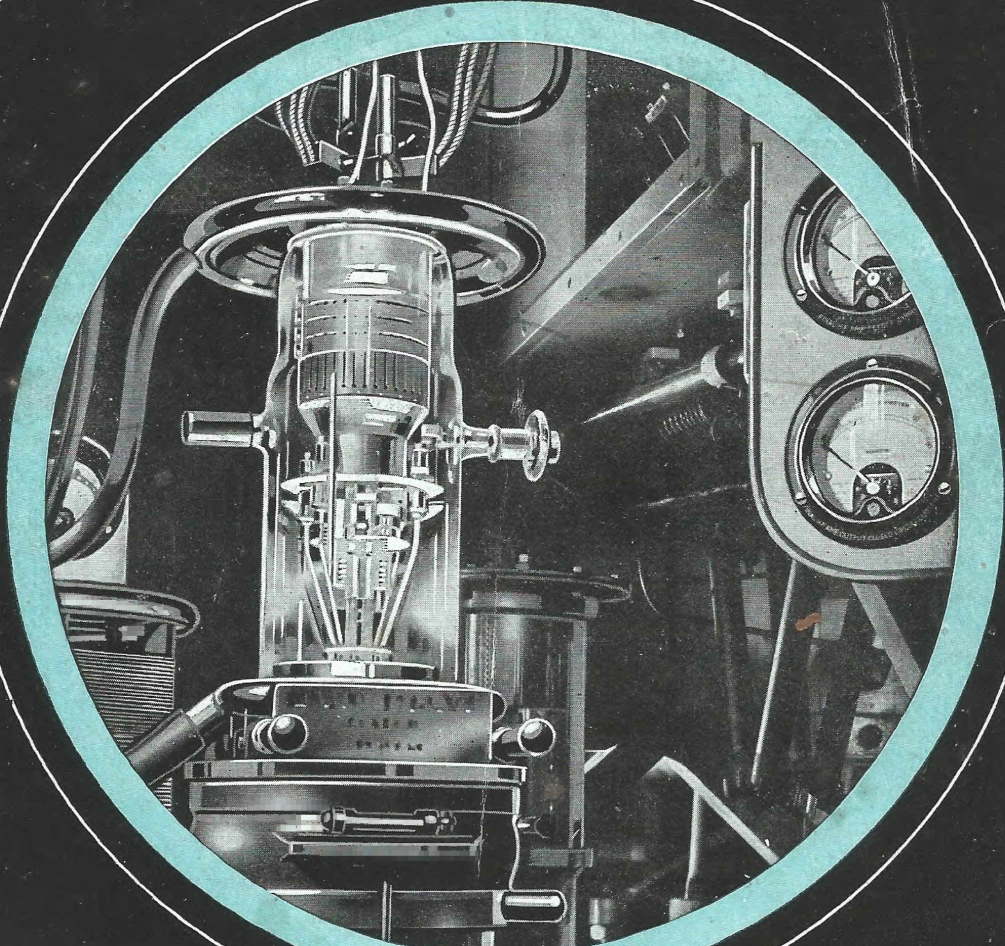
Wireless World

RADIO · ELECTRONICS · ELECTRO-ACOUSTICS



OCT. 1942

1/3

Vol. XLVIII No. 10

RADIO DATA CHARTS : NEW SERIES

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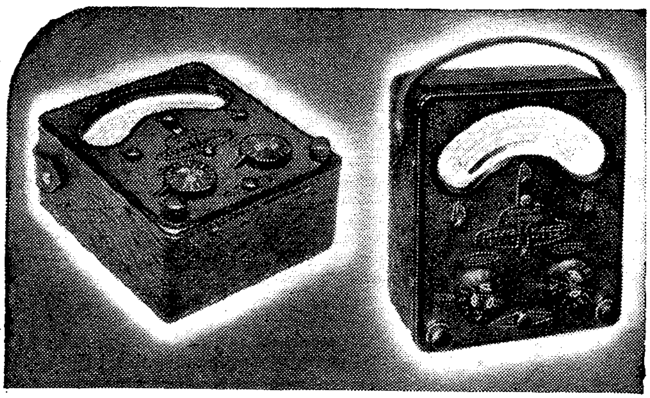
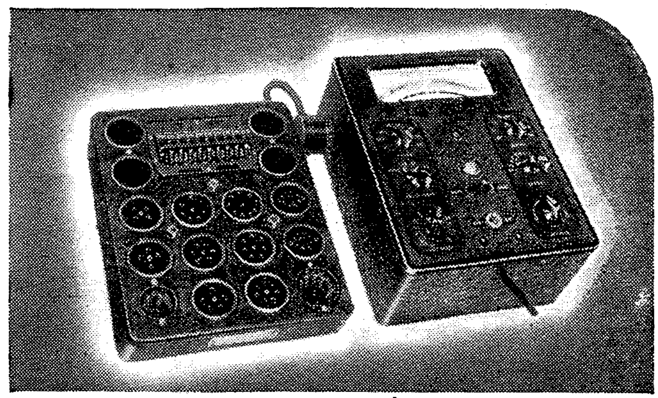
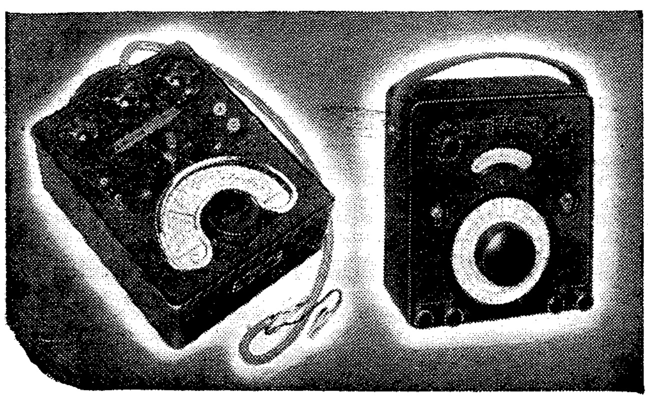


"Avo" Valve Tester with Universal Panel.





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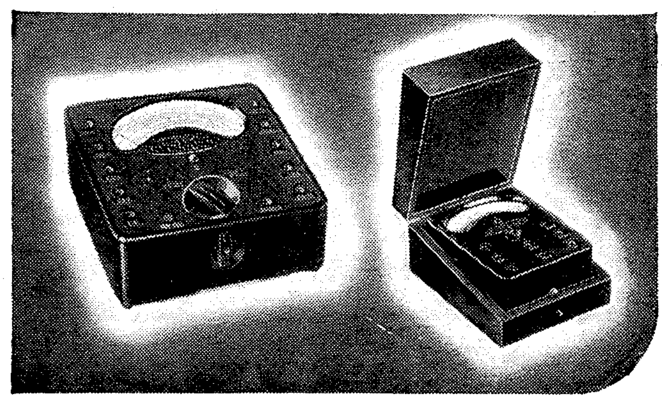

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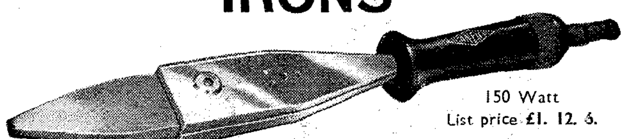

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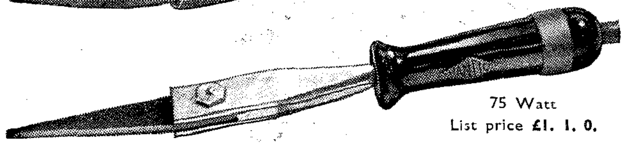

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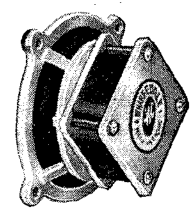

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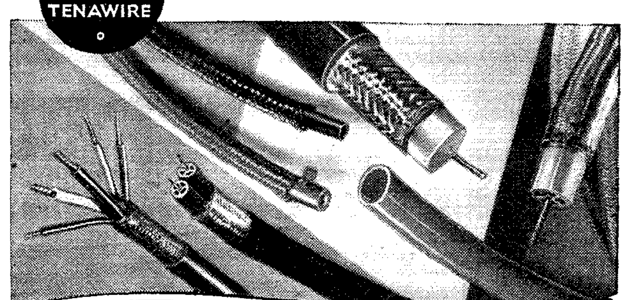
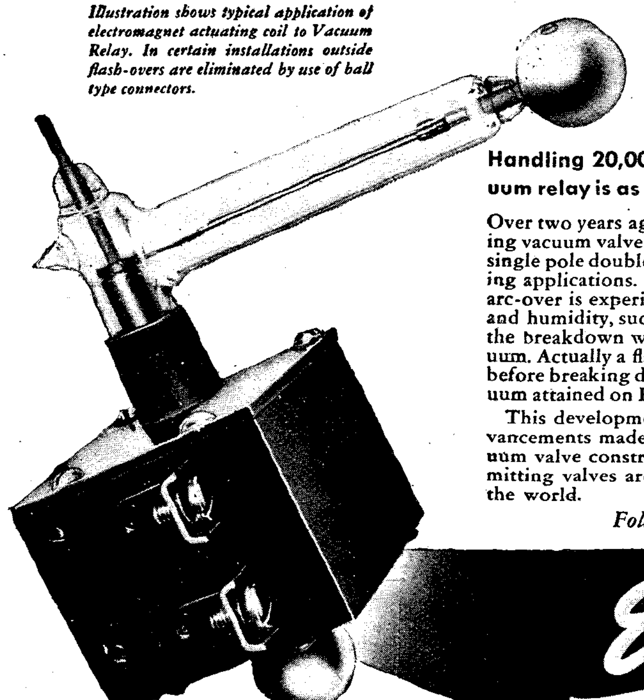


Another Eimac Achievement!

Illustration shows typical application of electromagnet actuating coil to Vacuum Relay. In certain installations outside flash-overs are eliminated by use of ball type connectors.



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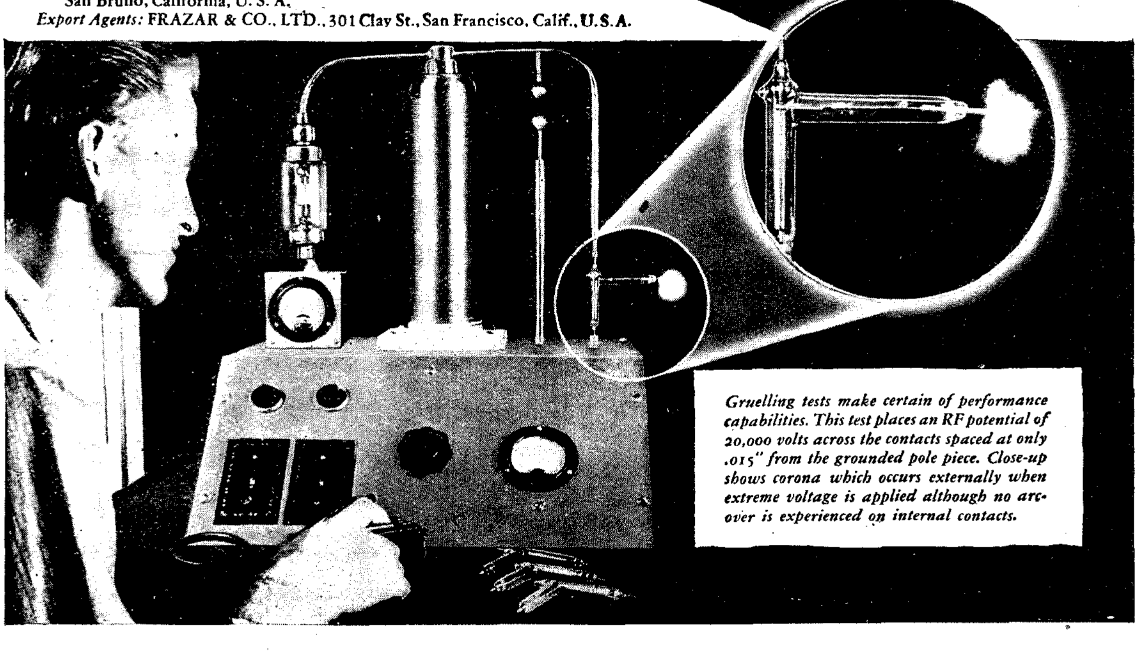
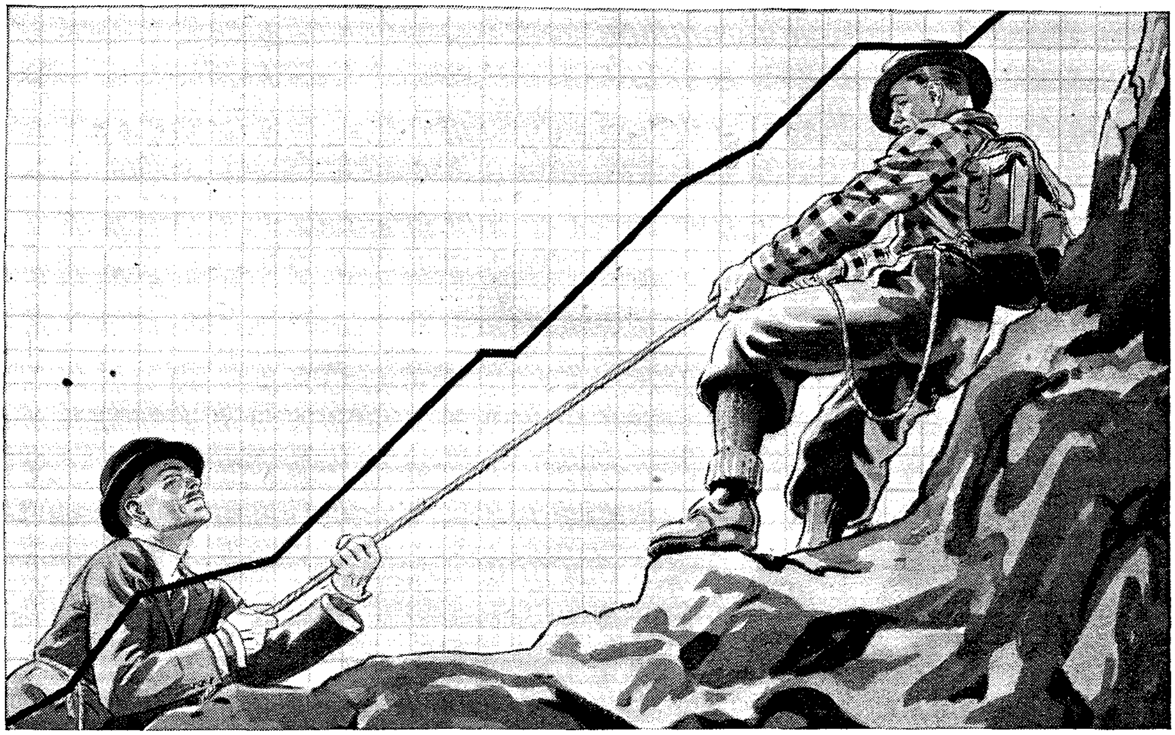


Gruelling tests make certain of performance capabilities. This test places an RF potential of 20,000 volts across the contacts spaced at only .015" from the grounded pole piece. Close-up shows corona which occurs externally when extreme voltage is applied although no arc-over is experienced on internal contacts.



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P.9.

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Wireless World

Radio • Electronics • Electro-Acoustics

32nd YEAR OF PUBLICATION

OCTOBER 1942

Proprietors :
ILIFFE & SONS LTD.

Managing Editor :
HUGH S. POCOCK,
M.I.E.E.

Editor :
H. F. SMITH.

Editorial, Advertising and Publishing Offices :
DORSET HOUSE,
STAMFORD STREET,
LONDON, S.E.1.

Telephone:
Waterloo 3333 (35 lines).
Telegrams:
"Ethaworld, Sedist, London."

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PUBLISHED MONTHLY

Price: 1/3

(Publication date 20th of preceding month)

Subscription Rate Home and Abroad 17/- per annum.

Branch Offices :

COVENTRY:
8-10, Corporation Street.
Telephone: Coventry 5210.
Telegrams: "Autocar, Coventry."

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As many of the circuits and apparatus described in these pages are covered by patents, readers are advised, before making use of them, to satisfy themselves that they would not be infringing patents.

Wireless World

Radio • Electronics • Electro-Acoustics

Vol. XLVIII. No. 10 OCTOBER 1942 Price 1s. 3d.

Competitive Broadcasting

Real Alternative Programmes

IT must be evident that when the war ends an unrivalled opportunity will arise for making, if need be, virtually a fresh start in the organisation of British broadcasting. Presumably most of the transmitters, and certainly nearly all the domestic receivers, will be long overdue for replacement, so the objections that are usually urged when any sweeping change in distribution technique is proposed will carry little weight. Here is a clear case for considering now whether improvements can be made; an attitude of *laissez-faire* will certainly mean that the opportunity will be lost.

