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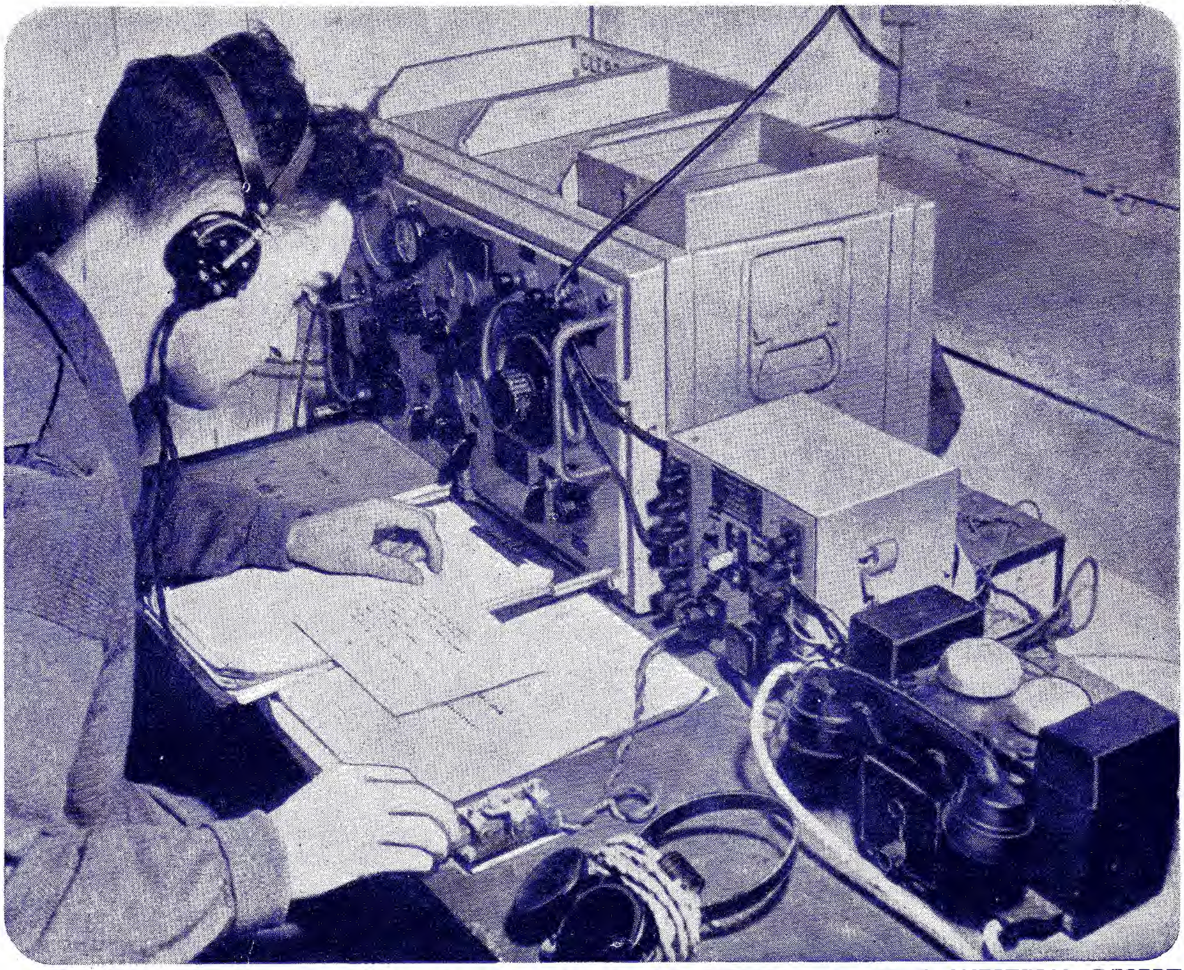

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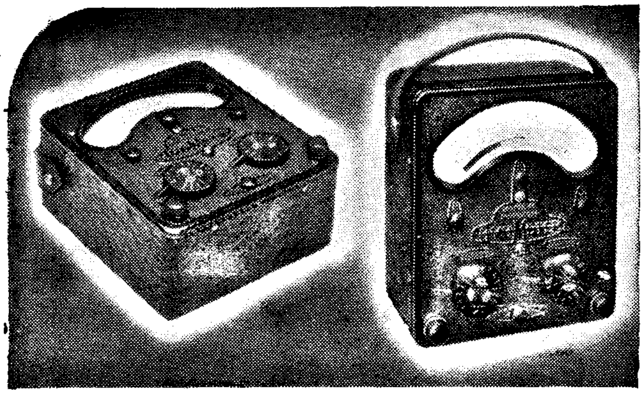

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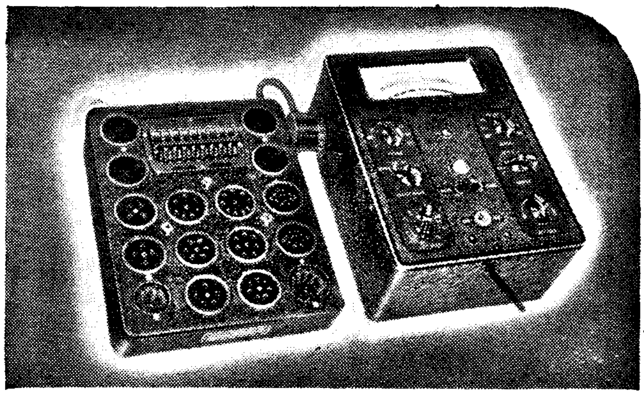

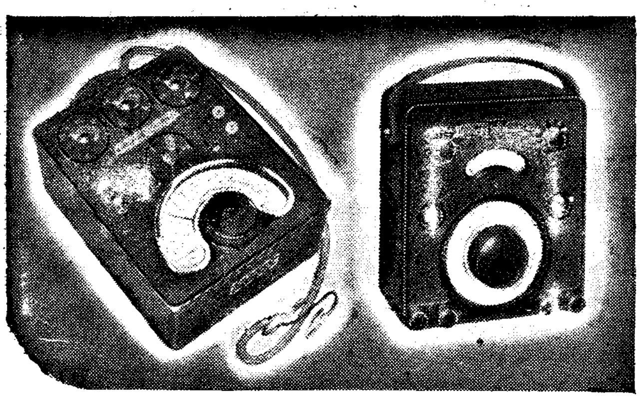

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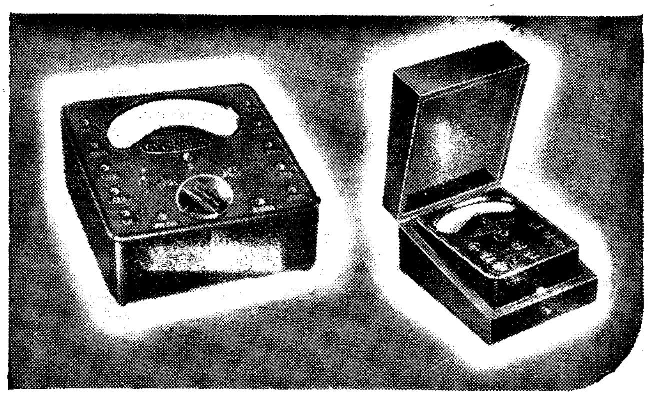

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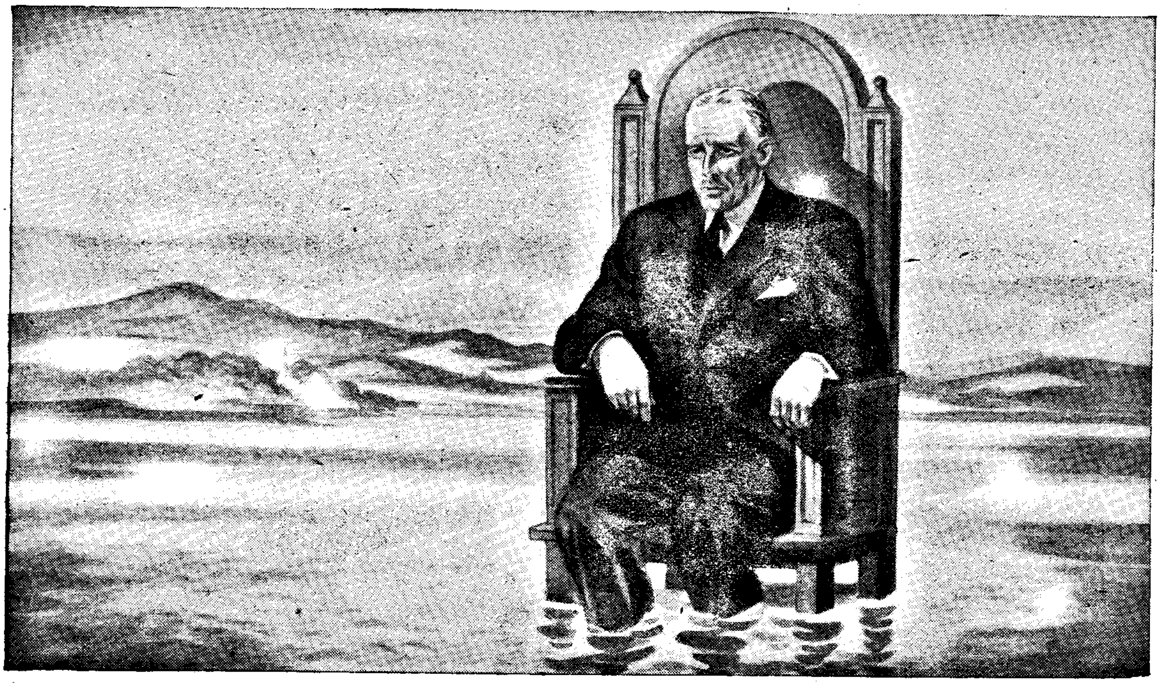

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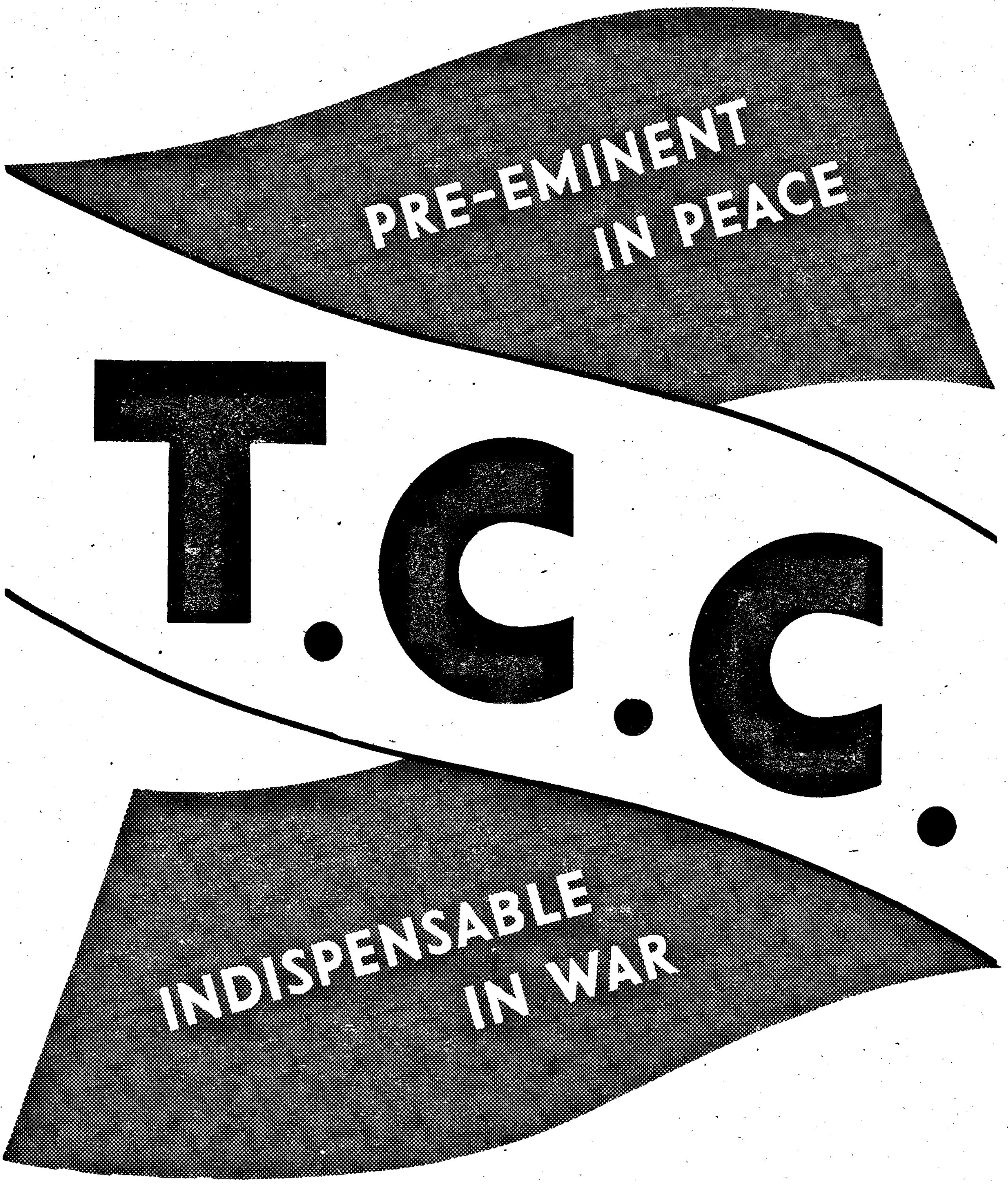

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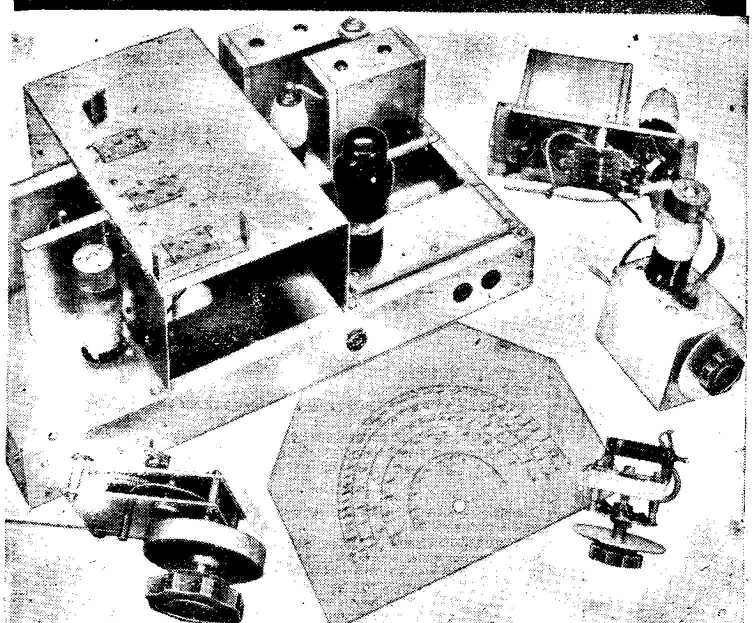

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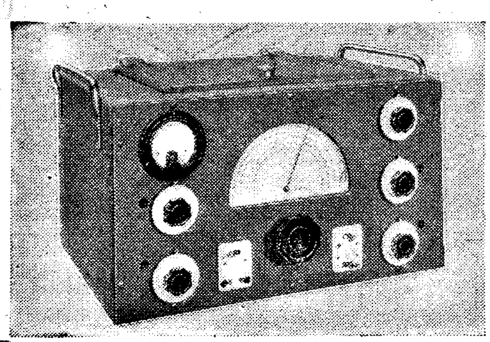

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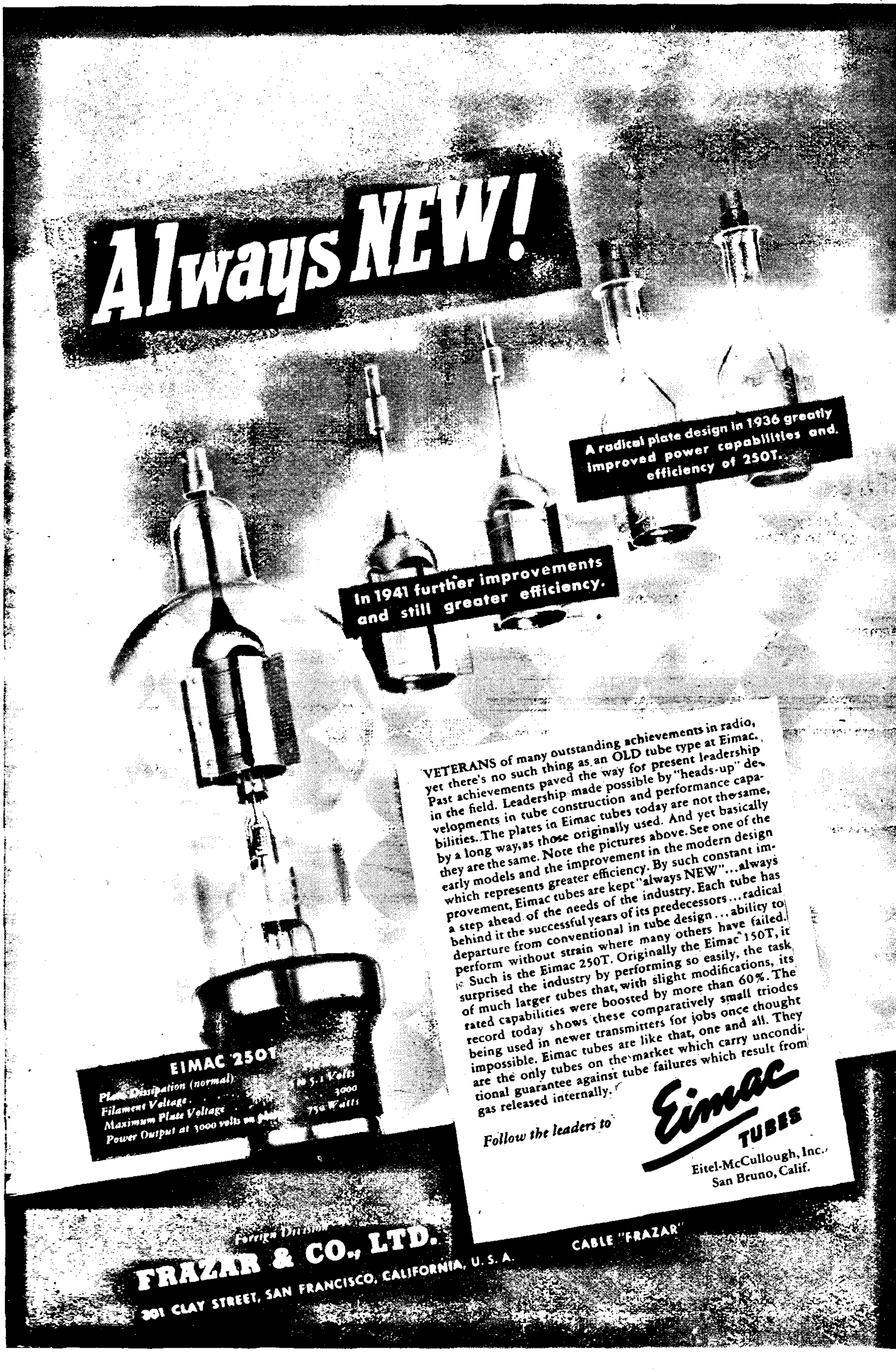
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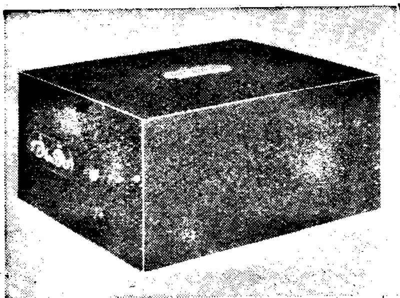

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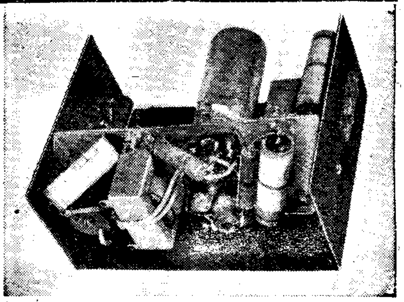

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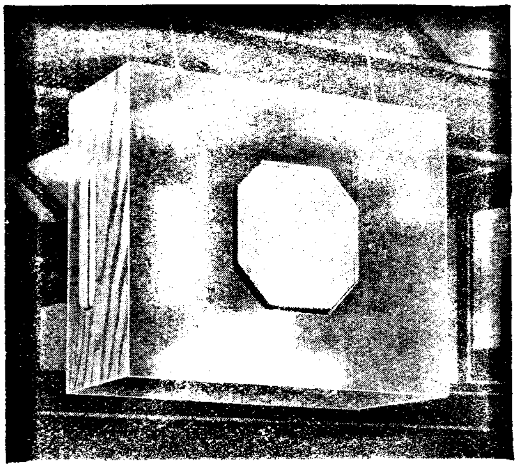

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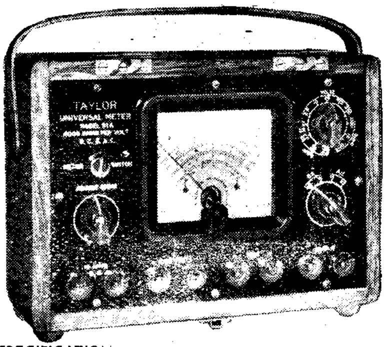

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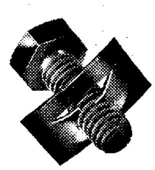

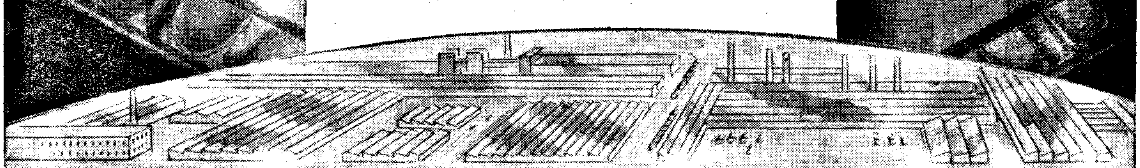

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Wireless World

COVERING EVERY WIRELESS INTEREST

ESTABLISHED 1911

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Training Technicians

Theory and Practice in Proper Proportions

CORRESPONDENCE, both published and unpublished, from readers of this journal would confirm our view that all is not well with existing methods of training wireless technicians. (That word is here used in its widest sense to cover everyone doing a technical job, whatever the responsibility involved in it.) At no time during the short history of wireless has training been taken seriously enough, and it is certain that even at the present time there remains much dead wood that must be ruthlessly cut away. But there is a lack of agreement as to even the broad lines on which a training syllabus should be planned.

