 45 triodes are most sturdy and will not mind running at 300 volts, or even higher, provided always that the bias is increased accordingly.

The 2A3 and 6A3 types will stand up to 300. Beyond this they tend to get a bit too hot for my liking, but I have seen them recommended, in an American magazine, to run at 400 volts.

Next suggestion for a meter check is the bias on the various valves in amplifier. The general idea is to make certain that any particular valve will have enough

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bias to carry the signal input which is fed to it. For example, the first valve in an amplifier fed by a crystal pick-up which delivers, say, two volts; this valve will need to have a bias of at least two volts. In fact, in order to safely accommodate the peaks from the pick-up without getting off the "straight" part of the curve, the bias should be about four volt.

Now, if this valve is expected to give a voltage gain of, say, 20 times, then the bias on the next valve will need to be from 40 to 80 volts. In the case of push-pull the bias will need to be half this figure for each valve, if resistance-coupling is used. If a transformer is used for coupling, the ratio of the transformer will need to be taken into account. Most high-fidelity transformers have fairly low ratios, about 2 to 1, so that 40 to 80 volts bias for each valve will be about right in such a case.

Checking Bias

As a further check on bias, it is not a bad scheme to leave a meter across the bias resistor of the first valve while the amplifier is actually in operation. The needle should remain steady. Then shift the meter to put it across the bias resistor of the next stage, and operate the amplifier. Again the needle should remain steady. Finally, test the output stage in the same way. No matter whether push-pull or single-ender, the needle of the meter should remain steady, even on heavy passages.

Normally it is OK to measure bias by putting a meter across the bias resistor, from cathode to earth, assuming that the grid is at earth potential, on account of being returned to earth by the grid resistor, through which no grid current should be flowing. But if grid current does flow through the resistor, or if the coupling condenser back to the previous stage is leaky or of low resistance, then we will have been misled. Bias, therefore, should be measured between grid and cathode of the valve at the valve socket connections. In the case of output valves the bias should be doubly checked by also measuring the plate current. If the valve is in good order, the plate current will indicate the true bias position.

With output valves and such, the makers' plate current, voltage and grid bias figures can be used as a guidance, but there is a trap for the unwary when it comes to the use of a valve with resistance coupling. You may turn up the valve chart and find that the 6C5 draws eight milliamps of plate current with eight volts bias. But in a resistance-coupled amplifier the plate may be fed through a resistor of 100,000 ohms, and a bias resistor of 5000 ohms used for bias. Under such circumstances the plate current will be nearer to one milliamp than the eight shown on the chart. The rule about bias voltage will still apply, however, and the bias should measure from four to eight volts.

With pentodes, such as the 6J7, the difference is even more noticeable. The characteritsics are probably given for the valve when used as an r.f. amplifier. When used in a resistance-coupled audio amplifier with a quarter-meg plate resistor the proper plate current will be only a fraction of a milliamp.

So when checking plate current of valves with resistance-capacity coupling be sure you consult a valve chart which covers them in this particular type of service.

The plate current drawn by a valve is a good indication of how things are going. If it is normal and according to expectations after consulting the valve data chart and measuring the plate voltage and bias, then all should be well. If the plate current is found to be too low the valves should be suspected for low emission, old age creeping on, and that sort of thing. If the plate current is too high you can start looking for parasitics in most cases. High plate current will also occur with a valve which is "soft," has not been properly exhausted, or is "gassy." But in all cases where the plate current seems high it is wise to make a double check on the bias, on the coupling condenser in its grid circuit, and with indirectly heated valves, for a short circuit between cathode and earth, such as via an earthed heater winding and an internal short circuit.

Unsteadiness of the plate current whilst the amplifier is in operation indicates distortion, and, in some cases, is also bad when the output valve loading is badly mismatched.

All of which goes to show you just how useful a multi-meter can be. You can build one up yourself from the University kit, model MK1 for about £8. A good multimeter lasts a lifetime, never goes out of date, and is always a sound asset.

Fitting the meter to read the plate current requires some thought. As far as possible the best plan is to take the cathode circuit current, making due allowance for screen, as well as plate current, when dealing with pentodes.

Especially with valves such as the 807 it is not good practice to try and insert a meter between cap of the valve and its clip. Long leads and the meter in the "hot" side of the plate circuit is almost sure to cause instability. Insert the meter in the cathode circuit.

PARASITICS

I have mentioned parasitics, how to detect them by checking plate current, but I haven't dealt with their suppression.

Required treatment may vary from amplifier to amplifier, but the first step is usually to try a couple of 10,000 ohm resistors in series with the grids of the output valves, soldered right on to the socket with as short a lead as possible. If these do not result in a cure they should still be left in circuit. Even if they don't seem to do any good, it is unlikely that they will do any harm. Next try a couple of 100 ohm resistors in the plate circuits, also soldered right on to the socket terminals and preferably resistors of non-inductive style, such as carbon resistors. The one-watt variety will serve, as although the plate current may be heavy there is little voltage drop in 100 ohms, so not much wattage dissipated. If the parasitics still persist it is hard to say which should be the next position for the fitting of stoppers, but possibly the cathodes should be treated in the same way as the plates, with 100 ohm resistors. In individual cases there are other recommendations for parasitic stoppers. Such was the case with the FFR amplifier we detailed in the December, 1947, issue. The quickest way to make this job completely stable was to fit screen and cathode stoppers, with .1 mfd. by-pass condensers direct from screen to cathode terminals at the socket. With all leads as short as possible this resulted in stopping every trace of parasitic trouble.

So you will appreciate that a certain amount of experimenting is imperative if you have to deal with a stubborn case.

The matching of the speaker by means of the output transformer is another point to watch, and quite difficult to check if you don't know the full history of the amplifier. Often enough it is found that an amplifier is designed to suit a speaker with a 15 ohm voice coil. Then at some stage of its life someone may replace the speaker with one having a 2 ohm voice call, but without changing the transformer. Such an example will lead to poor performance. The cause may be quite difficult to track.

If you know the correct load for the valve or valves used in the output stage of the amplifier and the impedance rating of the voice coil of the speaker you can calculate the correct transformer ratio by taking the square root of the ratio between load and voice coil impedance. For example, to give proper loading to a valve requiring a load of 5000 ohms, and a voice call of 2½ ohms, you will need a transformer with a ratio of the square root of 2000, which is about 45 to 1.

You can check the ratio of the speaker transformer by feeding an a.c. voltage of, say, 2½ volts into the secondary, and then read the voltage developed across the primary. By switching your a.c. meter from primary to secondary you should be able to get a fair idea of the ratio. But don't ask me how to check the motional impedance of the voice coil of an unknown loud speaker. It is much easier to find the maker's name and the type number of the speaker and then take the maker's word for it!

Another trap with an unknown amplifier is in regard to by-pass condensers which may have been fitted at some time or other. Unless you know the amplifier and its full history, you should go over the circuit to see if by-pass condensers have been added. At one time it was fashionable to have boomy bass reproduction. To get this effect the highs were lopped by fitting .02 mfd. condensers across the speaker, from plate to earth, both at the output stage and at the plates of earlier amplifiers. The amplifier will never sound brilliant with these by-pass condensers in place.

Another vital factor in the final quality of any amplifier is the baffling of the loud-speaker. Without a baffle any speaker is useless for quality reproduction. Many cabinets have resonance effects which make all low notes come out at the same frequency. Not bad to dance to, but impossible if you are in search of music.

Then there is the matter of field energizing for the speaker. If the speaker is of the permagnetic type there is nothing to worry about, but if it is of the electro-dynamic type you must check, by measurement and/or calculation that the field is getting enough wattage. Ten watts is the minimum for quality reproduction, even with a small speaker, and big speakers should be fed with so much power that they start to get quite hot after an hour's running. Some 12-inch speakers will stand 20 watts in the field. Nearly all of them will stand from 12 to 15 watts.

SUBSTITUTION

One of the quickest and surest

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AMERICAN TELEVISION

Television development has been brought to a standstill in the U. S. A. by a decision of the Federal Communiiations Commission not to issue any further licences until a decision has been reached regarding suitable engineering standards.

ANSWERS

(Continued)

ways to test amplifiers, and radio sets, too, is by the substitution method. If you can borrow the necessary equipment it is so much easier to replace one unit at a time and thereby judge its condition. For example, if you get two pick-ups and switch quickly from one to the other you can soon decide which one you like best, or which one is deficient. Valves and speakers also lend themselves to the idea of substitution, provided that you take pains to make sure that the item being substituted is suitable for the application.

Now to get on to the final portion of your query. What do we think of the 6V6 as against the 6A3?

When it comes to quality reproduction it is our policy to recommend triodes, such as the 6A3. It is possible to get good quality from the 6V6, which is a more sensitive and more efficient type of valve. But to do so calls for the application of inverse-feedback. Under proper conditions the feedback amplifier with beam power valves can give good quality, but there is always the possibility of the feedback not working just as you expect and it is quite a difficult task to check for such troubles. The amplifier does not sound quite as good as you expected it should, but you can't find the trouble. That seems to be the tale with feedback circuits only too often. We can recall only too well the set we detailed in the June, 1941, issue. It had a pair of 6V6 in the output, with a direct-coupled phase changer and inverse feedback. (Well ahead of its time in many ways.) Quite a few of these worked to perfection if built according to circuit. Others were not too good at all until a mica condenser of .00025 was run from the plate of one of the output valves to earth, and it wasn't always the same valve, either! What effect this condenser had, theoretically, we could never fully explain, but it must have corrected some phase displacement of some kind.

Probably the handiest type of valve for a fairly big amplifier is the 807. Really a transmitting tube, the type 807 is available at low price, even cheaper than either 6V6 or 6A3, can be used either as triode or beam power valve and will stand a lot of abuse. If you have a good power supply which can be adjusted to give you 400 volts to 450 volts at about 150 milliamps, then I think you would be better off with a pair of 807's than either of the types you mention. You can play around with the 807's and experiment with various forms of feedback. Then change them over to triode connection and decide for yourself which you prefer.

★ RADIO CONTROL FOR MODELS ★

AN interesting phase of the radio game, which appears to have become popular in other parts of the world, seems to have been sadly neglected in Australia. This is the control of models by means of radio signals.

If the world ever sees any more wars it is almost certain that radio controlled aircraft, submarines and missiles of various kinds will be directed by radio control. It seems a pity that some of our brighter young radio enthusiasts do not find time to direct their attention to the subject. There may come a time when there will be a sudden demand for radio engineers with at least an elementary knowledge of radio control units.

At the recent Wireless Institute convention in Melbourne, a display of a radio-controlled model aeroplane was scheduled, but those who attended were disappointed in this regard, as the model was not in evidence. Excuses offered about a clash of dates with a model aeroplane contest were rather inadequate, as the radio-controlled model was not seen at this contest, either.

In America a contest for radio-controlled models is a feature of the National Championships for petrol-powered model aeroplanes. Quite a number of commercially-built units for radio control are also available in the U.S.A.

In England, the Mercury model aeroplane people collaborate with the Cossor radio factory to offer a complete radio control unit, including transmitter, receiver, and relay for a price of 12½ guineas, complete with all equipment, including valves and aerial.

The Mercury-Cossor unit provides control for the rudder, elevator, and engine switch. In England it is sold with the claim that no technical knowledge of radio is required to operate it, and no licence is required. The range is from about half to one mile. Although primarily designed for the control of model aeroplanes of about six-foot span, the unit can also operate model boats, submarines and rockets.

Phase Splitter Designs

As promised in last month's issue, here is an article on the subject of the various forms of phase-splitting circuit arrangements which are being used to provide push-pull operation with resistance-capacity or direct coupling.

It has long been appreciated that there are many advantages to push-pull operation of output valves. The scheme gives greater power output with lower distortion. Originally it seemed that push-pull was entirely a matter for transformer-coupled circuits as the push-pull transformer consisted simply of an ordinary audio transformer with a centre-tapped secondary.

But about the year 1932, when resistance-capacity coupling had completely ousted transformer coupling from all ordinary single-ended applications, technicians started to work out schemes for getting push-pull operation with resistance-capacity coupling. As the years roll by the number of different phase-splitting arrangements become more and more numerous and it is easy to understand why our readers become over-awed and seek our advice as to which of them are to be recommended.

First of all, and the simplest of all is to have back-to-back arrangement consisting of a push-pull audio stage driving the push-pull output stage, with either direct coupling or resistance coupling. The input can then be obtained in push-pull form to drive the first two grids by arranging an artificial centre-tap across the pick-up by means of two one-meg resistors. This works out fine with crystal

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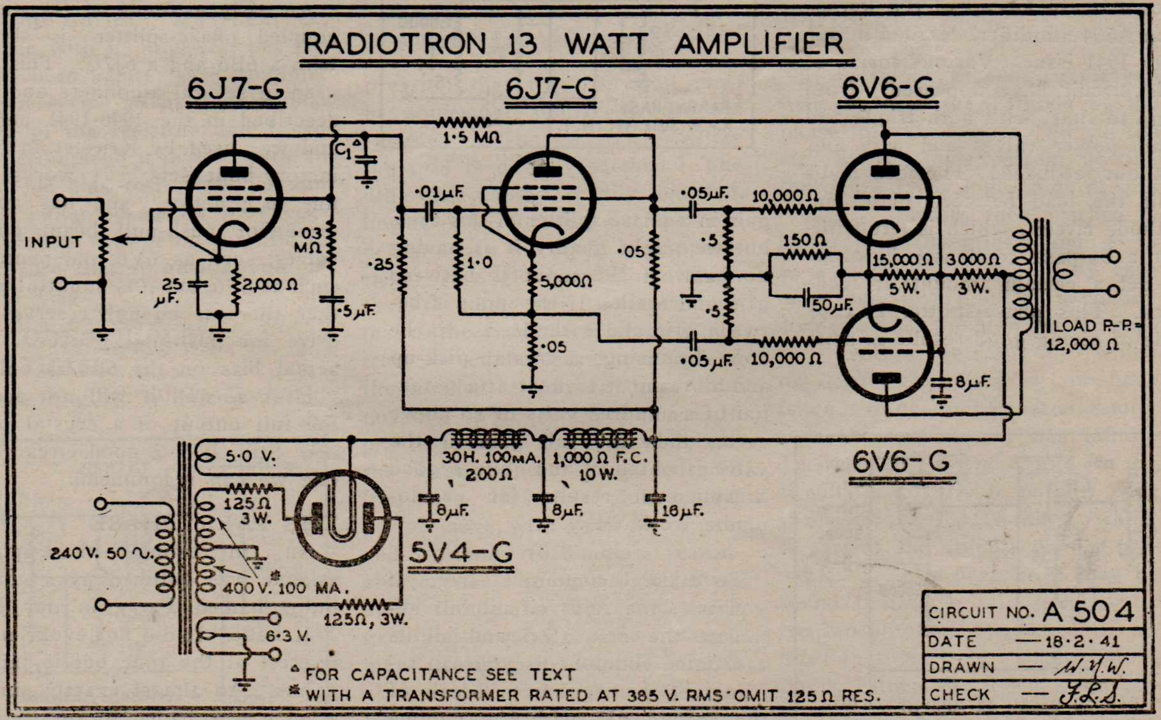


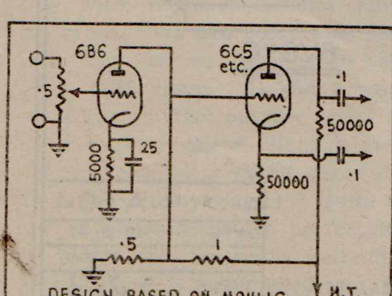
PHASE-SPLITTERS

(Continued)

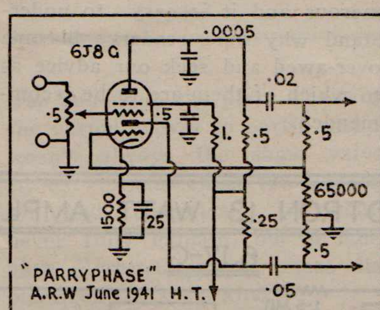
pick-ups with high voltage output, as no hum trouble it likely to be encountered, although neither side of the pick-up can be earthed. With low-output types of pick-ups it is necessary to have a centre-tapped secondary to the transformer which couples the pick-up to the amplifier. For radio use a push-pull output can be obtained from a diode detector with split load. Nobody seems very keen about this simple scheme, yet my own work on it has convinced me that it is quite foolproof and capable of giving the highest performance. A direct-coupled circuit can be built up along these lines without any condensers at all, except the usual filter condensers to the power supply.

