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CONTENTS

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* * *

Managing Editor:

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EDITORIAL

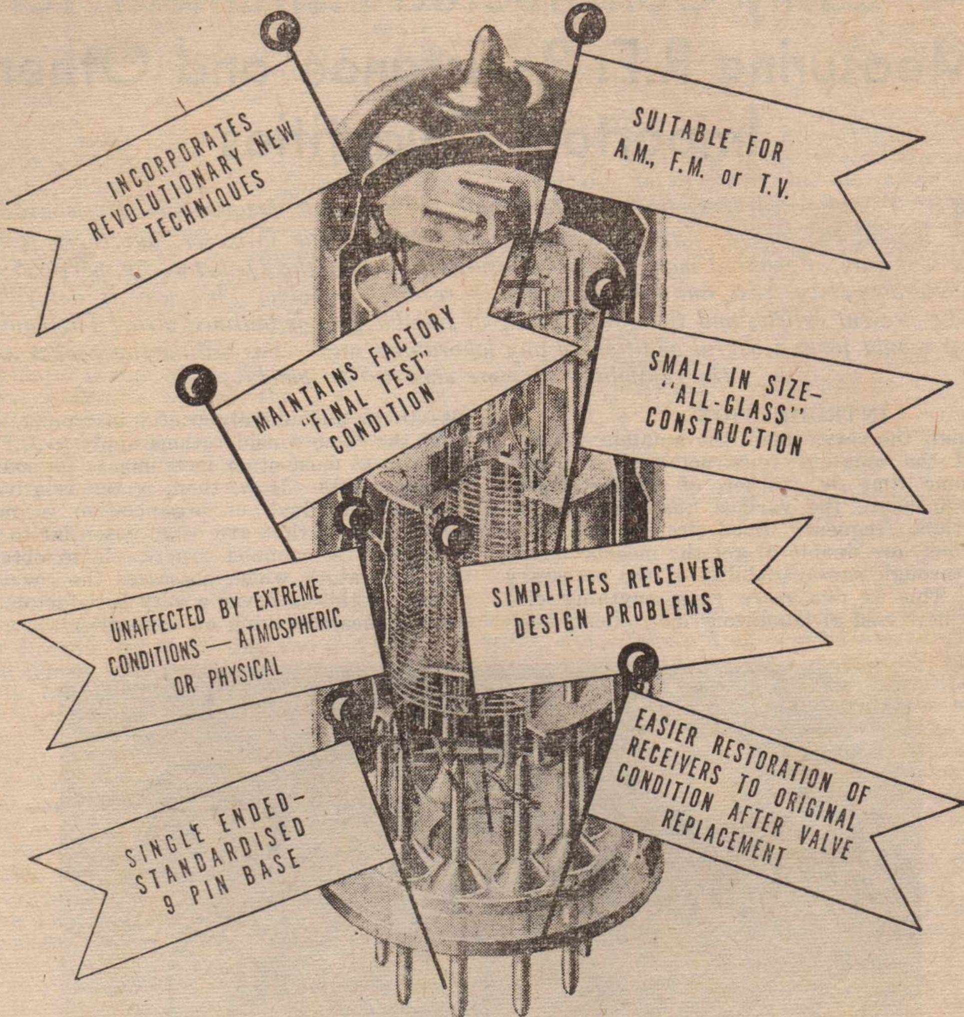
In a recent issue of the British magazine "Wireless World," is a short paragraph which draws attention to the late Lord Derby, and the fact that as Postmaster-General, in the year 1904, he was responsible for setting a precedent for which amateur transmitters throughout the Empire should be eternally grateful. The occasion was the passing by the House of Commons of the first Wireless Telegraphy Bill, and the noble lord's words during his second reading speech are worth quoting: "The class with whom I have the greatest sympathy," he said, "are those who wish to go in for experiments in this science, and I have been able to frame a clause which will give absolute freedom in that direction, merely requiring registration on the part of those who wish to engage in experiments. In a matter of this description the House will doubtless desire that the Act should be administered as liberally as possible, and I shall certainly do my best in that direction. For what it is worth I will give an undertaking that no request for a licence for experiments be refused unless the refusal has been approved by me personally."

These words might well be termed the Magna Carter of the amateur transmitter. Needless to say, the original delightfully simple state of affairs has not been retained, but it is important to note that the principal has not changed at all. The additional restrictions that have been placed on amateur activities have perhaps been regrettable, and no doubt call forth some nostalgic sighs from many "Hams" whose memories are not even as long as 1904, but the fact remains that they have been essential, in a world where radio communication has become such a vital service that every available kilocycle of the spectrum is needed. We are prone in these times to bemoan every additional restriction in an ever more regimented world, but the fact remains that with the frequency requirements of the nations so vast, amateurs are lucky to have any space left to them at all. Let it not be inferred that this journal does not believe that amateurs are worthy of every consideration. In the past, amateurs have rendered very great service to the nation, both in peace and in war, and it would be a very unjust thing if amateur activity were to be prevented because of restrictive legislation. On the other hand, amateurs should not forget that they possess their present frequency bands by way of privilege, and not as of right, and that given the appropriate conditions, they can be put off the air by legislation, as surely as they occupy their present position by virtue of other legislation. In time of war, amateur radio has to be suspended for a number of reasons, and it should be the constant concern of organised amateurs to see that their members themselves give no cause for peace-time restriction of their privileges.

There is a large body of amateurs whose interest in transmitting is not technical, but centres rather round the making of conversation with other amateurs, and forming "over the air" friendships. No one would say that those who go in for this sort of amateur activity should be discouraged. Indeed such a recommendation would be highly undemocratic. But some of these "talkers," as we may call them for want of a better term, are anything but an ornament to amateur radio. Their conversation and operating practice is on the air for all to hear, and many non-amateurs with all-wave domestic sets do listen to the amateur bands. It follows, therefore, that the "talkers" are those among the "Ham" fraternity whose activity comes most before the public view, if only for the reason that they spend more time on the air than many whose interests are elsewhere. Unfortunately, however, some of the worst operating practice comes from among their ranks, and some of it sounds fairly dreadful even to other amateurs, let alone to the general public. Again, the "talkers" are prone to long spells at the microphone, very often with quality of transmission that leaves a good deal to be desired. This sort of thing does not make them popular with other amateurs, particularly when the bands are so crowded, and it is quite understandable when in consequence, they are taken to task in the amateur literature for their lack of consideration for other users of the bands.

Even a casual search round the 80-metre band these days gives one cause to reflect that amateur radio is not what it was. At one time the people who came on the air and talked about anything but radio were fairly few and far between, because the main bond between amateurs was their common technical interest. Much of the technical talk that used to be heard was ill-informed, but almost all of it was characterised by an obvious desire to learn, and those amateurs whose technical knowledge was rather greater than the average were keenly sought after by the less knowledgeable. This sort of thing seems to us to be much nearer to the kind of amateur whom Lord Derby had in mind when he framed his 1904 legislation. He could not have forseen the "talkers," aforesaid, and the point we wish to make here is that he might have been horrified if he had been able to!

The moral of all this is that those responsible for controlling amateur radio by the granting of licences, and the administration and framing of amateur regulation do not have to foresee anything of the kind, because it is there for the hearing, and if a sufficiently large number of people among those in authority should decide that any section of radio amateurs is sufficiently little of an ornament not to be considered useful, it is not a long step to the restriction of amateur radio privileges, and not necessarily in a way that can be ascribed to the exigencies of ether space.



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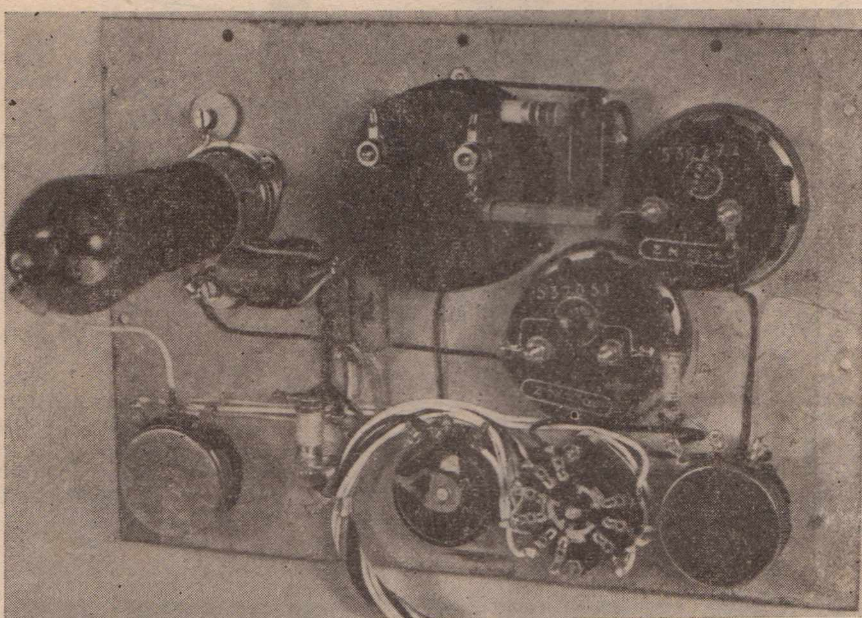
BEST FOR ALL ELECTRONIC APPLICATIONS

An Easily Constructed Instrument for Measuring R.F. Resistance and Other Important Quantities

MANY radio workers, both amateur and professional, frequently have cause to lament the lack of expensive instruments such as the Q-meter, but there is an excellent way of making many of the measurements that the Q-meter can perform at considerably lower cost, and with gear that is readily available. This way is described in the present article, and the construction of suitable gear is outlined also. The equipment would form a useful addition to any laboratory, and yet is within the pocket and the capabilities of more amateurs to build.

INTRODUCTION

The designer, the serviceman, the amateur transmitter and the amateur constructor all feel the need at some time or another, of an instrument which will measure the various quantities associated with radio frequency tuned circuits, and more often than not, are unable to get the measurements they need through non-availability of the necessary equipment. This is due more than anything else to the very high cost of laboratory instruments such as Q-meters, and R.F. bridges. The former is a very versatile instrument, since in addition to measuring the Q of a circuit directly, it is able to be used for accurate measurement of small capacities, the inductance of coils, and many other things, including actual R.F. resistance. The only difficulty about the commercial Q-meter is its very high price, which always runs into some hundreds of pounds. In addition, its accuracy is not very startling, high price or not, so that only a few of the most lavishly-equipped laboratories will generally be found to possess these undoubtedly useful instruments. Somewhat the same considerations apply to R.F. bridges, and also to most other instruments for making R.F. measurements. How, then, is the relatively impecunious individual, or organisation to make R.F. measurements that are often essential to the work in hand? A common practice is to obtain access to a laboratory which possesses the coveted equipment, but this is never a very satisfactory solution, since it means relying on someone elses generosity, and also entails taking the job to the instrument, instead of vice versa.



It is strange, therefore, to realise that there is a very satisfactory way of making many R.F. measurements with gear that is very simple to construct, and which can be built for less than ten pounds. The strangeness of the situation is even more apparent when it is realised that many radio men have never heard of the method, and that its scope is at least as great as that of the Q-meter, while for some purposes, its accuracy is considerably better. The simplicity of the equipment is almost unrivalled, too, since it consists only of a modified dynatron oscillator. The usefulness of this device has been publicised for many years by M. G. Scroggie, in his successive editions of "Radio Laboratory Handbook," but even so its virtues seem to have blushed unseen by the majority of radio men.

Readers will no doubt wish to know, at this stage, whether there is a "catch" in it, but we can solemnly assure them that there is not. The dynatron is the method we have used in our own laboratory for the last five years for measuring inductance, dynamic impedance, R.F. resistance, self-capacity, etc., of R.F. circuits, and the completed instrument's front panel is the cover picture for this issue.

WHAT THE DYNATRON MEASURES

The basic measurement that is made by the dynatron oscillator is that of the **dynamic impedance** of parallel-tuned circuits, and not the Q of the circuit, though this is closely related to the dynamic impedance. Actually, the dynamic impedance, or the parallel resistance at resonance, as it may also be described, is in many ways a much more useful thing to measure than the Q. It gives a direct measurement of the gain that can be expected, relative to that of another coil for the same frequency, when either is used in an amplifier stage, and is actually a better "goodness factor" than Q for most purposes. The Q-meter, as its name implies, measures Q directly, but from this and a measurement of inductance, the dynamic impedance can be calculated. In fact, the Q-meter and the dynatron are similar in that each can only make one basic measurement from which, with the aid of one or more additional measurements, other quantities can be evaluated. With the dynatron, the dynamic impedance is measured directly, and with a further measurement of inductance, the Q can be calculated. On this score, then, there is little or nothing to choose between the two, with, if anything, a slight advantage in favour of the dynatron, since it is usually more important to know the dynamic impedance than the Q. With both instruments, the other quantities listed have to be found by calculation from two or more measurements with the instrument itself, or with, say, a capacity bridge. But the latter is not a very expensive item, and is one found in any laboratory, and in many amateur workshops. It can be seen, therefore, that the dynatron is by no means to be sneezed at, since it will do practically all that the tremendously expensive Q-meter can, and just as quickly.

PRINCIPLE OF THE DYNATRON

Most readers will, no doubt, be familiar with the dynatron oscillator, at least in name. It was the first device to be discovered that exhibits negative resistance, and possibly the first two-terminal oscillator circuit. It relies for its operation on a characteristic of the early screen-grid valves that was in the first instance somewhat of a nuisance, and arises because of secondary emission within the valve. Readers will all have seen the plate characteristic curves of such valves as the 224, 235, 32, etc., which were in use as R.F. amplifiers before the advent of the R.F. pentode. Each curve on the family had a shape like the one illustrated in Fig. 1, which can be explained as follows.

Imagine the valve as having its normal screen voltage, say 100 volts, its normal grid bias of, say, —3 volts, and for a start, zero plate voltage. Under these conditions there will be no plate current, since all the electrons from the cathode will be attracted to the screen-grid and will flow in the screen circuit. Now if the plate voltage is gradually increased from zero, a few of the electrons which pass through the mesh of the screen will be attracted to it and a small plate current will flow. At first, the plate current will be approximately proportional to the plate voltage, but soon the plate current starts to rise less rapidly, as is shown by the curve becoming less steep. The reason for this is to be found in the occurrence of secondary emission at the plate. Some of the electrons striking it dislodge other elec-

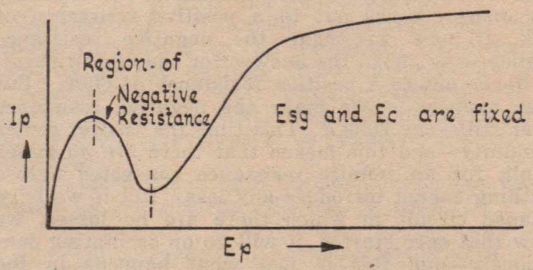


Fig. 1

trons from it. These dislodged, or secondary electrons, either fall back on to the plate, in which case they do not affect the plate current, or else being attracted by the higher positive potential of the screen, travel towards it and land upon it. Electrons which do this increase the screen current, but decrease the plate current, so that this is less than it would have been if secondary emission did not take place. As the plate voltage is increased, so a point is reached where the increase of plate current due to the higher plate voltage exactly equals the decrease due to secondary emission **from** the plate, so that there is no increase or decrease of plate current as the voltage is altered over a small range. This point is marked by the first vertical dashed line on Fig. 1. As the plate voltage is still further increased, the secondary emission increases **more rapidly** than the normal plate current does, so that the plate current actually decreases as the plate voltage is increased. This is the downward-sloping portion of the curve of Fig. 1, and is the one part of it that we are interested in practically, for this behaviour constitutes **negative resistance.** An ordinary, or positive resistance, is a component in which the current increases as the voltage across it increases. That is to say, it absorbs energy from the voltage source. A negative resistance, on the other hand, is any device in which an increase in voltage across it **decreases** the current through it, and must therefore actually supply energy itself.