On one matter, however, there seems to be unanimity. A higher proportion of the time allotted to training should be devoted to "background" work and fundamental theory, and less to practical details of apparatus. The need for "learning how to learn" is at last being widely recognised. Gone are the days when any one man could carry all wireless knowledge in his head; now, the most that anyone of average intellectual attainments can hope for is a thorough knowledge of one specialised branch, plus a background of fundamental theory on which to build where necessary. So great is the complexity of our subject that one can hardly imagine any training course of practicable duration which could turn out a graduate competent to undertake, without further instruction, posts of technical responsibility in such diverse spheres as a high-power transmitting station, a broadcast receiver design department, or an ionosphere research station.

The Economic Aspect

We think the best solution is that put forward by a correspondent in our February issue. He suggested that the system of training should allow the embryo engineer "to acquire the practical technique of some particular sub-section of radio by the particular age at which he requires to earn a living. . . . Having got a footing in the industry on the strength of his one specialisation, the engineer may then (if he has the time and inclination) study other branches of the art." There is no reason why this proposal should not apply to technicians generally, and not solely to engineers. Our correspondent's plea for a sound basic training in fundamental theory applies with equal force in all cases. Lacking this knowledge, any technician finds it difficult to assimilate new branches of his subject, and so may be compelled for life to follow a vocation that proves to be distasteful.

There seems to be general agreement that wireless knowledge should be built upon a foundation of physics, but few opinions have been expressed as to the most relevant branches of that science. A groundwork of atomic physics is a particularly valuable foundation for an understanding of some of the ewer and more difficult branches of our art. Mathematics, too, is more important than is generally realised.

It must not be forgotten that those responsible for the setting of qualifying examinations bear the major responsibility in determining what will be taught. It is natural, though perhaps sometimes regrettable, that there is always a tendency for training courses to be planned to teach students to pass examinations rather than to give them the knowledge they are likely to need. Clearly, the responsibility for improving the system of training cannot be placed in any one quarter; educational authorities, professional bodies, industrial and other employers of wireless technicians must all collaborate.

We attach importance to these matters because we are jealous of the status of all wireless technicians, which in some branches has not been as high as it should be. For proper fulfilment of their tasks they need both intellectual power and specialised training of a higher order than in other vocations that at first sight seem to be comparable. And finally, without urging "wireless without tears" methods, may we plead for rather more sympathy towards the student? He will put his heart all the more readily into the study of seemingly dull theory if its value in giving a proper understanding of practical applications is always kept before him. Similarly, he will take to mathematics all the more kindly for being shown that it can make things easier, and not more difficult, as he is inclined to suppose.

Electrons in U-H-F Valves

I.—Transit Time; a Limiting Factor in Conventional Technique

The trend towards shorter and still shorter wavelengths has called into being a radically new technique of valve operation. This is the first of a short series of articles written with the object of helping readers to understand the principles employed, particularly in velocity-modulation UHF generators.

By MARTIN JOHNSON, D.Sc.

A RECENT article on Velocity-Modulated Valves[1] has usefully drawn attention to some of the oscillators and amplifiers whose apparently fantastic design becomes necessary when the ultra-high frequency range is extended to wavelengths of only a few centimetres. But all such brief accounts of "Klystrons," etc., are likely to raise as many questions as they solve. It is probable that many enthusiasts are asking these further questions, not because the subject is of intrinsic difficulty, but because conventional discussion of triodes and pentodes for less extreme frequencies has tended to conceal some essential electrical principles which must be made to emerge before the newer technique can appear as rational as the old.

General Outline.—Three main considerations have played a part in deciding the direction of recent ultra-high-frequency engineering, as follows:—

(1) If the short but finite time for transit of electrons across a valve ceases to be negligible compared with the period of oscillation, the ordinary functioning of a triode tends to fail for several reasons; some of these are explainable, such as lowered grid-impedance, grid power loss, and diminished amplification, but some are not. The obvious remedy of increasing electron speeds, to keep transit time smaller than even the briefest oscillation period, has a scope strictly limited, as we shall show. The most effective of practical advances only began when finite time of transit was looked at from its other aspect, as implying a definite velocity of electrons. If velocities are modified by HF impulses along the path of transit, so that energy is lost by certain of the electrons and gained by others, they gather into groups of greater and lesser space-charge. Many recent devices are classifiable chiefly according to the details by which such "velocity modulation" is capable of affecting the flow of current in a tuned circuit and ultimately generating or detecting radiation.

(2) This new way of taming the valve-designer's enemy could have made little headway, because of the power losses to be faced in adapting the conventional coils and condensers to extreme frequencies, unless external circuits had been replaced by the long-known but long-neglected device of closed Resonators. These hollow cavities for containing radiation of sharply fixed frequencies are metal spheres, double cylinders, toroids and other shapes quaintly intruding among the radio stock-in-trade. They often present the worst obstacle to understanding ultra-high frequency technique, since they demand a radical overhauling of what is implied in commonplace notions of capacity, inductance, shunt impedance, etc., bewildering the expert who had accepted the older definitions and takes unkindly to the absurd simplicity of what he is now asked to believe.

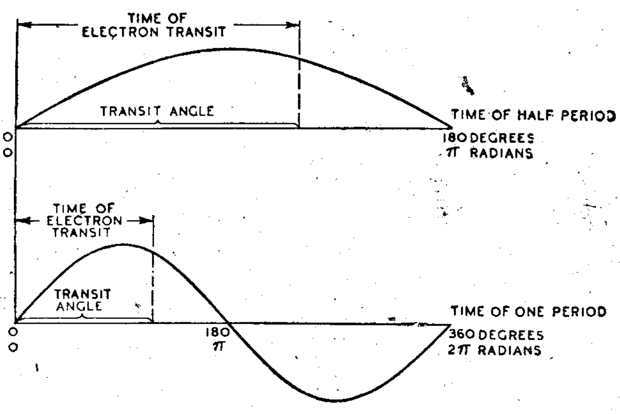


Fig. 1.—Angular representation of transit time as fraction of period. Example of transit angle kept constant for a doubled frequency by doubling speed through four-fold voltage.

(3) The further suggestion of exciting such resonators by energy transferred from an electron beam, which itself never touches the metal surface, solves at once the problems of power production and loss into which the older attack on transit time was bound to lead. But the underlying principle goes nowhere beyond what we have above outlined, the selection of a transit time to allow exchange of energy between electrons and a resonator which they traverse. Velocity-modulation technique, regarded in this way, can be linked with the behaviour of an ordinary cathode-ray beam such as is used in a television set; we only need to imagine that its plates form part of tuned resonating systems.

Transit Time, Transit Angle, and Volts.—The enlarged opportunities offered to the valve designer by velocity-modulation are not likely to be understood without some data to show where and why the conventional valve was incapable of improvement beyond certain limits. Consider, therefore, why transit time is really an obstacle which cannot be by-passed and must be re-approached to turn it from a liability to an asset. The swarm of electrons which constitute the moving space-charge carrying any anode current from a filament possesses so little inertia that even a fraction of a volt raises a speed of more than 10^7 cm. per sec. This is because each electron has a mass less than a thousandth of the lightest of chemical atoms. Hence, in ordinary radio, the time lag between grid impulse and anode current response is dismissed as too small to be serious, all electrons ending their journeys long before even a short-wave oscillation has proceeded far along a single cycle. Tables 1 and 2 show where this convenient provision breaks down.

TABLE 1

Anode Volts	Min. Time to travel 1 cm.
100	17×10^{-10} sec.
1,000	5.3×10^{-10} „
10,000	1.7×10^{-10} „
50,000	0.7×10^{-10} „

TABLE 2

Wavelength	Frequency	Periodic Time
1,000 m.	300 kc/s	3×10^{-6} sec.
10 m.	30,000 kc/s	3×10^{-8} „
1 m.	300 Mc/s	3×10^{-9} „
10 cm.	3,000 Mc/s	3×10^{-10} „

[1] *Wireless World*, Oct., 1941.

A quantity usefully summarising the combination of these two tables is "transit angle," or electron transit time for any inter-electrode distance divided by period of oscillation. This fraction must be kept very small; but these tables suggest that if anode current is to "follow" grid fluctuations as faithfully below one metre as at broadcast wavelengths, the required speeds of transit would entail impracticably high voltages. The whole insulating paraphernalia of an X-ray tube would have to surround every valve if mere speed were to get the electron to the anode before an ultra-high-frequency impulse had made appreciable progress along its cycle. The key to the situation is, in fact, that speed, and hence transit time, varies with the square root of the anode voltage.

Effect upon Input Impedance of Amplifiers.—For frequencies so high that transit angle begins to grow, the effect of such time-lag between grid impulses and current response is very complicated, and is not fully covered by any simple application of the conventions of low-frequency AC engineering. But the usual valve data, such as transconductance and anode impedance, must obviously be treated as vectors involving a transit angle dependant upon frequency. It is, however, not hard to recognise that an amplifier cannot amplify at all if its input power loss in the internal grid circuit approaches the magnitude of its power output; so that if grid input conductance ceases to be small compared with trans-conductance, the valve ceases to function as an amplifier. Now Ferris (Radio Corporation of America) and others have shown by experiments confirming theory that, when transit angle is no longer negligible, an undesirable input grid conductance grows proportionally with the square of frequency and of transit time. Much verbal argument has been expended on the exact reasons for this effect, but in a general way it is possible to see that if a grid is going through a cycle whose period is comparable with transit time, there must be instants at which current density is greater on the cathode side of the grid than on the anode side, and then vice versa, and the inequality of approaching and receding charge will have inductive effects allowing the grid to draw current even if negatively biased. The power thus lost can conveniently be expressed in terms of an equivalent resistance shunted between grid and cathode. For a particular American pentode the facts were as follows:—

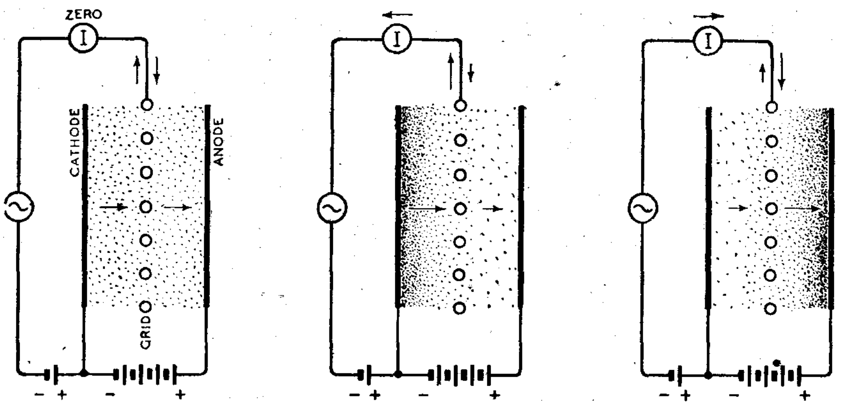


Fig. 2.—Source of grid power loss at ultra-high frequencies (adapted from Ferris). Arrows denote direction and volume of electron flow.

TABLE 3

Frequency	Input Resistance
1,000 kc/s	21 megohms
30 Mc/s	23,000 ohms
100 Mc/s	2,100 ohms

The amplification factor actually fell from only 15 at 30 Mc/s to less than unity at 100 Mc/s, showing the complete wrecking of the usual properties of the valve.

Possible Remedies.—Failure to amplify because of transit time, of course, is not the only difficulty in ultra-high-frequency valve design. Under the working conditions which we have been picturing, electrons trapped in awkward phasing may destroy the cathode by returning to bombard it. Since if grid phases can fluctuate much within transit time, there will certainly be instants when negative bias is in excess of cut-off. In any case the capacity of electrode systems and the inductance of leads will play havoc with any precise control of frequency by external resonant circuits. We have shown in our first tables that reduction of transit time by high speed involves inconveniently large voltages, as the velocity increases only with the square root of voltage. An attempt to tackle several of the difficulties simultaneously is the development of the tiny "acorn" or "shoe-button" valves. These owe their origin—and the pretty trickery of construction which they require—to the fact that if the linear dimensions of a valve are reduced, inter-electrode capacity and lead inductance and transit time are all reduced, while transconductance and plate resistance and amplification factor all remain the same. By making a valve only a fifth of normal size the input resistances of our Table 3 can be raised, by the relationship which we quoted, twenty-five times. The valve can therefore be worked at a frequency five times that of its normal sized prototype. A serious problem is, of course, that of persuading it to work at appreciable power, since a large fraction of the power must inevitably appear in the form of heat, with destructive consequences for the miniature electrodes of these tiny valves.

The situation obviously calls for a radical overturning of the whole viewpoint of the valve designer in ultra-high-frequency ranges, and our argument should be sufficient to show that transit time must be rationally exploited instead of vainly reduced.

Velocity-modulation devices are not the only answer to such a demand, and before discussing them we propose to say a little about how the older Barkhausen oscillator is really a logical development in the desired direction, although historically it was anterior to "acorns." We suggest that exposition and research upon the most modern devices, such as the Klystron, might gain in clarity by reconsidering the phasing experiments of the later workers on Barkhausen tubes.

The Barkhausen Attempt to Exploit Transit Time.—Experiments in this direction are within the reach of anyone who can obtain from the scrap-box one of those early triodes in which filament, grid and anode were coaxial cylinders; he should be warned that his experiments may burn out the grid. Apply the main positive potential to the grid instead of the anode, and either tie anode to filament or make it slightly negative. Very high frequency oscillations then readily appear, and can be made to form a stationary wave system along

Electrons in UHF Valves— a short pair of parallel wires from grid and anode. The UHF currents can be kept out of the battery system by quite small chokes. We illustrate one particular version of the circuit, that used with remarkable results by Potapenko.

As we are here concerned with the Barkhausen phenomena only as they throw light on the use of transit time in velocity-modulation, we will not discuss the subtle conditions which decide how much power can be taken by the anode even against the retarding potential of an external battery; it is sufficient to recognise in general that an electron accelerated through the positive grid is turned back before it reaches the negative anode, and again reversed before it gets back to the filament. If this is repeated and it does not hit a grid wire, it may perform several harmonic surges across the grid space. It is these surges which, if suitably phased for transfer of power, produce ultra-HF impulses in anode and grid leads. In this mechanism, transit angle is no longer the obstacle, since the actual period of oscillation is made up of the time of transit across the grid space and back again.

For many years there was controversy as to whether two main types of these oscillations (Barkhausen-Kurz and Gill-Morrell) could genuinely be distinguished among the welter of harmonics and stray frequencies. Quite astonishing frequency spectra were commonly reported by the Japanese workers, as also from their Magnetron oscillators. The arguments are of less practical interest now that Klystrons generate so much more power, for even with a carefully cooled grid the Barkhausen mechanism only produces a fraction of a watt at wavelengths of a small fraction of a metre. Nevertheless, from the physical principles of these tubes much can still be learned, especially as regards phasing and resonance. In fact, the "dwarf waves" of many Barkhausen investigators may well form the miniature testing ground for considerable future study of resonating systems and their excitation in selected modes. Perhaps the most ingenious worker was the Russian, Potapenko, in U.S.A., who actually traced first, second, third, and fourth order harmonics; these are important for the following reason. The wavelength in centimetres for a Barkhausen oscillation is given approximately by

$$\lambda^2 = 10^6\, d^2 / Eg$$

where d is the anode diameter and Eg is the grid potential. Hence 10-cm. waves would need a grid voltage of about 6,000 for an ordinary sized cylindrical anode; whereas Potapenko's high-order dwarf waves reached that very extreme frequency (3,000) in megacycles, with a few hundred volts only; actually he seems to have used a common Russian broadcast receiver valve.

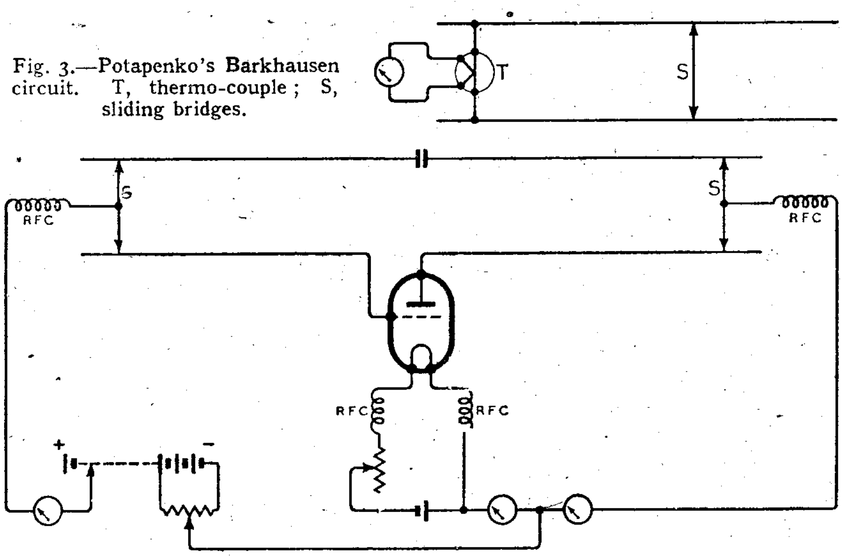


Fig. 3.—Potapenko's Barkhausen circuit. T, thermo-couple; S, sliding bridges.

