# Wireless World

RADIO · ELECTRONICS · ELECTRO-ACOUSTICS

NOV. 1944

1/6

Vol. L. No. 11

IN THIS ISSUE: ACOUSTICS OF SMALL ROOMS

# PRIMER ON RUBBER BONDING

NUMBER
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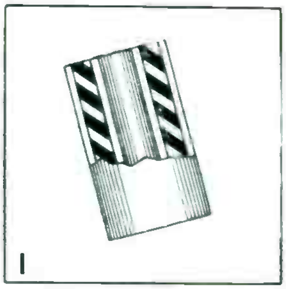

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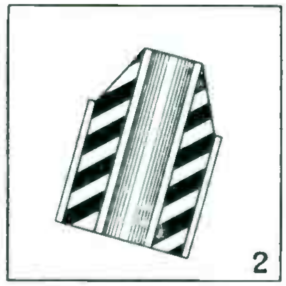

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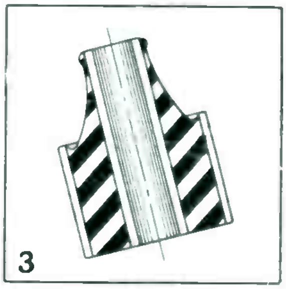

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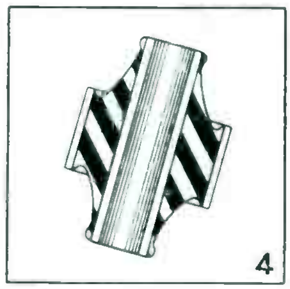

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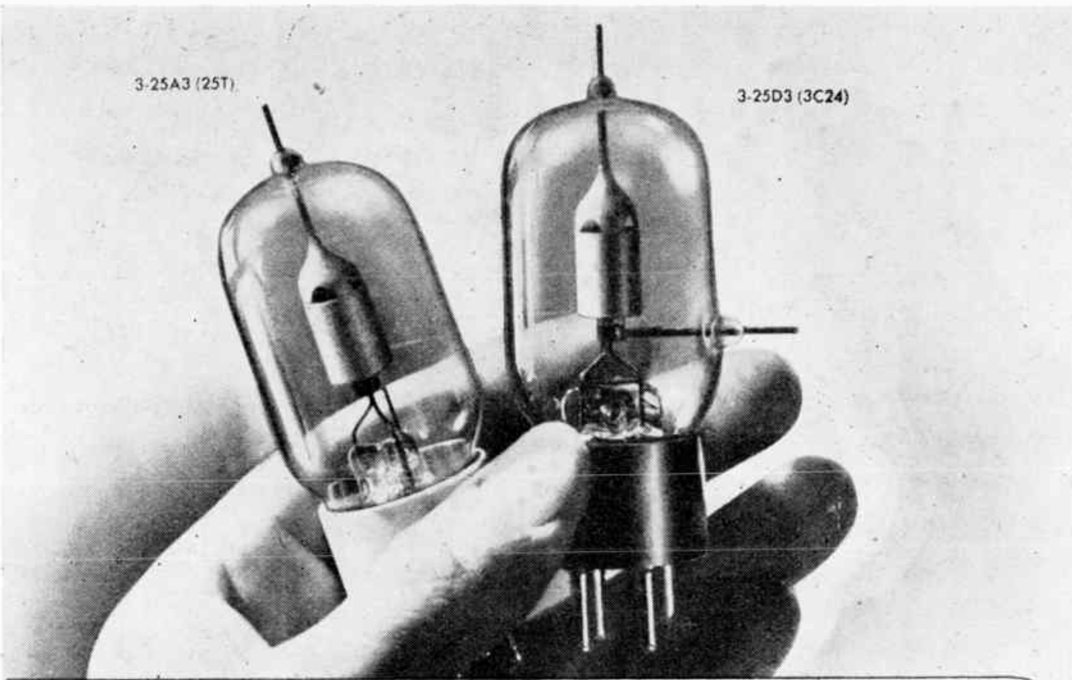


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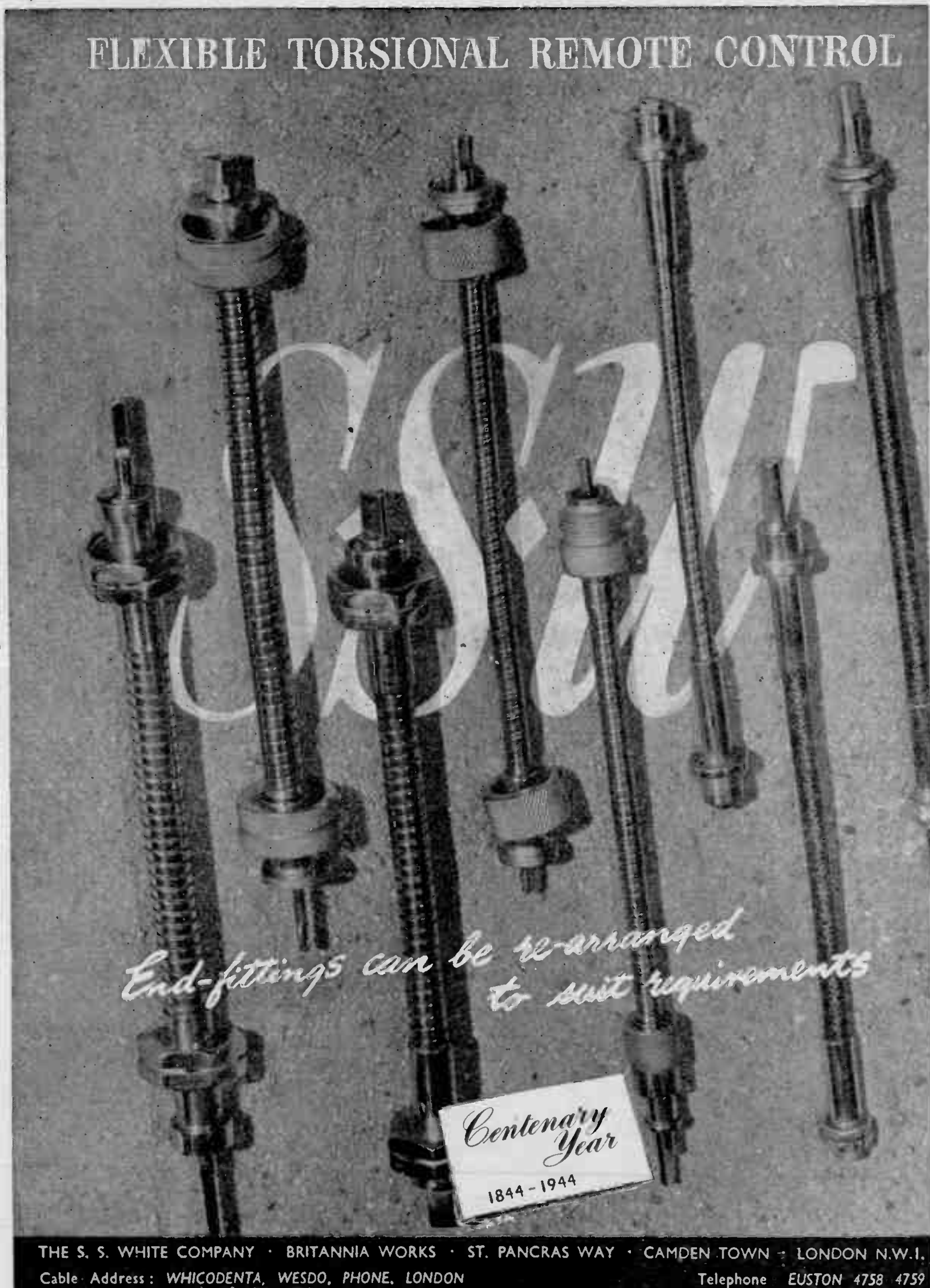


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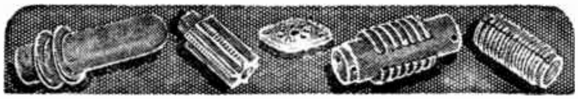

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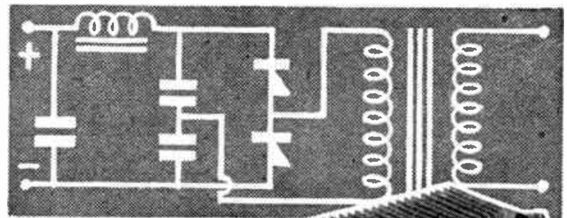

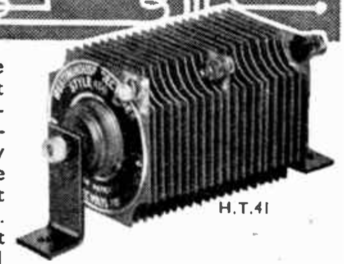


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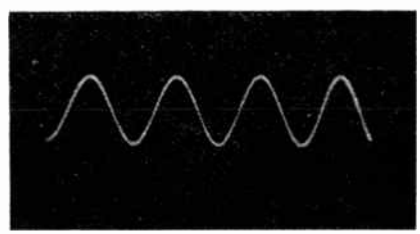

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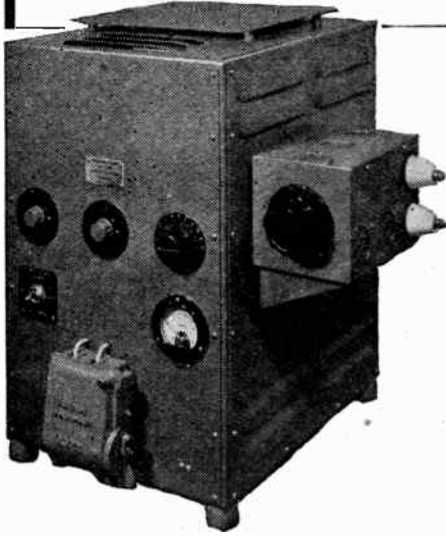

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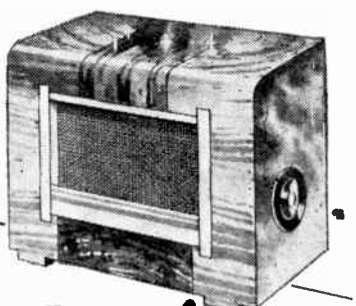

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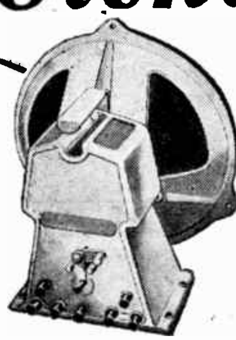

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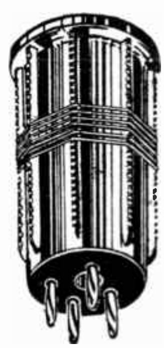

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# Wireless World

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# Monthly Commentary

## *A Place in the Ether*

WHEN we come to consider almost any question affecting the detailed design of wireless apparatus for use after the war, sooner or later we encounter an insuperable barrier to further progress: ignorance of the technical requirements that it must satisfy. The frequency band or bands to which the apparatus must tune, the bandwidth it must cover, the nature of the emissions which it must transmit or receive; all these are factors which must be known before anything approaching concrete designs, let alone production models, can be evolved. The answers to our questions can come only from an internationally constituted governing body; indeed, at every turn we are confronted by the essentially international requirements of radio governance. No national authority, however willing and competent, can by itself do much to pave the way for post-war wireless activities. Of one thing only can we be certain; the regulations and frequency allocations made at the Cairo Convention in 1938 are now hopelessly out of date, and will give little guidance for us in 194?.

Influenced by considerations such as these, *Wireless World* ventured, some eight months ago, to put forward a plea for an interim international convention. That suggestion was made with some diffidence. Though it seemed certain that no time should be lost in preparing for happier days, the war situation was such that the idea of international discussion appeared mildly ridiculous.

### *Intense U.S. Activity*

Since we made our plea, there have been few signs of any intense official activity in this country, but in America large-scale planning is now well under way. Industrial and other interests, with the fullest support, co-operation and leadership from the U.S. Government, have discussed freely and openly the many vexed questions of frequency allocation between the various wireless services. Discussions are rapidly approaching a stage where cut-and-dried plans will be ready for the American delegates to take to an international conference. According to a recent report in *Broadcasting* (New York) of a joint government-industry conference, great emphasis is laid on the need for haste; December 1st is given as the "deadline for a fully considered set-up of proposals for the State Department." A U.S. Government spokesman is quoted as saying that an international conference may well be held next spring.

It is natural that, in view of all this activity, we should look to America for ideas on the post-war organisation of wireless. One suggestion put before the conference just mentioned gives us some concern. In the proposals for allocations made by the official Inter-department Radio Advisory Committee the provision of frequencies for international long-distance broadcasting was completely omitted. When taxed with this omission, the Government spokesman suggested that programmes should be transmitted by point-to-point relay for rebroadcasting on the national systems of other countries. The view was expressed that effective direct international broadcasting would require an inordinate amount of space in the spectrum—probably 50 per cent. of the band 4-20 Mc/s.

This opposition can perhaps best be ascribed to disillusionment, brought about by the evident and admitted failure of world broadcasting during the few short years of its life to foster amity between peoples. But, though we can sympathise with such views, we cannot support them. Much short-wave broadcasting has been unadulterated propaganda, conducted for the most dubious ends. The fact that a medium has been misused does not condemn that medium. Ultimately, means will surely be found for using it properly, and a place in the ether must be reserved for a service with such obvious possibilities.

It is rumoured from America that another socially valuable wireless application—amateur transmission—has been threatened with curtailment, or even something more drastic; the U.S. journal *Electronics* used the word "liquidation." But we see that the tentative I.R.A.C. proposals provide frequency allocations for amateurs.

# ACOUSTICS OF SMALL ROOMS

## *Factors Affecting Quality of Reproduction*

By J. MOIR, A.M.I.E.E.

**The small room presents a number of problems to the quality enthusiast attempting to reproduce concert hall performance in domestic surroundings, and the following notes are intended as a preliminary survey of these difficulties. Considerable work has been carried out on the problem of production and reproduction in large rooms, but, as we shall see, the nature of the problem changes as the room size decreases and conclusions that are correct for the large hall may prove incorrect in small rooms.**

THE requirement to be met in obtaining a reproduction of a concert hall performance in a large or small room is deceptively easily stated. It is that the instantaneous acoustic pattern produced in space in the reproducing room shall at all times be identical with that existing in the concert hall. Further examination of the problem only serves to show that this apparently simple requirement is a long way from our grasp and while he is a bold prophet who suggests that improvement will never be achieved it is apparent that fundamental obstacles place the goal well out of sight (or more aptly, out of earshot) at the present time.

Most of the work that the writer has done on this problem refers to the room shown in Fig. 1, approximately 16ft. 9in. × 11ft. 6in. × 8ft. 6in. high, the walls being distempered, the floor covered with linoleum and carpet, the latter being rather thin.

About the year 1893 Sabine commenced his investigation of the acoustical properties of rooms, primarily to ascertain the factors which determined their suitability as music rooms, and this and his subsequent work laid the foundation stones of architectural acoustic theory. His ideas have stood up well to the searching test of time, so that a brief review of his early conclusions form a very valuable approach to the rather more specialised problem of the small room.

Sabine concluded that the most important factor was the time taken for sound energy to be absorbed by the room boundaries when the source of sound (speaker, singer or orchestra) ceased to emit sound energy. He established the term "reverberation time" as a suitable yardstick, defining reverberation time as "the time taken for the average sound energy density to decay to one millionth (60 db) of its initial value." He developed an empirical equation which enables the reverberation time to be calculated in advance of construction and made a subjective determination of the optimum reverberation time for speech and musical production.

If the growth and decay of sound energy in a room is examined, it is found to follow the natural exponential law, the average sound energy density rising exponentially from the instant the sound source commences to the final steady state when the energy is uniformly distributed throughout the room, with energy being absorbed by the room boundaries at exactly the rate at which it is emitted by the sound source. Similarly when the source ceases to emit, the average sound energy decreases exponentially, being absorbed and dissipated as heat by friction in the porous boundary surfaces.

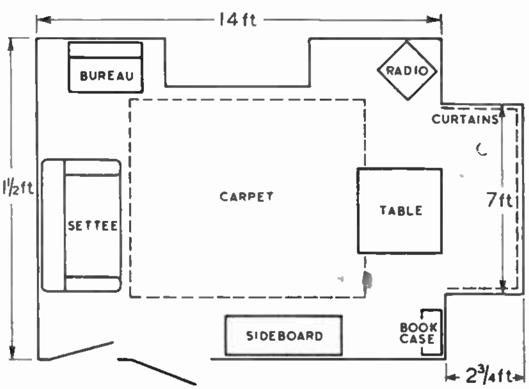



Fig. 1. Plan of small living room used for acoustic investigations.

The average sound energy density at any instant during the period of growth is given by—

$$P = \frac{4E}{cS\alpha}\left(1 - e^{-cS\alpha t/4V}\right) \quad \ldots \quad (1)$$

and during the period of decay by

$$P = \frac{4E}{cS\alpha}e^{-cS\alpha t/4V} \quad \ldots \quad (2)$$

where P = sound energy density
E = rate of emission of source
$c$ = velocity of sound
S = total surface area
$\alpha$ = average absorption coefficient
V = room volume
$e$ = 2.718.

In any one room, and at one frequency, E, $c$, $\alpha$, S and V are constants, and the relations may be reduced to the simpler forms

$P = K(1 - e^{-bt})$ for the period of growth

and

$P = Ke^{-bt}$ for the period of decay.

In this form they are seen to be similar to the well-known equations for the charge and discharge of a condenser through a resistance. It should be noted, however, that similarity exists between the *average* sound energy density and the condenser potential At any *particular* point in space there may be large variations about a mean rate which may or may not be exponential.

As previously noted Sabine was able to show that the decay rate was the important factor and we may see the reason for this from the following considerations. Speech and music consist of a series of syllables or phrases, following each other at well defined intervals, but if the decay rate in a room is so slow that energy from the first syllable is still present when the second syllable appears, it will be at once evident that confusion and lack of intelligibility will result. This is well illustrated by Fig. 2 in which the growth and decay of sound pulses of average syllabic length and spacing are plotted for two values of reverberation time. When the reverberation time is short, each syllable stands out well above the general level, but with a long reverberation time individual syllables are almost completely lost in the general sound level. By themselves the curves would suggest that very high rates of decay (short reverberation times) would be ideal, but in practice speech and more particularly music performed in rooms with very short reverberation times prove to be almost as unacceptable as when performed in rooms with very long reverberation times. Very short reverberation times give a very dull and lifeless effect, a subjective result probably connected with our long experience of living and listening in rooms having reverberation times of more average length.

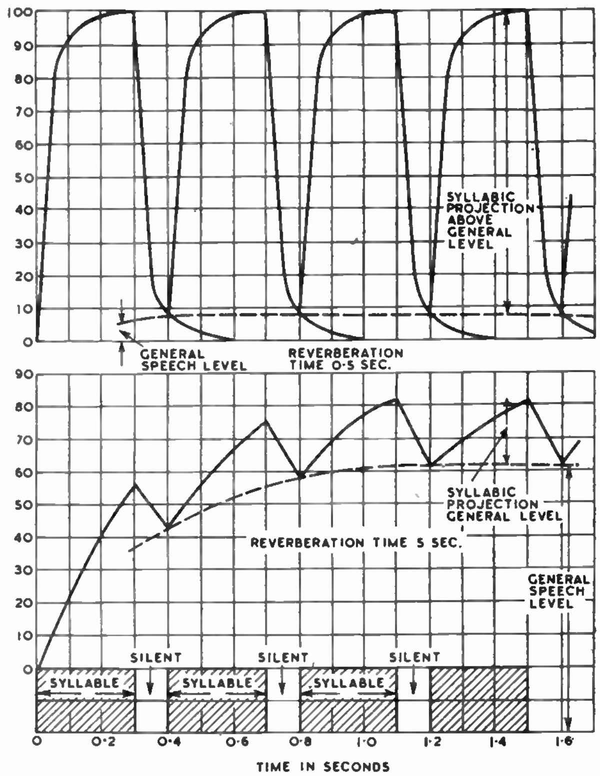



**Fig. 2. Growth and decay of sound pulses of average syllabic length in rooms with different reverberation times.**

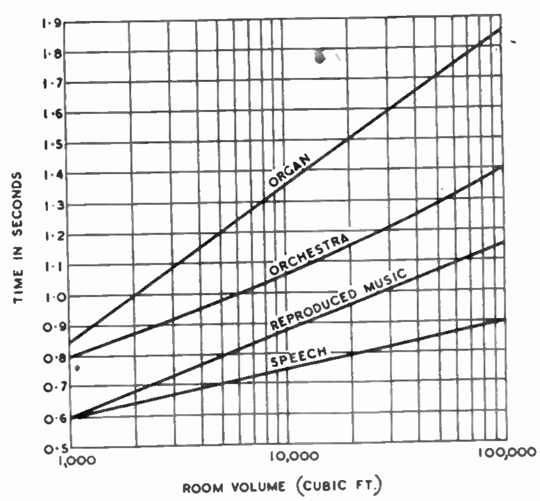



**Fig. 3. Subjectively determined optimum reverberation times for different types of sound plotted as a function of room volume.**

It follows from the above that somewhere in between the two limits there will be an optimum value of reverberation time, and it would seem probable that this will depend upon the type of performance for which the room is intended, being shortest for speech and longest for the production of a ponderous organ prelude. This is a purely subjective effect and theory has little to say on the question of the optimum reverberation time, although it predicts that rooms intended for reproduced music should have shorter reverberation times than those intended for a live production of the same class of music. This is quite reasonable as the recorded music will contain some of the reverberant sound from the recording room.