Now let us see what would happen if we connected a negative resistance across a tuned circuit. We know what happens if a positive resistance is so connected. It absorbs energy from the circuit, and causes the damping to be increased. A negative resistance, on the other hand, decreases the damping on the circuit, and therefore reduces the energy losses. A high positive resistance connected across a circuit will mean a small **loss** of energy, and in the same way, a high negative resistance will mean a small **addition** of energy.

If we imagine that the value of our negative resistance can be varied at will (and this can be done) an interesting situation arises. Suppose, for example, that we have a tuned circuit whose dynamic impedance is 200,000 ohms, and that we have a negative resistance of 400,000 ohms which we connect across it, in parallel. The question is, what is the resultant actual resistance? Since we know that the connection of negative resistance across the circuit **reduces** the energy losses, the answer **must** be a positive resistance higher in value than the original 200,000 ohms. If we use the ordinary formula for resistances in parallel, but taking account of the **signs** of the resistances, we find that the answer works out to a **positive** resistance of 400k. If now we make the negative resistance smaller—say 300k., the answer for the two in parallel works out to a positive resistance of 600k. But what happens if we make the negative resistance lower still—say 200k.? This time the answer comes to infinity—and this means that there are no losses at all, for an infinite resistance connected across anything cannot introduce any loss. But if we have a tuned circuit in which there are no losses, we know that once started, it will go on oscillating continuously—and this is just what happens in the dynatron oscillator. The circuit consists of a screen-grid valve in which the screen voltage is higher than the plate voltage, in the right ratio to put us on the negative resistance part of the characteristic. Then we use the control grid bias as a control of the amount of negative resistance. We connect our tuned circuit in series with the plate lead, and therefore in parallel with the plate cathode path of the valve, and thus in parallel with the negative resistance produced by the valve. The grid bias is adjusted to the point where the circuit just oscillates and no more, and in this condition we know that the positive parallel impedance of the turned circuit is exactly balanced by the negative resistance given by the valve. If we can now measure the amount of negative resistance the valve is giving, we will know the impedance of the tuned circuit. This, briefly, is the principle upon which the dynatron works as a measuring instrument.

Before we leave the mechanism of the dynatron, we should perhaps explain how it is that the negative resistance characteristic does not persist over the whole range of plate voltage. As the plate voltage is increased, the negative resistance decreases to its minimum value, as shown by the maximum slope of the negative resistance part of the curve, approximately in the middle. However, as the plate becomes more positive, more and more of the secondary electrons are attracted back to the plate, instead of going to the screen, and thus the negative resistance increases again, and at some point disappears altogether. This is the right-hand one marked with the dotted line, so that the circuit

Continued on Page 20

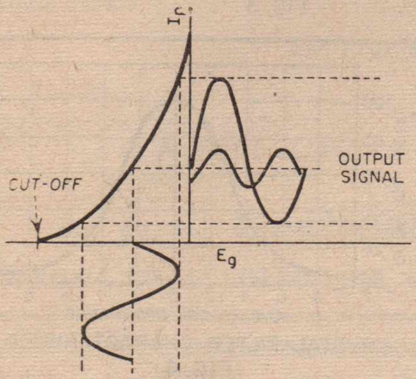
Audio Frequency Distortion Measurements

Part I — Methods of Measurement

By the Engineering Department, Aerovox Corporation

This is Part I of a series of two articles which will deal with audio frequency distortion measurements. Part II will give details of a simple, practical instrument designed to measure distortion in audio amplifiers.

The acoustical quality of an audio amplifier is related to the amount of distortion prevalent in the amplifier. If conforming to true Class A operation. the output plate current waveshape of the amplifier should duplicate the waveshape of the grid voltage input. Such not being the case, the amplifier has a certain percentage of harmonic distortion which, if excessive, deteriorates the audio quality and becomes annoying to the listener.



DISTORTION IN NON-LINEAR AMPLIFIER

FIG. 1

TYPES OF DISTORTION

There are three types of distortion found in an amplifier: (1) amplitude distortion; (2) frequency distortion; and (3) phase shift. In amplitude distortion, the fundamental plus harmonics are observed in the output. Frequency distortion is caused by the amplifier's inability to amplify all frequencies equally. Phase shift is present when the amplifier has different delays for all frequencies. The amount of distortion increases as the tube is operated outside of the linear portion of the tube characteristic curve, as shown in Fig. (1).

In addition to harmonic distortion, there is intermodulation distortion in audio amplifiers. Both are caused by non-linearity in the amplifier. Intermodulation results in the production of frequencies equal to the sums and differences of a low and high frequency (and harmonics). The intermodulation products of fundamental frequencies F1 and F2, are as follows: The intermodulation products do not resemble the original tones in the input.

F1 + F2 and F1 — F2
2F1 + F2 and 2F1 — F2
F1 + 2F2 and F1 — 2F2, etc.

Intermodulation distortion measurements more closely correspond to the non-linear distortion dedetected by the average radio listener than does a measurement of total harmonic distortion. It is interesting to note that intermodulation distortion can be observed even after no harmonic distortion is measurable.

The percentage of total harmonic distortion, represented as the disortion factor, is equal to:

$$\sqrt{\frac{\text{Sum of squares of harmonic amplitudes}}{\text{Sum of squares of fundamental and harmonic amplitudes}}} \times 100$$

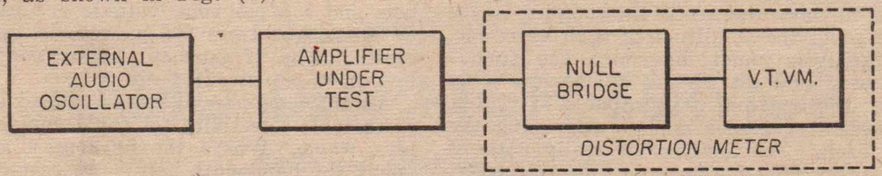
and is measured on the distortion meter. The distorted waveshape can be represented by the Fourier series, and the relative values of the terms of the series indicate the amplitudes of the harmonics in the complex wave.

The harmonic content of the signal includes all of the components which are higher in frequency than the fundamental. Signal components which are lower than the fundamental, such as noise from the power supply, are not usually measured. Total harmonic distortion measurements are most frequently made at 400 or 100 cycles per second. Even though this is the standard practice, additional distortion will usually be present at the lower frequencies. The Federal Communications Commission recommends a measurement of harmonics in audio equipment at frequencies of 30, 50, 100, 400, 1000, 5000, 7500, and 15,000 cps.

DISTORTION METER

Audio frequency distortion measurements can be made by using distortion meters, harmonic wave analysers, and intermodulation analysers. The distortion meter will be discussed first.

A distortion meter gives the percentage of total harmonic content and does not show how much of each harmonic is present in the output. A block diagram of the meter is shown in Fig. 2 Basically, it consists of a null bridge and a vacuum tube voltmeter. The null bridge is tuned to the fundamental such as 400 cycles per second and the bridge is balanced at this frequency to entirely remove the

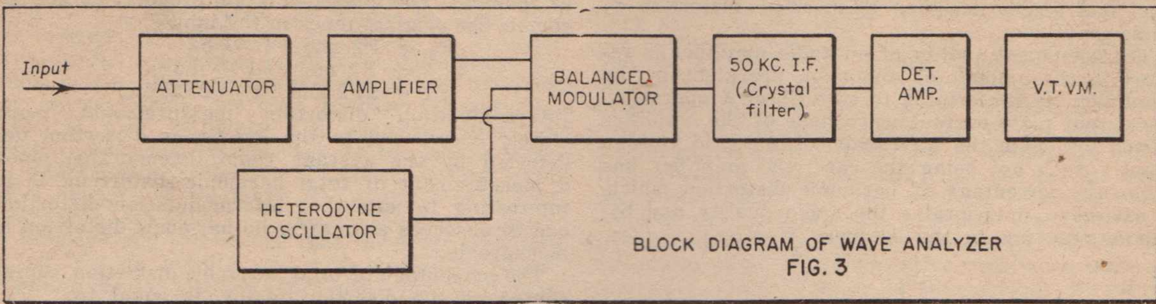


TEST SET-UP USING DISTORTION METER

FIG. 2

fundamental. The vacuum tube voltmeter will then measure only the amplitude of the harmonics. For accurate measurements, the oscillator generating the fundamental test frequency should be completely free of harmonics. In addition, the VTVM should represent the RMS voltage as truly as possible. This can be insured by operating the VTVM in a manner such that the square root of the plate current versus grid voltage is a linear function.

The most commonly known wave analyser is the heterodyne type. A block diagram is shown in Fig. 3 and is representative of a commercial analyser. The incoming audio signal is heterodyned with the frequency from a variable frequency oscillator and the resultant frequency is amplified by the narrow bandwidth IF amplifier and read on a vacuum tube voltmeter. When the difference between the oscillator and the input signal frequency is 50 kc/sec.,



BLOCK DIAGRAM OF WAVE ANALYZER
FIG. 3

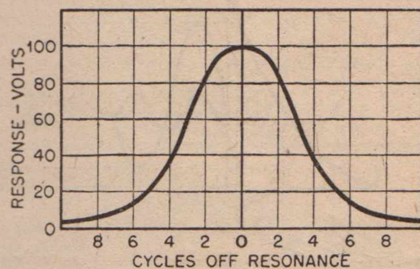
The distortion meter does not indicate which frequencies are present in the complex-distorted wave and the relative amplitude of each. In addition, certain random noises may be very disturbing to the listener and yet show only a small indication on the meter. Therefore, as in many test measurments, the operator must show sufficient skill to translate the results obtained with the meter into useful data.

A typical commercial distortion meter has a frequency range from 50 to 15,000 cps. The distortion percentage is read directly from a meter with calibrated full-scale deflections of 0.3 per cent., 1 per cent., 10 per cent., and 30 per cent. distortion. A diode vacuum tube voltmeter is used for measuring the percentage of total harmonic distortion. The scale is also calibrated in decibels. A 100,000 ohm unbalanced and a 600 ohm balanced bridge input circuit are provided. Distortion measurements are made on this instrument with an accuracy of approximately 5 per cent. A distortion-free sine wave oscillator should be used with the meter. Otherwise a residual reading will be measured which represents the oscillator distortion rather than that of the amplifier or other audio device being tested. There should be no distortion even at the very low audio frequencies.

HARMONIC WAVE ANALYSER

Unlike the distortion meter, the harmonic wave-analyser is a precision method of measuring distortion and indicating separate components. The wave-analyser tells the operator which frequencies other than the fundamental are in the complex waveform and also gives the amplitude of each harmonic.

Since the analyser must determine the fundamental frequency and all of the harmonics, it is necessary that the instrument be capable of tuning to each of these frequencies and of measuring the amplitude of each. The analyser is really nothing more than a highly selective vacuum tube voltmeter, and is similar to the conventional superheterodyne receiver except that the intermediate frequency is much higher than the input audio signal under observation. The wave analyser has a very narrow bandwidth, otherwise measurements of harmonic components at the very low audio frequencies would be impossible.



CRYSTAL FILTER CHARACTERISTIC
FIG. 4

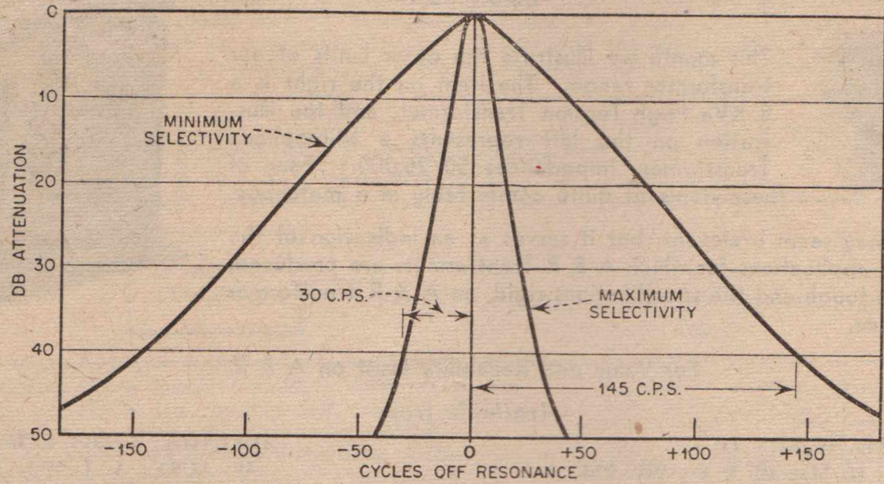
the signal will be tuned to the IF amplifier and the amplitude can be measured on the VTVM. The three-crystal filter incorporated in the IF amplifier assures a very high selectivity. A response curve of the crystal filter is shown in Fig. 4. The heterodyne oscillator covers a frequency range of 34,000 to 49,980 cycles per second but the dial is calibrated from 0 to 16,000 cps. Assume that the incoming signal is 500 cps. This would correspond to an oscillator frequency of49,500 since 49,500 plus 500 c.p.s. equals 50 kilocycles. A difference frequency F1 — F2 (49,500 — 500) cannot be amplified. The bandwidth is only four cycles and harmonics can be measured easily at the lowest audio frequencies. The input impedance is one megohm, which is sufficiently high to make loading effects negligible. The VTVM is directly calibrated in volts and decibels and a 5 per cent. voltage accuracy is obtained on all ranges from 300 microvolts to 300 volts full scale. The frequency calibration is accurate to ± 2% — (1 cycle).

Another commercial wave-analyser has the feature of variable selectivity for rapid analysis of the complex wave. Where the harmonics are spaced far apart, the bandwidth may be increased, thus making it easier to make measurements. If the harmonics are closed spaced, as at the very low frequencies, the instrument may be made more selective, to separate harmonics 30 cycles apart. A response curve of this analyser is shown in Fig. 5.