THE FLOATER

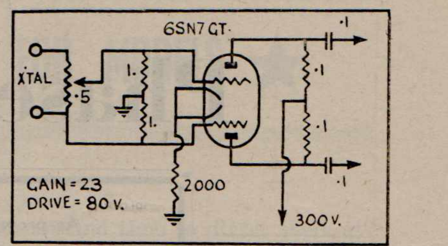
Possibly the best-known and most-used phase-splitter circuit is shown in the circuit of the Radiotron A504 amplifier, detailed in our July 1941 issue. Various forms of this circuit have appeared from time to time, with both triode and beam power valves and with and without feedback. The idea is to split the load between plate and cathode circuit, which is left without a by-pass condenser in order to get a certain amount of feedback. This phase-splitter is capable of giving good results in spite of rumours that hum trouble may be encountered if the cathode and heater circuits are at a difference of potential of a hundred volts or so, as in the case of the valve used as phase-splitter in this circuit. Others have claimed that capacity effects between cathode and earth can cause an upset to the balance, but in practice it seems to work out fairly well. There is no actual gain in this phase-splitter circuit, but it hands on the signal from the first valve at about a one to one ratio. By using a screen-grid tube for the first stage, with a gain of about a hundred, there is no trouble to drive the output grids fully from a signal input to the first valve of half a volt or less, according to the feedback used.



As we have just said, there is no gain in a phase-splitter of this type, but we might qualify it as having no gain if the input is between grid and earth. If the input is between grid and cathode, as can be done by using a crystal pick-up and allowing it to float at a potential of a hundred volts or so above earth, then the full gain of the valve is obtained and quite a good arrangement results for gramophone work only.



To make this point clearer; if you take the A504 circuit but eliminate the first 6J7G and all its associated components you can replace the 1 megohm grid-leak of the second 6J7 with the volume control potentiometer of a crystal pick-up. You will find that you have a good gramo amplifier with plenty of power and good tone.



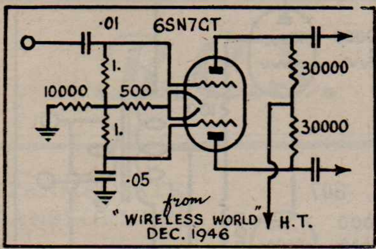
Circuit for centre-tapping a crystal pick-up with a pair of one-meg. resistors.

Direct-coupled phase-splitters are mostly of the same fundamental type as the floater just detailed, but with a direct connection between plate of first valve and grid of the actual phase-changer. This gives even wider frequency response, greater gain, better transient response and less phase displacement. In a nutshell, it has plenty of attractive features anl is deservedly popular.

An early example of the direct-coupled phase-splitter is shown, with a 6B6 and a 6J7G. This was used in several amplifiers and sets described in the 1940-1941 period, and was used by Kriesler in their factory-built sets. It works out fine in practice, and has ample drive for push-pull beam power valves, such as 6V6 and pentodes such as 6F6, but it is doubtful whether there is enough reserve of drive for push-pull triodes. The actual bias on the 6B6 is only a volt or so and it will not accept the full output of a crystal pick-up. Still, it is a good circuit and one we can recommend.

THE PARRYPHASE

An interesting phase-splitter scheme was outlined py a contributor named Parry in our June 1941 issue. It did not evoke much interest at the time but it had its points. An almost exactly similar scheme was hailed by an English



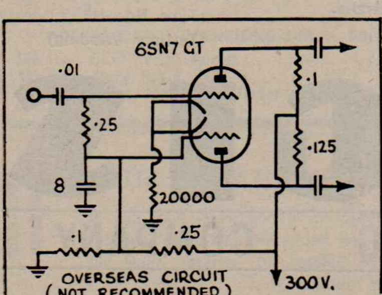
valve factory in one of their technical bulletins issued only a few months ago. The basis of the idea is to use the two sections of a converter valve, one as driver and the other as phase-splitter. The scheme could be used with twin triodes equally well, but with lower gain.

THE MOULIC DESIGN

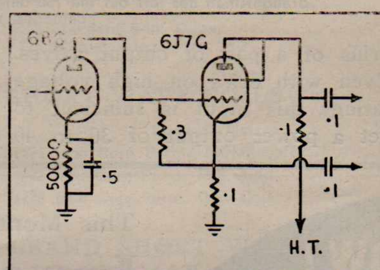
Another interesting circuit is one which resembles the 6B6 version mentioned above, but has a different feed connection for the plate of the 6B6. It comes from a handbook issued about 1944 in America, and has the advantage of operating the 6B6 with higher applied plate voltage. Consequently it can accept a higher input signal and deliver a higher driving signal for push-pull triodes. My slight experience with it, however, has not always been happy; each amplifier using it seems to need individual setting of the resistors and I can only recommend it if used with an adjustable bias resistor which can be set, either by ear, or by checking the bias voltage on the 6B6 to make sure that it gets a volt or two of bias.

CATHODE-COUPLED PARAPHASE

In the English "Wireless World"

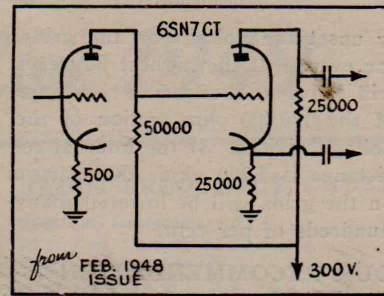


for December 1946 there was an interesting circuit for wide-range tone control, using a phase splitter of rather different type. It can be considered as being a modified form of cathode-coupled paraphase amplifier. In this type of amplifier a current change in the first half of the valve causes a change in the common cathode voltage, thereby producing an approximately equal and opposite change of current in the second half. As will be seen from the circuit, the way in which the grid of the second half of the valve is "earthed," from a signal point of view, through the .05 mfd. condenser, gives the im-



A recommended direct-coupled arrangement, taken from a series of articles by Parry which we ran in 1941.

pression that the operation must be somewhat similar to the old "Barnes Mystery" circuit, where the grid is directly earthed. The difference can be readily detected, however, by shorting out the condenser when the outfit is in operation. It might be said, however, that the use of the condenser makes the circuit one which is not truly direct-coupled; impedance of the condenser coming into the question of frequency response. In practice this is not noticeable, and the arrangement gives splendid frequency response and general performance, with a fair bit of gain and an ability to handle a reasonable signal. The input signal, however, should be fed in between grid and ground, so the arrangement is only truly suitable for use as a second stage. As a combination phase-splitter and wide-range



The basic arrangement of the direct-coupled phase-splitter which we used in the "World Standard" and in the "Hamlet" amplifier (February issue).

tone control it is a fine circuit and one which we can strongly recommend.

During 1947 and 1948 a number of circuit designers have been working along the lines of this phase-splitter, and they have evolved some slightly different arrangements. One of these seems to have been boomed along in overseas magazines, English, Belgian and especially in one magazine from New Zealand. Why is more than I can understand, as the arrangement seems to have a couple of the nastiest characteristics you could wish to come across.

If you look at this circuit you will see that the cathode of the phase-splitter is kept "up in the air" by the plate current flowing through a fairly high value of bias resistor. Bias is then worked in by keeping the grids above earth to a slightly less degree by running them to a point on a voltage divider across the high tension supply. One of the traps into which the designers of these circuits have fallen is in imagining that an 8 mfd. electrolytic condenser has infinite d.c. resistance. The 8 mfd. in the circuits is directly in parallel with a resistor of 100,000 ohms which is part of the voltage divider network. Now in practice it may be found that an 8 mfd. electrolytic has an internal resistance of almost anything from 5,000 to 100,000 ohms. Either way it will complete-

(Continued on next page)

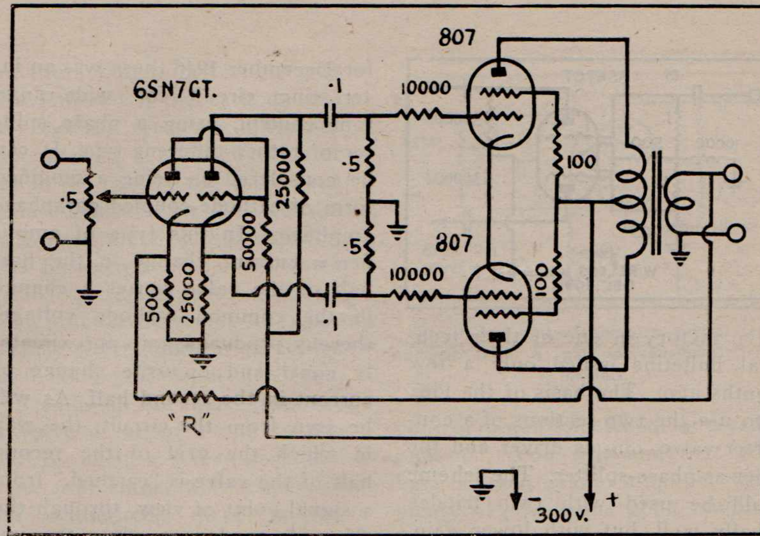
PHASE SPLITTERS

(Continued)

ly upset the voltage on the grids, for even if at the highest figure, it will halve the effective resistance of the 100,000 ohm section of the voltage divider. If the internal resistance is 5,000 ohms the voltage on the grids will be lowered many hundreds of per cent.

OUR RECOMMENDATION

Of all the phase-splitters we have tried, and we have tried every one we have ever heard of our read about, we still like the one which we used in the recent "World Standard" and in the "Hamlet" amplifier in last month's issue. This seems to be completely foolproof, gives a wide frequency range, little phase displacement, and can handle quite a solid signal. It gives a gain of about 20 and will accept a two-volt input signal, and deliver a 40 volt signal to the grids of a pair of output valves. Even with 807's on high voltage ratings this input is sufficient to get a power output of 30 to 40 watts. It has the added attraction of taking kindly to the application of feedback in its simplest form, from voice coil to cathode.



A powerful amplifier for use with crystal pick-up. Note that the circuit draughtsman has left out the 150 ohm. bias resistor which runs from the 807 cathodes to earth.

R.C.S. Price List for 1949

INTERMEDIATE TRANSFORMERS

STANDARD 455 K.C.
NEW TYPE

	s.	d.
IF 170 1st Stage Permatune Iron Core	13	0
IF 171 2nd Stage Permatune Iron Core	13	0
IF 172 1st Stage Permatune Iron Core	13	0
IF 173 2nd Stage Permatune Iron Core	13	0
IF 174 Low Gain Permatune Iron Core	13	0
Standard 460 k.c.		
IF162 1st Stage Perm. Iron Core	13	9
IF163 2nd Stage Perm. Iron Core	13	9
IF164 Low Gain Perm. Iron Core	13	9
Standard 175 k.c.		
IE74 1st Stage Perm. Iron Core	13	9
IE75 2nd Stage Perm. Iron Core	13	9

F.M. INTERMEDIATE TRANSFORMERS

ROUND CAN DIMENSIONS 2¼x1-3/8

IF 180 10.7 MEG. Iron Core Perm.	13	0
IF 181 Ratio Detector Iron Core Perm.	17	6

MAGNASONIC INTERMEDIATE TRANSFORMERS

Dimensions 2-in. x 1-in. Round

IF168 Midget Iron Core Perm. 1st	12	6
IF169 Midget Iron Core Perm. 2nd	12	6

MIDGET MAGNASONIC BROADCAST COILS

Dimensions 1-in. x 1-in. Round

E352 Iron Core Aerial	6	6
E353 Iron Core R.F.	6	6
E354 Iron Core Osc.	6	6
E355 Iron Core Osc. 6SA7 Valve	6	6

STANDARD SUPERHET. COILS

Dimensions 2-in. x 1-3/8-in. Square

E342 Air Core H. Gang Aerial Coil	6	6
E343 Air Core H. Gang R.F. Coil	6	6
E344 Air Core H. Gang Osc. Coil	6	6
E345 Iron Core Perm. H Gang Aerial Coil	8	6
E346 Iron Core Perm. H Gang R.F. Coil	8	6
E347 Iron Core Perm. H Gang Osc. Coil	8	6
E348 Iron Core Perm. H Gang Osc. Coil, 6SA7 Valve	8	6

NEW TYPE
ROUND CAN DIMENSIONS 2-in. x 1-3/8-in.

E 356 Iron Core Perm. Aerial	7	6
E 357 Iron Core Perm. R.F.	7	6
E 358 Iron Core Perm. Oscillator	7	6

F.M. COILS

	s.	d.
E 362 Aerial	2	6
E 363 Aerial Coupling	2	6
E 364 Oscillator	2	6

T.R.F. COILS

T81 Air Core H Gang Reinartz Coil	5	6
T82 Air Core H. Gang Reinartz Coil in Can	6	6
T87 Air Core H. Gang R.F. with Reaction Coil	6	6
T88 Air Core H. Gang Aerial Coil	6	6
T89 Air Core H. Gang R.F. Coil	6	6

LOOP AERIAL COILS

F125 Standard 6-in. Diam.	7	6
F126 Midget 4-in. Diam.	7	6

SHORT WAVE COILS

13 to 42 Metres

H121 Iron Core Perm. Aerial Coil	5	0
H122 Iron Core Perm. R.F. Coil	5	0
H123 Iron Core Perm. Osc. Coil	5	0

5-BAND SHORT WAVE & BROADCAST COILS

H124 10m. Aerial	4	6
H125 10m. R.F.	4	6
H126 10m. Osc.	4	6
H127 20m. Aerial	4	6
H128 20m. R.F.	4	6
H129 20m. Osc.	4	6
H130 40m. Aerial	4	6
H131 40m. R.F.	4	6
H132 40m. Osc.	4	6
H133 80m. Aerial	4	6
H134 80m. R.F.	4	6
H135 80m. Osc.	4	6
H136 B'cast Aerial	5	6
H137 B'cast R.F.	5	6
H138 B'cast Osc.	5	6

COIL KITS

K116 Standard Personal Coil Kit	2	2	0
K117 Standard 4/5 Dual Wave Coil Kit (complete with I.F.'s)	2	19	0
K118 Midget Per. Coil Kit	1	19	6
K119 Midget B/C Coil Kit	1	18	0

COIL KITS

K 120 5 Band Coil Kit	3	10	6
K 121 4/5 B/C Coil Kit	2	3	6
K 122 5/6 B/C Coil Kit	2	11	6

RADIO FREQUENCY CHOKES

	s.	d.
RF81 Silk Honeycomb R.F.	1	9
RF82 3 pie 1.7 M/H R.F.	4	6
RF83 4 pie 2.5 M/H R.F.	4	6
RF84 5 pie 4.0 M/H R.F.	4	6
RF85 6 pie 7.0 M/H R.F.	4	6
RF86 Cotton Honeycomb R.F.	1	6
RF106 Vibrator Low Tension R.F.	4	3