Two developments, both begun by several isolated workers, would have saved the Barkhausen oscillator: first, an understanding of resonators sufficient to produce "dwarf waves" or harmonics of required order at the expense of fundamental frequencies, and, secondly, some successful way of combining the phases of oscillation in the several grid spaces of a multi-electrode tube. It is a curious commentary on the working of the valve designer's mind that Barkhausen papers of half a dozen years ago contain much of the germ of phase control later utilised in velocity-modulation tubes, without being able to turn the notion to such practical use. For electrons might oscillate from virtual cathode to virtual anode and back indefinitely, without much transfer of power to any external circuit, unless the associated electrode potentials go through their cycles with the most favourable timing for exchange of energy between the retarded and accelerated stream and the metallic current flow. Actually, the technical difficulty of combining miniature electrode dimensions with high grid voltage according to the above equation left the situation hopeless, so long as lack of control over phasing and resonance kept the output power down to a few per cent. of the heat losses. Meanwhile, the novelty of combining beams of the CR tube type with closed resonators enabled another way of redeeming transit time to achieve a success denied to the Barkhausen tube. But even a rough understanding of those earlier attempts serves to show the principle of velocity-modulation as an opportune and common-sense use of an electro-dynamic mechanism by no means novel or unknown. In fact, it is an inevitable sequel to the phasing problem of any electron moving with finite velocity and thus made to recede at an appropriate instant from a metal upon which it exerts the usual inductive influence. To this sequel we now turn.

Transit Time and Velocity-modulation.—We suggested above that the velocity-modulation technique did not spring out of nothing as an entire novelty, and is best understood in the light of earlier work; indeed, both Potapenko and Gill made much enquiry concerning groups of electrons giving or taking power as they moved through the mesh spacings of a Barkhausen grid. Such loss or gain must ultimately depend upon how the externally applied electrode potentials and the charges induced by approaching and receding electrons recur with the correct phase relationship for reinforcing or opposing each other. Since it is not the electrons hitting the grid but those passing through which drive the Barkhausen tubes, we have already the notion of a moving charge with finite speed passing near to some conducting surface and by induction starting fresh impulses. A large step forward towards velocity-modulation is then taken if that surface is connected by a suitable metallic circuit to another across which the electrons must subsequently pass; careful matching of the time of transit to the time for propagation in this connecting circuit will cause some electrons to gain more and some to lose more in their energy exchange with the nearby conductors. A stream of them orginally all of one velocity will therefore sort itself into bunches, the faster and later crowding the slower and earlier which fall back towards them.

By this mechanism, any original DC flow of electrons acquires a periodic structure which can be utilised in more than one way. For instance, the periodicity may be used for exciting a second resonant circuit connected between a second pair of grids—the "catcher" corresponding to the "buncher" of the Klystron generator. Or, supposing the original flow to be given some periodicity from outside, a single resonating circuit can be excited without the first pair of grids, and the device then becomes an amplifier.

This motion of imposing modifications in velocity upon streaming electrons in addition to the quantity modification or "intensity modulation" familiar in valves for ordinary radio, might have remained a laboratory curiosity of low power like the Barkhausen oscillator; its use of transit time is quite comparable. But the grossest of the inadequacies which we have shown as limiting the power output were overcome by two developments which were emerging at the time when Barkhausen workers were enquiring into the phasing of their impulses. Of these two developments, the first was that electrons moving in pencils or directed beams from a "gun" were being studied in CR tubes owing to the growth of television. The second was the realisation that for very short waves the conventional circuit of coil and condenser could well be entirely replaced by closed box resonators; ideas of these had remained buried in the theoretical papers of an earlier generation, because it had never been worth constructing resonators many metres in size. Their dimensions are essentially about the size of a wavelength, so that when 10 cm. instead of many metres became fashionable in wavelengths a whole science of closed resonators was resurrected from limbo. It is the CR beam and the closed resonator which have rescued the velocity-modulation tube from the defects of the Barkhausen oscillator, and in subsequent articles we hope to describe the part played by each in making the velocity-modulation use of transit time a success.

Polish Radio Cars

Escape from the Nazis

AN interesting account is given by one of the principal figures in the former Polish broadcasting organisation of the activities of the Polish mobile broadcasting units after the German invasion. There were two of these units, or radio cars, as they are called, in Poland, and both are now in England.

Apart from microphone pick-up gear they have two complete recording outfits, the Neuman disc method being employed. It is interesting to note that included among the equipment are four condenser microphones together with their amplifying equipment.

Power to operate the transmitter and the auxiliary equipment is provided by large-capacity 12-volt accumulators. The actual capacity of the batteries—and there are four of them—is 220 Ah. They are kept in trim by a charging plant carried on the radio car. They supply power to a converter having a 12-volt input and a 220-volt AC output. In addition to the wireless and recording equipment, each van carries three field telephone sets, enabling it to be quickly linked up with any desired spot.

These vans escaped from Warsaw when it was all but surrounded by the German forces, and they could no longer serve any useful purpose. They crossed the Roumanian frontier and, after great difficulties in obtaining the necessary passports, they managed to reach France via Yugoslavia and Italy, in December. Here they did sterling service among the remnants of the Polish army which had managed to reach France. Many hundreds of messages from soldiers and refugees were recorded and subsequently broadcast from the transmitting station which was put at their disposal by the French authorities.

June, 1940, found them once again slipping out of the clutches of the advancing Germans. The station in France used for Polish transmissions had already fallen into German hands. Passing through Spain they reached Lisbon, and here they were once more faced with the difficulty of getting permission to go to an allied country. Eventually, however, they succeeded, and since that time have been serving in England until such time as they will be able to rumble across Europe in the victorious march home.

OUR NEW COVER

Next month marks the beginning of the 32nd year of publication of *Wireless World.* To celebrate the event, starting with the April issue the journal will appear in a new cover, with a design that more nearly symbolises our present scope.

Instruments: *Test and Measuring Gear and Its Uses*

By W. H. CAZALY

I.—Standard Signal Generators and Test Oscillators

THE differences between a service-bench Test Oscillator costing a few pounds and a Standard Signal Generator costing £100 are ones of refinement rather than of principle. A standard signal generator—known as an SSG for short—is a device that produces, across a known impedance, alternating voltages that resemble closely the radio or intermediate frequency voltages that are handled by a receiver; these "carriers" at RF or IF may be modulated or not as desired, and their frequencies, magnitudes, and waveforms, and the frequency and depth of modulation, are accurately known and precisely controllable. These artificially produced "signals" can be used to measure the performance of a receiver in definite units and terms that are independent of the personal feelings and abilities of the operator.

instruments found in thousands of service workshops. It is not proposed here to deal with high-precision apparatus of that nature. Nor is it proposed to deal with the lowest grades of cheap or home-made test oscillators. For general purposes in design labs. and on the work benches of serious experimenters, an SSG of an intermediate order of precision and complexity is very often quite satisfactory; while even the test oscillator may, in the hands of an intelligent man and if it is soundly constructed, provide *comparative* data of value quite equal for many extremely practical purposes (such as servicing) to that offered by its more expensive cousin the SSG.

Dealing with the SSG first, Fig. 1 is a block diagram of the essential parts of a system for measuring the main aspects of a receiver's performance. Each of the four main parts may be considered for the purpose of study as an autonomous device or instrument. The four of them—the Modulator, the RF Oscillator, the RF Output Monitor, and the Attenuator with its Dummy Aerial Terminating Impedance—are designed to work together in combination; each is separately and thoroughly screened, and as a whole they are enclosed in a large and substantial screening case. This screening is most important. Without it, the system is liable to radiate stray fields of unknown and uncontrollable intensity that hopelessly invalidate the data obtained with sensitive receivers that respond to these stray fields as well as to the terminal voltages at the SSG output. It may be emphasised that the foregoing states the minimum requirements for an instrument worthy of the name of *standard* signal generator; if an instrument does not possess all these features, or possesses them only in crude form incapable of precise and quantitatively known control, it may be merely an elaborate, expensive and handsome test oscillator.

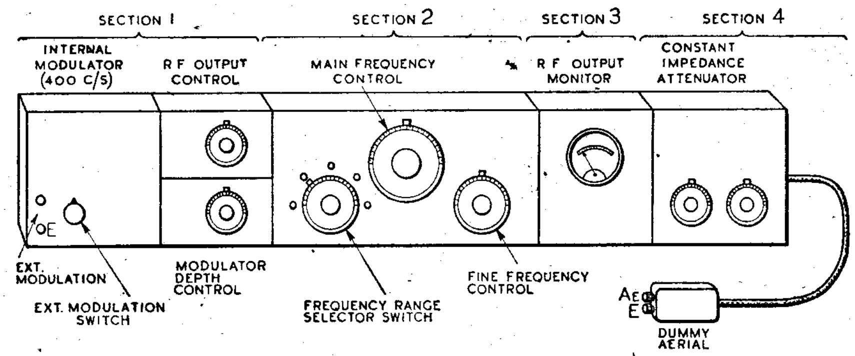


Fig. 1. The essential parts of a standard signal generator. Each part constitutes practically an instrument on its own, but all are designed to work in co-operation with each other. Modulation from an external source may be injected through the terminals marked "Ext. Modulation."

A device of such capabilities cannot be altogether simple. In a highly developed form, indeed, the SSG may be quite complex for it may then consist of several instruments, each of high precision and some complexity, specially designed for working in combination; the price of such a piece of apparatus might run into thousands of pounds, and for that an accuracy of the order of a few parts in several millions might be obtained. Yet the basic principles would be comparatively simple, and not really different from those employed by the humbler

Frequency Control

The RF oscillator, in an SSG, is often the least complex and most easily designed and constructed part; no very high order of inherent long-period constancy is demanded of either the frequency or the magnitude of the output, because both can, if necessary, be accurately measured or monitored by, respectively, an external precision wave-meter and the internal RF output monitoring device. It may consist merely of a robustly made valve oscillator with good, low-loss components selected for the constancy of their electrical properties. The "tuning dial," or frequency control, is usually calibrated in kilocycles and megacycles per second, and for most purposes the maker's calibration is sufficiently accurate as it stands. But an all-important adjunct to this main frequency control is a really well-made fine control that will enable the frequency of a signal to be changed or adjusted by small amounts, of the order of a few hundred or thousand c/s in several megacycles. This fine control usually takes the form of some mechanical adjustment, either as a vernier on the main control or by the movement of the stator vanes of the tuning condenser.

The RF output monitoring device may consist either of a valve-voltmeter that records the voltage developed by the oscillator across the input impedance of the attenuator, or of a thermo-couple (for instance, a vacuo-junction) meter that registers the current through, and, therefore, indirectly the voltage across, the attenuator.

Fig. 2 shows the essential parts of the RF oscillator section and the RF output monitor, together with a practical method of controlling the RF output of the oscillator, in this case by varying the anode voltage by a series resistance across which IR drop occurs with the passage of I*a*. The procedure usually adopted is to adjust the RF output by varying the value of this anode series resistance until the RP output monitor pointer comes to a "set-up" mark on its dial; it is then assumed that a definite predetermined voltage is being developed across the attenuator input. The voltage at the anode of the RF oscillator will be the full voltage of the power pack less the voltage drop across the series resistance, which depends on the I*a* of the RF oscillator. Since this I*a* varies with the intensity of oscillation, and this, in turn, varies with the Q of the oscillator, which will not be the same for all frequencies and L/C ratios, the RF output may vary with the setting of the SSG frequency control, but it can always be brought to the same value at the input of the attenuator by adjustment of the series anode resistance—or the V*a* of the RF oscillator.

Fig. 2 also shows in skeleton form a type of attenuator much used in SSGs for general purposes. It is not of truly constant impedance, for which a more elaborate and expensive form would be required, but the ratio between the variation of voltage across its output terminals and the variation of its input impedance can be made, by suitable design, very high. For example, a change of terminal output voltage of 10,000 times may be accompanied by a change of attenuator input impedance (towards the oscillator) of only two times, and as low-impedance coupling between the attenuator and the oscillator is usually adopted, the effect on the oscillator frequency may be negligible or easily allowed for. The design of constant impedance RF attenuators is a very lengthy subject, but it may here be mentioned that the elements of the network are usually resistive and are mounted in a casting of brass having compartments for the elements that effectively screen them from each other but are of sufficient dimensions to keep their capacity to earth to a reasonably small amount; in this way the attenuator is made practically purely resistive and almost independent of frequency variations of the signal it handles up to some 15 or 20 Mc/s. It should be obvious that the whole accuracy and value of the SSG depend upon the precision of control of the magnitude of the test signal sent out; hence the attenuator and RF output monitor are the most important parts of the whole apparatus. Unless they are really well designed and constructed, it is impossible to do more than obtain a rough idea of the magnitude of the output terminal voltage, which is not good enough for quantitative measurements of performance.

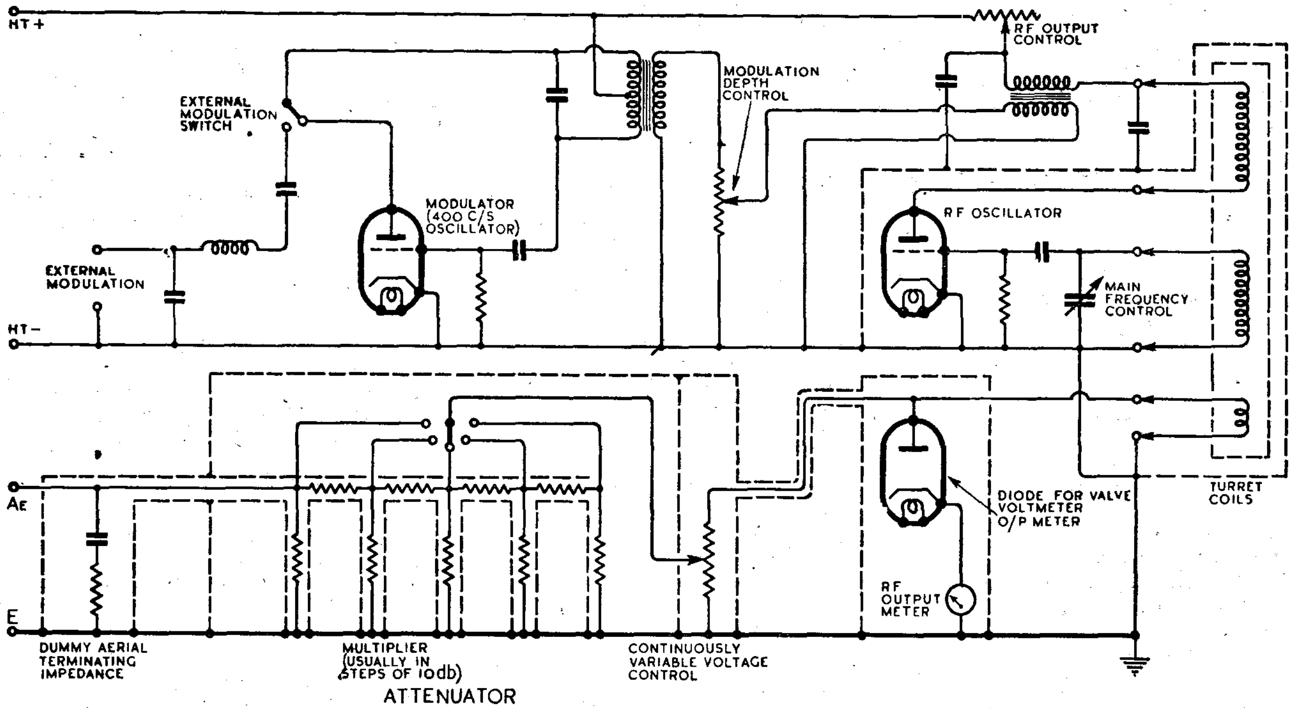


Fig. 2. Skeleton circuit of a typical SSG of general-purpose type. Note the thorough screening of each section separately, indicated by dotted line.

Modulation

Since the performance of receivers is largely stated in terms of the audio output, it is essential that the RF carrier of the test signal should be modulated. This may be done, in an SSG of the order of cost and comple ity under discussion, in two ways—either by an internal modulator consisting of a fairly simple regenerative AF transformer- upled oscillator producing anode modulation of the RF oscillator at a common standard frequency of 400 c/s, or by the injection of a modulating voltage from an external source such as a beat frequency oscillator or similar AF source. Further, it is essential for many tests that the depth of modulation be fairly accurately known. For the latter purpose, some control of the modulating voltage injected is necessary, and means must be provided for measuring or obtaining definite modulation depth

Instruments—
data. In Fig. 2 is shown one way of securing this facility.

It may be best, at this point, to study the behaviour of the various parts of an SSG by considering what can be done with and by it in some actual practical case of use. It will be assumed, therefore, that it is desired to ascertain (1) the overall absolute sensitivity of a receiver and (2) the adjacent channel response at 5 kc/s off-tune at, say, 1 Mc/s. The procedure will be roughly—varying, of course, with the make and type of SSG being used—as follows.

Measurement Procedure

First, the receiver is set going with an output meter connected across the correct load of the output stage, to indicate when the generally accepted standard output of 50 mW. is obtained. Next, the SSG is set up. For this, the internal modulation is switched on, the mod. depth control set to zero, and the RF output control set to minimum. While the SSG is warming up, the frequency control is set to the 1-Mc/s mark, with the fine control at zero, and the attenuator is set to the calibration point—say 10 μvolts—on its control at which it is expected that the receiver will produce approximately a 50-mW AF output. The dummy aerial at the end of its standard lead is connected to the aerial and earth terminals of the receiver through a condenser of the order of 0.001 μF. Now the RF output control is turned up until the output monitoring meter pointer reaches the "Set RF" mark; this means that 1 volt (say) is being developed at 1 Mc/s across the attenuator input; hence, if the attenuator is accurate, 10 μvolts unmodulated RF is appearing across the receiver AE and E terminals. The mod. depth control may now be turned up; a common standard depth is 30 per cent., and this may be marked on the mod. depth control, or the RF output meter (for modulation increases the power developed) may indicate it on its scale—methods differ with various SSGs. The RF signal to the receiver is now being modulated, and the resultant AF output should be recorded on the output meter. If it is below 50 mW, the RF input from the SSG will have to be increased, and this will indicate that the sensitivity of the receiver is below standard—or, of course, it may be found that, say, 8 μvolts is sufficient to produce an AF output of 50 mW, which means that the sensitivity of the receiver is above normal. That constitutes the whole of this particular form of performance measurement. It may be repeated, of course, over the whole range of frequencies handled by the receiver, and in this way any lack of sensitivity, due to poor design or defect in the receiver, may be definitely established.

Now for the "adjacent channel selectivity" test—a very important one. First, the receiver and SSG are set up, as before, both tuned accurately to 1 Mc/s and the voltage injected into the receiver by the SSG adjusted by the attenuator so that 50 mW output is obtained, as before. The setting of the attenuator for this is carefully noted. Next, the SSG frequency is altered to 1.005 Mc/s—i.e., 5 kc/s above 1 Mc/s. It will probably be impossible to do this accurately with the main frequency control dial, so the fine control will have to be used. There are, as a matter of fact, quite a number of ways in which this 5 kc/s mistuning could be secured very accurately, but they cannot be adequately described here. Since the receiver is still tuned to 1 Mc/s, its response to this off-tune input signal will be considerably less (or should be with a modern receiver) than 50 mW output. It can be restored to 50 mW by increasing the signal strength injected by the SSG by "turning up" the attenuator. The increase shown on the attenuator dial (which may, incidentally, be calibrated in terms of decibels as well as micro- and millivolts) is then a measure of the *decrease* in response of the receiver to the off-tune signal. Expressed in decibels, it may be stated, for example, as "14 db. down at 5 kc/s off-tune at 1 Mc/s."

The foregoing very sketchy outline of how to make two very important tests of receiver performance will have served its purpose if it indicates how all the parts of an SSG are involved and contribute valuably to precision of information about the receiver. It is plainly impossible to do anything as exact as this with a test oscillator. Nevertheless, a well-made and carefully treated test oscillator is capable of giving practical information to experimenters and service men of value comparable to that offered by its more impressive cousin. It may not be possible to make absolute tests of the sensivity of a receiver with a test oscillator, because it does not usually possess an accurately calibrated constant-impedance attenuator, nor is it usually possible, without an external valve-voltmeter preceding the attenuator, to ascertain precisely the RF output of the oscillator. But if a number of receivers, all of the same make and type, are being tested, and the average settings of the TO controls are found by experiment, the receivers can be classed as above or below the average by observing what TO control adjustments are necessary to bring the output of each one to some common standard level. The method may be made clear by considering a specific case such as a sensitivity test.