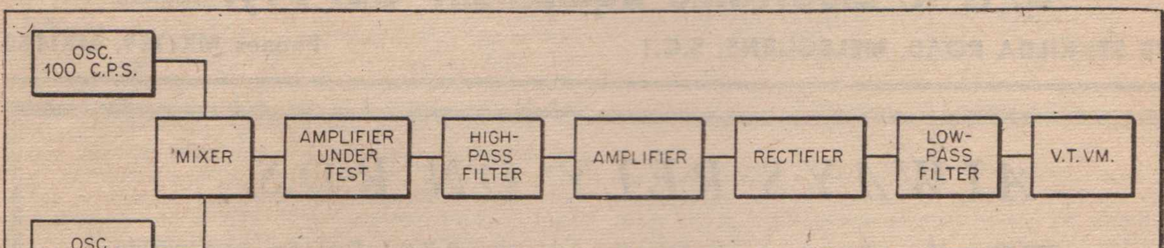
The operation of a wave analyser involves first tuning the oscillator dial to the fundamental and

then adjusting the attenuator until the meter reads full scale. Then the harmonics are found by changing the oscillator frequency dial and recording the amplitude of each.

In addition to its use for measuring the distortion in an amplifier, the wave-analyser can be used for measuring distortion in oscillators, transmitters, and telephone systems. It can also be used to determine the harmonics in power machinery and to analyse noise characteristics.



VARIABLE SELECTIVITY RESPONSE CURVES
FIG. 5



BLOCK DIAGRAM OF INTERMODULATION ANALYZER
FIG. 6

THE INTERMODULATION ANALYSER

A block diagram of a typical commercial intermodulation distortion meter is shown in Fig. 6. The amount of distortion is maximum at the highest and lowest transmitted frequencies. However, this discussion will be concerned mainly with intermodulation distortion measurements at the very low audio frequencies. At low frequencies, maximum power output from a tube is not realised because of impedance changes in transformers and reactances. The power output is similarly reduced at the higher frequency because of increased leakage and distributed capacity.

In operation, two frequencies shown on the diagram (Fig. 6) as 100 and 7,000 c.p.s. are combined in the mixer. The purpose of the 7,000 c.p.s. signal is to act as a carrier for the low frequency components. These two frequencies are commonly used, but a lower frequency ratio must be used if the amplifier under observation has insufficient bandpass. For best sensitivity, the amplitude of the lowest frequency should be 12db. above the higher frequency—a voltage ratio of 4 to 1. The output of the mixer is fed to the amplifier under test and its harmonics. The resultant signal, which is 7,000 c.p.s. modulated by 100 c.p.s., is amplified and demodulated by the rectifier. It is then fed to a low pass filter to eliminate 7,000 c.p.s., and the output is fed to a VTVM where the intermodulation products are present and the percentage of intermodulation distortion is read directly from the meter.

There is no direct relationship between the percentage of total harmonic content and the percentage of intermodulation distortion. With a 12 db ratio for the above frequencies, some authorities claim the percentage intermodulation distortion is equivalent to;

$$(h1\ h2\ h3\ \ldots\ hn) \times (n)$$

where h1, h2, etc., are the harmonics and is the order of harmonics. As an example, 10 per cent. intermodulation distortion is often equivalent to about 2.5 per cent. total harmonic distortion. Since there are no definite standards for these measurements, any figure of intermodulation distortion must be accompanied by a statement of test conditions.

It is hoped that this brief discussion of audio frequency distortion measurements will be helpful in clarifying the general subject distortion measurements. The next article will be especially helpful to those who wish to construct a simple meter for rapid measurement of the percentage of total harmonic distortion and indentification or harmonic wave components.

(To be continued)

A VERSATILE RANGE OF AMPLIFIERS COVERING ALL GENERAL SOUND REQUIREMENTS

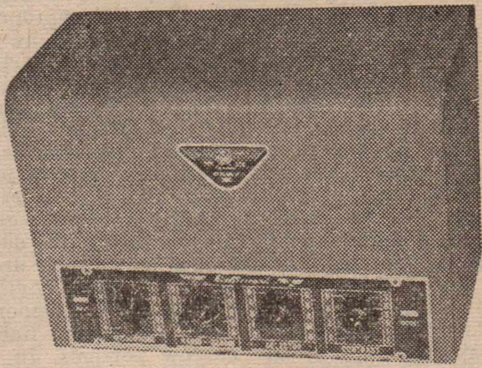
Details of Special Type Amplifiers, LARGE Power, etc., on request.

SPECIFICATIONS—MODEL X15

INPUTS, high impedance, gramo .5 meg., microphone .1 meg., radio .5 meg.
SENSITIVITY, gramo .25 volt, microphone .002 volt, radio .25 volt.
POWER OUTPUT, 15 wts. Noise level—50 db.
DISTORTION, maximum 5% at full output.

OPERATING VOLTAGE, AC 220, 240, 260 volts.
OUTPUT IMPEDANCE, 600, 300, 150, 75, 37.5, 18.75 ohms.

VALVES, 2/6AU6, 1/6SN7-GT, 2/6V6GT, 1/5V4G.
DIMENSIONS: 13¼in. x 9½in. x 8¼in.



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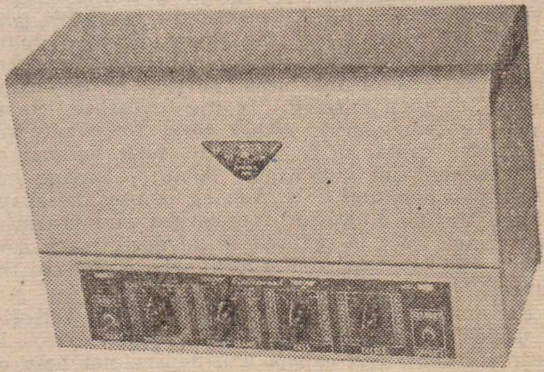
SPECIFICATIONS—MODEL XV25

INPUTS, high impedance, gramo .5 meg., microphone .1 meg.
SENSITIVITY, gramo .25 volt, microphone .002 volt.

POWER OUTPUT, 25 wts. Noise level—46 db.
DISTORTION, maximum 5% at full output.

OPERATING VOLTAGE, battery 12 volts or AC 240 volts.
OUTPUT IMPEDANCE, 600, 300, 150, 75, 37.5, 18.75 ohms.
VALVES, 2/6AU6, 1/6SN7-GT, 2/807, 2/6X5GT.
DIMENSIONS: 16in. x 10 in. x 8¼in.

NOTE: This amplifier is designed for use from either battery or A.C. mains. Changeover for either operation is made by simply changing connecting cables supplied with amplifier.

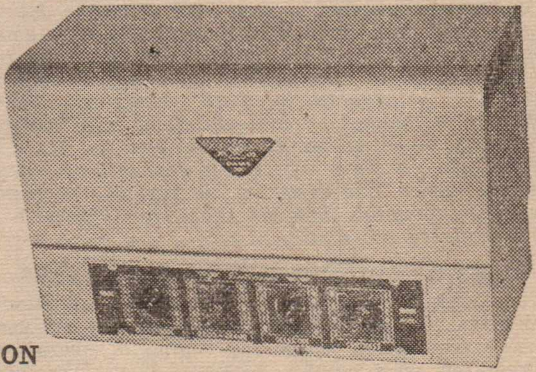


★

SPECIFICATIONS—MODEL X30

INPUTS, high impedance, gramo .5 meg., microphone .1 meg., radio .5 meg.
SENSITIVITY, gramo .25 volt, microphone .002 volt, radio .25 volt.
POWER OUTPUT, 30 wts. Noise level—50 db.
DISTORTION, maximum 5% at full output.

OPERATING VOLTAGE, AC 220, 240, 260 volts.
OUTPUT IMPEDANCE, 600, 300, 150, 75, 37.5, 18.75 ohms.
VALVES, 2/6AU6, 1/6SN7-GT, 2/807, 1/5V4G.
DIMENSIONS: 16in. x 10 in. x 8¼in.



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Some Wave Forms and How to Make Them

PART II

NOMENCLATURE OF PULSES

At the end of the first instalment of this article, we were discussing the nature of pulses, as distinct from square-waves, and saw that an appropriate definition can be made by regarding pulses as special cases of square waves, in which the portions above and below the datum line are not equal in amplitude. The difficulty that sometimes causes confusion to the newcomer is that different writers call what appear to be identical wave-forms by different names. There is a certain amount of justification for this, because a wave like that of Fig. 1 (b) can just as easily be called a positive-going pulse, or a negative-going square-wave **if the datum line is not inserted**. For example, as we have drawn it in Fig. 1 (b), it could hardly be called anything but a positive-going pulse, but if a D.C. component is added, it is possible to shift the datum line up to, say, the tops of the narrow portions. In this case, it might be more appropriate to call it a negative-going square wave, because the operative portion of the wave is now the longer, negative-going portion rather than the shorter positive bit, and because the idea of **shortness** inherent in the name "pulse", is then missing. In the literature, one is liable to come across either term for what will sometimes appear to be the same thing, because of the common, but undesirable habit of leaving out the datum line, and thus showing merely the shape of the wave. However, forewarned is forearmed, and if this fact is realised in advance, much confusion will be saved the student who is new to the subject.

For instance, one might just as easily call (b) a positive pulse, or a negative square-wave. In general, what it is called, will depend not only on its shape, but on how it is to be used. The difficulty is increased somewhat because very often the datum line is artificially shifted by inserting a D.C. component, so that the term "pulse" becomes inappropriate because of the inherent meaning of "shortness" that belongs to the word. However, if this difficulty is realised by the reader, he will find descriptions much easier to understand as, for example, when a wave like (c) is changed by bringing the datum line down to the tips of the negative-going portions, and yet the writer refers to it as a negative pulse still.

USES OF SQUARE-WAVES AND PULSES

The uses of square-waves and pulses are almost unlimited. It can be said briefly that they are used in any application where the timing of operations is required, on a regular, recurrent basis. The most obvious application is that of synchronising the receiver time-bases in a TV receiver with those at the transmitter. Another important application is the synchronising of the several operations that take place in a radar system. Yet another is the establishment of accurate time intervals in pulse-modulated multiplex telephony systems, not to mention the use of the pulses, modulated in some way, for actually conveying the several sets of intelligence.

Allied to timing operations are switching operations. For this purpose, square-waves are usually employed, as in the electronic switch used for making two pictures visible at once on the screen of the same cathode ray tube. Electronic switches have also been used in radar for automatically feeding the outputs of several aerials, in a definite time sequence, to the one receiver, and at the same time for switching the C.R.T. display circuits so that the signals from each aerial can be seen separately, and identified.

Electronic switches have also been used for automatically arranging for the strongest signal from a number of aerials to be heard in a set of diversity receivers, and for automatically producing repetitive sequences of events such as the operation of signal lights, etc.

Square-waves, in combination with saw-tooth waves, are used for measuring small time intervals, from micro-seconds upwards, and for performing a multitude of functions too numerus to mention. The examples given in this paragraph are only a few that spring readily to mind without any special thought. They are enough, however, to indicate that practically all the non-radio uses of valves find some application for square-waves and their generating circuits. They are to be reckoned a topic of major importance to anyone who aspires to know anything of electronics, as distinct from simple linear amplifiers and radio receivers, which themselves are no more than a special kind of linear amplifier.

METHODS OF GENERATING THEM

Perhaps the first important thing about the generation of non-sinusoidal wave-forms is the question of what they are made from. In general, they can be made in one or two ways, each of which is important, and has its own uses. The first way is to generate them directly by means of special oscillators, while the second is to start off with a sine-wave, and modify, or distort it, until the wave shape is the one needed for the purpose in hand. The main advantage of the first method is that it usually needs fewer valves, while the second method has the advantage that while several steps are needed, and several valves, it is often possible to use intermediate wave-forms throughout the chain for purposes required by the complete equipment for which the square-waves or pulses are being generated. These wave-forms are seldom an end in themselves, but are usually means of making an equipment perform its particular functions. The same thing can be said of the signals from a microphone, in that the electrical output of the microphone is simply a means whereby the use of amplifiers is made possible, since amplifiers are needed to operate loud speakers.

Very often, a combination of both methods is used, in which a sine-wave is used as a frequency standard and a particular point on each cycle as a time reference point. In this case the actual square-waves used may be made by multivibrators of one sort or another, synchronised by means of pulses derived from the original sine-wave for that specific purpose. In this article, however, it is intended to deal with the second method, as readers of this journal will have become reasonably familiar with the simple multivibrator. Besides, these interesting circuits are themselves material for several articles! Indeed, the whole subject of non-sinusoidal waves and their generation is one about which large and weighty volumes have been written. It is thus not possible in an article of this kind to do more than skim the surface.

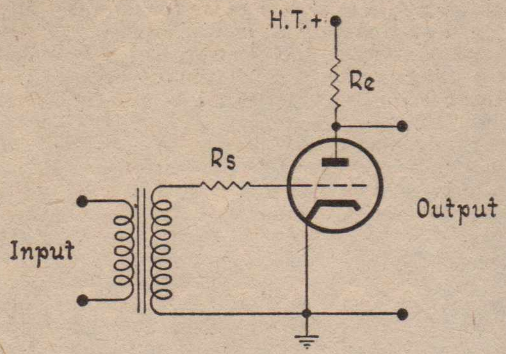

Fig. 2

THE DISTORTING AMPLIFIER

Perhaps the most widely used method of generating wave-forms from sine-waves is to use an amplifier, designed and arranged to distort the sine-wave in a particular manner. Those who have looked at the output of an audio amplifier using an A.F. oscillator and an oscilloscope will have more than a clue as to how this is done. If a valve is biased in the centre of the straightest portion of its characteristic, and if the input voltage is kept within certain prescribed limits, then the A.C. output voltage is an almost distortionless reproduction of the input wave, regardless of its shape. Of course, amplification is obtained at the same time, and for ordinary purposes this is the desired end. But if the input voltage is increased, two things happen. The negative half-cycles swing the grid of the amplifier valve past its cut-off voltage, and the positive half-cycles swing it positive, so that the current through the valve no longer increases when the grid voltage goes more positive still. Now both these occurrences cause the output voltage to lose all resemblance to a sine-wave, and it will be found that if the A.C. input voltage is increased sufficiently, the output wave will resemble Fig. 1 (a) much more closely than it resembles the original sine-wave.

This, very briefly, is the principle on which square-wave and pulse generators work. There is a good deal more to the question than that, however, and actual pulse generators are specially designed for the purpose, and not just overloaded amplifiers. But the principle of the over-driven amplifier is the basic idea behind a whole famiiy of important circuits, which we will discuss in the next instalment of this article.

One of the simplest distorting amplifier circuits is that shown in Fig. 2. Here we have a small triode, such as a 6C5, 6J5, or half of a 6SN7; in the plate crcuit there is a load resistor, R1, there is no grid bias, and the input is supplied from a transformer, through a series grid resistor, Rs.