Without entering into controversial matters that would be out of place in a technical journal, it is permissible to say that the view is widely held that our post-war society will be organised on a less strongly competitive basis. Indeed, it is generally admitted that many forms of competition in our pre-war national life led to avoidable waste of material and energy, and so to a lowering of the standard of living. But in such a sphere as the organisation of broadcast programmes some measure of competition is more likely to act as a spur to human endeavour than to produce harmful results. Lack of any tangible incentive—other than a vague and undefined idealism—to produce better programmes must be largely responsible for that annoying attitude of complacency on the part of the B.B.C. to which such widespread exception is taken.

This is not a plea for a violently disruptive reorganisation of British broadcasting, such as commercialising it on American lines. Though we find much to admire in American programme technique, our present system, though susceptible to improvement, is fundamentally on a basis better suited to our national temperament. In the present system of alternative "Home" and "Forces" transmissions we have the nucleus of an idea that might well pave the way for a real alternative programme organisation. The proposal is, briefly, that two entirely separate B.B.C. Programme Boards should be set up, with complete independence and freedom of action. The technical means of distributing the programmes would remain under a single control, as would the accountancy and similar branches of the Corporation. Funds for programmes would be divided equally between the two "networks" (we might call them the Red and the Blue, on the American model) and within the limitations of their financial allocations they would be free to bid against each other for the services of artists or speakers.

On the technical side, no particularly difficult problems would arise, especially as, not being bound by any limitations of existing receiver design, it would be possible to make wide use of ultra-short waves. Indeed, our pre-war system gave ostensibly two programmes to the great majority; that it failed in fact to provide true alternatives was the fault rather of the programme organisation than of the technical arrangement of the Corporation's stations. It is not surprising that both programmes were coloured by the views of the single directorate.

Although we have said that the existing Home and Forces transmissions provide the nucleus of the idea of what might be done, it is not suggested that the programmes of the competing networks should deliberately set out to appeal to different levels of taste or culture. Both networks should aim at producing, in the fullest sense, a complete national programme that would appeal to all tastes.

Independent Directorates

In our view, the head of each of the networks should take the same amount of responsibility for the matter broadcast by his organisation as was originally shouldered by the Director-General. Any collaboration between the networks might be confined to arranging that, whenever it could be conveniently arranged, the programmes at any given time should be of a contrasting nature.

Perhaps the most serious objection that can be urged against our suggestion is that, as the competing networks will naturally be judged on a "box office" basis, the temptation to scale down the matter broadcast to a level appealing to the great possible number of listeners would be almost irresistable. That criticism should not be lightly dismissed by anyone who is anxious to see the full realisation of the potentialities of broadcasting, but if we did not think that adequate safeguards against such an undesirable state of affairs could easily be found, we should certainly not put forward the proposal.

RADIO DATA CHARTS

No. 1. (3rd Series) — Output Transformer Ratios

By

J. McG. SOWERBY,

B.A., Grad. I.E.E.

(By Permission of the Ministry of Supply)

Many new problems that have arisen since Radio Data Charts last appeared in *Wireless World* will be dealt with in this new series. The problems chosen will generally be those that are more quickly and easily solved with the help of Abacs than by calculation.

A PROBLEM which is continually arising is the estimation of the turns ratio between the primary and secondary windings of an output transformer to provide the correct impedance matching between the loudspeaker and the output valve or valves. The problem may be complicated by the presence of two or more speakers of differing impedances which may be required to operate singly or in any combination, and to each of which a given proportion of the total power is to be delivered. This chart sets out to perform the requisite calculations with the minimum of trouble.

In the construction of this chart no account has been taken of the dimensions (electrical or mechanical) of the transformer, the only assumption being that its efficiency is 100 per cent. This is not such a serious assumption as appears at first sight, since if the efficiency falls to 50 per cent. (and readers are not expected to sink to such depths!) the error in the chart is only 2 per cent. for the ordinary transformer where the losses are equally distributed between the copper and the iron.[1]

The fundamental relation on which the chart is based is :—

$$\text{Turns Ratio} = \sqrt{\frac{R_P}{R_S} \cdot \frac{W_P}{W_S}}$$

Where R_P = Primary load; i.e., load on valve in ohms

R_S = Secondary load; i.e., speech coil impedance

W_P = Primary power; i.e., power delivered by valve

W_S = Secondary power; i.e., power supplied to speaker.

Of course, if there is only one secondary winding, all the power must be delivered to it, and if there are any number of secondary windings, the total of the power taken from them must be equal to the power delivered to the primary or primaries. Let us now consider the chart itself.

There are four scales and a reference line, and reading from the left these are scaled in primary load, turns ratio, secondary load and primary power, and secondary power and secondary load. The reference line is unscaled. The scales are used as shown in the two keys, and since the chart is really two charts superimposed it is essential not to muddle the scales. In addition, the two secondary load scales have extra figures for one decade which have been placed in frames. These figures may be used in place of their unframed fellows, but in this case the turns ratio—when found—must be divided by ten.

A Simple Example

Let us go through a simple example by way of illustration. An amplifier has an output of four watts in 6,500 ohms, and it is required to match it alternatively to 500 ohms, and an 8-ohm speaker. Following Key I, join 6,500 on the first scale to 500 on the fourth. The ruler cuts the turns ratio scale at 36.1, but since the framed scale was used this must be divided by ten. Hence the turns ratio is 3.61. Again, join 6,500 to 8 on the fourth scale, and the ruler cuts the turns ratio at 28.5. Thus the two required turns ratios are 3.61 for the 500-ohm load and 28.5 for the 8-ohm load. If convenient, the secondary could be wound in the form of one tapped winding.

The method given by Key I, then, refers to *alternatives* only. Suppose now it is desired to deliver one watt from the above amplifier into the 500-ohm load, and the other three watts into the 8-ohm speaker. To solve this we must use the method shown by Key II. Join 6,500 to 500 on the third scale, and note the point of intersection on the reference line. Join this point to four watts on the third scale (primary power) and a second point of intersection is found on the first scale. Join this point to one watt on the fourth scale (secondary power) and the ruler cuts the turns ratio at 72.1. Since the framed scale was used, the ratio is 7.21. A similar operation gives a turns ratio of 32.9 for the 8-ohm speaker. With these ratios, the two loads will always receive their correct proportions of the total power supplied by the amplifier; but it is worth noting that if either load is removed, the matching will be upset. If one or other of the loads are to be switched out, a resistance of the same value should be connected in its place to preserve the matching. It will be seen that the operation designated by Key II does not deal with alternative, but *simultaneous* loads, or loads in parallel.

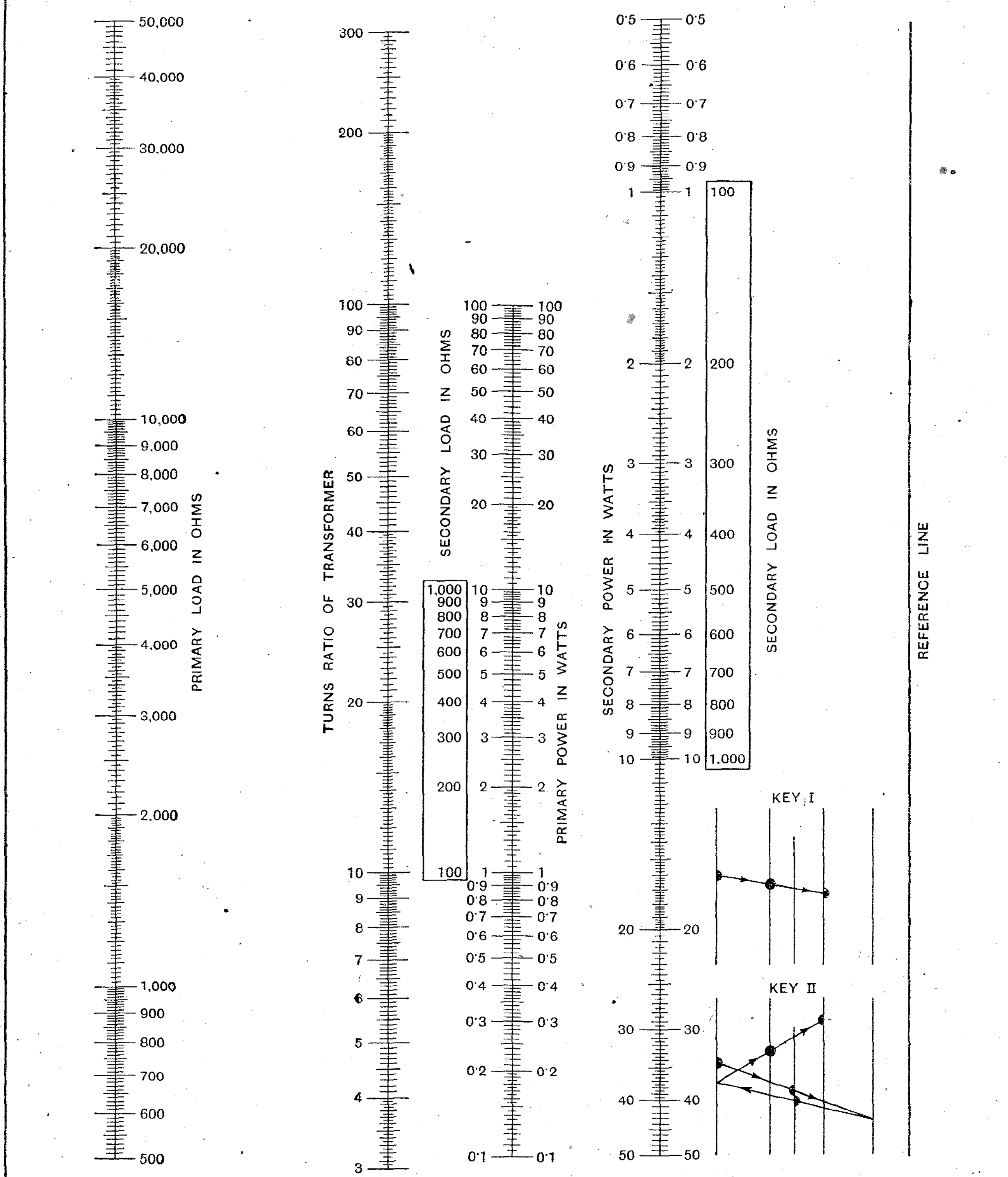
Let us now go through a final example of a fairly complicated system. A communication receiver has an output of 23 watts in 3,200 ohms. The operating room contains a morse recorder of 500 ohms impedance requiring five watts, and a monitor speaker (impedance 15 ohms) using four watts. In an adjoining room is a second morse recorder of the same type which is required to alternate with a speaker of 7.5 ohms impedance consuming five watts. The remaining

(*Continued on page 228*)

Primary	Secondaries				
	Impedance in Ohms	Power in Watts	Apparatus	Switching	No.
23 watts in 3,200 ohms	500	5	Recorder	On/dummy resistance	(1)
	500	5	Ditto	Change-over to (4)	(2)
	15	4	Monitor	None	(3)
	7.5	5	Extension	Change-over to (2)	(4)
	10.5	3	Ditto	On/dummy resistance	(5)
	10.5	3	Ditto	Ditto	(8)
	10.5	3	Ditto	Ditto	(7)

[1] Langford Smith. Radio Designer's Handbook, 1st Ed., p. 210.

ABAC No. 1. (3rd Series) — OUTPUT TRANSFORMER RATIOS



TURNS RATIO OF OUTPUT TRANSFORMERS
WITH SINGLE, MULTIPLE OR TAPPED SECONDARIES

Radio Data Charts—

nine watts is distributed to three extension speakers (impedance 10.5 ohms each) taking three watts each; these are required to be switched. To show clearly what is to be calculated, this data is tabulated on p. 226.

Since all these loads (or the dummy resistances simulating them) are connected simultaneously, Key II gives the correct procedure. Perhaps the reader would like to do the requisite calculations with the chart to achieve familiarity with it. The answers are given below, and Fig. 1 shows how the set-up might be connected.

No.	Turns ratio
(1)	5.42
(2)	5.42.
(3)	35
(4)	44.3
(5)	48.4
(6)	48.4
(7)	48.4

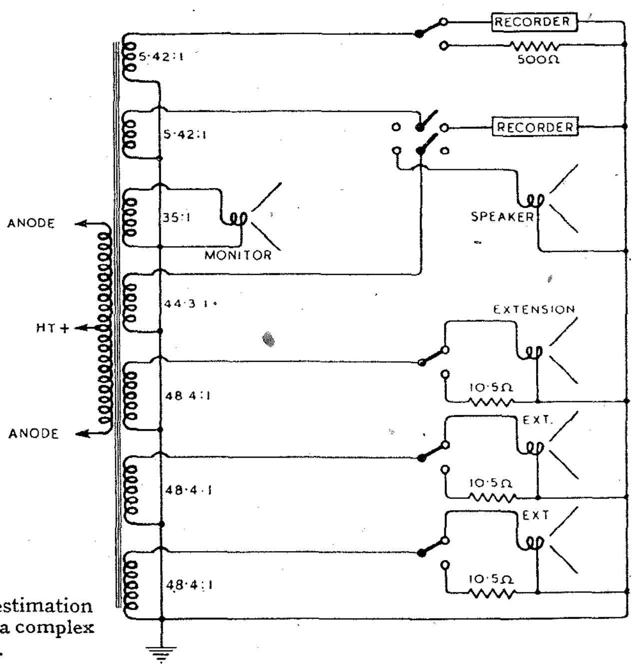


Fig. 1. Illustrating the estimation of transformer ratios in a complex output system.

Holes in the Ionosphere

Waves Lost in Space

DURING magnetic storms the ionic density in the F layer is known to decrease very considerably, and failure of short-wave communication to occur, because the ionic density becomes insufficient to ensure refraction of the waves. There is evidence that this effect is brought about by the action of streams of corpuscles which arrive in the ionosphere from the sun, but the precise nature of their action is not yet understood.

In a recent letter to *Nature*,[1] T. L. Eckersley makes an interesting suggestion as to how this effect may occur. Assuming that the corpuscular stream is in itself neutral, i.e., composed of equal numbers of positive and negative particles, he states that, on entering the atmosphere, the electrons would be retarded much sooner than the positive ions, the former coming to a standstill in the higher atmosphere while the latter penetrate down as far as the E layer. When this has occurred a large electric force exists between the E and F layers, and this, together with the force of the earth's magnetic field, causes a violent drift of the electrified particles in the F layer, which is, in effect, a west to east current in the layer. In the E layer there is a tendency for an opposite drift to occur, but, owing to the large molecular density at this height, the current is much smaller.

The ionosphere, in the region of the earth where the electric force was set up, is thus swept fairly clear of electrons and positive ions, and a big hole in the refracting layer is thus produced. Through this the radio waves can penetrate and so be lost in space.

[1] Issue of August 8th, 1942.

The R.E.M.E.

New Corps to Maintain Telecommunications Equipment

TO avoid the duplication and overlapping of engineering services which have arisen between the Royal Army Ordnance Corps and the Royal Engineers, a new Corps, which is to be known as the Royal Electrical and Mechanical Engineers, officially comes into being on October 1st.

In the past the R.A.O.C. has been responsible for ordnance stores, i.e., everything from guns to personal equipment of soldiers, and also for the engineering stores, including the technical maintenance of electrical equipment, instruments, wireless and line telecommunication equipment and radiolocation apparatus.

The new Corps will take over the supply, distribution and maintenance of all electrical and mechanical equipment other than the exceptionally heavy engineering equipment handled by the Royal Engineers.

A feature of the organisation of the modern army is the provision of facilities for the maintenance of equipment in the first echelon or front line. So far as radiolocation apparatus is concerned, this will in future be serviced entirely by Radio Maintenance Detachments of the R.E.M.E.

In the case of signals equipment, simple repairs are undertaken in the first echelon by Royal Signals personnel. The "permissive repair schedule" for this work has been laid down by the R.E.M.E. Where more detailed repairs are necessary equipment is returned to the second echelon (or support lines), where it will be undertaken by mobile wireless detachments of the new Corps. Where necessary, apparatus will, of course, be sent back to the telecommunications workshops in rear areas. Experience has shown that prevention is better than cure, and with this in mind "preventive maintenance"—regular tests of apparatus—will be undertaken by the new Corps in the second echelon.

The Telecommunications Division of the R.E.M.E. will deal with radiolocation apparatus as well as wireless and line communication equipment.

The personnel of the R.A.O.C. to be transferred to the R.E.M.E. includes Radio Mechanics, who wear the blue and red wireless flash and maintain radiolocation apparatus; Wireless Mechanics (who wear the white and blue flash); Armament Artificers (Radio and Wireless), who supervise workshops for their respective spheres; Radio and Wireless Maintenance Officers; and Ordnance Mechanical Engineers (Wireless), who will become Electrical and Mechanical Engineers, with the probable suffix "Tels"—the official abbreviation for telecommunications.

Wireless World

Brains Trust

Question No. 5

IS it theoretically possible to hold wireless communication with other planets? And is there anything in the nature of inexplicable radiations (i.e., apart from cosmic rays) reaching us from outer space?

(*Answer on p.* 231.)

