THE AUSTRALASIAN Radio World

1/6

Vol. 15 . . . No. 5 December 20, 1950

ASSOCIATED WITH
AUSTRALIAN
RADIO & ELECTRONICS

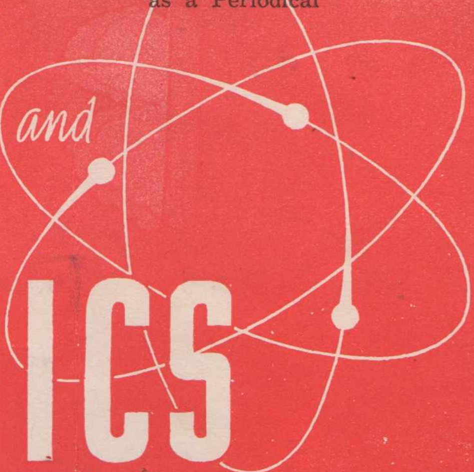
COMPOSITE ISSUE

Registered in Australia for transmission
by post as a periodical.

Registered in Australia
For Transmission by Post
as a Periodical

USTRALIAN RADIO and ELECTRONICS

incorporating
AUSTRALASIAN RADIO WORLD



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AND

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VOL. 6, No. 1

1/6

AUSTRALIAN Radio and Electronics

and incorporating

THE AUSTRALASIAN

RADIO WORLD

Vol. 15, No. 5 — COMPOSITE ISSUE — December, 1950

CONTENTS

OUR COVER

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Editorial December, 1950

IN this composite December issue, it is our desire to make known—nationally wide—all about the important transformation of "Australasian Radio World" to "AUSTRALIAN RADIO & ELECTRONICS".

Last month you were informed that "Australasian Radio World" had been taken over by a new Company, so we have pleasure in taking this opportunity of introducing ourselves to old friends, and new.

For your information our Associate Company—Radio & Electronics (N.Z.) Ltd.—has been producing "R. & E.", a New Zealand monthly magazine" since April, 1946, and, for some time, this journal has been imported to Australia, wherein it has enjoyed a highly esteemed reputation for the practical manner in presenting technical and scientific literature to its readers.

As the circulation of "R. & E." has increased tremendously here, it was felt that, if the journal was produced in Australia, re-edited to suit Australian conditions (whilst maintaining the same high technical standard), we would be in a more favourable position to solicit local advertising from the Australian Radio and Electrical Industry, and thus be able to produce bigger and better issues, which would be mutually beneficial to all concerned—especially our readers.

Also, in taking over the rights of "Australasian Radio World"—an old-established journal—and incorporating it into the new "AUSTRALIAN RADIO & ELECTRONICS" it is now possible for us to publish a combined periodical, retaining the best features of both.

As an entree, shall we say, to the new combined "R. & E.", our Company has just released on the market here, a new publication known as "THE R. & E. DIGEST OF CIRCUITS" Australian Edition—which, in progressive handbook form, covers everything from the simplest Crystal Sets to Multi-valve Receivers, Audio Amplifiers and Test Equipment. Although it is only "just out" on the bookstalls, we greatly appreciate the commending interest displayed to date.

Next month, a new year commences—so does your new journal—wherein many and varied topics will be covered, with special attention being paid to a PRACTICAL experimental TELEVISION PROJECT for home construction, by the production of images on a Cathode-Ray Tube Screen, without the use of costly camera tubes, such as Iconoscope, Emitron, Image Dissector, etc.

Our close liaison with New Zealand, and other overseas tie-ups, assures Engineers, Servicemen, Dealers, "Hams" and Hobbyists, that our articles will bring to them the latest developments for the advancement of Radio and Electronic knowledge.

In conclusion, we wish to extend our sincere thanks for your past patronage, and trust you will remain one of the new Journal's ardent followers . . . for we shall be "on the beam" . . . "Looking After Old Friends—And Looking Forward to New".

The Editor and Staff of Australian "Radio & Electronics" can offer our readers and advertisers, no better wish at this momentous time, than that they share with us, the old happiness of Yuletide and the achievements of the approaching New Year and the New Era it brings.

—LAY W. CRANCH.

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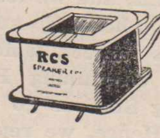

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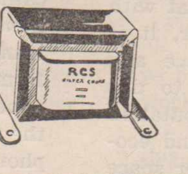

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The R. & E. Amateur Television Project For Home Construction

ALTHOUGH the following extracts of articles have been already published in the September and October issues of "RADIO AND ELECTRONICS" (New Zealand Edition), and circulated to many Australian readers, we ask these readers to bear with us the reprinting of said articles.

The reason for this request is because of combining "AUSTRALASIAN RADIO WORLD" to that of the new Australian "RADIO AND ELECTRONICS". Therefore, a great many "Australasian Radio World" followers, in all probability, will not have seen, let alone have read, these important editorials, and we feel it absolutely necessary that everyone should be, shall we say, "in on the ground floor", otherwise, numerous enthusiasts may have difficulty in catching up with the future features on this subject, which have been especially designed to allow HOME CONSTRUCTORS the opportunity of gaining PRACTICAL EXPERIENCE in Television, before the actual Television Transmitting Stations go "on the air" at some future date.

Hence, we reprint in this month's composite issue "Television and the Amateur", also "Television for the Amateur".

TELEVISION AND THE AMATEUR

In one of the latest issues of Q.S.T. to come to hand, there is an article which describes itself as a Progress Report on Amateur Television. This is a most interesting and informative document, and could well be included in that class of thing which, in the words of the classic "makes you think".

Many amateurs and enthusiasts seem to think and with considerable justification, too, that with full-scale television as far away as ever, it is impossible for amateur television to have any existence here, but we do not subscribe to this view. The amateur transmitter has a reputation for ingenuity in surmounting technical and economic difficulties. He also may have ether space allotted at some future date for television transmission so that it seems a pity that the amount of activity which is going on is almost zero.

Television demonstrations have been given by several renowned Companies to the public of Australia, which created wide interest and was highly publicised by the Press. **This was not actual television transmission per medium of the ether, since the video signals generated were simply sent over a wire link before being reproduced.** Now this required very costly equipment, and we do not suggest that sort of gear is what amateurs, without any but their own financial resources, should necessarily attempt, but there are a number of ways in which they could even now blaze a new trail, and this entails the expenditure of no more than many amateurs spend on an ordinary transmitter.

One of the ways in which amateur experimentation could well start would be by building a simple flying spot type of scanner. With this system a camera tube is not needed. The trick is to produce the scanning lines, or raster, on the face of a **cathode ray tube** of the ordinary kind. This can be easily done by using a pair or ordinary time-bases, which for initial experiments need not even be locked to any particular frequency, but even be free-running. This cathode ray tube with its scanned surface can then act as the light source. If we place a transparency in front of it, and allow the light from the tube to fall on an ordinary vacuum photocell, the light intensity is modulated by the transparency, and the amplified output of the photocell is the actual video signal, which can be transmitted over the air **or along lines.** In order to demonstrate the complete system on the bench, all that is needed is a second cathode ray tube, and a video-frequency amplifier following the photocell. The same pair of time-bases can be used for both tubes, thus eliminating synchronization completely, and then all that needs to be done to reproduce the picture on the face of the "receiving" tube is to apply the output of the video amplifier to the control grid.

This bench set-up could be used very effectively to demonstrate such things as the way in which the picture quality alters if the number of scanning lines, and the bandwidth of the video amplifier are changed, and with little extra complication could form the basis of a transmitter for still, and even moving pictures. For transmission, some kind of synchronization would be necessary, because it would no longer be possible to directly connect the scanning of the receiving tube with that of the transmitting one. However, for experimental work over short distances, there is little doubt that satisfactory synchronization could be effected by locking the time-base oscillators at both ends of the chain to the 50 cycles per sec. mains. This would eliminate the need for complicated circuits producing and transmitting synch. pulses and for separating these from the video signal at the receiver in order to use them.

Of course, there are one or two difficulties that would have to be overcome. It may be difficult to get enough light output from an ordinary green screen cathode ray tube to give a strong enough signal output from the photocell, but there are various ways in which this might be tackled. For instance, with a high-speed trace such as would be required, an ordinary cathode ray tube would probably stand up quite well with a considerable excess of H.T. voltage, and under these conditions it would certainly give a much greater light output. The tubes with the light blue screen of high actinic value would no doubt be preferable, and it may be that some of these are available from war disposal sources. Again, it may essential to use a photocell of the electron-multiplier type in order to get a high enough signal-to-noise ratio.

The point is however, that if someone got down to some genuine experimentation along these lines, the whole thing might prove to be easier than it appears. At any rate, there are plenty of us these days with a liberal supply of cheap cathode ray tubes, and it would at least show that the day of amateur initiative and resource is not over if someone were to try this and other schemes that might be thought up.

TELEVISION FOR THE AMATEUR

Readers may be surprised to note that these two sub-titles are almost identical—but not quite. It heralds, not the fact that experimental television circuits suitable for amateur use could be devised, but that this Journal has decided that the time is ripe for some work to be done along these lines, and that commencing in an early issue, some simple gear will be described, that will actually produce an image on the face of a cathode ray tube. This equipment is, of course, designed more particularly for amateur transmitters,, **but there is no reason why anyone interested should not build it,** since there is no legislation against the production of images on a tube as long as no radio transmission is indulged in!

Some little time ago, the writer was chatting with an amateur transmitter of several years' standing, who asked, in effect, where "ham" radio was going from here. "We have", he said, "transmitted on 80 metres, with key and mike, and we have worked DX with a multitude of countries. We have done the same thing on 40, 20 and 10, not to mention 6, and we have nattered locally on one or another of these bands for years. Now we're starting to natter on the very high frequencies, too, but once you've built the gear the procedure is just the same as it was years ago. So what are we going to do that's new? It looks as if we'll have to wait for television."

A good many amateurs will probably disagree with the attitude shown by our friend, but there are probably a good many, too, who would welcome something quite new in the way of something to experiment with. Television as a public service is on the way in Australia, and overseas publications reflect the tremendous interest in it in Britain and America. We do not know yet what will happen here, but as we have said before, there is no reason why the amateur should not start to take a practical interest, if some means can be found of circumventing the problems of expense and equipment.

After giving the matter some considerable thought, we have come to the conclusion that owing to our own peculiar circumstances, these major difficulties are by no means insurmountable, and that to make a start now would not be outside the bounds of possibility.

It has been decided, therefore, to institute the "R. and E. Amateur Television Project" forthwith, and indeed some of the required laboratory work has already been undertaken. Now, there are a number of ways in which a project like this could be tackled. One would be to draw up the plan of action, do the necessary developmental work, and when this was satisfactorily completed, burst into print with the whole story as a **fait accompli.** This would be all very well, but while the experimental work was going on, no one but ourselves would have the interesting part of the job—namely, making the gear. With techniques that are bound to be very new and strange to many readers, it would be better, we consider, to tackle the matter in a different way altogether.

In the first place, the plan of action must still be drawn up, and development work must still be carried out. But the work will divide itself into a number of more or less watertight compartments, each with its own set of problems which can be met, solved, and then stored up while another compartment is being dealt with. Jobs like these are not easy, though, and a num-

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50	85	4	0
100	40	2	6
120	20	2	0
175	20	2	0
245	55	4	0
250	20	2	0
300	18	2	0
300	55	4	0
350	25	2	6
435	55	4	0
500	27	2	6
500	30	2	6
500	55	4	0
600	40	2	6
700	20	2	0
850	20	2	0
1,000	55	4	0
1,000	85	4	0
1,000	120	5	0
1,500	10	2	0
2,000	20	2	0
2,000	25	2	6
2,500	10	2	0
2,500	20	2	0
2,500	85	4	0
3,000	18	2	0
3,000	20	2	0
3,300	20	2	0
3,500	10	2	0
3,750	30	2	6
4,000	20	2	0
4,500	12	2	0
5,000	20	2	0
5,000	55	4	0
10,000	55	4	0
12,500	20	2	0
15,000	30	2	6
24,000	55	4	0
30,000	85	4	0
100,000	120	5	0

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547 ELIZ ST. MELBOURNE

ber of difficulties can be foreseen, but from the point of view of those who will want to duplicate the work for themselves, and in the process learn something of the **practical side** of television technique, it would be much better, we think, if we break up the whole project into its component parts, and describe each one, and its particular problems as they crop up, and as they are solved.