The curves of Fig. 3 present some of the data of the subjectively determined optimum reverberation time for rooms, plotted as a function of room volume. As our present interest is mainly in the small room the region between 1,000 and 10,000 cubic feet is the most important.

Sabine derived the following equation expressing the relation between the factors controlling reverberation time.

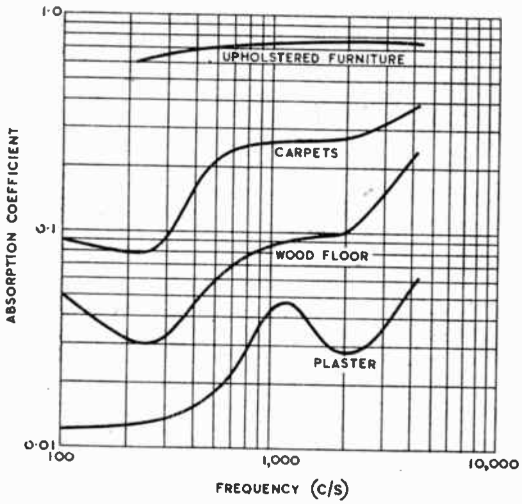
$$T = \frac{0.05V}{S\alpha} \qquad \qquad (3)$$

where T = reverberation time in seconds
V = room volume (cu. ft.)
S = surface area (sq. ft.)
$\alpha$ = average absorption coefficient.

the factor $\alpha$ expressing the effectiveness of the material in absorbing incident sound, being

**Acoustics of Small Rooms—**

low (below 0.1) for hard rigid materials and approaching 1 for soft porous materials. If the material absorbed the whole of the incident sound, reflecting nothing, the factor would be 1, but in practice an open window




facing the sky is the only surface with this property.

It will be seen that other things remaining constant, the reverberation time is inversely proportional to the absorption coefficient of the material used for the boundary surfaces and consequently if $\alpha$ varies with frequency the reverberation times will also vary with frequency. Fig. 4 presents some of the available data on the absorption coefficient of the materials commonly used in domestic architecture and it will be seen that there are large variations in $\alpha$ over the frequency range of interest to the musician and quality enthusiast. The reverberation time will therefore be a function of frequency, and although theory has little to say on the subject of the optimum reverberation times for any particular room and type of programme, the theoretical work of Knudson and McNair does suggest that the reverberation times should change with frequency in the manner shown in Fig. 5 where the reverberation time is plotted as a percentage of the reverberation time at 500 cycles as taken from the curves of Fig. 3. Practice appears to substantiate theory except above 3 kc/s when a gradual fall in reverberation time appears to be more acceptable than the rise suggested by Fig. 5.

Later work by Eyring, Sette, Norris, Millington and others has led to alternative forms for the reverberation time equation, that due to Eyring

$$T = \frac{0.05V}{-S\log_e(1-\alpha)} \quad .. \quad (4)$$

finding general favour. This is similar to the Sabine relation, differing only in replacing $\alpha$ by $\log_e(1-\alpha)$. For values of $\alpha$ less than 0.3 approx. the two expressions give the same result, but recent work by Morse, Bolt and Maa suggest that all these equations are approximate solutions, applicable in restricted cases, but nevertheless satisfactory in large rooms. Tempered by field experience, these equations form a very satisfactory approach to the problem of predicting the reverberation times of rooms in advance of construction.

Fig. 4. Variation of absorption coefficient with frequency for some common materials.

This necessarily brief review of the present position of room acoustics may now be applied to our problem of the small room, although later comments may show that this procedure is of rather doubtful value. Dealing first with the accepted criterion of reverberation time, Figs. 3 and 5 give the reverberation-time/frequency curve of Fig. 6 as being the optimum for reproduced music.

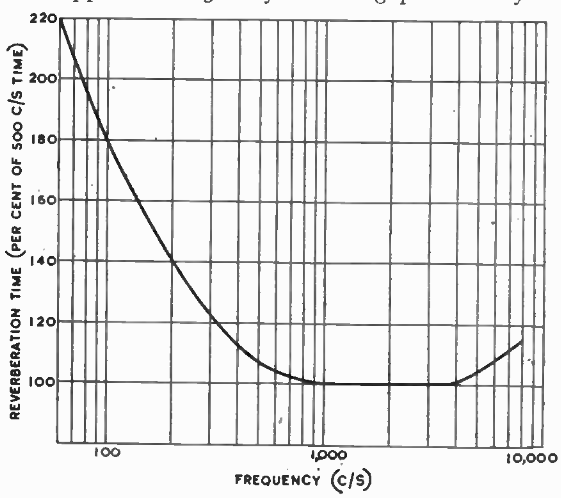



Fig. 5. Variation of optimum reverberation time with frequency, expressed as a percentage of reverberation time at 500 c/s.

Using formula (1) or (2) we might calculate the reverberation time of the room shown in Fig. 1, but as this is an instance in which the validity of the expressions are in doubt, the results of direct measurement are more satisfactory. The curve of Fig. 6 presents the measured result for direct comparison with the optimum curve. It will be seen that the measured time is well below the optimum time, leading to the conclusion that some of the absorbent material in the room should be removed. Unfortunately removal of all the disposable material, such as easy chairs, carpets, etc., proves inadequate in raising the reverberation time to the required figures, and we may conclude that the present methods and materials of domestic architecture lead to reverberation times well below the optimum figures.

The construction of the room has an important effect upon the acoustic performance, and, as we shall see, it appears that normal types of construction may have very undesirable effects. A study of Fig. 3 indicates that the furnishing materials commonly used have absorption coefficients that increase with increasing frequency. Application of either formulæ (3) or (4) will show that this should lead to a reverberation time/frequency curve having the general characteristics of the optimum curve of Fig. 5 the "rise" below 500 cycles being particularly important. The measured curve of Fig. 6 for the complete room does not exhibit this desirable feature and we are therefore led to reexamine the condition of test. In general, materials having little thickness, i.e., thin carpet, curtains, furniture, etc., do not form good absorbents at low frequencies suggesting that any errors that exist are not likely to be measurement errors. Absorption by molecular friction between the air and the porous surface of a material is, however, only one (though perhaps the most important) method of energy dissipation. At low frequencies it is found that the room structure, or large portions of the structure, may vibrate, the energy required to produce and maintain the vibration being absorbed from the incident sound energy and dissipated by internal friction in the vibrating structure.

It is rather difficult to believe that a 9in. brick wall may be moved by the sound energy from the domestic loudspeaker, but the theoretical predications have been carefully checked by measurement and qualitative agreement obtained. The physical properties of building materials are such that partitions, floors, ceilings, etc., exhibit resonant properties, particularly at low frequencies, a wall or partition giving an amplitude/frequency characteristic similar to the voltage/frequency characteristic of a parallel resonant circuit, although a wall will usually exhibit resonant properties at many frequencies as different sections of the wall pass through their individual modes. At, and in the vicinity of resonance, the wall vibration is many times greater than at frequencies remote from a resonant point, and where movement is large the energy absorbed from the sound field and dissipated as friction is also increased. Hard non-porous materials which we would expect to have a low absorption coefficient may thus have high absorption at low frequency due to the vibration of the partition as a diaphragm. As might be expected, increasing the mass of a partition will in general move the resonant frequencies, and therefore the regions of high absorption, to lower frequencies, but serious resonances have been produced in the audio range in walls *one foot thick*. In the early 1900's this would have been considered a reasonable minimum thickness for the walls of a small house, but modern standards will generally leave the domestic living room with two walls about 10in. thick and two internal walls about 5in. thick. In addition the floor will be constructed from ¾in. boards supported on 8in. × 2in. beams. The ceiling is generally of similar construction. All these boundary surfaces form excellent vibrating absorbers in the lower audio-frequency range and the general result is that the reverberation-time/frequency characteristic does not display the desirable low-frequency rise required by Fig. 5, but rather the bass-deficient curve of Fig. 6. The direct effect of this deficiency is an obvious lack of bass, as the sound intensity in an enclosure is almost directly proportional to the reverberation time; but there is a rather subtle difference, this lack of bass cannot be completely corrected by increasing the bass output of the speaker or amplifier, although it may be partially corrected in this manner. Reverberation adds coloration to the direct sound by adding components which persist after the original has ceased, while an increase in bass response merely increases the direct sound intensity. Experience of the difference between similar rooms having reverberation characteristics similar to the two curves of Fig. 6 has convinced the writer that this point is of more than merely academic interest.

Under favourable circumstances a vibrating surface may reinforce the reproduced sound at the resonant frequencies of the partition. The first condition is that in which mechanical vibration is transmitted by a direct path from the speaker through a cabinet to the floor, resulting in a large increase in the radiating efficiency at the resonant frequency of the immediate sections of flooring. The cure is easy and obvious, the addition of properly loaded isolating pads beneath the equipment. The second condition is again a little more subtle, a resonant partition may have a rate of decay, after excitation, that is comparable with or lower than the decay of the reverberant sound in the room at that particular frequency. Under these conditions the partition, excited at its resonant frequency by a transient sound component from the loudspeaker, will reradiate sound to the room after the normal room reverberation has ceased, equivalent to an increase in the reverberation time over the (usually) narrow band of frequencies to which the partition is resonant. If the reradiated sound energy was confined to the frequency of the incident energy, the effects would not be particularly troublesome unless the decay time was considerably below that of the room reverberation, but a transient sound having frequency components falling on the skirts of the resonance curve or harmonically related to the resonant frequency will also produce reradiation, mainly at the resonant frequency of the structure. The reverberant sound thus produced is particularly troublesome when it occurs near (in frequency) the incident sound, owing to the beat effects between incident and reradiated sound, a point referred to again in the section dealing with air resonance in rooms.

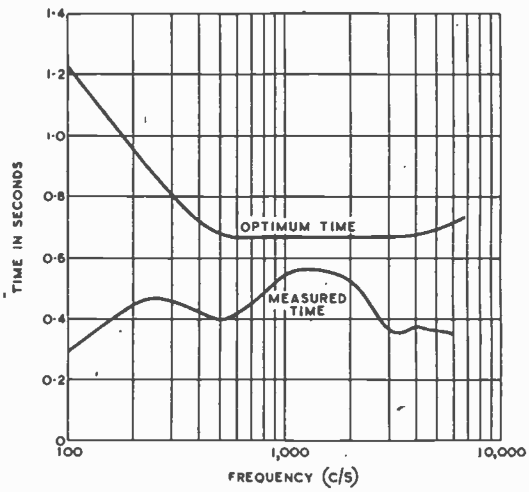



Fig. 6. Optimum and measured reverberation times for the small room shown in Fig. 1.

It might be remarked that the common idea that a vibrating surface will increase the direct sound intensity is only correct

**Acoustics of Small Rooms—**
when such a surface is mechanically excited by direct transmission. Where the incident sound is airborne, the reradiated sound can only contain the energy of the original, although it may increase the energy in a particular part of the room by focusing.

However, as we have suggested, there is considerable doubt about the validity of normal reverberation theory when applied to small rooms (i.e., rooms having dimensions comparable with the wavelength of sound) and our domestic rooms are definitely in this class. A note of 50 cycles has a wavelength of $c/f = 1125/50 \doteqdot 22.5$ft. in air. In these circumstances Lord Rayleigh predicted that any three dimensional space will behave in a similar manner to a stopped organ pipe, exhibiting an infinite series of resonant frequencies, the three lowest modes corresponding to the frequencies at which the length, width and height are one-half wave-length. He derived an expression for the series of resonant frequencies

$$f = \frac{c}{2}\left(\frac{A^2}{L^2} + \frac{B^2}{W^2} + \frac{D^2}{H^2}\right)^{-\frac{1}{2}}$$

where $L$ = length, $W$ = width, $H$ = height and $A$, $B$, $D$ are the integers 1, 2, 3, 4, etc., substituted in turn. The three lowest frequencies (or Eigentones) are given by putting in succession

$A = 1 \quad B = 0 \quad D = 0$
$A = 0 \quad B = 1 \quad D = 0$
$A = 0 \quad B = 0 \quad D = 1$

giving

Length oscillation frequency, $f_1 = c/2L$

Width oscillation frequency, $f_2 = c/2W$

Height oscillation frequency, $f_3 = c/2H$

Table I lists the first nine resonant frequencies for the room of Fig. 1. The dimensions of a rectangular enclosure of volume equal to that of Fig. 1 have been used in calculating the resonant frequencies.

With the present limited amount of data on the properties of surface materials, it is not possible to calculate the pressure rise at the resonant frequencies, but direct measurement indicates that it may be as great as 15 to 25 db. Our overall frequency characteristics may therefore have peaks of this order in the very dangerous region between 50 and 150 cycles.

For comparison it will be found that all the main resonant frequencies for the average cinema or concert hall are in the subaudible region below 10 cycles per second.

In a brief survey of this nature it is not possible to delve more deeply into this point at this stage, so we will pass on to some of the remaining implications. We have looked upon the sound energy decay process in a room as a gradual absorption of the sound energy by the room boundaries, a viewpoint that is perfectly correct in a large hall, but in the small room the decaying energy will be largely concentrated in the resonant frequencies of the room, so that the reverberation is present not at the frequency of the note sounded by the loudspeaker, but at the natural resonant frequency of the room.

**TABLE I**

| *A* | *B* | *D* | Resonant Frequency (c/s) |
|---|---|---|---|
| 1 | 0 | 0 | 36.8 |
| 0 | 1 | 0 | 51.1 |
| 0 | 0 | 1 | 68.6 |
| 1 | 1 | 0 | 62.9 |
| 0 | 1 | 1 | 85.5 |
| 1 | 0 | 1 | 77.6 |
| 2 | 0 | 0 | 73.6 |
| 0 | 2 | 0 | 102.3 |
| 0 | 0 | 2 | 137.2 |

The present theory of harmony is based upon the Helmholtz theory of the annoyance values of beats between the component frequencies of a complex tone. It is impossible to survey this in detail in a short article, but we may say briefly that the ear accepts as harmonious any complex tone in which the difference frequencies generated in the ear are low in comparison with the fundamental frequency, but rejects as discordant those complex tones producing difference frequencies which are an appreciable fraction of the fundamental. We now see that these difference tones (or beats) may be produced by the small room although they will in general be accepted as harmonious by the ear, as the difference frequencies are only a few cycles per second. Nevertheless, the characteristics of the reverberant sound differ considerably from those in a large room. In fact, the whole conception of an optimum reverberation time is of doubtful value when applied to small rooms, as the rate of decay may change rapidly with small changes in applied frequency and even over the period of decay.

There are further points which are rather disturbing to the seeker after quality reproduction. If the loudspeaker is reproducing a tone with a 5 per cent. harmonic when operated in the open air and we transfer to the small room with a resonance rise of 20 db. (10 times) at the frequency of the harmonic, the 5 per cent. harmonic would be found to have risen to 50 per cent. In fact, any component of a complex tone that happens to coincide with a resonant mode of the room will be increased in amplitude relative to the other components. It will be appreciated that this is likely to produce a considerable change in tone quality.

A further interesting point appears if we take a rather more searching view of the actual process of sound energy decay than is implied by taking an average rate of decay over the 60 db. decay required by the definition of reverberation times. It can be shown that the average distance which a sound pulse will travel in any enclosure before meeting a boundary surface is given by the expression

Mean free path = $4V/S$.

At time intervals given by the mean free path divided by the velocity of sound ($c$), i.e., time intervals of $4V/cS$ seconds, the sound pulse will strike a boundary surface and be reflected, each frequency component of the pulse being modified by absorption, being reduced to $(1 - \alpha)$ of its amplitude before impact. As $\alpha$ varies with frequency the frequency characteristics of the pulse will be modified at each impact. Considering two rooms, one having linear dimension ten times greater than the other, we will find that as V is proportional to length cubed and S proportional to length squared, the mean free path will be ten times longer in the larger room. The number of impacts per second is velocity of sound $c$ divided by $4V/S$, i.e.,

$$\text{Impacts per second} = \frac{cS}{4V}$$

and will be 10 times greater in the smaller room. Our main impression of quality is probably formed in the first 250 milliseconds, and we see that the small room will have approximately 10 times as many opportunities of impressing the room characteristics upon the sound quality as the large room would have had in the same time. High accuracy cannot be claimed for these last equations when applied to two rooms of such dissimilar size, but this does not affect the point in question.

We may now see why the requirement laid down in the early section is easy to state but difficult to achieve. The acoustic pattern is a property of the room and is controlled very largely by the room dimensions. These we are rarely free to manipulate, and there appears to be no way in which we might reproduce the pattern in miniature because the wavelength of our sounds remains the same in both large and small rooms.

So far this is rather unpleasant reading for the quality enthusiast and one that would be easy to dismiss as pure theory, but the following experience is interesting as it led to the theorising and subsequent measurement partly discussed in the preceding section. An opportunity occurred to compare the reproduction obtained in a local cinema, from sound film, and at home by radio of the same programme, a mixed variety of soloists and orchestral items. Both film and radio reproduction taken individually would have been classed as a little above average in their respective classes, but to the writer's great surprise the film reproduction in the cinema was definitely preferred. A repeat performance of both film and radio programme on the following day completely confirmed the first impression.

The electro-acoustic section of the cinema installation and the domestic equipment were to the writer's own design, and during an investigation of cinema sound quality* very full data had been obtained on this particular cinema and its equipment. Similar data on the electrical section of the domestic equipment was also available, and this led to a very positive bias toward the domestic reproducer, and the result was therefore wholly unexpected.

* *Journ. I.E.E.* September, 1941, or *Wireless World*, November, 1943.

In view of the past correspondence on the subject of cinema sound quality, one can visualise the domestic quality enthusiast rising in storm at the suggestion that the reproduction at the local cinema may be better than their own high-quality equipment. The conclusions that follow have a very definite bearing on this point. We may say :—

(1) Sound quality in small rooms is determined by important factors additional to those responsible in large rooms.

(2) Accurate "reproduction" of low-frequency notes appears impossible in small rooms.

(3) Sound quality in a small room may be "good," but never in the same sense as in a large room.

Our conception of good quality is probably based upon the accumulated experience of many years listening in large halls, as reproduction in small rooms was impossible until fairly recently. However the position is rapidly changing to one in which a very high percentage of our listening is done in small rooms, and we may expect our standard to undergo a gradual change. The precocious child's remark on being taken to a concert hall, "But this doesn't sound like Daddy's radio," may prove to be words of wisdom. "Out of the mouths of babes," etc.

The writer would like to express his appreciation to Mr. Warren, Director of Research, B.T.-H. Co., for making available the equipment used in the tests briefly described. The work has been pursued as a question of personal interest in the very restricted spare time available in the present circumstances.

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# WORLD RADIO CHARTER

THERE will be general agreement with the view that "electro-magnetic waves know no frontiers; the ether is, in its very essence, an international technical medium. It therefore follows that radio should be treated on an international basis." That is the guiding principle underlying proposals for an "International Radio Charter" recently put forward by A. Hubert, President of the International Radio Maritime Committee.

In the organisation and conduct of wireless services there is no place for the nation—or even for the . individual—who, like the Victorian woman novelist's oarsman, pulls two strokes to everybody else's one. International team work is essential; few of us would advocate a return of the state of anarchy that existed in the early days when some countries remained outside the Convention. Even in the 1930s we had a certain amount of piracy as part of the scramble for broadcasting channels.

The problems to be considered in framing an "International Radio Charter" under which a controlling body would work are set out at some length by Mr. Hubert. Allocation of frequencies naturally comes first in the list of technical problems, and it is urged that an international service should be set up to control the nature of emissions (bandwidth, power, etc.). Navigational aids, both marine and aeronautical, obviously need strict international regulation. An important point made in the proposal is that with regard to air communications the interval of five years between international conferences is too long, as progress is now so rapid. That principle, we think, might be extended to embrace all branches of wireless.

In the political sphere, an "International Police of the Ether" would, it is proposed, work under the supreme authority of an "International Radio Board." The board would be supported by advisory, administrative and technical bureaux.

During the short life of wireless, more has probably been already achieved than in any other sphere in regulating and controlling man's activities for the good of the whole world. But there is more to be done, and in framing the proposed Charter—clearly the keystone of the whole edifice—there is an inspiring opportunity to lay down just principles under which all the peoples of the earth can claim their due share of what radio has to give them.

# RADIO DATA CHARTS—17

## Attenuation of Wave Guides

By J. McG. SOWERBY, B.A., Grad.I.E.E.

(By permission of the Ministry of Supply)

THE general conceptions underlying the propagation of waves in tubes have been recently treated in this journal, so it is proposed to recapitulate as little as possible and deal only with the subject of the charts here presented.