TYPES OF DEAFNESS

Where Hearing Aids Can Help

DEAFNESS has always seemed to be the Cinderella among what may be loosely termed diseases of function. Not only has it always been the butt of music-hall comedians but it has been, and still is, singularly ill-served in the matter of scientifically designed apparatus to relieve it and of qualified persons to "fit," supply and maintain such apparatus. The simpler defects of vision seem to be adequately dealt with by the optician. He holds a diploma recognised by the medical profession, and, as well as supplying spectacles and other aids for defective sight, carries out tests to determine the nature of these defects. If he suspects serious disease, he will advise his customer to consult an oculist.

It has been suggested editorially in *Wireless World* that a strictly comparable state of affairs might well bring about economy and efficiency in the distribution of hearing aids to sufferers from deafness. It is assumed that the aids would be produced cheaply on mass-production lines by the wireless industry and sold by the wireless dealer. A role comparable with that of the optician in the field of vision might then be fulfilled by a qualified "otician" (either the dealer himself or an assistant), who should possess not only a diploma recognised by the medical profession but also evidence of competency on the electro-acoustic side. It has been pointed out that it would be wasteful to train newcomers to the art when there already exists a large number of men with wide knowledge and experience in the second and more difficult part of the subject. But, in addition to that, they must know how to choose or adjust a hearing aid to compensate for the defects of hearing of the person with whom they are dealing, and must be able to distinguish one type of deafness from another. A brief outline of some of these latter aspects of the subject will be of interest to all radio technicians who may wish to concern themselves with what is likely to become a very important offshoot of their art.

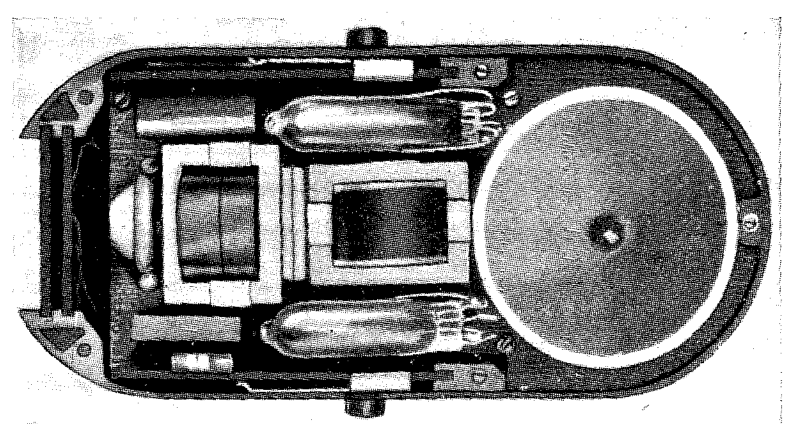
The ear is divided into three main portions known as the outer, middle and inner ear. The outer ear consists not only of the shell-like collector of sound known as the auricle or pinna which is visible to us, but also of a short channel—the auditory canal—leading to the ear drum or tympanic membrane which the air waves of sound cause to vibrate. At the other side of the drum the vibrations cross the middle ear by purely mechanical means, there being three small bones or ossicles which transmit them to the inner ear, which consists of a spiral cavity shaped something like a snail's shell, from which it derives its medical name of cochlea. This cavity contains fluid, the degree of compression of which is varied by the incoming vibrations. In the cochlea, among other things which do not directly concern us, is the basilar membrane with which is associated a very delicate part of the ear anatomy which analyses the vibrations before they pass via thousands of small nerve endings up the auditory nerve to certain centres of the brain which interpret them as the sensation which is called sound.

Deafness Classified

Writing in the July, 1942, issue of *Electronics*, Ira Kamen points out that deafness may be divided into three main types, so far as hearing aids are concerned. The first of these he calls conductive deafness, which is, as its name suggests, associated with those parts of the ear where vibrations travel along to the cochlea, where, as already mentioned, they are converted to what may conveniently be called nerve pulses. The causes of this kind of deafness are many and varied, among them being thickening of the ear drum, and stiffening of the joints of the ossicles. Sundry types of illness, among which the common cold is prominent, are in most cases primarily responsible for the trouble, although, of course, an accident may give rise to it. The main subjective symptom is a feeling that the ears are stuffed with cotton-wool. Probably most of us have been temporary sufferers from it at one time or another.

The second type of hearing defect, namely, nerve deafness, is due to trouble in the inner ear or cochlea where mechanical conduction ends and nerve transmission begins. Childhood diseases are frequently responsible and very often the trouble does not make itself evident until some years after the primary cause has passed away. In the case of sufferers from this type of deafness the hearing loss for low intensities of sound is relatively greater than for high. At high levels of sound the defective ear becomes practically as sensitive as a normal one and, at certain frequencies, what is known as the "threshold of pain" is reached far earlier than in the case of an ear not afflicted with this particular trouble. Anybody unfamiliar with this threshold need only don a pair of headphones and connect them across the primary of the LS transformer of a receiver which is operating at full volume in order to become acquainted with it.

It will be evident that some form of amplification limiter is a desirable addition to a hearing aid designed for this type of deafness in order to prevent the threshold of pain being reached. But, since this trouble, like other types of hearing defects, usually



(Courtesy *Electronics*)

Full-size illustration of a modern American hearing aid. Valves are decapped for compactness.

Types of Deafness—

varies considerably with frequency, the limiter must be a selective one and must, of course, be variable both in frequency and in amplitude adjustment in order that it can be adapted to the requirements of any particular sufferer. Another desirable feature is some form of negative feedback, as distortion greatly impairs the value of the hearing aid in practically all types of deafness, but more especially when the sufferer is advanced in years.

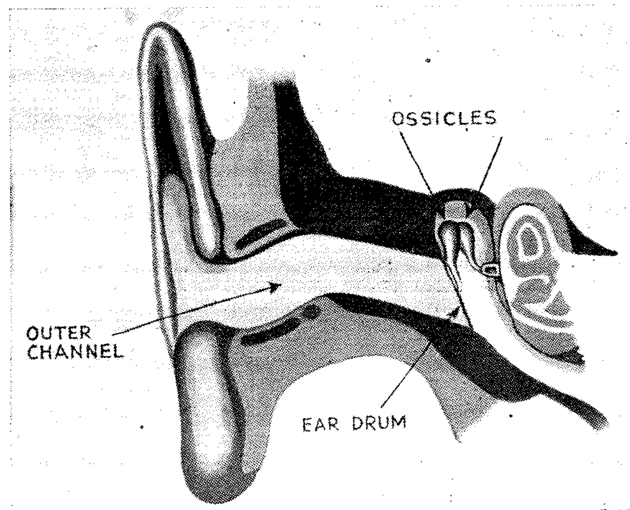
The third type of hearing impairment is referred to as cortical deafness. It is characterised by the fact that although the ear may be in good condition there is failure to interpret the incoming sounds correctly, and the person concerned is said to suffer from a loss of the "language factor." It mostly affects old people and those who have experienced a stroke or other cerebral troubles. In popular parlance the sufferer is "slow in the uptake," so far as hearing is concerned, but it will usually be found that if addressed slowly and deliberately he will be able to understand perfectly well. The only way in which a hearing aid can assist here is in cases where this kind of deafness does not exist alone but is accompanied by one of the other types. It should, in fact, be pointed out here that for the most part one type of deafness seldom does exist completely on its own.

Cortical deafness is sometimes due to long-standing conductive or nerve deafness. What happens is that due to long neglect of these other types of deafness the brain centres suffer from loss of sound memory. In other words, sufferers forget how to hear, so that when the actual ear defect is relieved there arises a temporary form of hearing impairment known as confusion deafness. This trouble can be cured by exercising the hearing faculties for a period; this has the effect of re-educating the brain centres.

Before the sufferer can be supplied with the correct type of hearing aid the otician would apply tests analogous to those used by the optician in the case of defective eyesight. According to the writer in *Electronics*, the process of testing has been widely developed in America. The first thing to be done is to decide which type of deafness is affecting the sufferer.

The principal tool in testing hearing is the audiometer, which, in its commonest form, consists of an oscillator calibrated in multiples of two in the audio spectrum. Its output can be varied in steps of 5 db. from the brink of audibility to the threshold of pain. It determines hearing losses up to 4,096 c/s quite accurately, but at 8,192 c/s it is less precise. Curves are taken both with the normal "air" earpiece and with a bone conductor, a compensated amplifier being used to counteract the peculiar frequency characteristics of the latter.

From the readings obtained, curves of the ear response are prepared and, apart from giving the frequency response of the deaf person's hearing faculties, a fairly accurate idea is obtainable as to the type of deafness which is present. From what has already been said about conductive and nerve deafness it will be fairly obvious how the curves



Simplified anatomy of the ear. Outer, middle, and inner ears are clearly distinguishable.

distinguish between them. If it is a case of conductive deafness a curve of ear response plotted against sound input at any given frequency will remain more or less level. In the case of nerve deafness, however, a point will be reached at which the curve will take a sharp upward turn. This will indicate that the ear response has started to increase out of all proportion to the sound input. Usually this upward turn of the curve will be indicated by the sufferer sharply removing the earpiece as the threshold of pain is suddenly reached. Cortical deafness will not be revealed by this use of the audiometer, as the pure tones of the oscillator are readily interpreted by the brain, and to detect this type of deafness a speech test is employed, as has already been briefly indicated. From the curves it can be decided what the output of a hearing aid should be at various frequencies; also at what sound level, and at what frequencies, the amplification limiter should come into operation if its use is necessary.

A hearing aid consists virtually of three parts, the microphone, the amplifier and the reproducer (earphone or bone conductor). Frequency compensation may obviously be brought about by varying the characteristics of one, two or all three in combination. It is usually more convenient to design two of the parts to provide a fixed characteristic as flat as is possible. The third part may be so designed that its characteristics can be readily varied, partly to compensate for any unavoidable defects of the other two, but mainly, of course, to compensate for the hearing defects of the person concerned.

In general, it is suggested by the writer in *Electronics* that the hearing aid should be designed to give normally as flat a response as possible between 500 c/s and 3,500 c/s. The response should be made to fall off below 500 c/s partly in order to minimise the rumbling noise of street traffic, but chiefly in order to permit the manufacture of a unit that is physically small and inconspicuous. The response above 3,500 c/s should be made to fall away in order to lessen background noises of the hissing type. The hearing aid must, of course, have a certain amount of response between 3,500 c/s and 5,000 c/s in order to reproduce the harmonics of speech. It should be emphasised that the above figures refer to the normal frequency response of the instrument, but this should be variable within wide limits to meet the needs of the particular sufferer concerned.

Bone conductors are fitted when severe conductive deafness is present. They act by mechanically short-circuiting the outer and inner ear and conducting the vibrations direct to the inner ear via the mastoid bone. The response of this instrument is such that, in order to compensate for it, it is usually necessary that it be fed with an input having a rising characteristic between 2,500 c/s and 5,000 c/s. This produces a flat output between 500 c/s and 3,500 c/s, and a falling output from 3,500 c/s to 5,000 c/s, which, as we have already seen, is what is required from the hearing aid before it is corrected to suit the individual sufferer.

Wireless World Brains Trust

Answer to Question No. 5

(*See page 228*)

THE mere fact that we are able to observe the light which is reflected from other planets shows that there is nothing to prevent an electromagnetic wave traversing the space intervening between the earth and those planets—or rather between the earth and the planetary atmospheres. For it must be noticed that this light—which originally comes from the sun—is not necessarily reflected by the surface of the planet itself, but may come from its outer atmosphere. Some planets have very dense atmospheres, others atmospheres of great rarity, while, in the case of Mercury, there is hardly any atmosphere at all. The spectra of some planets contain strongly marked absorption bands, indicating that the light has penetrated the planetary atmosphere, the gases of which have caused absorption of certain frequencies. The light waves in these cases have probably reached the surface of the planets themselves. In other cases the planetary spectra are very similar to that of the solar spectrum, which would indicate either that the planet had no atmosphere, or that the light had been reflected from the outer part of the atmosphere itself.

In some cases, therefore, though not in others, an electromagnetic wave—even one of such a high frequency as that of light — can penetrate the planetary atmosphere and reach the surface of the planet itself. And if a wave of light frequency can do this, why cannot also one of radio frequency? Where there is an atmosphere which is penetrable by the sun's rays there is probably also an ionosphere, brought into being by the action of the rays upon the gas molecules of the planetary atmosphere. And since the nature and distribution of the gases of planetary atmospheres differ from those of our own it is reasonable so suppose that the ionospheres of the planets—if they exist—would exhibit different characteristics from those of the terrestrial ionosphere. There is also the question of the intensity of the sun's rays at the planets to be considered in this connection. It is probable, therefore, that there may be planetary ionospheres which are impervious to different ranges of radio frequencies than those to which our own ionospheres is impervious.

It would appear to be possible, however, for a wave of radio-frequency to penetrate to the surface of a planet in some cases. The frequency used would have to be of such a value that the wave would easily penetrate both our own ionosphere and that of the planet in question, and would not be greatly attenuated by absorption in either of these regions. So far as the terrestrial ionosphere is concerned these conditions are suited by a radio wave in the "ultra high" part of the spectrum—of a frequency of, say, 50 Mc/s or higher.

The answer to the first part of the question would therefore appear to be "Yes—in the case of some planets." In order to "hold wireless communication," however, habitation of the planet by intelligent beings is implied, in order that the communication may be two-way. This would rule out a number of the planets, for it does not seem reasonable to think that intelligent beings could exist on those planets whose density is very low—in some cases it is less than that of water. In other cases there are other reasons for thinking that habitation of the planet is improbable. But in a few cases—such as that of Venus and of Mars—the existence of intelligent life is not so highly improbable.

Attenuation and Absorption

The *practicability* of holding wireless communication with an inhabited planet is quite another matter, and does not at present appear to exist. When a radio wave travels outward from a transmitter—even when it is sent out in the narrowest possible "beam"—it gradually "spreads" out in directions at right angles to its direction of travel, so that it covers a greater and greater area the farther it advances. But the energy present in the wave front at a great distance from the transmitter is the same as it was when the wave front was near the transmitter, and, since the wave front covers a greater and greater area as it advances, the energy present at any one point in it becomes less and less the farther it travels. This weakening of the wave with distance travelled is called "spatial attenuation" and will occur even when no absorption at all is taking place. Considering the relatively great distances involved between the earth and other planets—40 to 50 million miles is about the shortest distance—it is evident that spatial attenuation would be very great, and that colossal power would have to be used at the transmitter in order to overcome it and provide a workable signal—according to our standard—at the receiving end. A rough estimate indicates that a transmitter power of the order of 6,000,000 kW would be necessary in order to provide a radio field intensity of 5 microvolts per metre at the nearest planet in the absence of any absorption. True the power necessary could be considerably reduced if a highly directional transmitting aerial array were used, but even so it would still be far in excess of that radiated by any existing transmitting station. So we may rule out the possibility of getting through to the planets at present.

As to whether there are any inexplicable radiations reaching us from outer space, so far as the *Wireless World* Brains Trust is aware, no ionisation which is detectable by present-day apparatus occurs at the earth's surface which cannot be attributed either to cosmic rays, gamma ray radiation from the earth itself or to radioactive emanations in the atmosphere. The cosmic rays themselves are thought to be due to radiations occurring during the creation (or possibly during the disintegration) of atoms in interstellar space, and therefore, not to be associated with any agency on one of the planets. There may, however, be radiations reaching us which are of an entirely different character to those capable of being detected by existing apparatus. The answer to the second part of the question would therefore appear to be "Not known." T. W. B.

"Wireless Engineer"

THE first of a series of three articles on harmonic distortion in AF transformers and another on determining the optimum operating conditions for transmitting valves for Class C telegraphy are published in the September issue of *Wireless Engineer*.

The issue also contains the usual comprehensive collection of abstracts from and references to recently published articles in the world's technical journals. Some of the abstracts extend to a page in length, although this is not necessarily an indication of their importance; the difficulty of language and accessibility are factors which influence this.

Published on the first of each month, *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).

INSTRUMENTS: *Test and Measuring Gear and Its Uses*

By W. H. CAZALY

VI. Electrolytic Condensers: Inductance and Capacitance at Radio Frequencies

IN the last section of this series the measurement of inductance and capacitance by testers and bridges utilising mains and AF power supplies was dealt with. It was found possible to measure inductance between about 0.5 henry and 100 henries, and capacitance between 0.0005 μF and 50 μF, by such means. Before going on to the matter of measurements at RF, of very small values of inductance and capacitance, the measurement of electrolytic condensers may as well be clea .d up.

In an electrolytic condenser the dielectric consists of a very thin layer of oxide on an aluminium foil electrode, created by "forming," i.e., passing current from the aluminium to the solution (contact with the latter being made by another piece of aluminium or the outer case). Since the oxide layer can be made extremely thin, an electrolytic condenser can be made to have a very high capacitance for its size, compared with other forms of condenser. However, the oxide layer is not stable; it is rapidly broken down if the direction of the current through the condenser is reversed. If it is to handle alternating voltage, it must have a steady DC potential impressed on it so that at no time do the negative peaks of the alternating voltage exceed this DC potential; in fact, the alternating voltage must only be a comparatively small fraction of the DC if overheating and breakdown are to be avoided. Finally, since there is always a small leakage current through an electrolytic condenser, the power factor is always very much higher than paper or mica dielectric condensers. This does not matter greatly at mains and audio frequencies, which is why electrolytic condensers are so often employed as smoothing condensers.