The action of this circuit is as follows. Without any signal input, the valve will not draw excessive current, in spite of the fact that there is no bias, because of the relatively high value of load resistor. The input transformer provides approximately 100v. R.M.S. at its secondary terminals, and thus each half-cycle has a peak value of approximately 141 volts. The grid of the valve, in the absence of Rs would thus be driven between the limits of plus 141 volts and minus volts once in each cycle of the input voltage. First of all, let us see what happens on the negative half cycles. The valve does not draw grid current at this time, because the grid is negative with respect to cathode for the duration of the half cycle. Because of this, there is no voltage drop in Rs, and the full negative voltage of the input is applied to the grid. Because of the large input voltage, however, the valve becomes cut off after a very short time, but during the period in which the valve is still conducting, there will be a sharp rise in plate voltage, corresponding to the rapid fall in grid voltage, and actually being an amplified version of this part of the input voltage. However, as soon as the input wave takes the grid to cut-off, conduction ceases, and so does the rise of plate voltage. At this point, the plate voltage is equal to that of the H.T. line, because since there is no plate current, there can be no voltage drop in the load resistor. From now on, the valve remains cut off while the input wave completes the negative-going quarter-cycle, and reaches its maximum, or peak negative value. The voltage then starts to rise once more, but until it reaches the cut-off bias for the valve, the latter remains at cut-off. Now as long as this happens, the plate voltage remains static and equal to the H.T. voltage, so that during this cut-off period, the output way is a horizontal straight line, following the very quick rise mentioned above. But as soon as the input voltage reaches cut-off while proceeding in the upward direction, the valve starts to conduct again, and this it does for the whole of the remainder of the cycle. But while the input is travellng up from cut-off to the grid current point, the valve amplifies once more, and this time, the output is a rapidly falling plate voltage, and is an amplified version of the part of the input cycle which is crossing the grid-base of the valve. This process is illustrated graphically by Fig. 5, which gives a physical picture of what is happening over the whole cycle of the input voltage. This diagram shows the grid volts/plate current characteristic of the valve, and the input and output wave forms. The dotted input wave form represents the 100v. R.M.S. input, and and the figure illustrates why, with such a large input voltage, the times during which the valve conducts and amplifies, are so very short. The full-line part of the input wave is the effective part, for once the valve is cut off (referring again to the negative half-cycle), the shape of the wave input has no further effect on the shape of the output wave. (Note: In Fig. 5, the time scale for the input wave is from top to bottom of the picture, and for the output wave, from left to right.) If the figure is examined in conjunction with the description we have just given, it will be possible to visualise quite clearly what happens, and how the square-cornered **positive** half-cycle of output arises.

What, then, of the negative output half-cycle? This obviously occurs during, and corresponds in time to, the positive half-cycle of the input voltage. We have already described the rapid drop in plate voltage (AA on the diagram) which occurs while the input wave form is crossing the grid-base of the valve during the latter portion of the negative half-cycle and the beginning of the positive half-cycle. It is important to note that the datum line for the input wave is the zero-bias line, since there is no bias on the valve. The only portion of the output wave left to explain is the portion AB, in which the plate voltage is once again constant for a considerable time, but this time at a very low value. It will be seen that the valve has been shown as possessing a characteristic in which, after the grid has risen to only a few volts positive with respect to cathode, the plate current ceases to rise at all. If this is the case in practice, then once the input wave has driven the plate current to this saturation value, any further increase of positive voltage can no longer increase the plate current. This then remains constant, and high in value. There is thus a large and constant voltage drop through the plate resistor, giving the portion AB of the output wave, until the input wave-form returns on its downward journey to complete the positive half-cycle.

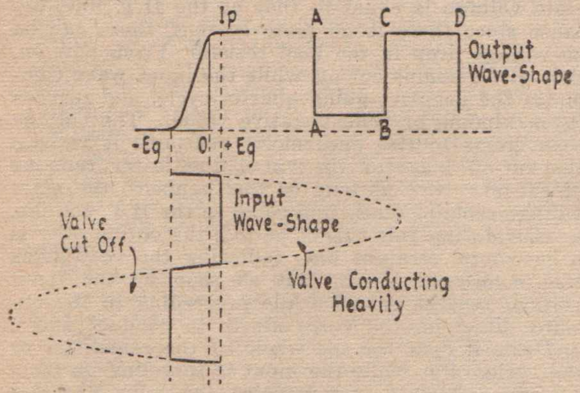

Fig. 5

The purpose of the series grid resistor has yet to be explained, however. The chief reason for its presence is that some means must be provided of preventing a very heavy, damaging flow of grid current from occurring during the positive half-cycle of the input voltage. Obviously few valves will stand positive grid voltages of over 100 volts for long without the grid becoming overheated through excessive grid current; the insertion of the series resistor actually prevents a very high positive grid voltage from occurring in any case, while having no adverse effect on the output wave-form. From an examination of Fig. 5, it can be seen that as long as the grid voltage goes the few volts positive that are needed to drive it into the saturated condition, any further positive voltage on the grid is unnecessary. Thus, Rs is inserted to act as a voltage divider, **but only during the positive half-cycles.** More strictly, the voltage divider action takes place only while the valve is drawing grid current. When this happens, the grid-cathode circuit inside the valve acts as a low resistance of only a few thousand ohms. If Rs is made high in value, it acts, together with a grid-cathode resistance as a voltage divider, so that only a small fraction of the input

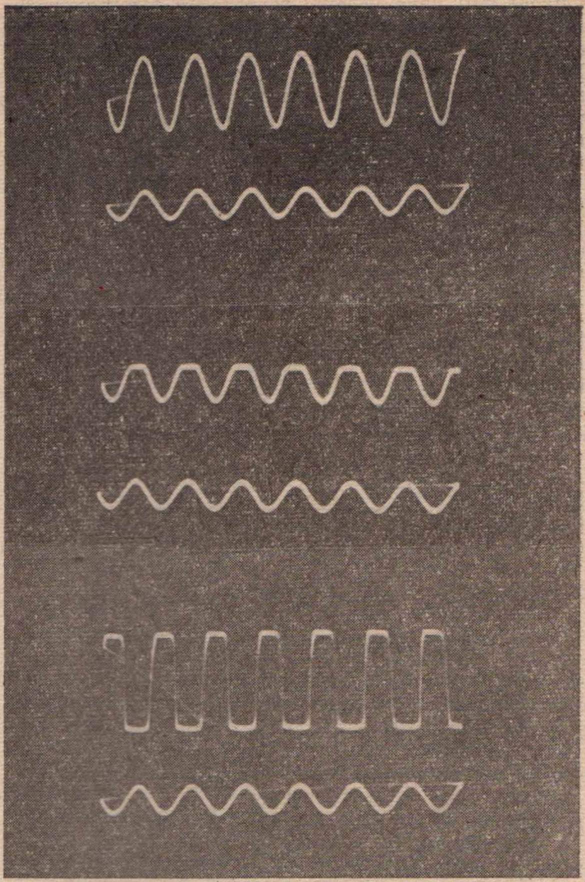

Fig. 6.

voltage is actually applied to the grid while grid current is passing. The net result is that contrary to first expectations, the valve never has its grid more than a very few volts positive, so that the high positive input voltage does no harm. Needless to say, the voltage dividing action does not take place once grid current ceases, and thus Rs has absolutely no effect on the **negative voltage** applied during the negative half-cycle, and thus, no effect on the shape of the output wave during this time.

This circuit can be seen to produce an output very similar to Fig. 1 (a), in that the positive and negative half-cycles are of almost equal duraton. With this arrangement they are not **quite** equal, because as can be seen from Fig. 5, the datum line for the input wave is nearer the saturation grid voltage than cut-off. The negative half-cycle of the input will therefore affect the plate current for a slighlty shorter period than will the positive input half-cycle. This will make the output **postive** half-cycle slighlty shorter than the negative one, but only very slightly shorter. The larger the input voltage, the smaller will be the time difference between the length of the half-cycles.

PRACTICAL PERFORMANCE OF THE CIRCUIT

In order to demonstrate the actual performance of some of the circuits about which we are writing, test circuits were constructed, and the actual wave-forms from them were photographed on the oscil-

(*Continued on Page 26*)

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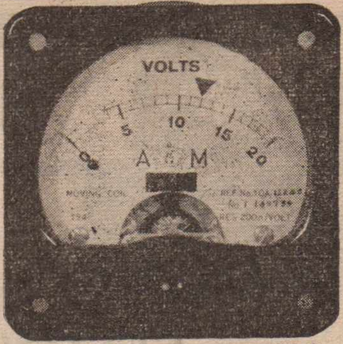

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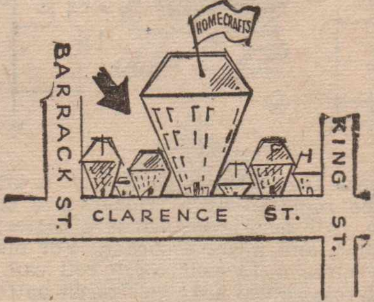

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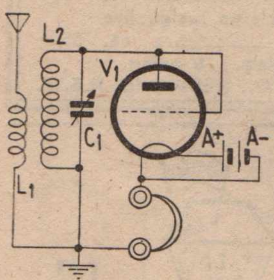
GETTING STARTED – Part 3

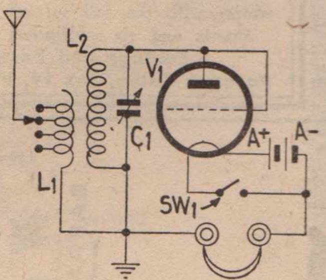
WHAT IS RADIO?

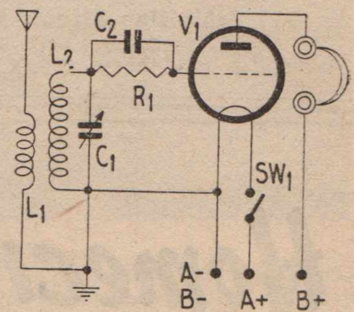
The first question to which many will desire an answer is: "What ARE radio waves anyway?" This, though a very reasonable request, is, strangely enough, very difficult to answer. The only REAL answer is the one which was given to the world by a very famous mathematician, Clerk Maxwell, but it is quite impossible to set it out here, for none of our readers would understand it if we did. At least, not unless they were mathematicians. However, it was Maxwell's mathematics that caused radio to be likened to waves in the first place, for he proved that in many ways, what we know as radio, behaves much as do waves on the surface of a sheet of water. (This was all the more remarkable, since, in Clerk Maxwell's day, no one had discovered practically that any such things as radio waves could be produced, let alone be used for communicating between remote places!)

So we have it that radio waves are like waves in water, but they are very different from water waves because they can be neither seen nor felt. This is where the radio set comes in. Its job is to allow us to detect the radio waves. Ordinarily the set does this by transforming them into mechanical vibrations which cause sounds that can be heard by our ears.

Using a Valve Instead of the Crystal







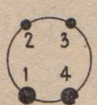
These two circuits show how a crystal detector can be replaced by a triode valve connected as a diode. All that is needed is a battery to light the filament, and a valve socket. For old-fashioned 2-volt valves a 1½ volt torch cell can be used, and for 4-volt valves a 4½-volt torch battery. The left-hand circuit shows Crystal set No. 3 altered to use the valve, and the right-hand one, crystal set No. 2. In the latter a switch has been added to turn the valve filament on and off.

V1 can be any of the valves shown in the table.

1G4-GT

1. N.C.
2. Fil
3. P.
4. N.C
5. G.
6. (absent)
7. Fil.
8. N.C

30 etc.



1. Fil
2. P.
3. G.
4. Fil.

These diagrams show the pins to which the various elements of the valves given in the table are connected.

N.C. stands for No Connection, and is used when the pin is present, but has nothing inside the valve connected to it.

The above circuit shows a more sensitive one-valve arrangement, which uses a B battery as well as the filament or A battery. The former can be a 45-volt B battery, or can be made from a few 4½-volt torch batteries in series. Three of them, giving 13½ volts, will give very good results. L1, L2, same as aerial and tuning coils in any of the crystal sets. C2 0.00025 to 0.0005 mfd. C1 same as tuning condensers in crystal sets. V1, any of the valves shown in the table below.

Tube Type	Fil. Voltage	Fil. Current	Type of Base
1G4-GT	1.4	0.05 amp.	Octal
1H4-G	2.0	0.06 amp.	Octal
30	2.0	0.06 amp.	4-pin
A-415	4.0	0.06 amp.	4-pin
A-409	4.0	0.06 amp	4-pin
PM2DX	2.0	0.06 amp.	4-pin

NOTE—The last three types are old Philips or Mullard battery valves, which may sometimes be bought quite cheaply second-hand. Even if very cheap, they should be tested before buying.

CIRCUIT DIAGRAMS AND SYMBOLS

If we set out to build anything at all, much the best way is to have a plan or a drawing of what we are going to build. Whether we are constructing a bookcase, a model aeroplane, or a radio set, does not matter — a plan of the article is essential. This is because we do not always build things which we design ourselves, and also because plans and diagrams can convey in a very small space information which would take thousands of words to describe if it were not possible to draw a plan.

For instance, to build the set we are about to describe, all that an experienced constructor would need would be a circuit diagram and a short list giving the exact specifications of the parts shown in the diagram.

To one who has never built a set, it is necessary to explain what the symbols of the diagram mean, but after he has mastered a few simple facts, he, too, will be able to look at a circuit diagram and know what it means in terms of the actual components which go to make up the set.

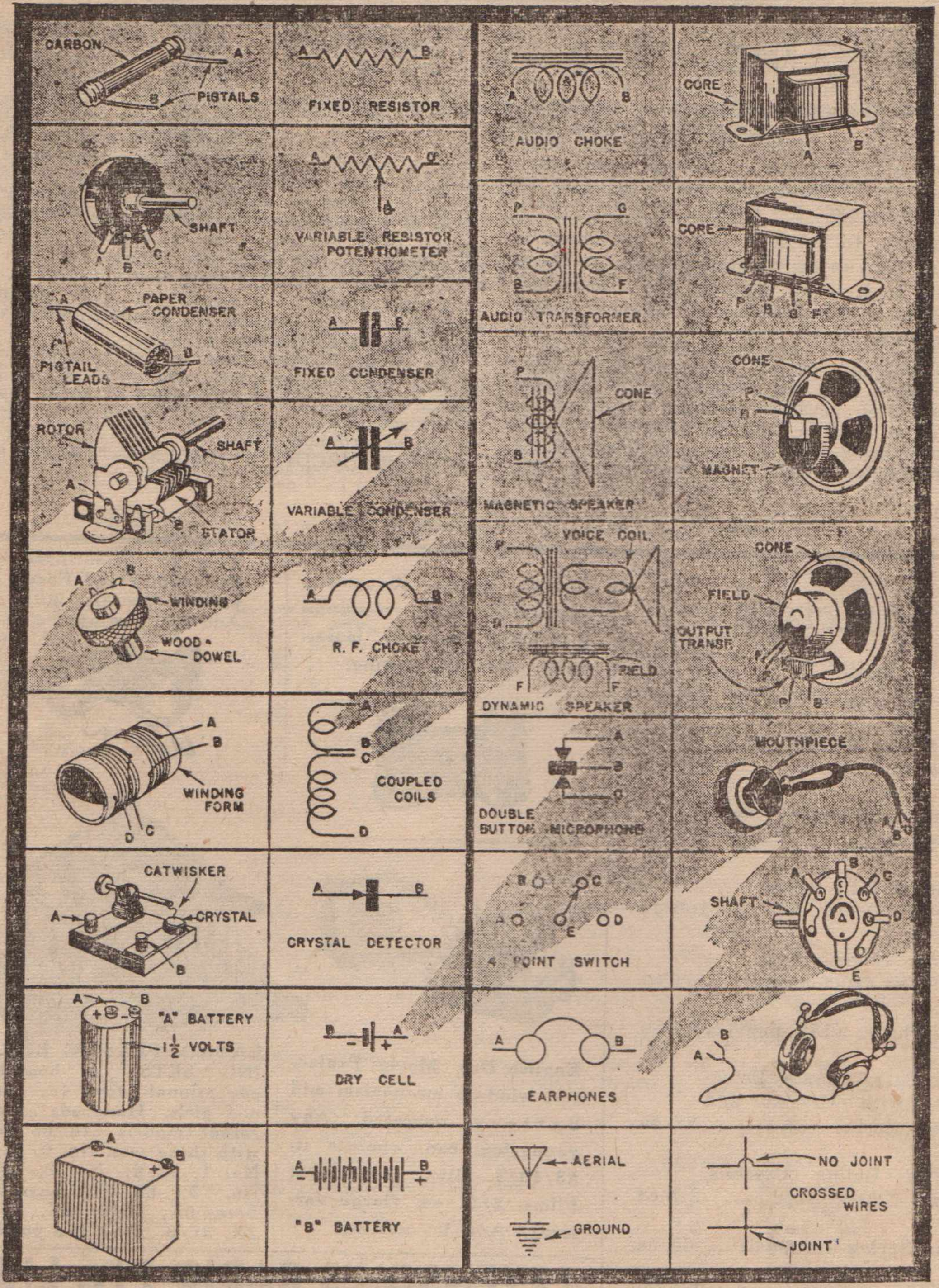
WHAT IS A CIRCUIT DIAGRAM?

