Wireless World

ELECTRONICS, RADIO, TELEVISION

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Transistor D.C. Stabilised Power Supply

This mains-operated d.c. stabilised transistor power supply is very suitable for general laboratory use. Stabilised voltage output ranges of 0 to 15V and 15 to 30V are included, as well as constant current output ranges of 0 to 10mA and 0 to 100mA. The design incorporates one of the recently developed Mullard OAZ203 zener reference diodes (D9).

Using a maximum current of 100mA, if the maximum voltage is 32V, the maximum dissipation of the series transistor (OC16) is 3·2W; this dissipation can be ignored in the design.

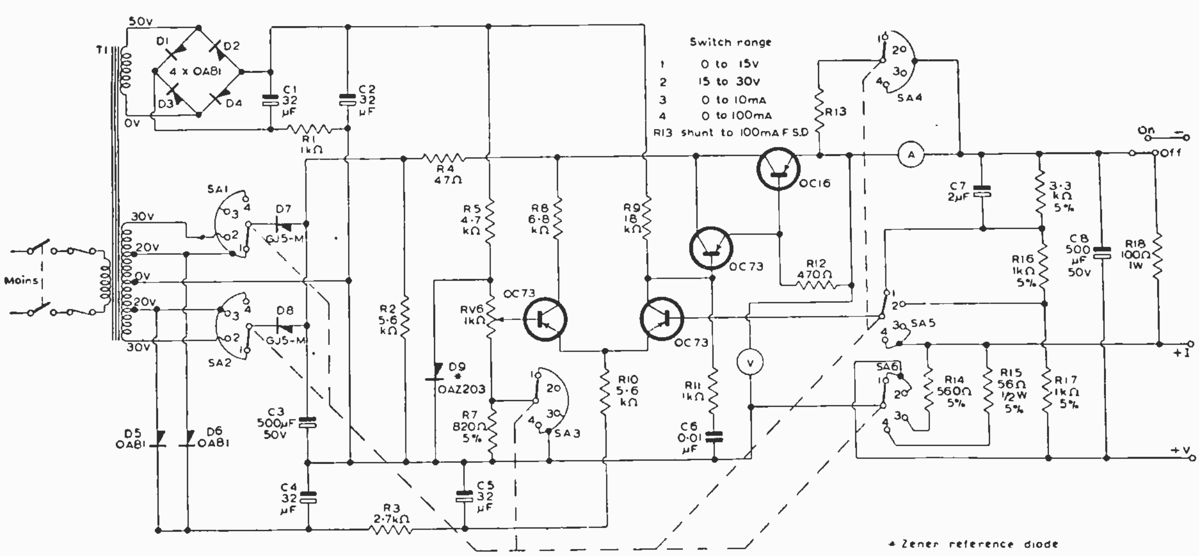
The simplest form of voltage stabiliser, using transistors, is the emitter follower with the base connected to a reference battery. The emitter follower may be a single or compound type. The emitter follower, in this design, consists of a Mullard OC16 and an OC73 transistor in cascade. The value of V_{be} is less than 0·5V, and, because of the high collector resistance, the variation of V_{be} with collector voltage is negligible. But even at a fixed current, V_{be} can vary with temperature (2·5mV/°C). This effect is increased proportionally with the number of transistors used. The relatively high output resistance leads to a consideration of d.c. feedback as a means of reduction.

The d.c. feedback is applied from the base of the emitter follower to the collector of the phase-reversing amplifier. The output resistance of the emitter follower is reduced by a factor $(1+A)$ where A is the gain of the feedback amplifier. The effect on the output of variation in the unstabilised supply can be eliminated almost completely, by supplying the feedback amplifier from a stabilised line.

The effect of applying feedback to a single transistor amplifier and a compound emitter follower of two transistors, is to reduce the output resistance by a factor of several hundred. The output voltage is dependent on V_{be} where this voltage applies to the right hand OC73 of the long-tailed pair shown in the circuit. This voltage, in turn, depends on the temperature variation of V_{be} for the first OC73. Using feedback, this variation is negligible compared with its own temperature variation (again 2·5mV/°C). The variation of output voltage can be minimised using a long-tailed pair as the amplifier. The temperature variations of the two Mullard OC73 transistors are equal and so balance out. The output voltage varies only slightly with V_{be}, as shown above. The d.c. output resistance is greatly reduced by the feedback, the long-tailed pair itself reducing it only slightly, by making it less dependent on the internal resistance of the reference source.

Separate terminals are provided for current and voltage outputs. The constant current output is obtained by putting fixed resistors in series with the output, and comparing the voltage across them with that of the reference source. The required output current is set up on the meter, with the switch in the 'Off' position (connecting a 100Ω load across the output), then it is switched into the load in the 'On' position.

Two voltage ranges are necessary to prevent excessive dissipation of the series transistor, there is a minimum overlap of the ranges of 1V. For a 10% change of mains input, the output variation is less than 1%. The output ripple is less than 1mVr.m.s., which is negligible compared with most output voltages required.



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Patterns of Trade

WHATEVER may be the outcome of the negotiations for the participation of the United Kingdom in a European Free Trade Area, its effects will not be fully felt for at least 10 years. During that period the pattern of world trade may have changed fundamentally, but in any case the general opinion seems to be that we should stand to gain rather than lose by joining a Free Trade Area.

In the meantime there is, in spite of tariffs of the order of 20%, a not inconsiderable trade with Europe and other continents in radio and electronic equipment with a balance in our favour. Total exports of components, transmitters, radar and navigational equipment, sound reproducing equipment, valves and domestic receivers to the value of £43M exceeded in 1957 those of any other group of the electrical industry. (Cables came second with £36.4M and generating machinery third with £35.1M.)

In the field of test gear there is an active exchange of equipment and ideas, again with a balance in our favour. At this year's Instruments, Electronics and Automation Exhibition at Olympia the atmosphere was very obviously international with a strong contingent of overseas visitors and many Continental firms exhibiting either independently or through their British associates or agents. One British firm with a high reputation for the originality and efficiency of its own designs and production methods announced its willingness to undertake the "anglicization" of foreign instrument designs and if expedient to produce them in this country. In the electronics field there would seem to be as much willingness to collaborate as to compete in satisfying the demands of an expanding economy. The removal of tariffs would accelerate these trends, but the fact that they have already started, in spite of existing restrictions, is significant.

The position of broadcast receiver manufacturers is less certain. Production capacity in all industrial European countries is more than sufficient for home needs and the removal of tariffs could greatly increase competition both at home and abroad. In the event of the establishment of the Free Trade Area individual firms might find their production costs too high for the mass market and some form of collaboration by the industry as a whole might be necessary to meet the situation.

But the mass market is not the only one, and there will always be other opportunities while there are customers who are willing to pay a little more for the product which is different. There is, for instance, a ready sale for Triumph TR2 sports cars in Germany, the land of the Volkswagen and the Mercedes, and it should not be beyond our wit to find and fill similar gaps in the range of European radio, audio and electronic equipment.

Leading Questions

THE answer given in a letter (page 278 of this issue) from the Public Relations Officer of the General Post Office is unlikely to turn away the wrath of those who, like "Free Grid" (May issue), have been asked to give a reason for non-renewal of their wireless licence.

We can find nothing in the Wireless Telegraphy Act, 1949, to support the contention that the Postmaster General has any specific obligation to see that people do not use broadcast receivers without his licence. He is authorized to issue licences, but the obligation of applying for one rests with the individual, who is guilty of an offence only if he installs apparatus (even if he does not use it) without being licensed to do so.

If the P.M.G. chooses to take upon himself the task of seeing fair play, why does he pick on those of us who at one time or another have held a broadcast receiving licence? Probably because it is easy. But the subjects of his catechism must feel rather like those unfortunates who are "known to the police".

Every citizen has the right if not the obligation to lay information with the police or a magistrate if he thinks he sees evidence that the law is being broken, and we would not deny the P.M.G. the exercise of this common right; but since he is so zealous in his search for information may we suggest that he writes also to those who have not so far taken out any licence, asking if they intend to do so, and if so why.

Standing Waves in Listening Rooms

Aural Effects Under Steady State and Transient Conditions

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

AFTER the publication in the October, 1957, issue of my contribution on "Loudspeakers in Parallel," Mr. G. A. Briggs pointed out† that paralleled and spaced loudspeakers did possess advantages in minimizing the standing-wave patterns in a room, a point not discussed in the original contribution. The following notes are intended to remedy this particular omission, though any exhaustive discussion of the use of paralleled speakers would require a complete issue of *Wireless World*. Thus the present contribution must, in military parlance, have "limited objectives."

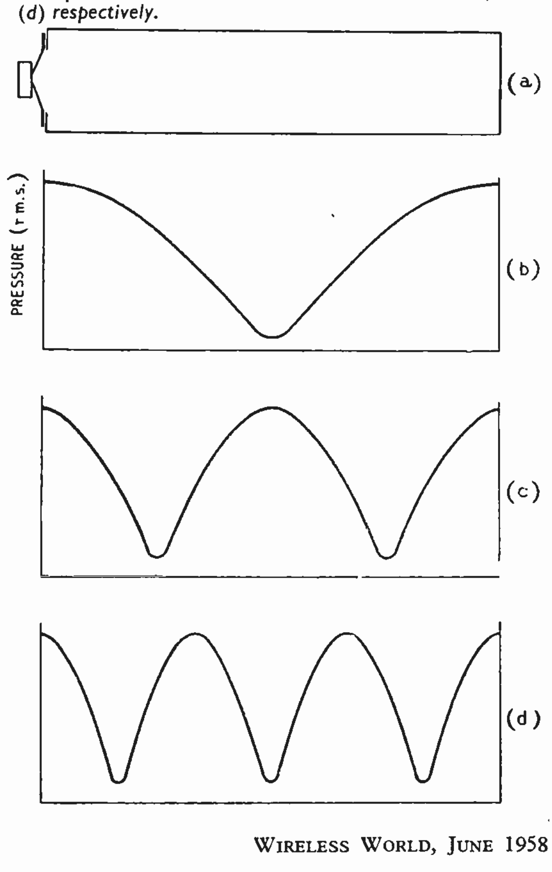
First of all, what are standing waves and in what sense do they "stand"? These questions are best approached by considering the simple and substantially one-dimensional example of a long, narrow tube closed at one end and having a loudspeaker mounted in the other end as in Fig. 1 (a). Any pressure change (i.e., sound wave) produced by the loudspeaker will travel along the tube with a velocity of 1,125 ft/sec. A single short sharp pulse will be reflected by the closed end and, after travelling back down the tube, will be again reflected by the speaker end, a process that will continue until the sound energy in the pulse is absorbed by the tube wall ends. If the tube ends are of hardwood or sheet metal and make a really airtight joint with the tube, the sound wave will lose about 5% of its energy at each reflection.

When the loudspeaker is driven by an oscillator and emits a steady sine wave, the process is a little more complicated, particularly for the special case where the emitted sound wave has a frequency which makes the tube exactly one half wavelength long. A specific example would be a tube 11.25ft long with the speaker emitting a tone of 50 c/s, a wavelength of 22.5ft.

On connecting the oscillator at the instant the electrical signal passes through zero, sound pressure will commence to build up in front of the speaker cone and a sound wave will start to travel down the tube. One half cycle later the wave front will have reached the closed end and be reflected, with its phase reversed, back towards the loudspeaker, just as happened with the single short sharp pulse previously considered. Exactly one cycle after its departure the wave front (or 95% of it) will arrive back at the loudspeaker end and again be reflected with a change in phase, but as the two transits of the tube occupy exactly the time of one cycle the reflected wave will be in exactly the same phase as the second cycle of the wave just leaving the loudspeaker. On the assumption that the reflected wave has lost five per cent of its energy at each of the two reflections the energy in the outgoing wave will now be roughly 190% of the initial energy. This neglects some interactions that are not of importance in this demonstration. One cycle later the process will be repeated with roughly 81% of the energy of the first cycle, 90% of the second cycle and the full energy of the third cycle being emitted at that instant by the loudspeaker. Thus in a short time the sound pressure in the tube will build up by multiple reflection between the ends to a value ultimately limited by the energy losses in the tube and as the reflected waves are at all points in phase with the direct wave emitted by the speaker, a standing wave pattern will appear in the tube. (A simplified explanation of the process).