By doing things in this way, **the reader would virtually be brought into the laboratories with us.** He would know what the difficulties are before they have been met, and would be able to follow **the progress of the work just as if he were here engaged on the project with us. By the time he has followed us through our development of the equipment, he would know as much as we have found out ourselves, and this is always considerably more than can be put into an ordinary article after the work has been completed.**

What then, are we to tackle? First of all, the production of images of still transparencies. This will be attempted by the flying spot scanning method, and in principle, the gear will be identical to that used by television stations to generate video signals from moving picture film. This will constitute the first part of the project, and a very important one it is. The great advantage of it is that it enables a video signal to be produced without the possession of a special camera tube —iconoscope, emitron, image dissector, or what have you. And it will be possible to get results of some sort using ordinary cathode ray tubes—as for example, the 5BPIs so many of which have been bought for a song from war assets stock. One of the things that cannot yet be foreseen is the actual picture quality it will be possible to get in this way. **If things were available here that unfortunately are not, the ideal would be to use white-screen magnetically deflected picture tubes such as are used in television receivers, and there is no doubt at all that picture quality comparable with standard televsion reception could be obtained in this way. But the idea is to see just what we can do with our own limited resources. But that is looking ahead a little. Not too far, however, for we hope to publish the first of our series of articles on the "R. and E. Amateur TV Project" in the January issue of this journal.**

Notes by the Way

These pages have always encouraged the new shortwave listener and have invariably requested that they do not hesitate sending their loggings even if it is only the more easily identified stations.

This month I have a letter from W. R. Anderson, of Paddington, New South Wales, who has only recently taken up shortwave listening and so far has not received any verification.

However, he is hopeful that he will receive them from:—

ZL3, KWID, VLH4, VLW3, LKV, ZL4, HER5, YDC, VLC5, VLB4 and KRCA.

Well, that is a very good start, and doubtless Mr. Anderson will be rewarded for his patience.

Inter Alia, Mr. Anderson says: "The only Magazine I buy now is A.R.W., as I think that this magazine caters more for the S.W.L. than any other publication." Thank you Mr. Anderson, and while you state that the stations that you have so far logged are only classed as "locals" by veterans, you will find that they will be a good guide for you, where to look for other stations.

I hope you will become a regular subscriber and wish you every success.

"I have decided to accept your invitation to write a letter with my 30/- for subscription for what I consider the best radio magazine on the market at the moment. I read your magazine as it is all radio and does not embrace subjects that have no interest to me, and further, I enjoy the general tone of the magazine because of its friendly manner, and yet it imparts the information needed by enthusiasts such as I. I had not the faintest idea of how a radio worked on my discharge from the Army in 1944, and at that time, like many others, I was like a fish out of water. I was hard to live with, I am afraid. So I decided to give radio a go and since then it has proved a most absorbing subject, but sometimes I fear that I am not much easier to live with, especially when some of the intermittent faults occur. I am a farmer, actually and don't have much spare time to work on radio but I certainly enjoy what time I have. I don't know of another occupation or hobby that binds people together like radio." — **Keith Dunse, "Kergunyak," Ricketts Marsh, Victoria.**

RECORDING

The Magnetic Tape

THE technique of magnetic recording on tape and wire, and more recently, on paper disc, has made spectacular progress over the past decade. Before World War II, magnetic recording was little more than a laboratory experiment, and apart from the B.B.C.'s expensive and elaborate Marconi-Stille equipment it had few practical applications.

By
P. D. THOMAS
Abernethy Road
Wattle Grove, W.A.

Several developments in technique and materials, mostly during the war years, changed the whole picture, and now it is possible for an amateur to make a recorder which will give a performance as good as, if not better than, that of the pre-war professional steel-tape recorder. Commercial models of tape, wire and paper disc recorders, some of them made in Australia, are now on the market and many amateurs are beginning to dabble in this branch of audio engineering.

This article is intended to give these and others who are interested in magnetic recording an approach to the theory of their subject in terms of elementary radio and electrical theory; with particular emphasis on the effect of using supersonic bias, the operation of which is at present much misunderstood.

Basic Elements

The basis of all present-day magnetic recording systems is a length or disc of steel or similar material, capable of being magnetized, which is moved at a constant or predetermined velocity past the closely-spaced pole pieces of an electromagnet having a core of soft iron or other high-permeability substance. The narrow gap between the pole pieces is at right angles to the direction of movement of the recording medium.

If a current is passed through the electromagnet the steel retains a residual flux after it has passed the gap. The polarity and flux density of any given point along the track depend upon the polarity and flux density across the gap between the magnet pole pieces at the moment when that point was passing the gap; and polarity and flux density in the gap depend in turn upon the direction and strength of the current in the winding. Therefore if an alternating current is passed through the winding, a series of alternate poles appears along the steel track, as shown in Fig. 1.

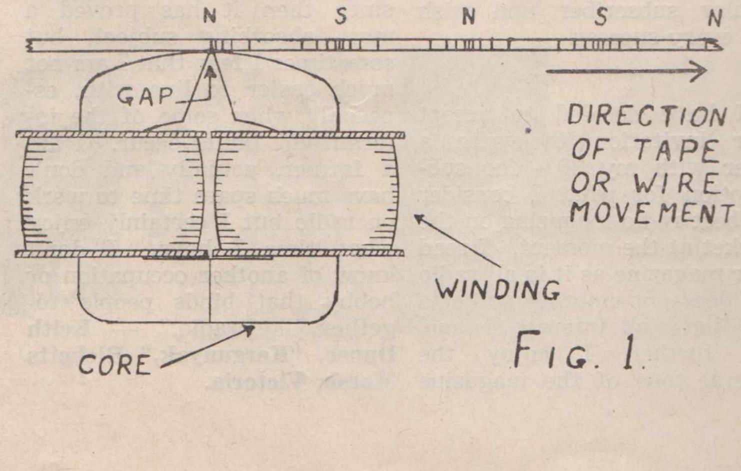

Fig. 1

Any electromagnetic process can be reversed, and if the magnetized steel is moved past the pole pieces again, the series of poles will induce in the winding a current which will be roughly a replica of the original alternating current passed through this winding. As there are losses in the process, its amplitude will be much lower than that of the original; and as will be explained later, there will be some distortion of the waveform.

It will be fairly obvious that the frequency of the induced current will depend upon the velocity of the magnetized steel, just as the frequency of an alternating current recorded on disc may be changed on reproduction by varying the turntable speed. However, it will be assumed that the velocity is the same in all cases.

Recording on Tape or Wire

The steel recording medium is usually made in the form of a tape or wire, which can be handled easily and drawn past

(Continued on next page)

RECORDING

(Continued)

the pole-pieces at the required speed. It may be either a solid steel or alloy, or a colloid of such a material coating or incorporated in a paper or plastic tape. The principles are the same in each case; only the practical details differ.

The electromagnet, known as the recording head, consists basically of a toroidal winding on a square or circular soft iron or alloy core broken only by a thin non-magnetic gap. The tape or wire moves past the outer end of this gap, at a tangent to the annular magnetic path around the core. This is illustrated in Fig. 1.

The same head may be used for both recording and reproducing, since, as previously described, the one process is simply a reversal of the other.

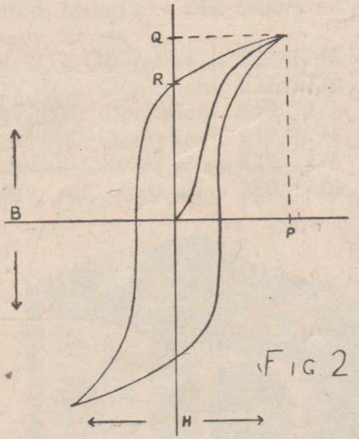

FIG 2

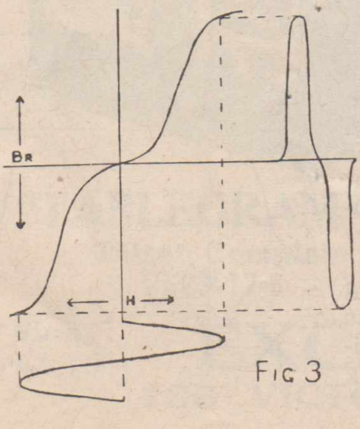

Fig 3

With any given recorded signal, the induced voltage across the reproducing, or playback head will be proportional to the following factors:

(1) The number of turns on the winding;

(2) The flux density in the tape or wire;

(3) The frequency of the A.C. recorded;

(4) The width of the gap in the core.

(1) is limited by the core size and wire thickness, (2) by the recording flux density which in turn is limited by the saturation point, (3) is determined by the recorded signal, and (4) is a compromise with the required maximum frequency and the tape, etc, velocity, as will be explained later.

Frequency Response

The lower frequency limit is reached when the change in flux density is so slow that the voltage induced in the playback head is too small to be of practical use. The rate of change, and hence the induced voltage, is proportional to frequency.

The upper frequency limit is chiefly determined by the width of the gap in the record-playback head core, but it is also affected by the tape or wire velocity.

At the frequency where one wavelength equals the gap width, the response is zero, since the flux in one direction due to one half-cycle cancels out that in the opposite direction due to the next half-cycle. This represents the cut-off frequency and in practice the maximum useful frequency would be about half this to give a recognizable waveform. Note that the wave-length referred to is derived from the tape or wire velocity and not the velocity of sound waves, etc., in air. It is found from the formula:

$$\text{Wavelength (inches)} = \frac{\text{Velocity (inches per second)}}{\text{Frequency (c/sec.)}}$$

Thus the wavelength of a 1,000 c/s signal with a tape velocity of 10in. per second is

$$\left(\frac{10}{1{,}000}\right) \text{ inches}$$

or .01in. A gap of .005in. or smaller would be required to handle this frequency. If the tape velocity were decreased to 5in. per second, the wavelength would become

$$\left(\frac{5}{1{,}000}\right) \text{ inches}$$

or .005in.; and at this speed a signal of 5,000 c/s would have a wavelength of

$$\left(\frac{5}{5{,}000}\right) \text{ inches}$$

or .001in., and would require a gap no wider than .0005in.

Between the upper and lower limits, the overall frequency response is not linear. While the voltage induced in the playback head tends to increase with frequency, the flux produced by the recording head decreases towards the cut-off frequency due to the effect of the gap width; and to keep the overall response linear, it is necessary in practice to boost the higher audio frequencies in recording. This, however, is a simple process and is easily arranged for in the design of the amplifier feeding the record head.

Waveform Distortion

It is possible to plot a curve of residual flux density in the recording medium against magnetizing force, derived from the B/H curve of the steel or alloy used. An example of the latter curve is shown in Fig. 2. If the magnetizing force H corresponds

RECORDING

to point P at a given moment, the portion of tape or wire between the gap at that moment will have a flux density corresponding to point Q. When it moves on, out of the gap, the residual flux will correspond to point R. A series of values of residual flux density may be collected corresponding to several values of H varying from zero to saturation level. If these are plotted on a vertical axis against their respective values of H on a horizontal axis, a residual flux curve similar to that in Fig. 3 is obtained.

Now consider the effect of applying a sine wave to the recording head. Assuming that no distortion occurs in the head itself, the magnetizing force, H, will follow a sine curve. If this is applied to the residual flux curve, starting at zero, it will be obvious that the corresponding values of Br., and hence the voltage induced into the playback head, will not follow a sine law since the curve is non-linear. Fig. 3 shows this graphically.

Use of D.C. Bias

If the applied current is reduced somewhat in amplitude, and given a value of D.C. bias corresponding to point C on the H axis in Fig. 4, it is seen that the A.C. waveform, confined to the short linear, or nearly linear, section of the curve, is more or less undistorted. An analogy here is the operation of a valve amplifier in class "A". H corresponds to Eg, Br to Ia, and zero on the H axis, approximately, to the cut-off point.

Thus D.C. bias may be used to overcome the non-linearity of the residual flux curve with some success, but it has disadvantages. The useful amplitude range is limited by the noise level at the lower extreme, and by distortion as the curved portions are approached at the upper extreme. Also the curve is not perfectly linear over the portion used and at higher audio levels a small percentage of distortion is inevitable, exactly as in a single valve operated in class "A". This situation presumably led researchers to pursue the valve analogy, and the logical conclusion was that the problem of non-linearity could be solved in much the same way as in valve amplifiers, where two valves are operated in class "B" push-pull so that the distortion due to non-linearity is cancelled out. In theory this would be done by operating the positive half-cycles from point E, Fig. 4, and the negative half-cycles from point D. This requires that the top and bottom halves of the curve be moved so that points D and E coincide. Now, with the operating point DE, instead of C, the system operates like a class "B" amplifier, and the available amplitude may be increased considerably before saturation point is reached.