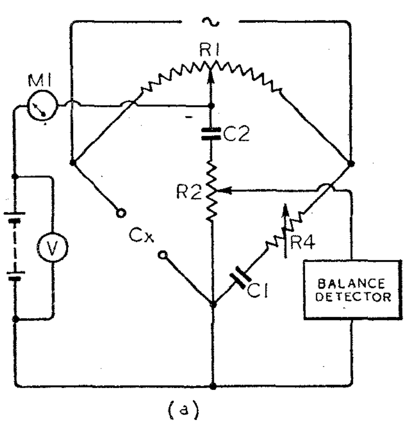
It is evident that they cannot be measured on the testers that have so far been described, since no provision has been made for the introduction of a steady DC polarising voltage. The form of bridge shown in Fig. 1 (a), however, enables a polarising voltage to be applied without affecting the action of the bridge, and by the inclusion of a milliameter M1, as shown, the leakage current can also be measured. The goodness of an electrolytic condenser is seldom given in terms of the "power factor," because this is always very high, but usually in terms of mA per μF "leakage." Thus a 10 μF condenser may, with its working voltage impressed across its terminals, have a leakage current of 0.1 mA, and the goodness will then be expressed as "0.01 mA/μF."

Since many electrolytic condensers are rated at several hundred volts (about 600 is roughly the maximum) it is advisable to employ mains supply power to energise the bridge and provide the polarising voltage, and for those who have a number of electrolytics to test it is worth while making up a mains-driven instrument for the purpose on the lines shown in Fig. 1 (b).

The balancing resistance R2 shown in the standard condenser arm is mainly for the purpose of securing a satisfactory zero indication of balance in view of the high power factor of the electrolytic being tested. Since the bridge is energised by a winding on the mains transformer at 50 c/s, a simple valve voltmeter is usually better as a balance indicator than headphones.

RF Measurements

The chief difficulties in measuring small values of inductance and capa-



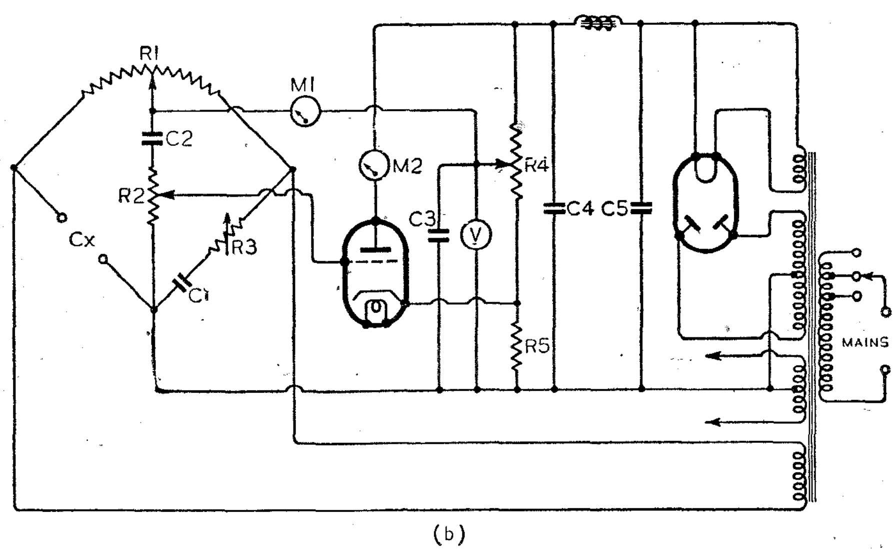


Fig. 1. (a) Circuit for testing the capacitance and leakage of electrolytic condensers, using batteries for the polarising voltage. 50 c/s from a mains transformer low-voltage secondary is a convenient and suitable means of energising the bridge, and a sensitive AC milliammeter or valve voltmeter should be used to detect balance. (b) A mains version. R2 is the sensitivity control, M1 the leakage meter, and M2 the balance detector in the anode circuit of the simple valve voltmeter. Smoothing must be extremely good.

citance by means of bridges arise from the very high or low reactances offered by them, and from the inevitable presence of stray reactances due to the various components of the bridge. For instance, a 10 $\mu\mu$F condenser offers a reactance at even 1,000 c/s of 16 million ohms. In the first place, a bridge with reactance of such an order in each arm would require an inordinately high energising voltage to enable balance to be accurately obtained. In the second place, if the reactance were to be reduced by increasing the frequency of the energising voltage, there would still be the stray capacitances to be reckoned with —as shown in Fig. 2. Bridges that are energised by RF at, say, 1 Mc/s, are, therefore, constructed with elaborate and careful screening systems that aim at making all the strays symmetrical.

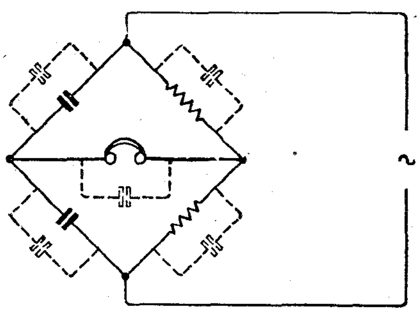


Fig. 2. The existence of stray and unknown capacitances in a simple bridge make it unreliable for measurements of low values without special precautions.

This makes the instrument costly, and. unless repeatedly checked, none too reliable. Balance is indicated by means of some form of valve voltmeter or oscillating detector, which adds further to the complication.

However, a RF bridge in a special form may be used to match two variable condensers on one shaft. The test condensers themselves are made to form one side of the bridge, as shown in Fig. 3. Two equal standard condensers, or resistances, form the other side of the bridge, and as the gang condenser under test is rotated, any inequality in the capacitances of the two halves is revealed by the development of a p.d. across A and B—i.e., balance is lost. It may be restored, of course, by adjustment of, say, split end-vanes in one or the other of the two ganged condensers.

The almost standard method of measuring very small capacitance is the substitution method, using a carefully calibrated variable standard condenser—a glorified "straight-line-capacity law" tuning condenser similar to a type that used to be employed in receivers at the very beginning of broadcasting before "log-law" and "straight-line-frequency" types came much into popular use. Such variable standard condensers are expensive and, unless extremely well made, apt to suffer from loss of accuracy due to temperature and other effects, but they are amongst the most useful pieces of apparatus in the laboratory. Their capacitance varies proportionally to the amount of meshing of stator and rotor vanes, and the scale is calibrated to read directly in $\mu\mu$F.

Substitution Methods

One way of using such a condenser for the measurement of a small value of capacitance is shown in Fig. 4. The variable standard condenser C1 is made to act as the tuning capacitance in a simple valve oscillator. The radiation from this oscillator is received on a simple form of oscillating receiver—the plain reaction type is suitable—which is tuned to zero beat with the testing oscillator. Under these conditions, the capacitance of the standard variable condenser is noted from its dial, and then the small condenser C2 to be tested is connected with very short leads across the standard. This will alter the frequency of the testing oscillator, and the oscillating receiver will then produce a beat-note in the headphones—unless the change in tuning capacitance brought about by the addition of the unknown condenser across the standard is so great that the beat-note is too high for audibility. In any case, the standard variable condenser is now altered in capacitance until zero beat is again obtained in the oscillating receiver phones, and the dial setting (or value of capacitance) required to do this noted. Then, plainly, the value of the unknown capacitance is equal to the difference between the first setting the standard variable and the second setting. With care, this can be a very accurate method of measuring small capacitance. The principle can be used, of course, to match the sections of a ganged con-

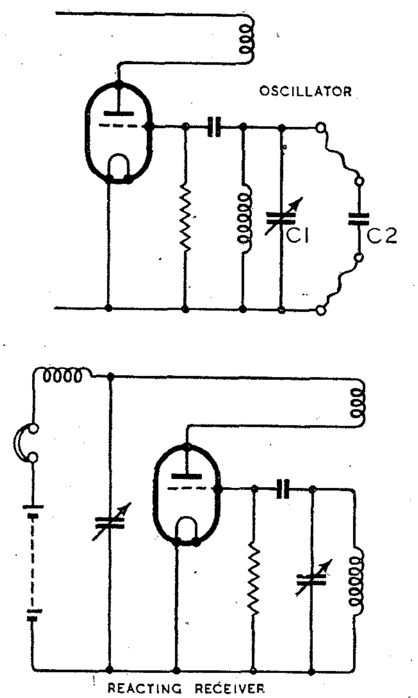


Fig. 4. Set-up for measuring a small capacitance, C2, by noting its effect on the tuning of the oscillator and consequent necessary alteration in the setting of the calibrated variable standard C1.

denser; first, the testing oscillator is tuned by one section of the gang and zero beat obtained in the checking or oscillating receiver, and then the lead is changed over to another section of the gang (without, of course, altering the setting of the gang common shaft), and if zero beat is obtained, the sections involved are of equal capacitance.

Before going on to the matter of measuring small coil inductance, mention must be made of two factors met with in RF work, that have much more importance than in ordinary AF measurements. In connection with

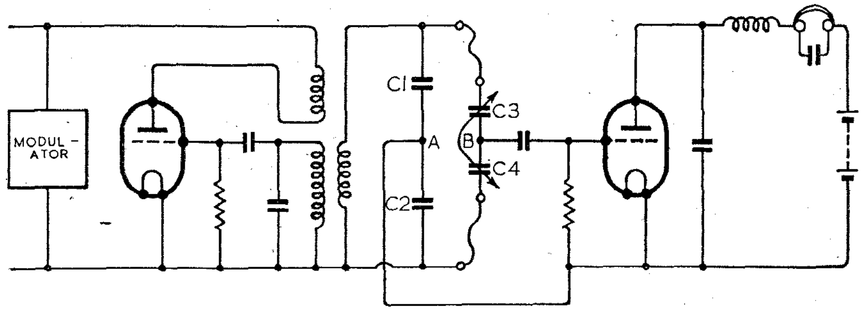


Fig. 3. A bridge for matching ganged condensers (C3C4). Very careful matching also of the stray capacities is essential.

Instruments—
condensers it is the "power factor" and in connection with coils it is "Q." It is important to realise that both these factors come into play in estimating the performance of a circuit at high frequencies as a result of a peculiar thing that is summed up in the words "HF resistance." A slight digression may here be helpful to what follows later. It should be understood that the essential effect of resistance, as differing from reactance, lies from a practical point of view in the loss of energy that it brings about.

For example, a condenser may have a high "power factor" even though the insulation between the plates is excellent and the capacitance normal. This may occur because the dielectric material is unsuitable. When a condenser is repeatedly charged and discharged and then charged up with reversed polarity and again discharged and so on—which is what happens when a condenser "passes AC"—the dielectric layer is subjected to cyclic strains in its atomic structure. The effect has an analogy in the compression and expansion of a piece of rubber. Suppose, however, that putty is used instead of rubber. Unlike rubber, when the putty is compressed it stays compressed or flattened and does not give back the energy required to flatten it. The energy devoted to the flattening and expansion manifests itself eventually as heat. An analogous sort of thing occurs in the dielectric of a poorly made condenser, and the final manifestation is again heat, which may eventually break down the insulation between the plates. It is for this reason that electrolytic condensers, although they can withstand a considerable steady DC potential between their electrodes, break down if too high and rapid an alternating voltage is superimposed on this DC potential.

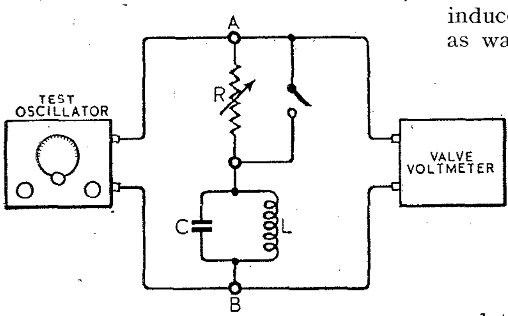


Fig. 5. Set-up for measuring the dynamic impedance of a parallel tuned circuit, LC. The variable resistance R must be of very low self-capacity and residual inductance. Some composition types are suitable even at intermediate frequencies.

Thus it may be plain how *losses* can occur in a condenser without any obvious "Ohm's Law" resistance being present. Moreover, the higher the frequency involved the greater the losses.

It is convenient to express these losses in terms of their electrical effects, which are the same as those of actual "Ohm's Law" resistance. One of these effects is a departure from the ideal 90-degree phase relationship between the current through and the voltage across a condenser passing AC—hence the apparently odd term "Cos θ" in which the "power factor" of a condenser is very often stated. This expresses the ratio between the true power and the apparent power in the circuit in terms of the phase angle θ between voltage and current. In a perfect condenser θ is 90 degrees and "Cos θ" is zero.

Defining "Q"

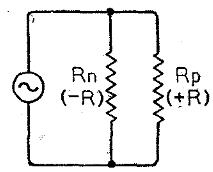
Losses can also occur in a coil, independently of the "Ohm's Law" resistance of the windings of the coil, which may be, in the case of a short-wave tuning coil, very small indeed. For example, a coil inside a screening can inevitably causes more loss of electrical energy than a coil without a can and mounted well away from conductors such as metal chassis and screening plates, although the "Ohm's Law" resistance as measured with DC is no greater. This is because the alternating current through the coil sets up a moving magnetic field that induces current in the screening can, as was explained in a recent article,[1] and this current in the screening can material, which always offers some resistance, means a transference of electrical energy from the coil to the can from which it cannot be recovered.

If the foregoing very sketchy outline of "HF resistance" has been understood, the meaning of "Q" may be clear, from what follows. "Q" is a term that has come to be accepted as a "figure of merit" for coils and tuned circuits. It is the ratio of the purely reactive impedance of a circuit to the resistance—resistance, in this case, and especially at RF, meaning the AC and not the "Ohm's Law" resistance. For a coil, therefore, $Q = \frac{\omega L}{R}$. For a tuned circuit containing both inductance and capacitance, it does not matter whether the resistance exists (or the losses occur) in the inductance or the capacitance so far as the behaviour of the circuit as a whole is concerned, and it is therefore possible, in theory, to regard Q as still dependent on the goodness of the coil. This is actually nearly always the case, since, except at the ultra-high frequencies, good air-spaced condensers have very low losses as compared with even the best of coils.

[1] "Intercircuit Screening," by M. Read. *Wireless World*, June 1942, p. 135.

The measurements that follow, of the dynamic resistance of a tuned circuit, the inductance and the Q of a coil, the comparative goodness of a condenser, and the self-capacitance of a coil, are carried out by means of apparatus that is not quite so simple in either construction or use as that which has been discussed already. The accurately calibrated variable condenser, of the order of 0.0005 μF maximum, is practically essential, and there are also required an accurately calibrated test oscillator and a good valve voltmeter. These three items are actually included in a form of composite instrument known as a "Q-Meter" that is available in several commercial forms. For present purposes, however, it may be best to regard them as separate instruments.

Fig. 6. Showing the principle of adding positive (Rp) and negative (Rn) resistances in parallel.



The dynamic impedance of a tuned circuit may be measured in several ways, of which only two will be dealt with—the "equivalent resistance" and the "negative resistance" methods. The principle of the first is simply that an actual ohmic resistance is placed in series with the tuned circuit and adjusted until either the make-up current through, or the voltage developed across, the tuned circuit is halved. The set-up is illustrated in Fig. 5. Taking the voltage method: first, the voltage developed across the

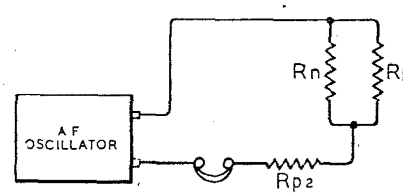


Fig. 7. General form of circuit for measuring the value of an unknown negative resistance Rn. The positive resistances, Rp, are familiar as "ordinary" physical elements. When Rp1 is equal to Rn, the parallel combination of Rn Rp1 offers infinite resistance, hence no sound is heard in the phones. Rp2 is a safeguarding resistance. Rn may be a valve circuit such as a dynatron.

tuned circuit LC by the test oscillator is measured by the valve voltmeter with the series resistance R short-circuited. Then the resistance is brought into circuit by the removal of the short, and adjusted until exactly half the first voltage is shown on the valve voltmeter. Then, plainly, the value of the ohmic resistance, which can be ascertained by the usual DC methods separately, is equal to the impedance offered by the tuned circuit. The usual precautions against stray capacitance due to wiring and to the resistance R itself have to be guarded against.

Negative Resistance Methods

A "negative resistance" is a device that supplies energy to a circuit—the opposite of a positive resistance, that is. It can be represented in a circuit by means of the usual symbol for resistance, and suitably marked to distinguish it from positive resistance. In Fig. 6 are shown a negative and a positive resistance in parallel, while a generator applies a p.d. across them.