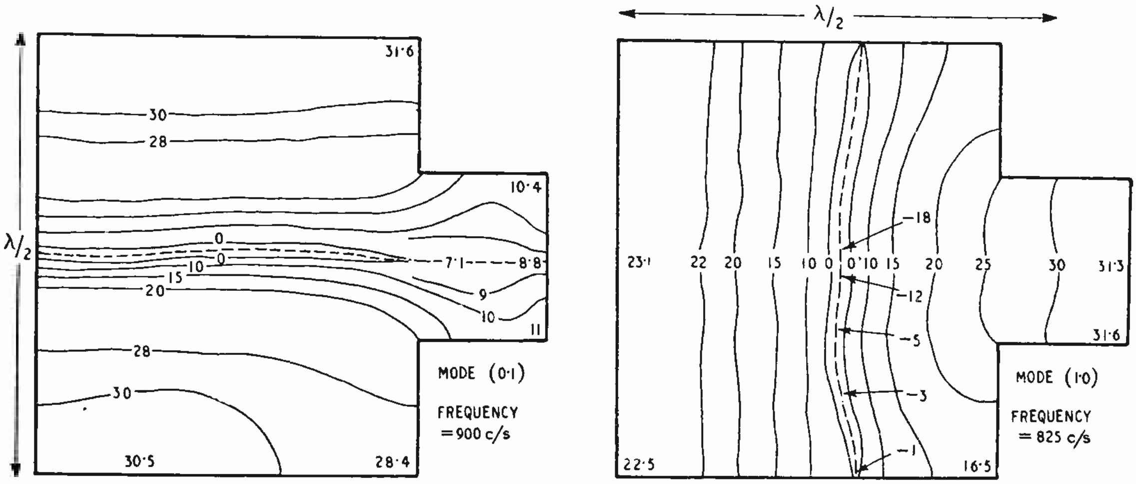
The sound pressure pattern is stationary only in the sense that a series of probe microphones inserted through the tube walls at several points would show that the *maximum* sound pressure at each point was constant, though the value would vary along the tube in the sinusoidal manner shown in Fig. 1 (b). If the tube end was open and "matched" by a

Fig. 1. In a closed tube (a) regions of maximum pressure always appear at the ends, and (b) shows the pressure distribution when the tube is λ/2 long. Pressure distributions for second and third harmonics are shown at (c) and (d) respectively.



* Electronics Engineering Dept., British Thomson-Houston Co., Ltd.

† Letter to the Editor, Dec 1957 issue, p. 592.



(a) (b)

Fig. 2. Experimentally determined pressure distribution contours in a model room (See Ref. 1).

horn to the atmosphere then sound energy would flow smoothly and steadily down the tube and out into the air and there would be no return wave. Under these conditions the sound pressure developed at each probe microphone would rise and fall sinusoidally in the normal way as each wave emitted by the speaker passed down the tube and out into the air but the *maximum value* would be the *same* at all points along the tube. Similar conditions would exist if the closed ends of the tube were completely absorbent and permitted no reflection.

Exactly the same process occurs if the exciting frequency is such that the emitted wavelength is ½, ⅓, ¼, etc., of the tube length. In this case standing waves are developed in the closed tube but the pressure variations along the tube increase in number as shown in Fig. 1 (c) and (d).

It is convenient to indicate the amplitude of the standing wave patterns by expressing in decibels the difference between the maximum and minimum sound pressures developed at the anti-node and node respectively. The standing wave ratio that results is almost solely a function of the efficiency of the tube ends as reflectors. If the ends are of a hard, rigid, non-absorbent material the standing wave ratio is high, but if the ends are of a soft absorbent material the sound energy is greatly reduced at each reflection and the standing wave ratio is low. The whole process is exactly the same as occurs in the development of standing waves on radio feeders, an excellent example of the basic uniformity that underlies all wave motion in nature.

The process has been made clear by considering the conditions in a long narrow tube. However, when we use a tube in which the width of the tube is an appreciable fraction of a wavelength it is found that there are sound pressure variations *across* the tube in addition to the end-to-end variations. This is a condition more closely analogous to those that exist in rooms. In practical listening rooms both width and height are generally comparable with the length and this results in a three-dimensional sound pressure pattern even at the single frequency at which the room length is a half wavelength. R. H. Bolt[1] has published some pressure distribution patterns measured on two-dimensional model rooms and in Fig. 2 two examples are shown. They are interesting in that they indicate the sound pressure distribution over the room for the simple condition where the *length* is one half wavelength (Fig. 2 (a)), and in (b) the pressure distribution when the room *width* is one half wavelength. These results may be compared with the measured pressure distribution shown in Fig. 3 for one of my rooms at the frequency which makes the room length one half wavelength.

The measurements on the model and on the actual room both show irregularities in the pressure distribution that are not accounted for by simple theory. The bottom right-hand corner of the model room exhibits lower pressures than the top corner (the room is symmetrical and the pressure distributions should also be symmetrical), a discrepancy that Bolt ascribed to an air leak in the corner. The measurements in my room exhibit similar irregularities on the right-hand side in the vicinity of the two doors and the fireplace. It may be significant that the open flue to the fireplace is almost exactly one half wavelength long at the frequency at which the pressure distribution was checked.

Non-parallel Walls

There is a general impression that the amplitude of standing wave patterns is decreased by building the room with non-parallel walls but Bolt's work shows that this impression is not well founded. A room with non-parallel walls exhibits standing wave patterns of just the same peak-to-peak amplitude as a room of similar construction but having parallel walls. Non-parallel walls make it difficult to calculate the frequencies of the room modes and troublesome to visualize the pattern of sound pressure distribution in the room, but the patterns are just as strongly developed as in a room with parallel walls.

The pressure build-up that occurs in a practical room is almost entirely a function of the room

[1] "Normal Modes of Vibration in Room Acoustics," by R. H. Bolt. *J. A. S. A.*, Oct. 1939.

Typical Mode Frequency Distribution for a Room 15.3ft × 11ft × 8.2ft

Mode No.	Frequency	Mode No.	Frequency
1	36.77	11	103.7
2	51.14	12	110.3
3	63	13	112.1
4	68.63	14	112.8
5	73.9	15	119.1
6	77.85	16	121.6
7	85.57	17	125.9
8	89.7	18	128.5
9	93.15	19	129.9
10	100.7	20	137.3

construction though it is affected to a slight extent by the room furnishings. Calculation of the pressure rise is possible for rooms of simple shape but tedious and generally not worth while. Measurement shows that typical rooms have a standing wave ratio of some 10 to 20 dB at the frequency at which the room length is one half wavelength and at the harmonics of this frequency.

So far discussion has been centred on the standing wave pattern developed as a result of reflection between the end walls with the wave passing down the length of the room, but similar standing waves develop as a result of reflection between side walls and between floor and ceiling. Fig. 2 (b) is an example of the pressure distribution at the frequency which makes the room width exactly one half wavelength and it is seen to have the same general shape as for the "length" mode though in this instance the pattern is complicated by the existence of an alcove. In each mode of propagation the lowest frequency is that making the width or height exactly one half wavelength, but each of these fundamental frequencies has a whole series of harmonics. In addition there are other series of resonances due to combinations of these dimensions but these are not of particular importance to the present problem and will not be further discussed at this point.

The whole series of room resonances are predicted by the Rayleigh equation—

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

where c=velocity of sound in air (approximately 1,125ft/sec), L=length, W=width, and H=height in ft. A, B and D may be each the integers 1, 2, 3, 4, etc.

The lowest frequency is obtained by making B and D=0 when the above expression simplifies to

$$f = \frac{c}{2L}$$

It is accompanied by an infinite series of harmonics having frequencies that may be predicted by making A=2, 3, 4, 5, etc.

The resonant modes due to the combined reflections between pairs of walls (one of the terms A, B, D being zero) or to the combined action of all three surfaces (none of the terms A, B, D being zero) are as powerfully developed as are the simple end-to-end reflections, but it is doubted whether their subjective effects are equally important.

These standing waves have an important effect in giving a characteristic "room tone" to any sounds produced in the room. The first effect will be fairly obvious. If room resonance gives an increase in sound pressure of 10-20 dB over narrow frequency bands, then peaks of that order will appear in the sound output from a loudspeaker which has a flat overall response when tested in the open air. The importance of these peaks will depend not only upon their amplitude but upon the frequency region in which they occur. If the music being played does not contain any appreciable amount of sound energy in the frequency region where the peaks are fairly well isolated from each other, then coloration is not likely to occur. It will be seen from the accompanying table that in a typical room the pressure peaks at the low frequencies are fairly well separated from each other, but as the frequency increases there is an increasing number of resonant modes, their spacing is diminished and the peaks stand out less obviously above the average sound pressure level In almost every instance the pressure peaks exist over certain well-defined areas of the room, a point illustrated by Fig. 3, and in many instances this makes the room coloration serious only over certain areas of the floor. One particular room in the writer's house has a rather obviously "bass heavy" region

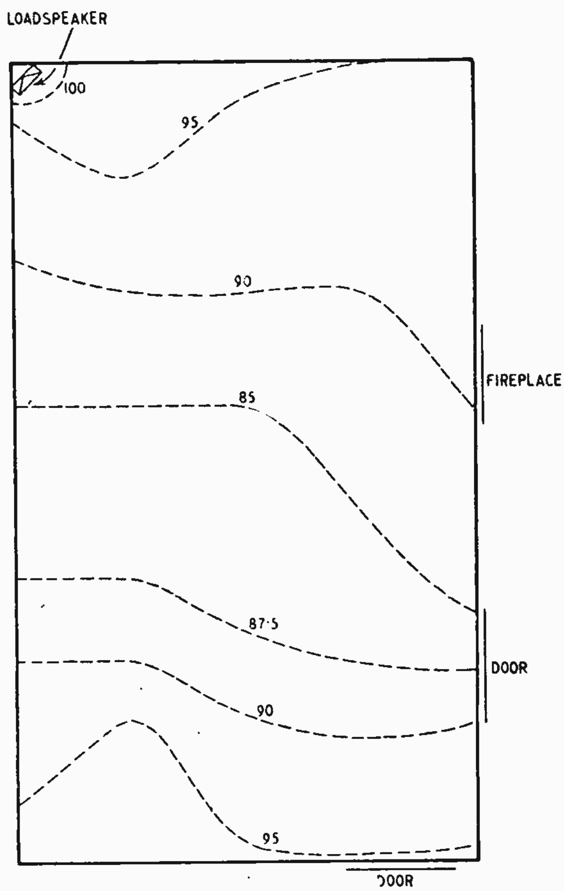


Fig. 3. Contours of equal sound pressure in a typical room when room length is one half wavelength. Figures on curves are sound pressures in dB above threshold.

over an area immediately in front of the fireplace and an equally "bass light" region over in one corner of the room. Where any of the room dimensions are 11ft or multiples of this figure, standing waves are likely to develop at mains frequency and its harmonics, and this may make mains hum serious only in certain parts of the room, a phenomenon that is regularly observed.

These may be called steady state effects in that the areas of the room that are "bass heavy" are easily discovered by exciting the loudspeaker from a variable frequency oscillator and listening carefully while perambulating around the room. However, there are transient effects that are not so easily demonstrated. When a wide frequency range signal such as speech or music is radiated by the loudspeaker the sound energy disappears gradually as it is absorbed by the walls and furnishings. During this decay period, which occupies about $\frac{1}{4}$ to $\frac{1}{2}$ second, the sound energy contained in the room undergoes a frequency changing process, being converted from the frequency at which it was emitted by the loudspeaker to the frequencies of the resonant modes. The remainder of the decay then takes place at these frequencies. Where there are two resonant modes close together in frequency, low frequency beats occur at the difference frequency as the sound decays.

In combination, the steady state and transient effects are mainly responsible for "room boom" and "single note bass" so typical of many small rooms. These are troubles that become increasingly serious as the room dimensions are reduced, for this brings the low-frequency modes higher up the frequency range where there is greater energy content in the spectrum of speech and music and where they are subjectively more obvious. There is no critical minimum size of room that gives acceptable reproduction, but any room less than about 15ft long begins to pose special problems.

Excitation Point

Having considered how standing waves are produced and their characteristic frequencies, let us have a look at the effect of speaker position on the pattern.

The sound pressure produced in an enclosure by a loudspeaker is a function both of the electrical input to the speaker and the efficiency of acoustic coupling between the speaker diaphragm and the air in the room. The efficiency of the acoustic coupling depends on the position of the speaker with respect to the standing wave system, the maximum coupling being secured when the speaker is standing at an anti-node (point of maximum sound pressure) and the minimum coupling at a node point of minimum pressure. For the simple example where the frequency has the value that makes the room length exactly one half wavelength, the maximum coupling and the maximum sound power output will be obtained when the speaker is mounted on the end wall facing down the room length. Minimum acoustic coupling and minimum sound power output will be obtained when the loudspeaker is standing at the node in the middle of the long wall.

At first thought it seems reasonable to assume that the standing wave ratio will be reduced by standing the loudspeaker at a node, but further consideration will show that this expectation is not well founded. The standing wave ratio (ratio of maximum to minimum pressure in dB) is a function only of the amount of reflection by the end walls and is not affected by the loudspeaker. However, placing the speaker at the node may be expected to lower the level of both maximum and minimum by the same factor and thus decrease the amount by which the resonant peak projects above the general sound level. The reduction in height of both maxima and minima obtained by moving the loudspeaker from anti-node to node proves to be equal to the value of the standing wave ratio in dB.