Comparative Sensitivity

First, the frequency (tuning control) of the TO is set at the frequency at which the test is to be carried out, and the output control is set at the average marking on its dial to give, with a receiver of the type and make under test in sound average condition, a standard output—say 50 mW, as measured by an output meter. For example, a particular make and model of domestic receiver may require the TO output control to be set at the 20-degree dial mark, with a 1-Mc/s signal and the TO internal modulator switched on. In these comparative tests, it is particularly important to specify the other factors, such as AVC operative or non-operative, the nature of the load across the output

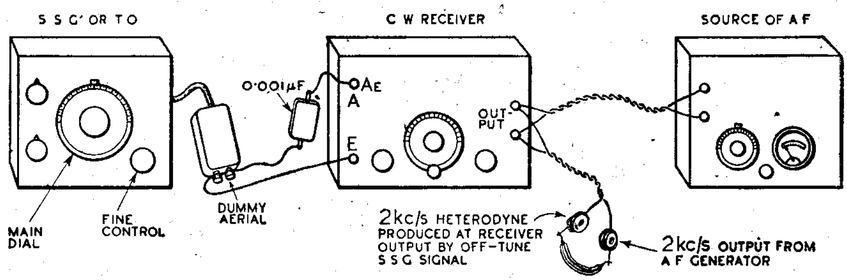


Fig. 3. An arrangement for accurately adjusting a signal to a given amount off-tune. This is essential when making adjacent-channel selectivity tests of a receiver. The CW receiver shown above is only used for this preliminary adjustment of the frequency of the SSG output.

stage including the output meter, the method of feeding the signal into the receiver (through, say, a 0.0005μF condenser), and the precise voltages of the HT and LT power supplies. If, now, another receiver of this make and model is tested, it may be found necessary, to obtain under the same conditions an output of 50 mW, to set the TO output control to the 25 deg. mark instead of the 20 deg. This would indicate, evidently, either that the sensitivity of this receiver was below average or that that of the first receiver was above average. Nor need comparative tests of this sort be confined to overall sensitivity checks. Stage gain and AVC efficiency and several other aspects of receiver performance may be similarly checked.

Plainly, it would be possible—and is done, by conscientious and intelligent workers—to compile, from careful and thorough records of such tests made on a large number of receivers encountered in the course of service and repair work, a very valuable and highly practical body of information, which would amply compensate for a lack of means to purchase more expensive and elaborate test gear. It will be obvious, however, that such comparative testing would be valuable only with three main provisos: (1) the test oscillator itself must be a soundly built and well-screened piece of apparatus of which the performance is subject to only small or negligible variations over reasonably long periods; (2) the TO must itself be given careful treatment and periodic maintenance attention and checking of the constancy of its output and frequency calibration; (3) the conditions of test, as mentioned previously, must always be the same for any particular make and model of receiver. These are points, of course, that will be obviously necessary to intelligent operators with conceptions of the meaning of the "scientific method."

Plotting Response Curves

It may not be out of place, at the conclusion of this article and with the object of hinting at the many "tricks" that can be employed by skilled operators of good instruments, to describe briefly one typical method whereby, with the aid of some AF source covering with reasonable accuracy about 1 to 6 kc/s, an SSG or a TO may be accurately "detuned" by a definitely known number of kilocycles on either side of some mid-frequency, for the purpose of ascertaining the "band-pass response" of a receiver, which is most important in estimating its selectivity and audio response. Assuming that this mid-frequency were 10 Mc/s, it is unlikely that the calibration of the main tuning dial of the SSG or TO would enable accurate discrimination to be obtained within a kilocycle or two at such a high frequency. It may be easily done, however, as follows. The *un*modulated signal from the SSG or TO is fed to a receiver capable of CW reception—either a "straight" type that can be made to oscillate or a superhet with a beat oscillator in the IF stages—and this receiver is tuned to give zero beat in the 'phones or speaker at its output. Now across this output load is connected the source of known AF—at, say, 2 kc/s. The arrangement is shown in Fig. 3.

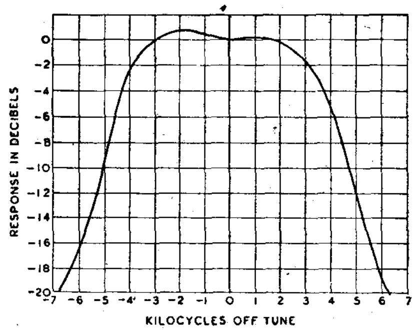


Fig. 4. Response curve obtained with the set-up shown in Fig. 3.

Next, leaving the main tuning control of the SSG or TO unaltered or locked, the fine control is adjusted until the SSG or TO signal produces a beat note that coincides with that of the AF source, that is, at 2 kc/s. Coincidence between two AF tones is very easily observed with a high degree of accuracy by listening for the "warble" or very slow rise and fall (a fraction of a cycle per second) that occurs when the AFs are very nearly in phase—a typical illustration of which may be taken from the all-too-well-known "beat" between two unsynchronised engines of German aircraft overhead! When the two notes produced by the arrangement in Fig. 3 are coincident as heard in the 'phones or speaker, the SSG or TO will be detuned from the 10 Mc/s mid-frequency by exactly 2 kc/s; whether it is plus or minus depending on whether the detuning has been done in the higher or lower frequency direction. Having noted carefully the settings of the fine controls necessary to obtain the three outputs—at 9.995 Mc/s, 10 Mc/s, and 10.005 Mc/s—the sensitivity, absolute or comparative, of the receiver may be checked as previously described at these three points. The process may be repeated for 3, 4, 5 and 6 kc/s on either side of the mid-frequency, and in this way the adjacent channel selectivity of the receiver may be pictured by plotting the variations in output against kc/s off-tune in the form of a graph, as in Fig. 4, which is the familiar band-pass response curve.

It is hoped to deal with the matter of what is meant by receiver performance in modern times later on, with the object of lifting it out of the realms of guesswork in the minds of technical users of radio. But for the time being, this glimpse of the possibilities offered by instruments capable of precise quantitative measurements will have to suffice.

Thinning Out Our Library

More Grist for the Paper Mills

AS was briefly mentioned in a recent issue, we have been getting down to the task of thinning out the shelves of our library in the interests of the paper salvage campaign. As in most collections of books, whether they be dignified by the name of library or not, we found quite a large amount of irrelevant and redundant material. In bygone years we seemed, among other things, to have accumulated quite a stock of textbooks on aspects of electrical engineering having no immediate connection with wireless, and these were the first to go. Some books on wireless and allied subjects were also consigned to the salvage heap for the simple reason that they were out of date and had been superseded by later editions.

When all this was done, we forced ourselves to remember the vital need that there is for shipping space, and we once more went through our shelves and did a little more weeding. Some books, we must confess, we sacrificed with a pang of sentimental regret, but in the end we kept only what was of real value. In these strenuous times the motto of all of us must be "Scrap until it hurts."

The Wireless Industry

WE have received from British Insulated Cables, Ltd., Prescot, Lancs, a folder giving comprehensive details of B.I. jointing tapes (rubber, bitumen, adhesive, oil resisting, etc.).

◇ ◇ ◇

A revised price list has been issued by Taylor Electrical Instruments, Ltd., whose instrument sales department is now at 148a, High Street, Slough, Bucks.

◇ ◇ ◇

"Hamofil" heat-resisting rubber-covered wire, in which the life of the covering is prolonged by the addition of free sulphur, is dealt with in a new leaflet issued by Hammans Industries, Ltd., 5, Regent Parade, Brighton Road, Sutton, Surrey.

Voltage - Multiplying Rectifiers

Obtaining High Voltage Without a Transformer

THE voltage-doubler circuit is very well known and quite widely used, but it is not always realised that the principle can be extended. Voltage-tripler and voltage-quadrupler circuits are quite possible, and in some cases form a cheap and easy way of obtaining a high-voltage supply.

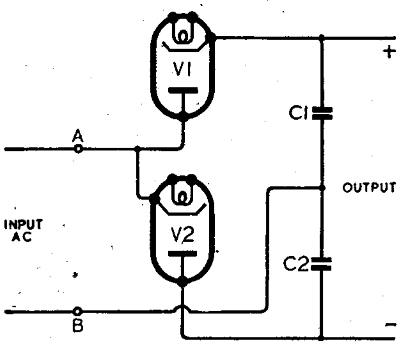


Fig. 1. This diagram shows the usual full-wave voltage-doubler.

They are all based on the voltage-doubler, and in order to understand how they work it is necessary to be quite clear about the mode of operation of this simpler circuit. The arrangement is shown in Fig. 1, and it will be seen that two valves are used with two reservoir condensers. The AC input can be either from a transformer or directly from the mains.

On the positive half-cycles of the input the point A is positive with respect to B, and the anode of V1 is positive with respect to its cathode, for this valve is connected in series with C1 across AB. The valve consequently conducts, and C1 charges through the valve, the upper plate of this condenser becoming positive with respect to the lower.

The valve V2, in series with C2, is also joined across the points AB. Its cathode is connected to A, however, so that its anode is more negative than its cathode. It is, therefore, non-conductive and does nothing.

On the negative half-cycles of input the position of the two valves is reversed. V1 is now non-conductive and V2 conductive. The condenser C2 now charges through V2, and its upper plate becomes positive with respect to the lower.

The output voltage is taken across both condensers in series, and is thus twice that on either condenser alone. When no current is taken from the

By W. T. COCKING, A.M.I.E.E.

Methods of obtaining a result with a minimum of material are always of interest, and this is especially so at a time like the present, when one often has to make do with parts that are to hand. A method of obtaining quite high voltages without having to employ a transformer is described; it forms a useful alternative to more orthodox circuits

output each condenser charges to a potential of 1.414 times the RMS value of the input alternating voltage. On load the output voltage is lower than this, and depends very largely upon the output current in relation to the capacity of the condensers.

The simplest way of looking at the voltage-doubler is to consider it as two half-wave rectifiers with the outputs in series. The rectifiers, however, conduct alternately and function on opposite half-cycles of the supply, so that the circuit as a whole is a full-wave rectifier.

The voltage-doubler of Fig. 1 is based upon the series-type half-wave rectifier of Fig. 2 (a) and consists merely of two of these used together. It is, however, equally possible to employ the parallel-type of rectifier

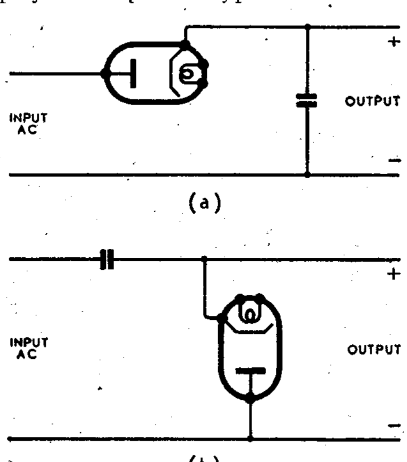


Fig. 2. The most generally used half-wave rectifier is shown at (a). This is conveniently termed the series type in contradistinction to the shunt type (b).

shown in Fig. 2 (b); it is so called because the output is taken in shunt with the valve instead of in series with it.

The operation is substantially the same. The valve conducts on the negative half-cycles and the condenser charges, its right-hand plate becoming positive with respect to its left-hand. When two of these rectifiers are put together in the obvious way the voltage-doubler of Fig. 1 results. This normal voltage-doubler, therefore, can be broken down into two series-type half-wave rectifiers, or into two parallel-type.

It is, however, possible to build a voltage-doubler from one half-wave rectifier of each type, instead of from two of either. This is shown in Fig. 3, and it should be noted that this circuit has one terminal of the input and output common. This may make it preferable, in some circumstances, to the conventional circuit.

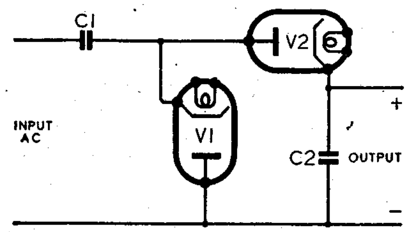


Fig. 3. This voltage-doubler consists of the combination of a series and a shunt-type half-wave rectifier. It has one input and output terminal common.

Before discussing this circuit, it is necessary to be quite clear about the simpler half-wave rectifiers of Fig. 2. The series circuit (a) works on the positive half-cycles of input, and on no load the condenser becomes charged to the peak value of the input voltage. On load, the condenser discharges to some extent during the time when the valve is not conducting, so that the voltage across it fluctuates. The mean discharge current constitutes the current drawn from the circuit and used in the load, while the fluctuations are the ripple, or hum, on the output.

In the case of the shunt circuit (b) exactly the same thing happens, so far as the condenser is concerned, but the output is now the condenser voltage in series with the AC supply. When no current is drawn, instead of the output voltage being constant at the peak value of the input, it is fluctuating between zero and twice the peak value, with a mean value equal to the peak value of the input.

This is why the circuit as it stands is never used. Even on no load, the ripply voltage on the output is equal to the mean steady voltage.

This effect is turned to advantage in the voltage-doubler of Fig. 3, however, and it will be seen that this circuit consists of a series-type half-wave rectifier following a parallel type.

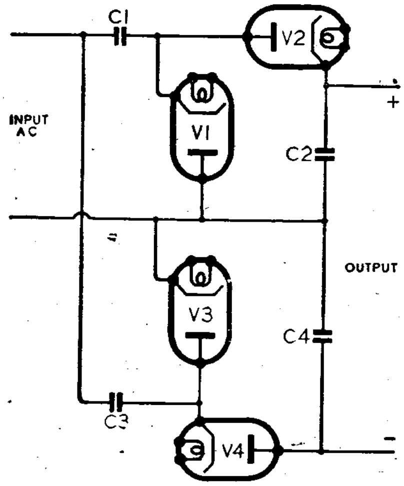


Fig. 4. Two voltage-doublers of the type shown in Fig. 3 can be connected together in the way shown here to form a voltage-quadrupler.

What happens is this. V1 conducts on the negative half-cycles of the input voltage, and C1 charges so that its right-hand plate becomes positive with respect to its left. V2 is non-conductive during these periods.

On the positive half-cycles V1 becomes non-conductive and V2 conductive. The voltage acting on V2, however, is not merely the input voltage but the sum of this voltage and that across C1. This total voltage acts through V2 to charge C2. On no load C1 is charged to the peak value of the input and C2 to twice the peak value. This condenser, therefore, must be rated for working at twice the voltage that will suffice for C1. The rating for the latter is, of course, the peak input voltage, and is adequate for both condensers in the usual circuit of Fig. 1. In this respect the arrangement of Fig. 3 is less economical.

It should be pointed out here that in the foregoing description the term half-cycle has been used as if the valves conducted for precisely this time. In actual fact, of course, the conducting period is usually less than one-half of each cycle, and depends on the load current in relation to the condenser capacity.

The voltage-quadrupler should now be clear. It is nothing more than two voltage-doublers of the type of Fig. 3, and the arrangement is shown in Fig. 4. C2 and C4 should be of twice the

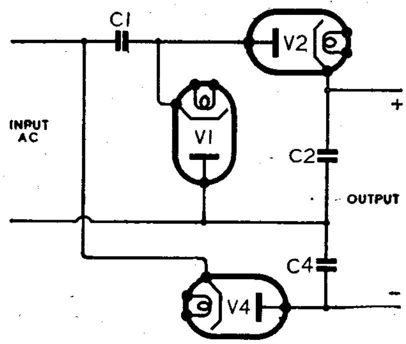


Fig. 5. This diagram shows a voltage-tripler. It consists of a half-wave rectifier in combination with a voltage-doubler.

voltage rating of C1 and C3, but the capacities can all be the same. The actual values used depend on the current, and can only be small when the current is also small.

The voltage-tripler is a combination of the voltage-doubler of Fig. 3, and the half-wave rectifier of Fig. 2 (a). It is the quadrupler less V3 and C3, and is shown in Fig. 5.

The regulation of these circuits is by no means good unless very large capacities are used. This is not only expensive but bad for the rectifiers on account of the high peak currents which will then flow. In general, therefore, they are most useful when high voltages at low currents are wanted. The quadrupler, for instance, could well be used for operating a C.R. tube, and with a 230 volt mains supply would deliver something like 1,200-1 300 volts without any transformer.

The performance of these circuits is well brought out by the curves of Fig. 6, which are reproduced from the May, 1941, issue of *Electronics*. In each case the condensers have a capacity of 2.1 μF, and the input is 115 volts at 60 c/s. Curve 1 is for a shunt-type voltage-doubler, and curve 2 for the series type; it is clear that the latter is the better when the current exceeds about 2 mA under these conditions. Curves 3 and 4 refer to the voltage-tripler and quadrupler circuits, and it is obvious that the high output voltage is only obtainable with quite low currents.

Above about 17 mA the output of the quadrupler is less than that of the tripler, and above some 22 mA both are inferior to the series-type voltage-doubler. With larger capacity condensers the cross-over points of the curves would be at higher currents; condensers of 2 μF capacity are definitely too small for any output greater than a few milliamperes. They are about right for a C.R. tube supply, but not for anything requiring more current.

Fig. 7 also reproduced from *Electronics*, shows the performance of a

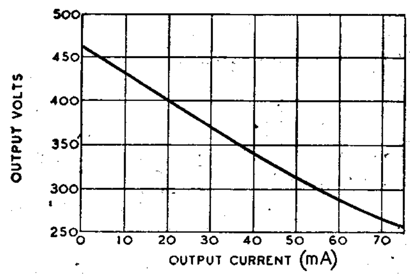


Fig. 7. When 8μF-condensers are used, the voltage-tripler has a much better performance than when they are 2 μF only.

tripler using 25Z5 valves and 8-μF condensers, the input being 117 volts. Although the slope of the curve is fairly steep, it is clear that the circuit is useful for currents up to 50 mA or so. At this current an output of just over 300 volts is obtainable.

In conclusion, it should be pointed out that, although the diagrams all show valves for the rectifiers, there is no reason why metal rectifiers should not be used. Indeed, they have the advantage of not needing a heater supply, for this is often troublesome to arrange economically in voltage-multiplier circuits.

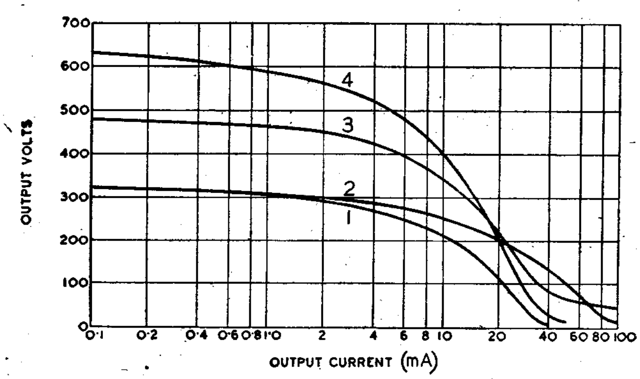
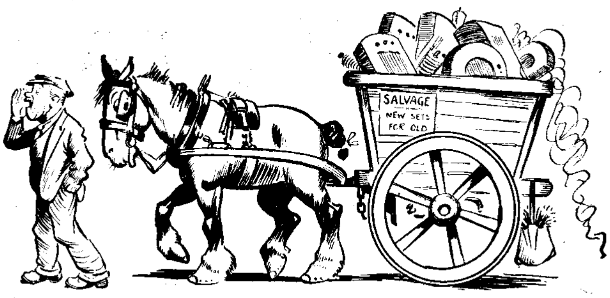


Fig. 6 These curves well illustrate the performance of the various rectifier circuits. Curves 1 and 2 are for voltage-doublers and refer to the circuits of Figs. 3 and 1 respectively. Curve 3 is for the tripler and curve 4 for the quadrupler.

UNBIASED

To What Base Uses

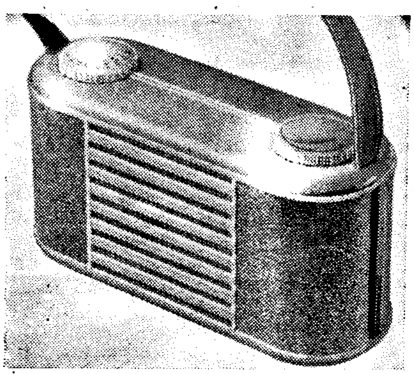
By FREE GRID



"Bring out your old televisors."