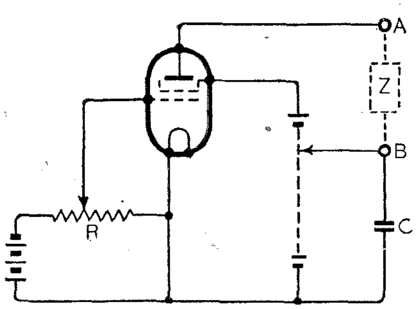
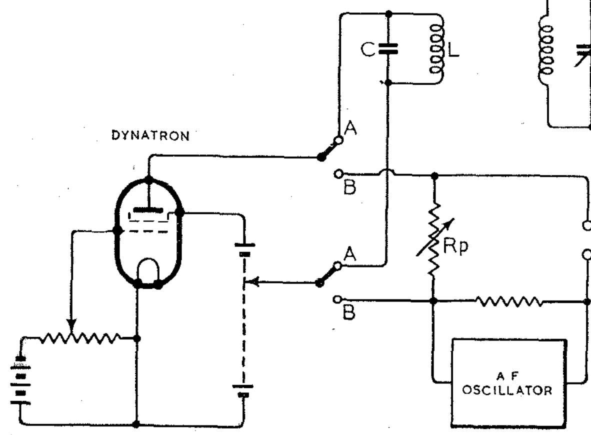


Fig. 8. A screened grid valve used as a dynatron, or as a negative resistance across A and B. The value of the negative resistance so produced may be controlled by a negative bias on the control grid. Z may be a tuned circuit. Note that the anode is at a lower HT voltage than the screening grid. This is a fairly critical adjustment. C is a by-pass condenser of large value.

The effective resistance of this parallel combination is given by $R = \frac{R_1 \times R_2}{R_1 \, (-R_2)}$ Now, if $R_1 = R_2$, $R = \frac{R_1 \times R_2}{0}$, which means that R is then infinite—and no current will flow through the parallel combination.

A circuit can be made up, therefore, to measure the ohmic value of a negative resistance, of the general form shown in Fig. 7. R_1 is adjusted until no sound is heard in the phones, which means that $R_1 = R_2$. R_1 may then be measured by ordinary means, using DC, unless, being a calibrated variable resistance, its resistance is already known from the dial reading.

There are several devices that provide negative resistance, of which the valve used as an oscillator is one, and the form of oscillator that is chiefly used in laboratory measurements is the "dynatron," on account of the ease with which tuned circuits to be tested may be connected (no "reaction coil" is needed) and the purity of the wave-form it generates.



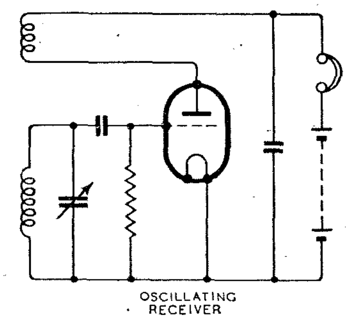


Fig. 9. Skeleton circuit showing general principles for measuring the dynamic impedance at resonance of a tuned circuit LC.

This is simply a screened grid valve, connected as shown in Fig. 8, and the tuned circuit to be tested is connected to the test terminals A and B. For the operation of this device, reference should be made to Fig. 9. The process —with variations due to any particular form in which the principle is employed in a practical instrument—is in general terms as follows: First, the negative resistance of the valve is adjusted by means of the grid bias until the tuned circuit is *just* set into oscillation. This is detected by a simple form of autodyne or oscillating receiver, in the phones of which a beat-note can be obtained when the tuned circuit under test is oscillating. Now the tuned circuit is disconnected and in its place is connected the circuit for measuring the screened grid valve negative resistance, which—since this was made just sufficient to maintain oscillation in the tuned circuit—will be the same as that of the tuned circuit.

The inductance of a coil of the order of millihenries can be measured by a bridge circuit, if a calibrated variable inductance is employed, as shown in Fig. 10, and the bridge is energised by a fairly high AF, say of the order of 1,000 c/s, from an oscillator. An inductometer provides the required standard variable inductance, and consists of a glorified version of what used to be called a "variometer"; two inductances are connected in series and arranged so that one is fixed and the other is rotatable so that its field may either assist or oppose that of the fixed inductance; the overall inductance of the two coils in series can thus be varied from zero to their sum with the mutual inductance aiding. But this bridge method is not satisfactory with inductances below a few millihenries, and recourse must then be had to first principle methods. A calibrated test oscillator, to energise the tuned circuit formed by the coil under test and a calibrated variable condenser, and a valve voltmeter to indicate resonance, are employed. The process is to set the condenser at some definite capacitance, and to connect the coil under test across it. Then the test oscillator is coupled to this tuned circuit in such a way that it does not also couple with the pick-up coil of the valve voltmeter.

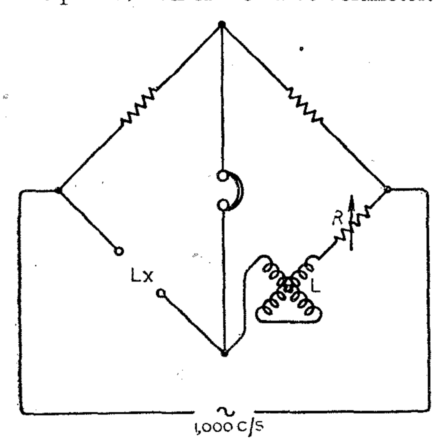


Fig. 10. Bridge for measuring an inductance Lx. The effect of the DC resistance of this coil is balanced by R, and L is a variable standard inductance.

Instruments—

The test oscillator is then tuned to resonance with the tuned ciruit which is indicated by maximum reading in the valve voltmeter. Knowing the frequency from the calibration of the test oscillator, and the capacitance of the condenser, the inductance of the coil can be worked out from the formula $f=\frac{10^6}{2\pi\sqrt{LC}}$ from which $L=\frac{10^6}{4\pi^2 f^2 C}$ where L is in μH, C in μF, and f in Mc/s.

The Q of a coil is measured by making use of the fact that the voltage developed across a coil in a series circuit with a condenser is Q times V, where V is the applied voltage. Reference to Fig. 11(a) shows the principle. First, the valve voltmeter measures the voltage applied across the series tuned circuit *at resonance*. At resonance, the only impedance offered by such a series tuned circuit is due to the resistance—which may be actual ohmic resistance due, say, to the resistance of the coil wire, or to some form of loss, as was explained earlier, such as the presence of a screening can. Let this applied voltage be V_1 and the RF resistance be R. Now the voltage existing across the coil is measured by the valve voltmeter, and it will be found to be much greater than the applied voltage—in fact, it will be $V=Q\times R$. Let this coil voltage be V_2. Then $\frac{V_1}{V_2}=\frac{R}{Q\times R}$ or $\frac{V_2}{V_1}=Q$.

If, now, V_1 is made equal to 1 volt, the voltage V_2 measured on the valve voltmeter is a direct indication of the Q of the coil. Since Q may be as high as 100, necessitating the use of a valve voltmeter capable of measuring 100 volts, and also in order that the impedance of the output of the test oscillator, which acts as a generator, may be so low that it can be neglected, a Q meter usually consists of an oscillator developing a low voltage of, say, 0.1 volt across a very low resistance which is in series with the tuned circuit, as shown in Fig. 11(b). Then a Q of 100 would be shown as 10 volts on the valve voltmeter scale, and so proportionately with other values of Q. If the tuning condenser happens to be a calibrated standard, of extremely good electrical construction—i.e., air-spaced and losses so low that they may be ignored in all but very high frequency circuits—the goodness of small test condensers with, say, solid dielectric, may be tested for their effect on the Q of the tuned circuit by placing them in parallel with the standard condenser and observing the difference they make to the Q indicated on the valve voltmeter.

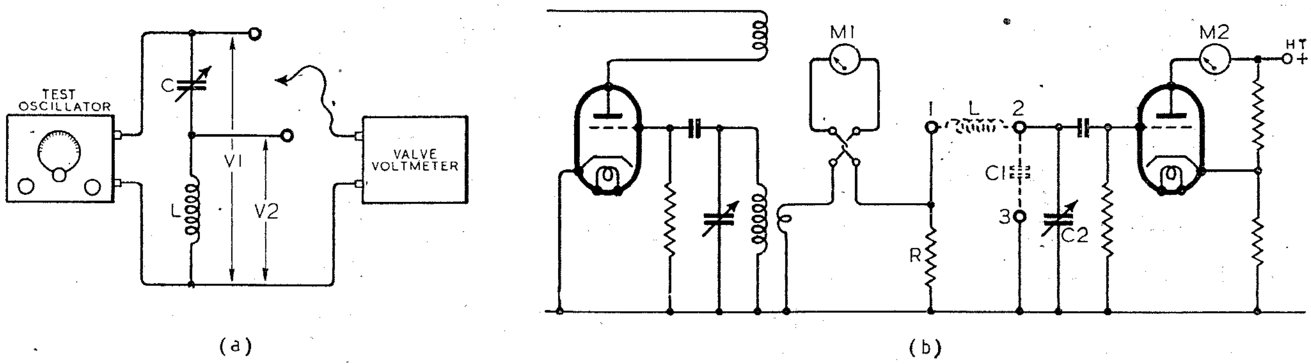


Fig. 11. (a) Circuit showing principle of coil "Q" measurement. (b) Basic circuit of a "Q" or Circuit Magnification Meter. M1 is a thermocouple RF meter used to develop a standard output from the oscillator across R the coupling resistance. The test inductance L is normally in series with the standard variable condenser C2, but across 2 and 3 a condenser under test may be connected.

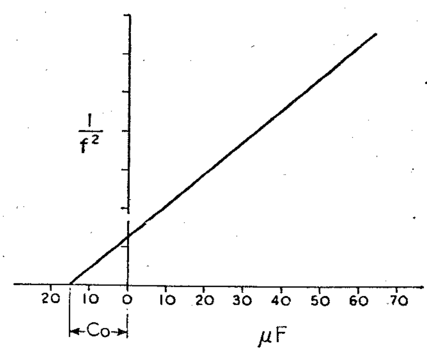


Fig. 12. Graph of frequency against tuning capacity, for ascertaining the self-capacity of a coil.

The self-capacitance of a coil is again ascertained by using a series of known frequencies from the test oscillator and the standard variable condenser. The procedure is to set up the apparatus as if for measuring the inductance of the coil, as has been described earlier. Then a series of observations are taken of the resonant frequencies obtained with known small increases of tuning capacitance. From these two sets of figures—frequency and tuning capacitance—a graph is plotted, as shown in Fig. 12, and the line made by joining the points is extended beyond the vertical ordinate, as shown in dotted line. Where this extended line cuts the horizontal or capacitance ordinate gives the residual capacitance due to the self-capacitance of the coil itself.

The foregoing presents a brief outline of a branch of measurement that has already a very wide choice of methods, and that is presenting fresh problems as the study of higher frequency phenomena expands. It will be seen that most of the measurements involve methods and precision instruments of the laboratory, rather than the ordinary workshop, type, and of deductions from first principles. There is considerable scope in this field for the ingenuity of the "practical man" in devising simple and easily operated devices and circuits for use with the ever higher frequencies that are becoming involved in modern wireless technique.

Waste Paper Appeal

In co-operation with the Waste Paper Recovery Association many trades and professions have started waste-paper drives to organise the salvaging of paper within their own ranks in support of the national effort. 5,000 tons of waste paper before Christmas is the target of the wireless industry in its salvage drive inaugurated last month.

"Sunspots and Short Waves"

The expression "non-critical frequencies" in line 21 of this article in our September issue, should, of course, read "*noon* critical frequencies." The same misprint occurred in the inscription to Fig. 1.

PHYSICAL FOUNDATIONS OF RADIO

II.—Semi-conductors, Superconductivity, and Alloys

By
MARTIN JOHNSON,
D.Sc.

IN the first article of this series we discussed the migration of "free" electrons along a wire as the source of its electrical conductivity. The question was raised as to what could be meant by the handing on of an outermost electron from one lattice atom to another along the crystal structure of a simplified model metal. It was found that without knowing definitely the length of "mean free path," or distance travelled by electrons between encounters with successive atoms, the Wiedemann-Franz law connecting thermal and electrical conductions could be explained.

The next step is to examine properties of common conducting materials not accounted for in that simplified picture. We have to see why metals of different chemical properties have different resistivity, and to follow these differences into the regions of semi-conductors and insulators. We have also to meet the difficulties raised by the specific heats of conductors, by their behaviour in magnetic fields, and by the fantastic state of superconductivity in which the ordinary properties of resistance seem to fail entirely. Finally we have to recognise that alloys possess laws of their own, which may be usefully exploited in selecting conductor and resistor materials.

Impure Metals, Semi-conductors, and Insulators.—In our previous account of free electron migration we utilised both of the two modern ways of regarding an electron: originally it was considered essentially a detachable planet revolving round its atom, but latterly it is credited with the properties of waves capable of penetrating potential barriers from atom to atom. But in each of these two incomplete models of electronic behaviour, the binding of the electron to its accompanying structure can be expressed in terms of its energy or the work required to displace it. Semi-conductors and resistance materials can be seen as beginning a transition towards insulator habits. By enquiring as to the energy associated with all those electrons which might, when liberated, join the conduction stream, we may be able to predict the electrical properties of the material.

For a pure metal, the electrons whose energy is relevant to conductivity belong to the outermost structure of each atom only; they are in general known as the valency electrons, since it is their binding which determines the possibility of chemical combination with other atomic species. Valency is more commonly studied for elements in solution, for instance as they are found in battery cells: there it denotes the actual number of electrons which a single atom loses or acquires in forming the positive or negative ion. The valency will also in the simplest cases be equal to the difference between the number of electrons possessed by an atom and the number possessed by the inert element nearest to it in the serial table of elements, since the inert atom has no available valency electrons and is incapable of entering into chemical reactions.

But conductivity by free electrons is not proportional to the number of valency electrons per atom. This is seen when we notice that the best conductors, copper and silver, are only monovalent; divalent or trivalent metals being often more resistive. A more decisive factor is the grouping of the electrons in "shells," as we shall see shortly. For instance, the possession of two valency electrons per atom instead of one may mean (at low temperature) a difference between the highest conductivity and a degree of insulation needing a million volts per cm. to transfer an electron; the reason appears as a complete rearrangement of the fitting of electrons into "bands." By "bands" in this connection has come to be meant the grouping of possible states, characterised by definite energy for any electron in that state—if these energies are closely alike they can be drawn as closely packed lines on a diagram looking very like an optical band spectrum.

For an impure metal, the energy of electrons in foreign atoms which did not belong to the original lattice may place them more favourably with regard to contributing to the free stream. On the other hand, these impurity strangers often impede the flow of the conducting stream. Along such lines are sought the explanations both of semi-conductors and of highly resistive alloys; in either case a small trace of foreign material often makes as much difference to conduction as if we were to exchange the pure metal for another pure metal of different valency (see Fig. 3).

Many semi-conductors only admit of migration of those electrons which are supplied by impurities present in the metal: for instance, in the cuprous oxide of some rectifiers the "free" electrons are probably supplied by the surplus oxygen atoms. To fit the facts the number of impurity molecules comes out at about 10^{17} per cubic cm., but this enormous number is only a small fraction, about 1 in 10^5, of the number of molecules of the pure substance. The temperature variation of conductivity in these materials, which are often oxides, halides, or sulphides, is in the opposite direction to that of a fully conducting metal, conduction rising instead of falling with heating. The discovery that some semi-conductors are light-sensitive, passing current only during or after suitable illumination, means that absorption of radiant energy can confer "liberation" on certain electrons, enabling the work to be performed which is needed in cutting across equipotentials too far apart for unaided leakage. This process is analogous to one we shall discuss for photo cells in a later article.

Electrons in Atomic Shells.—When we look around for the origin of these correlations between chemical classification and the availability of free electrons for conduction, we find that the selection of materials for conductors or resistors or insulators in practice will depend on how the electrons within an atom tend to fill up possible locations; these locations are referred to as "shells," though without any insistence upon spherical symmetry and without any idea of implying a static immobility.

There are 92 chemical elements, from the lightest, hydrogen, whose atom contains only one electron outside the nucleus, to uranium containing 92, the number of electrons constituting the "atomic number." Alphabetical letters are generally used to denote the shells, together with numbers, and in successive elements of increasing mass these shells become filled up.

For our case of electrical conductivity the most favourable conditions appear with the group which contains copper, silver and gold, which have one electron outside a closed set of shells of the other electrons. The alkali metals lithium, sodium, potassium, rubidium and caesium also have this electronic configuration, though for each of them it is a different shell; we have therefore the apparently haphazard sequence that the atomic numbers 29, 47, 79, and then 3, 11, 19, 37, 55, show high conductivity.

Strictly speaking, the quantity whose magnitude is large for these metals is not simple conductivity, but specific conductivity divided by atomic mass and square of a temperature characterising thermal vibrations; since our explanation of the temperature dependence suggests that "conduction per unit amplitude of lattice vibration" is what atomic structure really controls. The more precise specification eliminates the different ways in which lattice atoms are able to disturb the flow of electrons.