LINE FILTER COIL

RF15 Line Filter Coils	11	0

DUAL WAVE UNITS

DW29 Standard 4/5 Dual Wave Units	1	14	0
DW38 Standard 5/6 with R.F. Stage	6	10	0

SWITCHES

SW17, 5 Band Switch	3	0	0

LOW LOSS COIL LACQUER

KH34 Type	2	6

COIL FORMERS

1.24 6-Pin Plug in 1¼-in. Diam.	3	3
1.25 6-Pin Plug in 1½-in. Diam.	3	5

DIALS

DA7 D/W Portable Kit Dial	11	0

FILTER CHOKES

TC60 100 M/A 30 Henries 250 ohms D.C. Res.		13	6
TC65 50 M/A 30 Henries 400 ohms D.C. Res.		13	6
TC80 150 M/A 30 Henries	1	1	0
TC81 200 M/A 30 Henries	1	5	0
TC66 60 M/A 20 Henries 650 ohms D.C. Res.		10	0

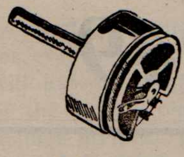
AUDIO CHOKES

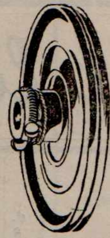
TA4 100 Henries 1000 ohms D.C. Res. 25 M/A	1	8	6

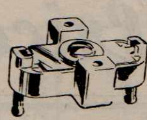
FIVE-IN-ONE TRIMMER

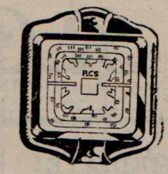
CG19 four-2 plate and one-3 plate	4	6

(Continued on page 28)


Potentiometer

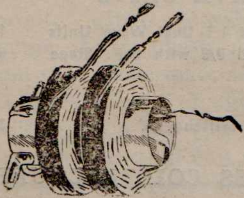

Dial Drive Drum

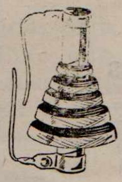

Padding Condenser

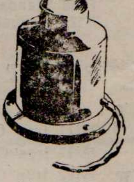


DA7 Dial

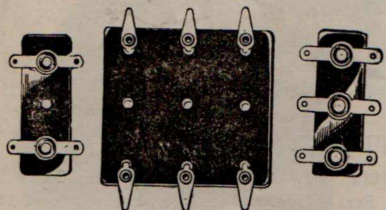
R.C.S. price List for 1949

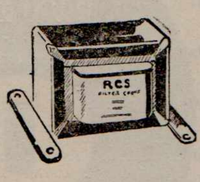

Line Filter Coil


Radio Frequency Choke


Line Filter

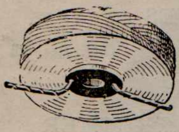
Low Loss Coil Lacquer

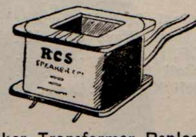

Resistance Strip



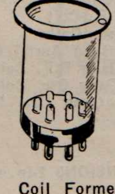
Filament Transformer

Audio Transformer


Radio Frequency Choke



Speaker Transformer Replacement Coil


Coil Former

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If you have been unable to purchase R.C.S. components from your local retailer, write us, and whilst we cannot supply you direct, we will arrange for your retailer to receive supplies immediately or advise you where supplies can be obtained.

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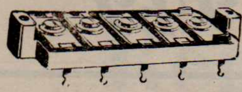
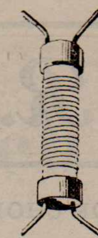
174 Canterbury Rd., Canterbury, N.S.W.



5-Line Trimmer

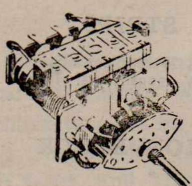
Standard Broadcast Coil

Resistors

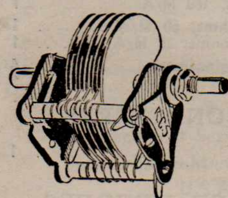


5 Band Coil

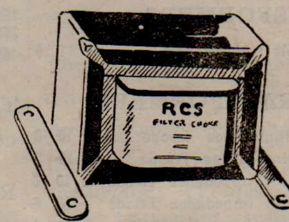
R.C.S. price List for 1949



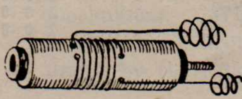
Dual Wave Units



Midget Variable Condenser



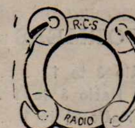
Filter Choke



Short Wave Coil

Trimming Condenser

F.M. Coil



Transposition Block

Voltage Divider

Intermediate Frequency Transformer

Loop Aerial Coil

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174 Canterbury Rd., Canterbury, N.S.W.

R.C.S. Price List for 1949

VIBRATOR CHOKES

TC58 Low Tension 3 Amps 50 M/H .5 ohm D.C. Res.	15 0
TC70 High Tension 50 Henries 450 ohm D.C. Res., 75 M/A	15 0

FILAMENT TRANSFORMERS

TP1 2.5 volts, 2 Amps 7 Watt	11 6
TP2 4 volts, 1 Amp 7 Watt	11 6
TP3 6.3 volts, 3 Amps 7 Watt	11 6
TP55 6.3 volts, 3 Amps 15 Watt	14 6

VIBRATOR TRANSFORMERS

TP81 135 volt, 6 volt	17 6

AUTO TRANSFORMERS

TP80 6.3 volt, 4 volt and 2.5 volt	11 6

SPEAKER TRANSFORMERS

TS23 Single Low Impedance Triode	10 0
TS24 Single High Impedance Triode	10 0
TS 25 Push Pull Low Impedance Triode	10 6
TS26 Push Pull High Impedance Triode	10 6
TS27 Single Low Impedance Pentode	10 0
TS28 Single High Impedance Pentode	10 0
TS29 Push Pull Low Impedance Pentode	10 6
TS30 Push Pull High Impedance Pentode	10 6

AUDIO TRANSFORMERS

TB42 A Class single Ratio 3 to 1	1 1 0
TB43 A Class Push Pull Ratio 3 to 1	1 2 6
TB44 B Class Push Pull Ratio 1½ to 1	1 1 0

DIAL DRIVE DRUMS

MO8 Dial Drive Drum, complete with screws, springs and cord	3 3

SPEAKER TRANSFORMER REPLACEMENT COILS

F132 Single Low Impedance Triode	5 6
F133 Single High Impedance Triode	5 6
F134 Push Pull Low Impedance Triode	5 6
F135 Push Pull High Impedance Triode	5 6
F136 Single Low Impedance Pentode	5 0
F137 Single High Impedance Pentode	5 0
F138 Push Pull Low Impedance Pentode	5 6
F139 Push Pull High Impedance Pentode	5 6

LINE FILTERS

LF20 Line Filter, .75 amps.	1 7 0
LF21 Line Filter, 3 amps	2 2 0
LF22 Line Filter, 5 amps.	3 0 0
LF23 Line Filter, 10 amps. (2 req.), each	3 0 0

AERIAL FILTER

AF21 Aerial Filter

CENTRE TAPPED RESISTORS

10, 20, 30, 75, 100 and 200 ohms	1 0

WIRE WOUND RESISTORS

0 ohms to 1500 ohms, 100 M/A	1 0
1500 ohms to 2500 ohms, 50 M/A	1 2
25000 ohms to 10000 ohms, 25 M/A	1 2
1000 ohms Field Replacement	4 0

TRIMMING CONDENSERS

CG15 2-plate	1 0

R.C.S. VOLTAGE DIVIDERS

VD25 15000 ohms 2 variable clips	5 6
VD28 25000 ohms 2 variable clips	5 6

POTENTIOMETER AND RHEOSTATS

Type	Ohms	M/A	Price
PT40	6	250	7 6
PT38	10	250	7 6
PT39	20	250	7 6
PT34	30	250	7 6
PT46	400	50	7 6
PT47	1000	35	7 6
PT49	2500	30	7 6
PT51	5000	30	7 6
PT52	10000	20	7 6

MIDGET VARIABLE CONDENSERS

Star Type with Face Support

Type	mmfd	Plates	Price
CV34	10	2	4 0
CV35	15	3	4 3
CV36	25	4	4 6
CV37	35	5	4 9
CV38	50	7	5 3
CV39	70	9	5 10
CV40	100	14	6 6

PADDING CONDENSERS

P21 460 K.C.	2 6
P22 262 K.C.	3 0
P23 175 K.C.	3 0

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MO3 ½-in. per 100	2 0 0
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R.C.S. Radio Pty. Ltd.

174 Canterbury Rd., Canterbury, N.S.W.

A JENSEN TECHNICAL MONOGRAPH

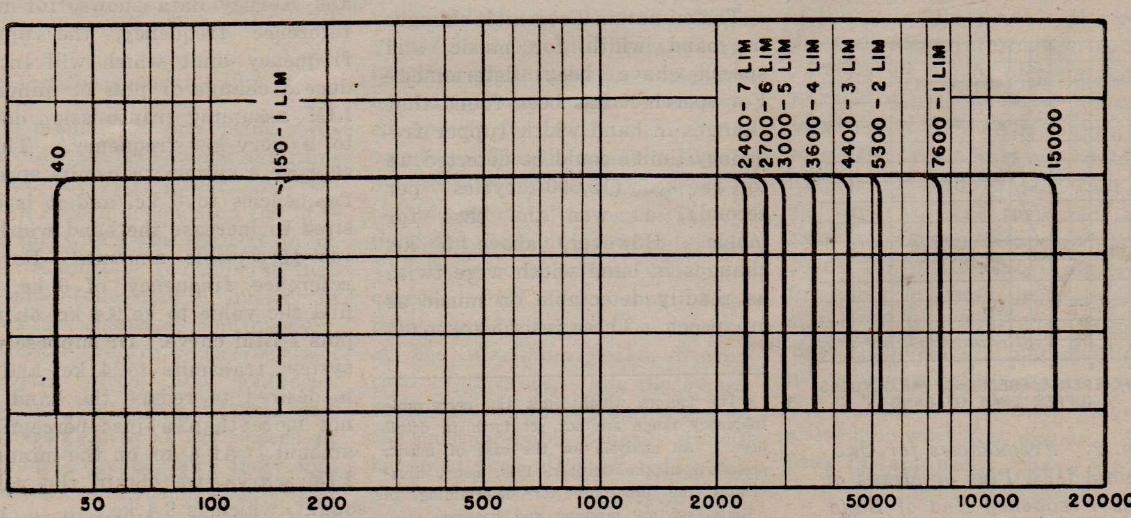
Reproduction of Speech

Our policy is to give technical articles of a popular type in an easily-read form. But, every now and then, we like to offer an article of deeper significance. Here is a complete survey of the problems associated with the clear reproduction of speech. It is surely one of the finest articles ever written on this subject. A similar article on the subject of the reproduction of music appeared in our issue for October, 1948. It has been noticed in our mail that many subscribers said that the one article was, alone, worth more than the cost of a full year's subscription.

By
Technical Service Dept.,
Jensen Radio Manufacturing Co.,
U.S.A.

In this monograph we are concerned mainly with the physical characteristics of speech which are of importance in the design of systems and components for its transmission and reproduction. Our interest centres on the component frequencies and their amplitudes and powers in speech after its production by the vocal mechanism. When speech is reproduced the acoustic waves produced by the talker are converted into the electrical state by a microphone, amplified and reconverted to the acoustic state and radiated by means of a loud speaker system, or delivered direct to the ear by means of a telephone receiver. There often will be additional transmission circuits involved, such as wire lines and radio links. Data regarding the physical characteristics of speech provide us with important information for the design, selection, and operation of microphones, amplifiers, receivers, loud speakers, modulators, and the many other components of speech systems.

Two quite different types of per-



SPEECH

(Continued)

formance may be required of a speech transmitting system, depending on the fundamental purpose to be served. They are:

1. The reproduced speech may be required to approach the characteristics of the original sound, and we may specify how close the approximation shall be. This is a *fidelity requirement.*

2. The reproduced speech may be required to convey satisfactorily the message from the talker to the listener. The quality of the reproduced voice in this case may be of little or no importance, and the idea or intelligence to be conveyed is all-important. Here relatively low fidelity is permissible, even essential, in many applications, for economic and physiological reasons which will be developed in this monograph.

Frequency Ranges in Speech

The entire frequency range of speech can be determined by objective physical measurements in which peak and average pressures are counted in a series of frequency bands covering the complete spectrum, and by subjective tests in which reproduced speech is listened to over a high-quality wide range system in which the cut-off frequencies may be extended until there is no further improvement in observed quality. A review of the principal literature on the subject leads to the conclusion that the complete frequency range of speech probably is only slightly less wide than that of music, which extends from 40 to 15,000 cycles per second. We know, however, that such an extreme range cannot be utilized effectively or economically under the conditions which prevail at most listening locations. Fletcher[1] has concluded that under average listening conditions a frequency range from 100 to 7000 cycles per second will afford practically complete fidelity for speech.* Furthermore, our objective is not always the *most faithful reproduction,* for frequently what is required is the *most effective communication* under all the existing conditions. As we shall see later, restricted frequency ranges are actually advantageous in the latter case.

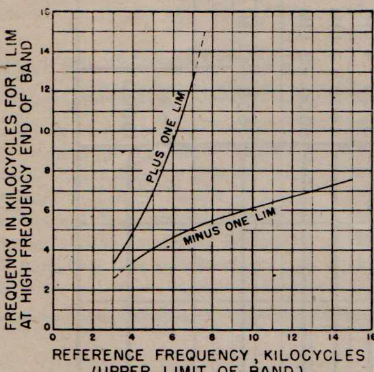


Fig. 2. Frequencies for One Liminal Unit Plus or Minus at High Frequency End of Band

Liminal Frequency Bands

The minimum discernible changes in band width for music and speech have been determined.[2] For speech it has been found that changes in band width (upper frequency limit) could be detected up to 15 kc. (15,000 cycles per second), as was the case for music. However, above 5 kc. changes in band width were twice as readily detectable on music as on speech. These tests were made on a variety of spoken programme material with direct comparison between the bands being judged. An average of sixteen observers, who were engineers accustomed to judging programme quality, were used for the tests. The difference limen was taken as the difference in band width (i.e.. difference in high-frequency cut-off) when 75 per cent. of the observers correctly identified the wider of two bands presented for comparison. It is reasoned that the difference limen is equivalent to (1) *the difference in band width which is actually detectable to half the observers* or (2) *the threshold difference in band width for which there is an even chance of its discernment by a listener.* The sensation due to a change of one difference limen is defined as one *liminal unit,* for which we have used the symbol LIM. The upper frequency limits, corresponding to one liminal unit (LIM) between them are: 15.0, 7.6, 5.3, 4.4, 3.6, 3.0, 2.7, and 2.4 kc. These are illustrated in Fig. 1. The frequency of 150 cycles indicated for 1 LIM at the lower end of the band is conjectural and has not been established by test, although it appears to be a reasonable value.

Fig. 2, derived from the Gannett and Kerney data shows, for any reference frequency, the upper frequency limit which will introduce a change of plus or minus 1 LIM, assuming transmission down to a very low frequency. Thus, suppose a system transmits speech frequencies to 6 kc. and it is desired to increase the band width a just-perceptible amount. For a reference frequency of 6 kc. we find the value to be 9.4 kc. on the plus 1 LIM curve. Or suppose the system transmits to 4 kc. and it is desired to reduce the band by not more than a just perceptible amount. At 4 kc. on the minus 1 LIM curve we obtain the value sought, which is 3.4 kc.

* The factors which limit the perceivable frequency range are not set forth in detail here. An analysis for the case of music, presented in the October, 1948, issue, illustrates the procedure for determining the limits set my masking and hearing.