It will be remembered that a wave guide of whatever shape of cross-section and excited in whatever practical mode behaves as a high-pass filter—there is, in fact, a critical frequency depending only on the dimensions of the guide, and waves of lower frequency than this critical frequency are greatly attenuated. So much so that in practice the guide is of no use as a means of transmitting energy at frequencies below the critical or cut-off frequency. At frequencies higher than cut-off the attenuation diminishes rapidly with increasing frequency, reaches a minimum, and then increases again slowly. The actual attenuation depends therefore on $f/f_c$ where $f$ is the working frequency, and $f_c$ the cut-off frequency. In addition, the attenuation diminishes with increasing guide dimensions, and with decreasing resistivity of the material of which the guide is made. From this last point of view silver would be the ideal material, but owing to its expense the practical choice would be more likely to be copper (nearly as good), and so the charts have been drawn on this assumption.

**The Charts.**—Since the attenuation depends on $f/f_c$ it is first necessary to find $f_c$, and this varies (in a given guide) with the mode of excitation, but always bears a simple relation to the guide dimensions—at any rate for simple shapes. The first chart is therefore a convenient record of the simple relations, and gives the cut-off frequencies (or wavelengths) for practical guides of square or circular cross-section for the three modes of longest wavelength (lowest frequency). As will be seen from the key, it is very simple to use.

Having found $f_c$, and the working frequency $f$ being known, $f/f_c$ (or $\lambda_c/\lambda$) is calculated and the attenuation found with the second or third chart, depending on whether the guide is circular or square in cross-section. It is fortunate that it is possible to express the attenuation of a guide in terms of $f/f_c$ and the dimensions, so that the second and third charts are simple to use; the procedure should be clear from the key, care being taken, of course, to use the curve corresponding to the mode for which $f_c$ was found. Two examples should make the operations clear.

**Example 1.**—A square guide of $2\frac{1}{2}$in. side and 500 yards length is to be excited in the $H_{01}$ ($TE_{01}$) mode. What is the attenuation at 5,000 Mc/s ?

First we must find $f_c$ from the first chart. Join $2\frac{1}{2}$in. (6.35 cm.) to the $H_{01}$ (square) gauge point. The ruler cuts the $f_c$ scale at 2,360 Mc/s. Now calculate $f/f_c$. This is 5,000/2,360 = 2.12.

Now turn to the second chart. Project a line vertically from $f/f_c = 2.12$ to cut the $H_{01}$ curve. At right angles a corresponding point is found on the left-hand (reference) line. Join this point to 6.35 cm. on the centre scale and the right-hand scale gives the attenuation as 10 db per thousand yards for all practical purposes; or 5 db for 500 yards.

**Example 2.**—What is the wavelength of lowest possible attenuation in a cylindrical guide 10 cm. in diameter? What is the numerical value of this attenuation ?

Take the third chart. From inspection it is obvious that the $H_1$ mode gives the minimum attenuation, and that the minimum of the curve for this mode lies at $\lambda_c/\lambda = 3.15$. Following the key, the attenuation of a 10 cm. guide when $f/f_c = 3.15$ is given as 4.49 db/1,000 yards.

Now turning to the first chart, join guide diameter = 10 cm. to the $H_1$ point, giving 17.3 cm. for the cut-off wavelength, $\lambda_c$. But since $\lambda_c/\lambda = 3.15$, then $\lambda = 17.3/3.15 = 5.5$ cm. Thus for a cylindrical copper guide 10 cm. in diameter, the wavelength of minimum attenuation is 5.5 cm., and the attenuation is 4.49 db/1,000 yards.

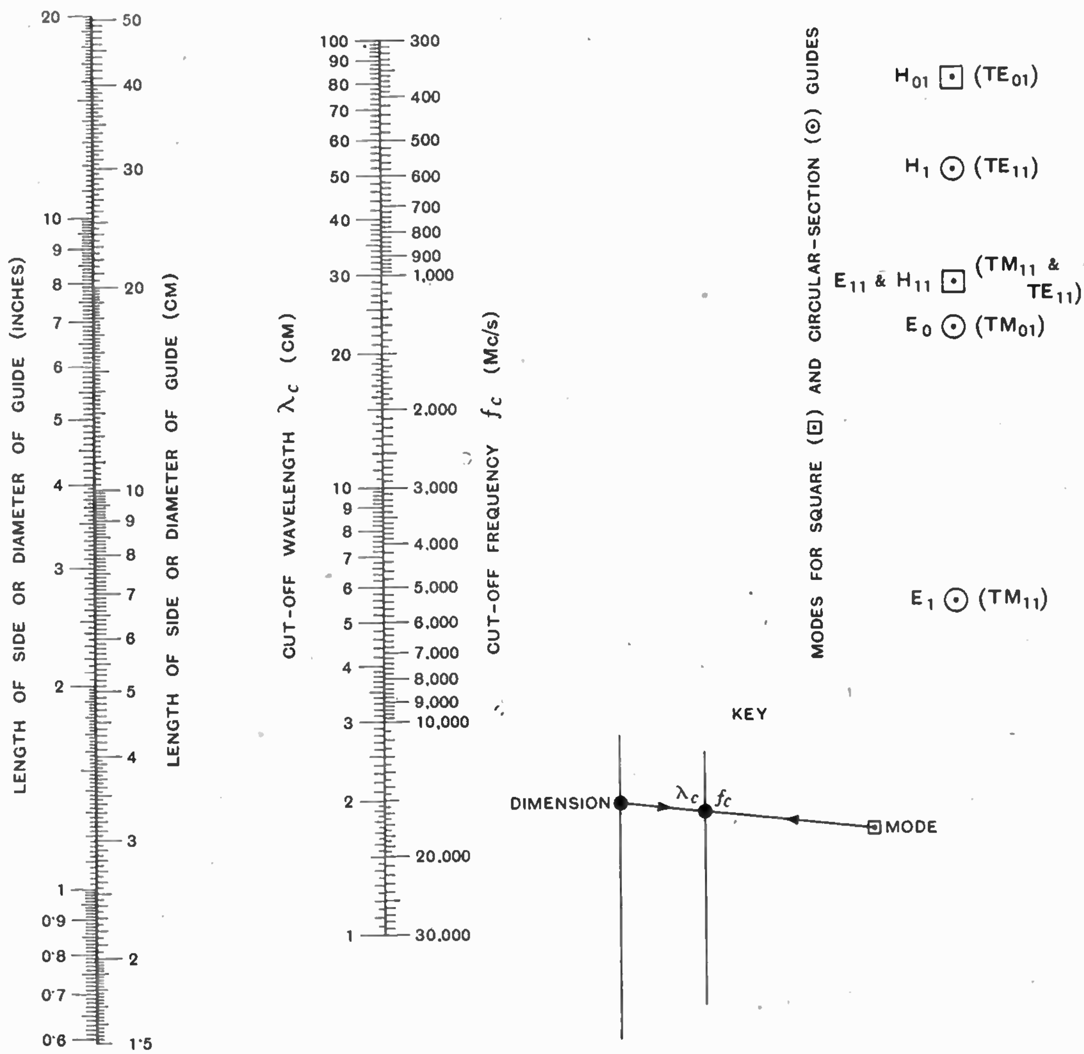
*Note.*—If the guide material is other than copper the attenuation given by the chart must be multiplied by a factor $F = 0.762\sqrt{\rho}$, where $\rho$ is the specific resistivity of the new material in microhm-cms. The factor F is tabulated below for a few materials.

| Material | F |
|---|---|
| Copper | 1.0 |
| Silver | 0.97 |
| Aluminium | 1.28 |
| Brass | 2.16 |
| Lead | 3.46 |

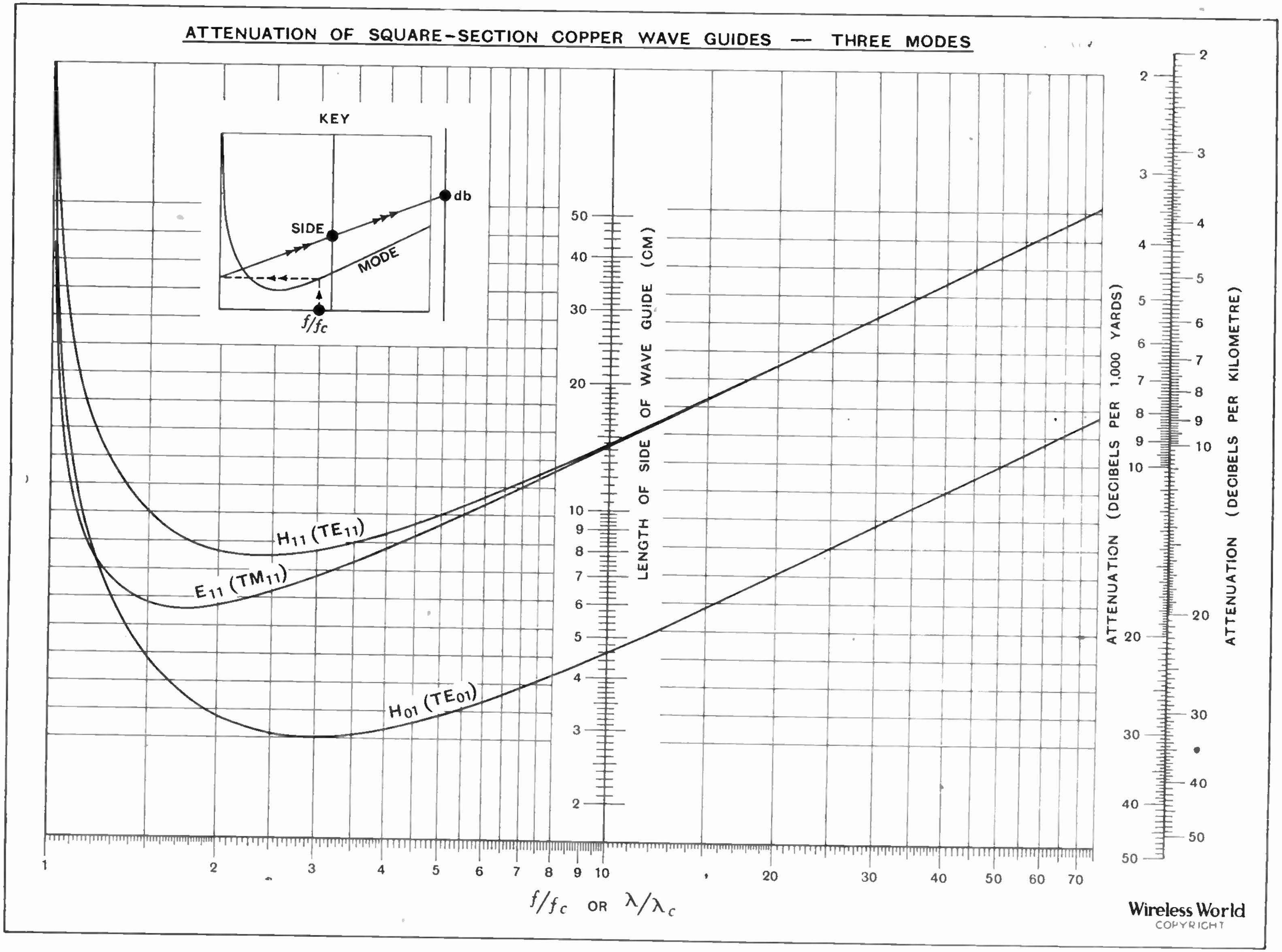
**PREVIOUS RADIO DATA CHARTS**

# ABAC No. 17

[Third Series]

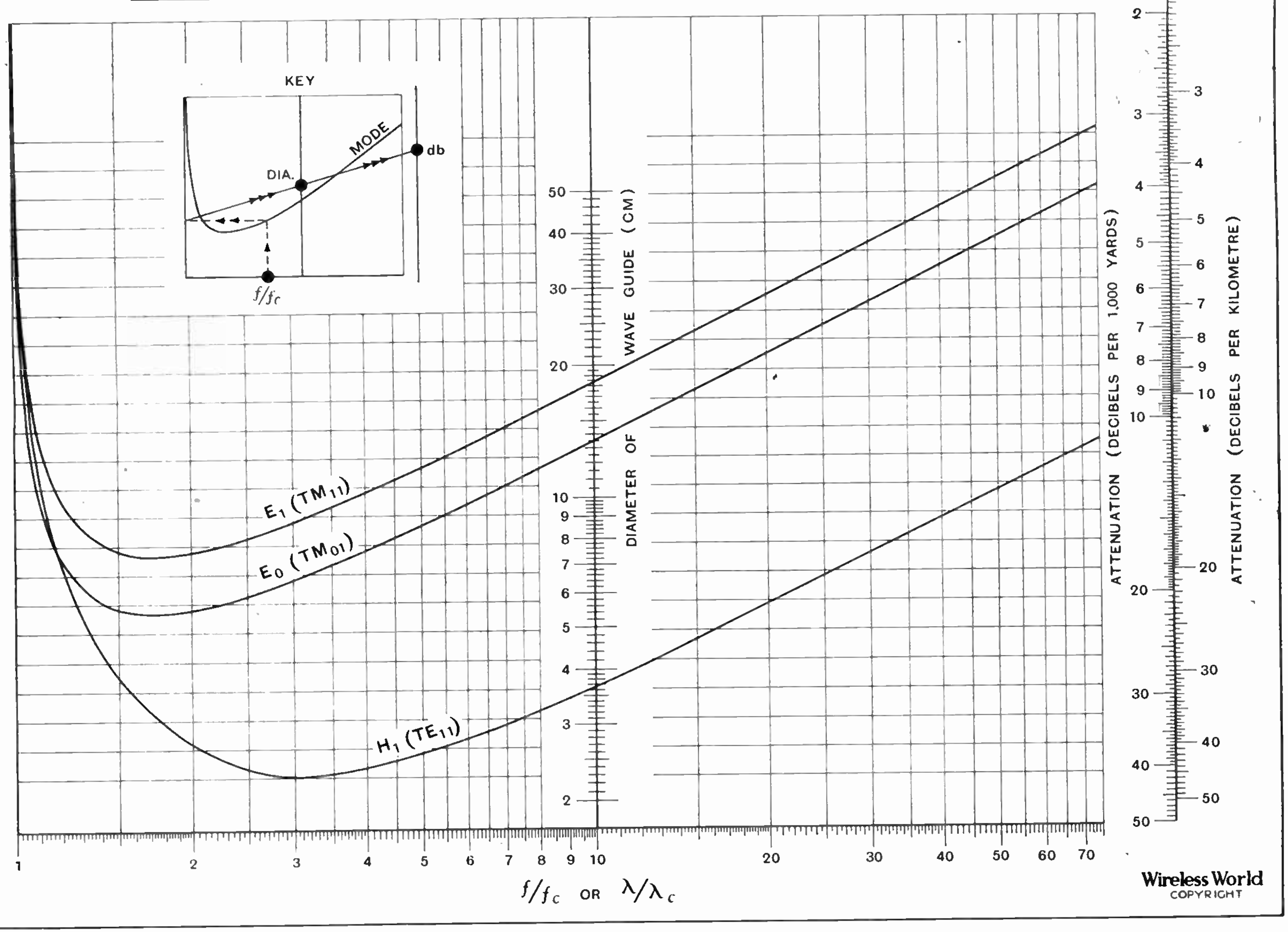



CUT-OFF FREQUENCY AND WAVELENGTH OF SQUARE AND CIRCULAR-SECTION WAVE GUIDES



ATTENUATION OF SQUARE-SECTION COPPER WAVE GUIDES — THREE MODES
KEY
SIDE
MODE
db
$f/f_c$
$H_{11}$ ($TE_{11}$)
$E_{11}$ ($TM_{11}$)
$H_{01}$ ($TE_{01}$)
LENGTH OF SIDE OF WAVE GUIDE (CM)
ATTENUATION (DECIBELS PER 1,000 YARDS)
ATTENUATION (DECIBELS PER KILOMETRE)
$f/f_c$ OR $\lambda/\lambda_c$
Wireless World
COPYRIGHT

ATTENUATION OF CIRCULAR-SECTION COPPER WAVE GUIDE — THREE MODES



# Improving HEADPHONE QUALITY

## Simple Correction Circuits for Use with Conventional Diaphragm-type Ear-pieces

By S. W. AMOS, B.Sc. (Hons.), Grad.I.E.E., A.M.Brit.I.R.E.

IT may come as a surprise to some readers—it did to the author—to find that the frequency range of the usual type of headphones with flat circular diaphragms extends from 50 c/s to at least 15,000 c/s though, of course, the response is certainly not uniform over this large range. The upper frequency limit is probably higher than 15,000 c/s, but this was the upper extreme of the AF oscillator used for test purposes.

Experiments with the oscillator showed that several resonances were present in the response. Measurements of their frequency and magnitude were found somewhat difficult to make, for both change according to the shape and size of the ears of the listener. The principal resonance for one pair of phones tested was at 800 c/s when they were "free" (i.e., with no ear pressed against them), but it changed to 750 c/s for one listener and to 900 c/s for another. There is usually a smaller resonance at about 3,000 c/s, and some types have a narrow sharp dip at roughly 7,500 c/s, neither of which is likely to mar reproduction to an appreciable extent. The chief resonance for all types tested occurred within the range 750 to 1,000 c/s and for all of them the response fell off slowly above and below this frequency, but the response at 50 c/s and 15,000 c/s is usually appreciable.

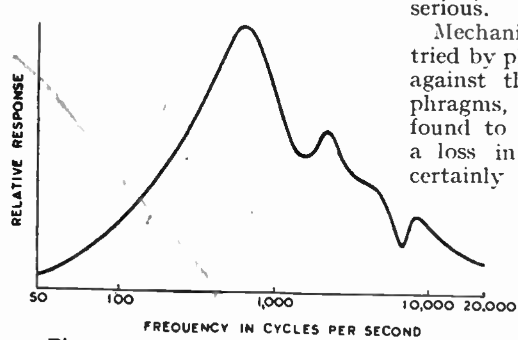



Fig. 1. Estimated response curves for a pair of headphones.

A rough response curve for a typical pair of phones is given in Fig. 1. This is not a scientifically determined curve, but was arrived at purely from the results of subjective observations using the AF oscillator. The resonance at 800 c/s is very pronounced, and it is this which is very largely responsible for the "tinniness" characteristic of the reproduction from headphones. If this resonance peak could be damped down, then a considerable improvement in quality should result, for the smaller resonances are not so serious.

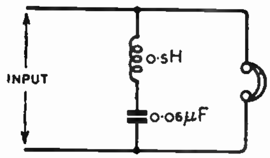



Fig. 2. Tone correction to headphones using a shunt acceptor circuit. This method was abandoned.

Mechanical damping was first tried by placing thin rubber sheets against the centre of the diaphragms, but this method was found to introduce far too great a loss in sensitivity, though it certainly removed the resonance peak. Incidentally, it is interesting to note that the mechanical damping has to be applied to *both* sides of the diaphragm equally, otherwise the operation of the phones becomes non-linear and harmonic distortion results.

Electrical "cooking" was next tried and the obvious method of using a tuned acceptor circuit connected across the phones to absorb most of the electrical input at and about the principal resonant frequency was employed. The acceptor was made a shunt circuit, as shown in Fig. 2, to avoid complications due to the highly inductive windings of the phones, which would make a series acceptor very difficult to design. Results were poor though interesting: the resonance had vanished but the quality was still markedly deficient in extreme bass and "top."

The next step took the form of boosting the bass and top, and the circuit which was used for this purpose is as shown in Fig. 3. In this R1 and R2 control the extent of the boost at both frequency extremes and the capacitances of the condensers C1 and C2 determine the upper and lower frequencies respectively at which the "lift" commences. As a very rough guide for design purposes the "lift" may be said to commence at that frequency which makes the reactance of the condenser equal to the resistance with which it is associated in the circuit.

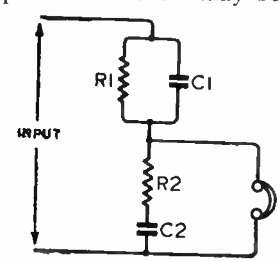



Fig. 3. Circuit finally found to be satisfactory.

The operation of this tone control circuit is as follows. Ignoring for the moment the two condensers, the circuit is a simple potential divider and gives a step down of voltage of $\frac{R2}{R1 + R2}$ times, which we can alternatively regard as a loss of $20 \log_{10} \frac{R2}{R1 + R2}$ decibels. At high audio-frequencies, however, the condenser C1 effectively short-circuits R1 and so gives a rising high-frequency response. At low audio frequencies the reactance of C2 becomes appreciable compared with R2 and so tends to give the potential divider a value of unity at these frequencies.