Conductivity drops by a factor of 2 or even 4 on passing from the above monovalent to the divalent metals which are adjacent to them in the periodic table of elements. An important item in the control of the situation by the atomic structure is seen from the low conductivity of the "transition elements": a "d" shell in each of these is incomplete in its complement of electrons, giving rise to a larger chance of the freed electrons becoming scattered in their migrations and having a shorter mean free path. Among these transition metals in common use for radio and other constructions are chromium, manganese, iron, cobalt, nickel, molybdenum, tantalum, tungsten and platinum. Radio designers will at once recognise that here we have resistor metals, especially when alloyed with others. The reason that some of them form a good base for cathode material is not, therefore, that they possess more available free electrons, but that the potential barriers preventing emission are amenable in these cases to doping by impurity, and also that they stand up to high temperature. This subject will recur later.

Specific Heat of Electron Gas in a Metal.—Everything we have said involves the notion that a metal differs from an insulator in containing loose electrons as well as fixed atoms, probably about as many of each. Then on the old principle that heat energy given to any material divides itself equally between the motions or vibrations of all the separate constituents, the heat required to raise the temperature of the metal atoms plus electrons (since the latter when free have separate motions) ought to exceed that required by an insulator whose electrons are bound to their atoms. Actually metals do not show this expected extra specific heat or atomic heat. Have the free electrons no capacity for absorbing heat although we have seen that they conduct heat? This anomaly was only understood when it became realised that the electron "gas," although freely flowing, corresponds to an enormous pressure far in excess of atmospheric experience. The free electron flow in the metal obeys not the familiar gas laws but the new ones of Fermi and Dirac, among which an extremely low heat capacity is predicted for other reasons. It has become intriguing and by no means unconvincing, to calculate the intrinsic energy of this gas of electrons which belongs only among the packed atoms of a solid metal; the molecular weight is one eighteen-hundredth of that of atomic hydrogen but the number of particles per unit volume, about 10^{22}, would in a molecular gas correspond to tremendous compression.

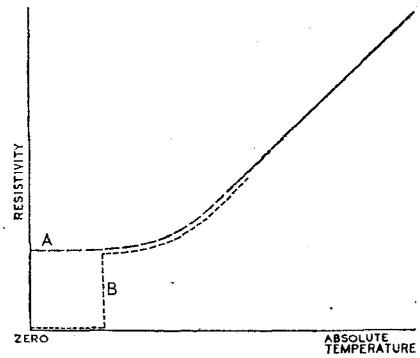


Fig. 1. Resistance phenomena near the absolute zero of temperature. A, residual resistance; B, superconductivity.

Conducting Metals in a Magnetic Field.—A metal carrying either a flow of heat or an electric current, if placed in a transverse magnetic field, shows a potential difference and a temperature gradient perpendicular to both field and flow. This is perfectly rational, as the electrons are inevitably deflected by the magnetic field. But what made this "Hall effect" more of a trouble than a triumph for the electronic theory, was that for some metals the direction of these sideways effects were opposite to the direction demanded by the negative charge of all electrons. A hint towards solving this anomaly is that a region of local deficiency in electrons may behave and move as if it were a spot positively charged, exhibiting a Hall effect of reversed sign.

Superconductivity.—This phenomenon will probably for long save us from too smug a complacency about our understanding of the electrical behaviour of metals. There are a few laboratories, notably that in the University of Leyden, in which has been developed the peculiar and difficult technique of experimenting at temperatures more than 260 deg. C. below that of ice, and within the last half-dozen degrees above the absolute and unattainable zero of −273 deg. Here, in baths of liquefied helium gas, metallic conduction "runs wild." On our simplest theory discussed above, specific resistance ought to diminish steadily to zero at the absolute temperature zero. Actually it often tends to break away as if intending to finish as a very minute "residual" resistance (line A in Fig. 1). But many metals reverse this tendency by suddenly losing all their resistance several degrees above the zero (line B in Fig. 1). This is known as "superconductivity," and though it has been said that we only have to induce this virtue at ordinary temperatures to solve many of the power engineer's difficulties, he would face a new nightmare if we succeeded. Actually, the "transition" temperature at which this strange effect sets in has been raised by alloying, but only a degree or two.

Direct resistance measurement here becomes weird and unmanageable, but one sidelight from familiar radio constants is of interest: we know that when a potential is applied or removed, the change in current is not completed quite instantaneously, and the "time constant" λ of a circuit with resistance R and inductance L gives the rate of decay or removal of potential as

$$i_t = i_o\, e^{-t/\lambda} = i_o\, e^{-\frac{R}{L}t}$$

The fall to $1/e$ or $1/2.7$ of initial value occurs in L/R seconds. Except for inductance of large choke size L/R is commonly a thousandth or a millionth of a second. But on a famous occasion, the Leyden physicists induced a current in a metal ring immersed in liquid helium at a few degrees above absolute zero, then removed the source of potential and sent the whole apparatus to an English scientific gathering by aircraft; so complete had been the loss of resistance in superconductivity that the fall of current took hours instead of microseconds, and the English gathering found the current still running. From the above equation R in some cases must be 10^{-10} of its normal value.

Alloys.—Most of these complicate drastically the simple resistance-temperature properties which we found true for pure metals when not too refrigerated. But their "irregularities," if tamed, can be very useful: for example "Constantan" (copper 60 and nickel 40 per cent.) and "Manganin" (copper 84, manganese 12 and nickel 4 per cent.) have a resistance almost independent of temperature over hundreds of degrees and are valuable for standardising. The "transition" metals which we mentioned before are especially useful for these artificial mixtures.

Alloys of the best conductors, silver-gold and copper-gold mixtures, often show a maximum resistance at about 50-50 composition, several times the resistance of either constituent alone, Fig. 2. When one constituent is only in small proportions its effect can be even more striking, for instance, when a trace of tin in copper nearly doubles the resistance. Such cases lead to the view that an impurity can seriously impede free motion in the otherwise regular lattice, just as in the opposite sense an impurity in a semi-conductor

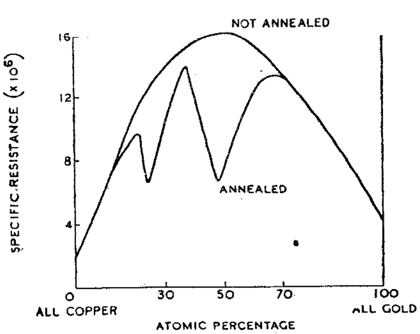


Fig. 2. Resistance of copper-gold alloys in relation to the proportions of the mixture (after Linde).

can confer conductivity. In general the "residual" resistance, referred to under superconductivity, is larger for alloys, and much ingenuity has been expended by laboratories in isolating it and by theorists in interpreting it. Like other features it emphasises that the simple theory which did so well for the purest metals at ordinary temperatures may be completely falsified by small irregularities in the lattice structure. These irregularities may be mechanical disturbance of the regular spacing of fixed atoms which had allowed long free paths, or chemical impurity of any atomic species capable of either supplying extra free electrons or capturing some of those already free to wander. We exhibit

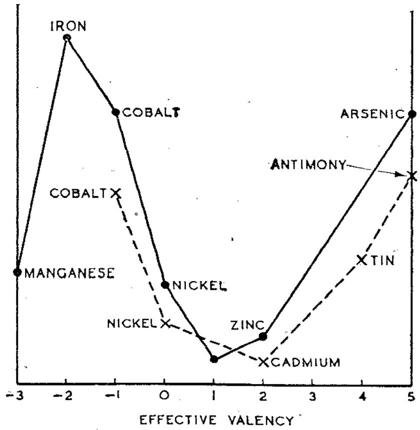


Fig. 3. Increase of resistivity per atomic percentage of impurity metals dissolved in copper (full line) and silver (dotted line), plotted against the effective valency of the dissolved impurities (after Linde).

(Fig 3) some results by Linde, showing that valency is of importance in the conductivity of alloys, as well as in pure metals. In fact, a really pure and structurally perfect metal would be less intriguing to the physicist and in many ways a less useful tool to the technologist.

Books Received

Problems in Radio Engineering, by E. T. A. Rapson.—This book, which is a fifth edition, contains problems drawn from examination papers of the I.E.E., the City and Guilds Institute and the University of London. The problems were originally collated to assist those studying for the Higher National Certificate at Southall Technical College. Pp. 150. 18 diagrams. Price 5s.

Elementary Mathematics for Wireless Operators, by W. E. Crook.—In addition to the usual subjects of arithmetic, algebra, geometry and trignomentry this book includes a chapter on mechanics. The author aims at presenting these subjects in the simplest and most interesting manner possible in order to overcome the inherent dislike of the ordinary non-mathematical wireless man to tackling these necessary preliminaries to a serious study of wireless. Pp. 74. 42 diagrams. Price 3s. 6d.

Wireless Terms Explained, by "Decibel."—All wireless terms in common use are dealt with in this book. As its title implies, it aims at giving explanations rather than short definitions. Pp. 74. Price 2s. 6d.

The above books are published by Sir Isaac Pitman and Sons, Ltd., Parker Street, Kingsway, W.C.2.

UNBIASED

By

FREE GRID

Silent Sets

A MOST astonishing item of news caught my eye the other day in one of our great national "dailies," which prides itself on its perspicuity and is for ever telling us what are Hitler's intentions and loudly calling on the Government to take action in this or that direction. The item of news was to the effect that of late a considerable and increasing number of telephone call offices were being put out of action each night by the removal of vital parts of the mechanism by fifth columnists, and, according to their political correspondent, it was causing the Government grave anxiety.

If these supposed fifth columnists' activities are really perturbing the Government, I am fortunately in a position to relieve their troubled minds. It is true, I fear, that a certain number of telephone call offices are getting put out of action in this way, but nobody but a fool would imagine that fifth columnists would go to the trouble of removing "vital parts" and risk being stopped by a suspicious constable while carting them away, when all they need do is to sever connections with a pair of wire-cutters.

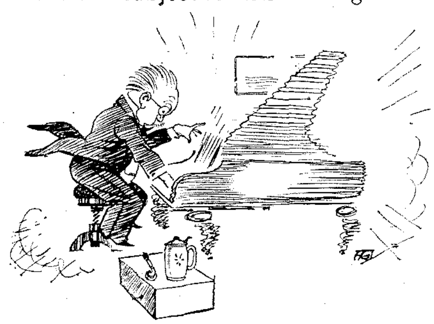
The explanation of these acts of depredation lies in the bewildering mass of contradictory instructions to the public issued from Whitehall. One moment we are told that it is vital to keep our wireless sets going in order that instructions may be issued to us in the event of a sudden emergency, and the next moment we are informed that it is criminal to spend money in wartime.

There is no section of the community which this Alice-in-Wonderland state of affairs affects more strongly than the patriotic citizen with a burnt-out choke or transformer in his wireless set. He cannot get a new choke from his dealer—even supposing the dealer had one—without paying for it and so making himself a criminal by spending money, and he cannot carry out the Government's instructions to keep his receiver working without obtaining a replacement. Naturally, therefore, he seeks to steer a middle course between this Scylla and Charybdis by obeying both instructions at the same time, which since they are equal and opposite is no easy task.

The only solution is to obtain a new choke or transformer without paying for it, and it is not surprising that the effort of trying to solve this unsolvable problem throws him off his mental balance and he casts all moral restraint to the winds, with the result that what the newspaper calls "vital parts" and what we wireless men call chokes and transformers disappear mysteriously from telephone kiosks, and Adolf's agents are unjustly suspected. The only and obvious solution is for the Government to arrange for a few more of these "vital parts" (not forgetting valves) to be issued free to the civilian population.

"Cathode Ray" Forward, Please

THOSE of you who can recall the old days before the war will no doubt recollect a well-known writer who, under the pen name of "Cathode Ray," used to charm away our cares each week and debunk our difficulties, making even the Calculus seem a fit subject for the kindergarten.



A pianist of international reputation

Where he is at the moment, I frankly do not know, but I have a problem after his own heart.

The problem arose at a reception given the other evening by a well-known Duchess to show off what she described as a pianist of international reputation, whom she had managed to get hold of. While the guests were arriving, loudspeakers were churning out the latest hot numbers on the Forces programme when one of the B.B.C.'s technical hitches occurred. Nothing daunted, the Duchess commanded the attendant menial to put on a record. When the record was put on I was very pleasantly surprised to find that instead of the falling-off in quality which is always to be expected when even the best of gramophone reproduction is substituted for its wireless counterpart, it was, if anything, rather better than before. This was, however, not so surprising when I noticed that use was being made of the amplifier described in this journal in the summer of 1939 and designed exclusively for reproduction from gramophone records.

While examining the amplifier my eye was attracted to a large grand piano complete with piano-player mechanism which was standing in the room, and I was soon plunged into an orgy of experimenting, comparing similar records on the piano-player and on the electric gramophone. As I expected, both suffered from that greatest of all fidelity defects which the wireless set also shares, namely, the fact that the recording or transmission as the case may be is "one-eared" and so lacks stereophonic realism. This was made startlingly obvious when the pianist whom we had come to hear took his place at the keyboard; realism, metaphorically speaking, immediately leapt at us, even though the pianist's "touch" was very third-rate.

What worried me, however, was that the recording rendered by the piano-player, although inferior to that of the live pianist, due to the lack of stereophony already mentioned, was markedly more realistic and satisfying than that of the gramophone, and nothing I could do altered matters. There was no question of any defect having developed in the pick-up, loudspeaker or any other part of the gramophone assembly and the record was practically new and by a first-class recording company. Volume was roughly the same in both cases and so was the position of loudspeaker and piano after I had rearranged things.

I was forced to admit, therefore, that for some reason or another, which I want "Cathode Ray" to explain, the reproduction of the piano-player was the better of the two. Is it, I wonder, something to do with scale distortion or contrast expansion and compression? One good lady who was present talked rather learnedly about the "psychic factor," whatever that may mean. In any case, I regard this as being entirely outside my province though I do not doubt for one moment that "Cathode Ray" could discourse learnedly upon it. Will he, therefore, remember that the good name of electrical reproduction is at stake and take up his too-long-disused pen.

The World of Wireless

COMPONENTS FOR MAINTENANCE

IT is understood that manufacturers are releasing, with the approval of the Board of Trade, a small quantity of radio components for the domestic market. They are to be used for the *maintenance* of domestic receivers, PA equipment and wireless relay equipment and for the *construction* of new PA ("music while you work") equipment and wireless relay systems.

Set manufacturers have already received an allocation of components for the completion of civilian sets in the course of manufacture, and the components now released must *not* be used for this purpose. To safeguard against the possibility of the misuse of these components, suppliers may be called upon by the Board of Trade to furnish particulars of the sales.

The components being released include vibrators, fixed and variable resistances, fixed and variable condensers, small switches, valve and CR tube holders, and transformer laminations.

The heavy demands of the Services limit the supplies of valves for domestic use, but it is understood that over the whole year sufficient valves of all except certain obsolete types should be available to maintain sets in use. The surest method of obtaining a replacement valve is to place a definite order with your normal dealer who will receive supplies as they are released.

SERVICE CERTIFICATE

NO official statement has so far been issued on the findings of the representatives of the British Institution of Radio Engineers, the Radio and Television Retailers' Association, and the Scottish Radio Retailers' Association, who recently met to discuss the question of awarding a national certificate in radio servicing.

It is, however, understood that agreement was reached and that the proposals recommending a servicing certificate examination are to be placed before the councils of the three organisations for ratification.

A.T.S. REPLACE MEN IN R.A.O.C.

AT an Ordnance Depot in the Home Counties members of the Women's Auxiliary Territorial Service are gradually replacing men in most of the branches of the Royal Army Ordnance Corps. The extent of "dilution," as it is officially called, will be one for one on the clerical staff and five for four on the stores staff, which covers all categories, including Wireless and Radio Mechanics.

A representative of *Wireless World* recently visited the depot to see what part the women were playing, so far as wireless was concerned. In the radio stores section they are replacing men in an ever-increasing number. It is suggested that ultimately men of the Corps will go to the depot and be trained by the women before being drafted for service oversea.

In one section the women were putting together, connecting up and subsequently packing for despatch the various units and accessories for complete transmitting and receiving stations. The apparatus handled varies in

A.T.S. Signals and Wireless Storewomen assembling and testing the R107 nine-valve AC receiver and No. 28 Pack Set.

World of Wireless—

power from the small No. 28 Pack transmitter-receiver o a 5-kW ground station. Incidentally, the No. 28 set is of the "all-dry" type, and is much lighter than its predecessor, No. 18. It is carried in a canvas case not much larger than a haversack.

In the section of the depot where radiolocation apparatus is handled, A.T.S. Radio Mechanics are given bench experience. They, too, will replace men both in the depots and in radio maintenance detachments which carry out repairs to radiolocation apparatus in the field. These girls, who must have reached matriculation standard at school, are given a four months' course at a polytechnic or similar school, and a two months' special course at a depot. They have a fairly high standard of technical training, so that when fully qualified they are quite capable of dismantling a radiolocation station section by section, locating faults, replacing the faulty components and reassembling. To facilitate maintenance, radiolocation stations are built on the rack system.