For any reference frequency, the upper limiting frequencies corresponding to plus 1 LIM and minus 1 LIM give us the frequency tolerances of the ear to changes in band width for a system transmitting speech uniformly down to very low frequencies. It must be remembered that these values were obtained under the conditions most favorable for detecting band width changes, that is, at high reproduction level, low noise level, and with direct comparison possible between the bands. For less favorable conditions, larger frequency changes undoubtedly would be indicated. To recapitulate, under the most favorable conditions for critical judgments, there is only an even chance that a listener would detect a change in upper cut-off frequency from 15,000 cycles to 7600 cycles, or from 7600 cycles to 5300 cycles, etc. The considerable reduction of band width in the first liminal step (15,000-7600 = 7400 cycles) confirms the known fact that there is very little speech energy in the region. At an upper frequency limit of say 3000 cycles, a change of one LIM is produced by a reduction of only 300 cycles, indicating that appreciable speech energy is present and that it is highly important to the speech characteristics as appraised by the ear.

Spectrum Levels in Speech

The manner of presenting data regarding the frequency distribution of intensity, power, or pressure in speech depends on the purpose for which the data is to be used. It must be remembered that the amplitude and frequency in speech is changing continuously, and that there are pauses between syllables, words, and sentences. Moreover, there are characteristic differences between the speech of men and women, and individual variations are considerable. Under these conditions, the problem must be approached statistically. The methods by which the sampling is performed in frequency bands and in the whole frequency range cannot be described here in detail because of space limitations.

Briefly, however, the equipment involves a microphone, suitable amplifiers, and sampling and analyzing equipment. The sampling and analyzing apparatus for peak determinations includes a series of gas tubes arranged to fire at suitable level intervals covering the range of levels of interest. Each time a particular tube fires, the counter in its output circuit registers the occurrence. A particular pressure peak in the speech will produce a proportionate peak voltage in the analyzer system. All tubes having firing levels equal to or below the particular speech peak voltage will fire and advance their counters by one number. The process is repeated in alternate 1-8-second or ¼-second intervals. At the end of the run the distribution of peaks may be computed from the counter readings. The analysis is performed on unfiltered speech, and on selected frequency bands with the aid of suitable filters.

Fig. 3 gives peak pressure data for conversational speech from the work of Dunn and White.[5] These values were obtained from a large number of samples in one-eighth second intervals taken on connected speech for six men and five women. The lines are drawn to connect pressure levels observed in the individual filter bands for the indicated percentage of intervals. The 1 per cent. values (which are exceeded only 1 per cent. of the time) may be taken as a measure of the maximum peaks of practical significance, while the 50 per cent. values are representative of the most probable peaks. It will be noted that all peak values are greatest in the 210-200 cycle band. As would be expected, the peak

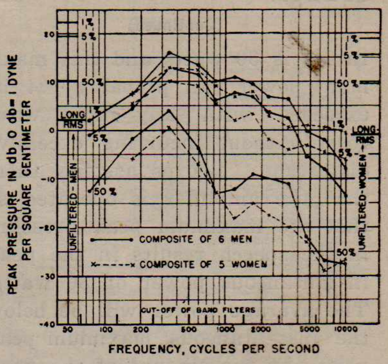


Fig. 3. Peak pressures in Speech in Frequency Bands. The Percentages are the Proportion of the Intervals in which the Indicated Pressures are Exceeded.

values for the entire frequency range (unfiltered) are greater than those in any band. This is because the peaks in two or more bands sometimes are in phase and add up.

Peak values cannot be interpreted directly in terms of hearing phenomena. However, they are of great importance in determining the overload point of electro-acoustic devices and amplifiers.

Data similar to Fig. 3 could be given for the *r.m.s. pressures* (root mean square) which are indicative of the *power* in speech. However, the equivalent information can be conveyed by a plot of *peak factor*, or ratio of peak to r.m.s. pressures as given in Fig. 4, in conjunction with the peak pressure data of Fig. 3. It will be seen that the long interval peak factor for both men and women is approximately 20 db for unfiltered speech while for short intervals it is approximately 10 lb. This can be immediately applied in amplifier loading problems. Suppose an amplifier is rated at 15 watts with the usual sine-wave test signal. The peak instantaneous power at the crest of the sine wave for full

(Continued on next page)

rating is 30 watts and this maximum power can probably not be exceeded with any input wave form without incurring excessive distortion. Let us assume, then, that the amplifier is operated so that the maximum peak pressure in the speech results in the peak instantaneous power of 30 watts. The average power will be below the instantaneous maximum peak power by the amount of the peak factor. For one-eighth second intervals, the peak factor is 10 db, which indicates an average power one-tenth of the peak power, or 3 watts. In long intervals involving a number of words, and including the pauses between speech sounds, words, and sentences, the peak factor rises to about 20 db, so that the power averaged over the long interval is only one one-hundredth of the peak power, or 0.3 watts. To sum up, if a 15 watt amplifier is operated on speech input so that on the peaks of speech the instantaneous maximum power is 30 watts (the rated peak instantaneous power for sine wave input) the individual speech sounds are likely to produce powers of about 3 watts, but the average power over a period of time will be only about 0.3 watt. This does not at all indicate that an amplifier of the lower order power rating could be used, for it is necessary to prevent nonlinear distortion. However, the relatively low average power many be taken into account advantageously in the design of loud speaker volume controls, line attenuation devices, and other components which are temperature-limited in their ratings.

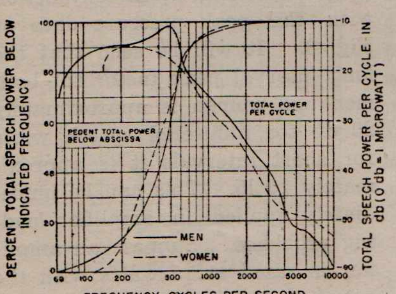


Fig. 5. Total Power and Power Spectrum for Speech.

If we wish to obtain the frequency distribution of speech power or energy on a spectrum basis, this may be calculated from measured r.m.s. sound pressures in the frequency bands and reduced to a per-cycle basis. The result is shown in Fig. 5 as given by Dunn and White.[5] Included also is the total power occurring below any particular frequency, expressed in per cent. of the power in the entire frequency range. It will be noted that 95 per cent. of the power is below 1000 cycles and about 65 per cent. is in the region below 500 cycles. It will be important to consider the frequency distribution of speech power in connection with the effect of frequency range on *articulation*, which is the measure of *intelligibility*, and this will be discussed later.

Intensity Levels in Critical Frequency Bands

All of the foregoing data deals with the purely physical aspects of the statistical acoustic pressures and powers, and, while useful for other purposes, furnishes no direct information as to the manner in which the ear evaluates speech sounds. Extensive study of the hearing precess by Fletcher and his colleagues has led to the conclusion that the ear integrates the varying sounds in speech over an interval of about ¼ second, and that the integrated sound energy in a critical band over this period of time will sound as loud as a pure tone in the same frequency band which produces the same sound energy in each ¼-second interval.[6,1] With our data in this form, we can express the intensity levels of speech on the same basis

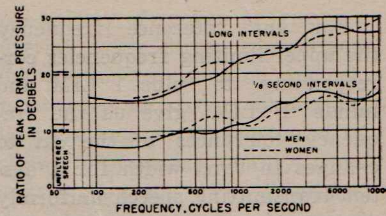


Fig. 4. Peak Factor in Speech in Different Frequency Regions in Long and Short Intervals. (After Dunn and White.)

as the hearing contours which are pure tone thresholds, investigate masking due to noise, and compute the loudness under various conditions.

Fletcher has given the maximum intensity levels in critical frequency bands for conversational speech of men and women and for declamatory (loud) speech[1] and these have been reduced to the indicated distances and are plotted in Fig. 6 along with the median population hearing contour under conditions of no noise. The corresponding most probable intensity levels, which are exceeded 50 per cent. of the time, have been computed, and are also shown in Fig. 6 because they are thought to be the most representative "average" levels under the assumed condition.[10] It will be noted that they are from 7 to 16 db below the maximum levels. The cross-hatched portion of the diagram represents the loss of auditory area due to the masking effect of the average residential noise level of 43 db.* Sounds whose intensity levels fall into the cross-hatched area would not be heard due to masking. Levels which lie below the threshold hearing contour will not be audible to the average listener. It will be observed that both hearing and masking limit the perceivable frequency range at the high-frequency end somewhat for the assumed speaking levels and distances. As the speaking level is lowered, the effect is to shift the curves correspondingly lower in the diagram with increasing limitation of the high-frequency range.

It is evident from an inspection of the intensity level curves of Fig. 6 that they can be represented quite well by straight lines drawn so as to average the deviations, especially in the significant portion of the range above about 300 cycles. The slopes of these lines are very nearly the same and values for the entire frequench indicate that the intensity levels fall, on the average, from 5.3 to 6.5 db per octave as the frequency increases. As we shall see later, this falling characteristic creates a special problem when it is necessary to reproduce intelligible speech in the presence of very high noise levels.

Articulation

In analyzing the effects of frequency range on the characteristics of speech, it is important to examine the matter of *intelligibility,* which is the attribute of speech which permits its recognition and understanding by the listener.

One of the most used and perhaps the most significant single measure of intelligibility is the *syllable articulation* usually referred to simply as the "articulation." A system is tested for syllable articulation by having a caller recite meaningless lists of syllables covering the fundamental sounds of speech. The listener writes down each sound as he hears it, and the number correctly identified, expressed in per cent., is the syllable articulation. Any type of distortion in the system tends to reduce the articulation, and extensive tests have been carried out to determine these effects. In this discussion we limit our consideration to the effect upon articulation of frequency range.

Fig. 7 shows the manner in which syllable articulation is governed by limiting the frequency range at either the low- or high-

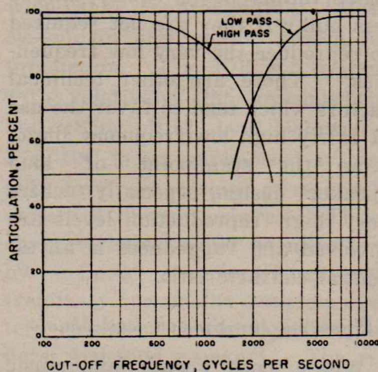


Fig. 7. Syllable Articulation for Low-pass (all Frequencies below Abscissa) and High-pass (all above Abscissa) Band Restriction.

frequency end of the band. For the curve marked "high pass" all frequencies above the abscissa were transmitted; for the "low pass" curve, all frequencies below the abscissa. It will be seen that the articulation is hardly affected until the lower cut-off frequency is raised to 400-500 cycles. Similarly, the upper cut-off frequency can be reduced to 5000-6000 cycles before the articulation begins to fall off. The articulation is about 70 per cent., whether all frequencies *above* or *below* 1000 cycles are transmitted.

The correlation between *discreet* and *discreet sentence articulation* and syllable articulation[7] are shown in Fig. 8. Even though some of the sounds which make up a word may not be individually recognized, the association of these sound groups permits the mind to make an overall recognition. For this reason, the discreet word articulation is very much higher than the syllable articulation, particularly at low syllable

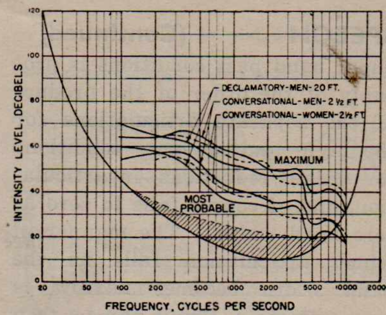


Fig. 6. Intensity Levels in ¼-second Intervals in Critical Frequency Bands for Typical Speech.

articulation percentages. Likewise, the mind grasps the complete thought of a sentence even though some of the words may be indistinct, and hence the discreet sentence articulation is higher than the discreet word articulation. Thus, even at a syllable articulation of 30 per cent. we find 65 per cent. word articulation and 87 per cent. sentence articulation.

Communication Bands

It would be desirable to have articulation data as the transmitted band width is simultaneously narrowed at both ends. It may be speculated that the articulation

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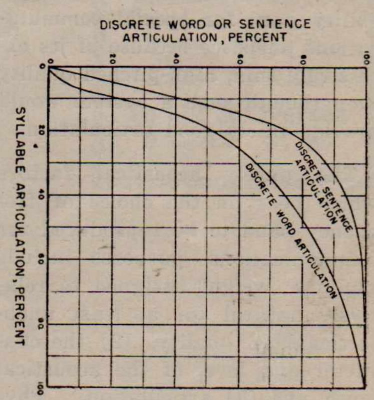

Fig. 8. Correlation between Syllable Articulation and Discreet Word and Sentence Articulation.

SPEECH (Continued)

under band pass conditions is probably of the order of the product of the separate articulations for the high- and low-pass conditions for small reductions in articulation, and of course falls to zero at zero band width. The manner in which articulation falls as the band width becomes narrow is very uncertain, but it can be seen from the articulation curves that it will depend on the position of the band in the frequency range. Presumably the best results for very narrow speech bands from an articulation standpoint would be obtained by centreing the band on about 2000 cycles. There is evidence that useful speech can be transmitted in this region with a band as narrow as 1000 cycles, although articulation would be undesirably low for most purposes. The quality of the speech would also be shrill and unpleasant. As the band width is widened, the system can be made to have better quality, but the band must be properly placed in the frequency scale. For example, the ear appraises a 3 kc. system in the range from 200 to 3200 cycles (representative of a telephone system) as possessing fairly good quality, yet a 3 kc. system in the range from 1000 cycles to 4000 cycles is probably outside the limits of acceptability even for special communications purposes because of its excessively thin, high-pitched quality even though such a system would provide fairly good articulation.

The purely acoustical factors which bear on the choice of frequency band to be reproduced for communications purposes include (1) the weight assigned to relatively natural (or at least unobjectionable) quality, (2) the character and level of the acoustical noise, and (3) articulation. Physical limitations on reproducing and amplifying equipment enter on the other side of the picture. As we have seen from the peak power and power spectrum curves (Figs. 3 and 5), the required amplifier power is rapidly reduced as the lower cut-off frequency is raised. Moreover, loud speakers, other things being equal, can be less bulky if they are not required to reproduce the very low frequencies. There are other technical factors which tend to favor the use of fairly high low-frequency limits from the standpoint of loud speaker design, especially where very high reproduction levels are involved and ruggedness is an essential characteristic.

Systems for Speech and Music

Where both speech and music are to be reproduced, the system may be designed for best results on one or the other, or a compromise solution may be adopted. A frequency band suitable for music (see Jensen Technical Monograph No. 3) will provide good quality and articulation on speech in low and medium noise levels where high level reproduction is not required. A high fidelity system for music, by virtue of its relatively wide frequency range, will afford high fidelity reproduction of speech. As the noise level becomes higher, as it is in industrial locations, masking tends to reduce the perceivable frequency range on music, and limits the effectiveness of speech unless excessively high reproduction levels are employed. Therefore at medium and high noise levels, the system is most frequently designed to give "good" results on speech and "fair" results on music if both must be accommodated.