At this point it might prove interesting to forsake theory for a little practice and get some experimental confirmation of the theoretical points just discussed, for some of them contradict the commonly held views on the subject. It is not particularly easy to get positive and repeatable evidence, a common trouble with acoustic measurements. In an actual room the standing wave pattern shifts slightly when the speaker is moved and the position of the node has to be redetermined each time the speaker is moved. The simplicity of the standing wave pattern suggests that the lowest modes be investigated, though it is not too easy to produce adequate distortion-free power at frequencies in the region of 25 c/s. Repeatable results are only secured by the use of suitable bandpass filters in the microphone circuit to ensure that only the sound pressure distribution at the fundamental frequency is being measured.

Standing Wave Ratio

With these precautions the standing wave ratio was measured in the room shown in Fig. 3. For the first test the speaker was mounted in the centre of the short wall and facing down the room. Sound level measurements were taken at 3-ft intervals along a line down the room though the position of the node was determined more precisely and showed a standing wave ratio of 11 dB. The speaker was then moved to the nodal position approximately in the centre of the long wall and the measurements repeated, the standing wave ratio proving to be 10 db. A spot check immediately before and after moving the speaker from anti-node to node showed that the sound level at both anti-node and node had dropped by 11.5 and 12 dB respectively. The tests were repeated for the width mode giving standing wave ratios of 8 and 7.5 dB for speakers standing at the node and anti-node. Moving the speaker from anti-node to node reduced both maximum and minimum sound pressures by 8 dB. These results give a substantial measure of confirmation to the suggestion that the standing wave ratio is not affected by the position of the speaker in the room.

Though the s.w.r. is not reduced by the change in speaker position, it is seen that there is a useful reduction in the amplitude of both maxima and minima of the standing wave. This is a significant reduction and it raises hopes that some overall improvement in sound quality can be obtained by a suitable choice of speaker position. However, hopes are rapidly dashed when it is realized that the nodal point for the lowest mode is the point of maximum pressure for other harmonics. Thus moving the speaker from the end wall to the centre of the long wall reduces the amplitude of the lowest mode by 10-12 dB but it is likely to increase the amplitude of the third harmonic mode by about the same amount.

Nevertheless, an overall improvement in sound quality may result from shifting the speaker, for as the table shows, the lowest mode room resonances generally stand isolated from the next highest modes merely due to the fact that the average room has one dimension much greater than either of the others. An isolated mode $f=51.1$ c/s or group of modes such as $f=110.3$, 112.1, 112.8 c/s shown in the table is much more serious than a mode such as that at 128.5 c/s in the middle of a large number of other modes all of roughly equal amplitude.

Two Loudspeakers

The next step is to consider whether anything is to be gained by using two speakers in parallel and spaced round the room in the hope of minimizing the sound pressure build-up in a number of modes. Once again the effect on the lowest frequency mode will be considered because of its simplicity. At an earlier stage it was shown that moving a single speaker from the anti-node to the node reduced the height of the sound pressure peak by an amount equal to the standing wave ratio. Two similar speakers in parallel will dissipate equal amounts of electrical power, but it was earlier noted that the loudspeaker standing at the node will be more inefficiently coupled into the room and will have an acoustic output lower by the amount of the standing wave ratio than its fellow speaker standing at the point of maximum pressure. With standing wave ratios in the range of 10-25 dB the speaker standing at the nodal point will make a negligible contribution to the total sound power. Once again our hopes of reducing the standing wave ratio by an appropriate choice of speaker position are dashed.

This point was also given an experimental check. With the two speakers standing side by side against the end wall, it was found that the addition of the second speaker raised the sound level by about 5 dB but if the second speaker were standing at a node there was less than 0.5 dB increase in sound level when it was brought into circuit.

Thus, theory suggests, and experiment confirms, that there is little to be gained in the way of reducing the standing wave ratio either by placement of the speaker or by the use of two speakers in parallel.

Though spaced speakers in parallel appear to offer no particular advantage in reducing standing wave troubles, it should not be inferred that this means that they do not improve the quality of reproduction. Showing that one particular explanation lacks confirmation does not prove that paralleled speakers do not improve the quality of sound, it merely indicates that we should seek another explanation once it has been established that there is some improvement. First of all, do two *spaced* speakers sound better than a single speaker; the word spaced being emphasized to indicate that the problem is not the same as when using two loudspeakers mounted together in a single enclosure.

This is a problem on which it is impossible to offer any soundly based theoretical advice, for we are woefully ignorant about all the factors that the hearing system considers important when assessing sound quality. Experiment is the only approach that can be trusted, though it is important to bear in mind that a real judgment demands a group of listeners rather than a single individual, however skilled he may be. The following comments are my own judgment and should therefore be treated with caution.

In my own room (21ft × 12ft × 8ft) two speakers in the same plane (both back against the end wall, Fig. 4(a)) and spaced about 8ft apart, have the normally expected advantages of increased efficiency in the bass. Peculiar results can be obtained if the listener sits on the axis of the two speakers, particularly when the two units have responses that differ slightly, but in general the results are not liked. Source size is not increased by any significant amount when the second speaker is brought into circuit, the overall results having been more fully described in the October, 1957, issue which might usefully be read in conjunction with the present discussion.

However, it was noticed that a listener seated back against the long wall in position LP1 Fig. 4(a) thought that the reproduction of music was improved when both speakers were working, but only when the second speaker S2 was back against the wall pointing down the room. During the investigation of the effect of two speakers on the standing wave system, it was noted that there was a marked improvement in quality when the arrangement of Fig. 4(b) was used. This was particularly interesting, for the previous measurements had shown that this arrangement of speakers gave no improvement in standing wave ratio. Very little investigation was needed to confirm that the improvement in sound quality was due to an increase in the amount of reverberant sound, for the improvement was greatest when the second speaker S2 was turned away from the listener. As might be expected, the quality of speech deteriorated considerably when the second speaker was in use, the position of the announcer being vague and remote.

If the improvement in the reproduction of music is really due to the additional reverberation, it suggests that a second channel might be used to transmit reverberant sound only for reproduction through separate speakers in the listener's room. Some simple experiments confirm that reproduction of the

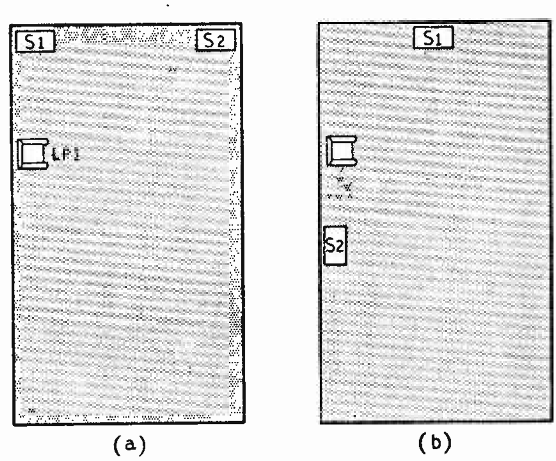


Fig. 4. Alternative positions of paralleled loudspeakers in the author's living room.

reverberation through separate speakers does effect a significant improvement in the quality of music reproduction though there is no doubt that when they are available, two separate channels are more usefully employed for a stereophonic reproducer system.

It is tempting to believe that the additional reverberation could be added by merely removing the microphone further from the sound source in the studio or by adding artificial reverberation in any of the well-known ways. Simple and obvious though this may seem, it fails to produce the desired results, for it is then necessary to reproduce both the direct and the reverberant sound from the same speakers. Direct and reverberant sounds approach the listener from the same direction and all the advantages are lost.

All the foregoing discussion has been concerned with the effects of standing waves in small (domestic sized) rooms and it is natural to consider their effects in large (theatre sized) rooms. If the first twenty or thirty resonant frequencies are calculated from the Rayleigh formula, it will be found that for a typical theatre, perhaps 140ft × 80ft × 40ft, they will all fall into the frequency band below about 15 c/s. Above this frequency they become very closely spaced and thus less important. It would appear that while there is little or no reduction in standing wave ratio to be gained from the use of multiple speakers in small rooms, there is even less to be gained in large rooms. Once again, it should not be interpreted to mean that multiple speakers have no advantages in large rooms. Mr. Briggs has stated that he has found that multiple speakers have proved very advantageous both in the Royal Festival Hall and in the Carnegie Hall in New York and I have not the slightest doubt that he is right in this.

My thanks are due to Chapman and Hall for permission to quote from my book "High Quality Sound Reproduction."

Standards for Stereo Disc Records

A Statement Issued by the Companies Represented at the Zurich Conference

THE present-day gramophone enjoys the advantage of an international dimensional standard and it is extremely important that any major development which necessitates a departure from these existing standards should be discussed in the broadest possible manner in order to establish the new set of standards which may also be acceptable to everyone interested in the development and manufacture of discs and replay equipment throughout the world. The development of the stereo disc has now passed the stage of possibility and is now a clear probability for the very near future. In order to avoid ambiguity with regard to the technical intentions of the various companies a meeting was held in Zurich last November with representatives of the European record manufacturers known to be active in the field of stereo disc recording. This *ad hoc* committee came to a unanimous decision to recommend the adoption of what is now defined as the 45/45 system, but withheld the publication until it was quite clear that these were in accord with the recommendations of the Record Industry Association of America. It is now certain that the U.S.A. recommendations will be in complete agreement with those arrived at independently at Zurich and therefore it is now considered safe to release details of the standards for the 45/45 system for publication.

Wherever possible the existing standards for microgrooves as laid down by the British and International Electro Technical Commission standards will be maintained. Thus the diameter of the disc, the speed and the recording characteristics will remain unchanged. It is however, necessary to reduce the radius of the reproducing point and the recommended limits are 12.5 microns minimum radius and 15 microns maximum radius. The angle of the reproducing point will remain the same as at present. The maximum radius of the bottom of the groove will be five microns, but the included angle will remain unchanged.

For the better understanding of the definitions which are to follow, the notation with regard to left and right channels will be as laid down in the I.E.C. publication No. 94 "Recommendations for magnetic tape recording and reproducing systems" in which the right-hand channel is defined as that which supplies the right-hand speaker as viewed by the audience.

The stereo disc will carry two channels of information arranged as follows:—

1. The two channels are recorded in such a manner that they can be reproduced by movement of the reproducing stylus in two directions at 90 degrees to each other.

2. The right-hand loudspeaker is actuated only when there is movement on the axis which is inclined at 45 degrees to the disc surface and intercepts the axis of rotation of the disc above the surface.

In normal practice the groove angle is nominally 90 degrees and for this particular case the two channels can be said to be recorded in such a manner that the right-hand loudspeaker is actuated by a modulation normal to the surface of the groove wall which faces the axis of the disc, and the left-hand loudspeaker is actuated by a modulation of the groove wall which faces away from the axis of the disc. The surface modulations of each groove wall will be 45 degrees to the plane of the disc and 90 degrees to each other.

3. A movement of the stylus point in a direction parallel to the surface of the disc shall provide equal, in-phase, acoustical signals from the loudspeakers.

It follows, from clause 3 above, that pickups designed for stereo reproduction will be suitable for playing normal microgroove single channel records. However, the majority of present day pickups are designed for single channel operation and are fitted with a larger stylus point than is recommended for stereo discs and many of them offer a high mechanical impedance to the vertical movement of the stylus and hence are not suitable for playing stereo discs.

C.O.I. Films

A LARGE number of films of interest to a wide variety of industrial audiences can be hired or borrowed free of charge from the Central Film Library of the Central Office of Information, Government House, Bromyard Avenue, London, W.3. The catalogue, "Films for Industry," and supplement containing details of over 700 films and filmstrips cost 2s.

"Atlantic Link," a colour film (recently shown publicly), giving an account of the manufacture and laying of the first transatlantic telephone cable with its 120 repeaters, is now available for private showing. It runs for 19 minutes and costs £1 to hire.

Marconi Doppler Navigator

FURTHER TECHNICAL DETAILS AND A FLIGHT DEMONSTRATION

Demonstration AD2300 Doppler navigator installed in a Viking aircraft of Airwork, Ltd.

THE Doppler principle and its application to the measurement of the ground speed and drift of an aircraft have already been described*. Briefly, the modified frequencies of the energy returned from four radio-frequency beams directed to the ground fore and aft and to port and starboard of the aircraft are compared. If the axis of the aerial system is rotated until the port and starboard return frequencies are equal it will be lying parallel to the course over the ground; the magnitude of the frequency difference between fore and aft beams is proportional to the speed over the ground.