A circuit diagram is simply an electrical plan of any device which is made up of electrical components. In it no attempt is made to show what the completed article actually looks like. In the case of radio sets, this would be almost impossible, owing to the fact that the actual size and shape of most electrical components have very little to do with their electrical specifications. Thus, in circuit diagrams all condensers or whatever other types of components are shown represented by a symbol their electrical size or capacity is shown by writing this alongside the symbol. It can be seen, therefore, that a circuit diagram tells us (a) what components are used, (b) their electrical specification, and (c) how the components are connected together by means of wires.

The circuit diagram does not tell us such things as how the various parts are mounted, or how they are placed on the base board or metal chassis of the set. These things can be shown by photographs or ordinary plans.

(REFER CIRCUIT SYMBOLS — PAGE 18.)

How To Read RADIO CIRCUIT SYMBOLS



Once you understand meanings of schematic symbols pictured in two vertical center columns above, radio circuit diagrams will no longer be a mystery. Pictorial sketches are shown at right or left of each symbol, with letters to show proper connections. Remember that short bar on battery symbol is always negative. Use terminals A and B for variable resistor; all three for potentiometer. B on potentiometer is always movable contact. Parallel lines always indicate iron core.

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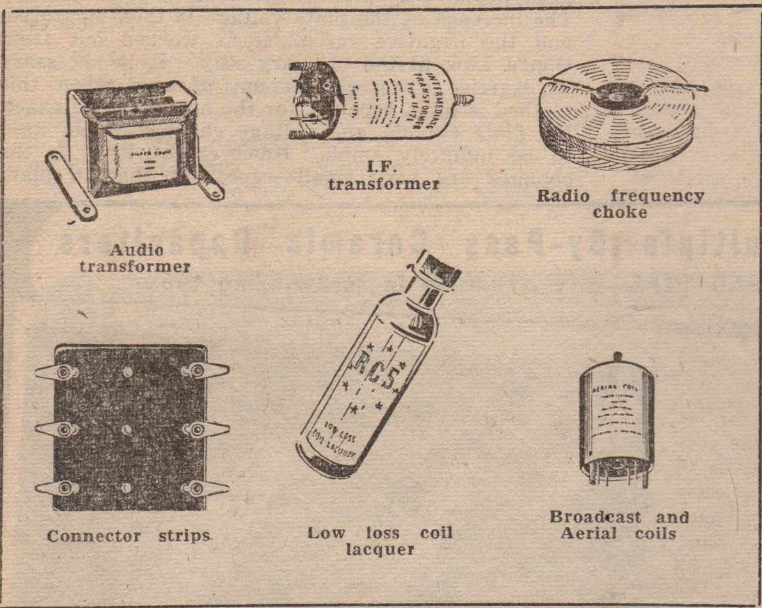

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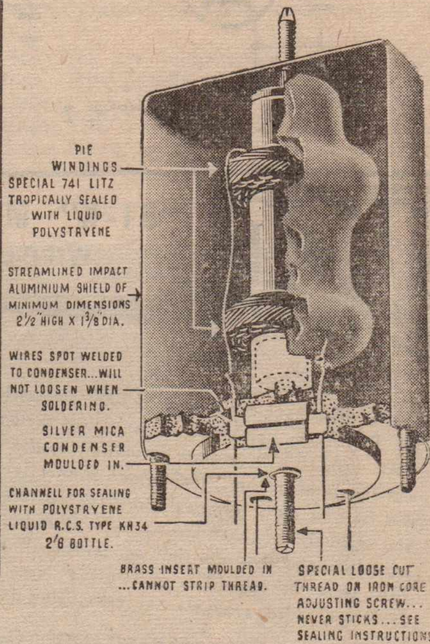

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R.F. RESISTANCE METER (*From Page 6*)

displays negative resistance only when the plate voltage lies between the values represented by the dotted lines. In practice, the centre of the negative resistance region is usually in the vicinity of 45 volts, so that we find the valve worked with a plate voltage of this value, and a screen voltage of 90 to 100 volts. The screen voltage should not be higher, because the screen current under some circumstances can become rather large, and damage the valve.

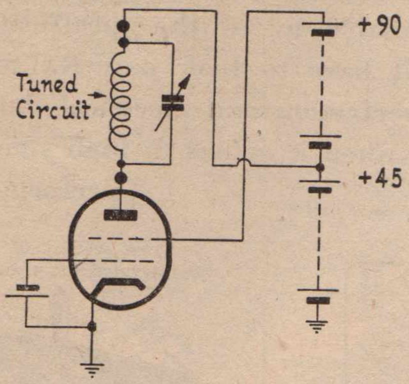


Fig. 2

In Fig. 2 is shown a practical circuit for a dynatron oscillator, with battery supplies for plate, screen, and control grid. This circuit is sometimes passed as a stable oscillator, and is the basic one from which the detailed circuit of the test instrument is derived, by means of various quite simple additions.

HOW NEGATIVE RESISTANCE IS MEASURED

In order to turn the dynatron oscillator into a measuring instrument, it is necessary, as we have mentioned, to be able to measure the actual negative resistance obtained. There are two main methods of doing this. One makes use of a special bridge circuit, which could be built into the measuring equipment, and the other, known as the incremental method, is the one used here. The idea is to make a slight change in the plate voltage, and to measure the change in plate current that results. Alternatively, we can increase the plate voltage until we have a specified decrease in plate current. The increase of the plate voltage is then measured, and the negative resistance is worked out from Ohm's Law in the ordinary way. It is necessary to exercise a certain amount of care when this method is used, because, for the answer to be exact, the plate current and voltage changes would need to be infinitely small. However, as long as the changes are very small—especially that in plate current—there will be no great error involved. In our own instrument, we have fixed on a standard plate current change of 10 micro-amps. This is quite small enough for all practical purposes, and is not too small to measure. The accuracy of measurement depends largely on the precision with which the current and voltage change can be measured. Thus it is best to use as sensitive a meter as possible for measuring the plate current change.

It is not impossible to estimate the necessary 10 uamps change even if a 0-1 ma. meter is used, but not with any great accuracy, because the movement of the pointer is so small. We have used a 0-100 uamp. movement, so that the 10 uamps on this represents a tenth of the full-scale deflection and can be judged quite accurately, The volt-meter, which measures the increase in plate voltage has a range of 0-5v. This, in conjunction with a measured change of 10 uamps, gives a reading which can be interpreted directly as hundreds of thousands of ohms. That is, a reading of 4v. indicates a resistance of 400,000 ohms, and of 1v., 100,000 ohms.

CONDITIONS AFFECTING A PRACTICAL METER

The circuit of Fig. 2 is quite practical, in so far as it will act as an oscillator as it stands, but for a practical measuring instrument a number of facilities have to be provided, as the above paragraphs will have shown. The essential features which must be added are:—

(1) A means of varying the grid bias smoothly so as to provide a smooth control over the negative resistance.

(2) Some means of balancing out the steady plate current, so that the 100 uamp. meter on which the small current change is read will not read the total plate current, but only the small change.

(3) A protective device which will prevent large changes of plate current, which will occur while the circuit is being adjusted, from overloading and damaging the sensitive meter.

(4) A scheme for adding small increments of plate, and of measuring these increments.

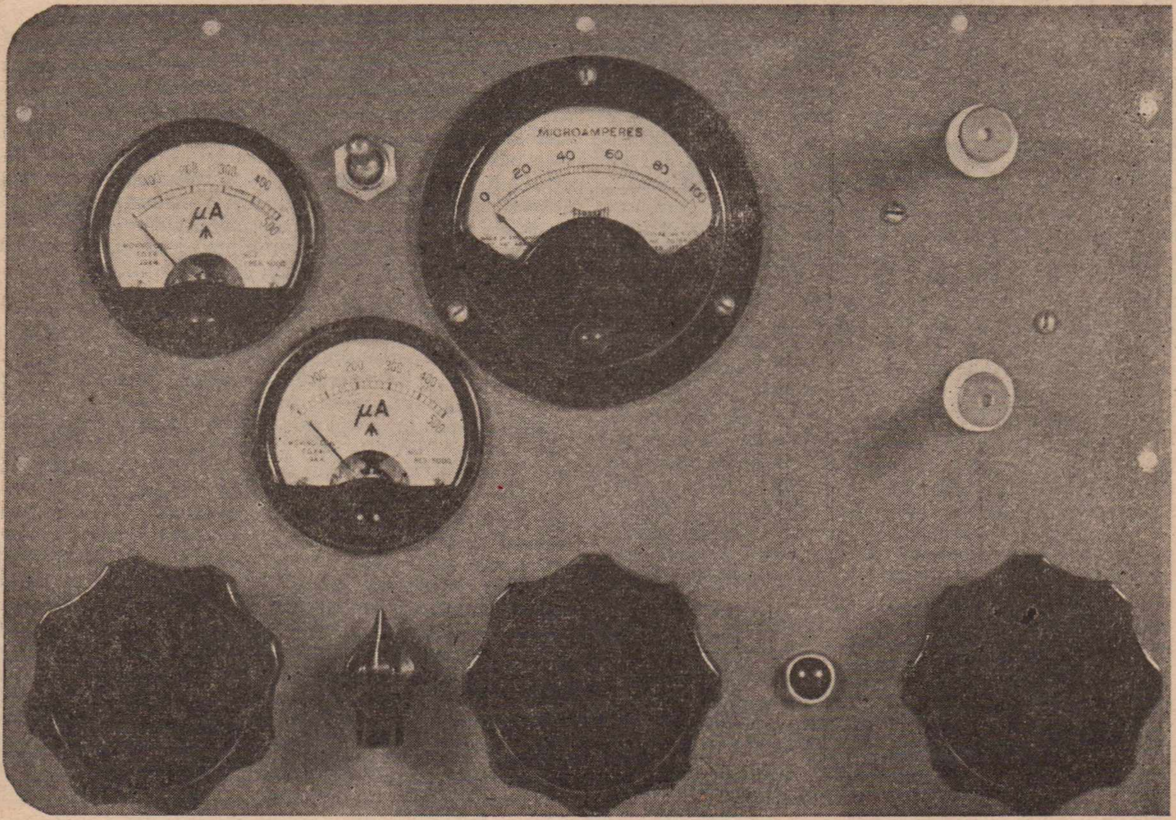
(5) A switching arrangement which will disconnect all batteries and prevent them from discharging while the instrument is not in use.

(6) Bypassing between the "cold" end of the plate circuit and the cathode of the valve so that all R.F. is confined solely to the tuned circuit.

(7) A convenient means of connecting tuned circuits to the plate circuit with as little lead as possible.

All these features are incorporated in the main circuit diagram. The panels at the bottom of this diagram represent terminal strips, one of which is used to terminate the wiring from the circuit to the batteries and the other, for the batteries themselves, together with the 2.5v. heater transformer for the

Continued on Page 28



SHOES and SHIPS

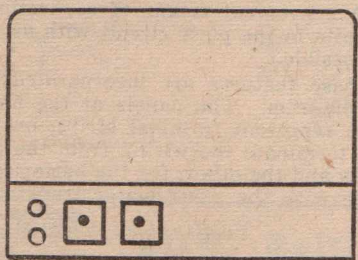
"The time has come," the Walrus said,
"To talk of many things. . . ."

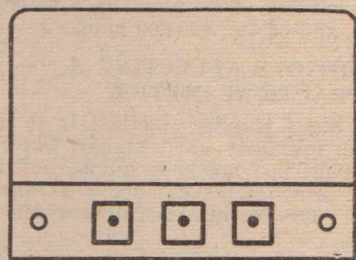
By Special Arrangement with the Walrus

SOME HINTS ON APPEARANCE

Most servicemen and constructors have at some time or other built amplifiers or radio equipment which calls for a panel bearing the necessary controls such as "volume," "bass," "treble," etc. This in it self does not present a great problem and probably the job turned out successfully to the complete satisfaction of the builder. However, before long one will see a professionally built instrument designed to do the same job and that niggling little demon rears its head and says "why doesn't mine look like that.:"

The answer is really obvious and can be summed up thus—attention to detail and balanced layout.





For instance, when fitting graduated gain plates over volume controls don't just put the plate on and screw up the nut. The chances are that the plate will twist at some odd angle and will very likely get scored by the spanner and almost certainly by the nut. The proper procedure is to put a nut on the potentiometer before insertng it in the panel, then put on the gain plate and screw the top nut down finger tight. The plate may then be straightened up, if necessary with a square, and then tighten the rear nut behind the panel. It's so simple but so much more effective! In cases where it is not possible on account of the chassis shape to get at the rear nut put a volume control washer between the gain plate and the top nut and hold the plate firmly in position while tightening. Having got this far it will be probably necessary to take it all to pieces again since the usual fault will occur!

When the pressure on the nut is increased it draws the centre of the plate in tight against the panels and pulls the outer edges away. This, of course, is unworthy of that "super job" so a little careful pressure with the fingers on the plate to give it a slightly convex shape before fitting makes all the difference since the locking nut now presses the outer edge of the plate down hard on the panel. Simple but just another worthwhile point!

In cases where small screws are used to fix escutcheons and name plates in position a good wrinkle to enhance the appearance of your product is to line all the screw heads with the slots for the screwdriver all facing the same way. Yes, it does take a little longer but you are gaining that professional touch.

