THE AUSTRALASIAN Radio World

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VOL. 9 ..... NO. 4 SEPTEMBER 15 1944

★ **How to design direct - coupled amplifiers with correct voltages**

★ **Circuit of crystal set which receives New Zealand stations.**

★ **Full data on radio frequency heating for hardening steels.**

★ **Design for a non - microphonic volume-expanding amplifier.**

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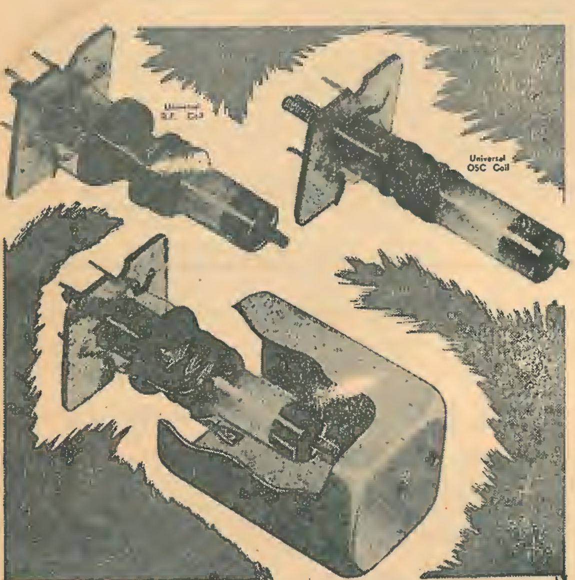

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THE AUSTRALASIAN RADIO WORLD

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★ PROPRIETOR —
A. G. HULL

★ Manager —
DUDLEY L. WALTER

★ Secretary —
Miss E. M. VINCENT

★ Short-wave Editor —
L. J. KEAST

For all Correspondence

★ City Office —
243 Elizabeth St., Sydney
Phone: MA 2325

★ Office Hours —
Weekdays: 10 a.m.-5 p.m.
Saturdays: 10 a.m.-12 noon

★ Editorial Office —
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EDITORIAL

Right in the midst of a lot of discussion about amplifiers there has been dropped a regular "block buster", full details of which we hope to reveal in next month's issue.

Following closely on the heels of statements about "amplifiers beyond reproach", and "perfect direct-coupled amplifiers", a completely new and revolutionary circuit has come to hand. This circuit is so unconventional as to appear absurd, but is actually a definite step in the right direction and full of the most amazing possibilities.

In a nutshell, it has been found that output impedance problems are solved if the output of a valve is taken by placing a load in the cathode circuit, instead of plate circuit. Tremendous loss of gain is incurred, but in these modern times this is of little importance, compared to the improved fidelity possible. As an example, an output valve required about twenty volts of signal input for ordinary use, but under the new operating conditions will require a signal input of 150 volts.

One application of the scheme is for inter-stage coupling, using a cheap audio transformer, which then gives performance comparable with that of a super-duper high-fidelity one.

Practical work with the new circuit has proved highly interesting and results are right up to expectations. Working with an audio transformer which cost 6/6 we have been able to get quality reproduction of a high standard, at the same time obtaining the advantage of low resistance in the grid circuit. This is highly desirable, but hard to achieve with resistance-capacity coupled amplifiers.

—A. G. HULL.

N.Z. RADIO MEN TO GO TO BRITAIN

A team of New Zealand radio technicians and scientists is to go to Britain at the request of the United Kingdom Government and will be attached to the United Kingdom Ministry of Production.

Acting P.M.'s Statement

The Acting Prime Minister (Mr. Sullivan) explained that for the past two years the radio manufacturing industry in New Zealand had been concentrated on the production of wireless signals equipment for our own and Allied fighting services. So favourable had been the reputation of this New Zealand-designed and produced equipment that the United Kingdom Government had requested the New Zealand Government to provide a team of technicians and scientists.

Fully Representative

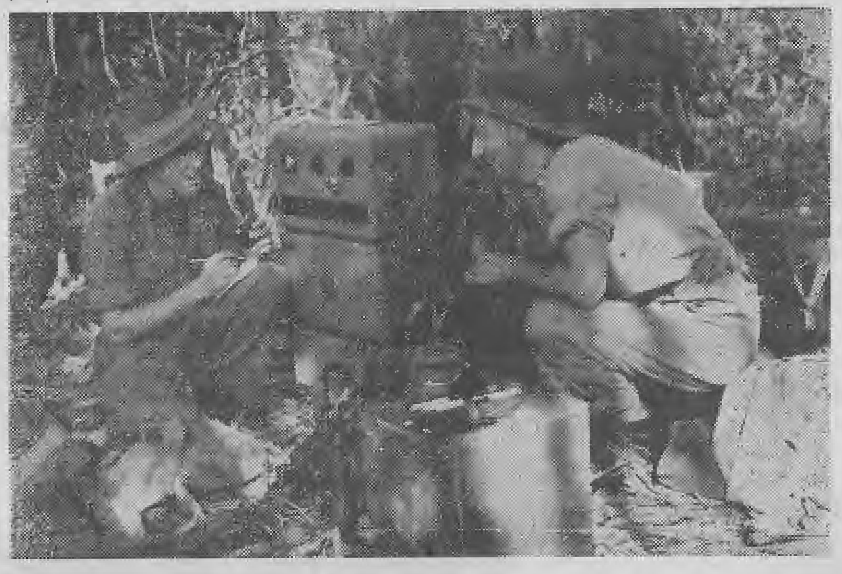
"The selection of the team, which is fully representative of the interests engaged in the production of this wireless equipment, has been no simple task," continued Mr. Sullivan. "The needs of the United Kingdom had to be given full weight while our own heavy production schedules had to be maintained. Certain key men whom we would have willingly sent because of their skill and knowledge we have been compelled to retain in New Zealand to supervise and work on the home front.

Serious Work Ahead.

"The men are going for serious and important work. The fact that they are going is a very high tribute to New Zealand, and to the skill of her radio technicians and scientists. It is very gratifying to me, as it must be to those engaged in the production, that such outstanding success should have rewarded their efforts."

The Minister said that after a careful study of all the factors involved it had been decided to send the following personnel:—Messrs. R. J. Orbell (Radio (1936), Ltd.), J. M. Gifford (Radio Corporation), A. Gregg (Philips Lamps), J. Walker (Radio Development Laboratory of D.S. and I.R.), P. C. Hill (P. & T. Dept.), L. Fergusson (International Traders), N. Curtis (Dominion Radio), R. Schrodroski (P. & T. Dept.), R. Long (Radio (1936), Ltd.), Captain K. Collett (2nd N.Z.E.F.), and Lieut. Josephs (Signals Experimental Establishment, N.Z. Army).

Mr. R. Slade, Controller of Radio Production, will accompany the team, and while he is in the United Kingdom he will be in a consultative capacity. He will also discuss supply and production questions with the authorities in Great Britain, and the United States of America.



RADIO WITH THE A.I.F.
An observation post manned by Sgt. Frank Parmater, of Coburg, Victoria, and Corporal Ivan Pritchard, of Kensington, N.S.W. in the jungle between Nassau Bay and Wubo. Communications are vital in jungle fighting.
—Photo from Department of Information.

ELECTRICITY IN ANCIENT EGYPT

Was Alexander Volta the first man to construct a galvanic battery, or did the ancient Egyptians employ similar cells 2000 years before his time? Was electricity first discovered and applied to practical uses in comparatively recent times, or were its principles understood and first put to use several thousand years ago?

Cells Discovered

These questions are raised by recent discoveries indicating that the ancients not only knew of electricity but understood how to make and use it. This assumption, based on the discovery of what appear to have been electrolytic cells in ruins near Bagdad, Tel' Omar and Ktesiphon, is reported by David O. Woodbury in the January, 1944, issue of "The Technology Review" edited at the Massachusetts Institute of Technology.

The first of these cells, brought to light in 1936 by Wilhelm Konig of the Iraq Museum, was a pottery jar about six inches high. Inside it was a copper cylinder closed at the bottom with a soldered plate. Within this were the remains of an iron rod, eaten down to a point at its lower end. Traces of asphalt around the neck indicated that the two metal parts had been supported concentrically but insulated from each other. Later four similar jars were discovered, three of which proved to have the same kind of copper cylinder although no iron electrodes were present. Iron and bronze strips were found near by, however, sugesting wires used to complete an electric circuit.

At the time of the discovery the significance of the jars was not understood. Data and drawings of the device were taken to Germany in 1938 and thereafter several articles were published regarding it. Consensus was that the relics were an ancient form of the galvanic battery devised by Volta, but were assigned a period some 2000 years before his invention.

Further Confirmation

Substantiating this conclusion, ancient Parthian bowls and vases of copper, plated with gold and silver, are to be found among the same ruins. Hitherto no one had discovered how the plating could have been done. Circumstantial evidence indicates that it was accomplished by means of these electrolytic cells.

Other cells were found with objects of the Sassanian period, which would date them back at least to the time of Christ. Even greater antiquity may

(Continued on page 26)

THE DESIGN OF DIRECT-COUPLED AMPLIFIERS

THE chief reason of this article is to try and present in non-technical language, an explanation of some of the extraordinary claims made for direct-coupled amplifiers.

From many quarters have been heard "D.C. amplifiers lack bass response." Might I correct anyone suffering under such an illusion and substitute the word "apparent" lack of bass response.

Rather than state that a direct-coupled amplifier lacks bass response it would be much better to say that lack

By

C. MUTTON

1 Plow Street, Thornbury, Vic.

of bass is due to the fact that although the coupling from plate to grid is direct we still have coupling from cathode to cathode which involves a capacity or an inductance.

Old-time Circuits

In many older types of radio receivers it was customary when using direct coupling between the second detector and output stage, to use the field of the speaker to raise the cathode or filament the required voltage above earth to provide the correct voltage which would buck the existing positive bias on the grid and hence create the correct negative bias. While this scheme is very economical and serves the dual purpose of energising the field and acting as a heavy duty bias resistance, it is not, however, to be commended when we require the ultimate performance from an amplifier using direct coupling. With direct coupled amplifiers it is desirable to keep capacities and inductive effects to a minimum. In connection with the high-frequency cut off point, this is only limited by shunt stray capacity and "Miller effect" in tubes. However by using push pull operation throughout input capacities are halved and the high frequencies are usually reproduced in direct-coupled systems with a brilliance which is hard to surpass.

Amazing Frequency Response

As regards overall frequency response the writer had occasion to be present at a test run on a direct-coupled amplifier of simple single-ended construction, using a 6J7 driving a 2A3, which had a flat response from 15 cycles per second to 20,000 with scarcely any variation at any point in the audio spectrum.

In fact had it been possible to extend the B.F.O. any further, it is quite in the bounds of possibility that the high frequency end could have been extended well into radio frequencies.

The chief objections in the past against direct-coupled systems can be summarised thus:—

(1) High voltages involved.
(2) Instability.
(3) Variation in similar type tubes affect the voltage distribution.
(4) Tricky circuit.
(5) Critical hum balancing adjustments required.

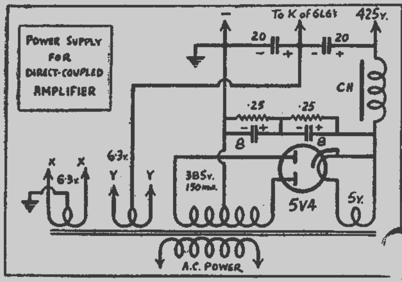
Modern Components better

In the first place, components to day (if obtainable) are far in advance of those used in the early "Loftin-White" days.

Where danger to electrolytics is involved they can be used in series, in which case there will be 100% safety margin.

Instability troubles are overcome by using push pull self-balancing circuits.

Variations in similar type tubes are taken care of by push-pull operation in that any change affecting the potentials in the amplifier caused by tube variation will automatically produce an equivalent unbalance in its adjacent channel.



Suggested Power Supply arrangement.

Not a Tricky Circuit

As to direct coupling being a "tricky" circuit this is entirely wrong, as all that is required is a working knowledge of Ohm's law and an understanding of how self bias is obtained, two factors of which I'm sure most of our readers have adequate knowledge.

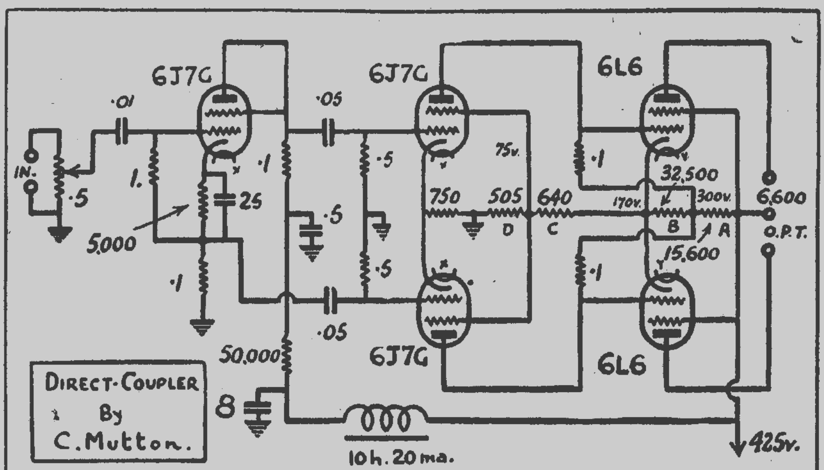
The amplifier about to be described was built for a small public address system four years ago, and has been in constant use for four hours nightly and three hours on Sunday, without ceasing. The writer has replaced o[...] noisy volume control over the fu[...] period of use.

This in itself speaks volumes f[...] such an amplifier, which incidenta[...] is capable of extremely good reproduction.

From American Designer

The man responsible for its design is undoubtedly one of the finest design engineers of audio equipment which the writer has come in contact with. To Mr. A. C. Shaney, the chief engineer of the amplifier Co. of America, all credit is due. In the writer's opinion he has removed all remaining obstacles which have prevented direct-coupled amplifiers being universally accepted.

In his own words he says "The results of our laboratory measurements made on the All Push Pull Direct-Coupled Amplifier have amazed me and my associated engineers. You will note that I have intentionally failed to supply a frequency response curve of the essential amplifier, inasmuch as I



Circuit of Mutton's Direct-Coupled Amplifier with twin drivers.

want to avoid being accused of drawing a straight line on a graph.