Speech Reproduction in High Noise Levels

Intensity levels of the order of 120 db are considered to be at the *threshold of pain,* and for this reason the maximum intensity levels in critical frequency bands of speech should not exceed this value. Industrial noise levels are

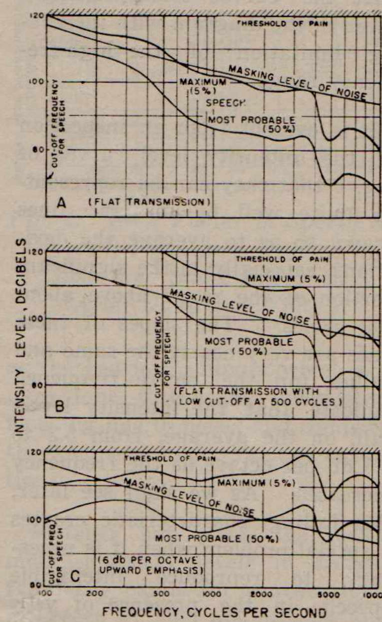

Fig. 9. The Effect of Transmission Characteristics on the Masking of Declamatory Speech by Noise.

occasionally encountered which result in masking levels close to the pain threshold. The problem of reproducing intelligible speech under these circumstances can be visualized by reference to Fig. 9A. The curve marked "masking level" is that obtained by assigning typical spectral distribution[8] to a noise which would produce a sound level meter reading of 115 db,* and then calculating the masking levels from these spectrum levels.[9] The maximum intensity level curve for declamatory speech has been shifted upward until its maximum level is 120 db. This is at 100 cycles. It will be seen that the curve for the maximum levels is below the masking level except for the part of the range from 100 to 600 cycles. Under these conditions the speech is substantially completely masked. Now if the low frequencies are cut off at 500 cycles as indicated in Fig. 9B, the intensity levels above this frequency can be increased about 11 db. This brings the maximum levels substantially above the noise level, although the most probable levels (exceeded 50 per cent. of the time) are masked 2 to 3 db in the important part of the frequency range. This means that the r.m.s. intensity levels will exceed the masking level something less than half the time. From experience we know that such a system would be useful and would have fairly good articulation. A third possibility, and one which has proven to be of great practical advantage where the highest noise levels are involved, or where the maximum loudness efficiency is required, is shown in Fig. 9C. It was pointed out previously that the r.m.s. intensity levels in critical frequency bands for speech slope downward with increasing frequency at a rate which averages 6 db per octave. Now if the air-to-air transmission characteristic (i.e., from sound pressure at the microphone to sound pressure at the listening position) is made to have an inverse or upward slope at a rate of 6 db per octave, it is obvious that the reproduced intensity levels in critical frequency bands will be uniform with frequency on the average. The result is that it is possible to raise the intensity levels in the frequency region above 1500 cycles to levels higher than those obtainable from the scheme of Fig. 9B, while still avoiding intrusion on the threshold of pain. And, since this frequency region contributes importantly to both articulation and loudness, the reproduction is very effective.

It may occur to the reader that racteristics which illustrate commercial of the overall air-to-air transmission characteristics which were discussed above are shown in Fig. 10. Fig. 10A is a relatively wide-range approximately "flat" system for high quality speech reproduction. Fig. 10B is a system with relatively flat transmission, but cutting off at about 500 cycles. Fig. 10C is an emphasized system with an average slope of approximately 6 db per octave. These characteristics would be measured by making an overall response frequency run on the complete system (including microphone, amplifiers, and loud speaker). The result may be stated in terms of the sound pressure from the loud speaker with constant pressure in the sound field at the microphone.

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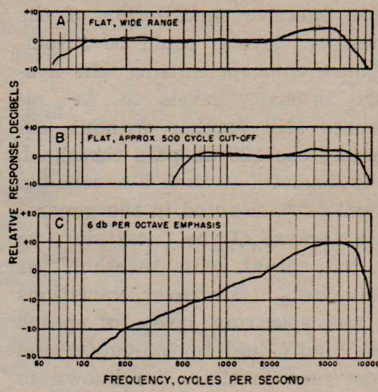

Fig. 10. Typical Overall Air-to-Air System Characteristics for Speech Reproduction (including Microphone, Amplifier and Loud Speaker.

* The 115 db reading would be obtained with the 40 db weighting network of the sound level meter. This manner of stating the level is that used by Hoth, and the absolute spectrum levels are identified in this way. Ordinarily at such a level, the meter would be used with flat response and a higher noise level would read. The masking curve is based on correction to flat response.

SPEECH

(Continued)

It may occur to the reader that more effective equalization of the intensity levels could be accomplished, thus permitting the average intensity levels to be increased still further without exceeding the 120 db pain threshold. It is doubtful if such a conclusion would be warranted in the general case because of the uncertainty as to the actual pain thresholds of individuals. Moreover, variations in the spectrum levels of speech from individual to individual and from time to time, are known to be considerable.

Comparison of Flat and Emphasized Systems

It has been said that the 6 db upward sloping transmission system (which we have called an "emphasized" system) provides high articulation and requires relatively low power compared with one which affords uniform transmission for all of the important speech frequencies. While we cannot evaluate the articulation of the emphasized system except by elaborate tests, its effectiveness has been adequately demonstrated in the field. We can, however, compute the power and the loudness of both types of speech and estimate the quality and performance under noise conditions.

Fig. 11 shows the total power in a speech band with either flat transmission or 6 db per octave upward emphasis, at various lower cut-off frequencies. The power in emphasized speech was computed by integrating the power spectrum data in Fig. 5 for male speech, corrected for the slope of 6 db per octave, and assuming the spectrum levels to be the same at 2000 cycles. The reproduced band is assumed to extend upward to 5000 cycles in order to include virtually all the power in the speech. Reproduction of the full range down to 60 cycles for male conversational speech requires 34 micro-watts (100 per cent.) at a normal level.[5] The emphasized speech, however, requires a total acoustic power of only 2.6 microwatts, or 7.64 per cent. If, instead of the full range,

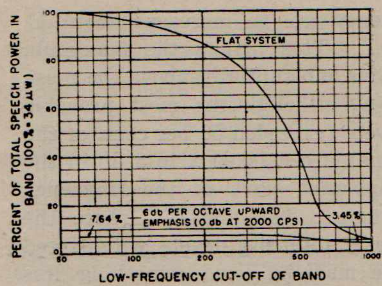

Fig 11. Relative Power in Reproduced Speech for Flat Transmission and 6 db per Octave Upward Emphasis.

the flat reproduction is cut off at 500 cycles, only 40 per cent. as much power is needed. Even so, the emphasized system will require only 19 per cent. of the power needed for the flat system with 500 cycle cut-off.

We must also consider the relative loudness and quality of the speech and the ability of the system to cope with the noise. This may be done by making loudness computations[1,9] of the speech at various levels, and of the noise.

TABLE 1

Loudness of Amplified Declamatory Speech, 35 db above normal level at 20 ft., based on 50 per cent. r.m.s. intensity levels in critical frequency bands, ¼-second intervals. Noise corresponding to 75 db sound level meter reading (40 db weighting).

FLAT RESPONSE

Loudness Units in Band (LU)

Band	Speech	Noise	Net above noise
125-500	38,300	11,700	26,600
500-1000	31,900	14,700	17,200
1000-2000	31,200	18,250	12,950
2000-4000	36,800	16,900	19,900
4000-8000	16,400	12,700	3,700
All Bands	154,600	74,250	80,350
All Bands above 500 cycles (Speech)	116,300	74,250	42,050

Speech power, all bands: 108,000 micro watts. (0.74 net LU per microwatt).
Speech power above 500 cycles: 42,100 microwatts. (1.0 net LU per microwatt).

EMPHASIZED RESPONSE

(6 db per octave, 0 db at 2000 cycles)

Loudness Units in Band (LU)

Band	Speech	Noise	Net above noise
125-500	16,500	11,700	4,850
500-1000	19,100	14,700	4,400
1000-2000	27,400	18,250	9,150
2000-4000	45,100	16,900	28,200
4000-8000	26,600	12,700	13,900
All Bands	134,750	74,250	60,500

Speech power, all bands: 24,200 microwatts. (*2.5 net LU per microwatt.*)
Relative loudness efficiency: Over 125-8000 cycles flat response: 3.38 over 500-8000 cycles, flat response: 2.5.

Fig. 12 shows the plots on the Fletcher-Munson loudness computation chart[9] for declamatory speech on both types of transmission systems, taking the intensity levels to be the same at 2000 cycles and 35 db above the normal level shown in Fig. 6, and using the most probable (50 per cent.) values. The noise masking is that corresponding to a sound level meter reading of 75 db (with 40 db weighting) and typical spectral distribution. The loudness in loudness units (LU) is proportioned to the area under the curve. When noise is present, the loudness of the speech corresponds to the area above the masking curve for the noise. The loudness units (LU) are numbers which represent the magnitude of the sensation due to sound.[6] If the sound intensity is increased so as to double the number of loudness units, it will sound twice as loud as before. To aid the reader in correlating these numbers with sensory impressions, it may be noted that the tick of a watch close to the ear has a loudness of 1000-2000 LU. Conversational speech is commonly experienced at loudness ranging from perhaps 2000 to 25,000 LU. Sounds which are so intense as to be painful have loudnesses of the order of 200,000 LU.

For convenience, the component contributions to total loudness in each case have been computed for frequency bands within the range from 125 to 8000 cycles and are itemized in Table 1.

The much higher relative loudness efficiency of the emphasized system is evident from the figures of 2.5 and 3.38 compared with the flat system cutting off at 500 cycles and full range, respectively. This is because the loudness of the emphasized speech is only about a fourth less than that obtained from the full range flat system, and half again as much as that of the flat system cutting off at 500 cycles, while the power in the emphasized speech is only about one-fourth and one-half, respectively.

It is known from experience that the emphasized speech sounds "thin" and sometimes "harsh." When the level is only slightly above the masking due to noise, it is characteristic to hear the comment that the speech appears to "cut through" the noise rather than to "override" it (an expression commonly applied to flat reproduction substantially above the noise level). The reasons are evident from a study of Table 1 and Fig. 14.

In the system which is flat down to 125 cycles (and thus provides quite faithful reproduction) the loudness contribution below 1000 cycles is almost the same as that due to frequencies above 1000 cycles. The situation is nearly the same for the speech in the absence of the noise. This provides a clue to the loudness balance which the ear identifies as "natural." With 500-cycle cut-off, the total net loudness of the speech is reduced to nearly half that for the full range and only about one-third of the loudness is due to frequencies below 1000 cycles. Such a system will sound somewhat "high pitched."

It is evident that the emphasized system is even more "high pitched," for here only a little more than one-eighth of the net loudness is due to the frequency region below 1000 cycles. The result is quite unnatural and the shrill quality is often considered strident

(Continued on next page)

SPEECH

(Continued)

and annoying. On the other hand, it is clear that emphasis of this type makes it possible to deliver very effective, articulate speech in the presence of very high noise levels, and this is accomplished with relatively little acoustic and electrical power.

Amplifier Ratings

While we have shown that increasing the lower cut-off frequency of a flat system, or emphasizing the higher frequencies at a rate of 6 db per octave reduces the acoustic power in speech and increases the loudness efficiency relative to a wide range flat system, it is important to consider what this means in terms of amplifier ratings.

In the first place, it must be remembered that we have been dealing exclusively with the acoustic power in the speech and that the frequency characteristics referred to are air-to-air, or overall characteristics. If the electrical counterpart of the speech at the grids of the amplified output stage is a faithful copy of the acoustic pressures at the microphone, then the output stage must handle the full range of peak values no matter what modification of the frequency characteristic are carried out in following parts of the system (i.e., in output networks, loud-speakers, etc.). On the assumption that non-linear distortion must not be permitted, increased economy in the output stage of the amplifier means that the grid swing which it accommodates must be reduced. Conversely, the effective power output on speech can be increased in a given emplifier as the peak voltages are decreased.*

Referring to Fig.3, it will be seen that the maximum peaks for male speech are in the 250-500 cycle region. Now, if somewhere between the original sound and the grids of the output stage, the transmission characteristic is given an upward slope of 6 db per octave, and the gain is so adjusted that the transmission is the same at 2000 cycles, then the maximum peak voltage will be reduced about 4.5 db and it will occur in the 3000-4000 cycle region. As compared with the flat characteristic, the amplifier stage could be reduced in rating (and in cost) to one just capable of handling the reduced grid swing. Or, what is perhaps of greater practical importance, the insertion of the emphasizing characteristic ahead of the output grids would make it possible to raise the acoustic intensity level at 2000 cycles by 4.5 db without overloading the amplifier. It will be recalled that the 6 db per octave emphasis yields practically uniform intensity levels in critical frequency bands over the entire frequency range. Assuming maximum grid swing in both cases, there is, therefore, a 4.5 db advantage in a given amplifier when the emphasis is introduced ahead of, rather than following, the output stage. This is equivalent to a power ratio of 2.8.

Theoretically, if our peak data were truly representative of an average talker, it could be shown that a 3 db per octave slope ahead of the output stage would provide an advantage of about 7 db. However, some uncertainty as to the magnitude and location in the frequency range of the peaks of individual talkers, and the impossibility of attaining an absolutely linear characteristic through the microphone up to the output stage, makes it doubtful that such an advantage could be realized in practice.

It can be seen by inspection of Fig. 3 that the low-frequency cut-off of a flat system must be placed

* The use of electronic peak limiting devices is another means for accomplishing this.

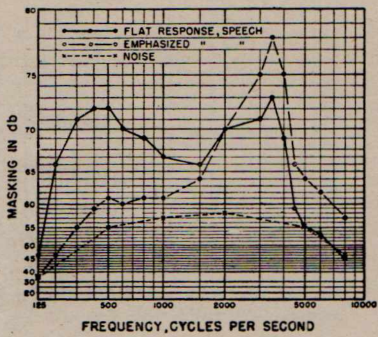

Fig. 12. Fletcher-Munson Loudness Computing Chart with Plots for Declamatory Speech (Flat and 6 db per Octave Emphasized Transmission) 35 db Above Normal Intensity Level at 2000 Cycles. Noise Corresponding to 75 db Sound Level Meter Reading (with 40 db Weighting).

in the vicinity of 700 cycles to accomplish the same reduction of the peak level. This is cited merely for comparison, for it may be desirable to place the cut-off elsewhere in the frequency range for other reasons.

Practical Considerations

How may the sloping emphasis and low-frequency cut-off characteristics be attained economically and conveniently? There are many circuit possibilities of which only a few will be mentioned.

Certain types of microphones, particularly the crystal variety, can be obtained with sloping characteristics of the right order. The sloping characteristic can also be attained by use of an appropriate corrective network between the output of any type of microphone and the input of the amplifier. The interstage coupling elements of the amplifier may be so designed as to achieve this result. Some or all of the emphasis may be inherent in the response characteristics of certain types of loud speakers.

TABLE 2

A Preferred Series of Audio Frequency Bands for Speech Reproducing Systems

Band No.	Cut-off Freq. Low	High	Articulation, Per Cent. Syllable	Word	Sentence
1	40	15,000	98	99.7	100
2	80	7,600	98	99.7	100
3	110	5,300	97.5	99.5	100
4	130	4,400	96	99	100
5	160	3,600	93	98.5	100
6	200	3,000	88	97.5	100
7	220	2,700	85	96.5	100
8	250	2,400	80	95	100

Note: Aural balance will probably be satisfactory if the low frequency cut-off in an adjacent band is substituted.

A high-pass filter may be used to cut off the lower frequencies. Such a filter in fact must be used with a flat input system if the loud speaker is designed for operation in the high frequency range only. Other means of achieving the low frequency cut-off include interstage coupling, transformers, and combinations of several of these methods.

It must be remembered that all of the components of the complete system contribute to the overall transmission characteristic and the achievement of any particular frequency characteristic must take into account all parts of the system.

It is not possible to lay down rigid rules for the design of speech communication systems because of the many factors which are involved, and the foregoing discussion is intended only as a general guide when efficiency, high noise levels and similar considerations are involved.