Name plates and potentiometer plates if cut square in a guillotine can generally be improved by running a file over the corners to round them off.

Now for balanced layout. Practically everything in radio is a compromise, very rarely can a man say he has constructed something which he considers is perfect. Somewhere or other he has had to defer to availability of material or for convenience sake include a piece of circuitry he would have preferred to leave out. If, then, we have to do this we can surely compromise a little with what is good in theory for the sake of gaining a lot in eye appeal. Therefore, instead of putting that mike gain control as close as possible to the mike pre-amplifier (good practice theoretically) group it nicely in the centre of the panel with the other controls. Provided it is carefully done and the leads are extended through shielding braid, very little need be sacrificed. Hum is much more likely to be incurred through indiscriminate earthing of grid leaks, bias resistors, and condensers, etc. Our diagram illustrates what is probably good for electrical convenience but what a horror it looks against our balanced amplifier which will more than likely operate just as well.

In the case where an odd number of controls makes grouping difficult, add something to create balance. For example, if amplifier No. 2 had only a phonograph input, volume control, bass and treble controls and no mike input add either a mains toggle switch or jewel lamp indicator to even things up. And now just an odd note on an awkward point. When you have to mark out a new cabinet for a radio a surefire way of drilling the front panel correctly is to put a small blob of white paint on the centre of each control shaft (volume, tuning, tone. etc.), and slide the set into the back of the cabinet pushing it up against the front panel hard. Nice clear marks should result. If the shafts are of different lengths drill out the marks made by the longest ones first then push the chassis in again for the shorter ones. Having got the controls positioned the dial cut-out is easily measured off from them with a ruler. This method is guaranteed to take the tremble from your hand when attacking that beautiful polished panel with your drill and saw.

HAM ACTIVITIES

Conducted by
J. A. HAMPEL, VK5BJ

IT'S certainly good to receive those occasional letters from you chaps who are enjoying reading this monthly potpourri on your fellow-hams' doings. An interesting one in the mail this month was signed by a very spicy call—HA4A. It belongs to Andre Domjan who recently arrived here and is now anxious to see if a VK call can be obtained.

N'AUSSIES

Other New Australians have asked the same query recently so an official enquiry has been made on the subject. The reply should be available by next issue. These men are starting off on the right foot too, by seeking membership in the W.I.A.—we the old Australians—or VK's in the language which is the same. Wherever Hams meet—welcome you.

CALLING C.Q.

Another welcome note came from Les Mallinson, VK4LM, who has taken the self-appointed task of VK4 correspondent and the idea could well be emulated by some enthusiastic chaps in other states.

SONIC TEST EQUIPMENT

The latest QST shows how deep Amateur Radio can become and how much it means to a blind person—like W2IJO. This zealous ham has built up a complete set of test equipment using the sonic principle. All measurements are indicated by **sounds** not valves or meters. The news of this latest development in the electronic field will surely be greeted enthusiastically by those chaps with a present handicap in this direction.

TVI

In the same magazine is demonstrated what a lot of ballyhoo has been made of TVI and just how easily it can be suppressed. A 600 watt suppressed rig had its antenna connected directly in parallel with the same line feeding a TV receiver and NO TRACE of HARMONICS could be detected!

DX

Still over in W-land, W1FH holds his lead as the top DX man in the states. He has 236 countries confirmed on c.w. with 196 confirmed on phone. These Yanks seem to find countries we never even find on the map. It is interesting to note that the next four leading DX men are outside the USA and the honours go to XE1AC, LU6AJ, VQ4EOR and EI2CK descending in that order.

For the next few weeks CM9AA will be operating on 10 and 20 from Guadeloupe Is. with the call FG7XA whilst his XYL will be there using FG7XB. Their period of stay on the island is unknown.

VK3 CONVENTION

Here are some important dates for some of you to remember:—

In VK3 the next Central Western Zone convention is at Ararat on 23rd September; the Eastern Zone will be at Warragul on 3rd and 4th November.

AROUND THE SHACKS

Eighty metres is the band for the choice ones now that the shorter days are with us. SP1JF has been one of the rare one causing panic on the band recently. If you want to be sold 80—see 5KO who picks off the Europeans as they queue up to work him.

4WB, Bill, put up a vertical and got tired of waiting for 20 mx. to open up to try it out so he put the rig on 40 mx and using the vertical is getting good reports from around VK.—.—.

John, 3AJI, was supposed to have travelled to Adelaide last Easter (complete with an SCR-522 too!) but so far no one has been able to find him. If John doesn't show up soon there will be one less VK5 going on 2 metres. I have been watching those "Wanted" signs outside the cells but none of the faces are familiar .—.—.

Russ, 4PN, is going strong on 40 and 20 meeting many old friends. Russ has been off the air for 20 years and has just made a comeback, making up for lost time .—.—.

3HK is using f.m. around 40 with very nice results. The a.m. receivers don't seem to mind very much .—.—.

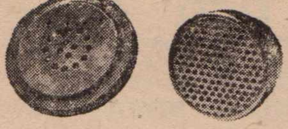
3YW is another experimenter who has appeared on 80 using S.S.S.C. but so far—no contacts .—.—.

4CI recently returned to his home town after three weeks in Sydney where he operated portable. Alex took back with him quite a supply of disposals gear, in fact, too much; ask the taxi driver who had to drive Alex plus all the junk home from Brisbane station .—.—.

4NC is very busy at the moment on a new three element beam so DX boys, look out for competition now .—.—.

Sad was the news that Luke, 5LL, was giving up Ham radio and was QRT for once and all. However those old-timers who know Luke too well and will always recall his joking voice on the bands up to twenty years ago are betting pretty hard on his return to the air 'ere long. Although his licence has lapsed the urge will be too strong to keep this OT silent .—.—.

(*Continued on Page 25*)



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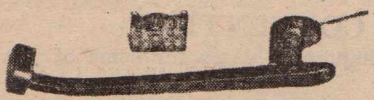
Single Button Carbon Mike Inserts Brand New, 2/6d.
Dynamic Mike Inserts Brand New, 7/6d.



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Shefi moving coil pick up for high quality reproduction. Worth £4/19/0. Our price, £2/15/0.

BELDEN SHIELDED WIRE

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FIXED CRYSTAL DETECTORS Type W.X. 6.

Suitable for use as crystal detector or diode. Brand new. Made in England. Only 6/6d.

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Type M.C. 125. A. vernier drive tuning unit, with 35 to 1 ratio. Robust Construction, Crackle Finish. Suitable for remote cable drive, or vernier on set. Price, 7/6d.

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Push Pull single pole with single hole mounting.
Worth, 3/6d.
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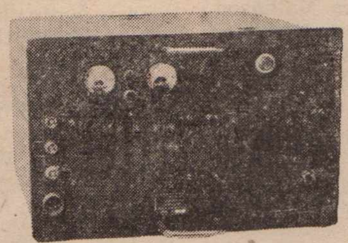
SWITCH WAFERS

will suit any Oak switch 3 pole 3 position or 2 pole 2 position.
Our price only 1/-d. each.
Single Pole 2 way Toggle Switches, Nickel plated single hole mounting made in U.S.A. and brand new. Easily worth, 5/-. Our Price, 2/6d.

DIAL GLOBES

6.3 volt globes suitable for all modern radio sets screw in type.
Usual Price, 1/5d. each.
Our Price, only 9d.

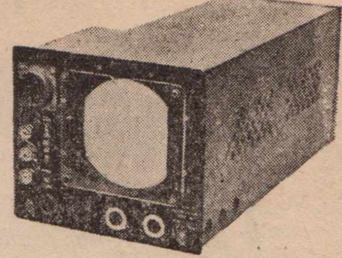


A.T. 300 TRANSMITTERS

This Radar Transmitter uses parts listed below and is valuable for stripping as well as for use in its present form. Parts include:

2 A.V. 11 Valves
2 Cyclatron Valves
2 4 Ceramic Sockets
1 24 Volt Motor
2 .01 5,000 Volt working Condenser
1 .02 10,000 Volt working Condenser
1 .001 5,000 Volt working mica Cond.
3 Transformers (Heavy Duty)
1 0-100 Volt A.C. Meter which is an 0-1 M.A. movement with 1 M.A. Dry metal rectifier fitted.
1 0-5 M.A. D.C. Meter.

and many other parts such as stand off insulators, coils, etc., easily worth £20. Our price only, £4/10/6.



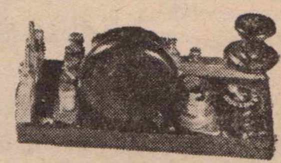
CATHODE RAY INDICATOR UNIT TYPE A.1

This is an ideal unit to be converted to an oscilloscope or stripped for the excellent parts, Valves, etc. Parts are:

1 5. B. P. 1 Valve Complete with socket and new-metal shield.
6 6 A c.7 (1852) Valves.
3 6. H.6. Valves.
12 Potentiometers.
10 Block. Condensers.
40 1 Watt. I.R.C. Resistors.
1 3 Position 2 Bank switch.
1 Toggle Switch.

All enclosed in neat metal case as illustrated. Easily worth £25.

Our Price, £8/10/0.



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(As illustrated)

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1 Morse Key
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1 Lamp Holder
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NOTICE

All parcels will be sent registered Post unless otherwise stated. Freight or postage must be included with orders.

MS MOTOR SPARES LTD.

547 ELIZABETH STREET, MELBOURNE

HAM ACTIVITIES

(*Continued from Page 23*)

5KB has been seen in Adelaide on a brief respite from Mt. Gambier. Afraid there wasn't any opportunity to talk Ham radio with Peter as both parties were handicapped to start on the subject due to YL presence! The Mount's 144mc hook-up on Monday nights is now down to only two members—5CH and 5CJ .—.—.

Cec 5BZ, has put away his portable Type III for the week-ends now the colder days are here and is devoting his time to a six metre rig so he will be ready for all the sporadic stuff next summer .—.—.

4FE, who is ex-VK1FE, has been playing with antennas since arriving home. Arthur's home is on the bank of the Brisbane River so that his yard is very steep and any antenna he erects is always about 20ft. beneath the shack's level. Arthur wishes he was back on Heard Island where one CQ was sufficient to raise a dozen countries. (Arthur must have been lucky as one VK1 was heard to call CQ for nearly two hours one night but he never raised one station!) .—.—.

Don, 5DL, has arrived in Brisbane looking for a flat—also waiting on a new VK4 call .—.—.

ZL3FL, Allan George of Christchurch is going to Brisbane to live. He told VK4LM in a recent QSO that he is bringing over all his gear except, of course, the beam .—.—.

By the time this is read 4PR will be haunting the Sydney disposals counters and signing portable while there on annual leave. Jim has 180 DX countries confirmed—nice work .—.—.

4GG has just returned from a trip to VK2 too. George is on 80 metres almost nightly and looks for even more contacts as he believes in this "populate or perish" theory. Same theory applies to the v.h.f. bands .—.—.

4PX, Arthur, has rebuilt his final now using an 813—on 20 and 10 .—.—.

Well this month I'll say nothing about wanting news from the various states, nor will I ask for any v.h.f. news either! Maybe I'll get a surprise in the mail box—Maybe! What's the address? Box 1589M, GPO, Adelaide. Cheerio chaps.

J.A.H.

loscope screen. The photos realating to the circuit of Fig. 2 are shown in Fig. 6. There are three pairs of wave-forms in this photograph. Each pair was taken at the same time with the aid of an electronic switch. By this means, it was possible to display the original sine-wave on one trace, and the derived wave-form from the test circuit on the other, thus showing the time relationships between the manufactured waves, and the original one. In each pair of wave-forms, the lower trace is the original sine-wave, while the upper ones are the derived wave-forms. At the top, we have the wave-form at the second of the transformer. It will be noted that it is larger in amplitude than the original sine-wave, and also that the transformer has distorted it somewhat. The middle pair show the wave-form at the grid of the valve. This demonstrates the clipping action of the grid-current, in conjunction with the series grid resistor. The upper portions of the positive half-cycles have been lost, and it can be seen that only the negative half-cycles are left. The bottom pair shows the output wave-form on the upper trace, and several points can be seen. First of all, it is clear that the "vertical" portions of the wave are very steep, but are certainly not vertical, especially near the cut-off and grid current points. This is because the characteristic of the valve does not have perfectly sharp transitions at either place, and indicates that the output wave can only approach the theoretical ideal, and not actually reach it. Actually, much better wave-forms can be generated by this method, but in taking these photographs, they were purposely made worse than the circuit is capable of, in order to show just how a practical circuit's performance differs from the ideal. All that was done in this respect was to reduce the input voltage somewhat, so that the transitions would be slower, and more easily seen. For example, it can readily be observed that the sides of the wave are steepest in the centre, where the valve characteristic is steepest, and that the slope becomes somewhat less, appreciably before the extremes of voltage are reached. Examination will show that the positive flat portions are approached more gradually than the negative ones, indicating that the curvature of the characteristic near cut-off is more gradual than the curvature near the grid-current point A comparison between the input and output waves in the bottom photo shows that the negative half-cycle of output arises from the positive half-cycle of input, and vice versa—in short, a demonstration of the phase-reversing property of the amplifier valve. It is also possible to see that the positive flat portions are actually flatter than the negative ones. The former come from the valve being cut off, while the latter occur while grid current is passing. The slight rounding of the

Continued on Page 32

Short Wave Review

Conducted by L. J. Keast
7 Fitzgerald Rd., Ermington, N.S.W.
Phone: WL 1101

ALL TIMES ARE AUSTRALIAN EASTERN STANDARD

NOTES FROM MY DIARY

U.S.A.

There has been so many alterations in schedules and such a number of new frequencies brought into use that I am printing in this issue the latest list received by airmail.

Daylight Hours

DX-ers will notice from now on many overseas stations, particularly London and European transmitters will be heard well during daylight hours. In the May issue I will print a list of some of the most likely to be heard.

Errata

Under the heading "The Doctor Comes to Town" in February issue a typographical error crept in. It is my fault as when checking my typed notes I overlooked I had shown Dr. Gaden as having arrived at Manila. It should have really been Manildra. The location of Manildra as given is correct.

Mr. Anderson Still Brings Them In

Mr. Anderson of Paddington, N.S.W., writes:—

"I am afraid this month's loggings have not been the best. However here are the few I have logged:

PCJ on 15.22 at 9.15 p.m. English.
SAIGON on 11.83 at 8.00 p.m. English.
MADRID on 9.585 at 6.15 a.m. English.
ROME on 15.12 at 6.15 p.m. English.
OIX4 FINLAND 15.19 at 9.45 p.m. Finnish until 10.00 p.m. then English.

"On a recent Sunday afternoon I also heard HCJB in 15.115 mc. at 2.00 p.m. in an English session.

"I am enclosing the latest schedule from Radio Ceylon from whom I received a very nice verification letter this week, bringing my total to 24 veries for a total of 15 counties.

"Well, I guess that is all for this month and keep up the good work in A.R. & E. which is still the only magazine I buy."