TRANS-RECEIVER PIONEER

LAURENCE HERMES, whose recent death at the age of 58 we regret to record, played a prominent part in the development of the portable transmitter-receiver. He was associated with broadcasting from its inception, and was later concerned with trade organisations and the early radio exhibitions. He introduced the Siemens-Karolus picture telegraphy system into this country. In partnership with his son, Major Lawrence W. Hermes, he was engaged in the development of compact ultra-short-wave equipment, and was joint managing director of Transreceivers, Ltd.

The late Laurence Hermes with one of the early transmitter-receivers designed by his son and made by Transreceivers, Ltd. The batteries were contained in a separate case.

VATICAN AND PRISONERS OF WAR

IT may not generally be known that the Vatican broadcasting station transmits the names of British prisoners of war in Italian hands on Monday and Tuesday mornings at 7 a.m. (BST) on a wavelength of 25.25 metres.

The staff of the *Catholic Times* undertook some time ago to listen to these transmissions and to communicate with the relatives of the prisoners. The home address of the prisoners has ceased to be given, and it will, therefore, be necessary for those desiring information of their relatives to forward details to 33, Chancery Lane, London, W.C.2.

IN BRIEF

China's Transmitters

THE Chinese Central Broadcasting Administration has established at Chungking the headquarters of the broadcasting service which now operates a dozen transmitters. The chief station is the medium-wave 75-kW transmitter XGOA, which has been transferred from Nanking to the present Chinese capital. Also situated at Chungking are two short-wave transmitters each of 35 kW. There is also a 10-kW short-wave transmitter in the province of Kweichow, and a 60-kW medium-wave transmitter in the province of Yunnan. In addition there are low-powered regional stations in other

NEWS IN ENGLISH FROM ABROAD

REGULAR SHORT-WAVE TRANSMISSIONS

Country : Station	Mc/s	Metres	Daily Bulletins (BST)
America			
WNBI (Bound Brook)	17.780	16.87	2.0†, 2.45‡, 4.0§‡, 6.0.
WRCA (Bound Brook)	9.670	31.02	7 0 a.m., 9.45 a.m.
WRCA	15.150	19.80	2.0†, 2.45‡, 4.0§‡, 6.0.
WGEO (Schenectady).	9.530	31.48	9.45 a.m., 9.0†, 10.55§‡.
WGEA (Schenectady).	15.330	19.57	2.0, 3.0, 7.45§‡, 11.0.
WBOS (Hull)	11.870	25.27	12.45 a.m.†, 12.0 mdt.
WBOS	15.210	19.72	2.0†, 2.45‡, 4.0§‡, 6.0.
WCAB (Philadelphia).	6.060	49.50	6.0 a.m.
WCBX (Wayne) ..	15.270	19.65	11.30 a.m., 3.30, 7.30‡, 9.30.
WCRC (Wayne) ..	11.860	25.30	11.30 a.m., 3.30, 7.30‡, 9.30.
WCW (New York) ..	15.870	18.90	3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0.
WRUL (Boston) ..	11.790	25.45	9.30‡, 11.45§‡.
WRUL	17.750	16.90	3.0‡, 3.45‡.
WLWO (Cincinnati) ..	6.080	49.34	6.0 a.m., 7.0 a.m.
WLWO	11.710	25.62	7.0, 8.0, 9.0, 10.0.
WLWO	15.250	19.67	3.0, 4.0, 5.0.
Australia			
VLQ6 (Sydney) ..	9.580	31.32	8.0 a.m.
VLG6 (Melbourne) ..	15.230	19.69	8.0 a.m.
China			
Chungking	11.900	25.21	2.0, 4.0, 9.30.
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			
SBU (Motala) ..	9.535	31.46	10.20.
SBT	15.150	19.80	4.0.
Turkey			
TAP (Ankara) ..	9.465	31.70	8.15.
U.S.S.R.			
Moscow	5.890	50.93	11.0.
	6.970	43.04	11.45.
	7.300	41.10	8.0. 9.0, 10.0, 11.0.
	7.360	40.76	11.0.
	7.560	39.68	11.0.
	9.390	31.95	4.0.
	11.830	25.36	4.0, 6.0.
	15.110	19.85	2.15 a.m., 12.40, 11.45.
	15.180	19.76	12.40, 11.45.
	15.230	19.70	2.15 a.m., 11.45.
	15.270	19.65	12.40.
	15.750	19.05	1.0 a.m., 2.0 a.m., 11.45
Kuibyshev	8.050	37.27	8.30.
	13.010	23.06	6.0 a.m., 2.0, 2.45.
	14.410	20.82	2.0, 2.45.
Vatican City			
HVJ	5.970	50.25	8.15.

MEDIUM-WAVE TRANSMISSIONS

Country : Station	kc/s	Metres	Daily Bulletins (BST)
Ireland			
Radio Eireann ..	565	531	1.40‡, 6.45, 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 on the opposite page.

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

provinces. The Chungking transmitting apparatus has been installed in bomb-proof shelters within the hills on which the city is built.

U.I.R.

TWENTY-FOUR countries were represented at the annual meetings of the International Broadcasting Union held at Ouchy, Lausanne, in June. Four of the countries participating were represented by proxy. The council of the Union decided to provide the wavelength checking station at Brussels with new equipment.

Dutch Station Sabotaged

THE powerful short-wave transmitter PHOHI at Kootwijk, which was one of the first high-power short-wave stations in the world, has not been transmitting since the beginning of August. The Dutch correspondent of *The Times* states that the Germans have arrested four Dutchmen who, it is said, committed an act of sabotage against a wireless transmitter, which is presumed to be PHOHI.

Germany's Clandestine Listeners

IN spite of the severe action taken by the National-Socialist authorities, it appears that many Germans have not revealed the existence of their receivers. From April, 1941, until March, 1942, the tribunals brought more than 1,700 actions against clandestine listeners; 1,482 of these have been sentenced, 40 to imprisonment and the others to fines of as much as 1,000 Marks.

Standardised Components

A SO-CALLED "European Convention" has standardised the types of wireless components to be manufactured in all Axis-occupied countries. It is also stated by the *Daily Telegraph* that an order limiting the manufacture of broadcast receivers in Germany and German-occupied countries to a "midget super type," which has no short-wave band, has been made by the official organisation of wireless manufacturers. This new set is apparently a smaller type of Volksempfanger.

Science of Navigation

Two prizes of £50 are to be offered this year by the Council of the Royal Society of Arts under the Thomas Gray Memorial Trust, the objects of which are "the advancement of the science of navigation and the scientific educational interests of the British Mercantile Marine." One of these will be given to any person of British or Allied nationality who may bring to the notice of the Council an invention by himself which in the opinion of the judges is considered to be an advancement in the science or practice of navigation. Competitors must forward their proofs of claim between October 1st and December 31st to the Acting Secretary, R.S.A., John Adam Street, London, W.C.2.

Listeners Condemned to Death

THE authorities at present governing Norway take more and more severe measures against those who listen to forbidden stations. Several of these "criminals" have been condemned to death, and not, as hitherto, *only* to forced labour.

Canada's Director-General

MAJOR W. E. GLADSTONE MURRAY, who prior to his appointment as General Manager of the Canadian Broadcasting Corporation in 1936 was Public Relations Officer at the B.B.C., has been appointed Director-General of Broadcasting in Canada. His successor as General Manager is Dr. J. S. Thomson, president of the University of Saskatchewan.

B.B.C. News in English

THE B.B.C.'s bulletin in English previously broadcast in the European service at 21.15 BST, is now radiated at the same time as the Empire bulletin at 21.45. The schedule of news bulletins in English and the short-wave bands in which they are broadcast are given in the following list. Times are BST.

0200, 0345, 0530	31, 25	1700, 1900	31, 25, 19, 16
0715	49, 41, 31, 25, 19	2145	49, 41, 31, 25, 19, 16
0900	49, 41, 31, 25, 19, 16	2245 (weekdays)	31, 25, 19
1200, 1400	25, 19, 16, 13	2345	31, 25

Record Salvage

THE KING, the Princesses and members of the Buckingham Palace staff, have contributed 140 gramophone records to the British Legion's drive to collect ten million discs for the reclamation of their shellac content. Any gifts of old or unwanted ten- or twelve-inch records of the nine brands controlled by E.M.I. and Decca should be taken to the local branch of the British Legion before September 30th. The proceeds from the sale of these records to the manufacturers will be shared between the Legion and the Hospital for Sick Children, Great Ormond Street.

Institution of Electrical Engineers

IT has been decided by the Council of the Institution of Electrical Engineers that it would be an advantage in the present circumstances for the meetings to commence earlier in the forthcoming session. The first ordinary meeting at which Professor Fortescue will give his presidential address, will, therefore, be held on October 1st.

Dr. R. L. Smith-Rose, the chairman of the Wireless Section, will deliver his inaugural address at the first meeting of the Section on October 7th, at 5.30.

Export Licensing

UNDER an Order (S.R. and O., 1942, No. 1640) which came into force on September 7th, licences are required to export the following wireless apparatus to all destinations.

Thermionic valve amplifiers, headphones and ear pieces and head bands therefor, hearing aids, loudspeakers and loudspeaker units, microphones, receiving sets and chassis, transmitting apparatus, valves and other electronic discharge tubes.

Scottish R.I.C.

THOSE in Scotland associated with the wireless industry who are interested in the formation of a Scottish counterpart of the Radio Industries Club are asked to communicate with J. Robertson, 95, West Nile Street, Glasgow, C.1.

B.I.C.

N. H. MILLER has been appointed London Branch Manager of British Insulated Cables, Ltd., in succession to H. J. Stone, who recently became Home Sales Manager.

Letters to the Editor

Receiver Data : Equivalent Circuits : Hearing Aids

Broadcast Receiver Data

YOUR contributor "Diallist," in the August issue of *Wireless World* remarks on the number of silent receivers owing to the extreme shortage of service-men, due to the requirements of the Armed Forces. Further to his remarks, I would suggest that the radio manufacturers could be a little more helpful in these times by supplying service and circuit data. The system whereby only registered dealers are entitled to service data, etc., is probably very fair and legitimate during normal conditions, but in the present circumstances who is to carry out receiver repairs?

I suggest that the necessary technical information should be supplied on application by the technician on his own business stationery, or if his application is supported by the firm employing him. A deposit of 5s., to be refunded on return of the data sheets, might be charged. Perhaps better still, a central library might be set up at the offices of one of the technical publications.

Though agreeing that the public should be protected against "dabblers," it seems a pity that test equipment and individual ability should be idle under present conditions.

N. R. HOLBROOK.

Birmingham, 14.

"Valve Equivalent Circuit"

WITH reference to Mr. Boyland's article in your May issue, a graphical treatment of the power aspect of the problem may explain more satisfactorily than a mathematical solution how an increase of power developed in the load is accompanied by reduced power in the valve.

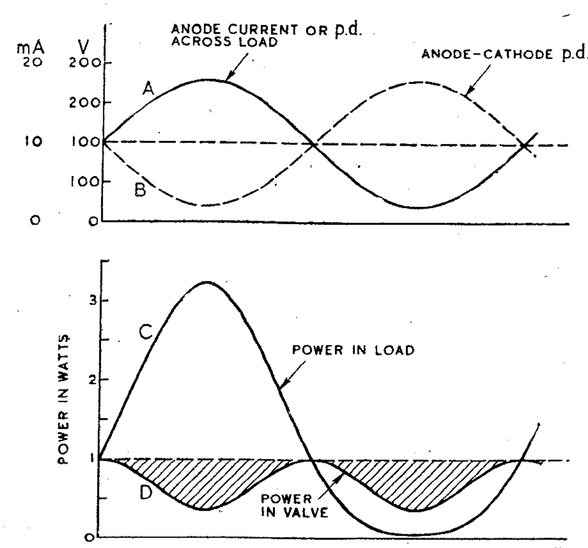
Suppose the valve to have a load resistance of 10,000 ohms and to have an anode-cathode p.d. of 100V when the anode current is 10 mA with no AC voltage applied to the grid. Corresponding p.d. across the load is 100V and power absorbed by load is 1 watt.

Next, suppose that with a sinusoidal voltage applied to the grid the anode current also varies sinusoidally between, say, 18 and 2 mA. Consequently, the p.d.'s across the load and valve vary as shown by the accompanying curves A and B respectively. The power absorbed by the load can easily be derived for various instants from the product of the anode current and the p.d. across the load (each being represented to different scales by curve A). This power is represented by curve C. Similarly, the power absorbed by the valve can be deduced from the product of the anode current and the anode-cathode p.d. and is represented by curve D. The shaded area represents the reduction in the energy per cycle absorbed by the valve; and since the total energy per cycle from the battery remains unaltered, the shaded area must be equal to the difference between the areas enclosed by curve C above and below the dotted axis.

I cannot see that there is any need to complicate this explanation by the introduction of "negative dynamic resistance." Mr. Boyland's mathematical treatment shows that the reduction of power absorbed by the valve is $\frac{1}{2} \times (8/1{,}000)^2 \times 10{,}000$, namely, 0.32 watt; and that this is also the increase of power absorbed by the load. In the equivalent circuit, the effective value of the current would be 5.66 mA, and the I^2R loss in the load would again be 0.32 watt. Hence the circuit is equivalent in respect of AC voltage, current and power.

EDWARD HUGHES.

Technical College, Brighton.



Curves referred to by Dr. Hughes.

"Hearing Aids for the Million"

AS one who has been fitting up the deaf since 1913, I have read with interest the article "Mass-produced Hearing Aids" in your July issue. I am sure the writer cannot realise the difficulties one encounters in fitting up the deaf, also the variety of aids required to do this efficiently.

Figures that I have collected show that, generally, over 50 per cent. of sufferers hear better with a non-electrical aid. On an average, only 14 per cent. of the electrical instruments sold are valve aids.

In conclusion, I would say that the wireless dealers in general have not the necessary medical knowledge or experience to fit up the deaf; also that it is impossible to sell valve instruments at £5 with a profit, however small.

W. H. PETTIFOR.

London, S.W.1.

RANDOM RADIATIONS

By "DIALLIST"

Big Books and Little Books

IT'S been rather a difficult matter during this war to know what to recommend when fellow-soldiers ask for the name of a sound and not too lengthy or too highbrow a book on the principles of wireless. There are lots of little books; but so many of them have their shortcomings: either they say little or nothing of things that matter a lot to the Army student of radio, or they may give explanations of which you don't approve. Then again there are plenty of big or biggish books; all very well for those who have some previous knowledge and are mathematically minded, but too strong meat for the semi-beginner. The best book that I've come across so far is A. L. M. Sowerby's "Foundations of Wireless" (revised by M. G. Scroggie). If you are in one or other of the Services and want something which gives a sound outline of the elements of the subject I do not think that you'll do better. It puts things simply and it deals well with the fundamental principles of radio.

Stumbling Blocks

The writing of instruction books of a simple kind on any technical subject is no easy matter, and I believe that it is in some ways more difficult for a brilliant man to succeed as the author of one of these than for one who has himself had difficulties in mastering the principles. There are points which are so straightforward and so obvious to the genius that he can't understand their presenting the slightest trouble to people of less nimble brains. But the writer who has to do a bit of puzzling over the text books of his student days appreciates the struggle that face those who are making their first acquaintance with the department of science that is more or less a mystery to them. Well do I remember one thing that worried me in my young days when I first tackled wireless. It will seem silly to some—yet I doubt not that there are many besides myself whose heads ached over it. Anyhow, here it is. The text books all showed that the amplifying valve (Class A, I mean; though the term wasn't then in use) was a purely voltage-operated device. They explained by means of characteristic curves how a voltage wave-form applied to the grid could be produced in the anode circuit a current wave-form of the same shape, but of greater amplitude. What they all omitted to explain, holding it probably as too obvious to call for explanation, was how in a cascade amplifier voltage wave-forms were amplified and passed on as voltage wave-forms from valve to valve. A grid-volts/anode-volts curve, taken with a resistance in the anode circuit would have cleared up that and many other valve difficulties.

Taken for Granted

Most of us, as a matter of fact, are apt to take the understanding of fundamentals far too much for granted when we instruct verbally or write books for the more or less uninitiated. And unless we are careful the results are not happy. Students and readers may acquire a kind of parrot knowledge without really knowing what it is all about. The other day I was examining some Army people of, presumably, rather better than average intelligence. One of them told me without hesitation and correctly that a dry cell in good condition should have an EMF of 1.5 volts. "And what," I asked, "does one-point-five mean?" That proved a complete facer! To this candidate (and as subsequently emerged, to not a few others of the same batch) one-point-five meant absolutely nothing. Again, questions about particular wavelengths produced pat answers that they were so many metres, from candidates who had not the faintest idea of what a metre was. The prize answer to that question was: "A metre is a wiggly line"!