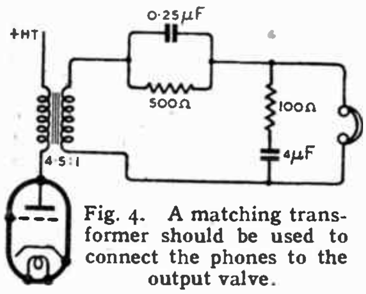



**Fig. 4. A matching transformer should be used to connect the phones to the output valve.**

If we decide that the bass boost shall commence at a frequency $f1$,

we have $X_C = \dfrac{1}{2\pi f 1 C2} = R2$

which gives

$$C2 = \frac{1}{2\pi f 1 R2} \quad .. \quad .. \quad (1)$$

Similarly for the network R1C1 we have

$$C1 = \frac{1}{2\pi f 2 R1} \quad .. \quad .. \quad (2)$$

where $f2$ is the frequency at which treble boost is required to begin.

Experiments showed that 15 decibels was a suitable amount for both frequency extremes and R1 should be about five times R2 to give this. The absolute values of R1 and R2 and consequently the values of C1 and C2 are determined by the impedance of the phones. If the DC resistance of the phones is 4,000 ohms then this may be taken as the impedance of the phones at very low audio-frequencies, but at 1,000 c/s, for example, the impedance, due to the highly inductive nature of the windings, is probably nearer 10,000 ohms. For the circuit of Fig. 3 to work satisfactorily the impedance of the phones must be great compared with the impedance of the series circuit of R2C2 at its greatest. Now if we decide that the bass boost shall begin at 400 c/s then $X_{C2}$ must equal R2 at this frequency. At 50 c/s then $X_{C2}$ will equal eight times R2, and this must be small compared with 4,000 ohms, the resistance of the phones. If we make $8 \times R2$ equal to one-fifth of 4,000 ohms, giving R2 as 100 ohms, we shall satisfy all requirements. Knowing R2 is 100 ohms we can now calculate the capacitance of C2 from equation (1). It is

$$C2 = \frac{1}{2 \times 3.14 \times 400 \times 100} = 4\mu F.$$

Suppose we decide to boost the high frequencies beginning at 1,500 c/s. From equation (2)

$$C1 = \frac{1}{2 \times 3.14 \times 1{,}500 \times 500} = 0.21 \mu F.$$

A component of 0.25 $\mu$F capacitance was actually used so that the final circuit values were as follows: R1 = 500 ohms; R2 = 100 ohms; C1 = 0.25 $\mu$F and C2 = 4 $\mu$F. The results on listening tests using these values in the network certainly justified the time spent in evaluating the circuit constants. It was found possible to follow the basses in orchestral concerts with ease and the reproduction of triangles and the consonants in speech showed the fop to be good also. The improvement in the reproduction is considered by the author, and others who have used the circuit, to justify the sacrifice of 15 decibels in sensitivity.

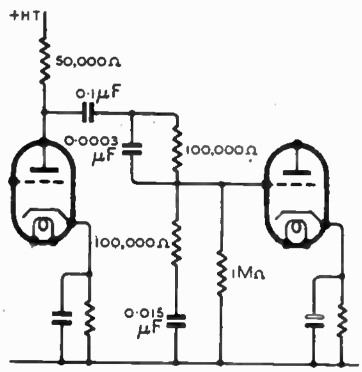



**Fig. 5. Bass and treble boost circuit which generally improves the response of a receiver or amplifier.**

A point to remember about this circuit is that it reduces the apparent impedance of the phones considerably. Without the boost circuit the impedance of the phones is, as mentioned earlier, probably about 10,000 ohms at 1,000 c/s, but the impedance with the boost network in circuit is only about 500 ohms. The exact value is actually a function of frequency, of course, but the average value is about 500 ohms. A matching transformer should therefore be used between the network and the valve supplying the AF output as shown in Fig. 4. If the optimum load of the output valve is 10,000 ohms (as it well might be for a small battery-operated output triode), then, applying the usual matching rules, the transformer should be a step down component with a ratio of $\sqrt{\dfrac{10{,}000}{500}} : 1 = 4.5 : 1$ (approximately).

Provided the anode current of this output valve is small, there is no reason why an old intervalve type of transformer should not be used as matching transformer, using its secondary as primary.

The circuit of Fig. 3 which gives bass and treble boost is a useful one to include in a receiver or AF amplifier, for most loudspeakers (and receivers) suffer from poor bass and treble response. A boost of 15 decibels is rather too much to use, however, and 6 decibels is better. It is most convenient for the bass boost to begin at about 100 c/s and the treble boost to begin at 5,000 c/s. A circuit giving this performance is given in Fig. 5. The circuit is shown embodied in the intervalve coupling of an RC amplifier.

## DUNDAS "DRYAIR" ELEMENTS

DESICCATING elements in a wide range of types have been developed by R. K. Dundas, Ltd., The Airport, Portsmouth. The active agent is silica in colloidal form which has the power of adsorbing water (and also organic vapours such as petroleum vapours, alcohols, esters, etc.) from the atmosphere. No chemical change is involved and when the element is saturated it can be regenerated simply by heating to approximately 200 deg. C. A colour indicator incorporated with the silica changes from blue to pink when the element is approaching saturation.

The principle has been employed on a large scale in air-drying plants for laboratories, etc., and at the other extreme in small hermetically sealed aircraft instruments. The elements could no doubt be employed with advantage in laboratory standard air dielectric condensers, and there is also an application in packing radio instruments for export to prevent internal sweating in transit.

# UNBIASED

## Shape of Things to Come

By

FREE GRID

THE absorbingly interesting article entitled "Towards Synthetic Music" which the Editor permitted to be published in the September issue of *Wireless World* has led to my feeling an entirely new sense of respect for him and his talents. Hitherto, I must confess I have been rather inclined to think of him as being of the earth, earthy; moving and having his being in the narrow world of physics and dealing only with such easily definable things as microvolts and decibels.

It is all the more pleasant, therefore, to find that he is, like myself, capable when occasion demands of venturing into the rather shadowy land of metaphysics wherein dwell "creative urges" and suchlike things with which the article deals, and I look forward in some future issue of this journal to reading a stirring demand from his pen for action on the part of the British Standards Institution for a quantitative definition of the creative urge, and for the production by our leading manufacturers of properly designed urgometers, accurately scaled and calibrated in micromozarts.

At the same time, while feeling deeply appreciative of the sincerity of the author I frankly cannot visualise Bach and Beethoven churning out what the B.B.C. would describe as their most nostalgic numbers, surrounded by cathode-ray tubes and other laboratory gear as he imagines. It may be true that in the course of their work the great composers probably had some such instrument as a harpsichord at hand to help them out and doubtless there were times when they experienced the vexation of a string breaking at a supremely creative moment, but it is highly improbable that every string went "phut" at the same time. In the case of valves and cathode-ray tubes, however, it would only need a moment's carelessness with the HT connections for the whole thing to be put out of gear, and a masterpiece mucked up.

The whole trouble is that the learned author does not go nearly far enough in his imaginative flight into the future of music. He seems to forget that a musical composition, like a painting, is first conceived in the brain of a human being, and it is perception by the brains of fellow human beings which is its ultimate goal.

I have long held the view that the link between one human brain and another must be a direct and simple ether wave link. The future of music, painting, etc., as I view it, is not bound up with crude intermediary links like auditory nerves, optic nerves, muscles and all manner of mechanical and electrical contrivances. The composer or painter of the future will simply sit and think and we shall receive his efforts by direct ether wave link from brain to brain; in other words by telepathy.

I am fully aware that these sentiments will not be at all popular with radio and other manufacturers, but I am not the sort of person to suppress the truth because of any considerations like that. As for "recording" musical or other artistic creations for future use, this will present no difficulty, as ether waves, once started on their way, go on for ever; at any rate, according to the latest text books on telepathy.

## Tympanic Titillation

I CANNOT refrain from referring to yet another ebullition in *Wireless World* for September, which seemed fuller than usual of good things, namely, that dealing with volume expansion. The author voices in it sentiments not greatly dissimilar to those which I expended in these columns over fourteen years ago. He is dealing with questions of contrast magnitude whereas I dealt more crudely with what I will term the general overall noise of a musical or other performance, but it all boils down to the same thing.

The idea seems to be prevalent among people who ought to know better that in order to achieve "realism," or to use the horrible but widespread redundancy "*true* reproduction," it is necessary to have in our rooms a wireless set kicking up the same quantity of noise as the performers in the concert hall. To produce in a suburban villa the same level of sound as exists in a *fortissimo* passage being ground out by the Philharmonic Orchestra can only lead to trouble with the police, if not to the actual disintegration of the house, and I think that there is no harm now in telling the world that the fostering of this appalling idea was one of the secret V weapons of Adolf's armoury. He deduced quite rightly that its carrying out would lead to more ill-feeling and dissension in our ranks than all the efforts of Goebbels and Haw-Haw.

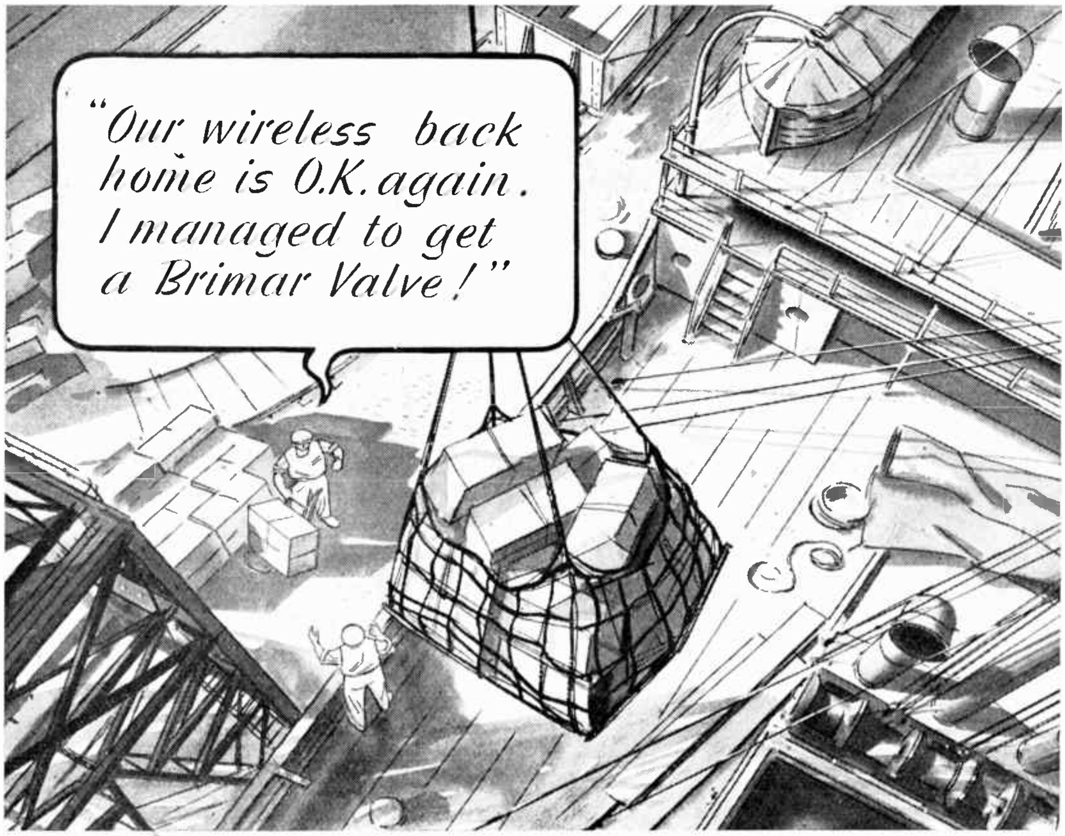
Reduced to its simplest terms, "reproduction" simply consists in

"Trouble with the Police."

designing apparatus to waggle our ear drums in exactly the same manner, and to exactly the same extent, as they would be waggled if we were sitting in the concert hall. We can do this just as well by using a few milliwatts of power in high-fidelity earphones as by using a lot of watts in a gargantuan loud speaker in the far corner of the room.

Furthermore, this method of reception would enable every member of the household to listen to the programme of his or her choice without interfering with the choice of other members of the household. This system of reception should please all members of the community, even including the radio manufacturers, since it would enable them to sell a separate set to each member of the family; two sets, in fact, if the B.B.C. gave us stereophony by providing a separate channel for each earpiece.

# *Angles on* BRIMAR PRESTIGE

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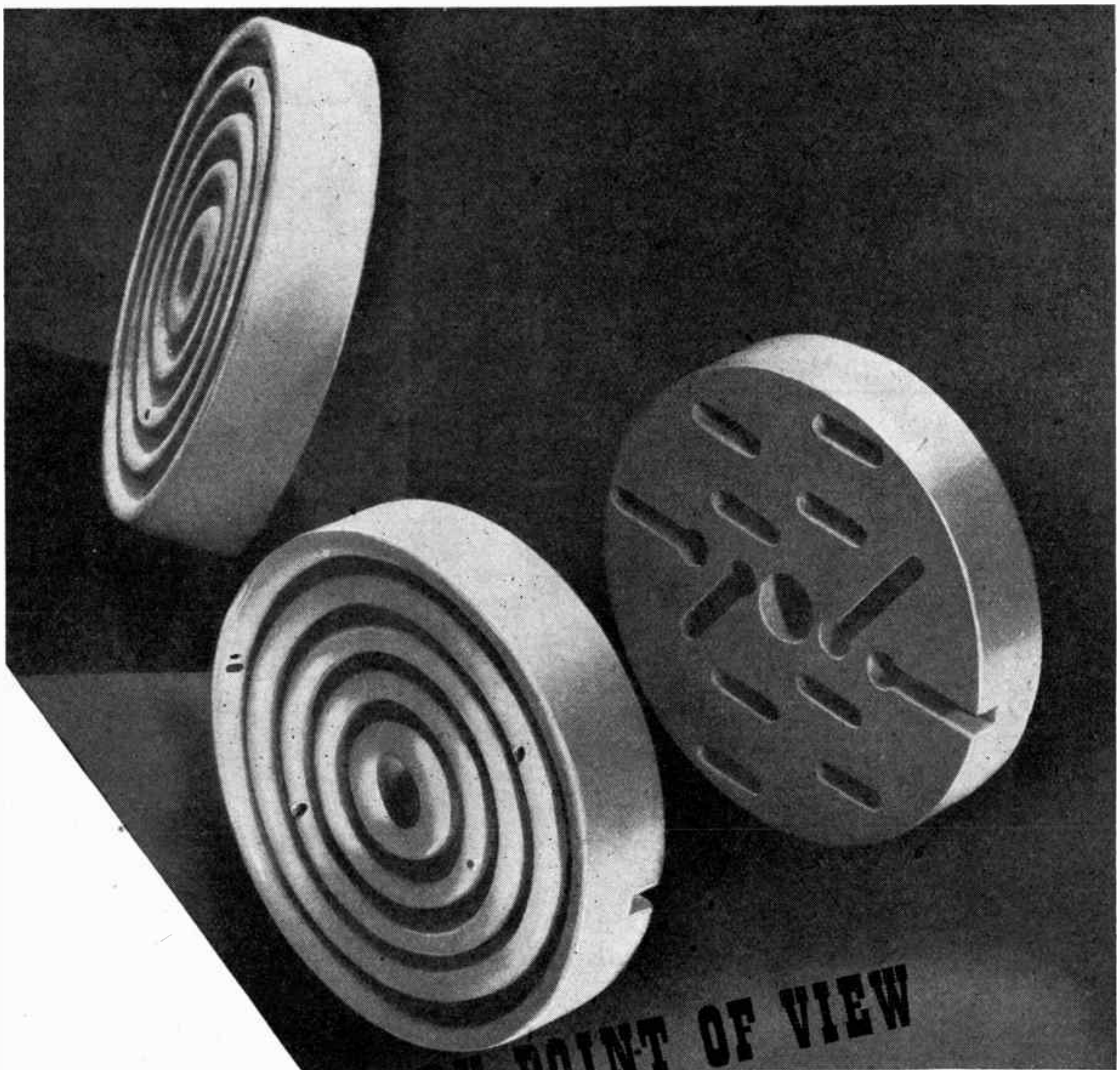


# RADIO NOISE

## *Interference Due to Natural Causes*

By T. W. BENNINGTON

At the output end of a radio receiver there is always present, in addition to the wanted signal—of whatever nature that may be—a certain volume of unwanted sound, which has no agreeable musical quality and which is called, in radio parlance, the "noise." This constitutes a source of interference to the wanted signal, and the latter will only be of an intelligible—or, alternatively, agreeable—quality if it has an intensity relatively great compared to that of the noise. Thus we have the situation where a very weak received field with a low noise may provide a more intelligible signal—or a more agreeable programme—than will result from a very strong field which is accompanied by a high noise level. In other words, as every radio man knows, it is the signal-to-noise ratio which is of more importance than the intensity of the signal itself.

In character the noise may vary all the way from a slight continuous "hiss" to an intermittent "crash" of unmusical sound, though it usually takes the form of a mixture of "hisses," "gratings" and "cracklings," and possibly there may be the "crashes" as well. These are due to the presence in the circuits of the radio receiver of certain unwanted voltages and currents, which give rise to the interfering sounds at the output device. We may speak, in a general way, of all these phenomena—whether of the electrical voltages and currents, or of the actual sounds resulting from them—as "noise."

**Different Types of Noise.**—The noise may, in the first instance, be divided into two categories; that produced within the receiver itself—called the "set noise" — and that produced externally and picked up by the receiving aerial together with the wanted signal—called the "radio noise." Although this article is to deal primarily with radio noise, we may as well say a few words about the set noise in passing. This set noise sets the absolute low limit to the value of signal field intensity necessary to produce a workable signal with a given receiver, since, in the absence of all external noise, it will still be present, and so limit the working capabilities of the receiver. It consists of two components. First there is the noise due to thermal agitation, caused by the movements of electrons in the material of the receiver circuits—principally in its input circuit. This thermal agitation sets up small voltages across the resistance of the circuits, which finally appear in the output arrangement as a slight hiss. Then there are noises produced within the valves of the receiver, due to the slightly intermittent nature of the electron streams arriving at the anodes, and this will also contribute something to the total noise appearing at the output arrangement of the set. There may also be some noise which enters the receiver from the electric supply mains, though this is, to a large extent, preventable.

But to return to the radio noise. The radio noise intensity may be defined as the field intensity, at any point, of all electromagnetic waves of an interfering character, and, with a given signal intensity will determine the signal-to-noise ratio, and hence the quality of the signal at the output of the receiver. Looked at from the transmitting end this means that the greater the radio noise intensity at the receiver the greater must be the power radiated for the receiver to produce a workable signal. Looked at from the receiver end, it means that the greater the radio noise intensity the greater must be the signal intensity of the weakest signal that is intelligible.

The radio noise is thus an important quantity in a communication system, affecting the design of both transmitting and receiving stations. It may be considered to consist of three separate components:

(1) Interfering waves produced by man-made devices, whether such devices are for the purpose of emitting signals or not.

(2) Interfering waves produced by natural phenomena in the earth's atmosphere.

(3) Interfering waves produced by natural phenomena outside the earth's atmosphere.

We do not, in this article, intend to deal with the man-made interference—a subject which would require an article to itself—but to speak only about the interference due to natural causes, as shown in the last two categories mentioned above.

**Atmospherics.**—By far the greater part of the naturally produced radio noise normally present in a receiver is that which is caused by lightning discharges occurring in the troposphere. These lightning strokes radiate electromagnetic waves which are picked up by the receiving aerial and which produce the interfering sounds called "Xs" by the older generation of wireless men, but now commonly referred to as "atmospherics," or occasionally, for some obscure reason, as "static."

Thunderstorms are occurring in some part of the world at practically all times of the day and night, and the electromagnetic waves produced by the lightning strokes travel outward in all directions from the source. During a lightning stroke an enormous amount of power is expended, and the flash itself really consists of a number of separate discharges, each discharge being made up of several current pulses. The channel down which the stroke occurs behaves like a radio aerial, and, because the air in the channel becomes ionised, its resistance, capacity and inductance alter as the discharge proceeds, and the frequency of the electromagnetic waves emitted changes. The nature of individual strokes varies considerably, and consequently the character of the radiated wave

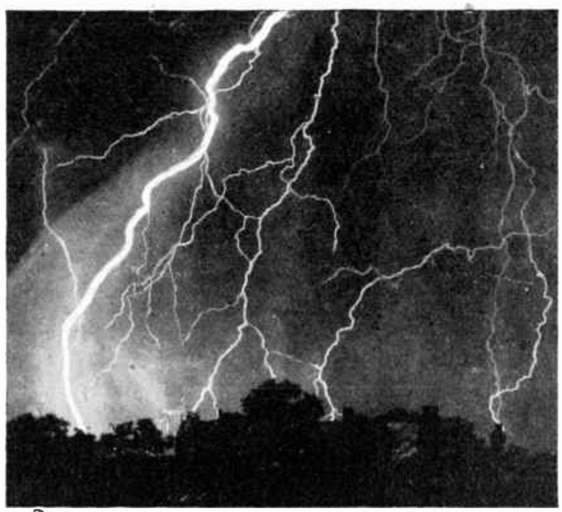
Radio Noise—

also differs. But it has been found that, while the predominating frequency emitted is in the region of 10 kc/s, waves of all radio frequencies are produced. In fact, the lightning stroke can be regarded as a radio transmitter radiating power on all frequencies, though, because of the relatively long duration of the current pulses in the stroke, the intensity of the field produced is much greater on the low than on the high frequencies. The noise intensity produced during a lightning discharge is, in fact, *approximately* inversely proportional to frequency, or directly proportional to wavelength. It is, broadly speaking, extremely high on the very longest radio waves, and, falling with decreasing wavelength, reaches almost, but not quite, negligible proportions on the ultra-short waves.