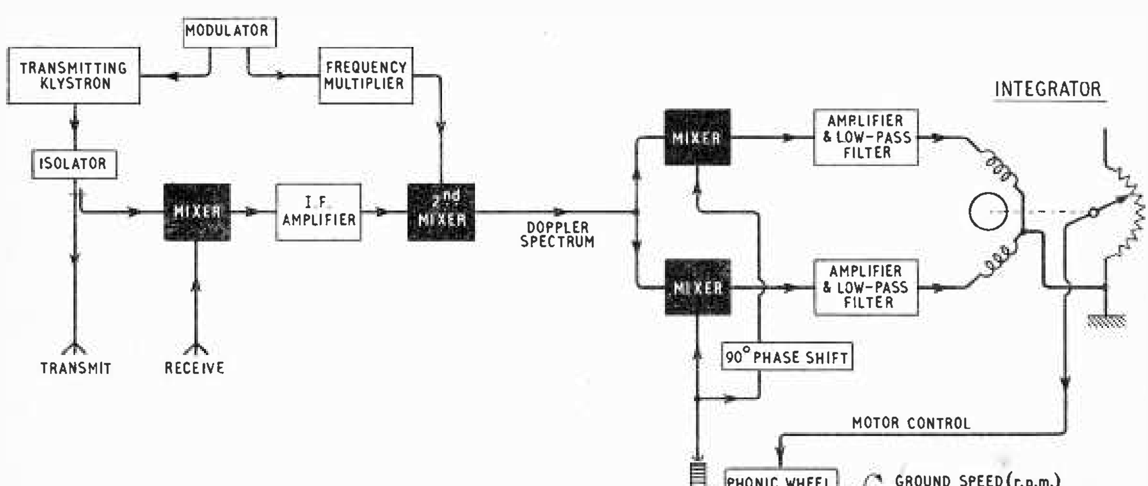
In practice, one of the difficulties of a simple c.w. system is break-through between transmitter and receiver. This has been overcome in the Marconi Type AD2300 by the use of frequency modulation. The amplitude of sidebands resulting from the mixing of a part of the transmitted with received signal is a function of the time delay, and is theoretically zero for no time delay or for delays equivalent to integral cycles of modulation. By choosing an optimum modulation index and a high modulating frequency (500 kc/s) the minima are closely spaced and are smoothed by the spread of Doppler frequency consequent on the use of a beam of finite width. The choice of a high modulating frenquency and the selection of a high-order sideband for i.f. amplification reduces noise and vibration amplitude modulation whose sidebands are grouped closer to the carrier.

In addition to automatic drift alignment in the horizontal plane the aerial system of the AD2300 is stabilized for pitch in the vertical plane up to 10° by signals arising from differences in forward and backward Doppler frequencies.

Automatic following of the Doppler frequency by a phonic wheel motor is achieved by continuously scanning the whole Doppler spectrum and comparing the output with the phonic wheel frequency. The resultant difference frequency is fed to an integrator which varies the motor speed to follow changes in the Doppler centre frequency. Without any manual adjustment this circuit finds and locks on to the signal. If for any reason the signal disappears temporarily, a memory circuit keeps the phonic wheel running at the last controlled speed until the signal reappears. The distance flown is indicated by a mechanical decade counter which does not require calibration; the indication is a function of the Doppler frequency and the calculated number of teeth on the phonic wheel.

We have had the opportunity of seeing this equipment in action in a Viking aircraft on a test

* *Wireless World*, 1957, May, p. 225; Aug., p. 396; Oct., p. 460.



Simplified block diagram of basic Marconi Doppler navigator.

flight of 106 miles. A modified demonstration model showing the aircraft position in miles of "northing" and "easting" was used (a full computer for latitude and longitude is available) and the readings at the start and finish of the flight showed an error of 2.2 miles in northing and only 0.2 miles in easting, this with a 40-knot wind and with a variety of steep banking turns, 360° circles, fast rates of climb and dive and other manœuvres which would not normally be inflicted on airline passengers, but which were introduced to show the responses of the navigator. A run over the aerodrome at a height of 50ft showed the indicators to be still working normally, and we noticed on landing that the indicator lamps did not show lack of synchronization until the aircraft was as low as 15ft from the ground. Under normal flying conditions there is little doubt that the makers' claim of 0.5% accuracy in distance flown, 0.5% ± 3 knots in ground speed, ±0.25° in drift angle and position accuracy to within 1% of distance flown when heading is down to within ½° could be substantiated.

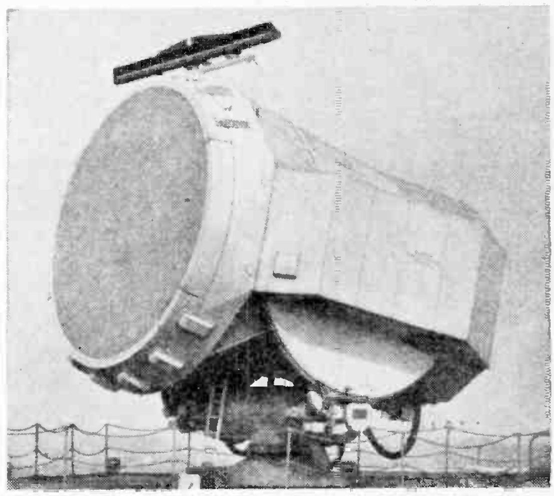
Navy's New Radar

Computers in Fighter Control and Early-warning Radars

THE aircraft carrier H.M.S. Victorious has been "reconstructed" to modern standards. One of the new pieces of equipment fitted during this process is a complete early-warning and tactical-operation control radar system, giving accurate interception data—height, range and bearing—simultaneously. This is achieved by the use of a complex scanning system embodied in one aerial assembly resembling, in external appearance, a very large head-lamp. This aerial produces several separate narrow rotating pencil beams, one of which is fixed in elevation to give early-warning coverage. As the aerial rotates the other beams scan overlapping vertical sectors, in synchronism, so that the maximum possible amount of information about the target is obtained in one scanner rotation. This is essential to the successful interception of targets travelling at high speeds in the short time available for defensive action to take place. All the beams are focused by a common lens made up by spot-welding together many pieces of aluminium wave guide of differing cross-sections and lengths. The whole aerial assembly (including transmitters and head amplifiers) weighs 27 tons and the lens is 14 feet in focal length with an aperture of f 1.

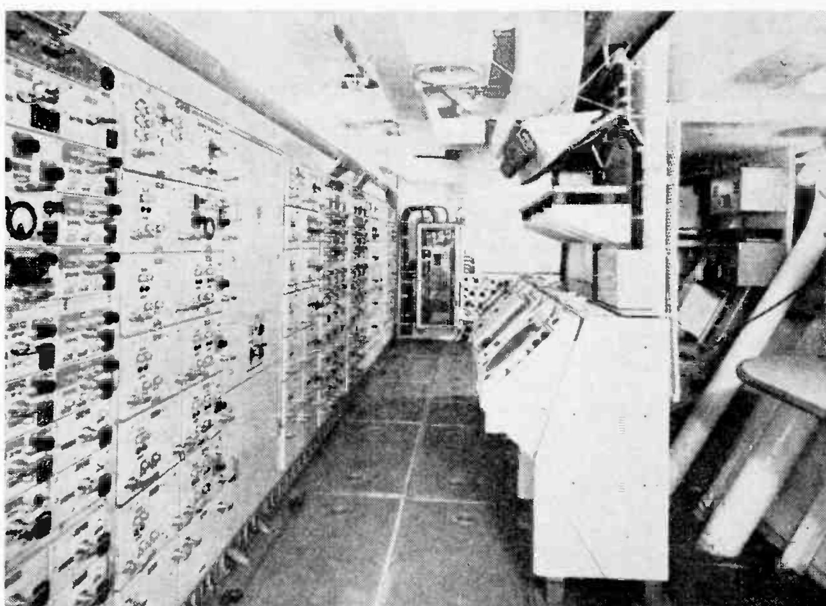
Another difficult problem which has been overcome is maintaining the i.f. output from the mixers constant in frequency. The aerial system does not achieve a perfect impedance match to the power source because the distance the r.f. has to travel varies from pulse to pulse as the beams scan vertically. This can "pull" the frequency of the transmitter magnetron, and the receiver local oscillator has to follow this change of frequency to maintain a constant i.f. The problem is further complicated by the use of separate receivers for each pencil beam. The a.f.c. system developed corrects, on a pulse-to-pulse basis, for deviations from the nominal transmitter frequency.

Control of the whole radar system is carried out from a central control desk below decks, where a computer is fitted to process and store all the information gained from the radar system. This information is then presented in a clear and comprehensive manner to the people making tactical decisions. The computer provides a display of when and where interception will take place from data supplied by the radar and instructions given to the interceptor by the controlling officer.



[Photographs: Crown Copyright Reserved]

Above: Aerial and its mounting. The complete assembly is supported on a single deck-ring. Below: General view of part of display processing equipment.



Variable-Output Mains Transformer

REVISED DESIGN PROVIDING WIDE RANGE OF VOLTAGES

By ***H. E. STYLES,*** *B.Sc.*

In an article published in the August, 1951, issue of *Wireless World*, the writer described a method of constructing a mains transformer capable of providing an output which could be adjusted to any integral value of voltage between zero and 280 volts. The design of this component was based upon the fact that, from the series $0, \pm 1, \pm 3^2, \pm 3^3, \pm 3^4, \ldots \pm 3^{n-2}$, terms can be selected so as to obtain any desired integral value.

This series was reproduced by providing secondary windings of 1 volt, 3 volts, 9 volts, 27 volts, etc., any of which could be connected together in or out of phase so as to correspond to the plus or minus values of the series. For voltages above 40, the transformer primary was connected in series with the chosen secondaries to give, in effect, an auto-transformer. Complete isolation from the mains was thus achieved only for the lower range of output voltages.

The foregoing transformer has proved to be an invaluable laboratory component but it has nevertheless been found to suffer from the following minor drawbacks:—(1) The design demands the use of a number of three-position, double-pole switches suitable for mains voltages and relatively heavy currents. Such switches are neither very readily obtainable nor cheap. (2) The necessary use of positive and negative switch positions tends to complicate computation of net output voltage and thereby introduces a liability to error in setting. (3) Isolation of output from the mains is often desirable at voltages greater than 40. (4) Connection of windings in opposition leads to increased copper losses which should be avoided if possible.

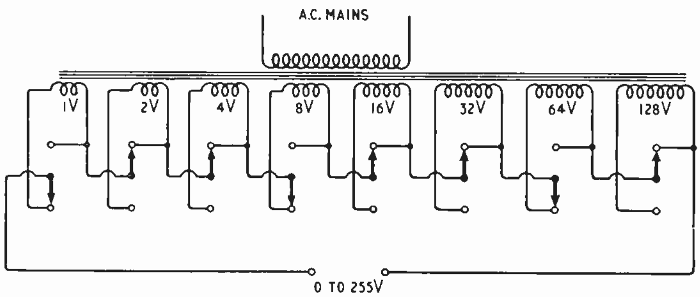


Fig. 1. Mains transformer giving any integral output voltage from zero to 255 with secondary isolated from primary.

At the cost of no more than a slight increase in the number of secondary windings employed, the drawbacks enumerated above can be avoided by designing on the basis of a different mathematical series. Most readers will no doubt be familiar with the binary system of numbers represented by the series $0, 1, 2, 2^2, 2^3, 2^4 \ldots 2^{n-2}$ from which it is again possible to obtain any desired integral value by selection of appropriate terms. In this case, however, all terms are positive and no need arises therefore for providing for any form of subtraction procedure.

A multi-output transformer based upon this series is shown diagrammatically in Fig. 1. It will be seen that the only switches required are of the single-pole, change-over variety of which many types suitable for mains voltages and currents are readily available at reasonable cost. The circuit of Fig. 1 enables any integral voltage between 0 and 255 volts to be obtained at will by operation of no more than 8 switches all of which correspond to positive values which can readily be added with little risk of error. Moreover, throughout the whole of this range of voltages, the transformer output is completely isolated from the mains input.

If desired, and provided that the transformer is wound with an even number of turns per volt, closer adjustment of output voltage can be achieved by the incorporation of one additional switch, together with a half-volt winding, which will provide for selecting any voltage throughout the whole range to within half a volt of the desired value.

The circuit shown in Fig. 2 enables the maximum output voltage to be raised from 255 to 511 volts whilst still retaining the facility of voltage adjustment to within half a volt throughout the whole range. This extension of range is simply achieved; the necessary modifications comprising merely the provision of a two-pole change-over switch (readily obtainable) and a 256-volt tapping on the primary winding of the transformer. The additional primary winding tappings shown in the circuit of Fig. 2 serve the purpose of matching the primary to mains supply voltages ranging from 221 volts to 261 volts, in steps of 5 volts provided by the tappings at the "line" end of the primary. These primary input tappings also enable adjustment of output voltage to within about one per cent of the nominal value indicated by the selected switch positions.

With the circuit of Fig. 2, outputs at voltages greater than 255.5 volts are, of course, no longer isolated from the mains supply. Warning of the change over to auto-transformer operation is automatically provided by means of a small neon indicator connected across the centre contacts of the two-pole change-over switch. A 2-volt flash-lamp bulb connected across the 1-volt secondary winding likewise serves to indicate when the transformer primary is energized.