"Nevertheless its response is flat from one cycle per minute (not per second) to 20,000 cycles per second.

"Unfortunately, there are no signal generators to produce such a low frequency, and there are no output meters available which will measure this low frequency response. A new method had to be adopted to measure the unusual low frequency response. This was done by connecting a dry cell into the input grid circuit and slowly varying the volume control from 0 to full setting. The output voltage is measured by a C.R.O. in the same manner that d.c. would be measured.

Unlimited High Response

"The high frequency response seems to be unlimited, as there are unusually low distributed capacities in the tubes employed. Although no measurements were made above 20,000 cycles, it is certain that its frequency response can be extended to radio frequencies, which makes this unit also admirable for television application at the video frequencies."

So much for the comments of the designer, which seem to also work out in practice.

Having built possibly somewhere in the vicinity of two hundred different amplifiers in the past ten years, I have never heard any amplifier which will touch this particular one in the matter of hum level. When the circuit is balanced correctly I defy anyone to tell by ear or touching the cone of the speaker whether the amplifier is operating or not.

Applications

(1) Hi-Fi P.A. Amplifier.
(2) Hi-Fi Phono Amplifier.
(3) Laboratory Standard Amplifier for comparing speakers, pick-ups, microphones, etc.
(4) Twin-Channel Amplifier.
(5) Constant 2-Way Communicator.
(6) Switchless Recording and playback.
(7) Reproduction of artificial echo and reverberation.
(8) Amplification of musical instruments.
(9) Replacement of obsolete amplifiers.

The Circuit

By examining the circuit diagram it will be found that the amplifier is virtually two single-stage amplifiers, back to back, with certain modifications. It will be recalled that some years back in the "Radio World" amplifier contest, the winner used a similar idea, except that he used two 57 tubes connected as triodes, direct coupled to two 2A3 power output triodes.

While the amplifier must have been exceptionally good to have won such a contest it could, possibly, have been improved. While not wishing in any way to belittle Mr. Hirst's design, I would like to explain a few points. In his explanation of the principles of design, he stated that he originally tried pentode drivers instead of triodes, but that triodes were more satisfactory. From this statement I draw my own conclusions as to why Mr. Hirst abandoned pentode drivers. Making a guess I would say that he struck trouble with what is commonly known as trigger action, which is a common fault with direct-coupled amplifiers.

WALKIE-TALKIES FOR FRONT LINE

An officer hands out Walkie-Talkie sets and signal gear to Lieut. W. Foster, Melbourne, and Corporal J. Worlock, of Bondi Junction, both members of a forward company between the villages of Reua and Nanda, in the Blucher Point area, New Guinea. These sets are used for inter-communication of companies in the front lines.

—Photo from Department of Information.

A Possible Error

Due to the fact that no bleed resistors were used from the high potential point in the B supply back to the cathodes of the output tubes or in the the case of 2A3's the centre tap of the filaments. This ensures that the plate potential of the input tube is independent of the plate current of the output tube. The writer personally struck this peculiar trouble in previous experiments on direct-coupled amplifiers, and it was found that at odd times the amplifier would go completely haywire and block up, but normal operation was restored by either touching either input grid or shorting one of the innut plates to earth.

An explanation of this trigger action may be helpful to those interested:—

(1) When an instantaneous negative potential appears on the grid of the input tube, less plate current flows, and a smaller voltage drop takes place in the plate resistor, thus causing a rise in plate potential. In turn the output grid potential rises which decreases the effective bias on the output tube hence increasing its plate current so causing the cathode potential to increase. This in turn raises the potential on the output grid through the common plate-grid resistor.

This cycle of events continues until the plate current becomes excessive and the tube is thrown off its E.G.—I.P. curve, and maintains itself in a blocked position. This condition being known as trigger action. By employing two resistors A and B in the circuit diagram the plate potential of the input tube is independent of the output tube plate current, and no trouble as outlined will be experienced.

Twin Drivers

The present amplifier uses two 6J7G tubes as drivers, direct coupled to two 6L6G's in the output. It is capable of producing 15 watts with less than 5%, and ten watts with less than 2% harmonic distortion. The 6J7's are operated at 150 volts on the plates and 75 volts on the screens, the output tubes are worked under 250 volt plate and screen conditions, class A, with —20 volts bias.

As the tubes are direct coupled, 150

(Continued on next page)

DIRECT-COUPLERS

(Continued)

volts positive potential will appear on the 6L6G output tube grids which means that to maintain correct bias the output cathodes will have to be kept at 170 volts above earth. In this case it is desirable to have a separate winding on the power transformer to supply the heaters of the output tubes, the centre tap of which goes back to the cathodes so that the filaments are at a safe operating voltage above earth. In this way the maximum heater to cathode voltage is not exceeded.

Design Problems

It is the writer's personal opinion that in addition to describing a specific amplifier, that if the design problems are explained also, then it becomes a simple matter for the average reader to apply the fundamental design, around his own particular amplifier.

Rather than spend many hours constructing amplifiers from existing published circuits, the reader will find intense self satisfaction and pride in his own work, if he will attempt to do something original. In the writer's case, experiments were firstly carried out, with the original design originated by the aforementioned A. C. Shaney. The same set up has since been used involving 6V6G's, 2A3's, EL3's, 45's and practically every well-known output tube. In each case it was necessary to work out a new set of design figures from the original amplifier which uses 6L6's in the output. It will be appreciated that any alteration in a direct-coupled amplifier, will completely upset the voltage distribution throughout the amplifier.

Now to start with our design: Just as a typical case let us use two 6J7 tubes direct-coupled to two 6L6G's in the output.

Voltage Requirements

We decide we want 250 volts on the plates and screens of the 6L6G's, 150 volts on the driver plates and 75 volts on the screens, allow for approximately 20 volts effective bias on the output tubes and a few volts across the filter choke which has a nominal inductance of 30 henries and is rated to carry 150 ma. Most large filter chokes of this type have a fairly low resistance hence the voltage drop will be fairly small, usually about five volts. Therefore, with those figures in mind, we have 250v + 150v + 20v + 5v which totals 425 volts.

From this it can be seen that somewhere about 430v at the rectifier filaments is needed. In the writer's case it was found that using a 150 ma transformer rated at 385 volts each half of the H.T. secondary in conjunction with a 5V4 indirectly-heated rectifier, the voltage was well over 500 volts. However, by inserting a heavy duty resistance, in between the rectifier filament and the filter choke this adjusted matters nicely.

Now for the voltage distribution and resistor calculation; looking at the circuit diagram the reader will see a voltage divider system consisting of A, B, C and D. Commencing at the filtered D.C. side of the choke we have 425 volts. Across each input tube we want 150 volts so that we require 300 volts for the two input tubes, so that 300 volts must exist at the junction of resistors A and B.

Now applying Ohm's law we wish to drop from 425v to 300 which equals a drop of 125 volts. The 6J7 will draw 1.5 ma plate current and .5 ma screen current with applied potentials of 150 and 75 volts respectively. In addition to the plate and screen currents passing through resistor A we must also make the bleed current through it equal to the sum of the total currents of both tubes. Therefore the bleed current will be 4 ma. That is 4 ma bleed current added to 3 ma for the two plate currents of the 6J7's and 1 ma for the two screen currents which is equal to a total of 8 ma. Hence we get this result

$$\frac{125}{.008} = 15{,}600 \text{ ohms}$$

Resistor A = 15,000 ohms 1 watt

Resistor B.—Across this resistor we wish to drop from 300v to 170v at the 6L6 cathodes which amounts to 130v drop. 4 ma have already left the circuit via the input tubes still leaving a bleed of 4 ma

$$\frac{130\text{v}}{.004} = 32{,}500 \text{ ohms 1 watt}$$

B = 32,500 ohms

Resistor C.—Here we drop from 170 to 75 volts which is 95 volts drop across resistor C.

Resistor C carries the total plate and screen current of both output tubes which

$$= 2\,(65 + 6.5) + 1 + 4 \text{ ma}$$

the 1 ma represents the screen current of both input tubes and still our 4 ma bleed current.

$$= \frac{95}{.148} = 640 \text{ ohms 20 watt rating}$$

Resistor D has to drop 75 volts across it at a current of 148 ma minus the screen current of the input tubes as this was bled away through the previous resistor

$$D = \frac{75}{147}$$

$$= 505 \text{ ohms 20 watt rating}$$

The only other resistance is the common cathode resistor on the input tubes which does not need by-passing.

Here we want 3 volts at the cathodes, this being simply calculated like so:—

$$\frac{3}{.004} = 750 \text{ ohms}$$

Now we want to feed a push pull signal into the two input grids. There are two alternative methods. Either use a line to push pull grids matching transformer or don't earth one of your pick-up leads and just feed the pick leads direct to the two grids. However both methods have their disadvantages so it was deemed necessary to fit a phase inverter preceding the 6J7's. This scheme worked out nicely in practice, and the old scheme of using the 6J7 as a degenerative phase changer with equal plate and cathode loads, triode connected was quite o.k. This means that one of the pick-up leads can be earthed, providing of course the isolating condenser is used as shown.

Caution.—Don't attempt to take the H.T. supply for the phase inverter from anywhere along the voltage divider system. Failure to observe this point will result in a complete unbalance of all the other voltages.

Now another point to be discussed.

FRONT-LINE RADIOMAN EATS AND WORKS

Gunner L. S. Crossland, of Hurstville, enjoys his lunch whilst working a wireless relay station for artillery fire at Nuzen River, New Guinea.

—Photo from Department of Information.

Feedback Avoided

Most readers when looking at the circuit will say "6L6's with no feed back!"

I have purposely avoided putting any inverse feedback in the circuit diagram for one main reason and that is: I find that there are so many amplifier enthusiasts with such widely varied tastes that it was deemed necessary to leave any frequency discriminating networks to the individual choice. However there are several types of feedback circuits which CANNOT be used. One is the scheme of feeding back audio voltage from one of the output plates into the screen grid circuit. The other is the type whereby a 2 to 3 megohm resistor is connected from the plate of the output valve to the plate of the driver. Such schemes will run you into trouble with your voltage distribution.

Fitting Feedback

If feedback should be desired either take the feedback voltage from the output plate through a series condenser in conjunction with a resistance and separate the input cathode by using separate 1500 ohm bias resistors and feed the feedback voltage in at the cathode. If desired the same scheme could be used from the secondary side of the transformer. In the latter case, however, a specially constructed output transformer is necessary, consisting of a 6.600 ohm plate to plate load to 500 ohm line. The 500 line secondary being the balanced type, having a centre tap which is earthed. Feedback is then taken off each outer leg of the 500 winding through a condenser and resistance into each cathode of the input tubes. In this manner we develop a push pull feedback circuit coming from each output circuit independently back into the driver circuit cathodes. If, however, the reader is not keen on feedback, the harmonic distortion and ear-shattering highs can be toned down by using a filter across the output plates in the following manner:—

From each plate to screen connect a .006 condenser in series with a 5,000 ohm one-watt resistor, on one side of the circuit come from the 6L6G plate through the .006 through the 5,000 resistor to the screen, now from the opposite 6L6G plate reverse the procedure, and come through the 5,000 resistor through the .006 condenser to the screen.

Triodes Can Be Used

This should just about cover all the points regarding the design features of this very fine amplifier.

This design will probably not suit the many triode enthusiasts we have in our midst, but there is not the slightest reason why those who want to use triodes shouldn't do so. Not forgetting, however, that you'll have to work out different resistance values for the divider network, as 45's, 2A3's or 6A3's draw much less plate current than the 6L6's.

In conclusion, should the question come up "What has a direct-coupled amplifier got that any other type hasn't?" Well the answer is at a risk of a storm of protest and very rude remarks from certain sections of the amplifier fraternity.

Pros and Cons

Against transformer coupling (some transformers!); direct-coupled amplifiers do not suffer from core saturation, magnetic lag and peaked or resonant circuits.

Against resistance coupling:

It is impossible to design a resistance capacity coupled amplifier whereby the coupling circuit comprising the driver plate load, coupling condenser and following grid resistor can be made to transfer an extremely wide band of audio frequencies. Make the coupling condenser large and the base response rises a few decibels but the highs suffer. Make it small and the base cuts off sharply, besides short circuiting of weak signals, and grid blocking of strong signals.

Direct coupling is free from all these defects despite the fact that mathematically it can be proved that direct-coupled amplifiers are relatively inefficient.

As a final point they are simple, providing their fundamental design is understood. They are more economical than any other type of amplifier.

Alright, amplifier fans, start your arguments. I'll just listen and hope to see you all at the A.R.D.X. Club Contest.

THE "FERRIER" SUPER CRYSTAL RECEIVER

VERY few radio engineers or enthusiasts ever give a thought to what could be done in the way of designing and building a good sensitive crystal set. It is a well known fact that a crystal set does not amplify the signal but merely rectifies it making it audible to the human ear, via headphones.

If a crystal set fails to work properly it is nearly always the crystal which gets the blame, because the way a crystal rectifies is still not properly understood, but nine times out of ten the crystal is doing its job better than either the coil or the headphones.

With this thought in mind I set about building the receiver I am now going to describe.

The coil came out of an old BC set, it is a good one, being wound on a bakelite former 3in. in diameter with 24 gauge plain enamel wire spaced the diameter of the wire. There are 52 turns in all with taps 17 turns from either end.

The condenser should be a good one with good insulation, it should also have a pig-tail connection to earth the rotor plates.

A vernier dial is a help although

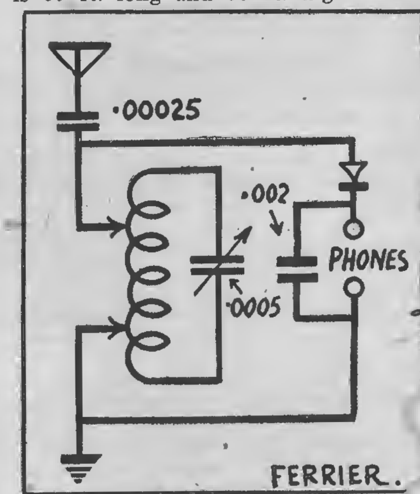
By
JAMES McN. FERRIER
"Winniburn," Coleraine, Vic.

not essential.

I have tried several crystals and found them all good, my "pet" crystal happens to be the Neutron.