Hearing Aids

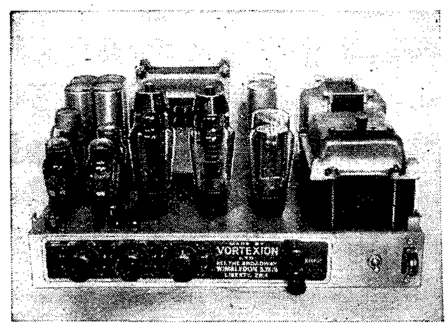
SOME years ago I studied the question of deafness and hearing aids, going into it as far as was possible for one without specialised medical knowledge. From what I learnt then I am against any suggestion that it would be within the province of wireless traders to prescribe suitable aids for each and every case of deafness. This disability actually takes many forms and is due to many causes. Unless the particular kind of deafness from which a patient is suffering can be diagnosed and its cause determined, any attempt to provide him with a deaf aid may do more harm than good. In other words, you may by simple trial and error methods provide a man with an apparatus which enables him to hear for the time being somewhat better than he did; but if it isn't the right apparatus such hearing as he has will rapidly become worse. An exactly parallel case is that of eyesight; a pair of glasses provided by a quack optician may ultimately wreck the eyes which at first they seem to relieve. As with eyesight, all but the simplest and most straightforward cases of deafness should be dealt with in the first instance by a qualified man. It is his business to diagnose and prescribe; the wireless dealer, like the optician, should supply the apparatus ordered and maintain it whilst it is in service.

Training

There is no reason why a number of wireless dealers should not qualify in the treatment of deafness as opticians do in the treatment of defects of vision. They could be taught to recognise the various kinds of deafness and the symptoms of ear trouble too serious for them to treat. It would be for these trained men to deal themselves only with cases which were straightforward and to recommend others to seek advice from medical men. As with glasses, the hearing aid often needs to be made or modified to the requirements of the individual, and to find out exactly what each case calls for is a skilled business It is not good enough to let a man try various deaf-aids and to supply him with the one with which he thinks that he hears best.

Changing Customs

One thing that we shall have to do is to change the outlook of the hard of hearing on aids. I know several people, nearly as deaf as the proverbial post, who won't use an aid because they think that it calls attention to their disability. It's not so long ago that spectacles were looked upon as a disfigurement.



"WREN" RADIO MECHANICS

Three-year Course in Four Months

WHILST there have been wireless telegraphists and radio operators in the Women's Royal Naval Service for a considerable time, a new sphere of work has opened up for "Wren" recruits by the introduction of the category of Radio Mechanic.

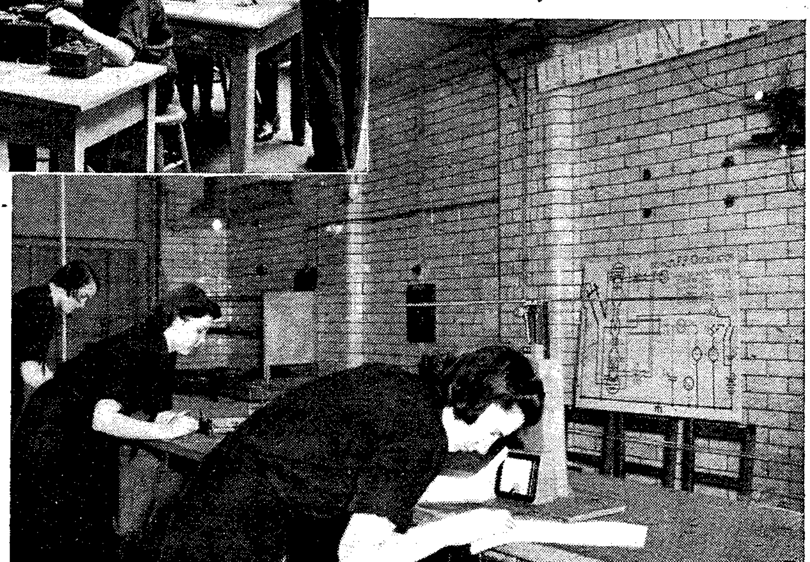
The function of these girls, who must have had a secondary school or higher education and attained matriculation standard or its equivalent, is the maintenance and repair of apparatus in machines of the Fleet Air Arm.

A *Wireless World* representative recently visited one of the schools in London where the girls receive their basic training. Some sixty Wrens were undergoing the sixteen weeks' course, which in peacetime would be spread over three years. It is obvious, therefore, that, as the senior instructor in charge pointed out, all the frills have been omitted.

The sixteen weeks' training is divided into three sections. The first, of five weeks' duration, covers magnetism and elementary electricity. The following eight weeks is taken up with the study of the basic principles of wireless, and during the last three weeks the students are taught high-frequency and U-H-F technique.

Each week of the training period consists of forty-one working hours in the school plus three hours for physical training. The week's timetable allows fourteen hours for lectures and tutorial study; twenty-two hours for laboratory work and five hours in the mechanical and electrical workshops, where training is concerned mainly with soldering and executing temporary repairs to Service receivers.

Wren Radio Mechanics receiving instruction on Service apparatus.



(Right) Exploring the propagation of ultra-high frequencies with the aid of Lecher wires and sliders. Variations are observed on the large scale on the wall. The half-wave dipole receiver in the foreground is used for exploring radiation.

Comprehensive Syllabus

The laboratory training is very comprehensive. It must be remembered that these girls, although they have reached matriculation standard or even higher at school, have little or no knowledge of radio. Among twenty or more entrants who were undergoing the first week of training at the school visited a very wide variety of previous occupations was to be found, including those of nurse, shorthand typist, accountant, research student and laboratory assistant. One of the students is a B.Sc. and another had obtained an inter in Physics. Their ages are mainly in the early twenties, although one or two are over thirty. Experience, however, has shown that the best age for absorbing the technical instruction is between 18 and 25.

A feature of the technical training of Wren Radio Mechanics is that the circuit of the Service apparatus under test is easily traceable on the large-scale diagram on the wall.

As the training is planned to give a working knowledge of radio communication in the short time of four months, it will be of interest to consider the syllabus in some detail. The ground is covered very thoroughly.

Starting off with the nature and effect of electric current the students progress by easy stages through Ohm's, Kirchhoff's and Lenz's laws. They are then introduced to resonance and the effect on frequency of change in L and C. A very thorough series of lectures on alternating current is followed by a course on radio-frequency circuits. Valve construction and the functions of the various electrodes lead up to a study of the principles of the CRO.

By means of dissected diagrams and demonstration units of the different stages in a receiver the trainees trace the signal from the aerial through each stage of the circuit to the output. Having thoroughly grasped the principles of reception they are given an outline of the transmitter. The final stage concerns the propagation of U-H-F, the travelling and standing-wave phenomena and the various receiving and transmitting aerials.

The tutorial work is combined with practical laboratory training. An interesting feature is that the Wrens are, as far as possible, given the opportunity of handling actual Service apparatus. The students are not, as is so often the case with special trainees, simply turned out as "production line" testers; they are trained in the technique of fault finding and are themselves quite capable of carrying out "running repairs."

Perhaps the most exacting part of the Wrens' training comes during the last three weeks, when they are taught the fundamentals of high-frequency and U-H-F technique. For this part of the course a 150 Mc/s push-pull oscillator has been erected in a completely screened room. All types of tuned line output circuits, feeders and aerials can be connected to this oscillator. Their properties are examined visually by the students with the aid of exploring sliders connected through Westector rectifiers to a reflecting galvanometer in a prominent position on the wall.

It has been found that the trainees can much more readily grasp the various phenomena in HF and U-H-F technique by visual means and so the chief instructor employs this method whenever possible.

Following the four month's basic training the girls have two months' Service training at a Fleet Air Arm station. Here they are taught the intricacies of installation work and shown the difficulties of servicing apparatus *in situ* in 'planes. Having completed their training they are posted as Wren Radio Mechanics to a Fleet Air Arm Station.

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

Recent Inventions

A Selection of the More Interesting Radio Developments

CORRECTING FOR TEMPERATURE CHANGES

THE effect of temperature variation on the tuning of a circuit which includes a tapped inductance is complex. It includes a constant factor and a factor which varies in accordance with the particular tapping chosen, and therefore with the particular working frequency. Put in another way, any attempt to correct for temperature changes in this type of circuit must take into account the amount of the "dead end" inductance left outside the actual tuned circuit.

The inventors overcome the difficulty by providing two temperature compensating condensers. The first is shunted across the normal tuning condenser, which bridges the whole of the inductance brought into circuit as the tapping point is moved. The second is permanently shunted across the first tapping point on the inductance, i.e., the one that tunes to the shortest frequency in the working range. The combined effect gives a frequency that is stable for any given tapping point in spite of temperature changes.

Marconi's Wireless Telegraph Co., Ltd., and N. Lea. Application date August 8th, 1940. No. 543126.

NAVIGATION BEACONS

IN order to avoid undesirable earth-reflection effects, it is usual to mount the aerial of a navigational beacon at a considerable elevation above ground. This, however, tends to produce a lobed radiation field having gaps in which no signal can be heard. Apart from other objections this may mislead the pilot of an aeroplane into thinking that he is immediately above the beacon, as this is the only location where he would naturally expect to find a cone of silence.

In order to avoid the possibility of such errors, the beacon is provided with five radiating dipoles, one arranged above the other. The two aerials are energised in rapid alternatives, and their relative spacing is originally adjusted so that any minimum lobes or gaps in the field radiated by one are filled by the maximum lobes of the other and vice-versa, thus providing a uniform overall coverage.

A second pair of aerials, set parallel with the first, may be used to provide a guide-path of the overlapping-beam type, the two sets of aerials then being separately modulated to define a median course-line.

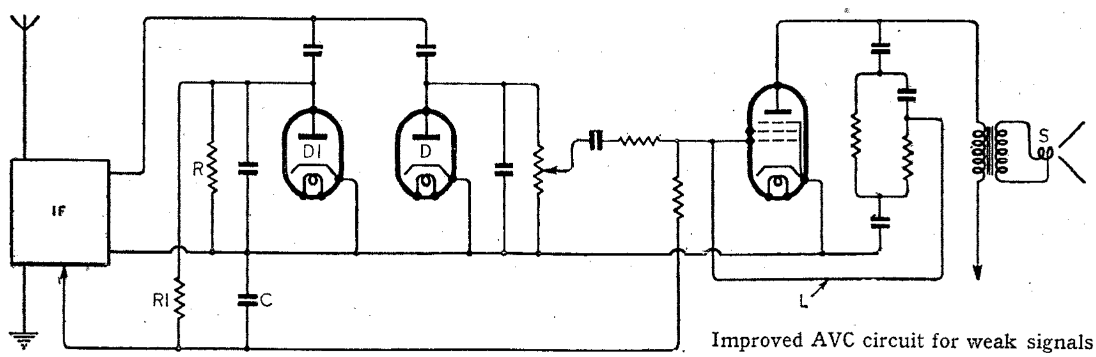
Standard Telephones and Cables, Ltd. (Assignees of A. Alford). Convention date (U.S.A.) October 19th, 1939. No. 543336.

AUTOMATIC VOLUME CONTROL

WHEN receiving weak signals, the effect of AVC is to accentuate the high-pitched background of inherent noise, though this can be offset by automatically suppressing high-pitched frequencies. Similarly, when receiving weak signals on short waves, the tendency to rapid fading produces a low-pitched frequency of the order of 60 to 80 cycles, which is likewise emphasised by AVC action, unless steps are taken to suppress the effect.

The drawing shows a circuit in which provision is made to cope automatically with both drawbacks. Signals from the IF amplifier are fed through a diode rectifier D to the AF amplifier and loud speaker S in the ordinary way. A second diode D1 supplies AVC voltage to a resistance R which is smoothed by R1 and C, and supplied both to the IF stage and to the control grid of the AF amplifier. The output circuit of the latter includes a resistance-capacity shunt from which a tapping is taken back to the control grid. The shunt impedances are such that the negative feedback automatically suppresses the very high and very low frequencies. The suppression comes into action only when the AVC control is near its maximum, i.e., when receiving weak signals.

Philips Lamps, Ltd. (communicated by H. V. Philips' Gloeilampenfabrieken). Application date, 23rd April, 1940. No. 543387.



Improved AVC circuit for weak signals

"SIMULTANEOUS" TELEVISION

INSTEAD of analysing the picture into a number of elements which are transmitted in sequence, and distributed by a system of scanning over the surface of a screen at the receiver, the inventors propose to transmit all the picture elements simultaneously on so many distinctive frequencies. At the receiving end, each signal is separated out by a series of filters and applied individually to a number of frequency selective reeds or meters so that the picture is reconstituted instantaneously.

In transmission the picture is first projected by a lens on to a screen which is backed by a series of photo-sensitive cells arranged in horizontal lines. In front of the screen are a number of light-chopping devices mounted on and driven by a series of vertical shafts. As the latter rotate, the light in each vertical strip of the picture is chopped at a frequency which differs from strip to strip. The resulting current from the horizontal photo-electric cells are fed to separate amplifiers, all of which may be used to modulate a master carrier-wave.

Scophony, Ltd., and F. Okolicsanyi. Application date June 10th, 1940. No. 543185.

SECONDARY-EMISSION SURFACES

IT is known that the normal secondary-emission from a given metal can be considerably increased by a preliminary process of "activation," which may consist, for instance, of subjecting the surface to heat, either in vacuo or in contact with oxygen or other gases.

According to the invention, the surface of an electro-positive metal, such as beryllium, is first degassed and is then subjected to bombardment by a stream of electrons of high current density. The metal then acquires a coefficient of secondary-emission substantially equal to that of a cæsium-oxide coating on silver, and will yield a higher total emission than the more complex surface without suffering deterioration.

International Television Corporation, Ltd.; P. Nagy; and M. J. Goddard. Application date, August 16th, 1940. No. 543201.

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.

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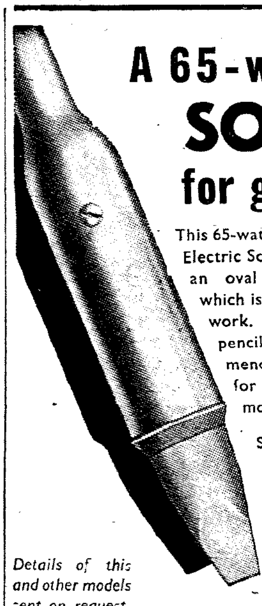

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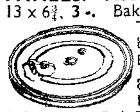

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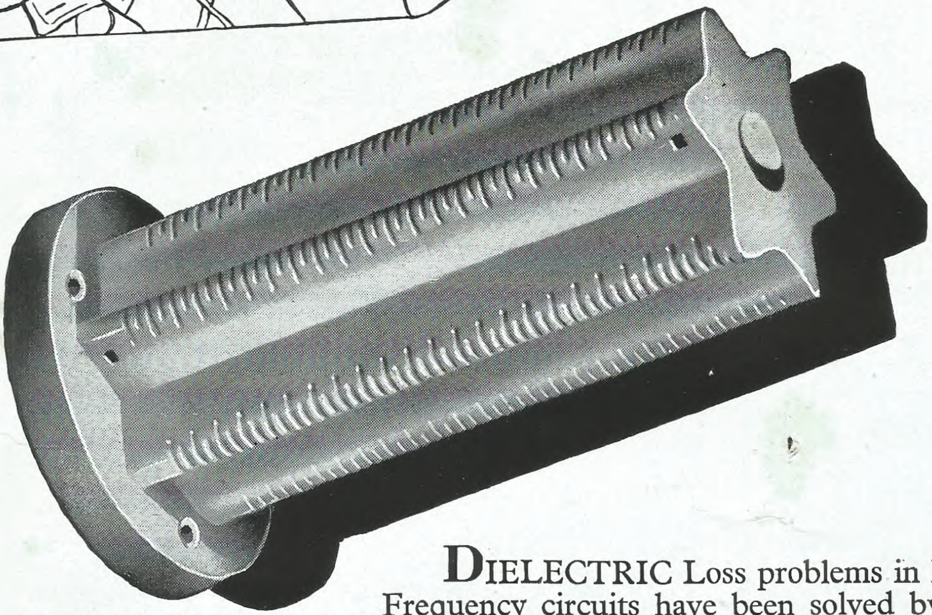

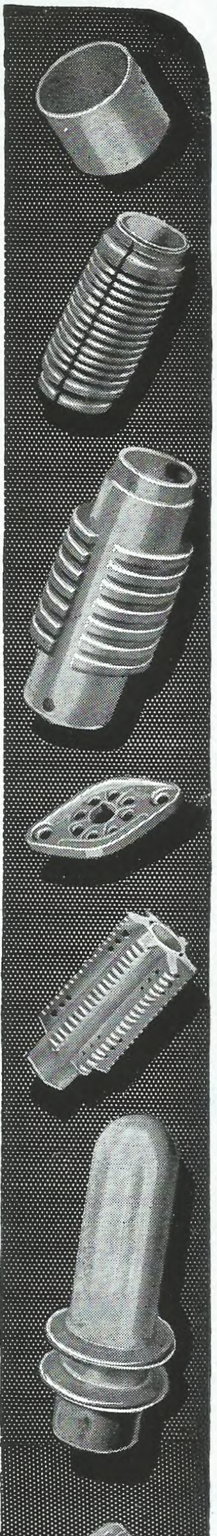

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