The size and precise design of the transformer can be varied according to the particular purposes for which the component is required. Thus, for example, the lower-voltage secondary windings may be wound with heavier gauge wire to permit power loadings appropriate to the lower voltages, in which case the switches employed must also be of sufficient current carrying capacity. Alternatively, all secondaries can be wound with wire of the same gauge as the primary, in which case the output current must always be limited to that corresponding to maximum transformer output permissible when used as a simple 1 : 1 ratio mains transformer. The same current can, however, be drawn with the transformer auto-connected to give outputs greater than 255 volts as, despite the increased power loading, the current through the primary winding will remain below the limiting value up to the maximum output of 511 volts.

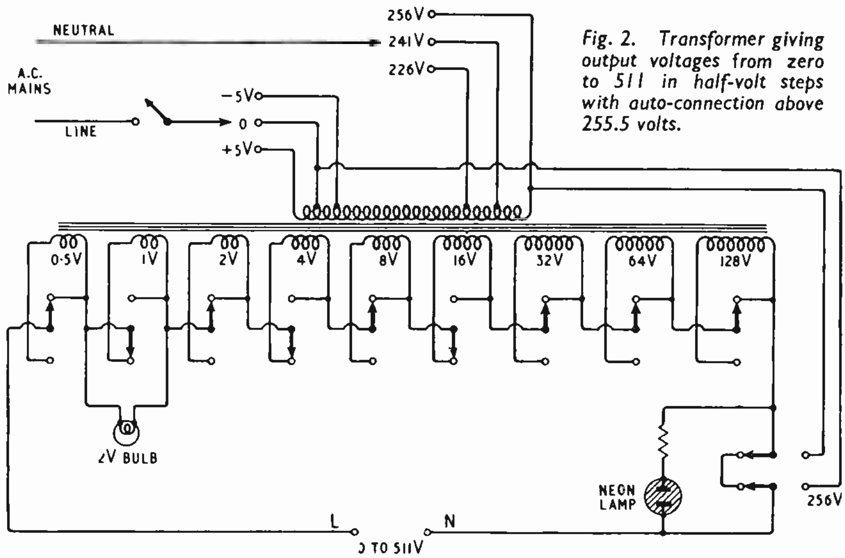


Fig. 2. Transformer giving output voltages from zero to 511 in half-volt steps with auto-connection above 255.5 volts.

If it be desired to employ the instrument for calibration tests on voltmeters, etc., care should be taken to ensure that the turns per volt of the transformer winding are sufficiently high to avoid waveform distortion arising from saturation of the iron core material. On the other hand, if the device is intended for use as a means of controlling, say, heating or motor-driven equipment, a lower turns per volt figure may be preferred so as to permit the use of a heavier gauge of wire, core saturation being limited by considerations of iron loss rather than wave-form distortion.

The versatility of the transformer can be further increased by incorporating an independent winding giving 6.5 volts with tappings at 2.0 and 2.5 volts. This will provide also 4 volts between the 2.5- and 6.5-volt tappings and thus enable supplies to be obtained for the filaments or heaters of a variety of valves. In addition, a separate, well-insulated winding of appropriate voltage can be incorporated so as to provide heater current for a valve rectifier. The latter, or a metal rectifier, can then be used in conjunction with this transformer to provide a variable d.c. supply, smoothed by a normal combination of capacitors and choke. Together with the separate low-tension windings, this will provide a useful source of power for valve testing, operation of experimental hook-ups and so on. One advantage to be derived from using a tapped transformer of this kind is that a particular voltage setting can be repeated precisely, whereas this is not often the case with devices employing variable resistances.

Instructional Films on Transistors

FIVE new 16-mm sound films have recently been produced by Mullard to illustrate the basic principles of semiconductors, transistors and their application in radio receiver circuits.

"The Transistor—Its Principles and Equivalent Circuit" lasts 15 minutes and is in colour. It is at a fairly high technical level and a detailed analysis of the complete and approximate equivalent circuits used in design is preceded by animated diagrams showing current carriers under different circuit conditions. This film serves as an introduction to "The Junction Transistor in Radio Receivers," which is in two parts: 1.—"Design of an I.F. Amplifier" (15 minutes) and 2.—"The Complete Receiver" (10 minutes). A third film, "The Manufacture of Junction Transistors" (10 minutes) gives a close view of the techniques employed at the Mullard factory at Southampton. All the foregoing are available from the Publicity Division of Mullard Ltd., Torrington Place, London, W.C.1.

Another 16-mm sound film, "The Principles of the Transistor" (20 minutes, black and white), and a colour film strip, "Semiconductor Devices" (35 mm), have been produced for teaching by the Mullard Educational Service in collaboration with the Educational Foundation for Visual Aids to whom schools should make application; other organizations should apply to the Mullard Education Service.

B.S.R.A. Constructors Competition

THIS was held this year in conjunction with the British Sound Recording Association's exhibit at the London Audio Fair, and the President's Cup and the Guy R. Fountain Award were won by B. H. Parks with an optical tape locating device in which an OCP71 phototransistor housed in one of the tape guides is energized by light passing through narrow gaps in the tape coating. These are easily made after the coating has been softened by a solvent such as acetone, and, if made *before* recording, the erase head removes any magnetic disturbance. An associated relay system enables any pre-determined point on the tape to be rapidly located.

The judges awarded the *Wireless World* prize to R. J. Fearn of Dundee for two beautifully finished lightweight moving-coil pickups tracking at 3 gms and 6 gms on 33⅓ and 78 r.p.m. records respectively.

A third prize was given to A. J. Harper for a pickup lowering device and an adjustable tweeter mounting.

WORLD OF WIRELESS

Flat Tube Demonstrated

THE Gabor-N.R.D.C. flat cathode-ray tube, described in our December, 1956, issue, was demonstrated at the I.E.E. on May 14th to a large audience. A horizontal line was traced on the slightly bluish phosphor and was made to give a "one-shot" type of scan in the vertical direction by manual operation of a switch. One possible method of achieving colour reproduction in the tube was demonstrated on a small section of phosphor material which changed colour when the energy of the electron beam was varied. Industry representatives at the meeting were frankly critical of the practicability of the tube design for mass-production techniques, but Dr. Gabor and his co-workers continued to assert that for colour television it was essentially simpler than the existing shadow-mask, beam-switching and beam-indexing tubes.

Standard Frequencies

IN accordance with the Atlantic City Convention the carrier frequencies of all B.B.C. short-wave transmitters are maintained to within ± 30 parts in 10^6, but in practice they rarely exceed the limits of ± 10 parts in 10^6.

For some years three short-wave transmitters, GRO (6.180 Mc/s), GSB (9.510 Mc/s) and GSV (17.810 Mc/s) and the 200-kc/s Droitwich transmitter have been guaranteed to have a stability of better than 1 part in 10^6 (sub-standard carrier).

From May 1st the three short-wave transmitters are no longer being maintained as sub-standard carriers. It is stated that this has been done to "provide for greater flexibility in the use of these frequencies between the overseas service transmitting stations."

The 200-kc/s transmission, which incidentally is used by the B.B.C. to control the carriers of a number of low-powered unattended transmitters in the U.K., will continue to be maintained as a sub-standard carrier. The results of measurements made daily by the National Physical Laboratory on the Droitwich transmission are given each month in our sister journal *Electronic & Radio Engineer.*

Audio Fairs

MORE than 47,000 visitors attended this year's London Audio Fair, and at one period the percentage of men was said to be as high as 97. This year's attendance was some 7,000 more than in 1957.

Plans are being made to hold an Autumn Audio Fair again in Harrogate (Oct. 24th to 26th). Audio Fairs Ltd., the organizers of both the London and Harrogate shows, is a non-profit making concern consisting of an honorary council of management under the chairmanship, this year, of D. A. Lyons, of Trix. The other members of the council are: G. Spark (M.S.S.), vice-chairman; L. H. Brooks (M.S.S.), secretary; M. L. Berry (Trix); J. Maunder (Vitavox); H. Slade (Garrard); T. R. B. Threlfall (Goodmans); and V. G. P. Weake (Pamphonic).

V.H.F. Ship-Shore R/T

TELEPHONE calls between U.K. subscribers and suitably equipped ships within a 40-mile radius of the North Foreland radio station will be possible within a few months. The G.P.O. introduced a similar service in the Firth of Clyde last May and is planning the installation of v.h.f. radio-telephone equipment in several other coast radio stations, including Niton (Isle of Wight), Mablethorpe (Humber) and Land's End.

The frequencies to be used by North Foreland are those internationally agreed at the Hague Maritime V.H.F. Radiotelephone Conference (January, 1957)—156.8 Mc/s calling, 161.9 Mc/s transmit, and 157.3 Mc/s receive. Transmissions will be frequency modulated.

Marconi's have been awarded the contract for equipping North Foreland and four other stations with the necessary v.h.f. gear.

B.R.E.M.A. Report

THE continued trend of reduced retail prices of domestic sound and television equipment is mentioned in the report of the British Radio Equipment Manufacturers' Association. It quotes the Board of Trade Wholesale Price Index which (with June, 1949, as the base rate of 100) shows that between 1954 and 1957, prices of sound receivers came down from 98.7 to 91.7%; TV receivers from 83.8 to 75.4%; and radiograms from 95.8 to 89.6%. During the same period the index for domestic electrical appliances as a whole rose from 111.7 to 115%.

The value of home sales of domestic receivers (at ex-works prices) last year was £83.3M, which was 22% above the 1956 figure but 4% below the 1955 total. Exports, too, were below the 1956 figure—£3.4M compared with £3.6M.

It is announced that it is proposed to form within the association a group for audio equipment manufacturers.

Earls Court

AN innovation at this year's National Radio Show (Earls Court, Aug. 27th to Sept. 6th) will be the inclusion of a number of sound-proof demonstration rooms in a section of the hall devoted exclusively to audio firms. All the 45 stands in this section, which will be on the First Floor, were allocated at the ballot on April 30th, although a few spaces remained unlet on the ground floor.

Technical Authorship

FOR some time the City & Guilds of London Institute has been considering the need for courses and examinations in technical authorship, and a scheme has now been prepared. The normal course of part-time instruction will extend over four years and amount to at least 600 hours study. The first intermediate examination will be held in 1960 and the first final examination the following year.

Television Society Premiums

THE Television Society has awarded Premiums to the following authors for papers read at London meetings of the Society in 1956/57:—

Dr. D. Gabor, F.R.S. (Imperial College), The *Wireless World* premium for "A New Picture Tube".

Dr. E. L. C. White (E.M.I. Research), the Mervyn premium for "Alternatives to the N.T.S.C. Colour System".

S. N. F. Doherty and P. L. Mothersole (Mullard Research), the Mullard premium for "Automatic Gain Control Circuits in Television Receivers".

Dr. J. A. Saxton (D.S.I.R. Radio Research Station), the E.M.I. premium for "Scatter Propagation and its Application to Television".

Dr. R. Pearce (E.M.I. Research), the *Electronic Engineering* premium for "The Return of Electrostatic Focusing".

Ian Atkins (B.B.C.), the Pye premium for "Studio Production Techniques".

Smale House.—Cable & Wireless have honoured J. A. Smale's long service and distinguished contribution to international telecommunications by naming its new five-storey building in Kirby Street, London, E.C.1, Smale House. Mr. Smale was with C. & W. from 1929 to 1957, and was for the last nine years engineer-in-chief. The development and workshop production sections of Cable & Wireless will be transferred from Radio House, Wilson Street, E.C.2, to Smale House. The staff numbers about 100.

Television Society Council.—The following were elected at the annual general meeting on May 9th to fill the vacancies on the council of the Television Society:—V. J. Cooper, Marconi's chief television engineer; C. L. Hirshman, Siemens Edison Swan's chief consulting and applications engineer; T. C. Macnamara, technical controller of Associated Television; and N. E. B. Wolters, executive controller of TV films and radio division of Napper, Stinton and Woolley.

R.I. Club.—Membership of the Radio Industries Club, which holds a monthly luncheon meeting in London and organizes the annual Radio Industries Ball, is now 952. The new president of the club is Sir Robert Fraser, director-general of the Independent Television Authority. W. E. Miller, managing editor of *Wireless Trader*, who was secretary of the club for nearly 18 years, is elected a vice-president. Collections for trade charities taken at the luncheons during the past year totalled £364, to which is added £262 resulting from the 1957 ball.

A.T.C. Recorders.—The first of a series of magnetic-tape recording installations for the principal airports of the Ministry of Transport and Civil Aviation is to be installed at Gatwick Airport. Manufactured by British Communications Corporation the equipment, which will be used by air traffic controllers, will provide as many as 17 channels on a single tape, although the Gatwick installation will use only eight.

8 Million.—During March the number of combined television and sound licences in the U.K. passed the 8 million mark. The month's increase was 95,280, bringing the total to 8,090,003. Sound-only licences totalled 6,556,347, including 333,729 for car radio sets.

Institute of Information Scientists has been formed to promote high standards and establish professional qualifications in scientific information work. Enquiries should be addressed to J. Farradane, Torran, Crofton Road, Orpington, Kent.