AN American correspondent who has recently evacuated his family to this country in view of the threat of possible eventualities over there, has written to me about my revelations that certain people in this country who call themselves scientifically minded are still using the old-fashioned shorthand to record speeches at public meetings instead of employing the labour- and time-saving method of a portable electric recorder. He is as distressed as myself over this lamentable state of affairs and points out that in America, where they always go to extremes in everything, they have brought the whole problem of recording speeches and suchlike to a very fine art.

Apparently the impetus which set the inventors to work on the problem was the need for a super-lightweight apparatus which could easily be disguised or concealed in order to be taken clandestinely to interviews and meetings to record certain statements and remarks which were supposed to be "off the record." By this means, such statements and remarks could be made to be very much "on the record" in more senses than one.



Like a Leica. This Philco pocket portable illustrates my point admirably.

In such cases a favourite dodge was to disguise the apparatus as a deaf-aid, or hearing-aid as the pedants would have me say. By using peanut valves and super-lightweight batteries of the type described in the January issue of *Wireless World*, together with a steel-wire recorder driven by a tiny electric motor such as is used for certain types of push-button receivers, it was found possible to produce exceptionally compact instruments.

Certain newspaper gossip - writers, or columnists, as I believe they style themselves, have been able to reduce the amplifying and recording equipment to a size no bigger than the "candid cameras" which such individuals also carry. Both instruments are employed for a similar purpose, namely to catch people off their guard—the one with regard to their facial expressions and the other with regard to their vocal expressions. The lapel microphone used on these occasions is very skilfully disguised as a rose and used as a buttonhole.

While I am grateful to my American correspondent for his information, and am not unmindful of the vast ingenuity displayed by his fellow countrymen in this matter, somehow the whole business leaves a nasty taste in my mouth. Science, so it seems, can be prostituted to very base uses, and I am inclined to side with the Editor in the lofty and detached view which he takes of the whole business.

Tanks or Televisors

NOW that television is getting under way in the U.S.A. and frequency modulation has been adopted for the sound side of the programme, one or two owners of television sets whom I know are getting a little uneasy lest the B.B.C. should suddenly spring this system on us after the war, thus rendering our sets useless.

Televisor owners were promised that standards would not be altered until three years had elapsed, and I do not forget that they will naturally expect these three years to be three years of actual television service, the barren war years being discounted. They could raise no objection, however, if the B.B.C. or some other body with more money than sense agreed to buy their existing sets from them, and this, in my view, is just what ought to be done, for two reasons.

In the first place there is a by no means negligible amount of aluminium and other metals useful to Lord Beaverbrook which is at present locked up in television sets, not only in our homes but in the warehouses of manufactures and dealers.

Another advantage which would accrue from the breaking up of television receivers would be that a large number of valves (several hundred thousand), fixed condensers, resistances, transformers, chokes and other components at present in short supply would be available to the radio industry for the purpose of getting on with the job which at present wireless service engineers are endeavouring to carry out under very great difficulties, namely the job of maintaining broadcast receivers in working order.

My second point is that if the B.B.C. *is* going to change over to FM for television sound at some future date (and it is by no means impossible that they may do so at some time or another), compensation will have to be paid to us set owners then. It is useless giving two years or so notice of an impending change, as this will cost just as much in the form of no-new-set-sales, since obviously most potential purchasers, having been given two years' warning, will hang back until the change-over has taken place.

If, therefore, the change is going to cost money in any case, as it obviously is, then it would be far better to do it now, when the sets would be of very real value as scrap, rather than wait until a few years after the war, when they will be of no use to man or beast and will represent a dead loss to everybody concerned. Apart from this, if the job were done now we television set owners would put up with far smaller compensation, knowing, as we should, that our sets were going to be turned into suitable form for bombarding Adolf.

Non-technical set owners would be doubly glad to do this, if it were pointed out to them that in any case their sets would probably need extensive servicing before being put into use after the war, as it is more than likely that most of them have neglected to follow the official advice to switch on for a few minutes every six months or so in order to keep the electrolytics in trim. The case for scrapping television sets seems absolutely unanswerable.

CR Tuning Indicators

Increasing Sensitivity and Extending the Usefulness of the "Magic Eye"

By G. A. HAY, B.Sc.

THE cathode-ray tuning indicator has been widely used as a null indicator in bridges and other laboratory gear in which measurements depend on a current balance. It will give a clear visual indication of a change of about 0.1 volt DC with a very high input impedance, and has the additional advantages of lack of inertia and—most important to the private experimenter—cheapness and robustness.

It occurred to the author that if this sensitivity could be increased substantially, the use of the "magic eye" would be extended considerably. As a result of some work undertaken with this end in view, the sensitivity has been increased about ten times with little additional apparatus, and more than a hundred times with some extra complication.

The principle underlying the arrangement giving the ten times increase is illustrated in Fig. 1. It is well known that the inclusion of an un-bypassed cathode resistor in a normal stage of amplication results in degeneration or negative feed-back, with resultant decrease in gain and increase in stability. This is due to the action of a single valve in introducing a 180 deg. phase shift. The tuning indicator, however, is the equivalent of two triodes in series or cascade, and therefore the anode current of the

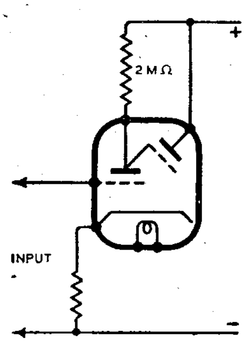


Fig. 1. Basic circuit of the improved indicator with the addition of a cathode resistor.

second stage (i.e. the target current), is 360 deg. out of phase with the grid voltage on the first triode; in other words, the two are in phase. The cathode current is the sum of the triode and target currents, and as the latter predominates, the cathode current is also in phase with the grid voltage, and an increase in the negative grid voltage will therefore result in an increase in the cathode current.

If we now place a cathode resistance in circuit, as in Fig. 1, feed-back will be obtained which is in phase with the input, and regeneration will result, giving rise to increased gain and decreased stability.

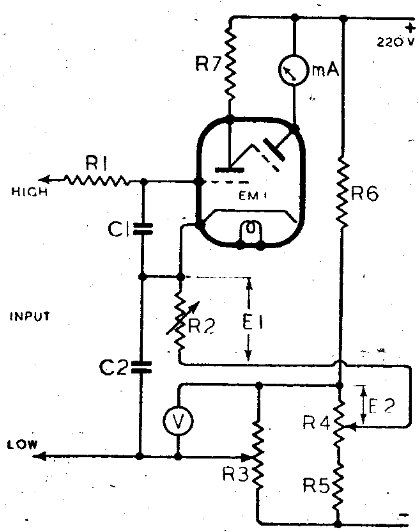


Fig. 2. Connections used for experimental investigation of the circuit. R1 = 1MΩ; R2 = 10,000Ω; R3 = 1,500Ω; R4 = 500Ω; R5 = 1,000Ω; R6 = 20,000Ω; R7 = 2MΩ; C1 = 0.01μF mica; C2 = 2μF.

In order to investigate this effect experimentally, the circuit shown in Fig. 2 was set up. R1 and C1 form a filter which will prevent the passage of alternating potentials to the grid in subsequent applications. R2 is the cathode feed-back resistance: as this gives an initial negative grid bias E, which is excessive, it is necessary to take the cathode return to a point negative to the grid circuit. This semi-variable potential E2 (controlled by R4) opposes E1 and thus it is possible to work the valve at any initial grid bias required. In addition to the initial value, extra negative potential as indicated by V is available from R3 for measurement purposes, slide back voltage, etc.

In estimating the sensitivity, the target current was taken as a measure of the shadow angle, maximum and minimum shadow corresponding to currents of 0.42 and 0.9 mA respectively. In addition, in the particular valve used, a Mullard EM1, there were two marks on the target itself which served as reference marks, thus avoiding the parallax inevitable with markings on the glass envelope, and making possible a very precise setting. Fig. 3 shows the increased sensitivity obtained with R2 set to 5,400 ohms, the points marked "high" and "low" in Fig. 2 being connected together. As expected, increasing the value of R2 gives continuously increasing sensitivity up to a certain point, when backlash and instability occur. At this point the increase in gain is about fifty times. It is therefore unwise to attempt an increase of more than ten times on account of the difficulty of adjustment and the effect of mains fluctuations, etc. With the 5,400-ohm cathode resistor, a definite movement of the shadow was obtained for a grid voltage change of ±5 mV, as compared with ±50 mV for the indicator used in the normal way. This was obtained with complete stability and lack of zero shift, without a regulated high-tension supply.

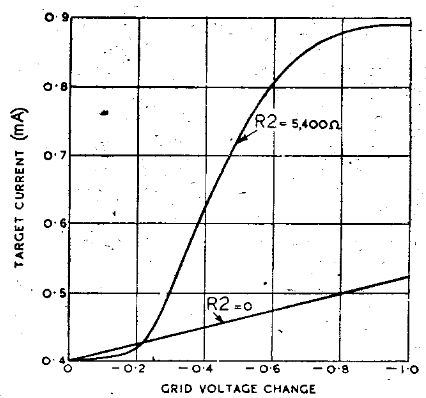


Fig. 3. Curves showing the increased sensitivity obtained with a 5,400Ω cathode resistor.

The indicator used in the manner described has been used in various pieces of laboratory equipment, of which two of the most useful have been a slide-back diode valve voltmeter and a "megohmmeter."

CR Tuning Indicators—

Various designs for diode valve voltmeters operating under slide-back conditions have appeared, but, to the writer's knowledge, all have involved the use of an extra valve to attain the required sensitivity in adjustment. With the above form of indicator, this complication becomes unnecessary, and hence a very simple circuit will suffice.

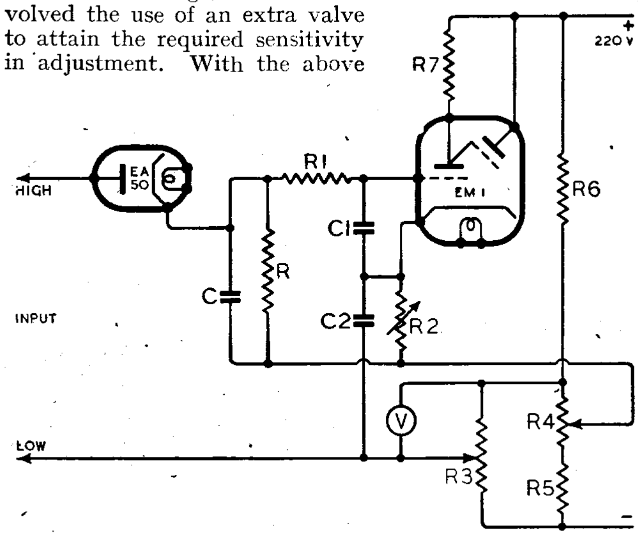


Fig. 4. Improved form of indicator used as a null indicator in a slide-back diode valve voltmeter. C=0.01 μF mica; R=10 MΩ; other components as in Fig. 2.

This, as finally evolved, is shown in Fig. 4. It will be seen that the null indicator is a duplicate of Fig. 2, while a series diode circuit has been added to act as a rectifier, the valve used being a Mullard EA50 television diode. The rectified current through this is detected by causing it to develop a potential difference across a 10 MΩ resistor R, shunted by a condenser C of 0.01 μF. At first the test leads are short-circuited, and the shadow adjusted to a reference point by using R4. The unknown voltage is then applied, and the slide-back voltage increased by means of R3 until the shadow returns to zero, when V indicates the peak value of the voltage.

In practice, errors occur, due to the curvature of the diode characteristic. Actually, as the calibration curve of the instrument shows (Fig. 5), the slide-back voltage is a true measure of the peak value for voltages above 1 volt peak. Below this the meter needs calibrating, and the minimum readable voltage is about 0.1 volt, which is quite satisfactory for normal use. The upper limit of voltage is restricted by the maximum permissible diode anode voltage—in this case 50.

Calibration was done at 50 c/s. There is no reason to suppose that this will not hold up to quite high frequencies; the errors involved in using the peak diode voltmeter at ultra-high frequencies have been previously dealt with (E. C. S. Megaw, *Wireless Engineer*, 1936). In any case, if the diode is made into the form of a probe with an extra 100 $\mu\mu$F silvered ceramic or mica bypass, little trouble will be experienced with it on any normal frequency.

The main disadvantage of the diode voltmeter is its extremely low input impedance on part of the positive half-cycle, thus taking power from the circuit under examination. The impedance consists of a resistance in parallel with a capacitive reactance. The latter is of the order of 5-8 $\mu\mu$F, and is, therefore, negligible at audio frequencies, while at radio frequencies it usually forms part of a tuned circuit. The resistance component is given approximately by the relation

$$Rz = \frac{R}{2}$$

and thus will be about 5 MΩ. Rough

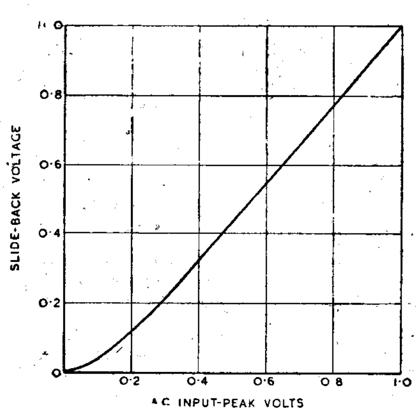


Fig. 5. Calibration curve below 1 V peak input for the diode voltmeter shown in Fig. 4.

measurement of this at 50 c/s gave an average value of 4MΩ, which is in reasonable agreement with theory.

When using the indicator as a DC voltmeter its input resistance is infinite; it can therefore be used for the measurement of very high resistances.

In Fig. 6 (a) R is a standard high resistance connected between the high and low input terminals of Fig. 2. The unknown resistance X is connected between "high" and a source of positive potential of 100 V, which may be a tapping on the main potential divider.

The two resistances, R and X, therefore form a potential divider across which a voltage of 100 is applied. The voltage E appearing across the standard is then measured. It is apparent that

$$\frac{X}{R} = \frac{100 - E}{E}$$

whence $X = \dfrac{100 - E}{E} \cdot R$

If we assume R to be 10 MΩ, and the measurable voltage range 0.1 to

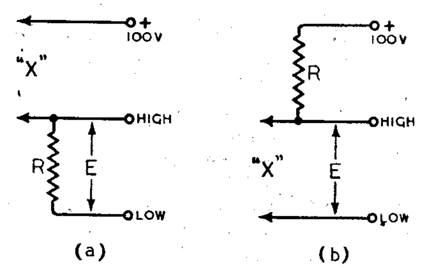


Fig. 6. Additions to Fig 2 making the indicator an accurate megohmmeter. R=10MΩ.

100 volts (actually greater in the case of DC), X ranges from zero to 10,000 MΩ.

If now X and R are interchanged, as in Fig. 6 (b)

$$X = \frac{E}{100 - E} \cdot R$$

and X ranges from 10,000 ohms to infinity. This represents a very satisfactory range for rough testing. Insulation of the various leads is important, and for this reason it is perhaps unwise to attempt any switching, but to use some scheme of link connections on terminals supported on mica. No trouble has been experienced from the fact that the EM1 grid terminal is on the base instead of a top cap. The 1 MΩ resistor in the indicator unit limits the flow of grid current at high positive potentials.

This form of megohmmeter has been used with success in a variety of measurements. Different ranges can be covered, of course, by using different standard resistances.

While the above principles have been treated in rather a general manner, it is hoped that an opportunity will occur in the future to describe a laboratory test instrument embodying these ideas, and capable of doing practically anything in the way of general testing.

THE WORLD OF WIRELESS

ENSURING SERVICING

Plan to Retain Radio Engineers

TO ensure, as far as national urgency permits, that sufficient service-men are available to enable the industry to undertake the public's radio repairs during the war, a scheme is being formulated for the retention of sufficient skilled and semi-skilled personnel to render a minimum service. Pending the completion of the details, the Ministry of Labour has agreed temporarily to suspend the call-up of service-men.

In a statement from the Radio Manufacturers' Association, it is pointed out that the difficulties with which the radio industry is now faced in giving a reasonable degree of maintenance service to the public will be further aggravated by the Government's latest policy of general de-reservation, and that unless the industry takes measures to conserve existing resources the situation may deteriorate to a level which may threaten seriously to prejudice public listening.

No definite plan, however, either for national or local use, can be laid down without certain essential information. Accordingly, the following six organisations, which represent different sections of the industry, have jointly prepared questionnaires which were sent out to every section of the industry on February 9th.

National Association of Radio Retailers
National Radio Trade Service Association
Radio Manufacturers' Association
Radio Wholesalers' Federation
Scottish Radio Retailers' Association
Wireless Retailers' Association

Any radio manufacturer, wholesaler, repair organisation or dealer who has not yet received the questionnaire should apply for a copy to Mr. R. P. Browne, Secretary, R.M.A., 59, Russell Square, London, W.C.1.

NO MORE SETS

IT is extremely unlikely that any new domestic receiving sets will be produced for the home civilian market during 1942. This fact is revealed in the second interim report by the Retail Trade Committee set up by the President of the Board of Trade.

The report also states that it is estimated that supplies to retailers are now at about only 5 per cent. of normal, and that it is reasonable to suppose that stocks are already low and eventually the trade will have to depend almost entirely on repair and maintenance work.

AMERICAN AMATEURS

50,000 Stations Shut Down on Declaration of War

EIGHT hours after the first bomb fell on Pearl Harbour American amateur transmission was suspended as such for the duration of the war. The first issue of *QST* issued after the outbreak of hostilities, which arrived in this country on January 30th, contains a four-page supplement entitled "War Comes!" In it details are given of the wartime control of amateur activities.

In the official notice from the Federal Communications Commission suspending all amateur operation in the continental U.S., its territories and possessions, it is stated that in instances where operation is deemed to be required for national defence permission will be granted. Within a few days of the publication of the suspension order, the volunteer communication system upon which the civilian defence of the U.S. will be built began to take shape, and hundreds of amateurs were being returned to the air by the Defence Communications Board to provide means for vital communication.

Most of the defence communication networks authorised within the first few days of the war were for 2.5- and 5-metre telephony, but some were for 80-metre CW operation and 160- and 75-metre telephony.

The special permits rigidly confine amateurs to defence work. The normal amateur regulations, however, are still to be observed by those granted special defence permits.

The order does not prohibit amateurs from keeping their aerials up, and retaining their apparatus.

All the regulations relate to the defence communications in the military emergency. At the time of writing in *QST* no provision existed for the usual amateur aid in the event of the interruption of communications by natural disasters, such as floods, hurricanes and earthquakes. The A.R.R.L. were, therefore, seeking to obtain Government approval of a plan whereby amateurs may retain their time-honoured privilege of maintaining communications in such emergencies.

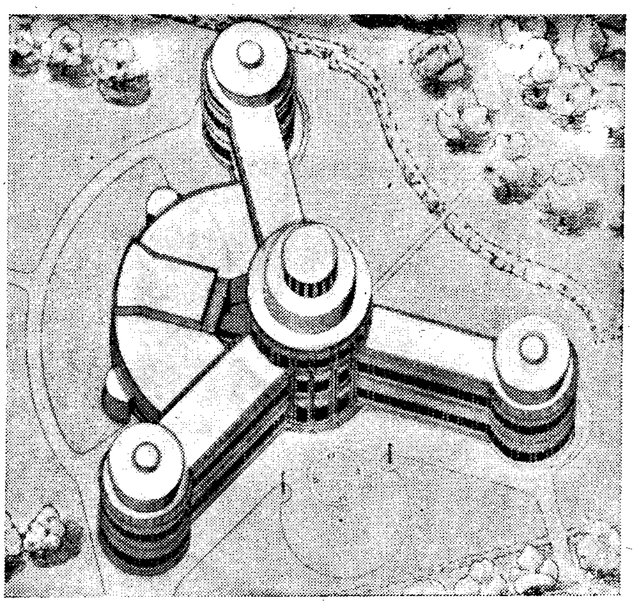
By special authority, the A.R.R.L. headquarters station, W1AW, is remaining on the air to convey Government announcements to amateurs and to keep watch on amateur bands.