Unfortunately the top and bottom halves of the curve cannot be moved relative to each other, in the way that the bias of two separate valves is chosen. Therefore the only practicable way to achieve this effect directly would be to record the same signal twice, biased to the same value in each case but in opposite phase, simultaneously on each half of a tape. When played back, the two fluxes would be combined and the resultant waveform would be an accurate replica of the original.

Supersonic Bias

At this would present several knotty practical problems to be solved, a system of electrical separation of the operating points was sought. It is not possible to operate simultaneously on points D and E, Fig. 4, as the two voltages would cancel out and leave a total bias of zero. However, it is possible to operate on these two points alternately, changing from one to the other several times during one audio

(continued on page 19)

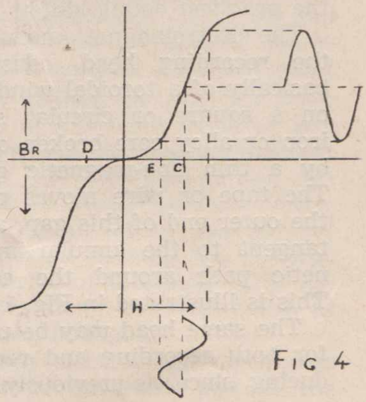

Fig 4

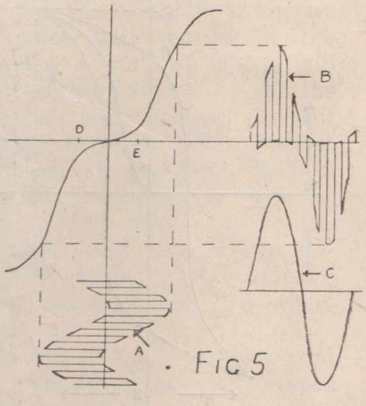

Fig 5

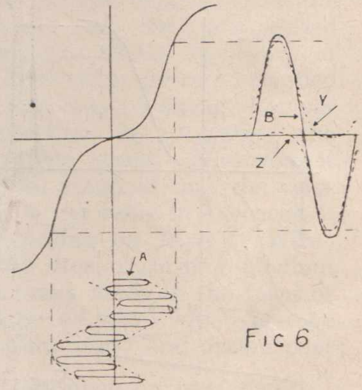

Fig 6

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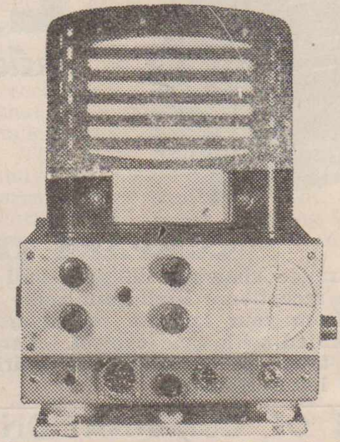

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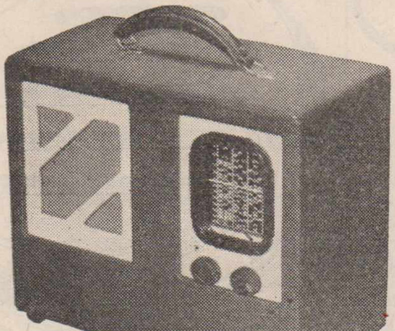

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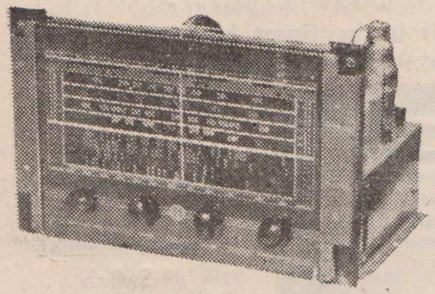

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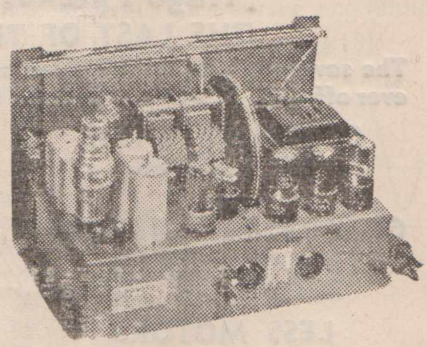

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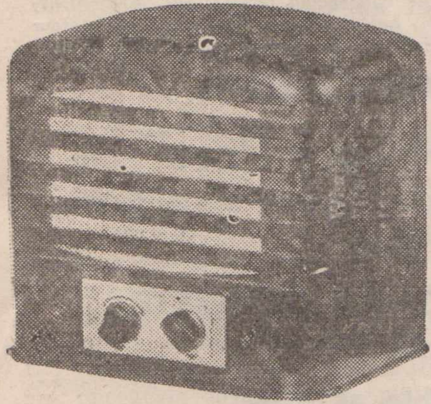

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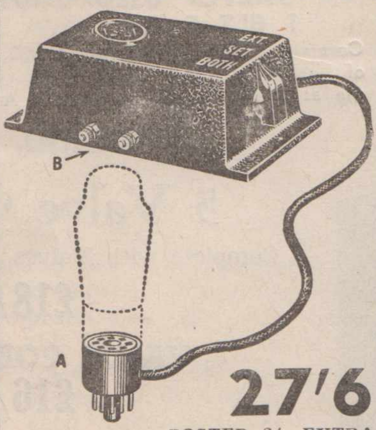

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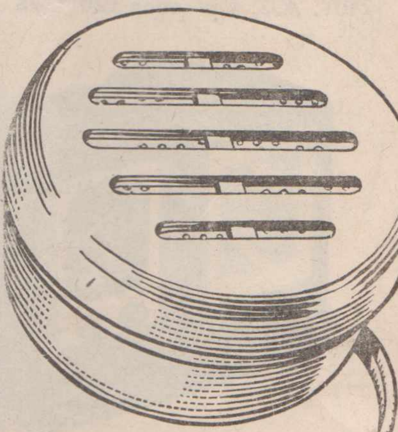

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Tracking Error in Gramophone Pick-ups

In this article the term "tracking error" is explained, and some indication is given of its importance and how it may be kept to a minimum.

Within the last year or two a great deal of work has been done on the subject of gramophone pick-ups and how improvement can be made in their characteristics. Principles new to pick-up construction have been tried in the laboratory with notable success, and some of the results of such work have even arrived at the stage of being put on the retail market.

Some of these new pick-up types such as the moving-coil and electrostatic varieties are quite suitable for home manufacture, and quite a number of articles describing their detailed construction have appeared in overseas periodicals. This has stimulated quite an amount of experimenting by amateurs and others interested in record reproduction. Practically all such articles, however, deal only with the construction of the pick-up heads themeselves, leaving to the individual important matters such as the design of the pick-up arm.

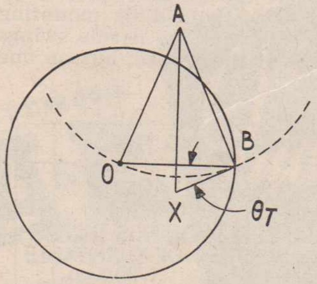


Fig. 1.

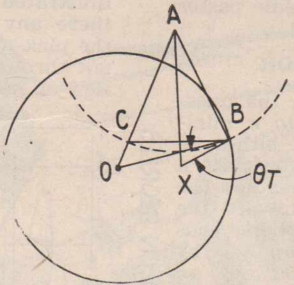


Fig. 2.

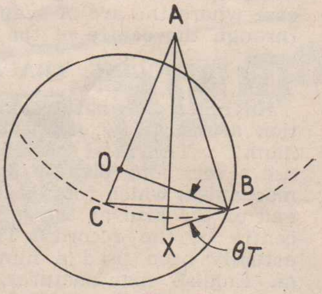


Fig. 3.

IMPORTANCE OF ARM DESIGN

In some respects, the design of a suitable arm is of just as great importance as that of the head, for however good may be the latter's characteristics, the results obtained from it can be rendered very poor by the use of a badly designed arm. It is not intended here to go into all the ramifications of arm design, but this article deals with one of the most important factors, namely, tracking error. This is very important to the proper performance of the pick-up, and luckily, can be treated quite separately from other equally important factors such as the absence of resonance and methods of counter-balancing.

WHAT IS TRACKING ERROR?

It is well known that when disc recordings are made, the cutting head, which makes the groove and simultaneously modulates it with speech or music, moves radially from the outside exactly towards the centre of the record. By this means, the lateral vibration of the recording stylus is always at right-angles to the direction of the groove. Thus, when a record is being reproduced, the playback needle should ideally be moved towards the centre in the same way as the recording stylus—i.e., radially—in order to ensure that the movement of the playing needle exactly follows that of the cutting stylus.

This ideal state of affairs could be achieved only by means of an expensive mechanical arrangement similar to that used to move the cutting head in the recording lathe, and is therefore impossible to realize economically. Instead, the pick-up is mounted on an arm of fixed length, which pivots about a point outside the area covered by the turn-table, with the result that the reproducing needle, instead of moving along a radial track, follows the arc of a circle whose radius is the distance between the pivot point, and the needle point. This is illustrated in Figs. 1, 2 and 3, in which O is the centre of the record, and A is the point on which the pick-up arm is pivoted. The full circle represents the outside perimeter of the record, while the dotted arc is the path travelled by the pick-up needle. In all three diagrams, B is the point at which the needle touches the outside groove of the record. Even a casual inspection of these diagrams is enough to show that with a mechanical arrangement of this kind it is not possible for the ideal condition for the movement of the pick-up needle to be realised over the whole travel from outside to inside on the record.

Thus the meaning of the term "tracking error" can be seen from a consideration of Fig. 1. Here BX has been drawn at right-angles to AB, the pick-up arm. Now since the head is fixed to the end of the arm in such a way that the side-to-side movement of the needle is always at right-angles to the line of the arm, BX represents the direction of movement of the needle point, caused by the lateral waves in the record groove which represent the recorded sound. Also, since AB is a radius of the dotted circle, XB must be a tangent to this circle. But OB is a radius of the record, and for the needle always to execute radial vibrations with respect to the record OB is the path on which ideally the pick-up head should move.

Thus we have OB as the line in which the needle **should** vibrate when it is at B on the record, and XB as the line in which it actually does vibrate. The angle OBX is therefore called the angular tracking error, or simply the tracking error for short. It is clear that for the best results, this error should always be as small as possible.

As the pick-up follows the record groove and moves closer to the centre of the record, the size of the tracking error changes. If a new point B is imagined, somewhere along the dotted arc OB (i.e., nearer to the centre of the disc), it can be seen from Fig. 1 that the angle OBX will be smaller than it is at the outside of the record, because the closer we go to the centre of the disc, the more nearly do OB and BX coincide. Ultimately at the centre of the record these two lines do coincide, and the tracking error is zero. However, this fact is of only academic interest, because the recording is seldom taken closer than two inches from the centre of the disc. Thus, for the state of affairs illustrated by Fig. 1, there is always some tracking error, and this is greatest at the outside of the record. It will have been noted by now that Fig. 1 is drawn for the special case where the arc of swing of the needle passes through the centre of the record.

REDUCING TRACKING ERROR

Having seen what tracking error is, the question arises, "How can it be reduced to a minimum?" The most obvious ways are either to use a very long pick-up arm, or else to devise a mechanism which rotates the pick-up head on the end of the arm as the latter swings toward the centre of the record. The latter scheme has actually been used a number of years ago by an English manufacturer, who turned out an arm whose head swivelled by means of a system of levers, and so kept the line of vibration of the needle radial with respect to the record. However, such systems are costly and difficult to manufacture satisfactorily, and are almost impossible to make both effective and pleasing in appearance.

Again, increasing the length of the arm to any useful extent is ruled out by reason of the large space required for mounting.

It is possible, however, to reduce the tracking error on 12-inch discs to a maximum of about 3° (which can be regarded as negligible) by the now well-known expedient of off-setting the pick-up head on the arm. By off-setting is meant the practice of mounting the head at a fixed angle with respect to the line of the arm, so that the lateral vibration of the needle is no longer at right-angles to the line of the arm. For a 12-inch record and a maximum tracking error of 3°, the arm can be as short as 8 inches with a properly designed arm. How this can be brought about will be seen later.