Next year's Electrical Engineers' Exhibition, sponsored by the Association of Supervising Electrical Engineers, will take place at Earls Court from March 17th to 21st.

Transistor Convention.—The I.E.E. is organizing an international convention on transistors and associated semi-conductor devices, to be held in London from May 25th to 29th next year.

B.S.R.A.—After serving the British Sound Recording Association as secretary for many years, R. W. Lowden has been elected president in succession to J. F. Doust. The new secretary is D. Winget with S. W. Stevens-Stratten as assistant secretary. G. A. Briggs joins M. J. L. Pulling, A. P. Monson and F. Langford-Smith as vice-presidents.

The British Wireless Dinner Club, founded after the 1914/18 war by Col. L. F. Blandy, who was responsible for wireless communications in the British Expeditionary Force, held its 35th annual dinner on April 25th. It was attended by 120 members. The president and vice-president for this year are Maj.-Gen. Sir Ronald Penney and Brigadier Sir Lionel Harris respectively. Captain F. J. Wylie, R.N., and L. T. Hinton are joint honorary secretaries.

The **Mullard Company** has made an offer to Oxford University of £50,000, payable over ten years, towards the cost of a new college which would accommodate 400 students, of whom up to half would be scientists, mathematicians or engineers.

I.E.A. Exhibition.—The number of visitors to the Instruments, Electronics and Automation Exhibition (Olympia, April 16th-25th) was 59,600, including 3,300 from overseas. This year's attendance was some 6,500 more than last year.

FROM ABROAD

Reliability.—The 5th National Symposium on Reliability and Quality Control in Electronics will be held in Philadelphia, Pa., U.S.A., from January 12th to 14th. The organizers would welcome contributions from outside the U.S.A. Further information about the Symposium and the procedure for submitting papers can be obtained from R. Brewer, of the G.E.C. Research Laboratories, Wembley, publicity area chairman for the United Kingdom and Western Europe.

U.H.F. Congress.—Proceedings of the international congress on u.h.f. circuits and aerials held in Paris last October are being published by the Société des Radio-électriciens, 10 Avenue P. Larousse, Malakoff (Seine), France. The texts of the 166 papers presented at the Congress will be published in either English or French, according to the language used by the author. The proceedings will cost 5,000 francs if ordered before June 15th, or 9,000 francs afterwards. Abstracts of the papers in both English and French are being issued as a booklet, price 1,000 francs.

Cybernetics.—The International Association for Cybernetics is to publish a quarterly review, *Cybernetica.* The annual subscription for non-members is 300 Belgian francs. The association is organizing a second international congress, which will be held in Namur, Belgium, from September 3rd to 10th. The U.K. representative on the organizing committee is Dr. W. Grey Walter, of the Burden Neurological Institute, Bristol, and the U.S.A. representative is John Diebold.

Magnetic Materials.—America's fourth conference on magnetism and magnetic materials, sponsored by a number of organizations, including the Institute of Radio Engineers and the American Institute of Electrical Engineers, will be held in Philadelphia from November 17th to 20th. Further details are obtainable from C. J. Kriessman, Remington Rand Univac, 1900 W. Allegheny Avenue, Philadelphia, Pa.

Norway, which already has 17 v.h.f./f.m. stations, is planning to double this number in the near future to give a satisfactory broadcasting service to the whole country.

A.R.R.L.—A 12% increase in its membership during 1957 is reported by the Amateur Radio Relay League. Members in the United States and its possessions now total 65,215 with a further 2,151 in Canada.

Personalities

L. H. J. Phillips, B.Sc., sales manager of the Electronics Department of Metropolitan-Vickers, has been appointed assistant commercial manager. An honours graduate of the University of Wales, Mr. Phillips became a college apprentice at Metropolitan-Vickers in 1927. A year later he joined the staff of the research department, where he remained until 1941 when he was appointed assistant superintendent of the Radio Department of the Royal Aircraft Establishment, Farnborough. In 1942 he was transferred to the Ministry of Aircraft Production as Deputy Director of Communications Development. He returned to Metrovick as sales manager of the newly formed radio department in 1945, becoming sales manager of the electronics department the following year He is succeeded as sales manager by **A. G. Barton,** A.M.I.E.E., who received his technical education at the Royal Technical College, Salford, and joined the company as a school apprentice in 1939. From 1943 to 1947 he was in R.E.M.E. with the rank of Captain. He returned to Metropolitan-Vickers in 1947 and has been sales engineer in the Electronics Department since 1955.

Harold Larnder, O.B.E., who was a member of Sir Robert Watson-Watt's radar research team at Bawdsey and has been in Canada since 1957, has been appointed Director of Scientific Intelligence in the Canadian Defence Research Board. Until recently he was director of the R.C.A.F. Directorate of Systems Evaluation. For his contributions to the development of radar, which included after-glow of cathode-ray tube screens, pulse analysis and monitoring and radar countermeasures, he received in 1952 a financial award on the recommendation of the Royal Commission on Awards to Inventors. For some time prior to going to Canada he was superintendent of weapons assessment at the Ministry of Supply's Armament Development Establishment.

A. F. Wilkins, O.B.E., M.Sc.Tech., M.I.E.E., another of Sir Robert Watson-Watt's Bawdsey team, has been granted the Fellowship of the American Institute of Radio Engineers for "his contributions to research, to short-wave direction finding, and to the early development of radar." He, too, received a financial award for his contributions to the development of radar, which included a method of height measurement in single-station radar, IFF apparatus and aircraft aerials for use with IFF and a device for reducing the effect of permanent echoes at CH stations. Mr. Wilkins, who is now a senior principal scientific officer at the D.S.I.R. Radio Research Station, Slough, was for the latter part of the war head of operational research sections of Fighter Command and at Air H.Q., S.E. Asia.

R. H. Cooke, a founder member of the Society of Non-destructive Testing, has been appointed director and general manager of the new company Research and Control Instruments, Ltd., mentioned on page 267. He is a member of the committee of the nucleonics section of the Scientific Instrument Manufacturers' Association.

E. **Duncan-Smith,** D.Sc., M.I.E.E., M.Brit.I.R.E., former United Nations radio adviser to the Jordan government, has been appointed telecommunications expert to Israel by the United Nations Technical Assistance Administration. He will be especially associated with telecommunications and electronic training at the Technion, Haifa. Dr. Duncan-Smith was at one time at the Admiralty Signal Research Establishment where he served for some six years in the technical secretariat and the Shore Station Division. After resigning from the Royal Naval Scientific Service and before going to Jordan, he was with Air Service Training, Hamble, and International Aeradio, Ltd., organizing radio technical training.

Gordon A. Spencer, A.R.T.C., M.I.E.E., has resigned his appointment as principal scientific officer with the Admiralty Signal and Radar Establishment to join Andec, Ltd., electronic engineers, of Reading, as assistant to the director. Prior to going to A.S.R.E. in 1950 he was production manager for Dawe Instruments, Ltd., which he joined on leaving the R.A.F., in which he served as a technical signals officer.

Hilary F. C. Williams, B.Sc., until recently chief engineer of Racal Engineering, Ltd., of Bracknell, Berkshire, has joined Andec, Ltd., as chief electronics engineer. For nine years prior to joining Racal he was with Cossors as a development engineer. During the war he was engaged on radar work at R.A.E. and was granted on honorary commission in the R.A.F.

A. St. G. Prynne, M.A., A.M.I.E.E., has been appointed commercial manager of Racal Engineering, Ltd. His department covers sales, service, contracts and estimating. It is also announced that **I. H. M. Campbell** has been appointed chief of sales (home and export) and will be responsible for publicity.

John P. Coleman, M.I.E.E., has resigned from the board of Data Recording Instrument Co., which he joined last year, and no longer has any financial interest in the company. He will be devoting himself fully to the activities of the Gresham Transformer group of companies, of which he is a co-founder and chairman.

J. W. Soulsby has been elected chairman of the Radio Officers' Union for the fourth successive year. In 1918, at the age of 18, he joined the Marconi Marine Company as a sea-going operator, and except for a short spell at the company's Newcastle depot has been at sea ever since. He is at present serving as chief radio officer in the British India Steam Navigation Company's *Uganda.*

W. S. Armstrong, elected for a second year as vice-chairman of the Radio Officers' Union, was on the Marconi Company's sea-going staff until 1947 when he was appointed to the permanent staff of the Union's Inspectors and Technical Employees' Section. He is 45.

K. P. Wood, B.Sc., A.M.I.E.E., who joined Cossor Radio & Television, Ltd., in 1956, has been elected to the Board and will assist **J. S. Clark,** the chairman and managing director, on the management side of the company's business. Prior to joining Cossor, he was in charge of the electrical engineering department of the Medway College of Technology, Rochester.

J. S. Wilson, who joined Thorn Electrical Industries, Ltd., in 1946, and became sales manager of the Ferguson Radio and Television Division two years ago, has been appointed to the board of Ferguson Radio Corp., Ltd.

W. Dalziel, production manager of Plessey's electronic and equipment group, has been appointed an executive director of the company. Mr. Dalziel, who is 41, joined Plessey in 1938. **H. Fox Wright,** contracts manager of the company, which he joined in 1937, has also been appointed an executive director.

H. G. Cutler, general manager of Egen Electric, Ltd., has been appointed a director of the company, which he joined as works manager on its formation in 1946. He has been general manager since 1954.

J. Irwin has been appointed works executive director, and **C. C. Hurst** an executive director of Aerialite, Ltd. Mr. Hurst retains his position as sales manager of the aerial and electronics division.

Arthur C. Crouch has joined Reliance Manufacturing Co. (Southwark), Ltd., of Walthamstow, as technical sales executive. He was with A.B. Metal Products until 1951, and rejoined them in 1953. In the interim he was with Ardente.

R. H. Vivian, B.Sc., A.M.I.E.E., for seven years with A. C. Cossor, Ltd., has joined the Trix Electrical Co. as chief engineer.

F. G. Sandham, who has been with the Trix Electrical Co. for the past six years, has been appointed works manager.

William Strange, formerly of Grundig (Great Britain), Ltd., has joined the Wyndsor Recording Co., as production manager. Until recently the company, which manufactures Wyndsor tape recorders, was known as the Magnetic Recording Company.

H. Sellers, formerly sales manager of Marconi Instruments, recently joined Livingston Laboratories as commercial manager.

OBITUARY

S. B. Smith, who retired in 1956 after 44 years' service with Marconi's W.T. Company, has died at the age of 66. After a few years in the company's test department he joined the research department in 1919 and later took a leading part in designing the first Adcock direction finder to be produced commercially. He was also concerned with the development of facsimile equipment. At the time of his retirement Mr. Smith was chief of the company's patents department.

News from the Industry

Associated Transistors, Ltd., is the name of a new company formed jointly by the Automatic Telephone and Electric Co., the English Electric Co., and Ericsson Telephones, for the development and manufacture of transistors and other semi-conductor devices. The company, for which a factory is being built at Ruislip, Middx, will be primarily concerned with the production of switching transistors for telecommunications, but will also manufacture semi-conductor devices of more general application.

Plessey-Brayhead Agreement.—The Plessey Co., Ltd., and Brayhead (Ascot), Ltd., have entered into a joint development and manufacturing agreement covering television tuners and f.m. permeability tuners. The first Plessey-Brayhead products to be marketed under the new arrangement will be the Brayhead BT16 tuner, now to be known as the P-B 1, and the new Plessey f.m. permeability tuner, to be known as the P-B 2. These products will be sold in the United Kingdom by both companies and throughout the rest of the world by Plessey International, Ltd.

John Brennan, Ltd., of Crail, Fife, have entered into an agreement with Griffiths Electronics Inc. and Electronic Industries, Inc., of New Jersey, U.S.A., to produce, initially from imported parts, the Griffiths Golden Grid cathode-ray tube gun for marketing in Great Britain, on the Continent and in the entire sterling area. The guns will be available to tube manufacturers and rebuilders and will also be used in the company's Truvu tube.

A.T. & E.—In his annual report, Sir Thomas Eades, chairman of the Automatic Telephone & Electric Company, stated that the company's output for 1957 was a record and that the group profit increased by £187,824 to £1,981,905. He announced that in December A.T. & E. jointly with Siemens Edison Swan entered into an agreement with the South African Posts and Telegraph Department for the supply of telecommunications equipment over the next 10 years. Among the subsidiary companies mentioned in the report are Hivac, whose turnover is now nearly five times that of the immediate post-war years, and A.T. & E. (Bridgnorth), whose turnover for 1957 increased by 50 per cent compared with 1956.

T.C.C.—In his report for 1957 the chairman of the Telegraph Condenser Co. announced that the group trading profit of £424,301 was a decrease of £35,725 on the previous year, but the major part of this was accounted for by the acquisition of a majority interest in a Canadian company. Since the end of the year T.C.C. have acquired the entire share capital of United Insulator Co., Ltd., the well-known ceramic manufacturers.

Murphy Group net profit for 1957 of £226,829 was some £30,000 more than in 1956.