This is the noise situation, then, in what might be called a *local* thunderstorm. We might define a local thunderstorm, very roughly perhaps, as one occurring within two or three hundred miles of the receiver, such that for frequencies within the medium wave band the receiver is within range of the ground wave of the waves produced. Such thunderstorms can continue to affect the receiver for some few hours, the time for which they do so depending of course on the frequency considered, for the range of a ground wave decreases with increasing frequency. Even on the short waves these storms have been found to produce noise affecting a receiver for four hours before and after the passing of the storm.

**Propagation of the Noise.**—But the electromagnetic waves produced when a lightning stroke occurs are propagated, not only as ground waves, but as sky waves as well. That is to say the waves may be propagated by refraction in the ionosphere, and so, on certain frequencies, reach to far greater distances than is possible for the ground wave. This means that on certain frequencies the range of the noise waves will be much greater than on others. Consequently, at a given location, the radio noise intensity will vary with frequency in a rather complex way, depending, not only upon the intensity actually produced, but also upon the propagation characteristics of the path between the noise source and the given location. Furthermore, its variations with frequency will show marked diurnal changes, and also seasonal changes, for the propagation conditions for various frequencies will change with time of day and season. Obviously also the noise intensity will vary greatly at various locations on the earth's surface, since thunderstorms are of much more frequent occurrence in some parts of the world than in others.

In temperate latitudes the "local" thunderstorm does not, as a matter of fact, constitute the main noise source, except perhaps on a few frequencies—though it can certainly be troublesome on most frequencies at times. But temperate latitudes are much more affected by distant thunderstorms—over the greater part of the radio frequency spectrum—because the noise emanating from distant thunderstorms is much more continuous in character than that from the local kind. It will be appreciated also that when reception of the noise is by sky wave then thunderstorms occurring over very wide areas can contribute something to the total noise received.



Lightning is the prime cause of "natural" interference with radio reception.

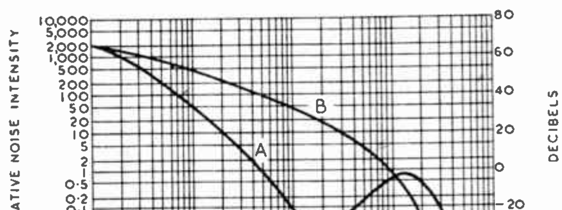
**Noise Zones.**—In the temperate zones of the Northern Hemisphere the radio noise arriving at a receiver—other than that which may be due to a local thunderstorm—has been found to come from certain well-defined directions, i.e., from the south, south-east or south-west. The principal thunderstorm-producing areas of the world are certain land areas lying in or near the tropical regions—notably India, the East Indies, North Australia, Central Africa and Central America—and it may be taken that the distant noise which affects the temperate zones comes from one or other of these regions. The exact location of these thunderstorm regions—or "noise zones," as we might call them—varies somewhat with the seasons, and they move North and South over a few degrees of latitude with the sun. The frequency of the lightning flashes occurring in these tropical thunderstorms is far greater than in those which occur in temperate zones, so that the noise emanating from them is more in the nature of a continuous "crackling" than of an occasional "crash." The thunderstorms occur more frequently during the local afternoon and evening than at other times of day, so that there is a diurnal variation in the noise produced. This has been estimated to vary in intensity by about five to one over the day, reaching a maximum in the late afternoon and a minimum in the early morning.

Within the noise zones themselves the noise received will principally be that due to the ground waves from the lightning strokes, since the sky waves will skip over the area, except perhaps on a very few frequencies. The noise intensity will be very much greater than that usually experienced in temperate regions, and if we plotted a curve of noise intensity against frequency we should expect to get a more or less straight line, sloping downwards from a high value at the very low frequencies to a low value at the ultra-high frequencies, because of the variation in the amplitude of the interfering waves with frequency. This curve would be very similar to that for the noise produced by a purely local thunderstorm in a temperate region.

**Noise in Temperate Regions.**—As has already been said, the local thunderstorm is not the principal noise source in a temperate region. In such regions local thunderstorms are of relatively infrequent occurrence, compared to those of the noise zones, and the lightning strokes in them do not occur continuously, but only at intervals so, on most frequencies it is the distant thunderstorms which are of more importance.

Just outside the noise zones the total noise received would be a mixture of that due to reception of the ground wave and of the noise waves which have been propagated via the ionosphere. As one proceeded farther and farther away from the noise zones one would expect the general level of the noise to decrease somewhat, due to the mere fact that the source is getting more distant and the waves becoming more attenuated. So that as the Arctic regions were approached the general noise level would have reached its lowest level for the whole world. This general picture of the geographical variation of noise intensity is largely true, and in Arctic regions the noise is indeed of lower intensity than anywhere else in the world.

In the figure are given some curves which show how the noise intensity varies with frequency at two times of day at a location in the Northern temperate zone. Let us study first the curve A, which is for midday. We see that on the very low frequencies the noise intensity is high, due first to the fact that, owing to the nature of the lightning discharges, the noise intensity produced is a maximum in this region, and also to the fact that low-frequency waves are well propagated to long distances at all times. Incidentally it has been found that when this low-frequency noise is particularly high the high-frequency noise is also high, showing that both are coming from the same source. As the frequency is increased the noise intensity decreases relatively sharply, because, during the day, sky wave propagation from the distant sources becomes poor and then impossible. The energy in the sky waves from the lightning strokes is, in fact, all absorbed in the lower ionosphere. At about 2 Mc/s what noise there is is mainly local and the noise intensity has become so low that it is, in fact, near the level of the set noise. Then we approach frequencies on which propagation from long distances by the ionosphere is possible, and so begin to get the sky waves coming from the distant noise sources. The noise intensity consequently increases with frequency up to about 15 Mc/s, because sky wave propagation becomes more and more favourable. The position of this peak—15 Mc/s at midday—will, of course, vary with time of day, and will also depend to some extent upon the season and epoch of the sunspot cycle. Above 15 Mc/s the noise intensity starts falling again, because the frequency is becoming too high for the ionosphere to sustain propagation, i.e. the noise waves begin to penetrate it. Somewhere around 30 Mc/s no noise waves are coming *via* the ionosphere, and the local noise being very low, the noise intensity again falls to a level near that for the internally produced set noise. Thus on the ultra-high frequencies there is an almost negligible intensity of atmospheric noise, and it is thus all the more unfortunate that the man-made noise should be at a maximum value on these frequencies.




Variation of radio noise with frequency at noon (A) and at midnight (B) in the Northern temperate zone. From curves given by R. K. Potter, *Proc. I.R.E.*, Sept. 1932.

Curve B shows how the noise intensity varies with frequency at midnight. On the low frequencies it is of the same value as it was at midday, these frequencies being propagated equally well at both times. But with increasing frequency the noise intensity decreases much less rapidly at midnight than at midday, because sky wave propagation is now possible on the medium frequencies. And at about 2 Mc/s, where at midday the intensity was at a minimum large values of noise intensity are now observed. Sky wave propagation of the noise, which at midday was impossible on frequencies round about this value, is now possible even from great distances. It will be seen that, on the medium frequencies, we have maximum values of noise intensity by night and minimum values by day.

At about 10 Mc/s the midnight curve begins to fall rapidly, and this fall continuing with increasing frequency, the noise intensity approaches the level of the set noise at a much lower frequency than during the day. The ionisation of the propagating medium is much less at midnight than at midday and so it is not able to sustain propagation on such high frequencies. Thus, so far as the higher frequencies are concerned the noise intensity is less at night than during the day. But it is to be noted that the frequencies on which the noise is very low would not be suitable for use at night. In fact, if a comparison is made between a suitable day and a suitable night frequency—say 6 Mc/s for night and 20 Mc/s for day use—it is seen that the noise intensity is *much* higher by night than by day.

The information obtainable from these two curves is necessarily restricted. They merely give an idea of the nature of the noise variation for two times of day. At other times the noise curves would take up positions intermediate to those shown, and exhibit characteristics partly of the midday and partly of the midnight type.

**Rain Atmospherics.**—So much for the normal radio noise which

**Radio Noise—**
is present, to a greater or less degree, with all received signals, and which the signal must overcome in order to be intelligible. The intelligibility of a signal will of course depend also upon its nature and its purpose—for telephony reception a greater signal-to-noise ratio is necessary than for telegraphy, while for satisfactory broadcast reception a still higher ratio of signal to noise is demanded.

We must now mention another form of noise which is due to natural causes in the troposphere. This is the phenomenon known in this country as "rain atmospherics" and in the U.S.A. as "precipitation static." In temperate regions it is of relatively infrequent occurrence—though it *can* be troublesome at times—but in tropical regions it is much more frequent, and forms a serious source of interference. It occurs during heavy rain or hail storms, or during dust storms, where the particles coming in contact with the receiving aerial —whether they be rain, hail or dust particles—have become electrically charged. These charged particles have fields associated with them which affect the receiving aerial, and currents are induced in it which eventually appear at the receiver output as a continuous hiss—often of an intensity such as to swamp the wanted signal entirely. This form of interference is of particular importance in aircraft, which, when flying through rain, hail or dust storms, frequently experience rain atmospherics of an intensity sufficient to interrupt communication.

**Jansky Noise.**—Now we come to the form of radio noise which was mentioned under the last of our three classes of radio noise above; i.e. noise due to electromagnetic waves coming from outside the atmosphere. This is the noise which was first recognised by Jansky in 1932 and which is sometimes known as "star static" by reason of its origin in the stars. It takes the form of a slight hissing sound, hardly distinguishable above the set noise but nevertheless unmistakable in the absence of other radio noise. Jansky, by the use of a sharply directional aerial system, found that it varied diurnally in a systematic way in its direction of arrival. He found that its direction changed nearly round the compass every 24 hours, except that in the middle of the night, when its direction had reached north-west, it also began to come in from the north-east, and so commenced another cycle of variation. At first he thought that it must be coming from the sun, but later disproved this, and found that it was in fact coming from the direction of the Galaxy. The theory has since been put forward that this noise is really thermal agitation noise caused by electrons which have been erupted from the stars, and which move about in interstellar space, all space being the conductor in which the thermal agitation is set up.

**Overcoming Radio Noise.**—Since the earliest days of radio there has been a constant endeavour to find some means of overcoming the effects of radio noise, and from time to time devices have been produced with this end in view. Not many of these have proved successful—the difficulty has been to reduce the noise without affecting the strength of the wanted signal, and in this they have largely failed. To get rid of the noise at the expense of losing a large part of the signal energy has not proved a very great advantage, and so we are left with radio noise as an ever-present feature of reception.

Since radio noise is present on all frequencies the noise energy present in the circuits of a receiver will be proportional to the width of its response band. So the most obvious way in which to reduce it is to restrict the width of the response band. But a certain band width is necessarily imposed on the receiver designer by the requirement that he must adequately accommodate the side bands of the wanted signal, so the best he can do in the way of reducing the noise is to make the band width no greater than is necessary for this purpose.

In some receiving systems the use of a "limiter" leads to satisfactory results, in which a diode is arranged in the circuit so that any voltage in excess of that required for a good signal is by-passed. This is claimed to be very effective when the noise consists of occasional heavy "crashes," but when it takes the form of a continuous "rattle" the device is less effective.

Perhaps the greatest noise reduction that can be effected is by the use of sharply directional aerial systems which, whilst giving a large gain in the direction of the wanted signal do not pick up the noise which is coming from all other directions. Their advantage must, however, be to some extent fortuitous, for it will depend largely upon the sort of noise conditions the aerial is "looking at," and if it should be that the wanted station is situated in a noise zone the fact that the aerial has a large gain in this particular direction will not be of much help from the point of view of noise reduction. Receiving stations in tropical regions would certainly derive a noise reduction advantage from the use of such aerials, especially when receiving from the north or south, and the same applies to stations in temperate zones when receiving from the east or west.

It will be seen then that there may arise many conditions when little can be done at the receiving end to nullify the effects of the radio noise, and then there is only one course to be taken in order to improve the intelligibility of the signals. This is to increase the signal intensity relative to that of the noise, by the radiation of more power by the transmitting station.

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## I.E.E. AND AMERICAN I.R.E.

CLOSER co-operation between the Radio Section of the British Institution of Electrical Engineers and the American Institute of Radio Engineers was foreshadowed by H. L. Kirke, the new chairman of the Radio Section. In his augural address, delivered in London on October 11th, Mr. Kirke reported discussions with the I.R.E. Board, held in America early this year. As an outcome, abstracts of I.R.E. papers will, when conditions permit, appear in the *Journal* of the I.E.E. and *vice versa*. It is also hoped that there will be a freer interchange of papers between the two bodies, both of which have set up Liaison Committees.

Dr. R. L. Smith-Rose and F. S. Barton took part, with the new Chairman, in the discussions in America with the I.R.E.

# THE "STABILISTOR"

## An Improved AC Voltage Stabiliser

By A. H. B. WALKER, B.Sc., A.C.G.I., D.I.C., A.M.I.E.E.
(Research Dept., Westinghouse Brake and Signal Co., Ltd.)

DURING recent years the problem of stabilising the AC supply voltage for energising many types of modern mains-operated apparatus has attracted greatly increased interest. This is no doubt due in part to the greater voltage fluctuations of the supply mains which have resulted from war conditions, and also to the increased use of many types of electronic apparatus in research and production.

The neon discharge tube, the barretter tube and various thermionic valve arrangements are frequently employed for stabilising relatively low power supplies such as the HT and heater supplies to amplifier valves, but these devices are not in general applicable to the stabilisation of the whole of the AC input power to such apparatus, as the fundamental principle of their operation inevitably involves the wastage of a considerable proportion of the power input.

For the purpose of stabilising AC supplies where considerable power output may be required the principle of the magnetic saturation of iron has been widely used, and a number of different designs of "Voltage Regulating Transformers" have appeared on the market. However, the majority of these designs suffer from two disadvantages which may prove serious in some applications. The first of these is that the saturation of the iron results in large harmonics in the magnetising current, and these harmonic currents flowing through the impedances of other portions of the circuit result in harmonic voltages which appear as a serious distortion of the output voltage waveform (Fig. 1). Another disadvantage frequently met with is that although the output voltage may be held constant at any given value of load, the device exhibits considerable regulation* of output voltage with load changes, and this may prove troublesome in apparatus with varying power consumption. A further, though less serious difficulty, is that the harmonic content of the output voltage may vary considerably with load changes, so that although the RMS value of the voltage may be quite steady, the form factor is changing with load, and as a result the DC output from any rectifier operating from the stabiliser will not remain constant. For instance, a stabiliser of this type would be useless for stabilising the supply to circuits used for meter calibration.

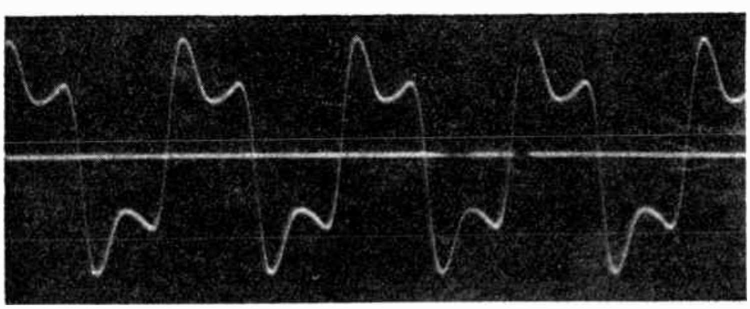


Fig. 1. Oscillogram of the output voltage of one commercial form of "Stabilising Transformer," showing the severe distortion which is caused by magnetic saturation.

The improved form of stabiliser described below, and known as the "Stabilistor," has been developed to overcome these disadvantages, and although it operates on the principle of magnetic saturation it will provide a substantially sinusoidal output voltage over a wide range of load; moreover, the output voltage is held within fine limits in spite of simultaneous variations in both input voltage and magnitude of load. The basic circuit of the "Stabilistor" is shown in Fig. 2 (British Patent No. 548,526).

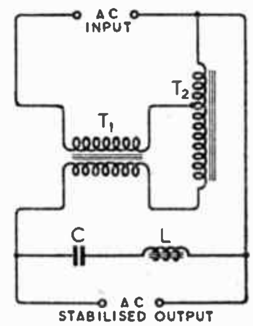



Fig. 2. Basic circuit of the "Stabilistor."

The circuit consists of a double-wound transformer $T_1$ and an auto-transformer $T_2$, with their windings interconnected. Across the output leads from these transformers is connected a filter circuit comprising a condenser C and choke L, in series. This filter circuit is designed to have a double action. In the first place L and C are chosen so that at 50 cycles the circuit behaves as a condenser and draws a leading current ($I_C$), this current being necessary for the stabilising action; but at 150 cycles the circuit is resonant, and appears as a low resistance, therefore providing a virtual short circuit to the third harmonic magnetising current of transformer $T_2$. Owing to the purity of waveforms which results from the use of this filter, the circuit may be analysed by vector diagrams, and for simplicity the effect of the choke L at 50 cycles, which can be allowed for in design will be neglected in these diagrams.

Fig. 3 (*a*) illustrates the conditions when the supply voltage is low, and the load is a maximum. The diagram is built up from the

* Defined as the change in output voltage when the load is reduced from the rated output to no-load.

**"The Stabilistor"—**

voltage $V_2$ across the primary of $T_2$. The magnetising current $I_m$ (50 cycles component only) of $T_2$ and the condenser current $I_C$ add vectorially to form a small resultant current $I_m + I_C$ which, added to the load current $I_L$, gives the total supply current $I_s$. $I_s$ flowing through the inductance of $T_1$ results in the voltage $V_1$ leading on $I_s$ by approximately 90°, and the vector addition of $V_1$ and $V_2$ must give the mains voltage $V_s$. The output voltage $V_O$ is obtained from the addition of $V_3$ and $V_4$, and is approximately equal to $V_3$, as $V_4$ is nearly in quadrature with $V_3$.

Now let us assume that the supply voltage is greatly increased, the load remaining unchanged (Fig. 3 (*b*)). $V_2$ and $V_3$ both increase slightly, but owing to the high flux density in the core of $T_2$ the magnetising current $I_m$ increases to a much greater extent. As a result of this, the current $I_m + I_C$ is very greatly increased, and lags further behind $V_2$. $I_s$ must therefore increase and lag further behind $V_2$, but this means that $V_1$ increases and moves nearer in phase to $V_2$, thus accommodating the increase in mains voltage $V_s$. The output voltage is still made up of $V_3 + V_4$, and although $V_3$ has slightly increased, $V_4$ has moved clockwise and increased in magnitude so that the output voltage $V_O$ remains fixed at its previous value.

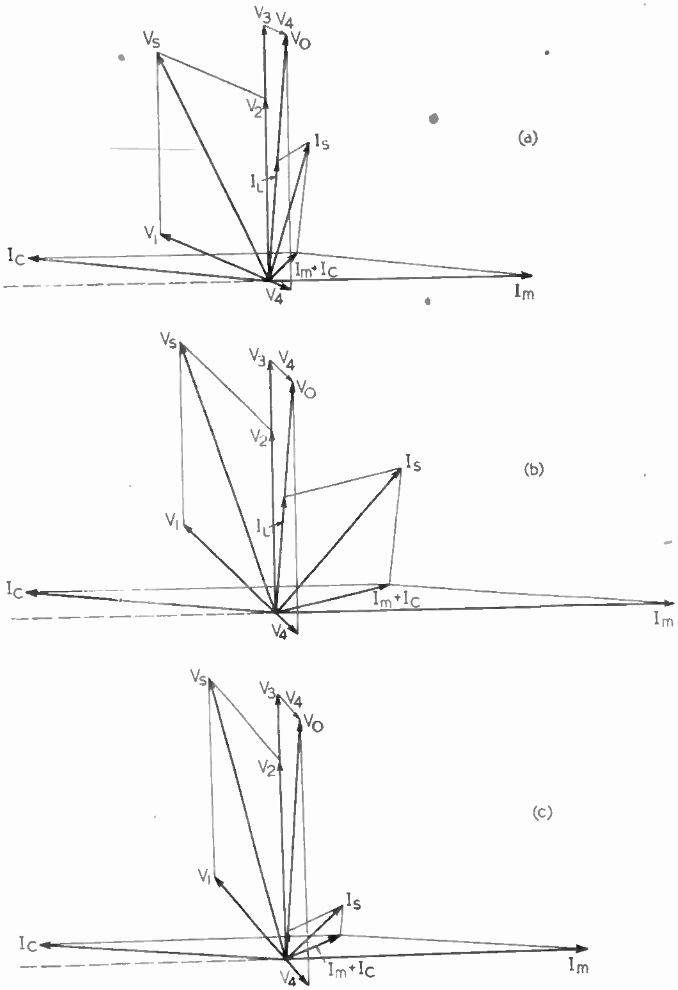



**Fig. 3. Vector diagrams of action of "Stabilistor": (a) supply voltage low, load maximum; (b) supply voltage high, load maximum; (c) supply voltage high, no load. The effect of choke L at 50 c/s is assumed to be neglible.**

The effect of changes in the load will now be considered. Assuming that the supply voltage is maintained high as in Fig. 3 (*b*), but that the load is thrown right off the new conditions are then as shown in Fig. 3 (*c*). The tendency of $V_2$ and $V_3$ to increase is continued further, and $V_3$ will increase even more, due to the regulation of $T_2$, so that the vectors $(I_m + I_C)$ and $I_s$ continue in their clockwise rotation (the load current $I_L$ having been reduced to a value representing only the losses in $T_2$). $V_1$ therefore moves more into phase with $V_2$, and also diminishes. However, $V_4$ has now moved more nearly into opposition to $V_3$, so that the resultant of $V_3$ and $V_4$, which is the output voltage $V_O$, does not change from its previous value.