A Preferred Series of Speech Reproduction Bands

A series of audio-frequency bands for speech which provide just discernible differences to the ear is a useful concept which aids in appraising the fidelity of systems on a basis of band width. A similar series of bands for music was described in Jensen Monograph No. 3.

Table 2 presents eight bands whose upper cut-off frequencies differ by one liminal unit, and whose lower cut-off frequencies are determined from the aural balance relationship previously described for music.[10*] Such a relationship has been found to hold approximately for speech. Flat transmission between the cut-off frequencies affords reproduction which sounds balanced to the ear, and is neither "high-pitched" nor "boomy." The quality is highest for band 1 and decreases in approximately just perceptible steps. It is probable that a band must be changed by two numbers if a really marked change under ordinary listening conditions is sought. The approximate articulation afforded by each band is also stated.

SUMMARY

The entire frequency range of speech is probably only slightly less wide than that of music which extends from 40 to 15,000 cycles per second. Under average listening conditions, a range of 100 to 7000 cycles is sufficient for complete fidelity for speech. It has been found that the minimum discernible differences in band width, assuming transmission down to a very low frequency, correspond to upper cut-off frequencies of 15.0, 7.6, 5.3, 4.4, 3.6, 3.0, 2.7, and 2.4 kc. From this data, it is possible to predict the change in the upper frequency limit for any particular speech band which will result in a just perceivable difference to the listener, and this, in effect, establishes the tolerance of the ear to changes in frequency range for speech.

The distribution of peak pressures in speech in frequency bands, the power spectrum levels, and the intensity levels in critical frequency bands are given. The peak pressure data are important in determining the overload level of amplifiers, while the peak factor, or ratio of peak to r.m.s., pressure in long and short intervals, indicates the relationship of peak to average power. In short intervals, the average power is 10 db below the peak power, while for long intervals it is 20 db below the peak power. This relationship is important in determining the load-

(Continued on next page)

* See October, 1948, issue.

SPEECH

(Continued)

ing of temperature-limited components of speech systems. The power spectrum shows that most of the power in speech lies below 1000 cycles.

What the ear hears is determined by the r.m.s. intensity levels in ⅛-second intervals in critical frequency bands, and these are shown for the conversational speech of men and women and for declamatory speech. On the average, these intensity levels fall off with increasing frequency at a rate of 6 db per octave.

The effect on syllable articulation of restricting the high and low frequency ranges is shown, as well as the correlation between syllable articulation and discreet word sentence articulation.

It is pointed out that understandable speech can be transmitted in a band which may be as narrow as 1000 cycles if the band is properly located in the frequency range. A band 3000 cycles wide will produce quite good quality (representative of a telephone) when covering the range from about 200 to 3200 cycles. However, a band of the same width in the range of 1000 to 4000 cycles would probably have unacceptable quality and be considered "high pitched" and "shrill."

A system which gives good quality reproduction of music will likewise provide good reproduction of speech and a system affording high fidelity music reproduction will provide high fidelity reproduction of speech since a narrower frequency range is involved.

When the speech reproducing system must provide communication in the highest noise levels (i.e., approaching the threshold of pain) there are special problems. It is shown that, compared with relatively wide-range flat reproduction, better results can be obtained by either cutting off the low frequencies at 500 cycles or higher, or by providing an emphasized characteristic with an upward slope of 6 db per octave. Both of these expedients require lower total acoustic power, afford increased loudness efficiency, and make it possible to substantially increase the actual acoustic levels. The relative efficiences and quality of reproduction are analyzed with the aid of loudness computations under noise conditions. The effect on amplifier ratings is shown.

A preferred series of audio frequency reproduction bands is constructed which provide balanced quality as appraised by the ear and just perceptible differences between them. These bands are useful for classifying the quality of speech reproducing systems.

———

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10—From a hitherto unpublished study by Ralph P. Glover.

AMONG OUR READERS

News and Notes from Subscribers about their Activities

"I MUST say I appreciate your magazine very much. It definitely has that personal touch lacking in most other radio magazines."—John Wilson, Cranleigh Lodge, Bay Terrace, Wynnum, Queensland.

*

"I have been a subscriber for some years now. Being an electrician and radio mechanic as well as a radio and mechanical hobbyist in my spare time, I find a great deal between the covers that is both interesting and helpful. I would like to get in touch with the author of the Home Recording Hints in the December issue. Record blanks are a rather sore point with me. The darn things cost from four to eight bob each, and it requires only a small amount of over-modulation, a mistake on the part of the performer, or a confounded aeroplane to fly over, to completely ruin a disc. Also, each time I settle down to make a few tests, I find that the rubber damping blocks in the head require adjustment, as they harden with age, and the lower register suffers. I groan inwardly and say to myself that there goes another dollar down the drain. During my experimental stages I tried everything, but settled down to the prepared acetate jobs. I used X-ray plate which is not too bad, if a smooth hard surface is used underneath it. The scratch level is rather high. I built my own traversing gear, but I would not recommend anyone to have this on as a construction job unless he has tons of time and patience. At the moment I am experimenting with a wire recorder. There are a lot of bugs to iron out before I can say the job is a success. It looked so easy until I really got into it."—E. J. Rains, 7 McKillop St., Belgian Gardens, Townsville, Queensland. (The author of the article was H. M. Watson of 89 Botting St., Albert Park, S.A.—Ed.)

*

"I had fully expected to be greeted with a notice of increased subscription rates, and realise that, with paper and printing cost as they are, you may yet have to raise the ante. My interest in radio is mainly mental these days, with a wife and three kids to keep there is not much left out of the salary cheque and practically nothing for radio parts. That doesn't prevent me from taking an interest in the subject and keeping up-to-date. Things are moving rapidly in the field these days and there is fresh interest all the time. I really want one of your contributors to say a piece on the use of electronic components in industrial equipment. My experience of the use of radio components for industrial service has been most unfortunate. The new "Red" series of valves released in the U.S.A. represents a step which must follow with other parts. The hit-and-miss parts we buy for radio sets just won't do for industrial and scientific instruments."—John L. Clayton, 24 Wahcumba Street, Brisbane, Queensland.

*

"I have taken Radio World for some years now and reached the stage where circuits mean little. I consider the main thing is to have the job working correctly. I suggest the finer points of balancing be given more space. Any old job will sound good if working well. Anyway, what's the use of extreme highs and lows if they are not on the record or put out by the station?"—V. C. Elliott, Pomona, Queensland.

*

"I liked your issue with the story about the 1933 Standard. I built for twenty years or more, and and a.c. models. It was a wonderful set. I will build the new model from the January issue."—James Hillhouse, VK4Z0, at present in Melbourne on a holiday.

*

"I have beein interested in radio for twenty years or more, and have been a subscriber to A.R.W. for three years. I would like you

(Continued on next page)

READERS

(Continued)

to know that I am one who appreciates your paper very much. Being a ham, I am really only interested in gear of use to hams, but always read your paper from cover to cover. The ham ranks are rising rapidly, here in New Zealand. Every half-yearly examination sees us with a few more to add to the QRM. There is an average of about 40 sitting in Christchurch each time. It has been so tough since the war that already 50% get through first time, but they all keep at it until they do. One poor beggar I know has been up three times and missed out. He is giving it another go next March." —G. J. Wilson, ZL3KN, Papanui, New Zealand.

"I have been getting Radio World every month and find it good reading. I built the circuit from the November 1948 issue, the direct-copled version of the Williamson amplifier, as described by H. D. Swift. I found the quality very good." —A. E. Rickey, Ethel Street, Pascoe Vale, Vic.

*

"Perhaps the most appreciated articles are those for the home constructor, but then I must confess that making things is a weakness with me. Somehow I get a great deal more satisfaction from the results of a pick-up or signal generator, made during spare moments than from an expensive piece of equipment purchased with hard-earned dough. Radio servicing, by the way, is a part time business. Maitland is situated on Yorke Peninsular, the chief industry is agricultural and pastoral. This little chip of Australia, incidently, grows the best barley in the world, and a great proportion of that grown in Australia, so next time you lift that foaming tankard, think of your subscribers over here! Writing to you is almost like writing to an old friend. It is about twenty years that I have followed your fortunes with "Wireless Weekly," "Q.S.T.," "R & H," etc. I shall never forget the enjoyment derived from searching the ether on the short-waves while the midnight oil was burning, in the days of W2X-AF, VK2ME, PCJ, etc."—Vic. Dutschke, Maitland, South Australia.

TESTED IN OUR LABORATORY

NEW ANGLE ON DIRECT COUPLING

For more than twenty years past the world's greatest radio engineers have worked on designing various forms of circuits to obtain the advantages of direct coupling between grids and plates of audio amplifiers. Up till now most of these circuits have required high voltages and have been tricky and unreliable. Now, a completely different approach to the subject has been suggested by a student from the Melbourne Technical School. It offers endless possibilities.

During the Christmas holidays we had a large number of visitors at our Mornington headquarters. Some were spending their holidays in Mornington, other dropped in during the day whilst on a trip down the Peninsula.

Chatting with these visitors we learned many things about our readers, their likes and dislikes, and further strenghened the personal bond which is such a strong tie between Radio World and its readers.

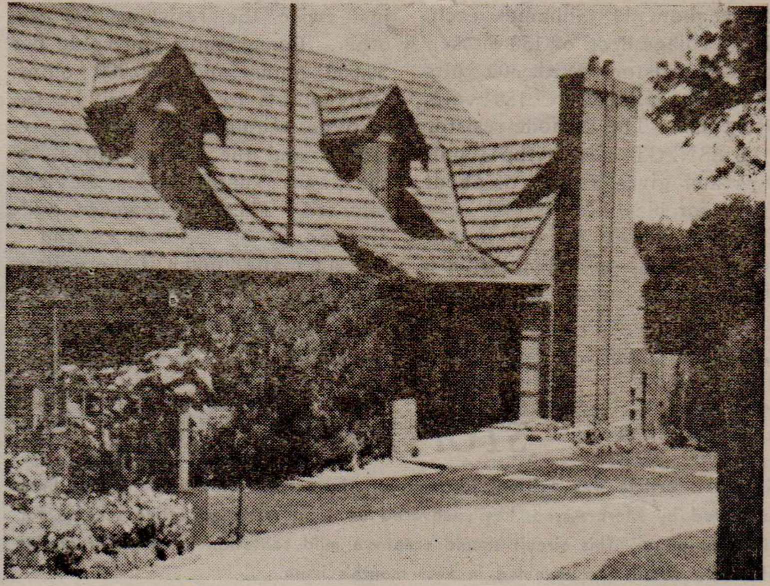
Among the visitors who were staying at Mornington was a young fellow named Mark Atyeo, who has been a subscriber for some years past. Mark has been doing a course at the Melbourne Technical School and has been thinking a lot about direct-coupled amplifiers, their advantages and dis-advantages. He even got around to working out a rather novel direct-coupler with two separate power supplies, thereby dodging excessively-high voltages, and getting a stabilised bias arrangement.

Mark had not gone beyond drawing up the circuit on paper, but we soon got it into practical form, a bit haywire, I suppose, but well enough to prove that the amplifier is quite a practical one and will really work. We ran into a fair bit of trouble with parasitics, which possibly indicates that the frequency response is much better than normal. Strangely enough we had more trouble with parasitics when using the 807's as triodes than when using them as beam power valves.

To try to explain the arrangement to anyone who has not previously studied direct-coupled amplifiers would be a big job, but those who know the voltage arrangements with the usual types of direct-couplers will soon pick-up the basic idea behind this design.

A separate power supply is used for the output valves and the flow of current in this power supply is kept within a closed circuit consisting of these valves and the output transformer. The negative

(Continued on page 44)



The de-centralized headquarters of Australasian Radio World at Beleura Hill, Mornington. The whole of the upper floor is devoted to office, studio and laboratory.

(Continued)

side of this power supply is then kept at a potential of about 200 volts above earth, by connecting the negative side to the tapping of a voltage divider across the other power supply.

It should be clearly understood that there is no current flow between the two separate power supplies; each keeps to its own circuit.

Bias for the output valves is obtained by keeping the cathode circuit about 50 volts positive in respect to grids. In other words, 50 volts more positive in respect to earth than the grids. Now the grids are tied to the plates of the 6SN7GT, and are about 150 volts positive in respect to earth. So all we need is to have the cathodes of the output valves about 200 volts above earth and we have proper bias.

Taking the circuit which we show on this page, the plate current of the 6SN7GT triode sections is about 1½ milliamps each, giving a volage drop of 150 in each plate feed resistor. With 300 volts applied, the plates are 150 volts above earth. The cathode resistor of the 6SN7GT carries the 3 milliamps and gives a drop of about 4½ volts for bias.

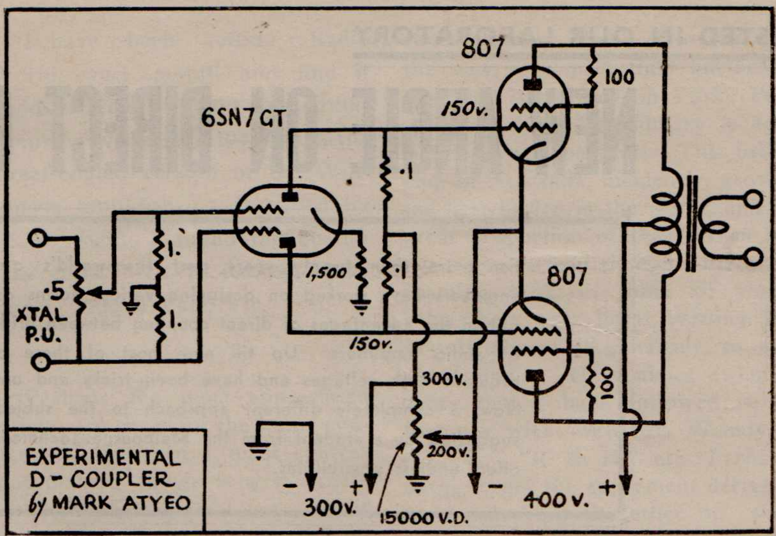
Cathode circuit of the output valves is tied up to a tapping on a voltage divider across the No. 1 power supply. There is no current flow in this divider, apart from the bleed current, so that the 200 volt tapping will be exactly two-thirds of the way up the divider. If so desired, a divider can be made up by using two resistances and it won't matter much what values are employed as long as one has just twice the resistance of the other. For example you could use 50,000 ohms and 100,000 ohms. Only points to watch will be the wattage requirements of the resistors and the actual voltage of the power supply under the load imposed. There is, however, quite an amount of self-balance and it doesn't matter much if the voltage of the No. 1 supply is 300 volts or 200, so long as the correct bias voltage appears between grid and cathodes of the output valves.

Actually this can best be checked by checking the plate current flow through the cathode circuit of the output valves.

Don't try to put a meter in the plate circuits.

Adjusting the tapping on the voltage divider is probably the simplest way of setting the plate current correctly. Total plate current for the two output valves with a 400 volt supply will be about 150 milliamps. Current drain on the No. 1 power supply will be only about 23 milliamps with a 15,000 ohm voltage divider, so the baby type of 285-volts-at-40-milliamps transformer should do the job nicely.

Incidentally, it will be noticed that we have used a rather unconventional input circuit, making an artificial centre-tapping by fitting two one-meg resistors across the output of a crystal pick-up. Neither side of the pick-up is actually earthed, but this does not cause any undue hum trouble or instability.



Experimental direct-coupled circuit using two separate power supplies, which can be cheaper than one power supply of high enough voltage to give full power with conventional direct-coupled arrangements.

STOP PRESS

Since this article was written, further work in our laboratory along the lines suggested by Mark Atyeo, has uncovered an even more attractive scheme for direct-coupling. This circuit should create a mild sensation in amplifier circles when the details are revealed in next month's issue.