Telcon Group profit for 1957 (before taxation) was £626,274, an increase of 26% on the previous year.

A New Instrument Company.—Research & Control Instruments, Ltd., of Instrument House, 207, King's Cross Road, London, W.C.1 (Tel.: Terminus 8444), have become the sole distributors in the United Kingdom for the electronic instruments and scientific equipment hitherto marketed by Philips Electrical, Ltd. The company, whose service department and stores are at 49, Temperley Road, Balham, London, S.W.12 (Tel.: Battersea 9166), have also been appointed sole distributors responsible for the sale and servicing in the U.K. of Mullard electronic measuring instruments and electro-chemical apparatus. Research & Control Instruments are also handling electronic instruments made by Elektro-Spezial A.G., of Hamburg, X-ray diffraction and spectrographic equipment of Norelco (U.S.A.) and X-ray equipment manufactured by C. H. F. Müller A.G., of Hamburg.

Kerry's (Ultrasonics), Ltd., of Warton Road, Stratford, London, E.15 (Tel.: Maryland 6611), have been appointed sole U.K. distributors for Mullard low-power ultrasonic tinning, cleaning and machining equipment.

Commercial Stereo Discs.—First release of stereophonic records by the Pye Group are scheduled for sale in June. They will include popular and "classical" items and will be recorded to the 45/45 characteristics which have been agreed upon by the leading record manufacturers. A range of suitable reproducing equipment has been developed by both Pye and Pamphonic, and will be available at the same time.

Atomic Instrumentation.—The joint services of Ekco Electronics, Ltd. (Southend-on-Sea) and George Kent, Ltd. (Luton) are offered for the engineering and manufacture of overall instrumentation schemes for both power and research reactors. Kents have produced the physical instrumentation for various reactors and Ekco the nucleonic control instruments and associated circuitry.

Mullard have set up a semiconductor division with G. A. Gilbert as head. Within the division there is a commercial department, of which P. A. L. Harris is manager and a technical department with G. D. Grimsdell as manager.

Remington Rand, Ltd., have renamed their electronics division the Univac Computer Division, and it has been transferred to 26, Kensington High Street, London, W.8 (Tel.: Western 8241). The division is part of the Business Services Division of which C. W. Elliott is now national sales manager. R. H. Williams is manager of the Univac Division.

Wirepots, Ltd., of New Road, Rainham, Essex (Tel.: Rainham 4143), announce that Richard H. Cramp, previously with Colvern, has joined them as joint managing director with Cyril May. The company, which was originally the North View Engineering Co., is concentrating on the manufacture of wire-wound potentiometers.

U.S.A. Visit.—Alfred Rose, managing director of Direct TV Windings, Ltd., and Direct TV Replacements, Ltd., is to visit the U.S.A. in June. He will be negotiating for the production in this country, under licence, of American television components and test equipment.

Perth Radios, Ltd., of Marten House, 39-47, East Road, London, N.1, have been appointed sole U.K. representatives for the Saja tape recorder made in Western Germany. It will be marketed under the joint Perth-Saja trade mark. The company recently appointed Baker Duthie and Co., of 131, West Regent Street, Glasgow, C.2, as their agents for Scotland and Northern Ireland.

Mullard inform us that they received orders for ultrasonic equipment to the value of £70,000 during the I.E.A. exhibition.

Southern Instruments, Ltd., of Camberley, Surrey, announce that Philip Sellars, who is managing director of a number of industrial concerns, has joined the board of directors as vice-chairman. It is also announced that the company is erecting a new laboratory wing, which will increase the floor space to about 70,000 sq ft.

Nu-Life Teletubes, whose reconditioning work on cathode-ray tubes was described in our May issue (page 247), are having a new factory built at South Ruislip, Middlesex, to cope with increased demands for their services.

Metal Blanks, Ltd., of Tudor Grove, London, E.9 (Tel.: Amherst 8484), the recently formed associates of Gate Electronics of the same address, have facilities for producing printed circuits in large or small quantities.

Gillone Electric, Ltd., component manufacturers, whose factory at Camberley, Surrey, was recently severely damaged by fire, are now back in production. The rebuilding of the factory is well under way and they are going ahead with their plans to build another factory giving an additional 15,000 square feet of floor space.

Welwyn Electrical Laboratories announce that their "V" series of vitreous-enamelled wire-wound resistors have been granted full type approval by the Radio Components Standardization Committee.

An American associate company, G. V. Planer, Inc., has been formed in New York by G. V. Planer, Ltd., of Windmill Road, Sunbury-on-Thames, Middlesex.

Henley's engineering sales department has moved from the company's head office in Hatton Garden to 59-62, High Holborn, London, W.C.1.

EXPORTS

First quarter's exports of British radio equipment of all kinds are estimated to be higher than in any previous quarter. The provisional total announced by the Radio Industry Council is nearly £11.5M, which is about £650,000 more than for the same period last year. The most marked increase was in the export of sound-reproducing equipment, which rose to over £3M.

British component manufacturers are planning to hold an exhibition in Stockholm from September 29th to October 3rd. It is the third Swedish exhibition organized by the Radio and Electronic Component Manufacturers' Federation, the previous two being in 1948 and 1953.

Canada.—An eleven-man delegation from the Dollar Exports Council, headed by Sir William Rootes, has been visiting Canada during the past month. In Canada the Council maintains British Trade Centres in Toronto, Montreal and Vancouver, which are managed for the Council by the Canadian Association of British Manufacturers and Agencies, whose directory ("CABMA Register") is issued jointly by our Publishers and Kelly's Directories.

Servo Test Equipment.—An order worth $121,000 for transfer function analysers for guided missile work has been received from the U.S.A. by the Solartron Electronic Group through its American distributing company Solartron Inc., of Los Angeles, California.

Doppler Navigator.—A Viking aircraft equipped with a Marconi civil Doppler navigator has carried out an extensive demonstration tour of Western Europe.

Sound reproducing equipment for Prince Rainier's new home on the outskirts of Monte Carlo has been installed by Pamphonic Reproducers. The installation includes a.m./f.m. receiver and amplifiers and loudspeakers are fitted in every major room and line source speakers are installed in the garden.

Radio-Telephone Equipment.—A repeat order from the New Zealand Post Office for the supply of multi-channel v.h.f. radio-telephone links has been placed with Marconi's by their agents Amalgamated Wireless (Australasia) Ltd. The order, valued at approximately £90,000, is for terminal equipment, repeaters, aerials and test equipment for four radio links each providing up to 48 telephone channels. All the radio equipment will be in duplicate, the standby gear being automaticaly switched into service should there be a failure. Marconi's are providing similar equipment for a link between Kingston and Montego Bay, Jamaica, for which the channelling equipment is being supplied by the Automatic Telephone and Electric Co.

Radar.—A complete mobile radar installation (Type CR21) has been ordered from Cossor by the Federal German Ministry of Defence.

Switzerland.—The market for industrial electronic equipment was explored by Dr. J. C. Simmonds, managing director of Airmec, Ltd., during a recent visit to Switzerland. He met representatives of the machine tool industry in Zurich and American industrialists in Basle to consider licensing arrangements.

Nigeria.—Ekiti (Anjuwon) Universal Trading Stores, 5a, Strachan Street, Ebute Metta, Nigeria, are interested in receiving catalogues and price lists from U.K. manufacturers of tropicalized domestic short-wave receivers, amplifiers, tape recorders and loudspeakers.

British East Africa.—A survey of the market for domestic receiving equipment in British East Africa, prepared by the U.K. Trade Commissioner in Nairobi, shows that whereas in 1955 the U.K. provided 34% of the imports of sound receivers and radiogramophones the figure for 1956 was 31% and during the first six months of last year it dropped to 30%. During the same period Western Germany supplied 35%, 35% and 31% respectively and the Netherlands 28%, 31% and 33%.

Measuring Instruments.—Wayne Kerr Laboratories, of Chessington, Surrey, will be demonstrating their universal bridge, Type B221, and its various chemical adaptors, showing the application of the Wayne Kerr three-terminal bridge technique applied to chemical measurements, at the ACHEMA Chemical Engineering Exhibition in Frankfurt, Germany, from May 31st to June 8th.

Instruments and equipment from a number of British manufacturers will be exhibited at the International Electronics and Atomic Energy Exhibition in Rome (June 16th to 30th), by Conway Dolman, of Via Sicilia 235, Rome. The company represents among others Plessey, Rank Cintel, Airmec, Furzehill, Nagard, Southern Instruments, Allied Electronics, Wayne Kerr, J. Langham Thompson, Winston Electronics and Emeco Electronics.

Poland.—For the third successive year Kelvin Hughes are exhibiting at the Poznan International Fair (June 8th-22nd). They will be showing marine equipment, industrial instruments and components.

A television link, using travelling-wave tubes both at the terminal stations and at the repeater stations, is to be supplied by Marconi's for the Yugoslav broadcasting authorities. It will link Belgrade and Ljubljana (a distance of some 350 miles). Provision will be made at Sljeme, near Zagreb, for the insertion of programme matter, which could be relayed to Belgrade and Ljubljana simultaneously or to either city.

Electronic equipment, including spectrum analysers and stabilized decade oscillators, worth £70,000, has been ordered by an Italian organization from Winston Electronics, of Shepperton, Middlesex.

Metal Cabinets.—A. G. Imhof, managing director of Alfred Imhof, Ltd., is touring the U.S.A. and Canada investigating the market for Imlok, the interlocking system of metal cabinet construction.

Italy.—Melchioni S.p.A., Via Friuli 16/18, Milan, are interested in securing the representation for Italy of United Kingdom manufacturers of sound and television components and accessories.

Switzerland.—Sorensen Ard A. G., Eichstrasse 29, Zurich 3/45, are interested in representing a U.K. manufacturer of semi-conductors.

Swiss Importers.—Willy Egli and Co., of Zurich, who are agents for a number of British companies, including Tannoy, T.C.C., Rola-Celestion, Ekco and Multicore, have changed their name to Egli, Fischer and Co. Their address is Gotthardstrasse 6, Zurich.

Components Exhibition

NEW DESIGNS AND METHODS SEEN AT THIS YEAR'S R.E.C.M.F. SHOW

THE exhibition was again held at Grosvenor House and Park Lane House, London, W.1 (from 14th to 18th April) and was no less congested than on previous occasions. Foreign representatives from 29 countries attended as well as the regular battalions of British designers, engineers and technicians from Government departments and industrial firms.

In the report which follows we deal with some of the new products which interested us and which we think will interest those who were unable to be at the exhibition.

Resistors:—Most manufacturers are now supplying their potentiometers with "spikes" and brackets for printed circuit applications. The Painton "Flatpot," which is designed also for easy stacking, is a minute ($1\frac{1}{4}$in × $\frac{5}{16}$in × $\frac{7}{32}$in overall) preset wire-wound potentiometer with a range of values between 10Ω and 10kΩ. A lead screw, provided with a screwdriver slot, carries the slider along the wire-wound rod and disengages the drive at the end of travel. Two other Painton developments are a new low noise self-cleaning brush gear for professional faders for which a 900:1 reduction in maintenance is claimed, and a potentiometer with an accuracy of linearity of 0·1 per cent without using a cam-corrected wiper. This accuracy is obtained by "potting" all of the winding except the contact surface.

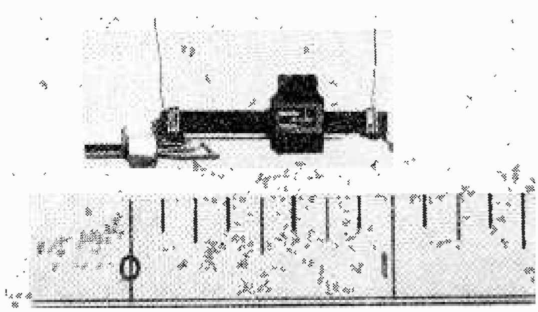
Ardente were exhibiting two new miniature potentiometers as well as the now well-known "hearing-aid" type. One is virtually a scaled-down version of the ordinary volume control and the other is possibly the smallest sliding contact potentiometer with on-off switch at present available in a wide range of values. Known as the Type VC1226 it is only $1\frac{3}{32}$in long overall and it weighs only 0.02oz. The resistance range covers values from 5kΩ to 3MΩ; with a normal tolerance of ±30%. The switch contacts are sub-miniature versions of relay contacts and operate with a wiping action, being actuated by a cam on the wiper carriage. The insulation resistance between the potentiometer and the switch in the "on" position is 100MΩ at 100V d.c.

The edge control potentiometer seems to be a popular solution to the mounting problems caused by the multiplicity of preset and main controls on the modern television receiver. Egen, for instance, group twelve of their Type 293 controls mounted in a panel space 7in × $1\frac{1}{2}$in. Another preset potentiometer by Egen, available in carbon or wire-wound versions, has a replaceable track to reduce costs and ease servicing problems; however, this is of a more conventional form. A.B. Metal Products also had edge control potentiometers on view, and a concentric preset type.