The aerial coupling condenser varies in accordance with the length of aerial and the aerial's capacity to ground.

With the aerial I have here, which is 60 ft. long and 60 ft. high I have



found a .00025 mfd condenser to be about right. A longer aerial will require a smaller condenser and a short aerial a larger one.

A good earth is as important as a good aerial and nothing less than a piece of pipe four feet in moist ground should be used.

With this set, the aerial described and a good pair of 'phones I have logged the following stations:

(Coleraine is situated about 200 miles west of Melbourne.)

All Melbourne "A" and "B" class stations. Many of the "A" and "B" class stations in N.S.W., Queensland and S.A. 6WA West Australia. 1YA and 4YA New Zealand. These latter were logged about 4.30 a.m., when there were no Australian stations on the air.

I would like to know if 1600 miles on the broadcast band with a crystal set is a record or not.

ECLIPSE STAFF HOLDS AMPLIFIER CONTEST

THE excitement and keenness which was evident between competitors and audience at the Eclipse Radio Amplifier Contest, held at the D.A.P. Theatrette, Melbourne, has formed in the writer's mind the opinion that hi-

By

N. HOWARD-JONES

Transmission Dept., Eclipse Radio Pty. Ltd., Melbourne.

fidelity reproduction has almost reached the stage of the much sought after [illegible]d dimensional sound.

The judges, Mr. E. Dawson and Mr. H. Barrow, were presented with the exceptionally difficult task of determining the winner, and after much deliberation and repeating of test procedure, awarded Mr. John Harvey, of Eclipse Radio's Transmission staff, first prize.

Interest shown by the large audience was in itself gratifying to the competitors. Points were awarded on public opinion, hum level and freedom from distortion.

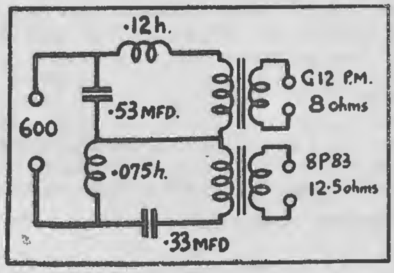
Contestants were allowed time to play a recording of their own choice at any output level the competitor considered would be suitable for the hall acoustics.

For technical judging all amplifiers were adjusted to a level of 4 watts, this level was obtained by playing a frequency disc operating at 500 C.P.S. and a microphone fitted with an output meter. By this method all contestants were judged at the same output level.

The pick-ups used by all contestants was a hi-fidelity, self-aligning, crystal type and was loaned by Mr. Dawson.

The Winning Circuit

Mr. Harvey's winning entry was as follows—6J7, tone control stage, 6J7 driver, 6F8 phase splitter and 6L6's push-pull in class "A". An interesting feature of this entry was a speaker network using a Rola G12 P.M. for bass and an Amplion 8P83 as a tweeter and a network giving frequency changeover at 800 C.P.S.



Circuit of the speakers' input arrangement.

Second Place

Second place was awarded to Mr. W. Holland, of Transmission Dept. His lineup was 6SJ7 driver, 6F6 as triode transformer coupled to pair of 250's in push pull, speaker network being Amplion "Diphonic" System with frequency changeover at 400 C.P.S.

Third Place

Third place was given to N. Howard-Jones, also of Tansmission Dept., whose lineup consisted of 6J7 driver, 6J7 phase splitter and 6F6's in push pull Class "A", speaker system being single Rola G12 dynamic.

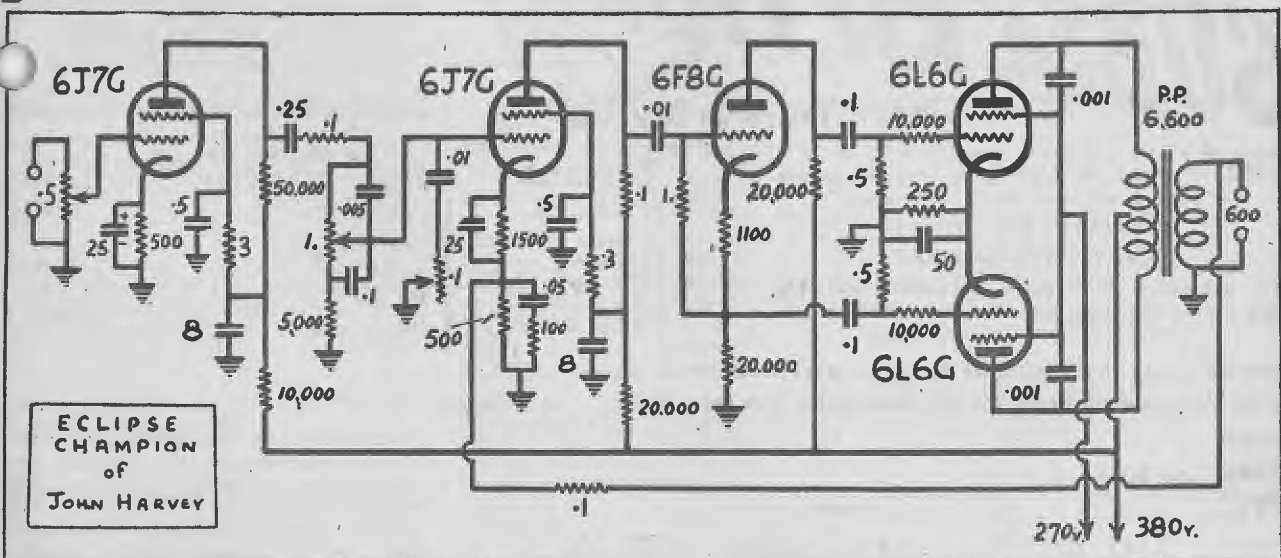
Fourth position went to R. King, of Wiring Line, his line-un being 6J7 driver, 6J7 phase splitter and 6L6's in push pull, speaker system Amplion "Diphonic" network.

I have mentioned these four place-getters because they were all particularly good amplifiers and caused the judges quite a harrowing time separating them.

A MOST COMMENDABLE INNOVATION

The executives of Eclipse Radio in Melbourne encourage members of the staff to take an intelligent interest in technical topics. They recently sponsored an amplifier contest, which was a great success and attracted a big entry of excellent amplifiers.

On this page we show the circuit of the winning amplifier and also a few details about the contest, written by one of the successful competitors and supplied to us by courtesy of Alan Hendy.



Circuit used by John Harvey, winner of the Eclipse amplifier contest.

A BUZZER MAKES A HANDY MULTIVIBRATOR

I READ with interest the recent article on multi-vibrators and although simple and comparatively inexpensive I consider that one which I built several years ago, and have used ever since to do exactly the same work and yet to cost only a small fraction of the cost of the one described in the April issue, the whole unit being built

By

W. COWIE

68 Elizabeth Street, Mayfield, N.S.W.

for about seven or eight shillings.

A further advantage of this unit is that it is self-contained, no external power being required, and is completely shielded. When this unit was built I built it entirely in a "100" cigarette tin (afraid I can offer no suggestion as to where to obtain any of these museum pieces to-day) from which I removed the paint by the simple expedient of boiling in a strong solution of soap. This provides excellent shielding and by using flush pin jacks stray fields are reduced to an absolute minimum.

The complete material used consisted of: a high tone buzzer, two pin jacks, a small switch, a three-or four-and-a-half volt battery, an .01 condenser and a small metal case (the above mentioned cigarette tin is perfect for the job).

The unit is so small that if desired a probe can be mounted on it permanently and the unit held in the hand.

If this method is adopted a bell push could replace the switch ensuring even greater battery economy although one 4½ volt battery has lasted for two years in the one I built.

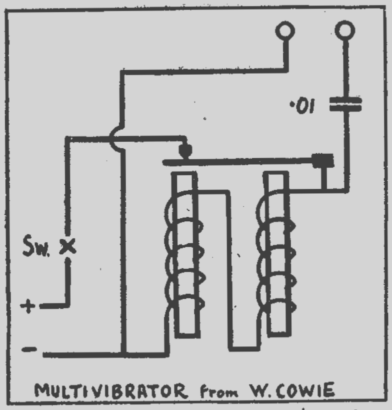
When building this unit make sure that the buzzer is not one of the type where the armature is earthed to the frame. If this is so the whole buzzer will have to be insulated.

Normally the second pin jack will not have to be used but in some low gain audio circuits it may be necessary to earth one side of the multi-vibrators battery in order to obtain a strong enough signal.

Checking a Receiver

In checking a receiver the "hot" probe is first put on the grid of the output valve when a signal will be heard in the speaker if all is o.k. If no signal is heard the trouble is obviously in the output stage or speaker. This procedure is continued stage by stage towards the aerial until the signal fades out and then the trouble is immediately localised and in all probability easily found. This procedure is well known to all radio men and really needs no explanation.

This unit is also very handy for



Circuit showing the method of connecting a high-frequency buzzer to operate as multivibrator.

aligning purposes although, of course, it does not supplant an oscillator. For a T.R.F. set the "hot" lead is held close to the aerial and trimmers adjusted for loudest signal.

The I.F. stages in a super can also be approximately adjusted if the padder is set correctly by putting the probe near (preferably not on) the oscillator grid and adjusting the I.F. trimmers for maximum noise. If however the I.F.S. are adjusted both trimmers and padders being adjusted for maximum signal with the signal being fed in the aerial. Its main use however is in location of troubles.

In my unit I mounted the switch on the side of the tin and the pin jacks in the top, only one of which needs to be insulated.

Controlling Output

As will be seen there is no method of controlling the output but this could be done by shunting a 1,000 ohm potentiometer across the output. I found this unnecessary, however, the signal being quite powerful enough to be heard amplified by the output valve alone and yet not blasting excessively even when on the aerial terminal.

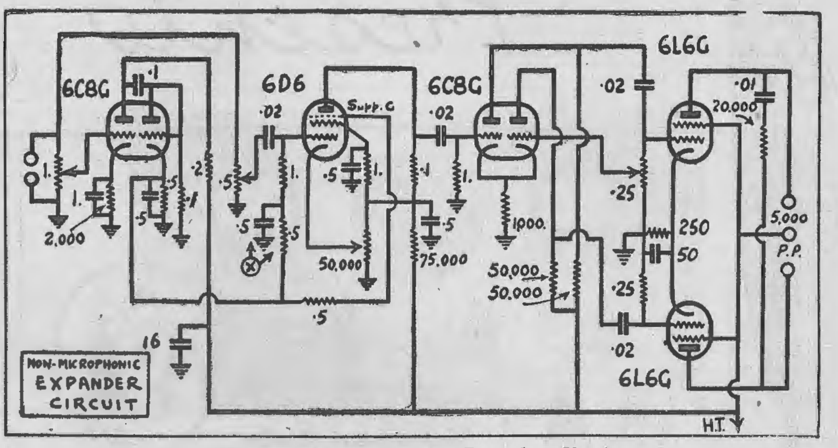
Other uses for this unit are in conjunction with a signal tracer for stage-to-stage testing and in conjunction with a vacuum tube voltmeter for stage-gain test.

Although this unit is very simple most radio men will find it well worth the little time and cost spent in making it, even if the possessors of more elaborate gear, as it simplifies various tests and provides audio as well as R.F. signals.

★

Scientists and engineers are conducting experiments that promise the transmission of radio waves bearing the aroma of coffee, the perfume of the rose, the salty tang of the seashore, and many other scents.—"Broadcasting."

A NON-MICROPHONIC VOLUME-EXPANDER CIRCUIT



Non-Microphonic Volume-Expander Circuit

AMID a great blare of trumpets R.C.A. hit the radio headlines with volume expansion, about 1935 and it was featured in many well-known receivers about that time over in U.S.A. Interest in this country, however was spasmodic and seemed limited to a few amateur fans and radio laboratories and quickly died a natural death. It should be pointed out, however, that volume expansion applied to a radio receiver is practically useless, so varied is the dynamic range handled.

Only a Sales Booster?

The great publicity it enjoyed in the "States" was merely used as a sales booster.

Unless broadcasting stations fit compression to their existing gear, volume expansion will continue to lie buried, as far as use in B.C.L. sets is concerned.

Original Circuit

The original circuit consisting of a 6C5 as the expander amplifier, 6L7 expander tube and 6H6 diode rectifier developed by R.C.A. may be found in the Radiotron Designers' Handbook, also its operational design features. However the original circuit suffered from microphonic defects and severe overloading of the 6L7.

In advocating the use of volume expansion it is interesting to note that the Bell Telephone Labs. when demonstrating "Stereoscopic Sound" at the New York World Fair used nothing more or less than exaggerated volume expansion. Use of volume expansion and compression was also used in the memorable Walt Disney "Fantasia", and who can honestly say that the experience of hearing the phenomenal sound effects, even at the small installation at the Savoy Theatre, Melbourne, was something to remember for a long time to come.

By

C. MUTTON

1 Plow Street, Thornbury, Vic.

As most readers will be aware of the fact that in the making of wax recordings, for technical reasons it is desirable to compress or restrict certain bass passages and bring up certain high frequencies, it becomes very apparent that a certain amount of realism is lost in the subsequent reproduction of the original rendition. Thus it is fairly obvious that volume expansion, intelligently used, should do much to enhance the reproduction of recorded music and restore much of that which is lost in the manufacture of the recording.

The New Circuit

In the expansion circuit about to be described a dual high-mu triode is used with one section of a 6C8G acting as the expander amplifier and the other section with the plate and grid tied together as the expander rectifier. The input signal is amplified in the normal manner and is picked off the first plate section of the 6C8G. From here the input signal is rectified by the second section acting as a diode rectifier and applied through a time constant network into the grid and suppressor of the 6D6 variable-mu tube. Simultaneously, by injecting this rectified voltage into the suppressor grid, we automatically vary the trans-conductance of the tube in accordance with the level of the input signal. By so doing, we, in effect, make the loud passages in the recording much louder than normal and lower the soft passages. In other words, we have extended the degree or the dynamic range of very soft to vey loud passages which if faked, nevertheless is most realistic to listen to.

Controlled Expansion

In practice it is a good scheme to place the volume expansion volume control close to the master gain, whereby the degree of expansion can be altered at will. All records have varied compression ratios so that no two recordings can be effectively played with the same degree of expansion.