LENGTHENING THE ARM

Using the simple system of Fig. 1 in which the arc of the needle passes through the centre of the record, any desired improvement can be obtained by simply using a longer arm, as described above. The performance of such a system can be estimated from Fig. 4, which gives two curves of tracking error against length of arm. The upper curve gives the error when the needle is at the outside edge of a 12-inch record, and the lower one gives the error at a radius of 1½ inches, which can be taken as a representative figure for the end of the record. Two things are abundantly clear from these curves: First, that the error at the outside of a 12-inch record is very great with short arms, and requires a very long one to reduce it to a reasonable figure; and secondly, that a reasonably short arm reduces the difference between the errors at the outside and inside of the record at about the same rate as the maximum error is reduced. This question of the difference between maximum and minimum errors with a given arm arrangement is an important one with respect to finding the best angle at which to offset the head, in cases where this can be done and in finding the remaining maximum error when the offset is taken into account. From Fig. 4 it can be seen that the arm would have to be impossibly long in order that the tracking error may be reduced to 3° at the outside of the disc.

OTHER METHODS

The discussion so far has centred on the case illustrated in Fig. 1, but the question arises, "Is there any advantage to be gained by mounting the pick-up in such a way that the needle swings not through the centre of the record, but on one side of it?"

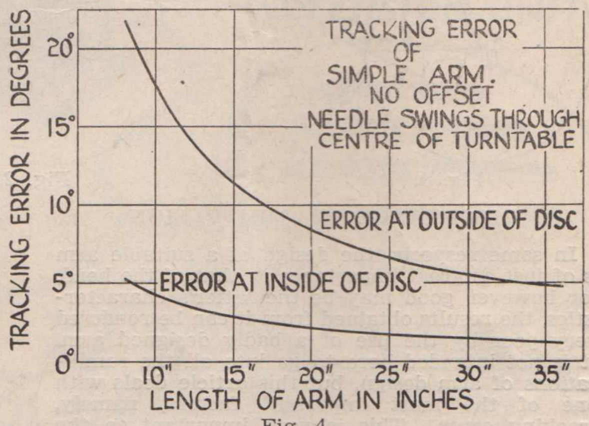
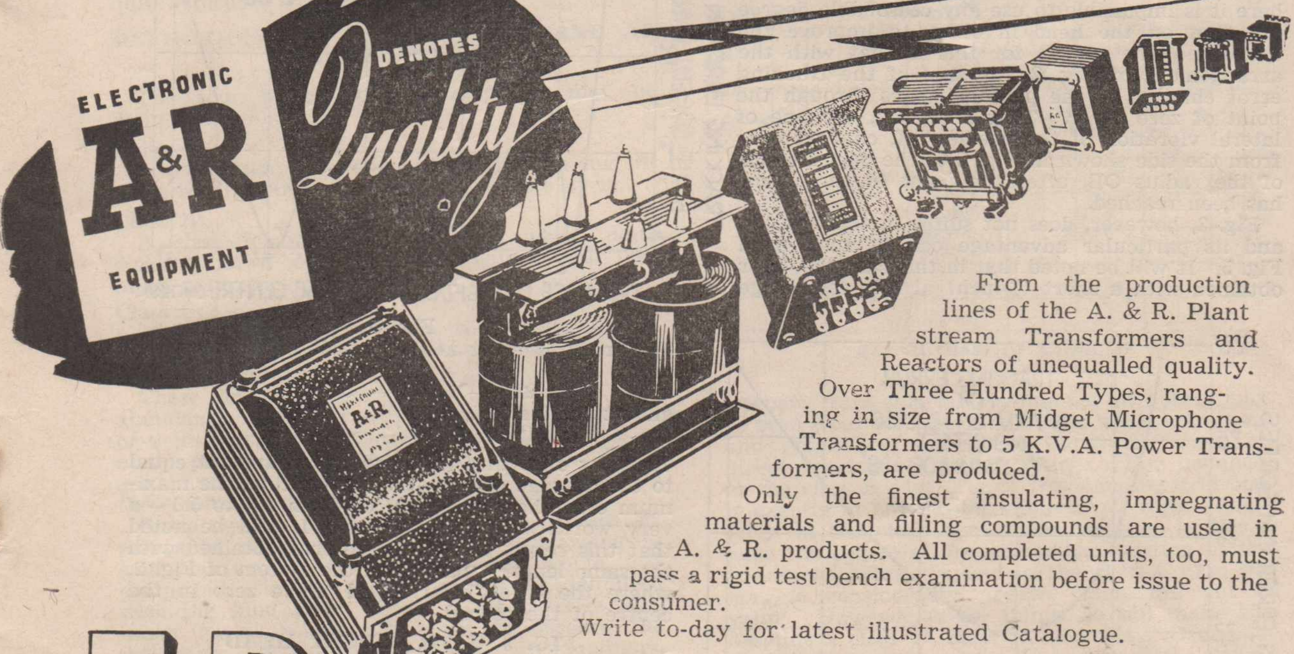


Fig. 4

This question brings up two more cases which are illustrated in Figs. 2 and 3. In the former, the arc of the needle passes between the centre of the record and the pivot point of the pick-up. In the latter, the needle arc passes outside the centre of the record.

This particular case is of interest because it enables the tracking error to be made zero at one particular point on the record. In this way

(continued on page 16)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Tracking Errors in Gramophone Pick-ups

(continued from page 14)

there is some error at both the inside and outside of the disc, less in quantity than if the simple system of Fig. 1 is employed.

EXAMPLE OF USE OF FIG. 2.

Taking the case of an 8-inch arm, which is representative of the lengths used for pick-ups designed to play up to 12-inch records, and assuming that the point of zero tracking error is at 4 in. radius on the record (approximately after half the record has been played), the following figures are obtained:—

Distance between pivot-point of arm and centre of record (OA on Fig. 2) ..	8.9 in.
Tracking error at outside of disc	9.1°
Tracking error at inside of disc	7.4°

Comparing these figures with those for the arrangement of Fig. 1, as shown in the graph Fig. 4, it can be seen that this method effects a considerable improvement.

CASE ILLUSTRATED IN FIG. 3

In Fig. 3 we have the third case which completes the general treatment. Here the pick-up needle swings in an arc **outside** the centre of the record. It can be shown that here no combination of dimensions can be found in which the tracking error is zero at some part of the pick-up's travel, so that at first sight it would not appear to confer any advantage at all. However, a disadvantage suffered by Fig. 2 is that here it is impossible to use any reasonable degree of offset on the head in order to improve the tracking. The reason for this is that with the arrangement of Fig. 2, the **sign** of the tracking error changes as the pick-up passes through the point of zero error. That is to say, the line of lateral vibration of the needle, BX, changes over from the side shown in Fig. 2 to the opposite side of the radius OB, after the point of zero error has been reached.

Fig. 3, however, does not suffer in this respect, and its particular advantage can be seen from Fig. 5. It will be noted that in this case the error obtained with a short (8-inch) arm is very large—much larger than is the case with Fig. 1—but that **the variation in error between the inside and outside of the disc is very small.** This is the most important feature of Fig. 3, and shows that offsetting can be used to great advantage.

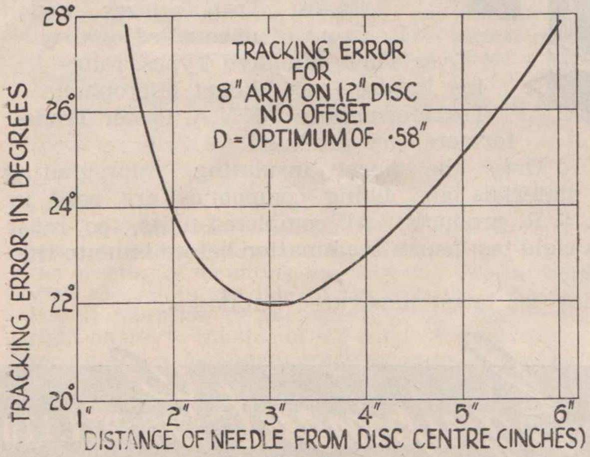

Fig. 6

OFFSETTING THE PICK-UP HEAD

So far we have been considering the three possible methods of mounting the pick-up arm, and have mentioned the subject of offsetting only in passing. The point arises as to how can offsetting the head reduce the tracking error, and can be briefly explained with the aid of Figs. 1 and 4.

In the case of an 8inch arm with the system of Fig. 1, Fig. 4 shows that the error at the outside of a 12-inch disc is 22° and at the inside of 10.8°. The average error is therefore

$$\frac{22 + 10.8}{2} = 16.4^\circ$$

Now, suppose that the pick-up head in Fig. 1 is rotated in a clockwise direction through 16.4°, so that there is now an angle of this value between the line of the arm and a line through the needle at right-angles to its direction of lateral vibration.

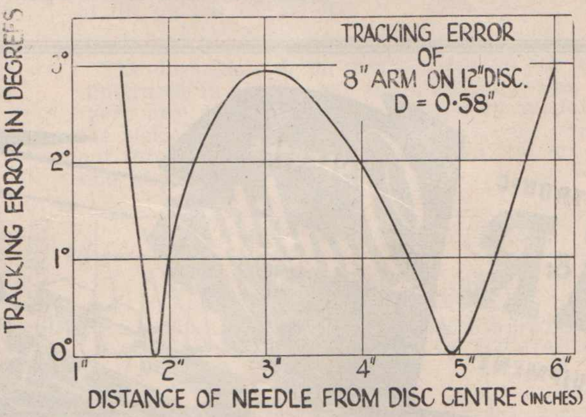

Fig. 5

The tracking error at the outside of the record is now

$$22^\circ - 16.4^\circ = 5.6^\circ$$

and at the inside is

$$10.8^\circ - 16.4^\circ = -5.6^\circ$$

Thus, by offsetting the head by an amount equal to the average error **without** offsetting, the maximum error has been reduced from 22° to 5.6°—a very worth-while improvement. It will be noted that this result is better than that obtained with the same length of arm and the system of Fig. 2, where the error is arranged to be zero in the centre of the record.

FIG. 3 WITH OFFSET HEAD

From Fig. 5 it is clear that the system of Fig. 3 without offset is quite useless in attempting to reduce the error to a low absolute value. Taking the working surface of the record as between 6 in. radius and 1½ in. radius (which is a little on

(continued on page 24)

AMPLIFIERS

Some Notes on the Classification of Amplifiers

Textbooks on electronics are by no means unanimous in their definitions of the various classes of amplifier. This is caused partly by reason of the fact that the class of an amplifier alters practically all its properties, and each writer is usually more concerned with one property than another. Again, some writers themselves appear to have been confused by the implications of the subscripts 1 and 2 (and their omission), in conjunction with the three main classes A, B, and C. This is hardly to be wondered at, for no sort of standardisation seems to have occurred yet in the manner in which the subscript numerals are used. Everyone knows that the subscript 1 means "without grid current" and that 2 means "with grid current," but the loose practice of omitting the numerals altogether, on the tacit assumptions that no subscript also means "no grid current" in the case of class A amplifiers and at the same time means "grid current" in the case of class B and C amplifiers, appears to the writer to be the cause of much misunderstanding, and greatly to be deplored.

The fact is that the letters A, B and C, and the subscripts 1 and 2 have their own meanings, quite irrespective of each other.

DEFINITIONS OF CLASS A, B, C, AND AB AMPLIFIERS

The four basic types of amplifier may be defined as follows:—

Class A:

A class A amplifier is one in which plate current flows at all points on the input voltage cycle.

Class B:

A class B amplifier is one in which plate current flows during approximately half the input voltage cycle.

Class C:

A class C amplifier is one in which plate current flows during appreciably less than a half cycle of the input voltage.

These definitions are simple, fundamental, and abundantly clear. It will be noted that not one of them makes any mention either of grid bias or of the presence or absence of grid current. These are important matters in connection with the three main classes, but **not by definition.**

Some writers tend to define the classes by means of rough specifications of the value of grid bias used, while some do even worse, and compound a mixture of this type of definition with the kind given above. This practice does much harm, because it tends to obscure the definition, particularly of class AB amplifiers. The correct definition of a class AB amplifier is as follows:—

Class AB:

A class AB amplifier is one in which plate cur-

tions given above are fundamental, in that they in no way specify the type of tube, the point to which it is biased, the amplitude of the input voltage, or anything containing any restrictive assumption whatever. In short they are completely general. The first three are illustrated in Figs. 1, 2, and 3, which show specific examples. Each shows the mutual characteristic of the valve, the input voltage waveform and the output current waveform, which is obtained by projecting values from the former on to the mutual characteristic. The arrows on Fig. 1 show the directions in which the time scale is assumed to increase. It should be noted that the scales of grid voltage differ on the three diagrams. This is purely for convenience, to keep the overall sizes of the three diagrams the same. Even a casual glance at these three diagrams shows that nothing in the illustration conflicts with the definitions already given.