GOOD GRAMO MOTOR

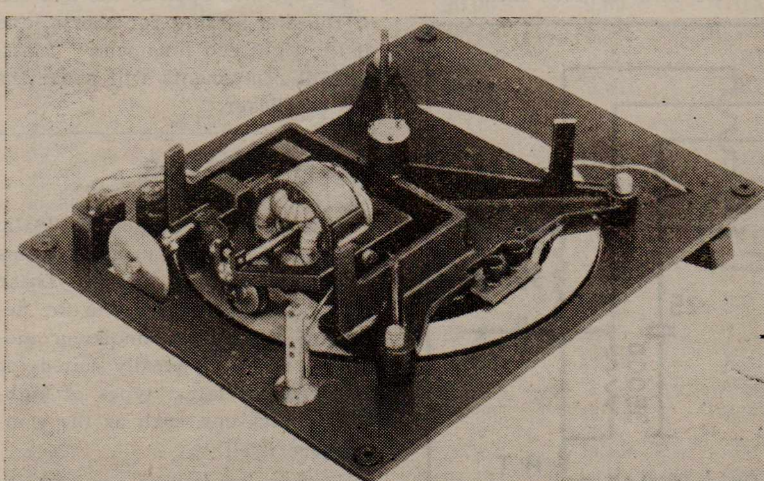
OFTEN enough, the unsuspected cause of poor amplifier performance is the gramophone motor. Unless the turntable maintains a steady speed through the deepest of lows and the highest of treble, you can't expect to reproduce them correctly.

The English "Connoisseur" gramophone motor, here shown complete with "Connoisseur" pick-up.

The drag of the needle varies according to the modulation of the record groove. Even if the motor turns the record at the correct 78 revolutions per minute there is no easy way of knowing whether it slows up momentarily when the needle runs into a heavy passage. For years past it has been recognised that the best gramophone motors should have a heavy turntable, machined from cast metal, and driven from the rim so that no gears, pinions or governors are required.

Turntables of this type have been used almost exclusively by broadcasting stations and recording studios, but they have been beyond the reach of the ordinary music enthusiasts.

The English factory which turns out that fine little moving-iron pick-up, the Connoisseur, has now released a rim-driven gramophone motor for home use. Samples have been landed by J. H. Magrath & Co., and already one of them has been installed at our Mornington headquarters.



Underside of the "Connoisseur" motor.

Speed variation is obtained by adjustment of a knurled control which alters the position of the rubber driving wheel on the underside of the rim. Accurate setting of the speed is easy with the special stroboscopic indicator which is supplied with the motor.

Most gramophone motors have lots of rattle and gallop when they are running, but it might be said that it is hard to tell whether the Connoisseur is switched on or off. When running it is dead silent and the turntable runs true, as might be expected from one machined out of a solid aluminium casting, weighing about five pounds.

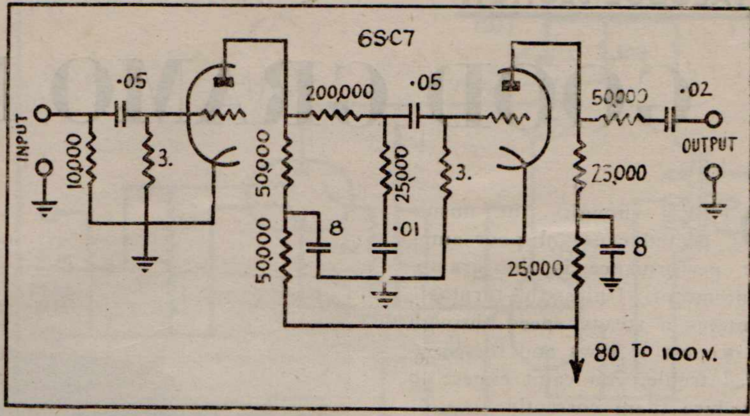
Some people have run into

(Continued on next page)

of the feedback control R11. Retard this until oscillations present themselves, and then back off slightly. The setting of this control will depend on the voice coil impedence and the quality of the output transformer.

A practice often suggested from time to time is varying the 6J7's element voltages to effect a change in the output tubes plate current. This method is not recommended, and its use may cause severe distortion due to incorrect operating conditions of the 6J7.

A word regarding the selection of the output transformer. While excellent results are obtained with the use of a standard type it is strongly recommended that a high quality type be purchased. Ferguson's OP23 is an example, and was used in the original set-up. The application of feedback around this transformer readily extends its response, as is evident from the plotted curves. In conclusion, it should be remembered that an amplifier is only as good as its associated equipment, so that results depend on the quality of both the speaker and pick-up. An input of 1-4 volts peak is necessary for full output of 8 odd watts.



PRE-AMP. WITH BASS COMPENSATION.
Here is a circuit for a pre-amplifier to suit low output pick-ups of the straight-line type, such as the English "Lexington" and "Connoisseur." It is based on a design issued by the G.E. Company in America for use with their super-reluctance pick-ups.

can keep our dial measurements reading in the same direction by employing a two-bank switch, which reverses the potentiometer connections constituting one-half of the bridge circuit with relation to the other half, made up by the standard component and that across the test terminals.

The standard condensers used in our circuit give us the following:

Switch position 1 = C x 10:
1 mmfd. to .1 mfd.
Switch position 2 = CX 1000:
100 mmfd. to 10 mfd.
Switch position 3 = CX 100,000:
.01 mfd. to 1000 mfd.

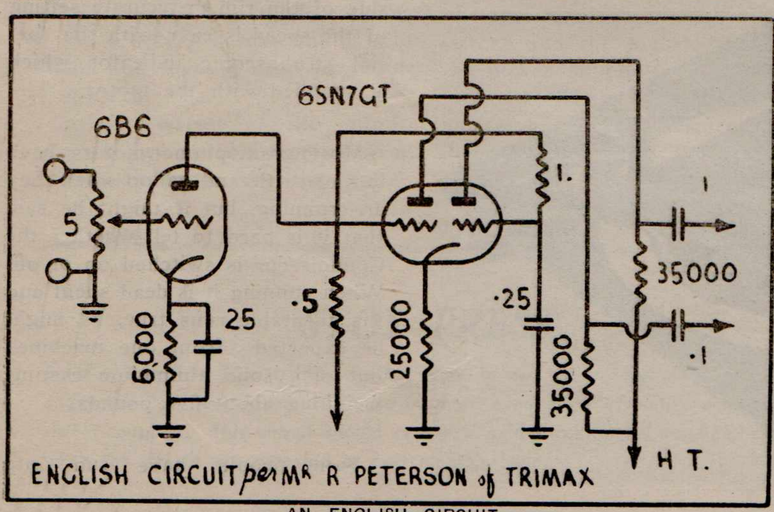
Application

The component it is desired to measure is placed across the test terminals and the range switch rotated to its appropriate position. The calibrated dial is then rotated until the 6E5 null-indicator closes to a sharp line, the sensitivity control being advanced as balance is approached.

Faulty Components

Condensers with a high power factor or low "Q" will cause the eye to be blurred on each side, the width of the blurr increasing with power factor.

The eye will open at the left end of the dial setting for shorts, and at the right end for opens. Intermittent components will cause the eye to flicker.



AN ENGLISH CIRCUIT
Here is an interesting circuit from England which offers an effective phase-splitter, which has wide frequency response and works well. For other phase-splitter circuits, see page 21 in this issue.

GRAMO MOTOR

(Continued)

trouble with hum and electro-static surface noise when using pick-ups with low output signal. These have been taken care of in the design of the new Connoisseur motor, so that it is ideally suited for use with the latest types of high-fidelity pick-ups, such as the Connoisseur itself.

Further particulars are obtainable from J. H. Magrath & Co. 208 Little Lonsdale Street, Melbourne.

Shortwave Review

CONDUCTED BY
L. J. KEAST

NOTES FROM MY DIARY

All times used in these pages are Australian Eastern Standard Time

THE AURORA AGAIN

Auroral disturbances on Monday, 7th February, again prevented telephonic between New Zealand, Sydney and San Francisco.

RUSSIA IS VERIFYING

A letter from Mr. J. B. Hargreaves confirms the suggestion I made in January issue that Russia was verifying reports again.

Mr. Hargreaves says: "Although I do not as a rule correspond to interstate magazines, I follow your Short-wave Notes. Your remarks in January issue about possibility of the Russians verifying was closer to the mark than you believed. I received one on the 25th January consisting of

(*Continued on next page*)

TRANSMITTERS OF THE B.B.C.

HERE IS PROBABLY THE FIRST COMPLETE LIST OF B.B.C. TRANSMITTERS PUBLISHED IN THIS COUNTRY

It should be of tremendous help to the new listener and also handy to anyone endeaouring to calibrate their receiver.

Band Metres	Mc/s	Call Sign
104.2	2.88	GRC
49.92	6.01	GRB
49.71	6.035	GWS
49.67	6.04	GSY
49.59	6.05	GSA
49.49	6.06	GSX
49.42	6.07	GRR
49.26	6.03	GWM
49.10	6.11	GSL
48.98	6.125	GWA
49.78	6.15	GRW
48.66	6.165	GWK
48.62	6.17	GSZ
48.54	6.18	GRO
48.43	6.195	GRN
42.40	7.075	GRS
42.13	7.12	GRM
41.96	7.15	GRT
41.75	7.185	GRK
41.66	7.20	GWZ
41.61	7.21	GWL
41.49	7.23	GSW
41.38	7.25	GWI
41.32	7.26	GSU
41.21	7.28	GWN
40.98	7.32	GRJ
31.88	9.41	GRI
31.61	9.49	GWF
31.55	9.51	GSB
31.50	9.525	GWJ
31.41	9.55	GWB
31.34	9.57	GWX
31.32	9.58	GSC
31.25	9.60	GRY
31.17	9.625	GWO
31.12	9.64	GVZ
31.06	9.66	GWP
31.01	9.675	GWT
30.96	9.69	GRX
30.43	9.70	GWY
30.53	9.825	GRH
30.26	9.915	GRU
25.68	11.68	GRG
25.64	11.70	GVW
25.58	11.73	GVV
25.53	11.75	GSD
25.49	11.77	GVU
25.43	11.79	GWV
25.42	11.80	GWH
25.38	11.82	GSN
25.34	11.84	GWQ
25.30	11.86	GSE
25.23	11.89	GWW
25.15	11.93	GVX
25.09	11.955	GVY
24.92	12.04	GRV
24.80	12.095	GRF
19.91	15.07	GWC
19.85	15.11	GWG
19.82	15.14	GSF
19.66	15.26	GSI
19.76	15.18	GSO
19.73	15.20	GWD
19.72	15.21	GWU
19.61	15.30	GWR
19.60	15.31	GSP
19.51	15.375	GRE
19.44	15.435	GWE
19.42	15.45	GRD
16.95	17.70	GVP
16.93	17.715	GRA
16.92	17.73	GVQ
16.86	17.79	GSG
16.84	17.81	GSV
16.64	18.025	GRQ
16.59	18.08	GVO
16.55	18.13	GRP
13.97	21.47	GSH
13.93	21.53	GSJ
13.92	21.55	GST
13.86	21.64	GRZ
13.84	21.675	GVR
13.82	21.71	GVS
13.79	21.75	GVT
11.65	25.75	GSQ
11.49	26.10	GSK
11.36	26.40	GSR
11.30	26.55	GSS

SHORTWAVES

(Continued)

two very nice postcards of the Red Square and a street scene of Gorki Street."

Mr. Hargreaves gives a very interesting account of how the letter was addressed to him, but as our printing press has not the necessary Russian characters I am afraid we cannot print that part of it.

Mr. Hargreaves has in twelve months listening logged 25 countries and has letters from 21.

(Many thanks for your letter Mr. Hargreaves. Will be pleased to hear from you again.—L.J.K.)

FERNANDO PO, SPANISH GUINEA

La Sociedad de Radiodifusion Intercontinental has started to construct a 200 k.w. S.W. xmtr., which will be the most powerful commercial broadcasting station in the world. Radio Atlantica will possess an initial record library numbering 55,000, and its programs will be in various languages. Fernando PO was chosen for its central position, being 4000 kilometres from Madrid, 5000 from London, 7000 from Buenos Aires, and 9000 from New York. The headquarters are at Madrid, where all programmes will be arranged. The station will be in the higher frequency bands, 13 and 17 metres. No further details available.

AND STILL THEY COME

The B.B.C. have during the last few months added 10 new transmitters to their already formidable list, and thus have 88 frequencies on which they can operate. It truly is a remarkable list, and I have printed elsewhere in these pages, this month, the complete list which should be of very great help particularly to the new listener.

The Canadian Mountie may get his man, but the B.B.C. certainly means to get their listener.

PHILIPPINE STATIONS ADOPT NEW CALL-SIGNS

I am indebted to "Radio Australia" for the following information.

New prefixes have been allotted, namely, DU, DY or DZ, with the result KZFM now uses the calls DUH-2 (6.17 m.c.); DUH-4 (9.615 m.c.); DUH-5 (11.84 m.c.).

KZMB becomes DZH-4 (6 m.c.); KZSH is now DZH-2 (9.57 m.c.); and KZRC takes the call DYH-2 (6.14 m.c.), KZBU will be DYH-3 (6.1 m.c.).

HELP WANTED

Mr. Alan Beattie writes:

"I wonder if you can help me to sort out the frequencies used in the 11.30 p.m. news broadcast from our "liberated" friends over

NEW STATIONS

GSZ, London,	6.17 m.c.,	48.62 met.			
GWZ	,,	7.20	,,	41.66	,,
GWX	,,	9.57	,,	31.34	,,
GWY	,,	9.70	,,	30.93	,,
GWV	,,	11.79	,,	25.43	,,
GWW	,,	11.89	,,	25.23	,,
GWD	,,	15.20	,,	19.73	,,
GWU	,,	15.21	,,	19.72	,,

XNCR and its relays. The last time I listened the announcement was: 'This is XNCR on 40 metres (that would be 7.5 m.c.) and 39.2 metres (equal to 6.96 m.c.). It doesn't, of course, and 221.6 metres and 49.6 met. Some of the frequencies I hear during the night announcing as XNCR are on 9.39 m.c.; somewhere around 34 metres, approximately 7.65 m.c. (this could be 39.2 metres); and a rather feeble signal on about 7.5 m.c."

"By the way is HCJB's 24 metre frequency still 12.455 m.c., or 12.445, as most magazines show it?"

(Taking the last first, the answer is 12.455 m.c. As regards XNCR, as far as I know they are mostly heard on 9.39 m.c. and 7.495 m.c., but the latter varies in frequency. In other words, there is sometimes a fair amount of drift. You mention 7.5 m.c. I believe XGOA were on this frequency and wandering about. Doubtless you have heard also XGOA on 7.53 m.c., which is where they appear to be "sitting pretty" at present.—L.J.K.)

VERIFICATIONS

Miss Dorothy Sanderson sends me an interesting note:

The following is an extract from a letter of verification received from Emissor Regional Dos Acores on the 27th December, 1948, and its schedule may be of interest:

"Emissor Regional de Radiodifusao is a local station of the Emissora Nacional de Radiodifusao, which has its headquarters in Lisbon. We are operating presently in two periods of emission. The first from 2000 to 2100 G.M.T. (6- a.m., Sydney) on the 27 metre band (11.090 kgs). The second from 2200 to 2400 G.M.T. (8-10 a.m., Sydney) on 61.92 metres (4845 kcs.).

"During the summer time we change the frequency of the first period to 40 metre band (7016 kcs.).

"(Signed) J. ASANYO."