There are a few points to watch with expansion, however, so we'll proceed to delve in a little further. Using the 6D6 or alternatively 6U7G, 6K7, etc., as the expander tube, the expansion capability of these tubes becomes limited, as the cathode bias is reduced, so that using more than 20 volts positive on the cathode of the tube will cause rectification to take place under conditions of no expansion.

Facts About Distortion

Distortion figures taken at the expander stage revealed the following state of affairs.

6D6 Cathode bias	Expansion	% Distortion	6L6 Output
14	0 to full	nil	10 watts
17	Full	1.11	10.4 „
20	Full	1.43	10.2 „

In using the 6D6 or equivalent tubes as an expander it is desirable to use a milliameter in the plate circuit and fit the cathode bias control in a convenient spot for ease of adjustment.

Set the plate current to a low value, i.e. .15 ma when used as an expander, and approximately .75 ma when using the tube as a straight amplifier.

Another point worthy of mention is the time constant of the diode voltage.

This is governed by the condenser and resistor specially marked in the circuit by a cross within a small circle. The values shown are for average speech and music. If the time constant is too short, speech will be unnatural; if too long parts of the speech will be carried over and the music will drag. This type of distortion becomes

(Continued on page 14)

EXPANDER
(Continued)

noticeable when using high degrees of expansion. To determine the time constant where (T) time is expressed in seconds, resistance in meghoms and capacity in microfarads.

$$T = R \times C$$

If the time constant is known

$$R = \frac{T}{C} \text{ or } C = \frac{T}{R}$$

By employing a 500,000 ohm variable potentiometer and a capacity of .5 mfd. a resistance variation from 5,000 ohms to .5 meghom will cover a time constant range of .0025 to .25 of a second.

A Caution

In conclusion a caution may be needed. Don't over expand recordings and you won't be disappointed. As stated before, a volume expander must be used intelligently, and if this is done the amplifier will more than re-pay the small effort put into building up an expander.

The rest of the circuit is straightforward and consists of another 6C8G, using the first section as the input stage, the other section as the para-phase phase inverter, deriving portion of the driving voltage in the correct proportion for equal grid drive from the upper 6L6G grid circuit.

It was deemed unnecessary to show a diagram of the power supply as the majority of readers are quite capable of meeting these requirements themselves.

Ingenious as is the wire recorder it can't do everything. Quoting Robert M. Yoder in the February issue of the "Rotarian", it "can't do the recording job one fellow wrote in about. Writing on the letterhead of a well-known insane asylum, he asked to buy or bor-row one of the new sets, with a good supply of wire, as soon as possible. Said he needed something like that to take down the voices he has been hearing, and show up a lot of cynics who have doubted him. 'Lot's of people don't think I hear these voices at all,' he complained."

★

A speedy, economical process for food dehydration which for the first time reduces the moisture content to 1 per cent. has been developed through use of r.f. energy.—"Science News Letter."

★

Five days before the first contingent of troops left England for the invasion of North Africa, a British firm began urning out batteries to replace those which had run down in American-made transceivers stored at the Signal Supply Division in England. At the end of those five days new batteries had been completed for the 11,500 Signal Corps handie-talkies requested by Gen. Eisenhower for the invasion.

SIMPLE AND EFFECTIVE VALVE TESTER

READERS will be interested in a small and handy valve tester that will not cost more than two or three pounds to build and does most of the tricks of its big and expensive brother.

It fits into a box of about 5in. x 5in. x 3in., does not contain any switches or variable range resistor and therefore is definitely foolproof and reliable in operation.

It works on a simple principle: Apply a voltage to the electrode closest to the cathode and read the resulting current on 0 to 50 milliamp meter. Other electrodes will show various

By

PAUL STEVENS

"Westdale," Fletchers Avenue, Bondi, N.S.W.

small readings when treated likewise and any variation here will be an indication of leakage, short or open circuit between them. If you disconnect the cathode from earth and still get your current through, it means short to heater. Well, that's just to give you a rough idea of the idea, later in this article there will be a more thorough description of the testing methods.

Layout and Circuit

Now to the little gadget itself. The diagrams show you the lay-out and the circuit. There is the meter, surrounded by the usual array of valve sockets and the heater voltage selector bushes: 4, 5 and 6 pin sockets are on the left, universal 7 pin, octal and [illegible] on the right. Below the meter is another octal socket with the contacts numbered and two black wires and one red one protruding out of the centre hole.

This socket serves as the electrode selector to connect the heater and cathode of the "patient" to the right contacts.

The Heater Wiring

The red wire is the "active" heater, the two black wires are grounded and represent the "neutral" heater and cathode connection. All three carry earphone pins, which fit very neatly into the holes of the selector socket.

The other end of the red heater wire emerges again next to the heater selector bushes and carries a banana plug to connect it to the various heater voltages.

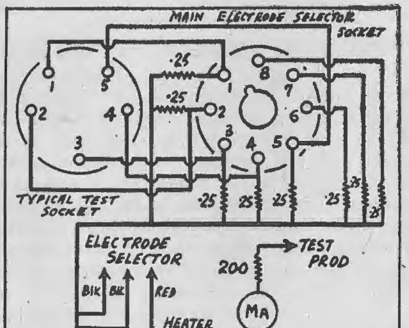
The corresponding contacts of all sockets, including the selector, are connected together, 250,000 ohm resistors between the pins and gound prevent charging effects on the otherwise open valve elements. A wire with large and small grid-clip and long enough to reach all valve caps connects the top electrode to its earthing resistor.

Using the Test Prod

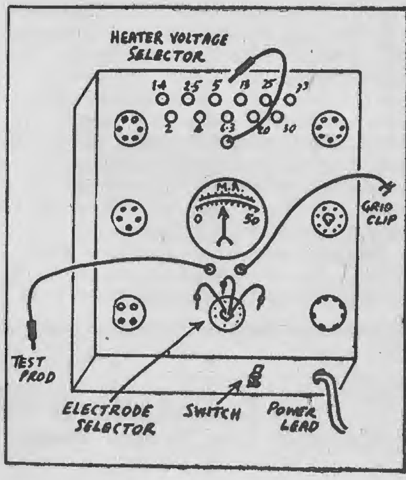
A test prod applies the test voltage to the desired elements. It is taken from the 30 volt tapping of the heater transformers in series with the meter and a 200 ohm resistor. The tip of the test prod must be thin enough to fit into the holes of the selector socket.

Now to the construction of the transformer: the well-known and still easily obtainable 240-6.3 volt filament transformer can be adapted for our purposes without much trouble: Take the laminations out and inwind the 6.3 volt winding, carefully counting the turns. Then divide 6.3 by the number of turns and you get the voltage per turn. Now you need not be a mathematical genius to calculate the required number of turns for the various heater voltages. The wire used for up to the 6.3 volt tapping should be about one-third of the cross sectional area of the original 3 amp. winding, while from there upwards the maximum is only .3 amps. and here only one tenth of the original winding will do. We have to consider this as there is very little space to wind and we have to put about 5 times the number of the 6.3 volt winding!

The tappings should be at 1.4, .2, 2.5, 4, 5, 6.3, 13, 20. 25, 30 and 33



Circuit of the Tester.



A rough sketch of the layout.

volts. The 30 or 33 volt tapping also provides the test voltage, which is automatically rectified by the valves.

Now we have finished our little tester; let us give it a try out! There is a 57 valve: the heater is on pin 1 and 6; so we put the red heater wire and one of the black wires into contacts 1 and 6 of the selector socket.

The Cathode Connection

The second black wire plugs into 5 to connect the cathode to minus. The other end of the red heater wire fits into the 2.5 Volt bush of the heater selector. Now connect the grid cap and switch the current on. When the valve is hot, touch the grid, in our case the electrode closest to the cathode, with the test prod and read the current, 20 ma would be pretty near to 100 per cent, 10 ma 50 per cent, and so on.

Testing Converters

If we test a converter valve like the EK2P we would have to put the test prod into number 5 hole of the selector socket as it is now the oscillator grid, which is nearest to cathode. Red and black heater would go to 8 and 1 and cathode to 7.

In case of an "80" and any other directly-heated valve only the heater is to be connected, the remaining black wire remaining unused. The test prod has to be applied to both plates of the 80, so we have to insert it into both contact 2 and 3 on the selector socket.

The "100 per cent current" varies with the type of valve and you will have to make yourself a chart. On my tester, for instance, the valves 6C6,

(Continued on page 26)

RADIO FREQUENCY FOR INDUSTRIAL HEATING

By

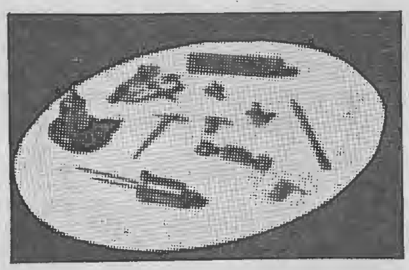
J. P. JORDAN

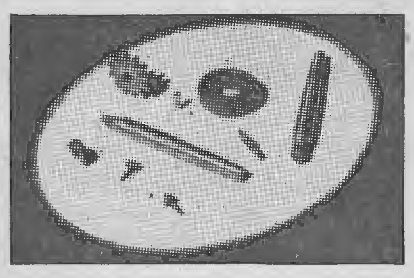
(Reprinted from "General Electric Review", U.S.A.)

THE term **Electronic Heating** covers the application of high-frequency vacuum-tube oscillators to two broad fields: the induction heating of metals, and the dielectric heating of non-metallic materials such as plywood, plastics, and foods. Although the equipments for both applications are somewhat similar, their methods of heat generation and its effect on the charge are widely different.

In induction heating, the part is placed in, or adjacent to, a water-cooled inductor coil which carries a high-frequency alternating current. The magnetic field thus produced induces a current in the surface of the part, by a process similar to that which occurs in a transformer. The resulting heat, due to resistance losses, is generated entirely in a surface layer of the part, the depth of this layer being determined by the frequency used.

On the other hand, dielectric heating is essentially a voltage phenomenon. The charge is placed between two plates, thus forming a capacitor, and a high-frequency voltage is applied. It is well known that losses occur even in the best capacitors in ordinary use because the dielectric material used is not perfect. Thus, when relatively poor dielectric materials are used, considerable power in the form of heat can be generated within this material. Since this phenomenon involves both a certain amount of conduction losses and heat generated by molecular friction due to the alternating electric field existing throughout the material, the heat is distributed uniformly through the mass.





Photographs of samples of machined steel parts which are suitable for hardening by r.f. treatment.

The oscillator circuits in use to-day for electronic heating are by no means new, having been used for many years in radio transmitters and in induction-heating equipment applied to the "baking out" of elements in vacuum tubes. Only recently, however, has equipment designed for industrial use been made available at a cost low enough to permit its general application.

The features of the present equipment, which differ from those built in the past, include simplicity of control, flexibility, and sturdy construction. Cost reduction has been achieved mainly by the elimination of many of the refinements necessary to the radio type of equipment and by new methods of construction.

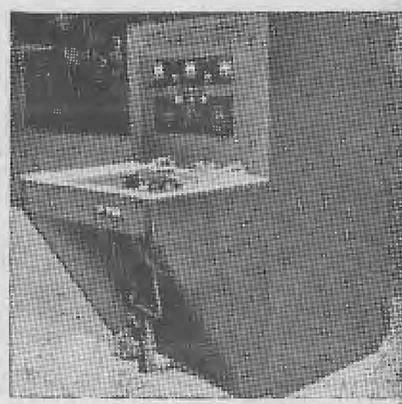
To apply and service this equipment properly, it is very desirable to have a mental picture of the theory of vacuum-tube oscillators, of eddy-current heating, and of dielectric heating. This article will attempt to present this theory in such a way that it will aid in the formation of mental pictures best adapted to this purpose without attempting a rigorous or complete analysis.

VACUUM-TUBE-OSCILLATOR THEORY

Resonant Circuits

The major element in any oscillator is the resonant circuit. The vacuum tube could be replaced by other elements, such as the various types of gaps, and the circuit would still oscillate, but an oscillator could not operate without some form of a resonant circuit. Furthermore, both the inductor coils used for induction heating and the elctrodes used for dielectric heating form part of this resonant circuit. Thus the following theory is of prime importance and should be understood thoroughly.

A pure resistor presents an impedance, to the flow of any current, that is equal to its resistance R. This impedance is not a function of freequency, remaining constant regardless of the type of current flowing, whether this be a.c., d.c. or r.f. However, a coil (or inductor) presents an impedance (inductive reactance) which varies directly with frequency, and a capacitor presents an impedance (capacitive reactance) which varies inversely with frequency as follows.



A general view of one of the complete r.f. heating units.

$$X_L = 2\pi f L \qquad (1)$$

$$X_C = \frac{1}{2\pi f C} \qquad (2)$$

where XL = impedance of inductor L
XC = impedance of capacitor C

Now, if an inductance and a capacitor are connected in parallel, a curious situation exists at some one frequency at which XL equals XC. Since XL varies directly and XC varies inversely with frequence, there is one frequence at which equality will exist. This frequency is called the resonant frequency. To determine its value, XL can be equalled to XC and solved for f as in Equation (3).

$$X_L = X_C \text{ or } 2\pi f L = \frac{1}{2\pi f C}$$

$$f^2 = \frac{1}{(2\pi)^2 LC} = f_r^2$$

$$f_r = \frac{1}{2\pi\sqrt{LC}} \qquad (3)$$

where fr = resonant frequency

If no resistance is present, further analysis would show that at the resonant frequency the current I in the line feeding the circuit, shown in Fig. 1, would be zero.

$$I = \frac{E}{\dfrac{-X_L X_C}{jX_L - jX_C}} = E\frac{jX_L - jX_C}{-X_L X_C} = E\frac{0}{-X'} = 0 \qquad (4)$$

whereas the current IL flowing in the inductor and the current IC flowing in the capacitor would equal the applied voltage E divided by their

Tremendous developments can be expected in post-war electronics. Far-sighted radio engineers are making a point of gaining all possible knowledge of the commercial applications of gear which is evolved from radio fundamentals. We recently mentioned the hardening of steel parts by radio frequency heating, and in response we have received dozens of requests for full data on this subject. Here we have the full story, straight from an expert of the American G.E. Company.

individual impedance XL and XC.

$$I_L = -I_C = \frac{E}{X_L} = \frac{E}{-X_C} \qquad (5)$$

Referring to Equation (4), the notation j indicates a phase angle of 90 degrees between applied voltage and current: plus j indicates a lagging angle, and minus j a leading angle. Thus it will be noted that the phenomenon of zero current input results from a cancellation of the currents through XL and XC, due to these

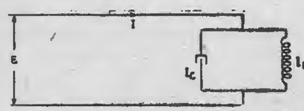


Fig. 1. Circuit of inductor and capacitor in parallel. At resonance $I_L = -I_C$ and $I = 0$, since there is no resistance in the circuit

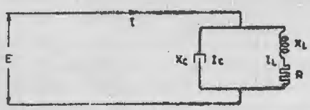


Fig. 2 Circuit of Fig. 1 with resistance added in series with inductor. The current I is no longer zero but supplies the energy loss in the resistance and is in phase with the applied voltage

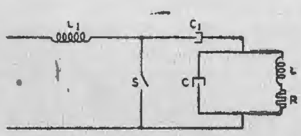


Fig. 3. Circuit of Fig. 2 with inductor L_1, capacitor C_1, and switch S added

currents being 180 deg. out of phase at all times.