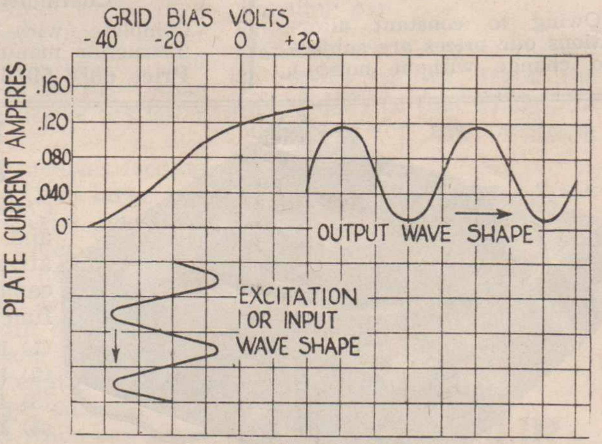

Fig. 1. Class A_1 Amplifier

Apart from this fact, a number of points may be seen from the diagrams which, while important and typical of the classes illustrated, have no direct bearing on the definitions. For instance, in the class B case, Fig. 2, the standing grid bias is exactly at the cut-off value of 40 volts. Similarly, in the class A example the tube is biased near the centre of the straightest portion of the tube's characteristic, and in the class C case the bias is considerably greater than the cut-off value. However, these things do not make the amplifiers class B, class A, and Class C respectively. They are merely the result of the definition in that such conditions of bias help in causing the tube to work according to the definitions.

(coutinued on page 29)

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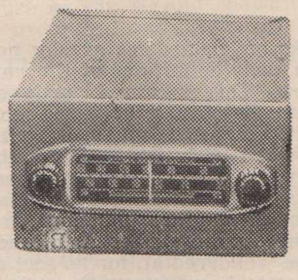

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The Magnetic Tape (cont. from page 10)

cycle; for example, 60,000 times per second.

In Fig. 5, if the actual form of the current in the recording head follows the solid line, A, this gives the flux waveform represented by the solid line B. If the envelope enclosing B is added algebraically, it will be found to give the sine waveform shown below (C), which is the resultant voltage output from the playback head.

In practice this operation is accomplished quite simply, by generating a current of the required frequency, usually 30 kc/s, and of such amplitude that, applied to the recording head, it produces a magnetizing force corresponding to D-E (peak to peak) in Fig. 5. The audio A.C. is now added to this, giving the waveform of Fig. 6 (A). Its positive and negative peaks, projected on to the curve, produce the curves Y and Z respectively, and these, added algebraically, give the resultant flux density waveform B.

It is important to note that modulation of the supersonic by the audio frequency must not take place. If it does, an envelope would be formed with the positive and negative half-cycles 180 degrees out of phase, and the resultant A.F. component would be zero.

Erasing

The great advantage which magnetic recording has over all other types is that when a particular recorded item is no longer required or has outlived its charm, it can be erased magnetically and the tape or wire is then ready to use again.

In its simplest form, erasing consists of passing the material concerned through a strong magnetic field which saturates it, thus obliterating the previous variations in flux due to the recorded A.F. This, however, is not entirely satisfactory, since the tape or wire is not demagnetized, but merely saturated; and although the supersonic bias does in practice bring the residual flux back approximately to zero, some distortion is inevitable. Also the noise level of a saturated tape or wire is excessively high.

Obviously what is needed is some means of demagnetizing the recording medium, as watches and precision tools are demagnetized when they have accidentally come under the influence of a magnet; and the most successful erase system makes use of a similar principle.

The method involves feeding a supersonic A.C. of large amplitude to a special recording head with a wider gap than usual; the tape or wire which is to be erased is drawn past this. The width of the gap is purposely made to exceed several wavelengths of the supersonic erase current, with the result that while any given point on the tape is passing between the poles of the erase head the supersonic flux has reversed its direction several times.

Thus that point has been saturated several times in each direction, leaving no possible trace of the original modulation which it carried; and if some supersonic flux is left on the tape or wire after it leaves the erase head, the effect will be the same as if it were completely demagnetized, since over a length of track equal to the wavelength of one A.F. cycle at the record head, the sum of the positive and negative half-cycles will be zero.

In a practical recorder, erasure of the old and recording of the new material are both done in one operation; so a reel of tape carrying Tchaikowsky's sixth symphony may be fed into a recorder, to emerge bearing a half-hour swing session, with no apparent intermediate stage. This is accomplished by mounting the erase head immediately in front of the record head, so that the tape or wire passes over it and becomes completely erased before it reaches the recording gap.

The supersonic erase current is usually drawn from the same supply as that which provides bias for the recording head.

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Cordially yours,

PARAGON RADIO

★ Ham Activities ★

We extend our heartiest congratulations to the Victorian Div. of the W.I.A. on its 25th Anniversary.—The Editor.

"PORTABLE, KULPARA . . ."

Being the description of the recent Field Day held at Kulpara, South Australia, by the VK5 Northern Network.

After a week's unsettled weather, Sunday, 29th October, brought a really typical South Australian day with all the makings of a field day which all knew had been well prepared and organised by 5UX. The day had been the main topic of discussion on the Net for many weeks previous and, in spite of lack of support from some quarters of officialdom, these chaps proved to the city hams what a grand day's outing these annual events can be.

Conducted by

J. A. HAMPEL, VK5BJ

Chief organiser Les Wallbridge, VK5UX, had hardly opened his eyes when he was hounded out from hiding by first arrivals 5DR and 5BJ who had left Adelaide at 5 a.m. After a short while, 5AL arrived in what was dubiously known as a car and loaned by an A.O.C.P. aspirant. Finding Bert and John had already bagged the only two basket-ball poles (height 10 feet — some antenna!), Ken flattened all and sundry by producing a telescopic pole which opened up to 25 feet! I have not studied the game the girls play very closely, but it was convenient for the originator of the game to place the two goal posts a half-wave apart on 40.

After establishing contact over the 200 yards distance between 5AL and 5BJ (the best DX for the day as far as we were concerned) on Type III's and a Type 108 Transceiver, the 'Pirie boys arrived with 5CO, 5WO, 5KS, 5EN and 5CE in the party. Mac, 5CE, later gained the prize for travelling the greatest distance from Whyalla. From then on, there was a steady stream of new arrivals marked by 5CY, 5XL, 5VM, 5KL, 5XR, 5GF and their respective XYL's and friends.

Highlight of the day was Ern's (5EN) skirmish with the frill-necked lizard so thoughtfully whisked from its noon siesta onto his back by that lizard tamer 5UX. Ern was content to call CQ in that position but both lizard and said "ham" adopted fighting tactics when Les deposited the lizard down said "ham's" shirt front! Of the two hundred or more photos taken that day, more are devoted to that scene than any other event. "5BJ only needed those little yellow tickets to hand out like the rest of the street photographers", said Len (5VM), as 130 different angles on the day were taken, besides all the other cameras present, and some of these shots will appear in these pages. I take this opportunity to deny Len's other report, handed to press and radio, that the car-load of girls came to see my half-wave dipole on the upper lip.

5DF, from Kadina, arrived just in time for the photo taking in the group and, at this point, 70 people were present, including the harmonics who were catered for with races and competitions. Once again the Adelaide trade was generous in donating suitable trophies besides local district business houses. As the day was a complete black-out on the lower frequencies, due to the sun-spot disturbance around 2230 the previous evening, Max (5GF) walked away with the fone and c.w. prizes as he was active on 6 metres and 2 metres. On 6 he made Adelaide at 2 miles per watt, and on 2 the average being 2½ miles per watt. A YL with an interest in getting the ticket was Mary Kelly who won the lucky lady contest while not snooping around some of the rigs to learn more about "ham" radio. Clarrie Castle (5KL), of 6-metre fame, had no trouble in winning a handsome prize for the best home-made piece of equipment—a 6-metre crystal-controlled converter. 5CE won some bezels and 5WO outshone everyone to read 28 w.p.m. of code, while 5AX, from Gawler, carried off the booby prize of "serviceable useless unwanted junk" from 5UX's shack. Besides being written up in many South Australian newspapers, the Day received attention in the A.B.C.'s news sessions. Everyone left around five that evening, feeling what a great job 5UX had done on the organising side and expressing the wish for another similar outing in the near future. See you at the next Field Day!

[News is now to hand that another Field Day is being organised to coincide with the W.I.A. National Field Day next January. See elsewhere for fuller details.]

Ham Activities (cont. from page 21)

W.I.A. 1951 National Field Day

Once again this annual event is approaching and many portable rigs being tested in preparation for the event. Of late, a rather apathetic approach has been made to National Field Day but it is hoped for 100 per cent. participation of all states this time. Days such as these are the ruling factor in deciding our usefulness in emergency and every Amateur should be prepared for this possibility by taking part in field days and other portable operations.

The 1951 N.F.D. will be on the week-end, 27th and 28th January, 1951, from 1500 hours E.A.S.T. on the 27th to 2359 hours E.A.S.T., Sunday, 28th. Intending operators should note that they must be five miles or more from their home location, must not draw their power from mains supplies or exceed 25 watts input to the final. A station may not be set up for the contest more than six hours before 1500 E.A.S.T. on the Saturday and only 24 hours of operation may be used out of the available total of 33 hours.

On the log it is necessary to include the following—

LOCATION OF THE STATION.
NAMES AND CALLS OF OPERATOR(S).
DESCRIPTION OF—Transmitter, Receiver, Antenna and Power Supplies.
POWER INPUT TO FINAL.
DATE AND TIME (Times to be in E.A.S.T.).
STATION WORKED.
BAND(S) USED.
EXCHANGE OF REPORTS.
POINTS CLAIMED.
BONUS CLAIMED.
LOCATION OF WORKED STATION.

Logs must reach the local division of the W.I.A. in each state for checking and subsequent forwarding by 20th February, 1951.

Get out that Type III, the Type A, No. 11 or No. 19 or what have you and we'll see you in the W.I.A. National Field Day.

T.A. (Adelaide) writes: I recently bought an output transformer to suit an eight-inch speaker fed by a single 6F6. A friend of mine tells me the primary has not enough resistance to give a correct match. What should be the resistance of each coil?

(A): Strangely enough, the resistance of the coils in itself has little to do with the matching; but what your friend had in mind was using the resistance measurement as an iddication of the **number of turns** on the primary coil, which should be as high as practicable. The better the transformer, the bigger it must be, so that heavier wire can be used, in order to keep the resistance low; and, as the size of the core is increased so the number of turns can be reduced, thus bringing about a further reduction of resistance.

The catch is that while the turns should be many, the resistance should be low, as resistance anywhere in the circuit causes losses and reduces the power available to the speaker.

"Have been in radio since just prior to the war, and have progressed along the way and now hold an amateur transmitting licence, VK2AJZ. Am in business as an electrical contractor. The result is that I don't get much time for ham radio, although I have started re-building the receiver. Has anyone got a spare kitchen sink, as I haven't got one of those in yet, but nearly everything else. Hi. I only hope the thing will work. Now, about Radio World, no complaints at all, but I would like to see articles of a more technical nature. However, I do realise that there is always the youngster who has to have something to get his teeth into for a start. Cheers, A.G. and 73's." — **Allan J. Zarth, 443 Waverley Road, North Carnegie, Victoria.**

Miniature Valve Pins

Owing to the fact that the pins of the new miniatures are made resilient to protect the valve, they can be distorted in normal handling. This alteration in alignment can be readily corrected with the use of a pin straightener—a compact device designed for mounting on the work bench, and selling at 12/6 net.

Another handy instrument for use with miniatures is the wiring jig which has been designed for use with sockets having floating or poorly aligned contacts. The jig holds the socket contacts in their correct position for alignment during the wiring of the receiver and prevents any lateral strain on the miniatures when they are plugged into the sockets. The wiring jig is available at 12/- net.

Both these tools are available from Amalgamated Wireless Valve Co., 47 York St., Sydney.