"RADAR"

British Radiolocation Methods in U.S.A.

IN referring to the many openings that exist in the United States defence services for professional and amateur wireless men, *Communications* (New York) for December says: "'Radar' men will operate the newly perfected radio device which

BROADCASTING HOUSE, NEW DELHI. An artist's impression of the ultra-modern building which will be the headquarters of All-India Radio and on which work was recently begun. It will provide accommodation for the staff which is at present dispersed in five separate buildings. The twelve studios will be located on the ground floor of the semi-circular section built between two of the two-storeyed wings radiating from the central tower. Work is progressing simultaneously on Delhi's 100-kW short-wave transmitter.



The World of Wireless—
locates planes in flight, the delicate and complicated instrument developed in England and used with such meritorious success by the Royal Air Force. The patents have been turned over to the United States by Great Britain. Details of the device are being kept a deep secret, but it is said to have been used both on the ground and in the air, and is a vital addition to the nation's defence armoury."

B.B.C. DIRECTORS

Mr. Ogilvie Resigns

AS was announced on January 26th, Mr. F. W. Ogilvie has resigned his Director-generalship of the B.B.C. For the duration of the war the duties previously discharged by the Director-general have been entrusted to two Directors-general. Sir Cecil Graves, who was appointed Deputy Director-general when Mr. Ogilvie was appointed D.G., and Mr. Robert Foot, recently appointed general advisor on wartime organisation, are to share the post.

Sir Cecil Graves joined the B.B.C. programme department sixteen years ago. In 1932 he became Director of the new Empire service, and was later made Controller of Programmes. He was knighted in 1939. He will direct general production policy.

Mr. Foot, who recently joined the Corporation as an expert administrator from the Gas Light & Coke Company, will direct the business side of the B.B.C.

U.S. PIONEER'S DEATH

DR. FRANK CONRAD, Assistant Chief Engineer of the Westinghouse Electric and Manufacturing Co. since 1921, died at the age of sixty-seven at Miami, Florida, in December. He is affectionately referred to as the father of broadcasting, for it was the experimental equipment used by him at his home that was employed when in 1920 he inaugurated the Westinghouse station KDKA, which is claimed to be the first commercial broadcasting station in the United States.

Dr. Conrad's experiments with wireless started in about 1912, and it was the success of his broadcasts of gramophone records from his garage transmitter that attracted the attention of the then vice-president of Westinghouse, who saw the possibilities of commercial broadcasting.

In 1922 Dr. Conrad operated the first Westinghouse short-wave transmitter, 8XS, on 100 metres!

R.S.G.B. STATION

Proposal in Annual Report

THE erection of a headquarters transmitting station by the Radio Society of Great Britain is foreshadowed in the annual report of the Council for the year 1940-41. It states: "The Council anticipates that if the present progress continues until peace returns, it will be possible to bring to fruition plans which were being considered just before the war for the creation of a more comprehensive headquarters. This would provide facilities for the erection of a Society station, and the organisation of an experimental department."

The annual report also records that the total of 719 new members elected during the year, which number included amateurs from Czechoslovakia, Norway, Yugoslavia and Poland, closely approached the pre-war record of 783 in 1937-38.

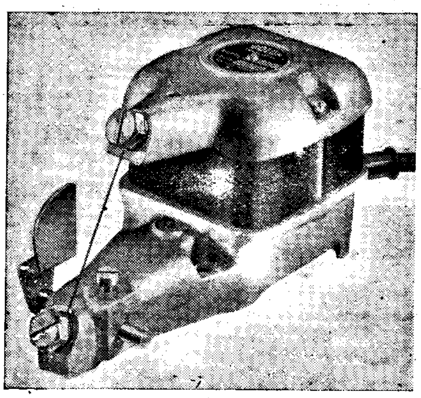
A record of British amateurs serving in the Armed Forces is kept by the Society. Up to the end of last September the total had reached 1,500.

FM AND THE WAR

"ANY idea that FM development would be stopped in the tracks by the war emergency certainly has been dispelled by events of the last few weeks," states a writer in a recent issue of our American contemporary *Broadcasting*. In December there were over twenty frequency-modulated transmitters in full commercial operation in fifteen cities. Another forty were under construction, and some fifty applications for stations were pending.

New York's first full-time commercial station, W71NY, was inaugurated in December. Its opening marked the establishment of a commercial network of seven stations which are linked by FM.

The use of FM by the American Armed Forces is bound to have an effect upon the development of FM apparatus for home use. It is being used by our American ally in the radio equipment of the latest tanks.



ELECTRIC WIRE STRIPPER. A red hot filament is the cutting medium in the "Solon" AC-operated insulation stripper recently marketed by W. T. Henley's Telegraph Works Co., of Milton Court, Westcott, Dorking, Surrey. The unit, which is suitable for bench mounting, will remove the insulation from tough rubber sheathed, taped or braided cables without risk of nicking the conductor.

DEATH OF MRS. HERTZ

MRS. ELIZABETH HERTZ, widow of Dr. Heinrich Hertz, whose name is a household word in the world of wireless because of his electromagnetic discoveries which are regarded as the foundation upon which the science of radio-communication has been erected, died at Cambridge a few weeks ago. Mrs. Hertz, although herself an "Aryan," came to England in 1936 at the age of seventy, as she felt it was undesirable for her to continue to live in Germany because of her late husband's Jewish ancestry. Donations from many sources in the wireless and electrical world made it possible for her to live in this country.

Although Hertz, who died at the early age of thirty-six in 1894, was honoured by the adoption of his name as that by which German scientists, and those of several other countries, refer to the unit of frequency, his work has of late been referred to in *Elektrotechnische Zeitschrift* as "speculative, complicated and difficult to follow, and unfruitful. This was apparently due to his half-Jewish ancestry."

FROM ALL QUARTERS

Trans-Pacific Radiotelegraph Circuit

AN exchange of messages between President Roosevelt and Mr. J. H. Curtin, Prime Minister of Australia, marked the opening of the first direct radio-telegraph service between the United States and Australia. The operating companies are R.C.A. Communications and Amalgamated Wireless (Australasia).

I.E.E. Meetings

"PUBLIC Address Systems" is the title of the paper to be given by Mr. S. Hill at the monthly meeting of the I.E.E. Wireless Section on Wednesday, March 4th. At an informal meeting of the Section on Tuesday, March 10th, there will be a discussion on the frequency stability of tuned circuits. The discussion will be under three headings: (a) raw materials, (b) components, and (c) complete assembly, which will be opened respectively by Messrs. G. P. Britton, A. H. Cooper, and C. W. Eggleton. A critical review of education and training for engineers will be presented by Dr. A. P. M. Fleming at an ordinary meeting of the Institution on Thursday, March 19th. All the meetings will begin at 6.0 p.m.

More Money for the B.B.C.

IN the additional civil supplementary estimates to be brought before Parliament, the Ministry of Information's grant-in-aid to the B.B.C. is to be increased by £1,300,000 to £6,900,000. This is needed to extend the Corporation's oversea services.

"Pan American Radio"

PLANS for the creation of a Pan American Broadcasters' Union, on the same lines as the International Broadcasting Union in Geneva, are discussed by John F. Royal, Vice-President of the National Broadcasting Company, in a new monthly journal, *Pan American Radio*, devoted to the fostering of broadcasting relations in the Americas. A novel and interesting feature of the journal is that the one edition is printed in English, Spanish, and Portuguese.

Radio Rentals

AT the fifth annual general meeting of Radio Rentals the chairman announced that the number of subscribers had increased to the limit of the supplies available. Negotiations have recently been completed for the purchase of the entire share capital of Rentertainments, Ltd., which was the second largest radio rental company.

Death of Former P.M.G.

LORD ILLINGWORTH, whose death at the age of 76 on January 23rd we regret to record, will chiefly be remembered as Postmaster-General from 1916 to 1921 when he was raised to the peerage.

Radio Officer's Bravery

THE Royal Humane Society's Stanhope gold medal for the most meritorious act of life-saving during last year has been awarded to Radio Officer Douglas S. Fairley of the Merchant Navy. Although severely burned and having broken his leg when his ship was sunk in convoy, Fairley held on to a lifebuoy with one hand and supported a shipmate with the other for 50 minutes until rescued by a warship. He has already received the Society's silver medal for his bravery on this occasion.

News in English

ALTHOUGH there are but few changes in the schedule of the transmission of news in English in the B.B.C.'s European and World Services, that which will be in operation when this issue is published is given below. Times are given in BST.

0200, 0300: 49.10, 31.32, 30.53, 25.53.
0530: 49.10, 31.32, 25.53.
0715: 49.10, 42.46, 31.55, 31.25, 25.53, 19.60.
0900: 49.59*, 48.43*, 42.46, 41.49*, 40.98*, 31.55, 30.96*, 25.53, 25.29*, 19.82, 19.66, 19.60, 16.86, 16.84.
1200: 31.86, 25.53, 19.82, 16.84, 16.77, 16.64, 13.97.
1400: 25.53, 19.82, 16.84, 16.77, 16.64, 13.97.
1700: 49.10, 48.54, 31.86, 19.82, 19.66, 16.84, 16.77.
1900: 49.10, 25.68, 25.58, 19.82, 19.66, 16.84, 16.77.
2145: 48.43, 31.25, 25.68, 25.53, 25.38, 19.82.
2215: 49.10, 31.32, 30.53, 25.53.
2300: 49.59*, 41.96*, 41.49*.
2345: 49.10, 31.32, 30.53, 25.53.

Wavelengths marked with an asterisk are those used for the European Service.

Mr. Max Railing

BY the death of Mr. Max J. Railing on January 14th, at the age of 73, an association with the G.E.C. of about fifty years was brought to an end. At the time of his death he was vice-chairman of the company and vice-president of the British Electrical and Allied Manufacturers' Association.

New American S-W Station

The World Wide Broadcasting Foundation, which operates the American shortwave stations WRUL and WRUW at Scituate, Massachusetts, has been radiating test transmissions from its new transmitter, WRUS, on 6.04 Mc/s.

WBOS, Boston, Mass

FOR some time the Westinghouse short-wave station WBOS, at Boston, Massachusetts, has been transmitting the same programmes as the N.B.C. international short-wave stations WNBI and WRCA. At present the station works on 15.21 Mc/s (19.72 metres) and 11.87 Mc/s (25.26 metres) with its aerial directed towards Europe from 2.0 p.m. to 9.30 p.m. BST.

AF Transformers

AT the next meeting of the British Institution of Radio Engineers, which is to be held at 3.0 p.m. on Saturday, March 7th, at 21, Tothill Street, Westminster, S.W.1, Mr. N. Partridge will give a paper on "Harmonic Distortion in Audio-frequency Transformers."

"A. J. Alan"—G2ST

"IT will come as a surprise to many members," writes the general secretary of the R.S.G.B., "to learn that 'A. J. Alan' (the famous raconteur), whose death occurred in December, was an experienced amateur transmitter." His real name was Leslie Harrison Lambert, and he lived in Notting Hill, London. He held the call sign G2ST.

"Constant Voltage Supply"

IN Fig. 4 of this article, which appeared in our last issue, the figures on the AC input side of the transformer were incorrectly shown. The supply volts should be 200 to 260, 50 c/s, and the transformer primary volts 205 to 225.

NEWS IN ENGLISH FROM ABROAD

REGULAR SHORT-WAVE TRANSMISSIONS

Country : Station	Mc/s	Metres	Daily Bulletins (BST)
America			
WNBI (Bound Brook)	15.130	19.83	2.15, 3.0‡, 4.0‡, 6.0†.
WRCA (Bound Brook)	17.780	16.87	2.15, 3.0‡, 4.0‡, 6.0†.
WGEO (Schenectady)	9.530	31.48	9.45 a.m., 9.0†, 10.55§‡.
WGEA (Schenectady)	15.330	19.57	2.15, 7.45§‡, 9.55§‡.
WGEA	9.550	31.41	9.45 a.m.
WBOS (Hull)	15.210	19.72	2.15, 3.0‡, 4.0‡, 6.0†.
WCAB (Philadelphia)	6.060	49.50	2.55 a.m., 6.0 a.m.
WCBX (Wayne) ..	11.830	25.36	7.30‡, 8.15†, 8.45§‡, 11.30.
WCBX	15.270	19.65	2.0, 5.0§‡.
WRUL (Boston) ..	9.700	30.93	12.15 a.m.‡.
WRUL	11.730	25.58	12.15 a.m.‡.
WRUL	11.790	25.45	9.30‡, 11.30§‡.
WRUL	15.350	19.54	5.0*, 9.30‡, 11.30§‡.
WRUL	17.750	16.90	5.0*.
WLWO (Cincinnati) ..	15.250	19.67	6 a.m., 7 a.m., 6.0†, 7.0†, 8.45‡.
Egypt			
SUX (Cairo)	7.865	38.14	6.50, 10.10.
French Equatorial Africa			
FZI (Brazzaville) ..	11.970	25.06	8.45.
India			
VUD4 (Delhi)	9.590	31.28	9.0 a.m., 1.30, 4.50.
VUD3	11.830	25.36	1.30.
VUD3	15.290	19.62	9.0 a.m.
Sweden			
SBO (Motala)	6.065	49.46	10.20.
Turkey			
TAP (Ankara).. ..	9.465	31.70	8.15.
U.S.S.R. (Moscow)			
31-metre band ..	—	—	7.0, 8.0, 9.0, 10.15.
Vatican City			
HVJ	6.190	48.47	8.15.

MEDIUM-WAVE TRANSMISSIONS

	kc/s	Metres	
Ireland			
Radio Eireann.. ..	565	531	1.40‡, 6.45‡, 6.50†, 10.0.

It should be noted that the times are BST—**one hour** ahead of GMT—and are p.m. unless otherwise stated. The times of the transmission of news in English in the B.B.C. Short-wave Service are given at the top of the page.

The American stations are now transmitting bulletins in addition to those tabulated as and when the necessity arises.

* Saturdays only. § Saturdays excepted. ‡ Sundays only. † Sundays excepted.

Science and the War Effort

Training and Utilisation of Technicians

MANY matters of interest to wireless technicians were discussed at a recent conference organised by the Association of Scientific Workers, of which the report arrived too late for inclusion in the last issue of this journal.

In the course of a review of University training of scientists, Professor J. A. Carroll (Aberdeen University) suggested that the honours degree course produced only research specialists, and that research at the University for a Ph.D. degree tended to narrow the specialisation still farther; degree courses covering a wider range of subjects would be better for those who did not intend to be research specialists, and more co-operation between industry and education was required.

Mr. R. T. Lattey (Electrical Laboratory, Oxford University) spoke on the difficulties arising in the intensive courses of instruction, mainly in radio, now being run for those studying under State bursaries, cadets of the Royal Corps of Signals, and cadets of the Royal Air Force. The chief difficulty is to instil a scientific outlook and to convince students that mathematics is merely a special kind of language. Laboratory work teaches the importance of details such as layout and wiring in radio circuits, and develops fault-tracing ability. Amateur radio experience is found to be useful if it has aroused curiosity and interest in the theoretical side of radio, but a hindrance if it has been limited to slavishly copying published designs. Dr. V. E. Cosslett (Electrical Laboratory, Oxford University) said that science teaching in schools must be brought up to date—in the Spens report on education (published 1938) wireless is mentioned only once in nearly 500 pages.

In the session on Training of Technical Personnel, Mr. J. A. Lauwerys (Institute of Education, London University) emphasised the need for including science in general education, and regarding it as forming as good a basis for a liberal education as languages, which are now preferred; he also referred to the need for improved contact between schools and the industrial world. He was followed by Dr. E. A. Rudge (West Ham Municipal College), who claimed that the Technical Colleges should form the link between school and industry; and that to effect this education must be transferred from local control to national control. Mr. D. A. Bell (Cossor Branch, A.Sc.W.) explained the importance to industry of part-time education, especially in present conditions when so many of the boys and young men with the best training are being claimed by the Services; in view of the restriction of evening classes by black-out, he recommended the method adopted by a number of radio firms of allowing junior assistants in research departments a certain amount of time off to attend classes during working hours.

Technical Man-power

In the discussion on Utilisation of Scientific Personnel, Professor W. Wardlaw and Mr. F. M. H. Markham represented the Central Register; it was explained that its purpose is to find specialists for urgent work whenever the occasion arises, rather than to act as an employment bureau for scientific workers looking for employment. The only exception to this attitude is in connection with the dereservation taking place this year; any man on the Central Register or having high scientific or technical qualifications (e.g., a university degree) whose employer is unable to apply for his deferment should notify the Central Register, so that he may be transferred to suitable technical work. (Many engineers with purely radio qualifications, however, will come under the Wireless Telegraphy Board.) Although there is as yet no National Certificate in radio, there may be some in the industry who have a National Certificate in Engineering. If so, they should note that the Technical Personnel Committee of the Ministry of Labour offers a six months' intensive training course (with maintenance allowance) to enable selected students holding the ordinary National Certificate to reach the standard of the Higher National Certificate; classes will be held in all parts of the country by arrangement between employers and local technical colleges.

Several speakers in the session on application of science to war problems referred to the importance of scientific weapons in altering the tactics of warfare; the importance of radio was indicated by the statement that all investigations into operational methods lead ultimately to a communications problem. An interesting suggestion was that it is a mistake to limit communications to the transmission of speech or pictures, and that more should be made of automatic control equipment which can be supervised from a distance. This sounds like an opportunity for the enthusiasts in telearchics.

Letters to the Editor

Technical Training : Status of Service-men : Wire versus Wireless

Training of Technicians

SURELY Mr. W. M. Dalton is asking too much! The radio man having completed his course only need study mechanics, biology and psychology to "eat" not only "the electrical engineers' subject" but to become a modern Aristotle by, say, 1960!

A National Certificate in Electrical Engineering (Radio) was gained by several students at Chesterfield Technical College in 1938-39. Examination subjects were Mathematics, AC Theory and Radio. Elementary Mechanics, Heat, Drawing, etc., had been taken during the previous years. Two further years were proposed for the Higher Certificate. The first year the subjects Maths., Physics, Radio; the second year Physics, Radio Theory and Radio Laboratory Work.

Throughout the course ever-recurring stress should be laid upon the fact that the student is being trained to learn and to grasp new and diverse ideas. My own detailed and intimate knowledge of the magnetic detector and the 31A crystal receiver is not *of itself* of much use in my present position.

The trouble is economic, both in industry and educational direction. Students could not be at the College for 7 o'clock on Fridays—they were needed in the shop. The trader had to impose these conditions due to over-production and unplanned marketing of radio receivers. The serious lack of technical training, the granting of State bursaries and the extra cost of making equipment fool-proof would not have retarded our efforts if the clear-cut pre-war problems had been tackled.

Let us hope the R.M.A. will concern themselves, and that action on the lines of the Spens Report in connection with the Youth Registration is taken *now*. G. C. OXLEY.

I CANNOT let Mr. W. M. Dalton's letter in the January issue pass without comment. It is a pity that he had to end his interesting letter in an abusive strain. Whether or not his statement is true that a "radio man could eat the electrical engineer's subject and then carry on with his own" depends entirely on what sort of radio man and what sort of electrical engineer he has in mind. Does he imagine, for instance, that the control and operation of the 132-kV "grid" and its generating stations could be dealt with by men trained solely in radio? And does he consider that the underlying principles of the thermionic valve, the intervalve transformer and the tuned circuit are one bit more complex than that of the grid-controlled mercury arc rectifier, the high-voltage three-phase power transformer and the Petersen arc suppression coil respectively?

I do not disagree with his statement that an electrical engineer cannot teach radio (although some can). Generally speaking, it is as true as its converse. The point to which I do take exception is that, having made his point perfectly clear, Mr. Dalton is not content, but must indulge in odious comparisons and in unnecessary and ridiculous claims.

F. P. MEADOWS,
B.Sc., A.M.I.E.E.

Haywards Heath.