## Performance

The degree of stabilisation produced by the "Stabilistor" is so good that it is impracticable to illustrate it by graphs unless these are drawn to a false zero, but the table below showing variations of output voltage will give a good idea of the performance of a "Stabilistor" rated for an output of 230 volts 80 VA. Similar performance has been obtained on "Stabilistors" having various ratings from 25 VA to 1,200 VA.

An interesting point brought out by these figures is that the regulation is almost zero with the mains voltage near the nominal value of 230 volts, but when the mains voltage drops to the extreme lower limit of 190 volts, the regulation becomes positive; while if the mains voltage rises to the extreme upper limit of 260 volts, the regulation becomes slightly negative.

| Load | Mains Voltage 190 | Mains Voltage 230 | Mains Voltage 260 |
|---|---|---|---|
| 0 | 233 | 229 | 228.5 |
| ¼ | 233 | 230 | 230.5 |
| ½ | 231.5 | 230.5 | 232 |
| ¾ | 228.5 | 230 | 233 |
| Full | 227 | 229.5 | 233 |

By means of this crossover of regulation curves the whole variation of output produced by varying the load from zero to full load, and at the same time varying the mains voltage by about ± 15 per cent., has been kept within limits of ± 1.3 per cent. If either the mains voltage or the load does not vary to these extreme limits, the variation of output will of course be reduced approximately in proportion.

The oscillogram in Fig. 4 shows the excellence of the output voltage waveform given by the "Stabilistor." This waveform remains substantially the same over all loads from ¼ to full load.

The form factor error which arises from this waveform when calibrating rectifier instruments against true RMS reading instruments never exceeds 0.5 per cent., and is less than 0.2 per cent. over normal ranges of supply variations. Where an even more perfect waveform is required, the condenser C is divided into two parts, one section being resonated at the third harmonic as described above, and the other section being resonated with a small additional choke at the fifth harmonic. The output waveform may then be regarded as perfect for all practical requirements.

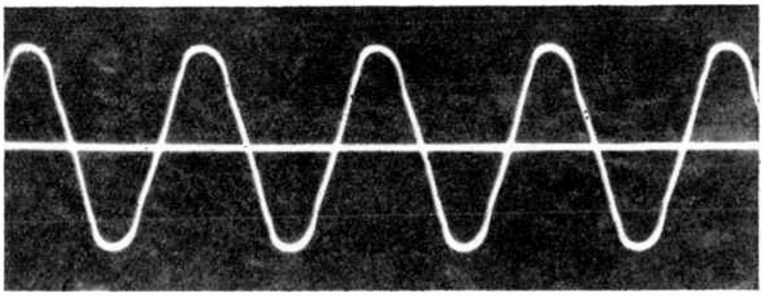


**Fig. 4. Oscillogram of the output voltage waveform of a "Stabilistor," showing the low harmonic content, compared with Fig. 1.**

# RANDOM RADIATIONS

*By "DIALLIST"*

## A Queer Accident

A RECENT report on accidents due to electrical causes contains one very strange instance in which a wireless receiving set was involved. The victim received a shock when opening the waste after taking a bath, in the course of which no untoward incident had occurred. It was found that a fault in the wireless set in the living room had caused the earth terminal to be at a potential considerably above earth. The terminal was connected to the lead sheathing of the telephone cable which was lying on a lead-covered roof outside and below the bathroom. The waste pipe of the bath lay also on this roof. Apparently the porcelain enamel of the bath insulated the bather until the waste knob was touched. The strangest of all accidents connected with a wireless receiver was one, many years ago, in which an old lady was electrocuted whilst listening in bed to the B.B.C. programme on—of all apparently harmless things—a crystal set. What had happened was this. On the table on which stood the crystal set was a metal bedside lamp, which had been known for some time to be defective and to give slight shocks to those who handled it. There was a bare place in the insulation of one of the headphone leads, and during some movement of their wearer's head this must have been brought into contact with the lamp. The fatal shock was conveyed *via* the metal headband of the 'phones and the sidepieces of her steel-framed spectacles. Moral: Attend at once to any domestic electric appliance from which even the slightest shock is felt. Better still, always use three-wire connections for such things and make sure that exposed metal parts are genuinely earthed.

□ □ □

## Dutch Wireless Towns

THE important Dutch wireless town of Eindhoven has been very much in the war news of late and the great Philips factory seems to have been badly knocked about. Huizen, some five miles south-east of Arnhem, is also in the battle zone and as I write Hilversum is still in German hands. One hopes that the fine short-wave system, of which the Dutch were so justly proud, will not suffer severely, though it seems likely that much damage must have been done. To old hands Hilversum is one of the best remembered of the early continental broadcasting stations. Its transmissions from PCGG on about 1,100 metres were well received in this country on the simplest of sets in the early 1920s. One station, not in Holland, but in the neighbouring Grand Duchy, is Radio Luxembourg. It appears to be quite undamaged for I have just received it strongly on a small portable.

□ □ □

## Electric Soldering Iron

SO far I haven't found an electric soldering iron with which I'm entirely satisfied as the right tool for wireless constructional work. Perhaps I've been unlucky, or have not looked far enough—but there it is. My grouse is that all the irons that I have bought or tried are on the clumsy side: too large, too heavy and not over-well balanced for fine work. Few, again, have sufficiently fine points to their bits, though one can deal with this in the following way. The iron of my collection that I like best (or rather dislike least!) has a straight bit made from $\frac{5}{16}$in. round copper rod, held in place by a setscrew and shaped like a screwdriver at its business end. That is all very well for the bigger jobs, but not ideal for fine ones. I have since made a set of bits of various kinds by cutting off pieces of $\frac{5}{16}$in. round copper rod just long enough to fill the socket of the iron, drilling and tapping them $\frac{5}{32}$in. or $\frac{3}{16}$in., inserting short copper rods of these diameters and shaping them to screwdriver or pencil points. I have also made round-the-corner bits. All of these do well so far as they go; but they don't, of course, get rid of the weight, size and general clumsiness of the iron itself. Does anyone know of an iron of the kind that I and doubtless many other radio enthusiasts want? If not, I suppose I shall have to make one when I get my workshop fully going again after the war.

## A Tinning Tip

LOTS of people seem to make heavy weather of the business of tinning the bit of a soldering iron—and it's surprising to find how many otherwise good men in the workshop keep their soldering bits in horrid condition. Tinning a

**Random Radiations**

bit and keeping it nicely tinned are no trouble at all if you work on the lines I suggest. One little tool is needed—a very simple one. It consists of about 4 inches of No. 16 gauge tinned copper wire stuck into an ordinary bottle cork to form a handle. First file up your bit to the shape and size you want (rub the file with ordinary chalk first of all and you'll have no difficulty in removing when you've finished the copper that would otherwise clog and spoil it), and finish with fine emery cloth. Heat the iron well, wipe it with a rag and take up a little blob of solder. Now dip the tinning tool in Baker's soldering fluid and you'll find that with it you can spread the solder over the point as easily as buttering toast. Wipe off any surplus with a rag and the job is as well done as anyone could wish. Bits should be examined from time to time for pits. When these are found, file them out and proceed as before.

□ □ □

## Last Word On π

A KIND correspondent sends me the best sentence for helping to memorise the value of π to 14 decimal places that I've come across yet. It is, I believe, attributed to Sir James Jeans. Here it is: "How I want a drink, alcoholic of course, after the heavy chapters involving quantum mechanics." Taking the number of letters in each word, this gives 3.14159265358979. To the same correspondent I am indebted for a continuation of the French aid to memory that I gave not long ago in these notes:

> Que j'aime à faire apprendre ce
> nombre utile aux sages!
> Immortel Archimède, antique
> ingénieur,
> Qui de ton judgement peut
> sonder la valeur?
> Poir moi ton problème eut de
> pareils avantages.

Learn the stanza and if you want π correct to 30 decimal places, there you are—

3.141592653589793238462643383279

And now I expect some reader will send me a poem enshrining π to six or seven hundred places! The verse quoted, by the way, is by Edouard Lucas, the French mathematician.

## The Other Problem

Squaring the circle (which boils down to finding the value of π) was one of the two great problems of the geometrists of antiquity. The other was to find a Euclidean method of trisecting an angle. The right angle was, of course, money for jam: describe an equilateral triangle on one side, bisect the part of the right angle remaining outside it and the deed is done. But the acute and the obtuse angle defied solution on Euclidean, or near-Euclidean, lines until 1621, when Willebrord Snell, of Leyden, produced a simple construction which did the trick. Curiously enough, he wasn't thinking of the trisection when he did it. Actually he was one of the great host of "π-chasers," and squaring the circle is what he was after. Apparently the trisectors are still at work, for the other day a friend brought me a little book on puzzles and perplexities that he'd recently bought and asked whether what was offered by the gifted author of the work as an original solution could possibly be correct. It certainly couldn't! The said author starts with the case of an acute angle, makes a quaint construction and follows up with an alleged proof—which "proves" (though he doesn't see it) that all acute angles must contain 90 degrees! His second case, the obtuse angle, is an even worse example of muddled thinking. Queer that a fellow who publishes that kind of book doesn't get someone with an elementary knowledge of geometry to look over such original solutions as he may wish to give to the world.

□ □ □

## Feeling AC

SEVERAL correspondents have chided me gently for not taking *au grand serieux* the reader who wrote in to say that if he touched a bakelite switch or socket he could feel at once whether AC was or was not passing. I didn't for one moment doubt his word. Personally, I've never possessed this most useful accomplishment, but quite a number of readers have told me that they are, so to speak, human galvanometers. The explanation that several of them offer seems reasonable. The plates of a condenser between which there is a PD are attracted towards one another and will move if free to do so. Vibration will occur if the PD is alternating. When a bakelite switch is touched the live conductor forms one "plate" and the fingers the other, the latter being more or less at earth potential. Hence if the PD is sufficient and the finger tips sensitive the actual 50-cycle vibration may be felt. It's perhaps rather curious that only certain people do feel it. The skin of my fingers is thin and I'm more than ordinarily sensitive to electric shocks; but try as I will I can't feel this vibration by touching or stroking the insulation of a live AC conductor or a switch.

□ □ □

## Radio Language

THE need for standardised international terms in science is great and it is particularly marked in wireless. Even the two great branches of the English tongue, those of our country and of the United States, have diverged so far in their radio terminology that an effort is needed to bring out a new common vocabulary and to get it adopted on both sides of the Atlantic. By that I emphatically don't mean that we should scrap all our own specialised words and adopt those of transatlantic "hams," to take one radio field as an example. Much could, no doubt, be done if the R.S.G.B. and the A.R.R.L. got together and brought out a list of English radio terms accepted by both parties. Both writers on wireless and those who read the text-books and the articles that their pens produce would benefit enormously.

# PROPERTIES OF RADIO COMPONENTS

## *Interpreting "The Label on the Bottle"*

By THOMAS RODDAM

MOST radio engineers pass through several stages in their outlook on components. They begin with a simple, indeed pathetic, faith in the label on the bottle. The resistor painted delicately in brown, black and green is one megohm, and will continue one megohm until physically destroyed. The condenser marked 0.1$\mu$F is exactly $10^{-7} \times 1.000$ farad, and if connected between the anode of one valve and the grid of another will pass AC but will not allow any trace of the anode HT to reach the grid and disturb the bias conditions. Heedless the little victims play, using simple circuits which no component deficiencies can prevent working. Soon, however, the day of initiation dawns; some simple experiment is repeated, some simple theory requires confirmation, or if the victim has been very lucky or very obtuse, a circuit goes into production. The circuit embodies, shall we say, an amplifying valve with a $g$ of 1.5 mA/V and a resistance marked 10,000 ohms. Clearly, a gain of 15. But the gain we get is only 10. Here, in hard fact, it is made clear that a 10,000-ohm resistance may be only 8,000 ohms, and that a valve which has spent long and arduous months in the laboratory may only have a $g$ of 1.25 mA/V instead of the value of 1.5 mA/V given in the book. As this idea sinks into the keen, receptive brain of our back-room boy, he passes the first stage towards becoming an engineer.

The next stage is harder. We have to learn that it is not just that the label is not quite right, but that no label can possibly be quite right. I switch on my broadcast receiver, and tune in a German short-wave station transmitting Mozart; when I come back from the telephone I find that I'm tuned to the B.B.C. broadcasting news in Turkish for listeners in South America. In the instruction books this effect is often wrapped up as "when the equipment settles down after a short warming-up period." In fact, the value of a resistance is dependent, in a short-term view, on temperature and also on the actual voltage across it. Stage 2 of the journey towards being an engineer involves learning to include and assess the importance of these effects.

From this level we can follow our young engineer through the mists and dews of East Anglia to the problems of tropical working and also to the industrial cities of the Midlands where blue litmus paper must be kept in sealed tins, to the salt-laden breezes on small islands, to great heights above the earth where the temperature may fall below −60 deg. C. and the pressure is only one-fifth of an atmosphere. Wherever man goes, he takes with him a device for killing other men, and radio equipment to assist and to announce his triumph. And each new place spreads a thicker mist over the label on the bottle.

### Standards

To keep under control the variations of components under all these arduous conditions, and also to warn the designer what he may expect, a vast rationalised scheme of documents dealing with radio components is being published by the British Standards Institution. These documents are prepared by a body calling itself the Inter-Service (Communications) Components Technical Committee, and are prepared in close consultation with another body, the Inter-Service Components Manufacturers' Council. These documents, apart from their current importance in con-

**Properties of Radio Components..**

nection with Service equipment, may, it is felt, be of tremendous importance in post-war design for export. They provide a criterion for "good" components as distinct from "good enough for home receivers" and may well replace the traditional dependence on the specifications of the Crown Agents for the Colonies. It is not intended to deprecate "good enough" components. A designer who uses tropical components for a home broadcast receiver is not an engineer; he might equally demand tool steel for making tin-openers. For sale abroad, however, better components are needed. The problems of maintenance are greater and so are the risks of breakdown. If this assessment of the importance of the Services' Radio Components Book is correct, it merits careful study.

The meat in the collection is undoubtedly the set of specifications. These actually cover the functional properties of the various components, and are thus the immediate concern of the designer while he is still at the bread-board stage. It is because of the form in which this material is presented that this study has been undertaken. The specifications are ordering documents for the supply ministries: they will appear in contracts and will be the subject of heated discussions between manufacturer, inspector and customer. They are, therefore, very dry and precise in form: an experiment is to be performed, a result is to be obtained. Our purpose here is to clothe these bones with flesh, and see, if we can, just how we may expect our components to behave in practice, if under test they meet the specifications. It is hoped that a broad picture of this sort will assist in the study of the documents by the designer, and thus lead to the widest possible appreciation of the properties and deficiencies of the materials from which all radio equipment is assembled.

The Services' Radio Components Book is made up of three main kinds of documents. A guide or code of practice, of which only two have yet reached the writer, gives a general discussion of the properties of components. The discussion, however, avoids mention, except rarely, of anything so indelicate as hard facts: (this comment refers particularly to the Guide on Fixed Resistors). The specifications, which constitute the second main kind of document, are broken up into three parts; a common general specification and two other documents for each component, one describing the tests and the other giving the performance limits. This presentation has been adopted in order to prevent anyone discovering at a first reading what it is all about. The third kind of document, the series of preferred lists, is an obvious attempt to reduce to reasonable proportions the variety of shapes and sizes which places an unnecessary burden on production.

## General Guidance

Before going on to analyse the component properties, as described in the specifications, the general guide and specification will be considered. Two sections of the guide are of special interest. The first is a warning to the designer that unless he makes sure that his components are not just fortuitously good, he cannot grumble when his circuit refuses to work with limit values. Thus a circuit in which a one-microfarad condenser must have a time constant (CR) of $10^5$ may work very nicely in the laboratory with a selected condenser. To use such a circuit in a production design is to ask for trouble. Trick valve circuits, too, are the cause of many headaches when values produced on different machines are found to have identical specified qualities, but completely different secondary properties, such as screen-suppressor mutual conductance. It would have been desirable in this connection, to remind the manufacturer also of his responsibilities here. If he wilfully makes a change in design which could affect a circuit designer, while retaining the same outward appearance, he should give some warning. No document can legislate for every possible contingency, and the component manufacturer should be regarded as a partner in design work. Often he does not realise how useful some property is—for example, the inductance of a wire-wound resistor.

The second section of particular interest is the discussion of climatic conditions in various parts of the world. It is not generally known that on the ground air temperatures may be experienced ranging from +60 deg. C. to −70 deg. C. (140 deg. F. to −94 deg. F.). If to the higher of these temperatures is added the additional heat inside a vehicle exposed to the sun, and the further heat inside a set when it is operating, it is seen that the demand for components to withstand 100 deg. C. is probably even conservative! Noticing also that an upper air temperature of −60 deg. C. is common, the equipment designer whose sets are to fly from desert airdromes is faced with a very pretty problem. Nor is this all: equipment may, according to this guide, be submerged to a depth of 20 feet for a week, presumably in sea water. Sunlight, fungus growths and the attacks of tropical insects are also mentioned, although there is no mention of the vapours from tropical plants which have been reported to affect materials. Almost trivial in comparison is the reminder that when lorries are being unloaded, a firm push off the tail takes the place of the delicate handling we should all like to see, and the guide accepts the inevitability of dropping on to a hard surface from a height of four feet. It is difficult to avoid the feeling, when the full details of these conditions are studied, and when we reflect on the complexity of the devices used in modern war, that the aim of the authors of this guide was to make our flesh creep. The Fat Boy of I.S.C. Tech. C., however, does not speak in a Pickwickian sense; the climates of the war zones really are unpleasant and somehow the components seem to work. In peacetime, in our happy ignorance, even telephone and broadcasting systems were functioning in the Far East and in Russia, without the assistance of the many components now specially developed for tropical and low temperature use.

The general specification is a less interesting document. It refers to the guide, and specifies the temperature ranges for the three categories of components now introduced. These are −40 deg. C. to +100 deg. C. for category A and −40 deg. C. to +85 deg. and +71 deg. C. respectively for B and C. It then states firmly that everything shall be well made of the most suitable material. Following this, a statement of test procedure is made. This is of considerable interest, and it is hoped to discuss it fully later. One defect in the specification is its reference to M.A.P. Specification D. C. D. WT. 1000. The mutual dependence of all these specifications leads to the mention in WT. 1000 of over 150 specifications, drawings, memoranda and the like to which reference must be made. To keep track of these, with their amendments, is quite impossible. It should not be impossible for this new publication to stand on its own feet.

This Services' Radio Components Book is a great project. Its actual authors will always remain anonymous, receiving no fame, no O.B.E.s and never themselves clear exactly what contribution each has made to the work.

Most of them will never see the true fruits of their labour, for it is our opinion that not only will the manufacture of warlike stores be aided by this book, but also the Indian village broadcast receiver, the inter-island telephone in the Pacific, the traveller's direction finder, all these will benefit. With these are carried the reputation of British workmanship to the developing markets remaining in the world. The reputation of British components is an important factor in maintaining your standard of living and mine.

## Nature of Tests

The properties of the components are defined as the reactions to a series of tests, which are basically the same for all components, and an examination of the tests will be profitable. Every component is subjected to a general inspection. This is, of course, principally a screening operation to eliminate obviously defective items, badly finished items and incorrectly sorted items from the consignment. In actual practice, as each individual component receives at least one other test before leaving the factory, this inspection really boils down to making sure that it is a condenser, not a lipstick.

Another rather formal test is that for dimensions. With modern production methods it is unlikely that any tools will produce components outside the wide limits laid down except when the machine goes hopelessly wrong, or the tool was incorrectly dimensioned initially. The robustness tests are more useful, the tests consist of operations simulating the most ham-handed wiring operators, pulling and bending leads and wires as if they were part of the person of the Chancellor of the Third Reich. Following this, bumping and vibration tests simulate conditions of use in mobile equipment. These constitute the standard mechanical tests: it is a Boojum, it's the right size, and it doesn't come to pieces in my hand. The electrical tests are more lengthy, and more precise. The basic property is measured (resistance, capacity or the like), the insulation of any nonconducting part is measured, and then the effects of load, of low pressure, of temperature are all studied. In addition, the changes due to soldering the component in position are noted. These tests, naturally, vary from component to component, but this broad outline appears to be common. This series is followed by the climatic condition. Based upon the 1942 edition of K110 the component is subjected to dry heat, wet heat, a period at −40 deg. C. and a further period of wet heat. After each period tests are made to determine the effect of this treatment on the component. Special tests are also applied to some components, providing a steam bath for some and a boiling water bath for others. Life tests conclude the series.