THE MONTH'S LOGGINGS

RADIO SWEDEN

		mc.	met.
10.00-11.30 a.m.	SDB-2	10.78	27.83
3.15-5.35 p.m.	SBT	15.155	19.80
	SBO	6.065	49.46
	SBT	15.155	19.80
5.35 p.m.-1.15 a.m.	SBP	11.705	25.63
	SBT	15.155	19.80
1.15-4.00 a.m.	SDB-2	10.78	27.83
	SBT	15.155	19.80
4.00-4.30 a.m.	SBO	6.065	49.46
	SDB-2	10.78	27.83
4.30-5.00 a.m.	SDB-2	10.78	27.83
4.30-5.00 a.m.	SBO	6.065	49.46
5.00-8.00 a.m.	SDB-2	10.78	27.83
	SBO	6.065	49.46

RADIO CEYLON

B.B.C. Broadcasts are as follows:—

	mc.	met.	
6.25-Midnight	17.73	16.92	Directed to Hongkong, China and Japan.
12.10-3.05 a.m.	15.12	19.84	Direct to India and Pakistan.
6.25 p.m.-3.05 a.m.	21.62	13.88	Directed to French Indo-China, Burma & Malaya.
6.45 p.m.-7.00 p.m.	17.73	16.92	To Far East
	21.62	13.88	

HIER SPRICHT LONDON

B.B.C. Programmes for Germany:—

	met.	met.	met.
4.00-5.45 p.m.	49.59	41.21	
7.00-7.15 p.m.	49.59	41.21	
Midnight-12.30 a.m.	40.98	31.17	25.15
3.00-3.15 a.m. / 3.45-4.15 a.m.	49.59	40.98	31.17
5.15-5.30 a.m.	49.59	40.98	
6.00-8.15 a.m.	49.59	40.98	
10.00-10.15 a.m.	49.59	40.98	

ICI LONDRES

B.B.C. Programmes for France:—

	met.	met.	met.
5.30-5.45 p.m.	48.54	41.61	
6.00-6.15 p.m.	48.54	41.61	
7.00-7.30 p.m.	48.54	41.61	30.53
10.30-10.45 p.m.	41.61	30.26	25.49
11.30-11.45 p.m.	41.61	30.26	25.49
3.00-3.15 p.m.	48.54	41.61	30.26
5.30-8.00 a.m.	41.61	48.54	

RADIO NEW ZEALAND

ZL8—WELLINGTON. 9.62 mc., 31.19 met: 4.00 a.m.-6.45 a.m. to Australia. Station on air till 5.00 p.m.

ZL10—WELLINGTON. 15.22mc., 19.72 met: 7.00 a.m.-4.45 p.m. to Australia. Closes week days 8.30 p.m. Sats. 9.20 p.m. Sundays 8 p.m.

ZL3—WELLINGTON, 11.78 mc. 25.46 met: 4.00 a.m.-6.45 a.m. to Pacific Is. Closes week days 8.30 p.m. Sats. 9.20 p.m. Sundays 8.00 p.m.

ZL4—WELLINGTON, 15.28 mc. 19.64 met: 7.00 a.m.-4.45 p.m. to Pacific Is. Station on air till 5.00 p.m.

THE EAST.

Formosa.

BED32 and BED9, Tiapeh, Taiwan, 3.22mc. 93.16 met: Reported by Arthur Cushen as heard from 9 p.m. English/Chinese lesson broadcast on Saturdays 9.00—9.30 p.m. Signal strength is fair.

Philippines.

DYH4, Damaguete, 6.055mc. 49.55 met: Operates from 8.00—11.00 p.m. from Silliman, University, Negros Oriental. Programmes are mainly Christian Missionary Services. Reported by Arthur Cushen.

DZH-5, Manila, 9.69mc. 30.96 met: Still another Eastern station reported by Arthur Cushen with a slogan "Voices of Catholic Philippines" operating from the University of Santo Tomas. Programmes are non-commercial and staff announcers, etc., are amateurs of the University.

DZH-8, Manila, 15.30mc. 19.61 met: 8.00—11.00 p.m.

Continued on Page 29

R.F. RESISTANCE METER

(*From Page 21*)

224 that is used as the dynatron valve. This method of drawing has been used to simplify the wiring up process, since there are six different battery units, and a purely theoretical diagram makes it necessary to do a considerable amount of sorting out of battery connections. Since batteries are used, and not a power supply from the mains, it is essential to have things arranged so that it is easy to change batteries when this becomes necessary. With an arrangement like the one shown, it is a simple matter to have a series of tagged leads, two for each battery unit, so that there is no need to make cross-connections at battery terminals. This removes a fruitful source of errors in connecting up new batteries. It will be noticed that the circuit is earthed at one point only, and is built otherwise completely insulated from the metal chassis. This helps to give a satisfactory R.F. circuit, without any ground loops which might cause losses that could be attributed wrongly to the circuit under test. It also enables the circuit to be grounded at an unusual point, so that there is very little risk of the operator getting a shock when connecting or disconnecting a test circuit from the terminals. Contrary to the belief of many, 90 volts of good battery can give one a very nasty nip, not at all to be despised. The circuit shows that both the screen, and the "cold" end of the test circuit are carefully bypassed to the cathode of the valve. Because of this, R.F. is excluded from the whole of the measuring circuit, which becomes, in practice as well as in principle, a purely D.C. affair. This, incidentally, is one of the advantages of the method, in that all measuring is done with D.C. instruments, which are inherently more accurate than any A.C. meters of reasonable price. Double bypassing is used, because the 0.1 u.f condensers will not be completely effective at high radio frequencies, which are then taken care of by the small mica condensers, which have considerably less inductance than ordinary paper tubulars.

THE CIRCUIT IN DETAIL

It might simplify matters if it is stated at the outset that the switches S1 to S5 are all on two double-pole three-position wafers, and are used for switching the batteries out of circuit when the instrument is out of use, or on "stand-by" when all that is left on is the heater of the valve. In the diagram, all are shown in the "on" position.

(*Continued on Page 30*)

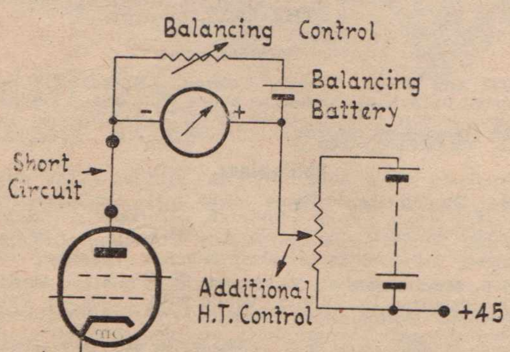


Fig. 3

SHORT WAVE REVIEW

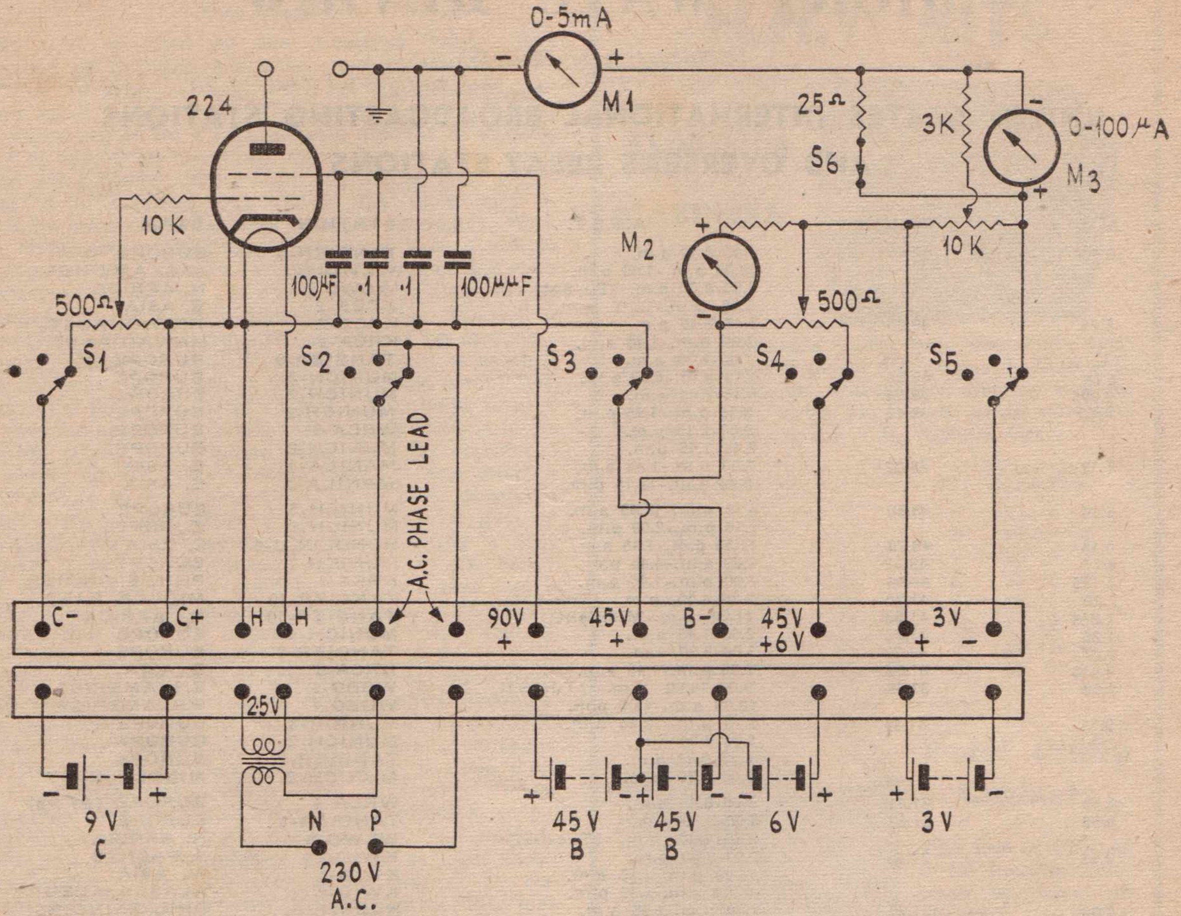
(*Continued from Page 27*)

UNITED STATES INTERNATIONAL BROADCASTING STATIONS AND OVERSEAS RELAY STATIONS

M/C	Met.	A.E.S.T.	STATION	BEAM
6.04	49.66	4.00-8.30 a.m.	TANGIER-4	EUROPE
		10.00 a.m.-1.00 p.m.	WLWO-1	W.S. AMERICA
		2.30-4.00 p.m. (Tu-Sat)	WLWO-7	N. AFRICA
		5.45 p.m.-12.15 a.m.	KCBR-2	E. ASIA
6.06	49.50	5.15-6.45 p.m.	KRCA-2	HAWAII/AUST.
		7.00 p.m.-1.45 a.m.	KRCA-2	HAWAII/AUST.
		7.00-8.30 a.m.	TANGIER-9	EUROPE
6.08	49.34	1.15 a.m.-6.00 p.m.	MUNICH-3	EUROPE
6.095	49.21	5.15-7.45 a.m.	MUNICH-2	EUROPE
6.10	49.15	8.15 a.m.-1.45 p.m.	MUNICH-2	EUROPE
		2.00-2.15 p.m.	WRCA-3	EUROPE
		2.45-1.45 p.m.	MUNICH-2	EUROPE
6.12	49.02	7.00 p.m.-1.45 a.m.	MANILA-3	E. ASIA
		8.00 a.m.-12.15 p.m.	MANILA-3	E. ASIA
6.14	48.86	6.15 p.m.-12.45 a.m.	MUNICH-5	EUROPE
		1.15 p.m.-2.00 p.m.	MUNICH-5	EUROPE
6.16	48.70	11.30 p.m.-1.45 a.m.	HONOLULU-1	E. ASIA
6.17	48.62	4.00 a.m.-4.45 p.m.	MUNICH-1	EUROPE
6.185	48.54	7.00 p.m.-1.45 a.m.	KRCA-1	PHIL/E. INDIES
7.20	41.69	2.30-4.00 p.m. (Tue-Sat)	TANGIER-10	MIDDLE EAST
7.214	41.58	11.00 p.m.-Midnight	TANGIER-10	N. AFRICA
7.25	41.38	2.00-1.45 a.m.	MUNICH-4	EUROPE
7.27	41.27	3.00-8.30 a.m.	TANGIER-3	EUROPE
9.515	31.53	7.00 p.m.-1.45 a.m.	KRCA-3	E. ASIA
9.53	31.48	9.00-10.00 a.m. (Tue-Sat)	WGEO-1	E.S. AMERICA
		10.00 a.m.-1.00 p.m.	WGEO-1	E.S. AMERICA
9.54	31.45	6.15 p.m.-12.45 a.m.	MUNICH-3	EUROPE
		1.30-5.00 a.m.	MUNICH-2	EUROPE
		5.15-8.15 a.m.	TANGIER-2	EUROPE
		2.00-2.15 p.m.	MUNICH-2	MIDDLE EAST
9.55	31.41	5.00-8.45 a.m.	WRCA-4	EUROPE (AFRS)
9.56	31.38	6.00-8.30 a.m.	TANGIER-1	EUROPE
		2.30-4.00 p.m. (Tue-Sat)	WLWO-8	N. AFRICA
9.57	31.35	7.00-9.30 p.m.	KWID-1	S. PACIFIC
		10.00 p.m.-1.45 a.m.	KWID-1	W. ASIA
		11.00 a.m.-6.45 p.m.	KWID-2	ALASKA/ALEU
9.60	31.25	7.00 p.m.-1.45 a.m.	KCBR-1	PHIL/E. INDIES
9.615	31.23	12.15-5.30 a.m.	TANGIER-9	EUROPE
		6.00-8.30 a.m.	WRCA-1	EUROPE
		2.00-2.15 p.m.	WRCA-1	EUROPE
9.65	31.09	10.00 p.m.-1.45 a.m.	HONOLULU-2	PHIL/E. INDIES
		4.30-8.30 a.m.	WABC-1	EUROPE
		Noon-1.00 p.m. (Tue-Sat)	WABC-1	S. AMERICA
9.67	31.02	2.30-6.45 p.m.	KGEI-1	MID-PACIFIC
		7.00 p.m.-12.15 a.m.	KGEI-1	MARIANAS/PHIL.
		10.00 a.m.-1.00 p.m. (Tue-Sat)	WRCA-3	E.S. AMERICA
		10.30 a.m. Noon	WRCA-3	E.S. AMERICA
9.68	30.99	6.00-7.00 a.m.	TANGIER-9	EUROPE
9.70	30.93	5.45 p.m.-12.15 a.m.	KCBR-3	E. ASIA
		12.15-2.45 a.m.	TANGIER-3	EUROPE
		6.15-8.30 a.m.	WRCA-5	EUROPE
		10.00 a.m.-1.00 p.m.	WLWO-8	W.S. AMERICA
		2.30-4.00 p.m. (Tue-Sat)	TANGIER-9	MIDDLE EAST
11.71	25.62	7.15-11.45 p.m.	TANGIER-3	EUROPE
		4.15-7.15 a.m.	WRUL-2	EUROPE
		8.00-8.15 a.m.	WRUL	EUROPE
		10.00 a.m.-Noon	WLWO-5	W.S. AMERICA
		Noon-1.00 p.m. (Tue-Sat).	WLWO-5	W.S. AMERICA
11.73	25.58	4.00-6.45 p.m.	KGEI-2	MID-PACIFIC
		7.00 p.m.-1.45 a.m.	KGEI-2	MID-PACIFIC
11.77	25.48	4.00-8.30 a.m.	WRCA-2	EUROPE
11.78	25.47	6.00-7.00 a.m.	WRUL-5	N. EUROPE
11.79	25.44	2.45-3.30 p.m.	KRCA-2	E. ASIA
		5.15-6.45 p.m.	KRCA-1	E. ASIA
		7.00-11.00 p.m.	HONOLULU-1	E. ASIA
		12.15-8.15 a.m.	TANGIER-10	EUROPE
		9.00-10.00 a.m.	WRUL-1	CARIBBEAN
		10.15-10.30 a.m. (Tue-Sat)	WRUL-1	E.S. AMERICA
		10.30 a.m.-Noon	WRUL-1	E.S. AMERICA
		Noon-1.00 p.m. (Tue-Sat)	WRUL-1	E.S. AMERICA