When a resistance is inserted in either branch of the circuit, shown in Fig. 2, the current I no longer is zero but has a component, in phase with the applied voltage, sufficient to supply the energy loss in the resistance. Equation (6) is a solution of this circuit at the resonant frequency.

$$I = \frac{E}{\frac{L}{RC} - j\sqrt{\frac{L}{C}}} \text{ (at resonance)} \qquad (6)$$

In this case, the circuit could be thought of as a very high-power-factor load containing a resistance r and an impedance x, as in Equations (7) and (8).

$$r = \frac{L}{RC} \qquad (7)$$

$$x = -\sqrt{\frac{L}{C}} \qquad (8)$$

For small values of R, the input is still essentially resistive and the voltage E times the current I (Fig. 2) will approximate the power dissipated in the resistance due to the current IL. However, note again that the current through the inductance L or the capacity C is a function only of the applied voltage E and the impedance, and does not flow through the external circuit. The product of this current, IL or IC, times the voltage E is termed the circulating kva which can assume considerable magnitudes with very small values of input current I. This circuit is sometimes referred to in radio parlance as a tank since it can be thought of as storing potential energy.

Basic Oscillator Circuit

Assume now that a d.c. supply is connected to this resonant circuit through a switch which can be operated very rapidly. If this switch were operated at the resonant frequency of the circuit, it is obvious from the equations given previously that high

(Continued on page 18)

R.F. HEATING

(Continued)

circulating currents would flow between the capacitor and the inductance, but the current through the switch would be only such as to supply the losses in the circuit.

Even though such a switch is available, this scheme has several disadvantages, among which is the fact that if the circuit through the inductance is broken for any reason, the inductor will be at full d.c. potential.

However, by shunting the switch across the d.c. supply and interposing a capacitor between the switch and the resonant circuit similar results can be obtained.

In Fig. 3, when switch S is open the voltage builds up across C, through L and L1. However, for the first instant of time, the inrush current causes nearly the full voltage to appear across the circuit L-C, and capacitor C becomes charged.

If, at this point, switch S were closed, the applied vlotage would drop and capacitor C would discharge into inductance L in the resonant circuit. Meanwhile, the full d.c. voltage would build up across L1. When S is reopened, L would discharge into C and the process would be repeated. Thus, if S were operated at the resonant frequency of the circuit L-C, the conditions previously noted would exist. That is, high circulating currents would flow through L and C while the current through Cl would only be great enough to supply the losses.

This process becomes clearer if it is recalled that, at the resonant frequency, the input impedance of the resonant circuit is very high (zero current input with full voltage applied), and thus if switch S were operated to supply short pulses of current at this frequency, the full voltage would appear across this high impedance. Capacitor Cl acts to block any steady flow of d.c. through inductance L but presents a very low impedance to the flow of the pulses of current feeding the resonant circuit. Inductance Ll is a coil (or choke) which serves to absorb the shot current pulses and prevents them from affecting other elements in the circuit. This, then, would be a satisfactory oscillator circuit—all that remains is to find an appropriate switch and to control it properly. A spark gap could be used as this switch at speeds below 200,000 cycles per second, but for the higher frequencies, the only satisfactory element is the vacuum tube.

The Vacuum Tube

The vacuum tube can be thought of as a contactor capable of operating at very high speeds. The tubes used for this application consist of three elements, an anode (or plate), a cathode, and a grid, all within an evacuated envelope. The cathode is generally a tungsten or thoriated-tungsten element operating at very high temperatures to provide a source of electrons. When any other element of the tube is positive with respect to this cathode, these electrons are attracted to it and thus establish a current flow. (Note that the conventional concept of current flow from plus to minus polarities is opposite to the actual flow or migration of electrons).

However, a wire-mesh screen (the grid), interposed between the plate and cathode, can control this flow of electrons by either cancelling or aiding the positive-voltage field set up by the plate. Thus, regardless of the plate voltage, if the grid is sufficiently negative, no current will flow, while if the grid is positive or only slightly negative, the electrons will flow, through the opening in the mesh, to the plate.

The Grid Circuit

Before the vacuum tube will operate to maintain oscillation in the circuit, the proper grid voltage must be determined and a means found to create it. The voltages that exist across the tube during oscillation will appear as shown in Fig. 4.

The plate-to-cathode voltage consists of two parts: the d.c. voltage a plus or minus the r-f voltage b. At point c, the voltage is at a maximum while at do it is at a minimum. The tube must conduct at that point during the cycle at which oscillation would be aided. If this occurred at point c, it would tend to reduce the r-f voltage at that point and increase it during the other half of the cycle. Thus, the tube must be made to conduct at point d. Also, since the vacuum tube always presents a certain resistance to the flow of current, the power loss within it will equal the summation of the products of the instantaneous voltage times the current. It is obvious that since the voltage is at a

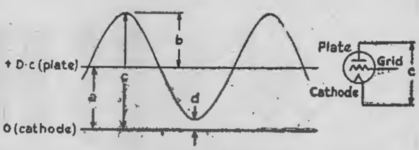


Fig. 4. Showing the voltage that exists across a vacuum tube during oscillation. This voltage consists of the d-c voltage *a* plus or minus the r-f voltage *b*.

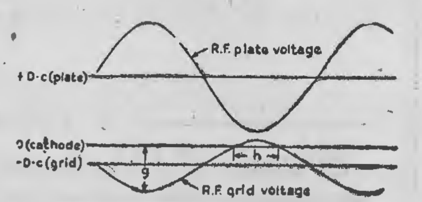
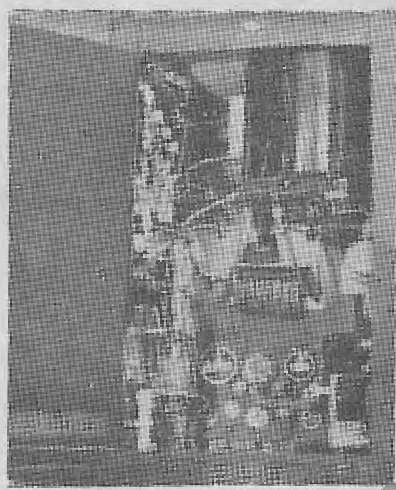


Fig. 5. Illustrating the grid voltage of the oscillator tube. This voltage consists of a d-c voltage (negative) on which is superimposed an r-f voltage that is 180 deg out of phase with r-f plate voltage



Internal arrangement of the unit.

minimum at point d and increases at all other points, it would be very advantageous to limit the period of conduction to a small fraction of a cycle centered at that point. To do this, it is necessary that the grid be sufficiently negative to prevent the flow of current at all other points, thus the grid voltage must consist of a sine wave, 180 deg. out of phase with the plate voltage, superimposed on a negative d.c. voltage as in Fig. 5. With a voltage of this type applied to the grid, the conduction period will be only slightly longer than h and the tube efficiency will be at a maximum.

Correcting D.C. Voltage

Logically, the r-f component of the grid voltage could be obtained dire from the resonant circuit while d.c. component is applied from an external source. But since this requires adjustment of the potential whene the magnitude of the r.f. compon changes, a scheme for automatically providing the correct d.c. voltage is normally used.

It will be noted (Fig. 5) that the grid voltage is shown as becoming positive for a short period h. Since, as was previously outlined, any positive element within the tube attracts electrons, a certain number of them will stop at the grid rather than pass through to the plate, establishing a unidirectional current flow. Thus, if, as shown in Fig. 6, a capacitor is interposed between the source of r-f grid voltage Eg and the tube, it will become charged during this period of conduction, with a polarity as indicated. When the r-f grid voltage decreases, during the remainder of the cycle, this charge will remain across the capacitor, thus holding the grid negative. To assure that this negative voltage (or bias) is always proportional to the amplitude of the r-f voltage, a resistor Rg is connected between grid and cathode to bleed off some of the charge during the period of nonconduction, thus allowing the capacitor to recharge each cycle.

Several methods are used to obtain the r-f grid voltage from the resonant circuit—and this is the main point of difference in the oscillator circuits now being used by the various manufacturers of induction-heating equipment.

It will be remembered that this voltage must be 180 deg. out of phase

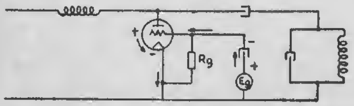


Fig 6 Showing how the grid of the oscillator tube becomes charged during the period of conduction shown in Fig. 5

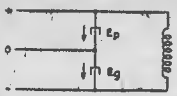


Fig 7 Circuit for obtaining the oscillator tube's r-f grid voltage directly from the resonant circuit

with the plate-to-cathode voltage. This phasing can be obtained in several ways. In the coupled grid circuit, the voltage is developed across a coil inductively coupled to a portion of the resonant circuit. By proper connections, this voltage can be phased nearly 180 deg. but due to the resistance inherent in any inductance, this phasing must be corrected in many cases by the addition of a phase-correcting capacitor.

In the Colpitts circuit, the grid voltage is obtained by direct connection to the resonant circuit, splitting the capacitor into two series sections as shown in Fig. 7. If the plate-to-cathode voltage is impressed on one section Eg, the voltage across the other section Eg will always be of opposite polarity, thus giving a 180 deg. phase angle.

Figs. 8 and 9 illustrate the major circuits in use. Section M represents schematically the mercury-tube rectifier commonly used to convert the 60-cycle voltage output of the high-voltage transformer T to the d.c. uti-

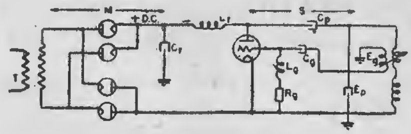


Fig. 8 The coupled grid circuit

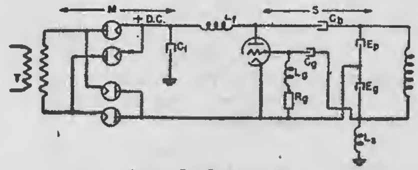


Fig. 9 The Colpitts circuit

lised by the oscillator circuit S. The Colpitts circuit (used in G-E equipment) has the advantage of greater stability, since the capacitor ratio Ep vs Eg is always fixed, thus providing a "stiffer" voltage source as well as better efficiency because the phasing is more exact. However, the coupled grid circuit affords a ready means of adjusting the amplitude of the grid volt-

(Continued on page 20)

R.F. HEATING

(Continued)

age which in some cases is advantageous.

It will be noted that since no effort is made to smooth out or filter the d.c. output of the rectifier, the voltage applied to the oscillator is actually a series of half sine waves. However, this in no way affects the previous analysis since for the duration of any one r-f cycle the voltage could be assumed constant.

To conclude this discussion of the oscillator circuit, it is important that several points be understood thoroughly because of their importance in the application of this circuit to induction and dielectric heating. These are.

1. Voltage and current in the resonant circuit have no relation to power output, being solely a function of voltage, frequency, and circuit constants. This current does **not** flow though the tubes.

2. All direct current from the rectifier flows through the oscillator tubes. Since the direct current times the voltage equals the power output of the rectifier, this current is proportional to the power input to the oscillator circuit at any fixed voltage.

3. The serviceable life of all oscillator tubes is determined by the life of filaments; this in turn is determined by their operating temperature. With thoriated-tungsten filaments, temperatures either too low or too high will seriously shorten their life. With pure tungsten filaments, the lower the temperature the longer the tube life. However, at reduced temperatures fewer electrons are emitted, thus limiting the permissible power output. It is always advisable to operate such tubes at the lowest filament voltage that does not affect the operating conditions.

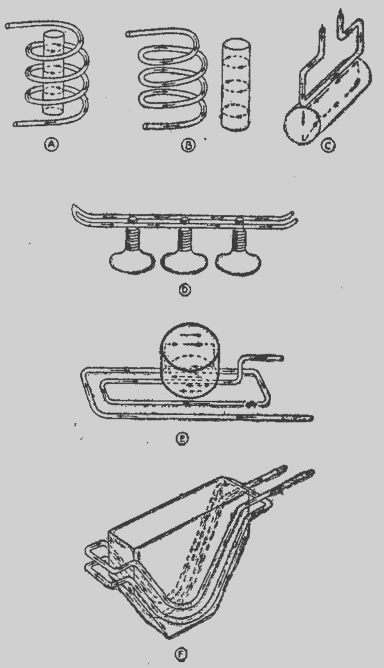


Fig. 10. Sketches showing direction of current flow in electronic heater coils and in parts being heated

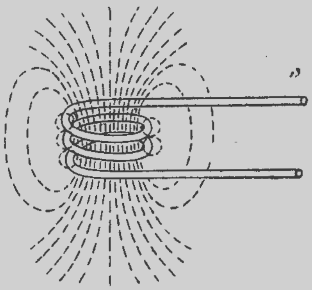


Fig. 11 Showing the disposition of the lines of magnetic flux in the space surrounding a multiturn coil

INDUCTION-HEATING THEORY

When an alternating current flows in any conductor, an alternating magnetic field is set up in the surrounding area. Likewise, when any conducting material is placed in an alternating magnetic field, a current flow is set up in that material. This current is such that the counter magnetic field generated by it will tend to cancel the existing field.