VALVE WARRANTY

The Australian Valve Manufacturers' Committee advises the adoption of the following warranty as applicable to valves used in broadcast receivers. This warranty becomes effective as from June 5th, 1950, and replaces all previous guarantee conditions:—

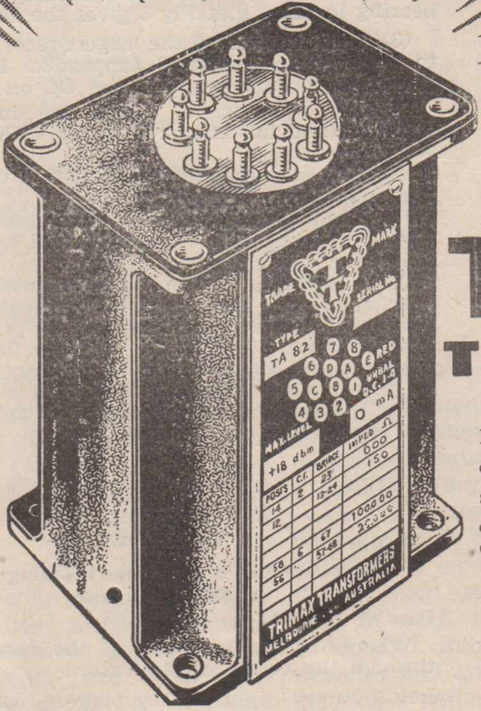
Radio Receiving Valves controlled by the A.V.M.C. and used in Broadcast Receiving sets are guaranteed in terms of warranty for a period of ninety days from the date they are put into service by the consumer. Claims for replacement under guarantee within this period will be considered only in relation to the manufacturing defects hereinafter detailed, but no claim will be considered after the expiration of a period of six months from the date of despatch from manufacturer's stores.

"I first became interested in Radio World through a circuit of a pre-amplifier I was badly in need of. The pre-amp was the first job I ever wired up, and is still in use. I have built the 20-watt amplifier described by Mr. Lawler (August, 1948), and it is a very fine job."—**O. Spinks, Waratah, Tasmania.**

(a) Defective vacuum.
(b) Glass strain.
(c) Open circuit electrodes (excluding burnt out filaments).
(d) Inter-electrode short circuit, permanent or intermittent.
(e) Loose element in bulb.
(f) Cathode out of mica.
(g) Open circuit shields.
(h) Arcing.
(i) Maximum dimensions exceeded.

In determining the actual status of the defect, it is to be expressly noted that the discretion of the individual manufacturer shall be exercised at all times and their decision shall be final.

Claims will not be considered where valves have been operated beyond manufacturers' maximum ratings and instructions concerning the type in question.



Tracking Errors in Gramophone Pick-ups

(continued from page 16)

the generous side), the error varies from 28° to 22°. The important point about this curve is that it reaches a minimum and then increases again, arriving at the same value at 1½ in. radius as it had at 6 in. radius. Now, the average error is approximately 25°, so that if this degree of offset is used, the maximum tracking error is only 3°, which is the best result of any presented so far.

The dimension D, referred to on Figs. 5 and 6, is the distance OC on Fig. 3, by which the needle overhangs the centre of the turntable. It can be shown (see appendix) that for a given record size, with both maximum and minimum radii specified, and for a given arm lengh, there is an optimum value of D which will ensure that the untracked errors at the inside and outside of the disc are equal. This value of D also ensures the minimum possible difference between the maximum and minimum untracked errors and, therefore, the best performance after the head has been offset. In the appendix at the end of this article will be found formulae which enable the tracking error to be calculated under any of the conditions met with in Figs. 1, 2 or 3. In addition, since Fig. 3, with offsetting, gives the best possible result for a given arm length, the full derivation is given for the formulae which refer to this case.

EFFECTS OF TRACKING ERROR

The presence of bad tracking error in a gramophone pick-up is harmful in a number of ways to both reproduction and record life. First, and most important, quite severe distortion can be introduced. This arises from the fact that, if there is any tracking error, the needle point has a component of motion in the direction of movement of the record, whereas, with no tracking error, the needle can vibrate only at right-angles to this direction. This causes the record to exert a different force on the needle on alternate half-cycles of the vibration, so that the amplitude of the needle vibration becomes less on the half-cycle on which the needle attempts to travel in the opposite direction to the record motion. This inequality is second harmonic distortion. At the same time, the inequality of forces on the needle-point during alternate half-cycles causes a heavily recorded passage to wear much more than it would if there were no tracking error. In extreme cases, it may cause the needle to jump a groove, by imparting a velocity to the head as a whole rather than just to the needle. Alternatively a heavier head is needed to cause the needle to stay in the most heavily recorded grooves, with consequent unnecessarily heavy wear on the more lightly recorded portions. Additional wear on the parts of the record where tracking error is small is caused by the unequal wear on the needle which occurs in the badly tracking portions. Thus, since the effects of record wear are detected both as distortion and increased surface noise, a badly tracked pick-up can greatly reduce the useful life of a record.

It is not intended here to enlarge further upon the deleterious effects of bad tracking, but a good deal has been written about it in the technical literature of record production, and enough has been said here to indicate that the subject is of considerable importance.

Thus, anyone who buys a pick-up, whether a very costly one intended for broadcast studio work or the cheapest type of home pick-up, should always follow to the letter the maker's instructions on the subject of mounting it. However well or badly the arm may be designed, the manufacturer can be relied on to recommend the mounting position which will give the best tracking to his pick-up.

Similarly, with the help of the simple formulae given below, anyone who is designing an arm and head mounting can achieve the best possible results in the space available.

RULES FOR DESIGNING AN ARM

The design of a pick-up arm can be reduced to a few very simple steps, as follows:—

(1) Since, with all the methods of mounting, the longest arm gives the least tracking error, the arm is made as long as space will allow.

(2) When the arm length has been decided upon, the system to be used should be chosen, bearing in mind that Fig 3 gives the best results.

(3) Bearing in mind the largest record that has to be played equation 8 (appendix) is used to find the optimum length D. (= OC on Fig. 3.)

(4) The appropriate values are inserted in equation, and the maximum error with no offset is found.

(5) Values are inserted in equation to find the minimum error with no offset.

(6) The average of the maximum and minimum values are inserted in equations 9 and 7 to find the minimum error with no offset.

(7) A drawing of the complete arm is made, bearing in mind that the pick-up needle must be the same distance from the arm pivot after the head has been offset as was assumed for the arm length in the calculations. For example, if AB on Fig. 3 was originally chosen as 8 in., then, when the arm has been designed, B must still be the position of the needle-point.

* * *

APPENDIX

Formulae for finding the tracking error in any given case.

Case A (Fig. 1)

Where the arc of swing of the needle passes through the centre of the record—

Let A be the radius of the pick-up arm.

Let R be the radius of the record at the outside.

Let r be the radius of the record at the inside.

Let θTo be the tracking error at the outside.

Let θTi be the tracking error at the inside.

Then we have

$$\theta T_o = \sin^{-1}\frac{R}{2A} \quad . . . . . . (1)$$

$$\theta T_i = \sin^{-1}\frac{r}{2A} \quad . . . . . . (2)$$

$$\text{Optimum head offset} = \frac{\theta T_o + \theta T_i}{2} \quad . . . . (3)$$

Case B (Fig. 2)

Where the arc of swing of the needle passes between the pick-up pivot and the centre of the record.

Definitions are as for Case A, with the addition that d = OC on Fig. 2.

As before we have

$$\theta T_o = \sin^{-1}\frac{R^2 + A^2 - (A + d)^2}{2AR} \quad . . (4)$$

$$\theta T_i = \sin^{-1}\frac{r^2 + A^2 - (A + d)^2}{2Ar} \quad . . (5)$$

In this case there is a point of zero tracking error. If r_0 is the the record radius at which this occurs, we have—

$r_0 = \sqrt{(2A + d)d}$ . . . . . . (6)

Also, in this case offsetting cannot be employed.

Case C (Fig. 3)

Where the arc of swing of the needle passes beyond the centre of the record.

Referring to Fig. 3, we have for the tracking error at any record radius R_1.

$\theta T = OBX = 90° - ABO$

In the triangle ABO we have that

$AO = (A - d)$
$OB = R$
$AB = A$

Where A, R, and d have the same meanings as before.

From the triangle ABO

$AO^2 = AB^2 + OB^2 - 2AB.BO \cos ABO.$

Rearranging and substituting values, we have

$$\cos ABO = \sin \theta T = \frac{R^2 + A^2 - (A - d)^2}{2AR}$$

$$\therefore \theta T = \sin^{-1}\frac{R^2 + A^2 - (A - d)^2}{2AR} \quad . . . (7)$$

For optimum tracking after offsetting the pick-up head, θT_o must equal θT_i or $\theta T_o - \theta T_i = 0$.

$\therefore \sin \theta T_o - \sin \theta T_i = 0.$

Thus we have

$$\frac{R^2 + A^2 - (A - d)^2}{2AR} - \frac{r^2 + A^2 - (A - d)^2}{2AR} = 0$$

Rearranging,

$$\frac{(R - r)\ (Rr - 2Ad + d^2)}{2ARr} = 0$$

The only significant case contained here is when

$Rr - 2Ad + d^2 = 0$

from which

$d = A - \sqrt{A^2 - Rr}$ . . . . (8)

The above equation gives the optimum value of d for a given record and arm radius.

Minimum Error with Fig. 3.

Let Rmin be the record radius at which minimum tracking error occurs.

Then from equation (7) we have that

$$\frac{R_{min}^2 + A^2 - (A - d)^2}{2AR_{min}}$$

must be a minimum.

Expanding this expression we get

$$\frac{R^2_{min} + 2Ad - d^2}{2AR_{min}}$$

must be a minimum, but $2Ad - d^2 = Rr$ from equation (8).

Thus

$$\frac{R^2_{min} + Rr.}{R_{min}}$$

must be a minimum.

Rearranging, and differentiating with respect to Rmin,

$R_{min} = \sqrt{R.r.}$ . . . . . (9)

Thus, when Rmin has been found, θT_{max} can be found by substituting R in equation (7) and θT_{min} may be found by substituting Rmin in the same equation.

Then the required angle of offset is

$$\frac{\theta T_{max} - \theta T_{min}}{2}$$

* * *

As a typical example of the efficiency of "VEGA" products, we quote extracts from "Radiotronics" No. 144, August, 1950 (the journal of Amalgamated Wireless Valve Co.), as follows:—

"The coils and I.F. transformers used in the Radiotron Reflex Receiver RD34 are of good quality, are slug tuned and have a "Q" of 100 and fixed tuning capacitances.

The Aerial Coil, "VEGA" Type VC1 has a secondary "Q" of 123 at 600 k.c. and 120 at 1400 k.c.

G.K. (Brunswick) is disappointed because we have not published a promised circuit of a fidelity tuner.

(A): The main reason why we held up on this project was because we came across something much superior in the way of t.r.f. tuners. It embodies an infinite impedance detector and automatic volume control, a rather unusual combination. It is so good that we are having a model built up so that we can give full constructional details with photographs. These should be ready for the next issue.

C.E.T. (Heidelberg) asks about the new Radiotron diodes..

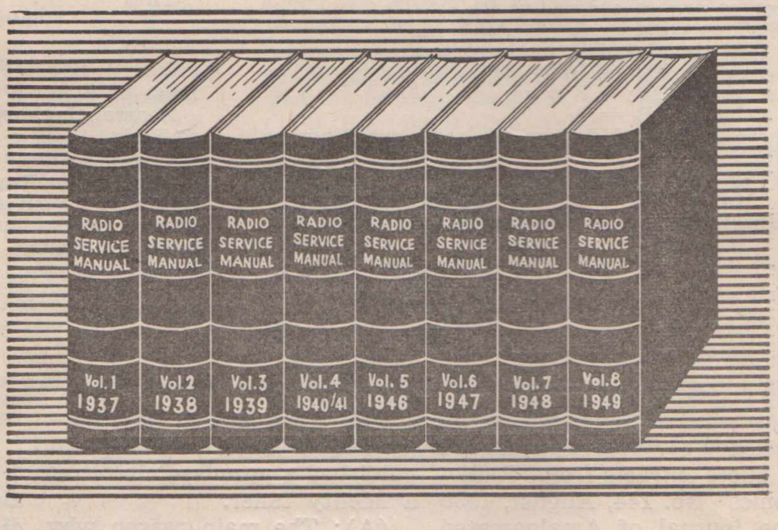
(A): Yes, these are now available at 8/- each. The type GEX44 would be best for use in a crystal set. We have not yet had a chance to carry out any actual experimenting with them, although we have a sample on hand. There seems little doubt, however, that one of these diodes should be as good as a good crystal with the catswhisker at its best.