Continued on Page 31

(From Page 28)



First of all, at the left of the diagram, is the grid circuit. This consists of a 10k. grid stopper in series with the grid lead, to prevent the occurrence of parasitic oscillations, and a 500-ohm potentiometer, one side of which is returned to the cathode of the valve. A 9-volt C battery is connected across the potentiometer, and this is sufficient to bias the valve to cut-off, or very close to it. A good wire-wound potentiometer must be used here, and it must have a large easily-moving adjusting knob, so that very smooth and fine adjustment of grid bias can be made. Since the actual value of the bias is not of immediate concern, there is no necessity to meter the grid bias. Next to the right we have the heater transformer. One side of the heater is connected to the cathode, and switching is performed in the primary circuit of the transformer in order to avoid switching the heavy heater current with the light contacts of a wafer switch. It will be noted that the heater is left running on positions 2 and 3 of the switch, the former being the stand-by position, and the latter, of course, the measuring position. Position 1 is "Off.' Next along the line we have two 45-volt B batteries in series. These give 90 volts for the screen, and 45 for the plate of the valve. These batteries are switched in their common negative lead, so that it will not be possible to purposely leave the screen voltage on without plate voltage applied at the same time, and also to avoid the necessity for a further switch section. So far the circuit is very simple, and the only complication comes in the plate circuit. Here, we have two additional small batteries. The first of six volts, is used to provide the controllable amount of additional plate voltage, while the three-volt battery is used as a bucking, or balancing battery for balancing out the majority of the plate current from the 100 uamp. meter.

In order to simplify things, this part of the circuit has been illustrated separately in Fig. 3.

The terminals to which the tuned circuit is attached are shown short-circuited, because the circuit should be removed, and a shorting bar substituted before the actual measurement of the negative resistance is made. The meter shown is the sensitive 100 uamp movement, and across it is connected a battery in series with a rheostat. The polarity of the battery is such as to deflect the pointer backwards, so that a deflection caused by the plate current is cancelled out. Then, by adjusting the rheostat, the current through the meter can be reduced to a value that allows the meter to read approximately half-scale. In this condition, it is possible to read directly a small change in plate current, such as the 10 uamps we are interested in.

Continued on Page 32

SHORT WAVE REVIEW

(Continued from Page 29)

M/C	Met.	A.E.S.T.	STATION	BEAM
11.81	25.40	5.00-5.30 a.m.	WABC-6	EUROPE
		11.15 a.m.-5.30 p.m.	KCBR-3	E. ASIA
11.830	25.36	7.15 p.m-3.45 a.m.	TANGIER-4	EUROPE
		4.00-8.30 a.m.	WGEO-2	EUROPE
		9.30-9.45 a.m. (Mon. & Wed.)	WABC-1	S. AMERICA
		9.45-11.00 a.m.	WABC-1	S. AMERICA
11.86	25.29	7.00 p.m.-12.15 a.m.	KWID-2	E. ASIA
11.87	25.27	2.15-3.00 a.m.	MUNICH-1	MIDDLE EAST
		3.00-3.45 a.m.	MUNICH-1	EUROPE
		4.00-8.30 a.m.	WBOS-1	EUROPE
11.89	25.23	7.00 p.m.-1.45 a.m.	MANILA-1	E. ASIA
		5.00-8.45 a.m.	WRCA-3	EUROPE
11.895	25.22	8.00 a.m.-1.00 p.m.	MANILA-1	E. ASIA
11.90	25.21	2.30-6.45 p.m.	KWID-1	S. PACIFIC
15.105	19.86	Noon-12.15 p.m.	KGEI-2	PHIL/E. INDIES
		2.45-3.30 p.m.	KGEI-2	PHIL/E. INDIES
15.13	19.83	7.15-7.45 p.m.	TANGIER-1	EUROPE
		2.00-8.30 a.m.	WABC-5	EUROPE
		10.00 a.m.-1.00 p.m.	KRCA-2	S. AMERICA
		2.45-6.30 p.m.	KRCA-1	E. ASIA
15.15	19.81	5.00-8.45 p.m.	WRCA-6	EUROPE
15.21	19.73	4.00-6.30 p.m.	KRCA-3	S. PACIFIC
		7.15 p.m.-5.00 a.m.	TANGIER	EUROPE
		6.30-8.15 a.m.	WABC-6	EUROPE
		10.00-10.30 a.m. (Tue-Sat)	WRCA-6	E.S. AMERICA
		10.30 a.m.-Noon	WRCA-6	E.S. AMERICA
15.23	19.70	2.00-4.15 a.m.	WRUL-1	EUROPE
15.24	19.69	12.15-2.15 a.m.	TANGIER-1	EUROPE
15.25	19.68	7.00 p.m.-1.45 a.m.	MANILA-2	E. ASIA
		2.00-8.30 a.m.	WLWO-5	N. AFRICA
		8.00 a.m.-6.45 p.m.	MANILA-2	E. ASIA
15.27	19.66	2.00-8.15 a.m.	WABC-2	EUROPE
		8.40-8.50 a.m.	WABC-2	MEXICO
		9.30-9.45 a.m. (Tue-Sat)	WABC-2	S. AMERICA
		9.45-1.00 p.m.	WABC-2	S. AMERICA
15.28	19.63	5.15 p.m.-12.15 a.m.	MUNICH-1	EUROPE
		2.30-5.30 a.m.	TANGIER-1	EUROPE
15.29	19.62	9.00-10.00 a.m.	WRUL-5	CARIBBEAN
15.31	19.60	2.00-4.00 a.m.	WRUL-3	EUROPE
		8.00-10.00 a.m.	KCBR-1	E. ASIA
		11.15 a.m.-5.30 p.m.	KCBR-2	ALASKA/ALEU
15.33	19.57	1.15-8.30 a.m.	WGEO-1	EUROPE
		9.00-9.45 a.m. (Tue-Sat)	WGEO-2	S. AMERICA
		10.00 a.m.-Noon	WLWO-6	W.S. AMERICA
		Noon-1.00 p.m. (Tue-Sat)	WLWO-6	W.S. AMERICA
		1.00 p.m.-6.30 p.m.	MANILA-3	E. ASIA
		7.00-9.45 p.m.	HONOLULU-2	PHIL/E. INDIES
15.34	19.56	5.45 p.m.-1.15 a.m.	MUNICH-2	EUROPE
15.35	19.54	11.15-11.30 p.m.	WLWO-5	W.S. AMERICA
		4.30-8.15 a.m.	WRUL-1	EUROPE
		8.45-10.00 a.m. (Tue-Sat)	WRUL-2	MEXICO
		11.00 a.m.-Noon	WRUL-2	CENT. AMERICA
17.75	16.90	2.00-8.30 a.m.	WRUL-4	EUROPE
17.76	16.89	2.15-8.45 a.m.	WGEO-3	EUROPE
		10.00 a.m.-1.00 p.m.	KWID-1	S. AMERICA
17.77	16.88	8.00-10.00 a.m.	KCBR-3	PHIL/E. INDIES
17.78	16.87	2.00-6.00 a.m.	WRCA-5	EUROPE
		9.30-9.45 a.m. (Tue & Th)	WRCA-5	S. AMERICA
		9.45 a.m.-1.00 p.m.	WRCA-5	S. AMERICA
		1.15-6.45 p.m.	MANILA-1	E. ASIA
17.80	16.83	3.15-3.45 a.m.	WLWO-8	N. AFRICA
		4.15-7.15 a.m.	WRUL-3	EUROPE
		10.00-11.00 a.m.	WLWO-2	W.S. AMERICA
		Noon-12.15 p.m.	KRCA-3	E. ASIA
		2.45-3.30 p.m.	KRCA-3	PHIL/E. INDIES
		5.15-6.45 p.m.	HONOLULU-1	PHIL/S.E. ASIA
17.83	16.82	1.15-8.30 a.m.	WABC-3	EUROPE
		8.40-8.50 a.m.	WABC-3	MEXICO
		9.00-10.00 a.m. (Tue-Sat)	WABC-3	S. AMERICA
		10.15-10.30 a.m. (W.Sat)	WABC-3	E.S. AMERICA
		10.30-Noon	WABC-3	E.S. AMERICA
21.46	13.98	10.00 a.m.-1.00 p.m.	KRCA-1	S. AMERICA
21.50	13.95	2.00-4.30 a.m.	WABC-6	EUROPE
21.52	13.94	1.15-8.30 a.m.	WLWO-3	NORTH AFRICA
21.57	13.91	2.00-4.15 a.m.	WABC-1	EUROPE
21.59	13.90	1.15-3.45 a.m.	WGEO-2	EUROPE
21.61	13.88	2.00-6.00 a.m.	WRCA-1	EUROPE
21.65	13.86	2.00-8.30 a.m.	WLWO-7	NORTH AFRICA
21.73	13.81	2.15-4.30 a.m.	WRCA-3	EUROPE
21.74	13.80	8.00-10.00 a.m.	KCBR-2	E. ASIA
		Noon-12.15 p.m.	KGEI-1	MID-PACIFIC

R.F. RESISTANCE METER

(*From Page* 30)

The remainder of the circuit is the arrangement for adding small increments of plate voltage. A small battery, separate from and additional to the 45-volt plate section of the H.T. battery, is connected across a low-resistance potentiometer, and the moving arm of the latter is taken off to the plate circuit as the final supply lead. The negative terminal of the battery is connected to the 45-volt tap on the H.T. battery. With this arrangement the potentiometer is able to provide any amount of additional voltage, from zero up to the full voltage of the extra battery. The potentiometer introduces a small extra resistance into the plate circuit, but this is quite negligible in comparison with the actual negative plate resistance, and in no way affects the results. Not shown on Fig. 3 is the method of measuring the additional plate voltage, but this consists merely in connecting a voltmeter across the lower portion of the potentiometer, from the 45-volt battery tap to the moving arm. Since this is a permanent connection, any effect on the voltage caused by shunting the voltmeter across the voltage source is of no consequence, since at all times the voltmeter reads the actual voltage added. For this reason, too, it is not advisable to try and use an external voltmeter in this position. An external meter could be used, but would defeat its own object, since it could not be used for any other purpose in the circuit by changing its position.

Coming back to the actual circuit, we find that the arrangement used is slightly different from that shown on Fig. 3, for the balancing.

The three-volt balancing battery is connected across a 10k. potentiometer, providing a continuously variable source of voltage, rather than a fixed source with a variable series resistor. Then, a fixed series resistor of 3000 ohms is used between the moving arm of the potentiometer and the negative terminal of the meter. The reason for this circuit change is to be found in the protective device that is used to prevent the meter from being overloaded. This was not shown on Fig. 3, and consists of the 25-ohm resistor, in series with the switch, S6. This switch is either a normally closed push-button, opening when pressed, and returning automatically to the closed positon when released, or a toggle type, with a similar action i.e., one which has to be held in the operated position, and springs back if released. The 25-ohm resistor is simply a shunt, which reduces the sensitivity of the meter except when the push-button is operated. Thus, unbalanced currents up to the full plate current of the valve can be passed through the meter circuit without damage, as long as the button is not pressed. The procedure for balancing the meter is to obtain a balance with the 10k. potentiometer, the shunt being still in circuit. Then, when the button is pressed, there will be only a small current left flowing through the meter, and the balance control can now be used to make the meter read at any convenient position on its scale. It is best not to balance out the current completely, but to allow about half-scale deflection, preferably with the pointer set exactly to one of the major scale divisions. The actual balancing circuit used has the advantage that, unlike the simple one of Fig. 3, the operation of the protective shunt does not have an appreciable effect on the balance position as it is cut in and out. It also keeps a large resistance always in series with the meter, so that there cannot be any appreciable error in reading the plate current change, owing to the shunting of the meter by the adjusting resistor.

The additional H.T. control is exactly as shown in Fig. 3, with the addition of the voltmeter M2. The series resistor has been left unmarked as to value, because this will depend on the meter movement used. It is simply a multiplier resistance, arranged to make the meter M2 read 0-5v. Please note that if any other scale is used, it will **not** be direct-reading, as explained above, and a small sum will have to be worked out every time a reading is made. It does not matter much what sort of meter movement is used, as long as it is a good one. A 1 ma. meter, of good make would be quite satisfactory, but there would be no harm in using a less sensitive meter, as long as its readings are accurate. In our case a war surplus 0-500 uamp movement was used, with very satisfactory results, so that in this case the multiplier required was 10k., less the 500-ohm resistance of the meter itself, giving a multiplier of 9500 ohms. (To be continued.)

WAVE FORMS

(*From Page* 26)

limiting action of the grid current is not perfect, so that the grid does go very slightly more positive at the peak of the input half-cycle. This illustrates very effectively the second reason for employing the grid stopper, Rs. It is that without this component, the bottom of the output wave would be anything but flat, owing to the fact that modern valves do not really have a saturation value of plate current at all. This is due to the oxide-coated cathodes that are used today. One feature of them that is not properly understood, even yet, is this very fact. As the grid voltage is made more and more positive, the plate current curve never quite flattens off, but continues to rise slowly. As a result, if the positive grid voltage were not limited by the grid stopper to a small value, the bottom of the wave would be quite rounded, and not "squared off" at all. Hence the use of the grid stopper. As well as protecting the grid from excessive current, it actually improves the output wave-form. Even so, the flattest portion of the wave is the top, because once the valve is cut off, it can never be "more cut off," however negative the grid may go.

DIFFERENT TIME RATIOS

The circuit we have described is frequently used where the square wave required is wanted to have the positive and negative half-cycles almost equal in duration. It requires a low-impedance source (viz., the transformer secondary) if it is to act in just this way, however, and we will see why when we come to examine the next circuit, which is designed to produce a square-wave in which the positive and negative half-cycles are not of equal duration. (To be Continued)