It is not known how close the correlation is between behaviour under these test conditions and behaviour in service. It seems likely that they will at least distinguish between good and bad, leaving the intermediate qualities to take their chance.

It is hoped later to discuss the individual component types, interpreting their properties as defined into real facts about the actual pieces which we are to include in our equipment.

**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.**

# WORLD OF WIRELESS

## AMERICAN POST-WAR TELEVISION

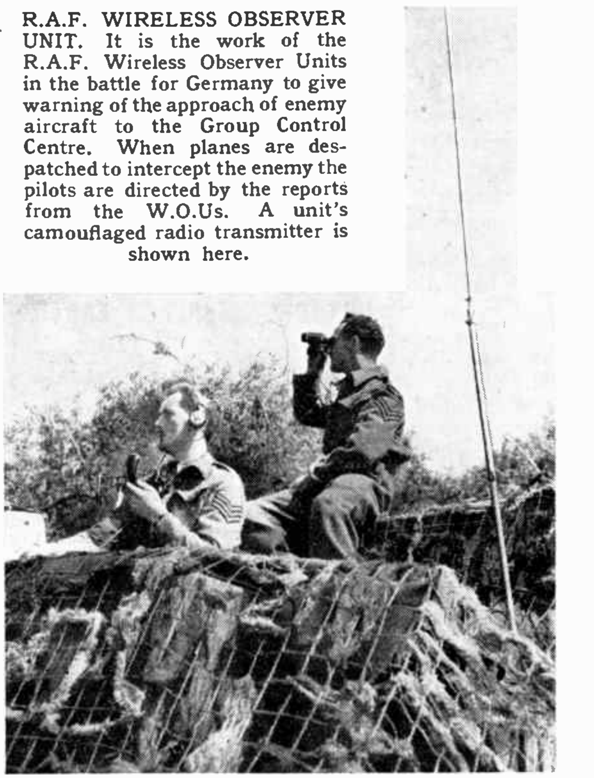
A DETAILED plan for post-war television in the United States representing the unanimous opinion of the Television Panel of the Radio Technical Planning Board has now been published, and is to be put before the Federal Communications Commission. Provision is made for twenty-six 6-Mc/s channels in the region between 50 and 246 Mc/s for main television transmitters, while OB and relay links are to have 10- and 20-Mc/s channels between 162 and 3000 Mc/s. In the region from 600 to above 10,000 Mc/s thirty channels of 30-Mc/s width are set aside for the experimental improvement of television services. This should permit work on systems up to 1,100 lines which would give definition comparable with 35 mm. cinema films.

With regard to the standards proposed for the main commercial stations it is proposed to rule out FM for the transmission of the picture and to confine the maximum frequency swing to 25 kc/s in the case of the associated FM sound channel. The sound "carrier" is to be spaced 4.5 Mc/s from the picture carrier.

The specification for scanning is 525 lines, interlaced two-to-one, with a frame frequency of 60 and complete picture frequency of 30 per second. This corresponds very closely to proposals arising from recent discussion of post-war television standards in this country.*

* See *Wireless World*, December 1943

**R.A.F. WIRELESS OBSERVER UNIT. It is the work of the R.A.F. Wireless Observer Units in the battle for Germany to give warning of the approach of enemy aircraft to the Group Control Centre. When planes are despatched to intercept the enemy the pilots are directed by the reports from the W.O.Us. A unit's camouflaged radio transmitter is shown here.**



## CIVILIAN WARTIME SETS

STATING in the House of Commons that whilst the components of the new "utility" radio sets are very good and efficient the outside appearance is cheap and nasty, a Member asked the Parliamentary Secretary if he had seen them and if he could do something about them. Capt. Waterhouse replied that he did not at all agree with the description. He had examined the sets and liked them—they were very good, practical sets.

## RAILWAY RADIO

RECENT Editorial reference was made to the use of radio communication for increasing the safety and efficiency of railway operation.

It is now learned that one of the United States' major railways, the Kansas City Southern, is installing radio equipment over 560 miles of its main line operating in mid-western and south-western parts of America.

The system to be employed will not be by radio waves only, but by induction telephony utilising carrier-current wires along the track. The system will provide end-to-end communication on trains as well as between trains and stations along the route.

Various systems have been used experimentally by U.S. railways, including FM, but this is the first sizeable permanent installation.

Tests are being carried out on the Canadian National Railway employing frequency modulation. Two locomotives, a diesel and an electric, operating from the Montreal terminus, and the terminal control tower have been equipped with 50-watt transmitters, receivers and FM aerials for the experiments. The installations are by the Canadian Marconi Co.

## NEWS IN MORSE

IN response to requests, we have obtained from the G.P.O. the latest schedule of morse transmissions of official news bulletins radiated by Post Office Stations. These transmissions are intended for oversea reception, but may be receivable in this country under favourable conditions.

The call letters and the wavelengths employed by the stations are:—

| | | | |
|---|---|---|---|
| GIA | 15.27 | GAY | 33.67 |
| GAD | 15.40 | GBC5 | 34.56 |
| GBL | 20.47 | GIJ | 42.95 |
| GID | 22.13 | GDB2 | 44.15 |
| GIM | 23.13 | GIY | 51.50 |
| GIH | 28.17 | | |

The following schedule gives the times of the transmissions in GMT and the call letters of the transmitters radiating them. Transmissions marked with an asterisk are continuations of the preceding broadcasts.

| | |
|---|---|
| *0045-0145 ... | GBC5 GDB2 |
| 0930-0945 ... | GIM GIA GIY GAY |
| 1302-1355 ... | GAD GIA GID GIY |
| 1602-1655 ... | GIA GIJ GIM |
| 1800-1945 ... | GIM GBC5 GBL (also GIJ 1915-1945) |
| *2000-2030 ... | GBC5 GIJ GIM |
| 2330-2400 ... | GAY GIH GIJ |

## ROUNDABOUT RELAY

SHORT-WAVE relaying often exemplifies the truth of the old adage that "the longest way round may be the quickest way there." A particularly good example of this fact came to light when Cable and Wireless were called on at short notice to restore the London-Paris radio-telegraph link. The frequencies allotted to the Paris station (in the 4-Mc/s band) were unsuitable for night working, and so Paris-Londonwards traffic was routed *via* the automatic relay stations at Ascension or Barbados! A long-wave station was available for direct transmission of London-Pariswards traffic.

## S.W. FROM INDIA

IT was recently announced that tests were being conducted with high-powered short-wave transmitters in India. These 100-kW transmitters are now in regular use by All-India Radio. Some of the transmissions from Delhi listed in our section "News in English from Abroad" are radiated by these stations from aerial arrays directed towards this country.

Reports on the reception of transmissions from India are welcomed by A.-I.R. They can be sent care of *Wireless World* or direct to the Chief Engineer, All-India Radio, 5, Sikandra Road, New Delhi.

## WHAT THEY SAY

ANCIENT AND MODERN.—Fishing round the dial for non-B.B.C. stations used to be fun. But, alas, our sets (old) are not what they were, and our sets (Utility) are not what they ought to be.—*Frederick Laws in "News Chronicle."*

UNDERGROUND RADIO.—The Germans long ago confiscated all the wireless sets belonging to the people of Eindhoven, but it was a futile thing to do in a city where almost every other man is a radio engineer. The Philips' workers turned out thousands of clandestine sets—in fact, they practically mass-produced them, made in tiny biscuit boxes out of parts which they took from the works.—*Frank Gillard, B.B.C. War Reporter.*

THINGS TO COME.—Surely, the communication engineer of the future, in harnessing electricity to world amity, will have something more fundamental to contribute than blind speed and a nerve-wracking staccato. . . . The possibilities are so intriguing, may one be forgiven for romancing? Under conditions of idealised communication, diplomacy, if bungled at all, will be bungled at the top. For Parliaments will no longer *ratify* treaties, they will *make* them, in person, through trans-oceanic, 24-hour, two-way, full-colour television, in three dimensions on a 30-foot screen, with binaural sound channels, equipped with privacy devices and, if desired, with English-French and French-English speech inversion. The documents themselves, including signatures, will, of course, be exchanged by facsimile before the ink is dry. Because of its simplicity, the whole process can be repeated as often as the treaties so concluded are denounced by one of the parties.—*I. S. Coggleshall, addressing the New York Section of the I.R.E.*

## IN BRIEF

**Proposed Leeds Radio Club.**—A movement is on foot to reform the Leeds Radio Society or to start a new club. Late members of the Society or interested readers in Leeds and district are asked to communicate with E. Benden, 40, Grosvenor Terrace, Blackman Lane, Leeds, 7.

**Brains Trustees.**—Four past-presidents of the Institution of Electrical Engineers are on the panel for the Brains Trust Meeting of the London Students' Section of the Institution. They are: Col. Sir A. Stanley Angwin, Sir Noel Ashbridge, Sir John Kennedy and Dr. Clifford C. Paterson.

**Obituary.**—It is with regret we record the death on September 17th, at the age of 64, of S. H. Rawlings, founder and joint managing director of the Automatic Coil Winder and Electrical Equipment Co., Ltd.

**B.R.V.M.A.**—The permanent address of the British Radio Valve Manufacturers' Association is now at Piccadilly House, 16, Jermyn Street, London, S.W.1. Regent 5186.

## PERSONALITIES

**Major A. S. Delaney,** Director-General of Egyptian State Broadcasting and Chairman of the Marconi Telegraph Co. of Egypt, has recently been honoured by the King of Egypt with the decoration of Commander of the Order of Ismail "for distinguished services to broadcasting in Egypt."

**Jacques Lassaigne** has been appointed director of the French radio service in Liberated France. He was formerly director of the Fighting French Press Bureau in the Levant States and French announcer in the Palestine broadcasting service.

**Dr. P. M. Fisk** has been appointed Chief Chemist at the Research Laboratories of Multicore Solders, Ltd.

**Augustin Frigon,** who has been assistant general manager since 1936 of the Canadian Broadcasting Corporation, is now general manager.

## MEETINGS

**Television Society Meeting.**

AN Extraordinary General Meeting of the Television Society will be held at the I.E.E., Savoy Place, London, W.C.2, at 2.30 p.m., on October 28th. After the meeting, a paper on "New Types of Test Gear for Television Production" will be read by P. D. Saw.

**Institution of Electrical Engineers.**

*Radio Section.*—Two papers will be given at a meeting of the Radio Section on November 1st at the I.E.E., Savoy Place, Victoria Embankment, London, W.C.2. One by Dr. E. B. Moullin on "Theory and Performance of Corner Reflectors for Aerials," and the other by H. Page on "The Measured Performance of Horizontal-dipole Transmitting Arrays." P. R. Coursey will open a discussion on "New Aspects of Post-war Interference Suppression" at a meeting of the Section to be held on Tuesday, November 21st. These meetings commence at 5.30, as usual.

*Cambridge and District Radio Group.*—"The Design of Wide Band Amplifiers for Radio Frequencies" is the subject of a paper to be given by J. E. Cope on October 31st. H. L. Kirke, Chairman of the Radio Section, will repeat his inaugural address at a meeting on November 28th. Both these meetings will commence at 7 o'clock and will be held at the University Engineering Department, Trumpington Street, Cambridge.

*North-Western Radio Group.*—Prof. Willis Jackson and J. S. A. Forsyth will repeat their paper on "The Development of Polythene as a High-frequency Dielectric" at a meeting to be held at 6 o'clock at the Engineers' Club, Albert Square, Manchester, on November 10th.

*South Midland Radio Group.*—E. May will open a discussion on "In-

**World of Wireless—**
dustrial Applications of High Frequency Power" at a meeting to be held at the James Watt Memorial Institute, Gt. Charles Street, Birmingham, at 6 o'clock on October 30th.

*Brit.I.R.E.*—At a joint meeting of the British Institution of Radio Engineers and the Physical Society on October 31st, Prof. E. N. da C. Andrade will lecture on "Physics and Radio." The meeting will commence at 6 o'clock at the Institute of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1.

# NEWS IN ENGLISH FROM ABROAD

| Country : Station | Mc/s | Metres | Daily Bulletins (BST) |
|---|---|---|---|
| **Algeria** | | | |
| UNR (Algiers) .. | 9.535 | 31.46 | 0915, 1200, 1500* |
| | 9.610 | 31.21 | 1500* |
| **America** | | | |
| WLWK (Cincinnati) | 6.080 | 49.34 | 0600, 0700 |
| WNRA (New York).. | 6.100 | 49.18 | 0200, 0300, 0400, 0500, 0600, 0700 |
| WOOC (Wayne) .. | 6.120 | 49.03 | 0300, 0400, 0700, 0800 |
| WCBX (Brentwood).. | 6.170 | 48.62 | 0700 |
| WGEX (Schenectady) | 6.190 | 48.47 | 0300, 0400, 0500, 0600 |
| WLWRI (Cincinnati) | 6.370 | 47.08 | 0500, 0700 |
| WGEA (Schenectady) | 7.000 | 42.86 | 0500, 0700 |
| WGEO (Schenectady) | 7.250 | 41.38 | 0700 |
| WNRX (New York).. | 7.565 | 39.65 | 0000, 0100, 0200, 0300, 0700 |
| WLWO (Cincinnati).. | 7.575 | 39.61 | 0600, 0700, 0800, 0900 |
| WOOW (New York).. | 7.820 | 38.36 | 0300, 0400, 0700, 0800 |
| WLWRI (Cincinnati) | 7.832 | 38.30 | 0900, 1000 |
| WCBN (New York) .. | 9.490 | 31.61 | 0800 |
| WGEA (Schenectady) | 9.530 | 31.48 | 0900, 1000, 1100 |
| WGEX (Schenectady) | 9.550 | 31.41 | 0000, 0100, 2200, 2300 |
| WBOS (Boston) .. | 9.570 | 31.35 | 0900, 1000 |
| WCRC (New York) .. | 9.590 | 31.28 | 0900, 1000 |
| WOOC (New York) .. | 9.650 | 31.09 | 0100, 0200 |
| WNBI (New York) .. | 9.670 | 31.02 | 0900, 1000, 1100 |
| WRUW (Boston) .. | 9.700 | 30.93 | 0800, 0900, 1100 |
| WNRI (New York) .. | 9.855 | 30.43 | 0100, 0200, 0300, 0400, 0700, 0900, 1000, 1100, 2300 |
| WLWO (Cincinnati).. | 11.710 | 25.62 | 2000,* 2100, 2200 |
| WRUW (Boston) .. | 11.730 | 25.57 | 2000* |
| WCRC (Brentwood).. | 11.830 | 25.36 | 1430,* 1530, 2045 |
| WGEA (Schenectady) | 11.847 | 25.32 | 1900 |
| WGEX (Schenectady) | 11.847 | 25.32 | 1100, 1300, 1415, 1600 |
| WOOW (Wayne) .. | 11.870 | 25.27 | 0100, 0200, 1300, 2100 |
| WBOS (Boston) .. | 11.870 | 25.27 | 1100 |
| WRCA (New York) .. | 11.893 | 25.22 | 1000, 1100 |
| WNRI (New York) .. | 13.050 | 22.99 | 1300, 2300 |
| WNRX (New York).. | 14.560 | 20.60 | 1415, 1600, 2300 |
| WRUS (Boston) .. | 15.130 | 19.83 | 1300, 1415, 1600, 1700, 1800 |
| WOOC (Wayne) .. | 15.190 | 19.75 | 1300, 2100 |
| WBOS (Boston .. | 15.210 | 19.72 | 1300, 1415 |
| WLWK (Cincinnati).. | 15.250 | 19.67 | 1415, 1800, 1900, 2000* 2100, 2200 |
| WCBX (Brentwood).. | 15.270 | 19.65 | 1430,* 1530 |
| WGEO (Schenectady) | 15.330 | 19.57 | 1200, 1300, 1800, 2000 * 2100 |
| WRUW (Boston) .. | 15.350 | 19.54 | 2000* |
| WRUW (Boston) .. | 17.750 | 16.90 | 1600, 1800 |
| WLWO (Cincinnati).. | 17.800 | 16.85 | 1415, 1800, 1900 |
| WCBN (New York) .. | 17.830 | 16.83 | 1430,* 1530 |
| WGEX (Schenectady) | 17.880 | 16.78 | 1900, 2100 |
| WNRA (New York) .. | 18.160 | 16.52 | 1415 |
| **Australia** | | | |
| VLI4 (Sydney) .. | 7.240 | 41.45 | 1515 |
| VLG (Melbourne) .. | 9.580 | 31.32 | 1515 |
| **Belgian Congo** | | | |
| Leopoldville .. .. | 15.167 | 19.78 | 1200 |
| **Brazil** | | | |
| PRL8 (Rio de Janeiro) | 11.715 | 25.61 | 2030† |
| **China** | | | |
| XGOY (Chungking) .. | 9.635 | 31.14 | 1500, 1700, 2130 |
| **Ecuador** | | | |
| HCJB (Quito) .. | 12.455 | 24.09 | 0000, 2030 |

| Country : Station | Mc/s | Metres | Daily Bulletins (BST) |
|---|---|---|---|
| **Egypt** | | | |
| Cairo .. .. .. | 7.510 | 39.94 | 1845, 2100 |
| **French Equatorial Africa** | | | |
| FZI (Brazzaville) .. | 11.970 | 25.06 | 1945, 2145 |
| **India** | | | |
| Delhi .. .. | 6.190 | 48.47 | 1550, 2030, 2330 |
| | 7.275 | 41.24 | 0730, 1230, 1430 |
| | 7.290 | 41.15 | 0245, 2030, 2330 |
| | 9.630 | 31.15 | 1430 |
| | 11.790 | 25.45 | 0430, 0630, 1030, 1230 |
| | 15.195 | 19.74 | 0630, 1030 |
| **Iran** | | | |
| EQB (Teheran) .. | 6.155 | 48.74 | 2225 |
| **Mozambique** | | | |
| CR7BE (Lourenco Marques) .. .. | 9.830 | 30.52 | 2050 |
| **Newfoundland** | | | |
| VONH (St. John's) .. | 5.970 | 50.25 | 2315 |
| **Palestine** | | | |
| Jerusalem .. .. | 11.750 | 25.53 | 1615 |
| **Portugal** | | | |
| CSW6 (Lisbon) .. | 11.040 | 27.17 | 2000 |
| **Spain** | | | |
| EAQ (Aranjuez) .. | 9.860 | 30.43 | 2050† |
| **Sweden** | | | |
| SBU (Motala).. .. | 9.535 | 31.46 | 2220 |
| SBP .. .. .. | 11.705 | 25.63 | 1700 |
| **Switzerland** | | | |
| HER3 (Schwarzenburg) | 6.345 | 47.28 | 2050 |
| HER4 .. .. | 11.775 | 25.48 | 2050 |
| Berne .. .. | 10.340 | 29.00 | 0200, 2045 |
| **Syria** | | | |
| FXE (Beirut) .. | 8.035 | 37.34 | 1735 |
| **Turkey** | | | |
| TAP (Ankara) .. | 9.465 | 31.70 | 1800 |
| **U.S.S.R.** | | | |
| Moscow .. .. | 6.980 | 42.98 | 0015 |
| | 7.300 | 41.10 | 1800, 1900, 2000, 2100 2200, 2300 |
| | 7.322 | 40.92 | 1800 |
| | 8.940 | 33.56 | 1240 |
| | 9.480 | 31.65 | 0100, 0200 |
| | 9.860 | 30.43 | 1240 |
| | 10.445 | 28.72 | 0730, 1240 |
| | 11.830 | 25.36 | 1600 |
| | 11.950 | 25.11 | 0100, 0200, 2347 |
| | 12.190 | 24.61 | 1240 |
| | 12.260 | 24.47 | 1220 |
| | 15.040 | 19.85 | 2347 |
| | 15.230 | 19.70 | 2347 |
| | 15.570 | 19.05 | 1200, 1240, 1320, 1700 |
| **Vatican City** | | | |
| HVJ .. .. .. | 5.970 | 50.25 | 2015 |
| | **kc/s** | **Metres** | |
| **Algiers** .. .. .. | 1,176 | 255 | 1200, 1500 |
| **Athlone** .. .. .. | 565 | 531 | 1340, 1845, 2200* 2210† |
| **Tunis** .. .. .. | 823 | 365 | 0000, 2200, 2300 |

It should be noted that the times are BST—**one hour** ahead of GMT. * Sundays only. † Sundays excepted.

# Letters to the Editor

## Surplus Government Stocks
## Synthetic Music

### *War Surplus Disposal*

WHEN the war is over, immense stocks of wireless material surplus to Services and Government requirements will have to be disposed of. The position is at present far from clear, since no definite intentions or projects concerning the uses to which this valuable material will be put have been officially announced—beyond somewhat vague generalisations against profiteering in war surplus stocks such as occurred after the last war and inconclusive mention of disposing of them "through normal trade channels."