Since the external magnetic flux must penetrate the surface before reaching the interior of this conducting material, the greater part of the current flow will be near the surface. The intensity of the counter magnetic field set up by the current flow in the body is a function of the frequency; thus, as the frequency is increased, the current flowing on the surface becomes more effective in generating the total counter magnetic field required, and less current will flow in the layers below the surface. This is known as the skin effect since it results in concentration of current flow on the surface or skin of the body. The currents themselves are called eddy currents and the heat caused by the resistance of the materials to their flow is known as eddy-current loss. It will be noted that the intensity of the external field affects only the magnitude of the eddy-current flow, whereas the frequency affects the depth to which these currents will penetrate.

In induction heating, the inductor coil (or heater coil) can be thought of as the primary of a transformer with the charge being a single-turn secondary. Thus the load appears as a resistance in the heater coil. However, although this is true in all cases, in complicated applications it is often easier to think of the coil as setting up a magnetic field of a certain shape, which in turn causes currents to flow in the desired areas in the charge. Note that these currents must flow in closed loops in the same plane as the coil currents—thus if a coil is placed around a bar, as shown in Fig. 10A, the current will flow in a closed loop around the surface of the bar in the same plane as in the coil—but, if the same bar is placed close to the outside of the coil, Fig. 10B and C, the current will still flow in the bar as before, although with a considerably smaller magnitude since the magnetic flux density outside a coil is less than that within it. Fig. 11 shows the magnetic-flux lines existent in the space surrounding a multiturn coil. The heating is proportional to the amount of flux impinging on the surface of the charge.

The remaining sketches (D.E. and F), in Fig. 10 serve to illustrate the application of the above concept to actual heating problems. In all cases the current flow is indicated in both the part and the coil.

In magnetic materials, the hysteresis loss will create some heat, but it is generally so small in comparison to the eddy-current losses that it can be discounted.

The rigorous equations for eddy-current losses are quite complex and of little general use. However, some approximate formulas will serve to show the relationship of the various parameters, although since many of the factors are difficult to measure with any degree of accuracy, they cannot be applied to practical problems in most cases. Equation (9) gives the amount of power dissipated as heat, in the surface of a part, in terms of the magnetic-flux density, the frequency, and the electrical characteristics of the metal being heated.

$$\Delta P = \frac{H_t^2 \sqrt{\rho \mu f}}{8\pi} \qquad (9)$$

where ΔP = power dissipated as eddy currents
H_t = tangential component of magnetic flu. at surface of charge
ρ = resistivity of charge
μ = permeability of charge (unity if non-magnetic)
f = frequency

Since the magnetic-flux density (Ht) is proportional to the ampere turns in the coil, the factor Ht2 could be replaced with I2N2 (times a constant) where I equals the coil current and N is the effective number of turns in the coil.

Equation (10 gives a measure of the depth of penetration of the heat for any given frequency and material. To be exact, this is the depth at which the eddy currents fall to a value equal to $\frac{1}{e}$ (37 per cent.) times their magnitude at the surface.

$$\rho = \frac{1}{2\pi}\frac{\sqrt{\rho}}{\mu f} = \text{depth of penetration} \quad (10)$$

Combining Equations (9) and (10)

$$\Delta P = \frac{H_1^2 \rho}{16\pi^2 p} \quad (11)$$

Examining equations (9), (10), and (11), it can be seen that the rate of heat input is directly proportional to the square root of the frequency and the resistivity, and inversely proportional to the depth of the penetration factor p. Also note that the permeability, which is a measure of the magnetic properties of the metal, has a value of one for all non-magnetic materials but can be of major importance when heating magnetic metals below the "Curie temperature" (1420 F. for low-carbon steel), above which magnetic properties effectively disappear.

DIELECTRIC-HEATING THEORY

Dielectric heating is the name generally applied to the generation of heat in nonconducting materials by their losses when subjected to an alternating electric field. The term "electrostatic heating" is a misnomer, since it is impossible to generate heat with an electrostatic field.

All capacitors in general use in industry for power-factor improvement, motor starting, etc., are imperfect in that heat is generated when an alternating voltage is applied. While some of this heat is due to resistance losses in the leads, the remainder is generated within the insulating material itself and is uniform throughout the mass. The cause of this loss is not clearly understood, but it is thought to arise from two sources—actual current flow through the material due to the potential gradient existing across it, and the dielectric hysteresis which is somewhat analogous to magnetic hysteresis in iron. In practice, no effort is made to differentiate between them, and the ratio of the total loss to the total impressed volt-amperes is known as the power factor of the material. This loss is directly proportional to the impressed volt-amperes and since the impedance of a capacitor drops as the frequency is increased, the applied volt-amperage and thus the losses are directly proportional to the frequency at any given voltage.

Another factor of importance is the specific inductive capacity or dielectric constant. Different materials, when placed between identical electrodes, will result in different total capacities. The dielectric constant is a measure of this effect and is the ratio of the capacity of two electrodes, with the material as the dielectric, to the capacity of the same electrodes in a vacuum.

Unlike induction heating, the heat loss in any insulating material due to dielectric losses can be calculated to a fair degree of accuracy. When an alternating voltage is applied to any two electrodes, an alternating potential gradient exists in the intervening space. If these electrodes are flat, parallel plates and if the insulating material fills the volume between them as is most generally the case, the total capacity can be calculated. From the capacity, voltage, and frequency, the impressed volt-amperes can be determined, which, multiplied by the power factor, gives the heat generated in watts. Equations (12), (13) and (14) present these factors in a convenient form and can be used for estimating purposes.

$$C = \frac{2248\,A\,K}{10^{10}\,d} \text{ (for parallel plates)} \quad (12)$$

where
C = capacity, mfd
A = area of one elctrode, sq. in.
d = distance between elctrodes, in.
K = dielectric constant

$$W = \frac{2\pi f C E^2 \text{(P.F.)}}{10^6} \quad (13)$$

where
W = power loss as heat, watts
f = frequency, cycles per sec.
C = capacity, mfd
E = applied voltage (rms)
P.F. = power factor

$$H = \frac{M S \Delta T\, 10^3}{56.9} \quad (14)$$

where H = energy required, watt-minutes
M = weight of material to be heated. lb
S = specific heat
ΔT = temperature rise, F

Precautions in Applying Equations

In applying these equations, the following precautions should be observed:

(1) The power factor of most materials varies with frequency and temperature. Thus, the power factor used in the above equations should be measured at or near the operating frequency and at a known temperature.

(2) The dielectric constant changes relatively slowly with frequency and temperature, and can be taken from published tables with fair accuracy.

(3) The above equations hold only for uniform electric fields. Since the field at the edges of the elctrodes is always distorted, a good approximation is possible only when the minimum dimension of the electrode is large compared to the distance between plates. Also, to reduce non-uniform heating at the edges, it is advantageous to use plates somewhat larger than the material to be heated.

(4) Because of corona and arching effects, the maximum voltage applied to the electrodes is approximately 14 to 15 kv rms with 2 to 3 kv rms per inch of separation being the maximum for smaller spacings.

(5) An analysis of the above equations will, for some materials, indicate the desirability of very high frequencies. However, the tubes and equipment commercially available at this time limit the maximum frequencies obtainable to approximately 200 megacycles for power outputs up to 100 watts; 30 megacycles for power outputs to 40 kilowatts; and 4 megacycles for the higher power ratings.

Note also that at the higher frequencies, the maximum electrode dimensions must be limited to at least one-eighth of a wavelength to avoid standing waves which result in non-uniform heating.

A convenient formula for determining wavelength is given in Equation (15).

$$\lambda = \frac{300}{f} \text{ (in air)} \quad (15)$$

λ = wavelength meters
f = frequency, megacycles

(6) The charge to be heated must be of uniform analysis throughout and must contact each plate. An air gap between the electrodes and the charge results in a series-capacitor effect and introduces serious errors in the above equations.

The dielectric constants for most materials fall in the range of 2 to 6, but may vary from 1 for gases up to 1,000 for some ceramics, while the power factors usually lie between 0.02 and 0.07 but may be as low as 0.00015 (mica, polystyrene) or as high as 0.15 (asbestos). Gases and pure water have power factors that are essentially zero and cannot be heated.

It is sometimes desirable to employ electrodes designed to provide an air gap between electrodes and the work. In such cases, the voltages employed must be much higher to provide the same potential gradient across the charge as would exist with contact electrodes.

ELECTRONIC-HEATING EQUIPMENT

It should be obvious that the oscillator previously described is an ideal power source for many induction and dielectric heating applications. Part of the inductance in the resonant circuit can be replaced by an inductor coil, and the high currents thus obtainable used to generate the necessary magnetic flux required to heat the charge. Likewise, the capacitor can be replaced with external electrodes and non-conducting materials heated by the high-frequency voltages obtainable. However, the original costs and the maintenance costs are definitely higher than for motor-generator equipment, thus limiting their application to those jobs where higher frequencies are advantageous. The very high frequencies required for dielectric heating can be obtained from no other source, but many induction-heating applications can be done as well, or better, by using frequencies below 10,000 cycles supplied by motor-generator equipment. The melting of metals, through heating of large masses for annealing or forging, and the deep surface hardening of shafts and other parts over approximately 2 in. in diameter having no sharp contours are definitely low-frequency applications. But, surface hardening—where a very thin case is required (less than $\frac{1}{16}$ in.) or where it is desired to conform to relatively sharp contours—and the heating, in general, of parts less than approximately $\frac{1}{2}$ in. in diameter require the use of the higher frequencies. The extensive group of work remaining can be done equally well with either type of equipment and the deciding factor must be either the potential application to larger or smaller parts, or the power requirements (electronic heaters are generally more economical below 15 kw).

Operation of Electronic Heaters

G-E electronic heaters for induction heating are provided with four controls which require adjustment for proper operation.

(1) The filament voltage control is a rheostat in the primary of the filament transformer and permits adjustment of the filament voltage for different line voltages and operating conditions. (In the 15-kw equipment, an additional fixed resistor is mounted in the top of the cabinet to extend the range of the rheostat). The filament voltage of the 5-kw electronic heater should be maintained within 5 per cent. of the rated value since it uses thoriated-tungsten filaments and operation outside of that range would seriously reduce the tube life. The 15-kw electronic heater should be operated at as low a value as is consistent with proper operation. Too low a filament voltage will result in limiting the plate current and thus the power output obtainable.

(2) The coarse power control is a tap switch operating through an auto-transformer to vary the voltage applied to the oscillator. Since the current in the resonant circuit is proportional to the voltage, the power output will thus be varied.

(3) The fine power control is a rheostat in the grid circuit of the oscillator, which by increasing the d.c. bias voltage impressed on the grids will reduce the over-all efficiency of the oscillator and thus reduce the current owing in the resonant circuit when it is loaded.

(4) Output taps are provided to permit use of widely different coil sizes. These taps are connected directly to the turns of the resonant-circuit inductance. Since the frequency and the current in the resonant circuit are functions of the total inductance, it is advisable to maintain it at approximately the correct value. If the heater coil is large, less of the internal inductance is required and vice versa. A mean operating frequency of 550 kilocycles plus or minus 30 kilocycles can easily be maintained by this means. As far as operation of the equipment or the application of it is concerned, a variation of even 100 or 200 kilocycles is unimportant. However, in some cases radio interference may be created by these oscillators, and the frequency band between 501 kilocycles and 560 kilocycles is the least used for communication purposes.

Coil Design

It must be borne in mind that the heat generated in a part is entirely due to the magnetic flux created by the inductor coil; only by changing the intensity of the flux pattern at the part can the loading on the electronic heater be affected. This magnetic flux is directly proportional to the ampere turns in the coil, i.e., the coil current times the effective number of turns. Also, since the flux density is greatest at the conductors themselves, diminishing rapidly in the surrounding space, the closer the coil is to the part the greater will be the loading.

The following notes will aid in coil design, but it must be remembered that because of the complexity of the factors involved, it is necessary in all but the simplest cases to determine the final design by actual trial-and-error methods.

(1) The coil should roughly conform to the shape of the part if no sharp contours need be considered. Symmetry is important, i.e., the part should be centred in the coil as far as possible.

(2) Sharp contours will heat first because of the concentration of flux and the lack of mass. Thus the coil should be farthest from the part at these points.

(3) If dissimilar metals are being heated for brazing, etc., the magnetic flux must be concentrated on the slowest heating metal; in general, magnetic steel heats more easily than any other material, with stainless steel, brass, copper, and silver following in the order of their resistances.

(4) In brazing, the joint should be at the correct temperature before the brazing alloy melts so that it will be drawn into the joint. Thus a concentration of heat on the brazing alloy should be avoided.

(5) In hardening, double-bank coils are sometimes necessary because of the current limitations of electronic heaters. However, since the outside layer of turns is far less efficient than the inner layer, such coils should be used only if essential.

(6) To obtain uniform heating at the circumference of a disk or bar, rotating the parts is advisable so as to avoid the heating effects of the coil leads.

(7) The number and size of coils that can be used on any equipment is determined by two factors: the power capability of the electronic heater, and the maximum inductance allowable.

In order to obtain a highly concentrated band of heat on a part or to heat zones which are not readily accessible, it is sometimes desirable to use a single-turn coil carrying a high current. Since generally it is not economically feasible to construct electronic heaters with a circulating current in the resonant circuit above approximately 300 amp. it is necessary to resort to output transformers. Obviously, it is impractical to use an iron coe, so air core designs must be applied. Thus the coupling between the primary and secondary windings is poor and the over-all efficiency is reduced. Furthermore, to accommodate coils of various sizes, it is often necessary for best results to use different turn ratios.

However, such transformers do permit grounding the centre point of a coil, which in many cases reduces the maximum voltage to ground. Also, for small coils, the voltage between terminals is lowered. For larger coils, this is not necessarily true; in fact, for some large coils the terminal voltage is actually increased by use of single-turn coils.

Improvised Soldering

If a blowtorch or spirit lamp is not available for a heavy soldering job, an excellent Bunsen burner can be improvised for use on the kitchen gas range. An empty vegetable can of a size which will make a snug fit is inverted over a gas burner. A small hole is punched in the end of the can, the gas turned on, and a match applied at the hole. A pencil point of hot blue flame will result which will heat any job that can be moved to the burner and make it ready for the solder in jig time.—"Q.S.T."

★

To clean a volume or tone control on your receiver, pour carbon tetrachloride over the outside of the control, using enough so that the fluid will get inside. Turn the control through its complete rotation several times. Repeat if necessary. Most controls can be made as good as new by this treatment.—"Q.S.T."