Status of Service-men

SINCE war stimulates scientific development to an extraordinary degree, the time appears to have arrived when very serious consideration should be given to the post-war status of the service-man The term is one which has fallen into such low repute that it would be better discarded. However, it is not much use discarding an old name and tagging a new one on to the same article!

There is no need for me to dwell upon the shortcomings of the pre-war service engineer. This is a subject that is common and painful knowledge to the listening public, though the extent to which manufacturers' and retailers' reputations have suffered in the past as a direct result of bad servicing is not, I am sure, appreciated by those most concerned.

The Editor does not necessarily endorse the opinions of his correspondents

Controlling an organisation which concentrates solely on service to the trade, I am appalled at the bad workmanship and poor materials found in receivers which have had earlier attention. I am equally appalled by the damage caused to sets by the use of unsuitable components, which could only have been fitted because the man responsible was too ignorant to know the risk involved or because his employer was too "keen" to miss the opportunity of making a couple of extra pence profit.

The attitude of the retailer, with some notable exceptions, appears to have been dictated by the very mistaken notion that professional pride and ability could not produce profits; a view disproved by the rapid growth and extensions of firms specialising in trade service.

Post-war years will show vast changes in the general technique of broadcasting. We shall have receivers employing new and possibly more critical circuits and components than we have known in the past, and a new and more capable class of technician will be required for maintenance work.

So why should we not let the service-men be buried when we bury the hatchet of war; why should we not have maintenance engineers to repair the post-war sets in the post-war world?

The maintenance engineer is a very important link between manufacturer and owner, and on his work and skill depends, ultimately, the reputation of the goods which he has to keep in order. Let us make it clear that the man with the necessary qualifications expects, and is worthy of, a reasonably good salary.

I feel that the ideal condition will not be reached until every radio retailer in the country has a qualified engineer either in his employ or indirectly (as in the case of trade service firms) at his disposal.

There is much we can do towards achieving such an end, and I am certain that action along these lines would be in the interests of all those professionally engaged in the radio industry, and last, but far from least, the man in the street. The British Institution of Radio Engineers, the City

Letters to the Editor—

and Guilds of London Institute, and various manufacturers and retailers' associations have attempted schemes of examination for determining the qualifications of a radio maintenance engineer. It is unnecessary that all organisations connected with the industry should attempt the same object, and here, I suggest, is an opportunity for the interested organisations to get together and agree upon one examination. H. C. RYLATT,

Hon. Secretary,

National Radio Trade Service Association.

Wire versus *Wireless*

FOR an effort in speech with the tongue in the cheek and arguments framed of contradictions in terms, the "Eckersley Plan" (your January issue) is a masterpiece! No greater evidence is wanted to point to the determination to circumscribe public liberties of thought—embodied and enjoyed under the present system of broadcasting, both local and international—by self-appointed planners of an expected post-war era, who hope to occupy the "Rostrum of Democracy."

The plan obviously envisages the following aims. May we consider each with possible results?

(1) A "Vested" Corporation will supply and hire these smaller and simplified sets for reception of their "wired" news.

A possible and probable result of this will be financial loss to those whose capital and enterprise put wireless into being as a commercial asset of such considerable value. Matters will be aggravated by those "in the know" on legislative possibilities by playing "bear" in the markets, to benefit accordingly.

Another serious effect will be the virtual elimination of the amateur and enthusiast who has contributed so much to the rapid advancement of this young applied science.

(2) Public opinion is to be "canalised" and kept "local." "The range of ultra-short waves is restricted," the account says, yet the plan speaks of preserving some short-wave stations in order "that our liberty to hear across frontiers is still preserved."

Again, what sincerity towards the body politic can there be in a plan which "preserves some medium and long-wave stations" when the officially allowable receiving sets will be "simplified" for the reception of "wired" news only?

Finally, it is very debatable as to whether the skilled technician will flourish best under a system of closed vested interest or in honest open competition with his fellows, in this realm of real applied scientific endeavour. It is one thing for the plan to appeal to the professional cupidity and another to its common sense.

It is questionable also as to whether the country can successfully be "wired for vision" in view of the carrier frequencies involved.

HERBERT G. HOLT, B.Sc.

Bristol.

MR. P. P. ECKERSLEY'S suggestion for the post-war cancellation of all internal radiated broadcasting must by its very inference promote a sense of despondency and futility in many thousands of minds.

The vital problem of absorbing skilled labour after the war was dealt with by Sir Noel Ashbridge in his recent Presidential Address to the I.E.E., to which Mr. Eckersley refers us; also by Mr. Edward E. Rosen in your November issue. Mr. Eckersley is apparently content to undermine the efforts of leaders in the profession, because by his own confession he "disregards the means to a chosen end, and assumes they will be found."

One is loath—nay, frightened!—to attack on technical grounds such an eminent veteran as Mr. Eckersley. But, since his basic theory of distribution does take account of television, which is bound ultimately to take a major place in almost every British home, is it not reasonable to ask whether the responsible authorities would be justified in asking the public to meet the expense of the laying and balancing of expensive cables throughout the length and breadth of the country? For, judging by the system of estimating the cost of supplying individual houses at present adopted, the additional cost of laying special television cables, especially in the more remote areas, would more than offset the cheapness of the "selector" to which Mr. Eckersley refers.

In his articles, Mr. Eckersley assumes the laying of special cables will not be necessary. But, since a modulating frequency up to a maximum of 2.5 Mc/s is required to produce high-definition pictures, it is difficult to visualise the utilising of present domestic wiring for such a service.

Again, since the "split-band" method of transmission has been vetoed because of the difficulty of "reassembly" at the receiver, it is obvious that the production of an artificial carrier would be necessary in the wire broadcast system in order to affect separation. Surely this will add still further to the complexities of wire broadcasting?

If the future of present broadcasting technique is as black as Mr. Eckersley paints it, surely, too, the answer lies in exploring other channels in the ether instead of throwing in the sponge and adopting a system that must spell disaster to thousands of skilled radio men. Because of this it is a system that this Association, together with many others in the profession, must morally oppose. Any authority that creates an industry and discards it with the snap of a finger must suffer the same moral opposition, no matter how sincere and genuine that authority may be.

J. W. POLLOCK.

Hon. Editor,

Civil Service Radio Officers' Association.

MR. ECKERSLEY'S two interesting articles on broadcasting over the supply mains deserve more recognition than an Editorial and one letter, and I therefore offer some further criticisms of his scheme.

On the technical side it was obviously impossible to give more than an outline of the system. It would be interesting to know, however, whether the author has successfully experimented with the propagation of ultra-high frequencies over the mains; he lightly touches on the possibility of using his system for, among other things, "wired" television, but I have, up till now, been under the impression that an extremely expensive co-axial cable was the only satisfactory method of transmitting vision signals by wire, except for comparatively short distances. Has he been able to use the mains successfully in this connection or is his suggestion merely an example of his obviously unbounded enthusiasm?

The claim in his second article that his system *entirely* overcomes interference seems somewhat sweeping, particularly in view of a statement in his first article that it can deal with symmetrical interference only; the latter certainly constitutes the bulk, but certainly not the whole, of the interference normally experienced, and the assymetrical residue can still cause quite a lot of bother.

As for any reduction in the physical size of receivers—in the name of fidelity, and with memories of that abomination, the midget receiver—may heaven forbid!

It is obviously essential to the whole scheme, as propounded by Mr. Eckersley, that the receiver and its installation and maintenance, as well as the transmiting end, must be entirely under the control of the broadcasting authority. I presume, therefore, that the retail radio trade would be permitted no interest, except an academic one, in the system whatever, and that receivers would be made to a standard specification by a small number of manufacturers; installation and maintenance would be carried out by the authority's own engineers and, in short, the whole service would be run on very similar lines to the G.P.O. telephone service. The reaction of some thousands of retailers, who have spent many years in building their businesses up to a point where they have been able to reap a reasonable reward for all their hard work, can be imagined!

A reminder that the factor of psychology is by no means to be ignored may not be out of place. Prior to the war, although the average domestic receiver was tuned for, probably, 90 per cent. of its working time to the local station, its owner would, in most cases, have indignantly refused to buy it had he been told that it was capable of receiving six stations only.

Finally, I would remark that whilst the proposed system undoubtedly has its merits, Mr. Eckersley seems to have let his enthusiasm run away with him to a great extent; he would do well, I am sure, to review the snags very carefully before pressing his scheme on any responsible authority.

G. MORGAN.

Harpfield, Stoke-on-Trent.

Scale Distortion

IT must be assumed that Mr. Evans carefully examined the scale distortion bomb before he dropped it, in your January issue, to make sure that it was not a brick. He has obviously never listened to a concert in Queen's Hall from a seat tucked well up below the circle, and will not now be able to verify my statement; but I can assure him that both bass and treble disappeared. It was amusing to watch the double-bass players sawing away so ineffectively and to try to tell the difference between the sound of a violin and a clarinet. Complex concert-hall reflections no more affect the matter than do the complex reflections of expensive loudspeakers. It might also be noted that distance in the open air definitely does alter the balance of frequencies.

Mr. Evans should listen to reproduction from a three-part amplifier such as the SS Tri-channel, in which treble and bass are separately amplified, separately controlled, and feed separate speakers, in addition to a straight-line amplifier and speaker. Suppose, with the main volume control at a low level, he sets treble and bass gain controls to give realistic reproduction. If he turns up the main control he will find both treble and bass badly out of proportion; yet the power delivered to each speaker has increased proportionately. Also, if he listens to any orchestral work which ends *fortissimo*, he will find that he is able, by turning up the bass and treble, to bring the orchestra back into the listening room, and stop its retreat into the distance as the B.B.C. indulges in its playful habit of compressing the peaks of the finale. Note that the medium frequencies are no louder than before.

It is hard to understand the relevance of the bass boost recommended by Mr. Evans. If a transmission is deficient in bass, one naturally boosts it, whether separate bass amplification is employed or not, and it seems reasonable to improve the response of a speaker by the method advocated. This does not touch the problem. Neither do the figures given for the sound output required, a subject which has been frequently discussed in *Wireless World*.

All that Mr. Evans says in his article is that *his* amplifier, working in *his* room, with a certain make of speaker operated at a certain level, was improved by a degree of bass boost (which, incidentally, is less than that customarily used to correct for the falling bass characteristic of gramophone records). Perhaps it can be shown from these facts that scale distortion is a myth. But perhaps the bomb is, after all, a brick.

W. J. SHANNON.

London, N.19.

What the Sunspots Foretell

ON seeing the graph of sunspots in your January issue, I compared it to political events. The curve peaked in 1937; compare it with the various happenings of the time. It may be sheer coincidence (or it may not) that this curve might have been a curve of appeasement. Incidentally, it reaches its lowest in 1944, which probably means peace. It would be very strange if this happened. Personally, I see no reason why sunspot activity should not affect us, just as it affects ionosphere conditions.

DAVID OWEN FRENCH.

Norwich.

Mutual Inductance

A Simple Method of Calculation for Single-layer Coils on the Same Former

By T. H. TURNEY, Ph.D.

PROF. NAGAOKA'S formulae and figures for the inductances of single-layer coils can be used to find the mutual inductance of two coils when both are wound on one former. The two coils may be close together or else they may be separated by an air space. The first case is shown in Fig. 1 and the second in Fig. 2, the latter being the more difficult.

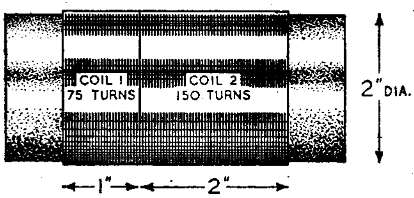


Fig. 1. Two coils touching end-to-end.

Once the mutual inductance is calculated, the coupling coefficient may be calculated from the formula $k = \frac{M}{\sqrt{L_1 L_2}}$. The L_1 and L_2 are the self-inductances of the two coils and M the mutual. The "k" is the coupling coefficient. Capital K is reserved for the constant in Prof. Nagaoka's formula or for the constant in the particular form of his formula in use in finding the self-inductances.

His work has been described in a recent article [1] and the formula $L = \frac{N^2 r K}{10^3}$ is given with a table of values of K for various ratios of $\frac{r}{l}$.

The way in which those results can be used to calculate mutual inductances is as follows. The total self-inductance ($L_{1,2}$ say) of two coils L_1 and L_2 in series, aiding each other, is known to be the sum of their self-inductances plus twice the mutual,

$$L_1 + L_2 + 2M = L_{1,2}$$

If, then, in Fig. 1 the inductance of the whole coil is calculated, as L_1 and L_2 can be calculated too, M is the only unknown; and so

$$M = \tfrac{1}{2}(L_{1,2} - L_1 - L_2)$$

The inductance of the whole coil $L_{1,2}$ and the inductances L_1 and L_2 are calculated in accordance with the article in the April, 1941, issue.

[1] "Inductance Calculations," by S. W. Amos, *Wireless World*, April, 1941.

Take the following as an example of the calculation of mutual inductance. Let the coils be 1 inch diameter, let the first be of 75 turns 1in. long and the other 150 turns 2in. long, the two coils just touching end-to-end as in Fig. 1. In finding inductances it is the ratio $\frac{d}{l}$ which is the important figure used by Prof. Nagaoka to obtain from his curves the value of his constant K. This is put into the formula for inductance. Some writers use $\frac{r}{l}$ which is half $\frac{d}{l}$.

In this example the ratio $\frac{d}{l}$ is 2 for coil 1 and 1 for coil 2 making $\frac{r}{l} = 1$ for the first coil, a half for coil 2 and one-third for the whole coil.

This makes

$L_1 = 297$ microhenrys.
$L_2 = 775$ „
and $L_{1,2} = 1285$ „
and so $M_{1,2} = \frac{1}{2}(1285 - 297 - 775) = 106$ microhenrys.

The coupling coefficient in this case, is given by $k = \frac{106}{\sqrt{L_1 L_2}} = 0.22$.

Spaced Coils

The coil in Fig. 2 may be thought of as the whole coil (if one imagines the empty space wound) less the centre portion. If, then, the inductances are called L_1, L_c and L_2 these may be calculated separately by the formula given by Nagaoka. Then the mutual inductance between L_1 and L_c, the mythical centre coil, may be calculated as shown above. Let it be called $M_{1,c}$. The mutual inductance between the centre coil and coil 2 may also be found. Call it $M_{c,2}$. The inductance of the whole length with the centre portion (if it had been wound) may be calculated, so we find that the inductance of (L_1 and L_c and L_2) $= L_1 + L_c + 2M_{1,c} + L_2 + 2M_{2,c} + 2M_{1,2} = L_x$, say.

Then $2M_{1,c} = (L_1 \text{ and } L_c) - L_1 - L_c$ which is $L_y - L_1 - L_c$ if we call L_y the inductance of L_1 and L_c in series. Similarly if L_z is L_c and L_2 in series, $2M_{2,c} = L_z - L_c - L_2$.

Then $L_x = L_1 + L_c + 2M_{1,c} + L_2 + L_c + 2M_{2,c} - L_c + 2M_{1,2}$ by adding and subtracting L_c. Now put in the value L_y and L_z.

Then $L_x = L_y + L_z - L_c + 2M_{1,2}$ making $2M_{1,2} = L_x - L_y - L_z + L_c$.

There are, then, four inductances to be found in calculating the mutual inductance, so the rule is, when finding the mutual inductance between two coils L_1 and L_2 with a space between, to imagine the space to be wound, and calculate its inductance, and the inductance of the whole coil, and that of the left-hand and centre section, and also that of the right-hand and centre section regarded as a single coil. Add the first two, add the last two and take the difference of those last two sums. The result is twice the wanted mutual inductance.

As an example let us find the mutual inductance between two coils, one 1 in. long of 40 turns and one 2in. long of 80 turns, the space between being ½ inch. The diameter is given as two inches, as shown in Fig. 3.

There are now four coils to be calculated (the half-inch space would take 20 turns), so the coils are (Fig. 2).

X 3½in. long, 140 turns, inductance 447.6 microhenrys.

Y ½in. long, 20 turns, inductance 29.2 microhenrys.

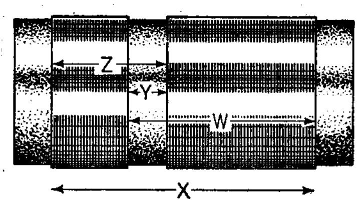


Fig. 2. Two coils of equal diameter but with a space between.

Z 1½in. long, 60 turns, inductance 153.5 microhenrys.

W 2½in. long, 100 turns, inductance 296.0 microhenrys.

Thus $2M_{1,2} = 447.6 + 29.2 - 153.5 - 296 = 27.3$ and $M_{1,2} = 13.6$ microhenrys.

This result is of interest because it does show how little is the mutual inductance of two such coils with half an inch of space between them. This explains why such a pair of coils might fail to oscillate in, say, an octode oscillator circuit.

Since $k = \frac{M}{\sqrt{L_1 L_2}}$ and since M involves the sum and difference of simple self-inductances, any factor in the formula which is the same for an entire calculation will cancel.

Take the variation of the Nagaoka formula given in the *Wireless World* (April, 1941).

It is $L = \frac{N^2 r K}{10^3}$

the factor K is found from a table or a curve plotted against values of $\frac{r}{l}$.

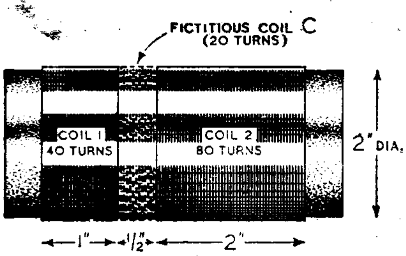


Fig. 3. Two coils with a space showing inductances which must be calculated to find the mutual inductance and hence the coupling coefficient.

Since the total turns N come in, and depend on l, N^2 depends on l^2 or for a given radius on $\frac{l^2}{r^2}$. Thus if the K in the table is divided by the factor $\left(\frac{r}{l}\right)^2$ the quantity $\frac{Kl^2}{r^2}$ becomes a measure of inductance. This, then, can form a new factor which may be called K′ tabulated against $\frac{r}{l}$ just like the old K but now when one looks up K′ it is a measure of the inductance as it includes the number of turns, and when one only wants the coupling coefficient (that is K, and not M), the 10^3 and the "r" and also the "turns per cm" contained in N all cancel, so one may look up K'_1 for inductance of the coil L_1, K'_2 for L_2 and K'_T for the total coil. One may then subtract these and divide thus:—

$$k = \frac{\frac{1}{2}(K'_T - K'_1 - K'_2)}{\sqrt{K'_1 K'_2}}$$

Putting this into a formula makes it look more difficult than it really is. The same method is directly applicable to the more complicated case of a coil with a space.

One may use K′ then as the inductance of the coil in calculating the coefficient of coupling, and to avoid any working out of the separate inductances just take a figure from a table for each one, then begin subtracting. The writer has prepared a brief table of K′ from which curves can be plotted or intermediate values extrapolated.

TABLE OF FACTORS FOR CALCULATING COEFFICIENT OF COUPLING

$\frac{r}{l}$	K′	$\frac{r}{l}$	K′
0.1	363.2	1.1	18.03
0.2	167.7	1.2	15.84
0.3	103.8	1.3	14.05
0.4	72.55	1.4	12.55
0.5	54.36	1.5	11.29
0.6	42.60	1.6	10.22
0.7	34.48	1.7	9.309
0.8	28.59	1.8	8.320
0.9	24.17	1.9	7.821
1.0	20.74	2.0	7.213

The table may be used to check the coil shown in Fig. 1 as follows:—

Coil 2 $\frac{r}{l} = \frac{1}{2}$, so $K' = 54.36$

Coil 1 $\frac{r}{l} = 1$, so $K' = 20.74$

Whole coil $\frac{r}{l} = 0.333$, so $K' = 90$

Then 2M is represented by

$$90 - 54.36 - 20.74 = 14.9$$

or M by 7.45 and $L_1 L_2$ by 54.36×20.74 so

$$k = \frac{14.9 \times \frac{1}{2}}{\sqrt{54.36 \times 20.74}} = 0.22$$

which agrees with the longer calculation given earlier.