Short-Wave Review

Conducted by L. J. Keast

EAST COAST STATIONS—

Call Sign	Frequency	Wave Length
WLWO-1	**6.08**	**49.34**
WGEO-1	**9.53**	**31.48**
WRUL-4	**9.57**	**31.35**
WABC-1	**9.65**	**31.09**
WRCA-6	**9.67**	**31.02**
WLWO-8	**9.70**	**30.93**
WLWO-7	**11.71**	**25.62**
WLWO-5	**11.71**	**25.62**
WRCA-5	**11.77**	**25.48**
WRUL-1	**11.79**	**25.44**
WGEO-2	**11.83**	**25.36**
WABC-5	**15.13**	**19.82**
WRCA-6	**15.21**	**19.73**
WLWO-5	**15.24**	**19.69**
	15.25	**19.68**
WABC-2	**15.27**	**19.66**
WBOS-1	**15.285**	**19.63**
WRUL-1	**15.29**	**19.62**
WRUL-3	**15.31**	**19.60**



WGEO-1	**15.33**	**19.57**
WGEO-2	**15.33**	**19.57**
WLWO-6	**15.33**	**19.57**
WLWO-5	**15.35**	**19.54**
WRUL-1		
WRUL-2		
WRUL-4	**17.75**	**16.90**
WRUL-5	**17.75**	**16.90**
WGEO-3	**17.765**	**16.88**
WRCA-5	**17.78**	**16.87**
WLWO-7	**17.80**	**16.85**
WLWO-2	**17.80**	**16.85**
WABC-3	**17.83**	**16.82**
WABC-6	**21.50**	**13.95**
WLWO-3	**21.52**	**13.93**
WABC-1	**21.57**	**13.90**
WGEO-2	**21.59**	**13.89**
WRCA-3	**21.61**	**13.88**
WLWO-7	**21.65**	**13.85**
WRCA-3	**21.73**	**13.81**

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10.00 a.m.- 1.00 p.m.
10.00-11.00 a.m.
6.45- 8.30 a.m.
10.00-10.30 a.m. (Wed.-Sun.)
10.30 a.m.-Noon
10.00 a.m.- 1.00 p.m.
6.30- 8.15 a.m.
10.00 a.m.-Noon (Daily)
Noon- 1.00 p.m. (Wed.-Sun.)
6.15- 8.15 a.m.
10.30 a.m.-Noon (Daily)
Noon- 1.00 p.m. (Wed.-Sun.)
6.15- 8.30 a.m.
2.15- 8.15 a.m.
10.00 a.m.-10.30 p.m. (Wed.-Sun.)
10.30 a.m.-Noon
2.30- 5.30 a.m.
6.30- 8.30 a.m.
1.30- 8.15 a.m.
8.40- 8.50 a.m.
9.30- 9.45 a.m. (Tues.-Thur.)
9.45 a.m.- 1.00 p.m.
5.00- 8.45 a.m.
9.00-10.00 a.m.
2.00- 4.00 a.m.
6.00- 6.30 a.m.
2.00- 8.30 a.m.
9.00- 9.45 a.m. (Tues.-Sat.)
10.00 a.m.-Noon
Noon- 1.00 p.m. (Tues.-Sat.)
11.15 p.m.-Midnight
3.30- 8.15 a.m.
9.45-10.00 a.m. (Tues.-Sat.)
11.00 a.m.-Noon
1.30- 7.00 a.m.
9.00-10.00 a.m.
2.15- 8.45 a.m.
2.00- 8.15 a.m.
9.30- 9.45 a.m. (Tues.-Thur.)
9.45 a.m.- 1.00 p.m.
11.15 p.m.-Midnight
11.00 a.m.-Noon
2.00- 8.30 a.m.
8.40- 8.50 a.m.
9.00-10.00 a.m. (Tues.-Sat.)
10.15-10.30 a.m. (Tues.-Sat.)
10.30 a.m.-Noon
1.30- 8.15 a.m.
2.00- 8.30 a.m.
2.00- 6.30 a.m.
9.30- 9.45 a.m. (Tues.-Thur.)
9.45 a.m.-Noon
2.00- 6.00 a.m.
2.15- 8.15 a.m.
2.00- 6.15 a.m.
2.15- 8.45 a.m.

On Wednesdays . . . . 10.00-11.00 a.m.
Fridays and Sundays
also at . . . . 8.00- 9.00 p.m.

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SBP, STOCKHOLM—
11.705 m.c. 25.63 met. 5.35 p.m.-
1.15 a.m.

SDB-2, STOCKHOLM—
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1.15- 8.00 a.m.

SBO, STOCKHOLM—
6.065 m.c. 49.46 met. 3.15- 5.35 p.m.
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5.35- 9.00 p.m. Mondays, Wednesdays and Saturdays, SBP and SBT
9.00-10.15 p.m. daily. SBP and SBT
10.30-Midnight daily. SBP and SBT
Midnight-1.15 a.m. Sundays and Mondays, SBP and SBT
1.30- 4.00 a.m. daily. SDB-2 and SBT
4.00- 4.30 a.m. SBU, SDB-2
4.30- 5.00 a.m. daily, SBO
5.00- 8.00 a.m. daily, SBO and SDB-2

SOUTH AMERICA

ARGENTINA

LRT, TUCUMAN—
11.84 m.c. 25.34 met.
"Radio Independencia".
Moved back from 11.85 m.c. 25.31 met., when it was interfered with by Radio Australia.

RADIO SPLENDID, BUENOS AIRES—
15.22 m.c. 19.72 met. 6.00- 9.00 a.m.

RADIO BELGRANO, BUENOS AIRES—
11.83 m.c. 25.36 met.

LRY, BUENOS AIRES—
9.455 m.c. 31.73 met. 12.15- 4.00 p.m.
(English at 12.15)
7.00- 8.50 a.m.
(English at 8.05)

LRS, BUENOS AIRES—
11.88 m.c. 25.25 met. Midnight-9.30 a.m.
(English at 5.00 a.m.)

LRU, BUENOS AIRES—
15.29 m.c. 19.62 met. Noon- 4.00 p.m.
(English at 12.15)
3.15- 6.45 a.m.
(English at 3.15)

U.S.S.R.

——, ALMA ATA—
9.34 m.c. 32.11 met. 10.00 p.m.-2.00 a.m.
Also heard on 9.38 m.c. 31.98 met.

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15.20 m.c. 19.74 met.
Daily 6.00- 9.00 a.m.
Sundays 6.00- 9.15 a.m.

VLA-4—
11.85 m.c. 25.32 met.
Daily 6.00- 9.00 a.m.
Sundays 6.00- 9.15 a.m.

To British Isles, Europe, South Asia and New Zealand in English—

VLA-10—
17.84 m.c. 16.82 met. 4.55- 6.15 p.m.

VLC—
15.20 m.c. 19.74 met. 4.55- 6.15 p.m.

VLB-4—
11.85 m.c. 25.32 met.
Daily (ex. Sat.) 4.55- 6.15 p.m.

To Tahiti and Europe in French—

VLG-11—
15.21 m.c. 19.72 met. 4.00- 4.40 p.m.

VLC—
15.20 m.c. 19.74 met. 4.00- 4.40 p.m.

VLA-4—
11.85 m.c. 25.32 met. Midnight-2.15 a.m.

To New Caledonia in French—

VLG-10—
11.76 m.c. 25.51 met. 5.45- 6.45 p.m.

THE PHILIPPINES—

Note: Changes in Call Signs

		m.c.	met.	
Manila	2	21.57	13.9	6.35- 6.45 p.m.
	*3	17.78	16.87	7.00- 1.45 a.m.
	2	15.33	19.57	5.15- 6.45 p.m. 7.00 p.m. - 1.45 a.m.
	2	15.25	19.68	7.45- 8.00 a.m. 9.00-11 a.m.
	1	11.89	25.23	7.45- 8.00 a.m. 9.00-11 a.m.
	*1	11.89	25.23	7.00 p.m. - 1.45 a.m.
	1	11.87	25.27	5.30- 8.30 a.m.
	3	9.53	31.48	9.00-11.00 a.m.
TANGIER	1	6.06	49.5	
		7.214	41.61	
		15.21	19.73	
	2	11.79	25.41	
		15.25	19.68	
MUNICH	1	15.28	19.64	
		11.87	25.27	
	2	9.54	31.45	
	3	6.08	49.34	
	4	7.25	41.38	
KGEI - 1		9.67	31.02	7.00 p.m. - 12.15 a.m.
KRCA - 2		9.65	31.09	7.00 p.m. - 12.15 a.m.
KWID - 2		9.57	31.35	11.15 a.m. - 6.15 p.m.
KWID - 1		9.57	31.35	10.00 p.m. - 12.15 a.m.
KRCA - 1		9.515	31.55	7.00 p.m. - 12.15 a.m.

Classification of Amplifiers (cont.)

Again, it can be seen from the diagrams that the input voltages are progressively greater going rent flows for less than the complete cycle of input voltage but for considerably more than a half cycle.

It should be pointed out that the four defini-from class A to class C via class B. But here again these things do not make the amplifiers what they are.

For example, if a tube is biased to cut-off the input voltage can have any value, but the amplifier will always be operating in class B. To take a further example, consider the case of a valve biased much closer to cut-off than to the zero bias line. The fact that it is biased in this way does **not** determine to what class it belongs, since with only a small input voltage it would be operating class A, with a larger input voltage it would be operating class AB, and with a larger voltage still, class B.

The point to be made here is that in defining the class of an amplifier the actual operating conditions individually have no bearing on the matter. It is only when all the operating conditions are taken into account and the end result is noted that the class of amplifier can be stated.

It may seem to some that such insistence upon proper difinition is academic, and impractical, but such is not the case at all. Terms such as those under discussion are a convenient means of shorthand among technical people versed in a particular subject, but if the exact meanings of the terms are not stated, or if there **are** no exact meanings, then the shorthand becomes confusing, which is exactly what has happened to the classification of amplifiers.

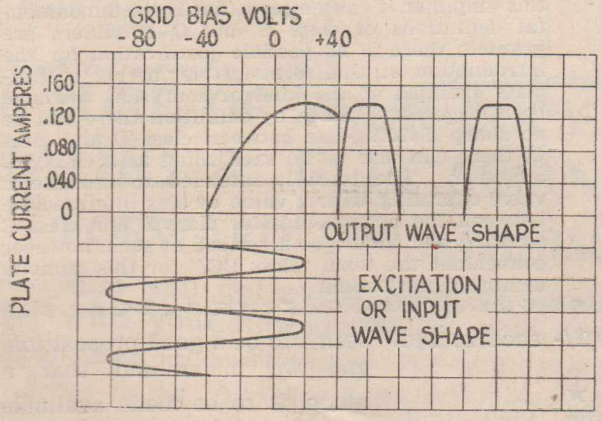

Fig. 2 Class B_2 Amplifier.

THE QUESTION OF SUBSCRIPTS

A little of the trouble caused by the subscript numerals to indicate the presence (or otherwise) of grid current has already been indicated. In our opinion, these numerals should be used with every literal classification, at all times.

As was pointed out earlier, there seems to be a tacit assumption in the term "class A" that there shall be no grid current at any part of the input cycle. Similarly, "class B" and "class C" have grown to imply that grid current is present. These tacit assumptions, inherent in the omission of the numerals from the classification, are tantamount to denying the possibility of such operation as A_2, B_1, and C1. True, these types of operation may be unusual—even exceptional—but they are possible, and even common in some types of equipment.

To give an example, a valve acting as a pulse amplifier, grid modulated in such a way as to produce amplitude-modulated pulses, is operated in class C_1. That is to say, plate current flows only during the positive pulse excursions, and yet at no stage is grid current allowed to flow, because if it did the modulation would no longer be linear.