It is perhaps not too early to suggest that the people who should have priority claims to purchase a little of this material for their own use, on at least equal terms with the dealers, are the professional technicians in uniform who have contributed so much to the successful prosecution of the war. Many of them will, on demobilisation, be faced with urgent problems of livelihood, which could be solved by special facilities for obtaining, at rates within their slender means, some of the tools of their trade—test and design equipment, constructional and servicing gear, and components for constructing their own outfits of instruments. They have been using these tools for the purpose of indirect destruction for the last five years, and it seems only fair and sensible that they should be given the chance of using them in the constructive tasks of peace, instead of being abruptly reduced, on demobilisation, to the status of unskilled labour through either the high cost of the gear they require or restrictions on their obtaining it from surplus sources.

It is suggested, therefore, that a scheme could easily be put into operation, whereby any wireless technician, who can show that he was a *bona fide* professional before the war up to a modest standard of competence and will depend on this professional skill for a livelihood after the war, should be able to buy limited quantities of material *on the same terms as a dealer* from the disposal stocks of the Government for his own use and not for re-sale. This would enable a large number of deserving professionals to re-equip themselves with the tools of their trade, and thus not only make themselves independent of assistance, but be able to make use of their special services to the community in the huge task of reconstruction in a war-damaged world.

W. H. CAZALY.

London.

### *Synthetic Music*

HAVING been interested in the practical possibilities of synthetic sound recordings for quite a long time I feel compelled to protest against H. A. Hartley's arithmetical "proof" of the impossibility of producing music by this means. His calculations could equally well be used to prove the impossibility of setting up a page of intelligible printed matter, were it not for the fact that we all know each line to be built up from combinations of units of the alphabet, and not from a selection of several billion complete lines. In just the same way any practical method of sound synthesis must provide for the combination of numbers of comparatively simple waveforms; this may be done by electric, photographic, or mechanical means, and it is quite easy to show that a few of them can be combined to give a resultant that would appear to "defy analysis" if there is no simple relationship between their frequencies.

The logical basis for musical synthesis is to work with a number of tone units, each one of which can be controlled for pitch, amplitude, and harmonic content (i.e., waveform), with provision for grouping and controlling the combined output of these units. I have constructed and used three such units so far, and with a

**Letters to the Editor—**

dozen of them Mr. Hartley could have his Chopin Polonaise without any great difficulty. An important point is that a synthetic recording can be made at a leisurely speed which allows small details of scoring to be attended to in a manner quite impossible with any actual instrumental performance, or with any existing mechanical instruments.

The term mechanical music has been used so persistently in a disparaging sense that I think it is worth while considering the reasons for this. A mechanism is primarily a means of achieving a certain result. Any evil effects of mechanisation are usually due to these three causes—the mechanism may be imperfect; the user may possess insufficient manipulative skill; the result aimed at may be bad in itself. If these faults are avoided there is bound to be some advantage derived from its use, whether the ultimate purpose is utilitarian or artistic.

If the pianola is to be regarded as a mechanism to reproduce exactly the actual performance of some artist it is an imperfect mechanism, and Mr. Hartley is therefore quite justified in preferring the original performance; on the other hand, if the instrument is designed to give a sequence of notes exactly as scored, it can probably do this quite accurately, but its purpose cannot be regarded as having great artistic merit since our system of musical notation is far from perfect, and relies on a fairly large measure of musical sensibility on the part of the executant. Again, the actual performance would be preferable. But what if a perfectly designed pianola which could produce exactly the same sequence of sounds as an actual performance on the same instrument by a first-class artist? It is probably that Mr. Hartley, and many others also, would still prefer the original performance for psychological reasons quite distinct from purely musical appreciation. It is true that an orchestral performance provides an interesting demonstration of performers using a high degree of skill to overcome mechanical difficulties, but since the same may be said of a performance of acrobats I do not feel that any of its musical value can reside in this particular aspect. It is necessary to sort out these various factors very carefully before concluding that all mechanical methods are incapable of artistic development. Incidentally, both the piano and the organ, for which some of the finest music in the world has been written, employ more complicated mechanisms than any of the other instruments.

I am among those who believe that ideally there are only two essential factors in music—the composer's ideas, and the listener's reception and appreciation of these. The intervening medium is unimportant provided that it does not distort, or limit, those original ideas. Most composers will admit that modern instrumental methods are imperfect in both these respects, and if Mr. Stevenson's article encourages any technicians to find means of avoiding such defects he will be helping to achieve something really creative; Mr. Hartley's suggestions, though of interest, cannot possibly do this.

C. C. BUCKLE.

Winterbourne Monkton, Wilts.

### *American Recordings*

I WAS most interested to read H. A. Hartley's remarks on American recordings in your October issue, as I had thought that I was alone in this opinion.

There is one other point I would like to make, however, in favour of most English and some Continental recordings as compared with those made in the U.S. and that is in the matter of "balance."

I find that in all American recordings of orchestral music, the strings, and particularly the first violins, are quite out of proportion to the rest of the orchestra—indeed it is often impossible to hear any woodwind at all unless one is following with the score; whereas in the better English recordings, the other instruments of the orchestra are at least allowed to have something to say! In this connection I would like to add to Hartley's list of good recordings these, which are, in places, superb, both from the point of view of instrumental balance and an even frequency response.

My list (all H.M.V. recordings) includes: Dohnanyi's "Variations on a Nursery Theme"; Bizet's Symphony (conducted by Walter Goehr); Schubert's C Major Symphony; Brahms' Fourth Symphony; Brahms' First Symphony; the last three all conducted by Bruno Walter.

All the above are English recordings, with the exception of the Brahms No. 1 which is by the Vienna Philharmonic.

I think that Bruno Walter might well be added to Hartley's list of conductors who have "mastered the art of making records"; some of his work is beyond praise, and none of it is bad.

PETER W. GRANET.

Cobham, Surrey.

### *The Interference Problem*

THE recent correspondence in your columns about electrical interference rightly urges the use of induction motors in place of the present all-too-common "universal" motors, and the further suggestion that 3-phase motors might be used to deal with higher speeds is also very interesting; this would have to be based on the grid standard of 400 volts between conductors, as the provision of a large number of small power transformers, apart from introducing losses, would be quite prohibitive in capital cost.

However, I suggest that all this takes too much for granted. The 3-phase system at high voltage, or any other arrangement of a similar nature, would be quite safe when properly installed and maintained, but certainly not under conditions commonly prevailing in domestic, commercial and even factory premises. Quite as much interference with radio and television is caused by "switch clicks" and bad connections, and defective wiring generally, including accidental earth leaks, as by appliances which are themselves liable to produce interference.

Going up to television frequencies, there are now thousands of military vehicles with efficient suppressors. Unless the opportunity is taken to prevent it these will be removed when reconditioned for civilian use, or at least not replaced when faulty, and motor manufacturers will pour on to the market thousands of unsuppressed new vehicles.

Legislation, badly needed to prevent manufacture and sale of interfering appliances, must not stop there. It must establish a rigid standard of periodical inspection of all electrical equipment when actually in use, and the complete elimination of amateur wiring, and retail sale of electrical equipment requiring skilled installation.

Is there a single enlightened Member of Parliament who will fight this crusade in the present welter of post-war planning? The opportunity will never return.

G. W. M. LUSH.
Thorner, Nr. Leeds.

### *Extending Wireless Applications*

YOUR note in the September issue dealing with Railway Radio is very timely and I believe that experiments have been made with both radio and audio frequencies, but it seems likely that many organisations will be clamouring for permission to operate both point-to-point and mobile radio-telephone services.

Docks and harbours, Trinity House, transport organisations, municipal undertakings, police and fire brigades, the motoring, aircraft and yachting associations all have a claim to a place "in the air."

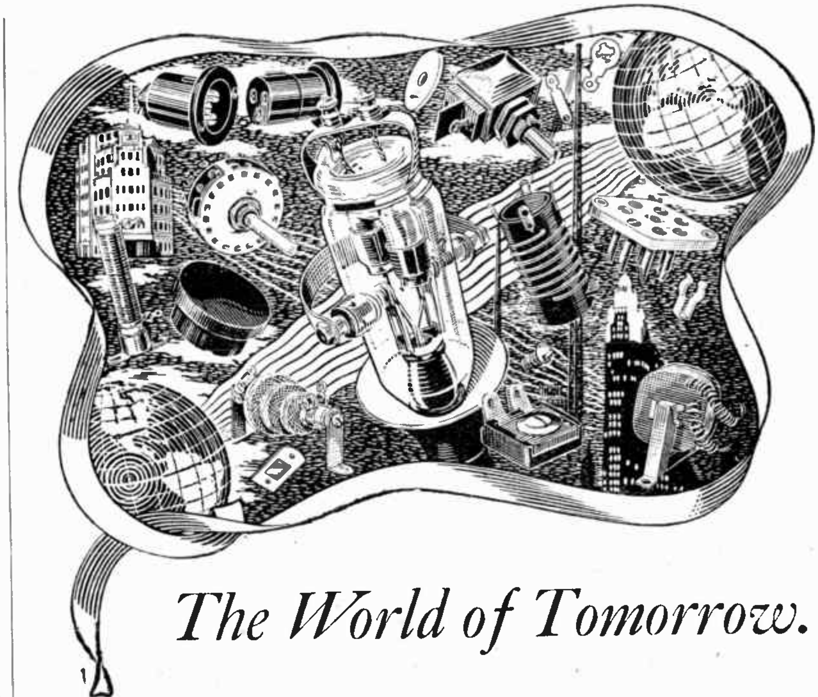
Moreover, at the end of the war there will be a very large surplus of gear, of production facilities and of trained operators and mechanics employable only on this specialised form of communication.

It seems unlikely, however, that this vast field can be opened up without a change in the present Post Office licensing regulations and those interested should see that when the next International Conference is convened their claim is already well staked.

H. HART.
Orrell, Lancs.

### *"Willans Oscillator Circuit"*
#### *A Correction*

IN the circuit diagram accompanying Dr. Hanney's letter, published in our October issue, there were two omissions that may have misled readers. A resistance of 20,000 ohms should be shown next to C1 and in series with it. The resistance between grid of the MH4 valve and earth line should be marked 1,500 ohms.



# RECENT INVENTIONS

## *A Selection of the More Interesting Radio Developments*

### TUNING ARRANGEMENTS

A QUICK and easy method of manual tuning, particularly suitable for motor car sets, where one's attention is liable to be distracted, is provided by the use of a control spindle which is swung laterally for station selection and is then rotated about its own axis for fine adjustment.

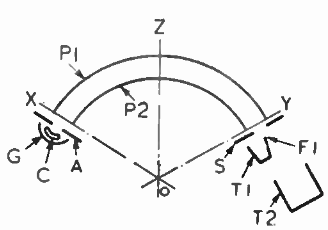
The extent of the lateral swing is regulated by a spring-controlled pin, which is mounted on the control spindle and engages one or other of a number of recesses provided along the edge of a curved arm or scale, which is concentric with the pivot of the spindle. The recesses are spaced apart to coincide with the tuning of selected transmitting stations, and the lateral swing of the spindle rotates the main tuning condenser to a corresponding degree.

For fine tuning, a cord is passed over a driving pulley and two jockey pulleys, and is then anchored at both ends to the control spindle in such a way that it drives the main pulley backwards or forwards according to the direction in which the control spindle is rotated about its own axis.

*Philips Lamps, Ltd., and C. L. Richards. Application date October 1st, 1942. No. 560471.*

### "BEAM" VALVES

ELECTRONS from the cathode C are forced by a concave screen G, held at cathode potential, to pass through a slot in the first anode A (+400 volts), where they are formed into a diverging ribbon-stream having its width perpendicular to the plane of the paper. The stream is then subjected to the field from two curved deflecting plates P1, P2, which are cylindrical in section and subtend an angle XOY of 110 degrees; these are biased equally above and below the anode, carrying steady voltages of 320 and 480 respectively. Following an arcuate path, the diverging electrons are gradually deflected and brought to a line-focus across a point F1, which coincides with the edge of the first target or collecting anode T1.




Electron beam valve

An input signal of a few microvolts, applied across the plates P1, P2, will then deflect the stream so as to vary the number of electrons that strike the target T1, the remainder being collected by a second target T2. A variable bias on a slotted screen S allows the position of the line focus to be adjusted axially; the screen also serves to collect secondary emission from the targets T1, T2. The focusing system is particularly free from aberration, and the amplifier shows a high factor of mutual conductance.

*A. C. Cossor, Ltd., L. Jofeh and B. C. Fleming-Williams. Application dates June 26th, 1940, and May 7th, 1941. No. 560689.*

### DF BEACONS

THE effective width of the blind-approach path marked out by a radio beacon is defined as the angle subtended at the transmitter by two points, at opposite sides of the equi-signal line, where the ratio of the field strengths of the two overlapping beams is 20 to 1. The object of the invention is to regulate that width.

Radiation takes place from two pairs of "folded" dipoles, orientated at right angles to each other. The dipoles forming the centre pair are spaced apart by half a wavelength and are energised in phase-opposition. The other two dipoles are set at equal distances from, and on opposite sides of, the line joining the centre pair; they, too, are fed in phase-opposition from the RF source. The overlapping field-pattern is produced by alternately reversing the sign of the RF currents in one pair of aerials with respect to the currents in the other pair, this being effected through a relay which is linked with the keying switch for superposing the usual A-N or other "interlocking" signals.

It is shown that under these conditions the effective width of the guiding path can be reduced to any desirable extent by adjusting the relative strengths of the currents in the outer and centre pairs of dipoles.

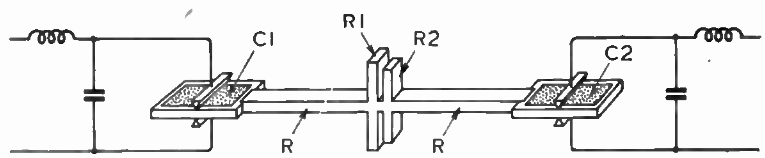
*Standard Telephones and Cables, Ltd., and L. J. Heaton-Armstrong. Application date November 10th, 1942. No. 561277.*

### WAVE FILTERS

A ROD of aluminium or of ceramic material is used as a mechanical resonator in a band-pass filter. The rod, which is approximately equal in length to half the wavelength of the middle frequency of the band to be transmitted, is fitted with one or more cross-bars which serve to determine the width of the band.

As shown, the resonator R is inserted in the transmission line between two piezo-electric crystals C1, C2, one of which transforms the signal currents into pressure vibrations for driving the rod, whilst the other converts the transmitted impulses back into electric currents. The crystals are glued or otherwise secured to each end of the rod, which is provided with flanges to strengthen the joint.

The ratio of the total mass of the two cross-bars R1, R2 to that of the rod regulates the width of the transmitted band, whilst their relative sizes fixes the position of the front and rear cut-off flanks; if the two cross-bars are made of equal size, the band will be symmetrical about the middle frequency.




Electro-mechanical wave filter

*Western Electric Co., Inc. Convention date (U.S.A.) November 25th, 1941. No. 561088.*

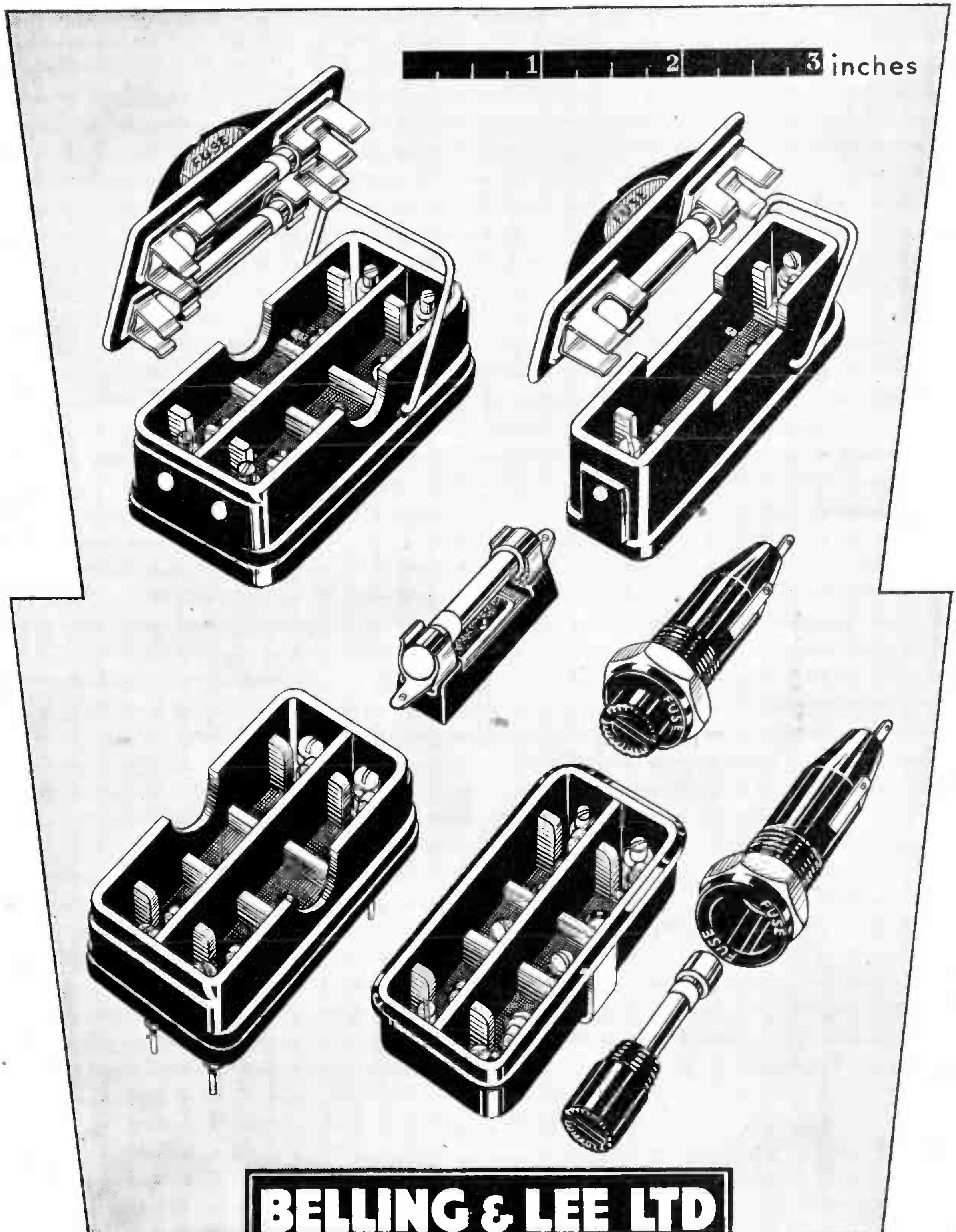
### MODULATORS

VARIOUS devices, such as limiters or spark-gaps, are frequently used to protect the choke coil of a modulator valve from voltage surges, due, say, to switching or overdriving at some prior stage of the transmitter. They are apt, however, to suppress or blur the sharp transients that are required to maintain a high quality of transmission.

This difficulty is overcome, according to the invention, by shunting the high-tension supply to the modulator valve by a gas-filled rectifier arranged in series with a resistance. The cathode of the diode rectifier is connected to the positive HT line, whilst the anode is coupled through a condenser to the anode of the modulator. In normal operation the voltage across the rectifier is such as to render it non-conductive. A transient voltage which is larger than that stored by the coupling condenser will, however, automatically discharge itself by reversing the bias across the diode, and so making it conductive.

*Marconi's Wireless Telegraph Co., Ltd., and N. H. Clough. Application date September 10th, 1942. No. 560906.*

**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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H.P. RADIO SERVICES, Ltd., 55, County Rd., Walton, Liverpool, 4. Tel. Aintree 1445. (Estab. 1935.) [3150

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LOOK out for our valve tester combined with circuit analyser.

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RADIOSALES, BCM/Sales, London, W.C.1, offer, post extra (list 1d.):—

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Assembled on black Crackle-finished chassis fitted with separate Tone Control, Volume Control with on/off switch, sockets for microphone, gramophone and extension speaker. Hum free, good quality reproduction. A.C. only. Input 200/250 v. Size overall, 8 x 6¼ x 7½in. Ready to play. Price, including valves and speaker **10 Gns.**

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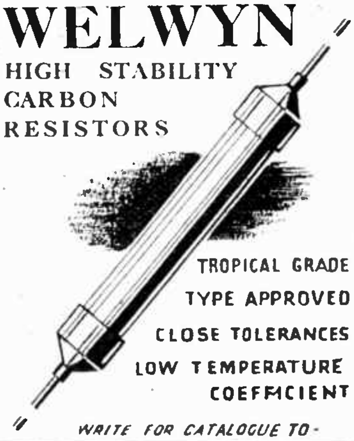

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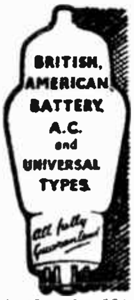


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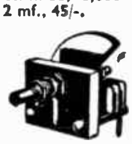

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