Shortwave Review

CONDUCTED BY
L. J. KEAST

NOTES FROM MY DIARY—

SWISS BROADCASTS TO AUSTRALIA

Receiving advice from the Consulate General for Switzerland, Sydney, that a change was to be made in frequencies and schedules to the Tuesday and Saturday broadcasts to Australia, I checked them on Tuesday, August 22. The transmitters are: 25.08 and 23.14 metres and schedule is 3 till 4.30 p.m. The signal on 25.08 averaged R8 Q4 and that on 23.14 R6 Q3, so both the change in time and frequency is to be welcomed.

As heretofore, broadcast on Tuesdays is in English and on Saturdays the national languages are employed.

HELP WANTED

Mr. Wally Young, of Adelaide, has been hearing a station on 19.68 m. closing at 3.30 pm. Western records are played and language seems like Spanish. When closing says, "Good morning, everybody." It can just be separated from VLG-6.

Mr. Roy Matthews, of Perth, enquires about a station on 7170 kc., which opens at 11.45 pm, closing at 12.20 am. Programme consists of music with announcements in French. Mr. Matthews thinks it may be a Russian.

FIXED SCHEDULES

Here are a few regular and popular American broadcasts:—

The Gracie Fields' Show

KROJ, 19.75 m. Sundays, 9.30 am.
K.R.O.J., 30.31 m., KWIX 30.44 m., Sundays 7.15 pm.

Command Performance

KROJ, 19.75 m.: Wednesdays, 12.30 pm.
KROJ, 30.31 m., KWIX, 30.44 m., Wednesdays, 6.30 pm.

Front Line Theatre

KROJ, 19.75 m. Tuesdays, 1.15 pm.
KROJ, 30.31 m., Tuesdays 8.00 pm.

NEW STATIONS

WCZN, New York, 17.83 mc., 16.83 m.: A further outlet of the Columbia Broadcasting System on the air from 10.15 pm till 9 am.—L.J.K.

XGOY, Chunking, 7.15 mc, 41.96 m.: Now operates from 9.35 pm on this new frequency instead of 7.17 mc. Can be heard well in parallel with 31.10 m.

. . ., Leopoldvile, 9.39 mc, 31.95 m.: Mr. Matthews of Perth says, 'Now on 9.38 mc, at 2 am, and often also in mornings early, only fair signal owing to Morse interference. Ern. Suffolk of Adelaide reports them audible at 5 o'clock.

KWID, 'Frisco, 17.76 mc., 16.89 m.: Appeared to come in to regular Latin-American service on August 2. Schedule is 6—9.45 am. Is mostly in parallel with KGEI from 7 am and KWIX from 8.30—L.J.K.

CHANGE-OVERS: As from August 18, KGEI now operates on 9.53 mc, 31.48 m., and KGEX is heard on 7.25 mc, 41.38 m. They have both taken their programmes with them. KGEX is in the clear now, from opening at 7 pm with programme to the Philippines, but KGEI is in trouble with WGEA till the New York station closes at 10 pm—L.J.K.

WNRI, New York, 9.855 mc., 30.44 m.: Still a further transmitter to the already long list operated by The National Broadcasting Corporation. Takes the usual East Coast "V of A" programmes with languages. I am indebted to Mr. Edel for phoning me about this one also. When he rang at 3.50 pm they were in Italian, and at 4 gave call sign and news in English. Closed at 5 pm with call and frequency but no mention of schedule.—L.J.K.

WSCO, Somewhere in China, 8.00 mc, 37.48 m.: This station, which is one of the American Expeditionary Force's transmitters has been heard for some time, but it is only the last week that call has been heard. I am showing the generally accepted call of WSCO, which is what I consider call is, although others are confident call is WRCO whilst WFPA has been suggested.
The location is given as China, but no town or city is mentioned. Programme, which consists mostly of American transcriptions, commences at 10 pm, although it is often 10.30 or 11 o'clock before it becomes audible here, owing to morse.—L.J.K.

KGEX, 'Frisco, 15.29 mc, 19.62 m.: Heard on August 3 apologising for interruption to programme at 6.54 am., and recommending tuning to KWID on 17.76 mc, for continuation of "Boston Serenade." Announcer said, "Latin-American programme will be resumed in about 5 minutes on KGEI, the International Broadcast station on 15.29 mc. KGEX is now signing off."—L.J.K.

KGEI, 'Frisco, 15.29 mc, 19.62 m.: First heard on August 3 when opening at 6.59 am with anouncement, "This is G.E. Station KGEI on 15.29 mc, with programme specially directed to the Americans in the South." Schedule is 7 am till 2.59 pm and programmes provided by The United Network are good.

ABSIE, 9.73 mc, 30.82 m.: Mr. Gillett of Adelaide reports the American Broadcasting Station in Europe being heard on this new spot in parallel with the other outlets at just a fair signal till closing at 8.45 am. Is interfered with by CE-970.

VUD-, Delhi, 14.57 mc, 20.58 m.: Mr. Wally Young, of Adelaide, reports hearing this new All India Radio channel most of the morning.

VUD-, Delhi, 15.19 mc, 19.75 m.: Heard on July 1 calling the BBC in the early evening but now appear to be on regularly opening at 8 o'clock with French.—L.J.K.

VU-.?, Delhi, 11.64 mc, 25.77 m and 11.95 mc 25.10 m.: These two new All India Radio outlets were mentioned to me by Mr. Edel and the former provides a grand opportunity to test the selectiviy of your se. Situated right between Leningrad on 25.79 m. and "another" on 25.75 m., and the signal being very weak it takes a lot of coaxing in. The signal on 25.10 is about the same strength, but in the clear. From 9.45 till 9.52 pm they are in relay with 25.45 and 25.51 m, but from then continue in parallel on their own.
When Mr. Edel rang me we checked them together on our respective sets and if not easy to hear are important for calibrating receiver.—L.J.K.

ALL-WAVE ALL-WORLD DX CLUB

Application for Membership

The Secretary,
All-Wave All-World DX Club,
243 Elizabeth Street, Sydney.
Dear Sir,

I am very interested in dxing, and am keen to join your Club

Name ....

Address ....
(Please print both plainly) ....
....

My set is a ....

I enclose herewith the Life Membership fee of 2/- (Postal Notes or Money Order), for which I will receive, post free, a Membership Certificate showing my Official Club Number. NOTE—Club Badges are not available.

(Signed) ....

(Readers who do no want to mutilate their copies can write out the details required.)

Shortwave Notes and Observations

OCEANIA

VLW-?, Perth, 9.68 mc., 30.99 m.: Now heard of a morning.—L.J.K.

Note call of 30.99 m. in mornings is VLW-3 (Young).

(Yes, I have heard call, VLW-3, several times, but Mr. Matthews wires VLW-6.—L.J.K.

VLC-2, Australia, 9.68 mc., 30.99 m.: General MacArthur's H/q put in a terrific signal from 7 till 8 pm (Matthews). and Mr. Gandy of Parnell, N.Z., says so too.

VLC-6, Shepparton, 9.615 mc, 31.21 m.: Very good signal at 1.30 am (Matthews).

VLQ-3, Brisbane, 9.66 mc, 31.05 m.: Gives an R8 signal at 1 pm (Gandy, Flack).

New Caledonia

FK8AA, Noumea, 6.208 mc, 48.39 m: Good strength 7—8 pm (Matthews, Gandy).

New Zealand

ZLT-7, Wellington, 6.715 mc, 44.67 m.: Good at 7.15 pm (Young).

Fiji

VPD-2, Suva, 6.13 mc, 48.94 m.: Good on Sunday afternoon (Matthews)

AFRICA

Algeria

AFHQ, Algiers, 9.61 mc, 31.22 m. and 9.53 mc, 31.46 m.: Give news at 3 am (Gillett).

Belgian Congo

RNB, Leopoldville, 9.785 mc, 30.66 m.: Relays BBC news at 2.30 pm. This programme has been mistaken for a new BBC transmitter, but at 2.44 RNB announcer says, "You have been listening to Leopoldville on 30.66 m. 9785 kilocycles. We are on the air daily from 1.30 to 4.45 G.M.T. (11.30 am—2.45 pm, Syd.) This is Leopoldville The Belgian National Broadcasting Station."—L.J.K.

French Equatorial

FZI, Brazzaville, 11.97 mc., 25.06 m.: Heard in French from 4 till closing at 4.30 pm. (Miss Sanderson, Young).

FZI, Brazzaville, 9.44 mc, 31.78 m.: Opens at 2 am at good strength. News at 2.07 am. Schedule now extends to 2.30 (Matthews). Heard at various times of the day from 5.30 am till 4 pm (Gillett).

Mozambique

CR7BE, Lourenco Marques, 9.86 mc, 30.42 m.: Quite fair on Sundays at 8 pm. (Matthews).

South Africa

ZRL, Capetown, 9.607 mc., 31.22 m.: Surprised to hear good signal from 9—11 pm (Matthews).

ZRH, Johannesburg, 6.007 mc, 49.95 m: Heard at midnight (Young). Good at 1.30 am (Matthews).

ZRD, Durban, 5.945 mc, 50.47 m.: Also heard at midnight by Mr. Young and Mr. Matthews finds signal O.K. at 1.30 am.

U.S.A.

KWID, 'Frisco, 17.76 mc., 16.89 m.: Heard well till closing in mornings (Fluck).

KGEX, 'Frisco, 15.33 mc, 19.57 m.: Excellent until closing at 3 pm (Matthews, Edel, Fluck).

KGEI, 15.29 mc, 19.62 m.: This is the call when closing at 2.45 pm (Gillett). (Yes, they open at 7 am —L.J.K.).

KGEI, 15.13 mc, 19.83 m.: Splendid at 3 pm but fades away (Matthews). (Sometimes fades here, but have copied till closing at 8.30 pm on several occasions.—L.J.K.)

KWIX, 'Frisco, back again on 11.9 mc., 25.21 m. from 8.30 am till 2 pm. —L.J.K.

KROJ. 9.89 mc, 30.31 m.: Excellent to fair from opening until closing at 11 pm (Matthews, Fluck, Gaden).

KWIX, 9.855 mc., 30.44 m.: Very good till closing at 8.30 pm (Matthews, Edel, Fluck).

WGEX, New York, 9.55 mc., 31.41 m.: Heard with good volume at 9.30 am (Gillett).

KGEX, 'Frisco, 9.53 mc, 31.48 m.: Very good in programme to the Philippines (Matthews).

NOTE.—Calls, as from 18th August is KGEI and schedule is 8.45 pm—3 am. News from British News Room in 'Frisco is given at 10.45 pm. Programme for Philippines is given over KGEX on 7.25 mc, from 7 p.m. —L.J.K.).

WGEA, New York, 9.53 mc., 31.48 m.: Heard at 5.15 pm (Young.)

KRCA, 'Frisco, 9.49 mc., 31.61 m.: Spoilt on opening at 4 pm by GW —L.J.K.

WLWO, Cincinnati, 7.57 mc, 39.60 m.: Good at 5.15 pm (Fluck).

KWY, 'Frisco, 7.56 mc., 39.66 mc.: Heard opening at 10.30 pm and copied till 11.40 pm. (Miss Sanderson).

KGEX, 'Frisco, 7.25 mc, 41.38 m.: As from August 18th is directed to the Philippines from 7 pm.—L.J.K.

WGEA, New York, 42.86 m. is good at 4.45 pm (Young).

KROJ, 'Frisco, 6.10 mc, 49.15 m.: Heard closing at 5.45 pm (Miss Sanderson). (Very good signal, too, after WNRA withdraws at 4 o'clock. —L.J.K.).

WNRA, New York, 6.10 mc, 49.15 m.: Do not know when opens, but annoys KROJ till 4 p.m.—L.J.K.

SOUTH AMERICA

Brazil

PRL-7, Rio de Janiero, 30.86 Heard at 7.25 am. Fred Astaire's song "I'll Capture Her Heart," but anouncements between items was Spanish (Gillett).

Chile

CE-1180, Santiago, 25.01 m.: Fair

signal at 8.45 am (Gillett).

CE-615, Santiago, 48.78 m.: Fair volume at 10 pm on good nights (Gillett).

Ecuador

HCJB, Quito, 9.958 mc, and 12.46 mc., still very good in morning until noon (Matthews).

GREAT BRITAIN

Mr. Matthews, of Perth, reports: G.S.V., 17.81 mc.; GSG, 17.79; GWE 15.435, and GSO, 15.18 mc., all good at night, the last being the best.

He finds GSB, 9.51 and GRJ 7.32 mc., excellent in the mornings, often good till 1 pm.

Mr. Gillett says GRU is now officially listed in "London Calling" as 31.73 m.

U.S.S.R.

Leningrad on 25.79 and 30.85 m. is heard at 2.05 am in relay with Moscow on 30.43 m (Edel).

Moscow on 22.05 m. good at 2.15 pm, and on 28.72 m at 2.45 pm (Young).

Moscow gives news in English at 2.45 pm over 25.36, 25.79 and 28.72 m.—L.J.K.

Khabarovsk on 50.54 m, relays Moscow at 6.30 and 8.30 am; 1.59 to 3.15 pm and at 7.30 and 11 pm (Edel).

West Indies

COCU, Havana, 7.175 mc, 41.82 m.: Heard him announce at 8.45 pm (Young).

Slogan is: "Radio Emisora Oriente" —L.J.K.

At 10.10 pm on approximately 23.06 m. Moscow gives full schedules of roadcasts in English. Space does not rmit of full list, but some are:—

8.47 to 9.27 am, 19.85, 19.7 and 19.05 metres.

10 am till noon 19.05 m.

9—10.20 pm, 19.05 m.

9.20—9.40 pm to Australia 24.47 m (not always a good signal).

9.40—10.20, 25.24 and 28.72 m. and for the all-nighters, to India 1 am on 25.36 m. To U.S.A. at 2 am on 19.05 and from 3 till 8 am to Great Britain on 41.10 metres.

THE EAST

China

XGOY, Chungking: Hear him every morning and every night on 25.19 m. but signal has dropped to R5. Also hear them on 41.96 and 31.10 m. (Young). (Glad to have Mr. Young's confirmation that XGOY has moved from 41.8 m.—L.J.K.).

XGOY, Chungking, on 15.20 mc., 19.73 m. calls Moscow at 9 pm irregularly (Gandy).