SAYS WHO

Rex Gillett sends along a fine batch of interesting notes:

"GOA uses a 500 watt transmitter directed on NE/SW. It is a Telephone and Radio Corporation job, and was made in U.S.A. Present broadcasts on 7.23 m.c. are only of an experimental nature, and it was expected from January 1st 9.61 m.c. may be used. Schedule is from M/N—1 a.m. daily, and several languages are used. Address is: Emissora de Goa, Portuguese India. . . .

Tom Varese, of American Hour JJOY, U.S. Corps of Engineers, Athens, Greece, stated my report was the first from South Australia. The 'American Hour' is put on by the U.S. Corps of Engineers in Athens. It consists of 15 minutes of news and 45 minutes of transcribed music. I would like to emphasize the fact that we are not in any way connected with the Armed Forces Network. Our station consists of a Collins' 30 kw transmitter using a doublet antenna and a 72 ohm feeder. My correct frequency is 8000 k.c.; power output approximately 375 watts. Address is District Engineer, Grecian District, Athens, Greece. Have noticed HS8PD, Bangkok, has made a slight frequency adjustment and now seems nearer 6.olm.c. News is still broadcast at 9.15 p.m. (Previously they were on 5.994 m.c.—L.J.K.)

"Kuala Lumpur seems to have moved, too (why I don't know), and I can't decide whether they are on 6.015 or 6.02 m.c. Interference is suffered from JKD. Radio Sario, Menado, Celebes, is another to move, this one now being tuned on 9.72 m.c., and can be heard signing off at 10 p.m. (previously were on 9.55 m.c.—L.J.K.) Have heard English for first time from Norway (this seemed to be one of the few countries not using it). LLN, 17.825 m.c., can be heard from 11 to 11.30 p.m. in Norwegian. . . . However, two English announcements are usually made. LLN announces as 'Radio Norway,' and asks for reception reports. It is stated transmitters in the 19, 31, and 41 metre bands are also in use at the same time.

"What seems to be a new Moscow station is being heard on 7.215 m.c. It is heard at 5 a.m.,, and also earlier at 3.15. At this latter time 7.2 m.c. is in relay. HH2S, Port-au-Prince, 5.948 m.c., is being heard from opening at 9.30 p.m., with fair to good signals. Well-known musical numbers are played until 9.50, when French is spoken.

"KEN, on 6.845 m.c., was logged when contacting BAD-21 Shanghai to sign off at 11.15 p.m. BAD-21 sounded like the call of the Shanghai station, but I am not sure of the first letter."

BLACKOUTS

If you find your set appears to be letting you down, don't get the hammer and bash it, as maybe old Sol has had something to do with it.

Several keen listeners noticed that during January there were four times when radio communication from London was impossible.

Speedy Query Service

Conducted under the personal supervision of A. G. Hull

K.R. (Annandale) wants to measure the current drain of an a.c. operated electric radiator.

A.: As you have discovered, the ordinary meters do not attempt to cover the reading of a.c. current. The job is not so easy to do except with a current transformer. We have an article in hand, which will probably appear in next month's issue, explaining how to use a current transformer and an ordinary 0-1 milliameter to make up a current reading device for a.c., with several ranges. It is a most handy piece of equipment for any radio repair man.

C.A. (Coburg) is about to buy a soldering iron and wants to know what size he should get.

A.: Many people contend that it is best to get used to handling a heavy iron, as in the long run a heavy iron makes for faster soldering joints. You need apply the heavy iron for only a small fraction of a second to get enough heat into any ordinary joint. On the other hand, a lighter iron is easier work if you have a long job on hand. For serious work you really need three irons of different weight. But to answer your query more definitely, we would suggest a 75 watt iron with a 3/8-in. bit. This should be OK for all round work. Later, especially if you build any baby portables, you will find it worth while to add a 40-watt iron with a 3/16th-inch bit. Another way is to have interchangeable bits for the one iron.

B.G. (Canterbury) is a student, and finds the subscription rate a bit stiff on his pocket money, but doesn't want to miss an issue.

A.: *Radio World* has a heart and soul, and is not just Big Business. In any cases where hardships are claimed we will be pleased to meet you with special terms. In your particular case, since you are only 14 years old we will be pleased to let you travel at half-price, in other words put your name on our subscription list for half the usual rate.

M.C. (Ipswich) is interested in the Aegis 5-band coil assembly, but is a bit surprised at the price.

A.: The price seems big compared to what you may pay for a small dual-wave bracket, but the Aegis assembly includes two 3-gang condensers, tuning dials and a lot of sundry components, as well as the actual coils and switching. As you say, it may cost you almost £50 by the time you get the set completed and housed, but where will you buy a similar type of set for anything like this price? It is a really fine performer, and should be ideal for your purpose.

A.D. (Camperdown) wants to know what becomes of the sets we build up for photographing for the articles we publish.

A.: In the past it has been our custom to pull them down again and use the bits in another set or put them back into the store. We do find, however, that it is a rather wasteful routine, and so have in mind to consider selling some of the sets and equipment from time to time. Watch the Bargain Corner for items in future, or if you are particularly interested in anything you see published, drop us a line as soon as possible after the publication of the article. The set you mention has already been dismantled, but we could let you have the main components, as they are still lying around under the bench, somewhere.

BARGAIN CORNER

Advertisements for insertion in this column are accepted free of charge from readers who are direct subscribers or who have a regular order placed with a newsagent. Only one advertisement per issue is allowed to any subscriber. Maximum 16 words. When sending in your advertisement be sure to mention the name of the agent with whom you have your order placed, or your receipt number if you are a direct subscriber.

FOR SALE: AR14 receiver, complete with instruction book, also University multimeter, type MVA, with latest instrument. Both £8/10/- each. 3 Kingsley Crescent, Mont Albert, Vic. WX 4059.

FOR SALE: Imported RCA 12" speaker, 7,000 field coil. Fine job. £3. Apply No. 8497, C/o Radio World, Mornington, Vic.

FOR SALE: Induction voltage regulator, GE type MS1R of 2 kva. capacity, 110/240/480, single phase, 50 cycle. £60. Write to No. 8498, C/o Radio World, Mornington, Vic.

WILL SELL: "Radio World," Feb. '45 to date, "R. & H." Nov. '43 to date, all as new, also 32 earlier issues. Best offers, whatever they are, to K.C.M., 5 Aberfeldie Street, Essendon, Vic.

WANTED: 32 volt power pack, suitable for operating radio from 32 volt house lighting plant, new or second hand. Trade or private replies appreciated. E. H. Cowled, "Balgowlah," Bethungra, N.S.W.

FOR SALE: Electric gramophone motor, good running order, £3. Write to No. 8499, C/o Radio World, Mornington, Vic.

FOR SALE: Two high-voltage block condensers, 1 mfd. at 4,000 volts working and 4 mfd. at 2,000 volts working. £1 each. No. 8500, C/o Radio World, Mornington, Vic.

WANTED: Palec valve and circuit tester, type VCT. Will pay £15 for instrument if in good order. No. 8501, C/o Radio World, Mornington, Vic.

RED LINE

TRANSFORMERS OF DISTINCTION

HIGH TENSION PLATE SUPPLY TRANSFORMERS

The units listed in this Section are high-tension transformers for full-wave rectifier circuits. Valve heater windings are not incorporated, as they are designed for use in amateurs' transmitters, large public address and paging installations, and many other applications where it is necessary to break the B positive D.C. supply line for "stand-by" operation.

ITEM 20 — TYPE No. 27/600

Primary: 200-230-240v.	150 vA 50 cps.
H.T. **600/500/500/600.** 250 mA Choke Input	
Base: 5x5x4-5/8 in. H.	Wgt. 13 lb.
Mntg.: V15	"S" is 2-inch

D.C. VOLTS	CHOKE INPUT
866	(A) 515v. (B) 415v.
5Z3	(A) 415v. (B) 310v.

ITEM 21 — TYPE No. 27/880

Primary: 200-230-240v.	250v.A 50 cps.
H.T. 880/710/710/880v. 275 mA Choke Input	
Base: 5x6x4-5/8-inch. H	Wgt. 18 lb.
Mtng.: V15	"S" is 3-inch

D.C. VOLTS	CHOKE INPUT
866A	(A) **765v.** (B) **615v.**

ITEM 22 — TYPE No. 4/1250

Primary. 200-230-240v. 500 vA. 50 cps.	
H.T.: 1250/1250v. 400 mA Choke Input	
Base: 6½x6x6½-inch H (app.)	Wgt. 27 lb.
Mntg.:	Not Shown
D.C. Volts	1000v. 866 Rectifier

ITEM 23 — TYPE No. 4/1400

Primary: 200-230-240v. 575vA	50 cps.
H.T.: 1400/1400v. 400 mA	Choke Input
Base: 6½x6½x6L-inch H (app.)	Wgt. 30 lb.
Mntg.:	Not Shown
D.C. Volts	1250v. 866 Rectifier

CHOKES

The Chokes covered in this Section are tested under measured inductance values with rated D.C. flowing, as the meaningless "30 Henry" values are misleading to the uninitiated, and ignored by the engineer. They are smoothing inductances for use as the first choke in condenser input systems, or, of course, as the second choke for choke input circuits.

All inductances are sufficiently high for effective filtering, while D.C. resistance values are made low to maintain good regulation.

ITEM 24 — TYPE No. 3068

Maximum Direct Current	60 mA
D.C. Resistance	400 ohms
Voltage Drop	24 Volts
Maximum Inductance	25 Hys.
Minimum Inductance	15 Hys.
Base: 3½x2x2¼-inch H	Wgt. 1 lb. 8 ozs.
Mntg.: MH1	"S" is 1-inch
Insulation	500v.

ITEM 25 — TYPE 50825

Maximum Direct Current	80 mA
D.C. Resistance	500 ohms
Voltage Drop	40 Volts
Maximum Inductance	30 Hys.
Minimum Inductance	18 Hys.
Base: 3x3x2¾-inch H	Wgt. 2 lb. 10 ozs.
Mntg.: V2	"S" is 1½-in.
Insulation	750v.

ITEM 26 — TYPE No. 301214

Maximum Direct Current	125mA
D.C. Resistance	300 ohms
Voltage Drop	38 volts
Maximum Inductance	30 Hys.
Minimum Inductance	12 Hys.
Base: 3¼x3x2¾-in. H	Wgt. 3 lb. 2 ozs.
Mntg.: V2	"S" is 1½-in.
Insulation	750v.

ITEM 27 — TYPE No. 201515

Maximum Direct Current	175mA
D.C. Resistance	200 ohms
Voltage Drop	35 volts
Maximum Inductance	25 Hys.
Minimum Inductance	12 Hys.
Base: 3¼x3x2¾-in. H	Wgt. 4 lb. 4 ozs.
Mntg.: V14	"S" is 1½-in.
Insulation	1000v.

ITEM 28 — TYPE 102512

Maximum Direct Current	250 mA
D.C. Resistance	100 ohms
Voltage Drop	25 volts
Maximum Inductance @ 10v. A.C	15 Hys.
Maximum Inductance @ 80v. A.C.	20 Hys.
Full Load Inductance @ 10v. A.C.	7 Hys.
Full Load Inductance @ 80v. A.C.	10 Hys.
Base: 3¾x2-7/8-in.-x3½-in. H	Wgt. 5 lb. 4 ozs.
Mntg.: V14	"S" is 2-in.
Insulation	1000v.

ITEM 29 — TYPE No. 5735

Maximum Direct Current	300 mA
D.C. Resistance	60 ohms
Voltage Drop	18 volts
Maximum Inductance @ 10v. A.C.	10 Hys.
Maximum Inductance @ 80v. A.C.	14 Hys.
Full Load Inductance @ 10v. A.C.	5 Hys.
Full Load Inductance @ 80v. A.C.	7 Hys.
Base: 4x3-7/8-in.-x 4-in. H	Wgt. 7 lb. 12 ozs.
Mntg.: Not Shown	"S" is 2-in.
Insulation	1000v.

ITEM 30 — TYPE No. 35215

Maximum Direct Current	15 mA
D.C. Resistance	350 ohms
Maximum Inductance	30 Hys.
Minimum Inductance	15 Hys.
Base: 2x1-3/8-in. H	Wgt. 8 ozs.
Mntg.: MHO	"S" is 11/16-in.

ITEM 31 — TYPE No. 294

Maximum Direct Current	1 Amp.
Filament Choke	4 m/Hy
Base: 2x1-1/8-in. H	Wgt. 8 ozs.
Mntg.: MHO	"S" is 11/16-in.

University News

For the Serviceman Who Expects CONSISTENT ACTION

THE MODEL EVA ELECTRONIC VOLTMETER . . .

is the ideal form of vacuum-tube voltmeter for radio service and experimental work. It is reliable, simply operated, accurate, and is ruggedly constructed in a compact metal case, making it a perfect portable instrument. Operation is from 240 volt A.C. power mains. Consistent accuracy is assured by the use of a balanced bridge circuit with a high degree of negative feedback, making it almost independent of line voltage changes or ageing of tubes.

D.C. VOLTS. Its high input resistance of 11 megohms on all D.C. voltage ranges enables the accurate measurement of A.V.C., bias, screen and plate voltages, even in circuits containing high values of resistance. It can measure positive or negative voltage with respect to a receiver chassis without the necessity of reversing test leads or resetting to zero Accuracy on D.C. voltage ranges plus or minus 2 per cent. on full scale value.

A.C. VOLTS. The input resistance on all A.C. voltage ranges is 1 megohm. Accuracy at 50 cycles is plus or minus 2 per cent. of full scale value. Frequency response varies from the 50 cycle value by no more than plus or minus 3 per cent. or .25 decibel between 30 and 20,000 cycles. This means that the instrument can take frequency response curves of gramophone pick-ups or audio amplifiers. The instrument is completely electronic on alternating voltages; no copper oxide rectifier being used. Unlike simpler and less effective instruments it responds to the "mean" value of both half cycles of an alternating wave and consequently does not suffer from "turnover" effect. It is calibrated in effective values of a sine wave and, due to the much more constant relationship between mean and effective values than between peak and effective values, any error introduced by distorted signals will be much less than with the simple half-wave peak reading type.

OHMS. Six ohms ranges are provided covering values from 0.2 ohm to 1,000 megohms. The extensive coverage is not only ideal for all ordinary resistance tests, but also for condenser leakage and insulation testing. No external batteries are required and a single adjustment to zero on any ohms range is equally effective on all other ohms ranges.

D.C. MILLIAMPS. Six ranges of D.C. milliamps cover values up to one ampere. The milliamp ranges do not require connection of the instrument to power mains.

R.F. VOLTS. An input socket is provided on the case to allow an external plug-in diode rectifier probe to be connected for the measurement of R.F. voltages up to 100 volts at frequencies as high as 100 megacycles. This probe is available as an extra.

RANGES. D.C. Volts. 0/3, 10, 30, 100, 300, 1000. Resistance 11 megohms on all ranges. Accuracy plus or minus 2 per cent. of full scale value. A.C. and Output Volts. 0/3, 10, 30, 100, 300, 1000. Resistance 1 megohm on all ranges. Accuracy at 50 cycles plus or minus 2 per cent. of full scale value. Frequency effect within 3 per cent., or 0.25 db of 50 cycle value from 30 to 20,000 cycles. Ohms. .2-1000, 2-10,000, 20-100,000, 200-1 megohm, 2000-10 megohms, 200,000-1000 megohms. D.C. Milliamps, 0-3, 10, 30, 300, 1000. A complete set of shielded leads, special test probes, ordinary test probes and full operating instructions are supplied. R.F. Volts, 0-3, 10, 30, 100 at high input impedance with special probe available as an extra.

RADIO AND ELECTRONIC TEST EQUIPMENT

University

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