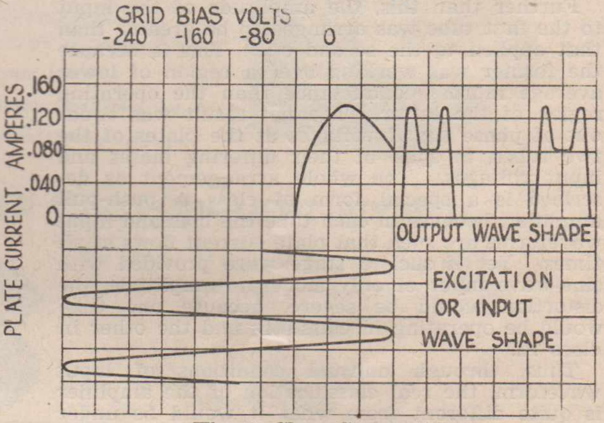

Fig. 3. Class C_2 Amplifier.

Since examples such as this can readily be found in current practice, there seems to be no good reason for omitting the numerals, and every reason for including them at all times. Not only do the subscripts complete the picture, but if used all the time, they eliminate much possible misunderstanding.

ACQUISITION OF MEANINGS

It is unfortunate, but in some ways inevitable, that technical terms, like other words, should acquire by association, meanings other than those implied in their definition. For example, it has long been thought that class A amplifiers are capable of higher fidelity than those of any other class. It has recently been shown that this is not necessarily so, but the statement may be said to have as much truth as a good many generalisations. Because of it there is a pronounced tendency to regard a class A amplifier as one which is biased in the middle of the straightest portion of the valve's mutual characteristic, and in which the input voltage is limited to this straightest portion. If it is realised that such operation is the method whereby a class A amplifier is caused to operate with least distortion, well and good, but it should be noted that the term class A does not in itself imply this type of operation. As long as the valve is operating with plate current at all times, its operation is class A irrespective of how much distortion it produces.

There is a very informative example of this in a number of British radar receivers that were produced during the early years of the last war. The problem was one of providing as much output voltage as possible from a pair of small pentodes connected in push-pull so as to give balanced deflection for the Y-plate of the display C.R.T. It was very ingeniously solved by having regard to the input waveform, which consisted of very narrow pulses. Because of this the tube whose grid accepted the pulses in the positive-going phase was biased almost to cut-off, while the other tube was biased as little negatively as its plate dissipation would allow, since the signals at its grid were negative-going pulses, identical in shape but reversed in phase as compared with the input to the first tube.

Further than this, the amplitude of the input to the first tube was arranged to be greater than that applied to the second one. This is because the former was working over a region of lower average mutual conductance than the operating region of the latter. The net result was equal out of phase signal voltages at the plates of the two tubes, in spite of their differing biases and input voltages. The whole arrangement as described is a special form of class A push-pull amplifier, because in each tube the bias and input waveforms are such that plate current flows at all times. Yet if such a stage were provided with sine-wave input of only moderate amplitude, the distortion would be severe, because one tube would be operating in class AB_1 and the other in class A_2.

Thus, through unusual conditions of input waveform, the real classification of the amplifier is quite different from what it would be under other conditions of input voltage. Unless the fundamental definitions given at the beginning of this article were used, such an amplifier would be incapable of classification, and the classifying system would break down.

Other examples can readily be found of the accretion of non-fundamental meanings to the classifications. One has already been mentioned, namely, the assumption of grid current in class B and class C amplifiers, but there are many others and all of them tend to obscure the real meaning of the terms.

CLASS A AND CLASS AB

A very bad example of the sort of confusion which has arisen with the system of classifying amplifiers is that which surrounds the class AB amplifier. Too many textbooks define this as being intermediate between class A and class B, and leave it at that. The result is that the question, "What constitutes the dividing-line between class A and class AB operation?" brings forth blank looks and a suspicion that it is a "catch" question. If our definitions are taken, there is no difficulty at all. An amplifier ceases to be class A and becomes class AB the moment the plate current drops to zero at the negative peak of the input signal. And yet one very well known textbook rather leads the reader to believe that the question is solely one of bias in relation to the mutual characteristic of the valve, making no explicit statement whatever.

OTHER TRANSITIONS

It should in fairness be pointed out that though there **is** a sufficiently clear-cut dividing-line between class A and class AB, such is not the case between class AB and class B; or between class B and class C. This is because of the inevitable latitude contained in the definitions of class AB, B, and C amplifiers. It would be unnecessarily restrictive if by definition, a class B amplifier passed plate current for **exactly** a half cycle of the input voltage, because in practice many class B amplifiers (particularly those using zero-bias tubes) pass a small but definite plate current with no signal input. Such an amplifier still fulfils the condition laid down by the definition. For this reason there can be no hard-and-fast dividing-line between class AB and class B working, nor can there be any between class B and class C.

THE CLASS "BC" AMPLIFIER

There has arisen in the literature comparatively recently a new class of amplifier which has been called class BC. This term is used to refer to a particular type of grid-modulated amplifier, but without going into the manner of operation of this amplifier it can be seen that if the fundamental definitions of class B and C amplifiers are granted, there is no possible justification for the introduction of this term. It is merely a first-class example of the kind of confusion we have been discussing. Since by definition there can be no sharp dividing-line between class B and class C, there can also be no such thing as a class BC amplifier. The term is intended to indicate a valve operating with a value of bias intermediate between the normal bias for class B and class C working and should be described as such, however convenient the term "class BC," for this name is definitely misleading.

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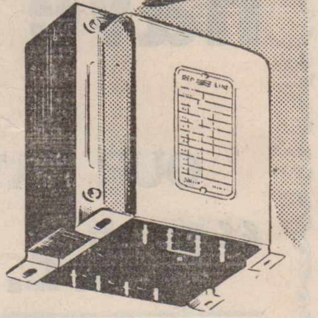

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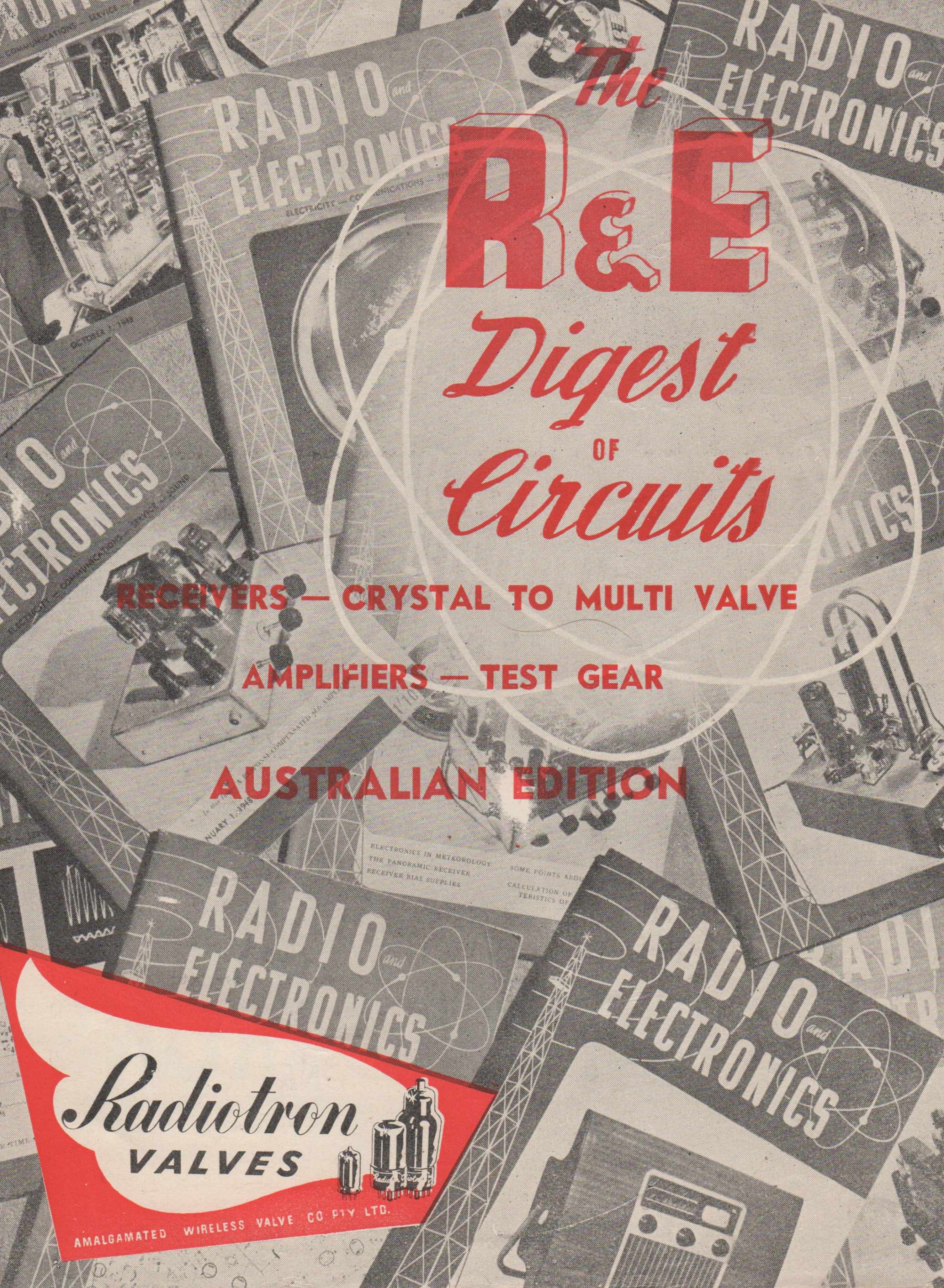

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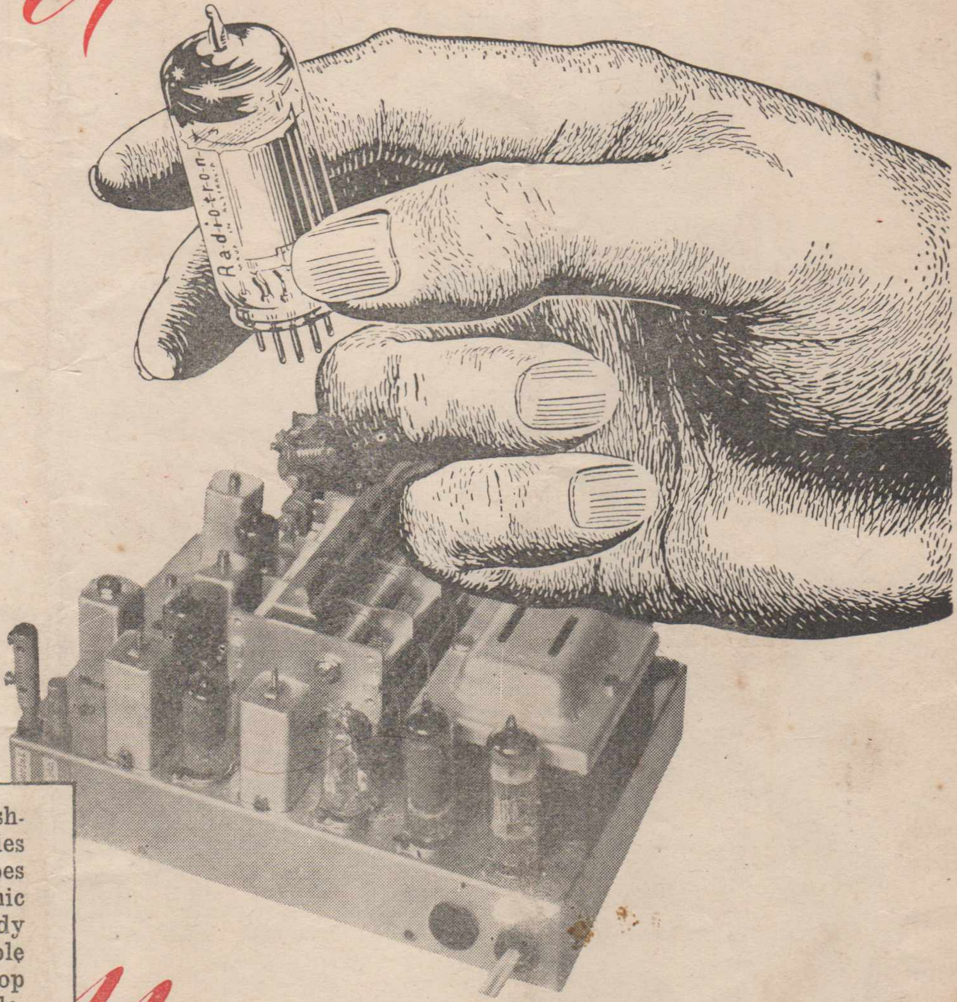

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