India

. . ., India, 14.57 mc, 20.58 m.: See "New Stations." Also for 25.11 and 25.77m.

VUD-, Delhi, 15.19 mc., 19.75 m.: Opens in French at 8 pm—L.J.K.

VUD-2, Delhi, 7.295 mc., 41.15 m.: Heard at 8.20 am (Gillett). R6 at 11 pm (Gandy).

VUC-2, Calcutta, 41.61 m.: Good at 9.15 pm (Young).

MISCELLANEOUS

Army Testing

JCJC, Jerusalem, 7.22 mc, 41.55 m: Opens at 1 am with strong signal (Gillett).

Arabia

ZNR, Aden, 12.11 mc, 24.77 m.: Is a fair signal at 2.35 am with Arabic type programme (Gillett).

British Mediterranean Station on 31.03 and 41.58 m. gives news at 2.45 am (Gillett).

Madagascar

Radio Tananarive on 48.62 m is only fair strength on opening at 1 am (Gillett).

Mexico

XERQ, 9.615 mc, 31.21 m.: Very good at 10 am (Matthews).

XEWW on 31.58 m.: Heard as late or early as 3.15 am after opening at midnight. Very good at 3 pm (Gandy). (Gillett).

Turkey

TAP, Ankara, 31.70 m.: News daily at 3 am. On Fridays at 6.30 am gives talk to British Isles (Gillett).

Portugal

CSW-7, 9.735 mc, 30.82 m.: Very good when closing at 11 am. Announcements easily recognised (Matthews).

Location Unknown

WSCO, 8.00 mc, 37.48 m.: Heard Bob Hope Show one Wednesday night. Very good signal excepting for morse. (Gillett, Edel).

O.K. at 10.30 pm (Young).

WFPA, 8.02 mc, 37.40 m. See "New Stations."

Egypt

SU-, Cairo, 7.50 mc., 40.00 m.: Announces in English at 1.45 am. Gives time as quarter to 7 and says, "This is Cairo." (Matthews).

(Must have daylight saving in Cairo as ordinarily they are 8 hours behind Sydney.—L.J.K.)

Syria

Radio Levant, Beirut, 8.035 mc, 37.34 m.: Messrs. Matthews and Edel both report this station as being heard on or about this new frequency (which is that recently held by CNR1, at Rabat, and not mentioned as heard for some time.)

What They Say

In the first World War our radio and sound production just about equalled one week's production in World War II. . . . Battles are won and lost on the strength of communications. Some of Rommel's earlier successes in Africa were due not so much to the numbers of his tanks as to the superiority of his communications.—Rear Admiral Stanford C. Hooper, U.S. Navy, writing in the "Proceedings of the I.R.E."

Found, while primrosing in Kent: strands of silver-coated radio dislocation paper. . . . Zoe Farmar, writing in "News Chronicle."

FM is of age and has come to stay. . . . It now stands on the threshold of as tremendous a development as did standard broadcasting in the 1920's.—F.C.C. Chairman, J. L. Fly, at the fifth annual meeting of FM Broadcasters, Inc.

★

B.B.C. Income.

It is understood that the Government grant to the B.B.C. has been cut by one million pounds—from £10,000,000 to £9,000,000—in the Civil Estimates just out.

★

Gramophone Bible.

The American Foundation for the Blind has recently completed a recording of the Bible. This "talking-book" comprises 169 discs, of the slow-speed (24 r.p.m.) type, and takes a little over 84 hours to reproduce.

★

A new recorder developed by Fonda Corp. of New York provides eight hours of recording on a 350-foot cellophane tape. The endless ribbon of cellophane passes over a ring of idler wheels at a speed of about 40 feet per minute. One loop runs over a felt bed where the stylus embosses a groove of constant depth, modulation being applied laterally. The tape is one inch wide and accommodates 60 adjacent grooves. Permanent gem points, producing no shavings, are used for both recording and play-back.

★

An "electronic ear," called the "Sonotest," is now being used in ordnance plants to test shell cases for the 20-mm. automatic cannon used in fighter planes and on warships. The sound caused by dropping shells on an anvil is picked up by a microphone and fed through a series of tubes. Perfect shells have a different vibration frequency and will ring longer than damaged ones. Relays light green indicator lamps if the shells are good and red if they are imperfect.

SPEEDY QUERY SERVICE

Conducted under the personal supervision of A. G. HULL

W.H. (Brighton) is worried about unbalanced push-pull valves.

A.—When push-pull was first introduced in the early days it was quite common to find writers who stipulated that each valve must be biassed separately and balanced by means of the bias so that each valve would draw exactly the same plate current. The whole idea died a natural death and is seldom encountered these days, except perhaps in the selection of a couple of valves which match up on a valve checker, indicating similar characteristics. We doubt if there are any grounds for your fears and even if the valves are slightly different it is not certain that they would be exactly similar in every way even if they were biassed differently in order to bring their plate currents to a similar figure. You would need to have a considerable amount of unbalance before the effect would be noticeable to the ear.

●

T.T. (Atherton) does not agree with one of our contributors.

A.—Quite a few of our articles are published for what they are worth and we would hate to take the full responsibility for every opinion expressed, especially about subjects which are extremely contentious even amongst recognised authorities. We find that we get into worse trouble if we start to blue pencil the contributions too much and so we publish them in full under the name of the author. Of course we take precautions to avoid as far as possible the publication of unsound or incorrect statements, but the point you raise is one about which experts could argue for hours.

●

K.B.R. (Kyogle) has several suggestions for improvements to our journal.

A.—Yes, we readily agree that the ideas you mention would be a vast improvement, but surely you appreciate that it is quite impossible at the moment to divert half a dozen technicians and laboratory full of equipment from the war effort in order to work out new and original ideas for the sole benefit of our enthusiastic readers. We can only ask you to wait until the war has been brought to a satisfactory finish and then we will be able to do things the way we would like to do, not the way we are compelled to do by circumstances.

At the same time, there is one point on which we do not agree, and that is in regard to reprinted articles. Don't forget that magazines like the Reader's Digest use nothing but reprints and are very popular. Within reason we think it is quite sound policy to reprint those articles which appeal to us. Keep hoping for the best.

●

C.F. (Melbourne) has a plan for post-war manufacture of components.

A.—We never could understand the virtual monopoly which existed in the manufacture of gangs before the war. We feel sure that it was simply a combination of circumstances, the popular gangs being well-made, reasonably priced and were accepted as a standard by coil and dial manufacturers. There does not seem to be any reason why you couldn't crack the post-war market with a good job if you got properly organised and had the necessary capacity for production and testing. There is no essential need to use aluminium for plates as brass or steel would serve.

●

T.G.K. (Sydney) enquires about kits of parts for a set published some years ago.

A.—No, you cannot buy a kit of parts for these sets now. Certain vital components, such as gang condensers, and speakers are controlled and cannot be bought readily. Some components are in plentiful supply, but it is against our policy to advocate re-building jobs which require a number of components.

●

S.G. (Hurlstone Park) intends to fit out a caravan and go on a land cruise, selling and servicing radio sets, when the war is over.

A.—Seems to us as though there will be a great many people with the same idea. Of course there will be a big demand for new sets and also plenty of old ones needing service, but even in the smallest of the furthest outback townships there seems to be a local reader of "Radio World" who can do this sort of work. It would be good fun and a most interesting life, but you wouldn't want to count too much on getting a continuity of work to keep you going eight hours a day, every day.

J.L. (Brisbane) seems to doubt the effects of inverse feedback.

A.—We cannot understand your attitude to this subject and feel sure you have been entirely misled. Inverse feedback makes an enormous difference when applied to beam power valves, a difference immediately noticeable to the naked ear (as you might say). By no means is the difference purely academic or only detectable in a laboratory. If the feedback is being properly applied it should cut back the gain of the amplifier to a considerable extent.

●

"Essay" (Double Bay) complains about high prices being asked for gramophone motors and pick-ups.

A.—Theoretically, all secondhand goods are covered by a rating that the maximum price at which they can be sold is 75 per cent. of their original price when new, or something like th[illegible] To find owners who are prepared to [illegible] at that figure may be difficult at the moment. We noticed recently where an advertiser in the daily papers was offering £20 for a good pick-up and motor. New prices for pick-ups ranged about £3 to £5 and about £4 to £8 for motors.

●

D.F. (Armadale, Vic.) enquires about a certain valve type.

A.—This valve is on the "secret" list, being specially developed for Radar use. At the moment we cannot release any details, but, as soon as we can, we will. There are some treats in store for enthusiasts when this spot of bother has been properly finalised.

ELECTRICITY IN EGYPT

(Continued from page 5)

be established, as objects in that region were plated with gold and silver as long as 4000 years ago.

The first news concerning the discovery was brought to America by an expatriated German scientific writer, Willy Ley. The facts he reported came to the attention of Willard Gray, an electrical engineer at General Electric's Pittsfield plant. Mr. Gray built an exact duplicate of the ancient device, using copper sulphate as an electrolyte, and found that the cell operated perfectly.

VALVE TESTER

(Continued from page 5)

6D6, 57, 58, 77, 78, 80, 42 all sl[illegible] about 20 ma; EL3, CL4, 25Z6, EBL1 about 35-40 ma, pentodes of the continental A and C series about 30 [illegible] converters between 20-25, and so o[illegible]

Other elements in the valve show very little current flow: Screen grids 2-3 ma, diodes 2-5 ma, pentode plates nothing at all. Inter-electrode shorts can be detected by variations in these valves. If, for instance, screen and control grids are leaking or shorting, the screen current will be increased up to equality with the grid current.

Shorts to cathode will be indicated by the meter behaving as if A.C. was flowing through, which actually is the case. A moving coil meter will just kick and return to zero, while a moving iron type will show a big deflection.

The tester just described is not in my possession any more, but I have had one working on the same principles (and built together with a test speaker and other devices) operating for the last three years and it has always given me faithful service (touch wood!).

Eimac Vacuum Pump

To create the nearly perfect vacuum within Eimac valves and put vaccum pumping on a mass production basis, Eimac Engineers developed a whole new vacuum technique and much special equipment.

One of the devices resulting from these years of research and development is the Eimac HV-1 Diffusion Pump together with the special vaporizing oil which it requires.

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This Eimac HV-1 pump is one good reason why Eimac valves are unconditionally guaranteed against premature failures which are caused by gas released internally. This reason plus outstanding performance, great stamina and others have made Eimac valves first choice of leading Engineers throughout the world.

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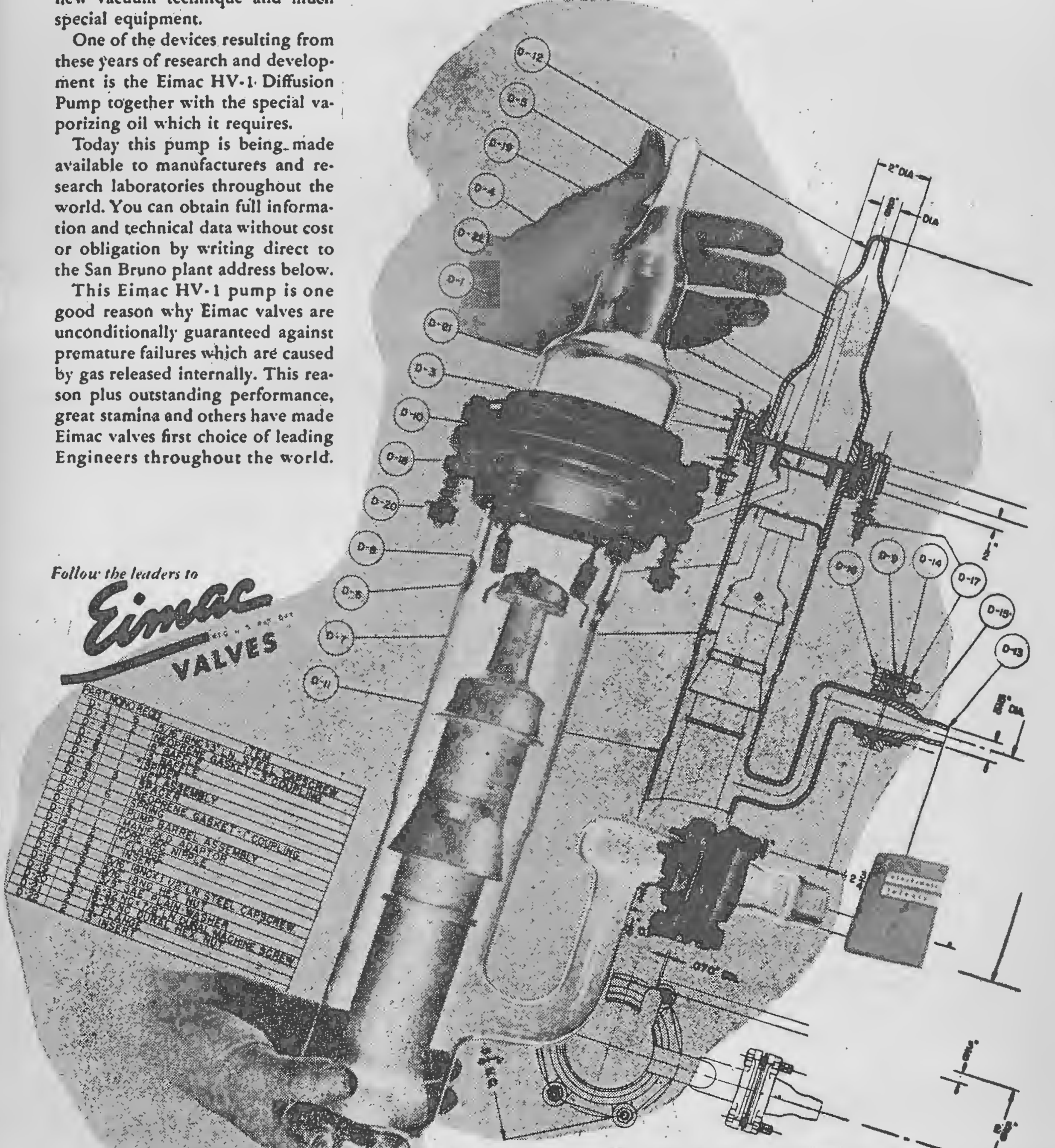

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—H.B., Western Australia

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