Abstracts and References

AN abstract of some 650 words of a paper on a new pulse generator for television by A. Castellani, of the Italian S.A.F.A.R., which was published in a recent issue of the German journal *Zeitschrift für technische Physik*, is among the 250-odd papers referred to in the Abstracts and References section of the February issue of *The Wireless Engineer*. The length of an abstract, however, is not necessarily an indication of the importance of the work. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a parenthetic addition to the title, while a paper of similar importance in German, Italian or Russian, may be given a long abstract.

This regular monthly feature of our sister journal occupies 27 pp. of the February issue, which also includes an article describing an insulation resistance meter, another in which is given a graphical method of determining the current induced in an external circuit by electrons moving between two plane electrodes, and also the conclusion of a paper on air-cored inductances.

The Wireless Engineer is obtainable to order through newsagents, or direct from our publishers at Dorset House, Stamford Street, London, S.E.1, at 2s. 8d., including postage.

Random Radiations

By "DIALLIST"

Leave Plans

As I write I'm enjoying a spot of leave, the first for many months. Very welcome it is, but, as is the way of leave in wartime, it passes all too fast. If you're sailoring or soldiering or flying I expect you do much the same as I. As soon as you know that there's a chance of leave you begin to make plans about all the marvellous things that you'll do. You get home. It's such a relief to be able to do what you like when you like that you decide to take it easy the first day. That proves so enjoyable that you repeat the prescription, and before you know where you are the end of your spell is in sight without your having done any of the wonderful things that you planned. Personally, I intended *inter alia* to find and sort out the wireless gear that had to be put away in all kinds of odd corners in August, 1939, when every room was wanted for evacuees. I'm sorry to say that the job is still unfinished and will have to wait till my next leave, whenever that may be, for its completion The job will be a long one, for I wasn't there to do the aforementioned putting away, and no one in the home seems to remember where things were stowed. Still, I expect I'll find most of them in the end.

For Fine Soldering

Lately I've noticed with pleasure advertisements of soldering irons that look really suited to the kind of jobs that the wireless man has to do. Hitherto I've never been able to buy an iron, electric or plain, that struck me as ideal. Either the bit was so large and clumsy that it wasn't well adapted for fine, neat work, or it was so small that it wouldn't hold the heat long enough. For fine work I must say I prefer a plain iron heated by means of a bunsen burner. My own tip for making an iron for wireless set soldering may be useful to workshop-minded readers. Buy an iron with a longish shaft and a bit about the size of the last joint of your thumb. With a hacksaw remove the point, then drill about $\frac{3}{8}$in. deep into the place where the point was and tap the hole $\frac{1}{4}$in. Whitworth. Cut off about one inch of $\frac{1}{4}$in. copper rod and thread it with a die. Trim the other end to screw-driver shape and make the "blade" about $\frac{3}{16}$in. wide. Screw the rod tightly home into the bit and make all secure by punching. Tin the end of the copper rod and you have as handy an iron as you could want. The point is fine enough for delicate work and there's enough body in the original bit to retain the heat for a reasonable time.

No Marking Time

A DISMAL JIMMY with whom I was talking the other day was very gloomy in his news on the probable course of wireless after the war. Whenever it ended, said he, wireless would have been more or less at a standstill for years . . . and so on, and so on. Wireless hasn't been at a standstill. Does this Dismal Jimmy think, and do others of his kidney believe that the nations at war have been doing nothing in the way of radio development? And I don't mean just their Navies, Armies or Air Forces. Pretty considerable developments have been made in long-distance short-wave broadcasting by the authorities in many countries. I don't think that one needs to be much of a prophet to foretell that so far from having marked time, radio all over the world will be found to have made vast strides when peace returns. It was so in the last war, you know. In 1914 wireless was a very infant science, unknown to the average man save by garbled accounts of various feats that he read in the lay papers from time to time. But between 1914 and 1919 the infant became a very lusty youngster, though comparatively few realised what was happening.

Going Ahead

And once that war was over things moved in the world of wireless. Many hundreds had received a radio training in one or other of the Services; they had seen the progress as it was made, and, once back in civil life, they were eager to make a peace-time hobby of what had been a war-time job. In this they were helped enormously by the vast quantities of Government surplus electrical and wireless goods that became available at old-song prices. Thousands of keen amateurs were soon at work, and it is to them that we owe not a few of the major forward steps that have since been made. It will, I believe, be much the same when this war comes to its welcome end. We shall find that intensive research during the fighting days has worked even greater wonders. And the number of keen amateurs to return to civil life will be vastly bigger than it was in 1918 and 1919. It's true that listeners can't buy much in the way of new sets nowadays! They've got to carry on with old apparatus, often repaired in makeshift ways. But they need not fear that the post-war receivers are going to be just the pre-war articles in slightly different form. Once the radio industry has had time to settle down again and adapt itself to peacetime conditions we shall see that wireless has gone ahead right enough during the years of war.

Service-man Shortage

There is a considerable shortage of wireless service-men in some districts, and the position would become much worse were those who are now or in the near future liable for call-up obliged to join the Forces. This is a very important matter, for broadcasting in wartime is something much more than a means of entertainment; it is the greatest of connecting links between the authorities and the people of the country. In any great national emergency its value might be inestimable. Hence it is vital to keep as many receiving sets as possible in action. This is no easy business to-day, when so much of the equipment in use is old and inclined to be cranky. The average age of broadcast receivers is now much higher than before the war, for smaller numbers of new sets have been available during the past $2\frac{1}{2}$ years. Old sets, as we all know, become more and more liable to develop faults with use; hence the comparatively small number of service-men left have been very hard put to it to keep pace with the demand for repair work. Nor is radio service work anything like so straightforward as it was. In the days of peace, if a valve or other component were found to be faulty, it was extracted and another of the same kind put into its place.

GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

Vital Work

As often as not that kind of thing can't be done nowadays. The particular valve or component may not be available, and the repairer, if he is to make a job of a defective set, has to exercise considerable ingenuity and skill in adapting it to work with a substitute part, whose characteristics may be very different from those of the original. Thus the semi-skilled service-man, who might rub along in peacetime, is likely to find himself far out of his depth if he tackles the problems of to-day. Pooling of repair work has done something to improve the position; but we have reached a point where the numbers of service-men able to deal with necessary repairs have come down to somewhere very near the bare minimum necessary. I believe that the position is realised by the powers that be, and I hear that action may be taken to defer the calling-up of men with big demands on their services who cannot be replaced. I hope devoutly that this may be so, for good radio service-men are certainly doing work of real national importance.

Any Old Records?

YOU may have missed the appeal that was broadcast recently for gramophones or gramophone records for the use of our troops in lonely and out-of-the-way places. As one who spent the first two war winters in isolated spots at the back of beyond, I can tell you that the need is very real and that almost any old record played on almost any old gramophone is a help at times when dullness and loneliness are getting you down. Lots of you must have records that you don't use once in a blue moon. If you have, rout them out of cupboard or attic or lumber room, and send them to The Director, Army Comforts Depot, St. Mary's Butts, Reading, Berks. I can assure you that they'll be warmly appreciated.

Worse Than His Bite?

BRIGHT spot in an Army lecture the other day. The name of Barkhausen cropped up: "My German is not too good," said the lecturer; "but the eminent scientist's name looks to me as if it might mean dog kennel." It will remind you, possibly, of the translation of Konigswusterhausen as "King's sausage houses."

RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

MEASURING ULTRA-HIGH FREQUENCIES

RELATES to the use of a cathode-ray tube for measuring voltage variations of the order of 1,500 megacycles, corresponding to a wavelength of 20 centimetres. It is pointed out that although the cathode-ray tube lends itself admirably to the measurement of high-frequency phenomena, a limit is gradually imposed by the increasing absorption of power across the deflecting plates as the time of flight of the electron stream between the plates becomes an appreciable fraction of the period of the oscillation to be measured. For the same order of frequencies, a further loss of power is also caused by the increasing capacity effect between the two plates.

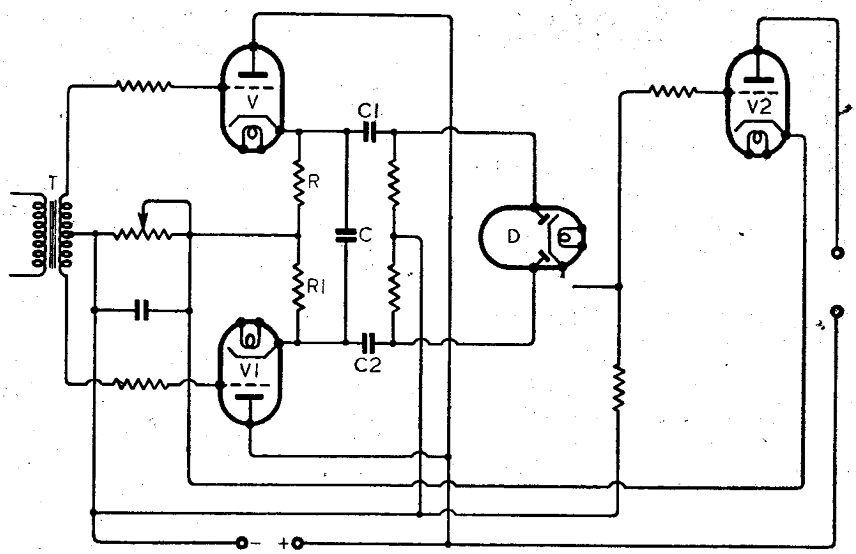
The object of the invention is to measure voltage variations of the order first mentioned without absorbing power in the process For this purpose, the ordinary method of controlling the stream by variable deflection voltages is replaced by a method of first "bunching" the stream and then measuring the deflection caused by a steady deflecting field. The cathode-ray tube is built to include two transverse wires forming part of a Lecher-wire system. The Lecher wires are coupled to the voltage to be measured, and are tuned to it by a sliding bridge. The electron stream passing through the wires is bunched by the so-called Rhumbatron effect, and in this condition is passed through a steady deflecting field. The resulting deflection can then be calibrated in terms of frequency.

Standard Telephones and Cables, Ltd., and J. H. Fremlin. Application date February 6th, 1940. No. 538610.

FREQUENCY-MODULATED SIGNALS

WHEN converting frequency-modulated signals into equivalent amplitude variations, it is necessary to get rid of any casual amplitude variations that may be present in the original signal, since these tend to distort the final output. According to the invention, this difficulty is avoided by using a demodulator which is "insensitive" to the presence of undesired amplitude components, though it gives an output which varies in amplitude in accordance with the original frequency-modulated signal.

The essential element in the demodulator is a pair of valves V, V1, which are fed in push-pull by a frequency modulated signal across a transformer T. The valves are of the gas-filled type, and are so interconnected that when one passes current the other is paralysed, and *vice versa*, the arrangement forming, in effect, a relaxation-oscillation unit or flip-flap relay. During one half-period of the applied signal say, the valve V conducts and charges the condenser C through the cathode resistance R. During the next half-cycle, the condenser C is oppositely charged through the cathode resistance R1, and the valve V is cut out because its cathode voltage rises. Meanwhile, the condensers C1, C2 are alternately charged and discharged, and corresponding pulses are fed through the diode D to the amplifier V2. The amplitude of these final pulses will depend upon the number of cycles received in unit time, but will not be affected by incidental variations in their amplitude at the input terminals.



Amplitude filter for FM.

Marconi's Wireless Telegraph Co., Ltd. (Assignees of G. R. Clark). Convention date (U.S.A.) May 22nd, 1939. No. 539254.

The British abstracts published here are prepared with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office 25 Southampton Buildings, London, W.C.2, price 1/- each.

CATHODE-RAY TUBES

THE electron stream of a cathode-ray tube contains a certain proportion of negative ions and similar electrically charged particles, which, because of their comparatively large mass, are not deflected by the control fields applied to the stream, and therefore follow a more or less straight path from the cathode to the fluorescent screen. In course of time, the continual localised bombardment due to such particles destroys the fluorescent coating and so produces a black spot or blemish near the centre of the screen.

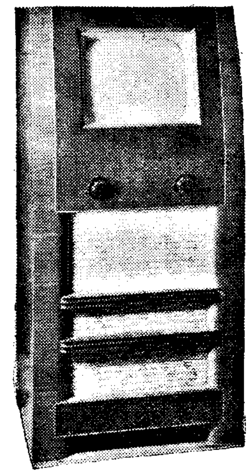
The object of the invention is to prevent this by removing the undesired particles from the electron stream before the latter reaches the fluorescent screen. For this purpose the electrons proper are focused into a stream of small cross-section, i.e., they are brought to a "cross-over" point, just before they pass through a small aperture formed in a barrier electrode interposed between the cathode and the deflecting plates. At the same time, the stream is subjected to independent magnetic and electrostatic fields which are so adjusted that their effect is substantially balanced so far as the electrons are concerned, though there is a residual component sufficient to deflect the heavier and more slowly moving particles out of the straight-line path. This causes them to miss the aperture and to strike against the surface of the barrier, which thus filters them out from the main stream of pure electrons.

Philco Radio and Television Corporation (Assignees of H. Branson). Convention date (U.S.A.) February 25th, 1939. No. 538684.

AERIALS

IN order to vary the effective height or length of an aerial, particularly for microwave working, the conducting part consists of a column of mercury in an open tube of insulating material. The lower end of the tube is immersed in a sump of mercury, and the height of the column is adjusted for varying wave-lengths by hydraulic or pneumatic pressure supplied through a calibrated gauge. The invention is applicable to a number of dipoles forming a directional array.

A. C. Ducati. Convention dates (Italy), October 15th, 1938, and August 30th, 1939. No. 535425.



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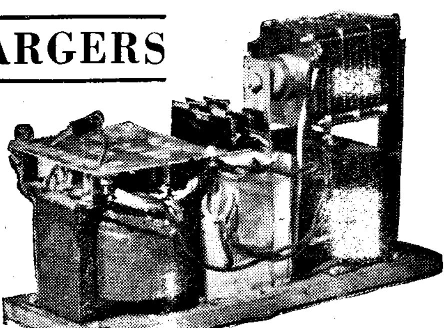

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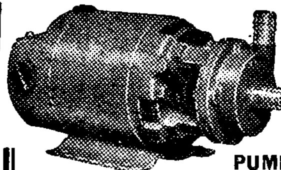

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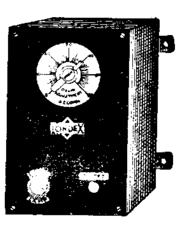

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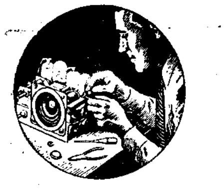

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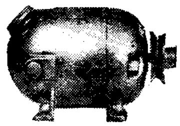

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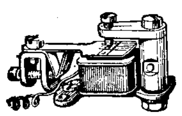

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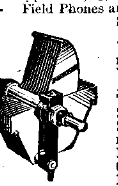

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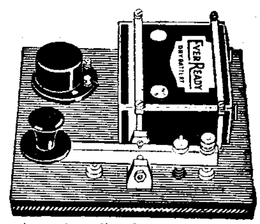

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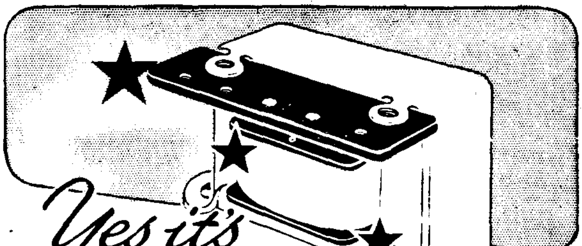

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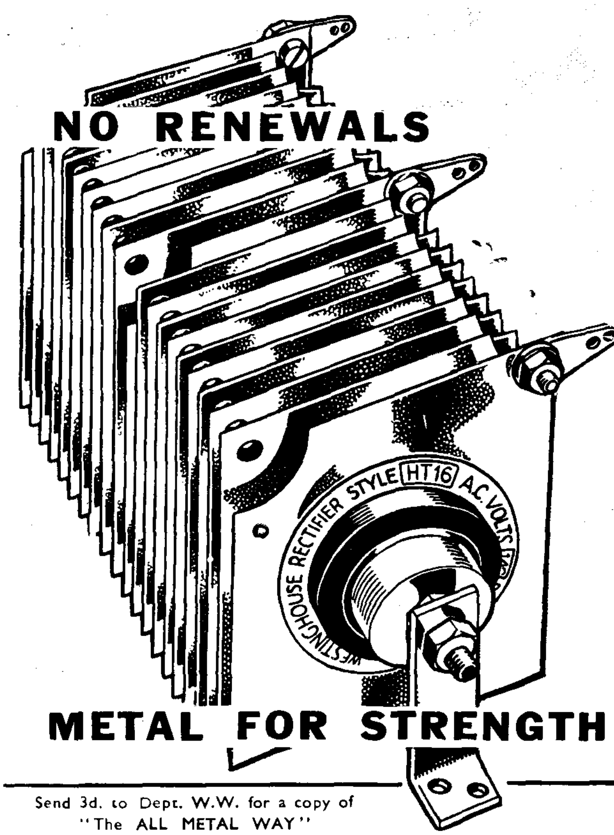

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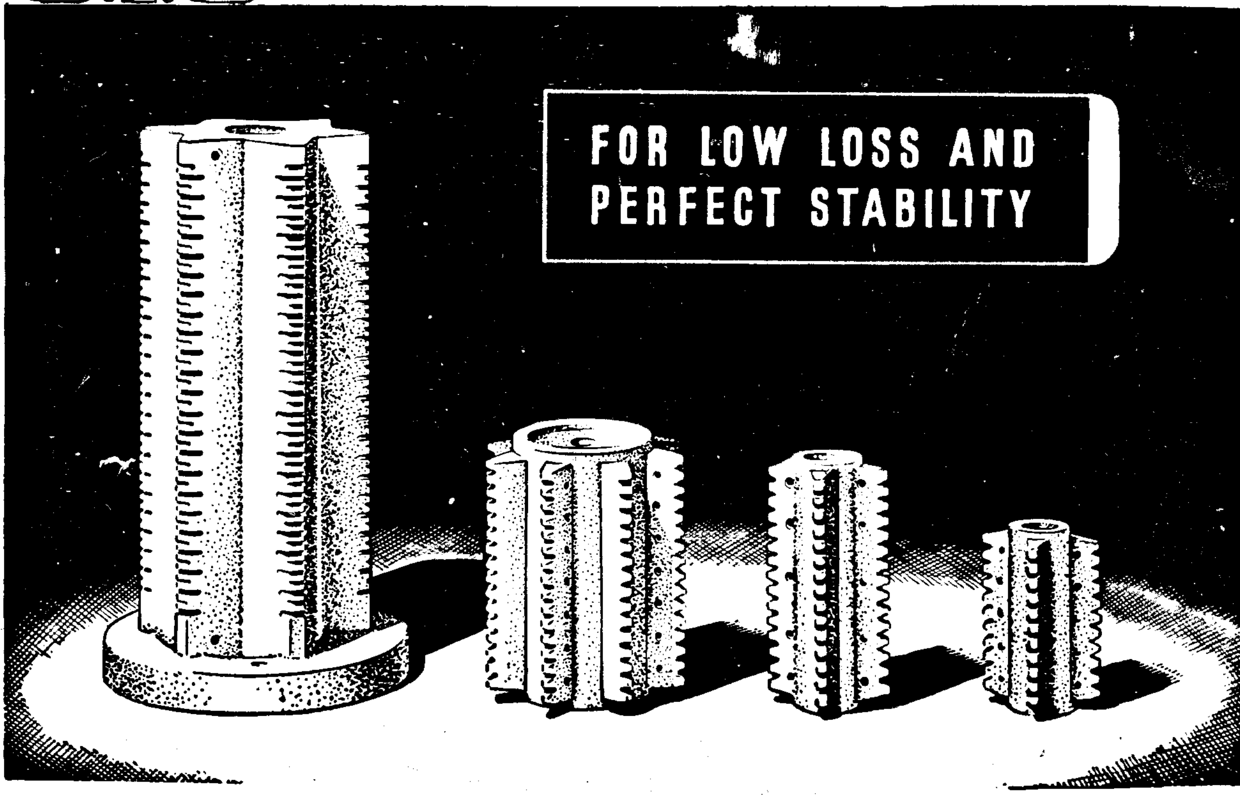

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