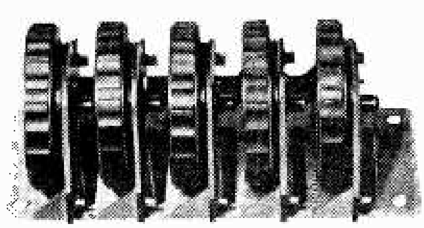
Morganite are producing ganged volume controls, matched for stereophonic use. The matching process employed involves balancing on voltage measurements and the potentiometer is claimed to give outputs within $1\frac{1}{2}$dB of each other.

Ordinary fixed resistor developments are, in the main, confined to extensions of ranges (Dubilier, for instance, now produce their Grade 2 range in values between 10Ω and 22MΩ), and modifications for printed circuit use. The conventional wire-ended resistor has several disadvantages when employed on a printed circuit board, including the difficulty of ensuring correct operation of bandolier feed assembly equipment and fire risk due to the body of the resistor being in close contact with the board. Erie have introduced a new range of resistors with rigid metal tags at right-angles to the main axis of the body, so making insertion less difficult. "Shoulders" on the tags, which are shaped to retain the resistor in position for dip soldering, prevent the element itself contacting the panel, thus reducing the fire risk.

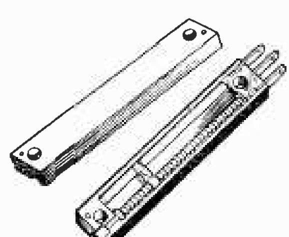
Special-purpose resistors were prominent at the exhibition. Metallic film and oxide film resistors were shown by, among other manufacturers, Plessey and Welwyn. The Plessey "Metallux" resistor consists of a nickel-chromium alloy film on a cylindrical ceramic former. The self-inductance is very low, and noise levels compare favourably with wire-wound components. Possibly the most interesting feature of these resistors is that, under pulse conditions with a suitable duty cycle, large overloads can be tolerated. The Welwyn resistor has the oxide film coated on to a ceramic body with silvered end-contacts. Another pointer from Welwyn is that it is possible to obtain greater stability over a wider range



Ardente sub-miniature sliding-contact potentiometer with switch. (Scale in inches.)



A.B. Metal Products edge control potentiometer assembly.



Painton "Flatpot" miniature wire-wound potentiometer (actual size).

of values than with the previous pan-climatic coating by using Melinex to coat the ordinary high stability resistor.

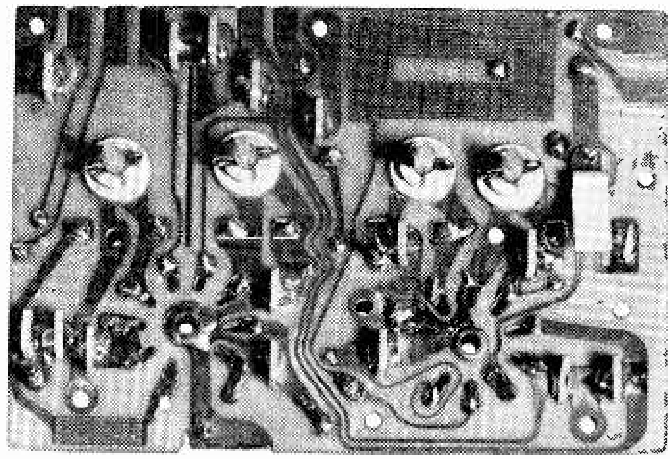
Morganite exhibited "Morganohm" non-linear resistors made from silicon carbide and clay. These ranged from G.P.O.-approved types, similar in appearance to a ceramic disc capacitor, for protection of low voltage switch and relay contacts to large ½in thick discs designed to fit into 15-A power sockets in lightning-prone areas, and long "pencil" types for TV e.h.t. stabilization. The laws vary between $I \propto V^4$ for a small disc type unit up to $I \propto V^9$ for a 21-kV e.h.t. stabilizer.

Manufacturers*: A.B. Metal Products (W, F, V); Ardente (V); British Electric Resistance Co. (W, V); Bulgin (W, V); Colvern (V); Dubilier (C, HS, W, V); Egen (V); Electronic Components (W); Electrothermal (C, HS, W, F); Erie (H, S, W); Morganite (C, V); N.S.F. (V); Painton (HS, W, V); Plessey (W, V); Reliance (V); Salford (W); Technograph (F); Welwyn (C, HS, W); Zenith (W, V).
***Abbreviations:** C, composition; HS, high stability; W, wire-wound; V, variable (wire-wound or composition); F, flexible.

Capacitors:—Although most manufacturers have produced small tuning capacitors for transistor receivers probably the smallest on show was the Type C.V.1 on the Ardente stand. This twin-gang capacitor is only about 1in × 1in × 0.6in overall, yet it provides a maximum capacitance of 250pF approximately. Tracking is accomplished by shaping the vanes appropriately and the overall law is designed to widen the tuning over the band occupied by B.B.C. medium-wave stations. The interplate insulation—this is a solid-dielectric capacitor—is p.t.f.e. or polystyrene. Ball bearings are used and the capacitor is mounted in a dust-proof cover.

Jackson Brothers were exhibiting a miniature three-gang capacitor of more conventional construction, which incorporates an epicyclic slow-motion drive. Capacities on this item are r.f. and aerial, 208pF; oscillator, 176pF. It is only slightly larger than their "OO" ganged capacitor.

Whilst in principle not new, a tuning capacitor incorporating a double-pole switch (Plessey) should be mentioned. This two-gang capacitor has a pair of contacts mounted so that, when fully open, the rotor short circuits these to earth. Plessey suggest that this component may be used to switch in preset tuning for the long-wave Light Programme, avoiding the extra complication, size, weight, losses and expense associated with a separate wave-change switch and coils.



"Chassis" of Cyldon printed circuit TV tuner.

The London Electrical Manufacturing Company's ceramic trimmer for printed wiring consists of a small ceramic tube carrying tags for vertical or horizontal mounting. Part of the exterior of the tube is silvered and forms one "plate," the other being an 8 B.A. brass screw, passing into the centre of the tube. The ceramic material can be chosen to give a compensating temperature coefficient and the trimmer is available in capacities up to 10pF. Mullard announce that they have adapted their popular "beehive" trimmer for printed circuit use.

In the realm of fixed capacitors evidence of development was rather sparse but where it had taken place the results were startling. For instance L.E.M. have produced extremely small 50V-working silvered mica capacitors for transistor applications (Type SM701). Values between 10pF and 500pF are only seven millimetres long and one millimetre in diameter.

It might be thought that glass capacitors are the beginning of a regression to the days of teak and brass terminals. This is not so; L.E.M. have also produced a range of capacitors encapsulated in glass for high ambient temperature applications. They are claimed to perform satisfactorily at 250°C.

A. H. Hunt were exhibiting a range of electrolytic capacitors of values from 75μF at 3V to 0.25μF at 25V in two sizes $\frac{11}{16}$in × ⅛in and $\frac{11}{16}$in × $\frac{3}{16}$in using plain or etched foil. They also had on show double (i.e. $10^3 + 10^3$pF) ceramic discs and "wedge" ceramic decoupling units. These latter were also shown by L.E.M. who have developed a finish for ceramic disc capacitors which acts as a flux—instead of the more usual deterrent action of the coating—for soldering!

Other modifications of existing types were shown by Suflex. These included the use of a Neoprene disc on the wires of single-ended capacitors to keep the wire spacing constant and tinned bronze wire terminations on physically small capacitors. Both modifications ease considerably the insertion by automatic methods of these components into a printed wiring board.

A 0.25μF spark discharge capacitor with self inductance of only 0.1μH was shown by Wego, who were also exhibiting a 50μF 75V capacitor only 3in × 3in × 1½in with an insulation resistance better than 200MΩ. This used Melinex film as a dielectric.

The T.C.C. stand featured the "Superlytic" high quality low leakage electrolytic capacitors which are now in full production. Another T.C.C. capacitor of note is the small metallized polystyrene type. The excellent electrical characteristics of this form of construction renders it ideal for use at r.f. in tuned filters, etc.

Manufacturers*: B.I.C.C. (H, P); Sidney Bird (T); Bulgin (T); Daly (E); Dubilier (C, E, F, H, M, P, T); Erie (C, F, H, T, V); Hunt (C, E, F, H, M, P); Jackson (T, V); L.E.M (C. H, M, P); Mullard (T, V); Mycalex (M); Plessey (A, C, E, F, P, T, V); Stability Capacitors (C, M); Static Condenser (P); Stratton (V); S.T.C. (E, H, M, P); Suflex (F); T.C.C. (A, C, E, F, H, M, P, T); T.M.C. (A, C, F, H, M, P); Walter (T); Wego (F, H, M, P); Welwyn (C); Wingrove and Rogers (T, V).
***Abbreviations:** A, air dielectric; C, ceramic or glass; E, electrolytic; F, plastic film (polystyrene, etc.); H, high voltage; M, mica; P, paper, T, trimmer; V, variable (tuning, etc.).

Coils and Transformers:—The latest i.f. transformers produced by Weymouth are notable for their extremely small size (½in square by 1$\frac{5}{16}$in high). Available for i.fs. of 470kc/s, 1.6Mc/s and 10Mc/s, they have Q values (at 470kc/s) of nominally 100, and up to 150 can be obtained in special versions. The 470-kc/s types have bandwidths of 7.5kc/s at the −3dB points. A 38Mc/s ratio detector transformer for use in combined f.m. and t.v. receivers was shown by Sidney Bird (Cyldon). An a.m. suppression/ratio of 30dB in the centre of the band has been achieved.

Q values up to 105 at frequencies from 12 to 36Mc/s have been reached in a range of miniature r.f. coils wound on low-loss ceramic formers shown by Plessey.

A number of miniature components for computers were shown by Oliver Pell. These included toroidal chokes and transformers, C-core transformers, and relays (for punched card applications).

New ranges of transformers shown by Gresham include some especially designed for maximum heat conduction, a miniature range suitable for use with transistors, and another for high-quality audio amplifiers.

A new range of high-power audio output transformers, the P6000 series, was shown by Partridge. The power ratings are 100 watts at 35c/s or 60 watts at 25c/s for less than 1% total harmonic distortion.

Manufacturers: *A.f. and mains transformers and chokes:*—Richard Allan; Ardente, Associated Electronic Engineers; British Electric Resistance Co.; Electro Acoustic Industries; English Electric; Ferranti; Fortiphone; Goodmans; Gresham; Haddon; Hinchley; Oliver Pell; Parmeko; Partridge; Plessey; Power Controls; Reproducers and Amplifiers; Rola Celestion; Standard Telephones and Cables; Weymouth; Whiteley; Woden; Zenith. *I.f. and r.f. transformers and chokes:*—Plessey; Standard Telephones and Cables; Stratton; Weymouth; Wireless Telephone Co.

Television Components:—The provision of v.h.f. sound facilities on a television receiver does not add an appreciable amount to the cost because modifications to only two sections of the receiver—the tuner and sound detector—are required. Opinion seems to be divided on the best method of providing f.m. facilities in the tuner—for instance A.B. Metal Products have modified their "Fireball" tuner (announced at last year's show) to include three v.h.f. positions on the switch in addition to 14 TV channels (one u.h.f.). This method is also adopted by N.S.F. on their incremental-inductance tuner. The Plessey-Brayhead BT16 tuner provides a choice of this system or one f.m. switch position with continuous tuning over the f.m. band by the fine tuner.

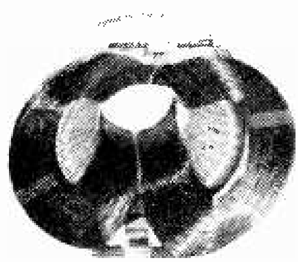
An interesting tuner development was shown by Sidney Bird (Cyldon). Their tuner uses a printed circuit, as distinct from printed wiring. The coil circuits too are printed and these have no pre-set tuning adjustments. The fine tuning control is a small metal plate which is bent towards a single turn printed on the main board, in series with the oscillator coil at the "hot" end. This provides both a capacitive and an eddy current effect. On a low frequency channel the major part of the control is capacitive, tending to reduce the oscillator frequency as the plate approaches the board, but as the frequency is raised the eddy current effect (raising the oscillator frequency) exerts an increasing influence. By balancing carefully the two effects the fine tuning range is constant at 2.5Mc/s on each channel. For the f.m. function the coil circuit is provided with a large oscillator coil stud which shorts out a small capacitor in series with the fine tuner, extending the range to 7Mc/s.

The broad outline of the circuit follows normal lines, but many small refinements are incorporated—i.e. "low noise" a.g.c. feed resistor; screen compensation of the mixer to improve Band III performance; eddy current-tuned i.f. output coil; new low-inductance valveholders; a special board material with good high-frequency characteristics and "wedge" decoupling capacitors, designed to be pressed into slots in the wiring board. The valves used (PCC84 and PCF84) were both specifically designed for a printed circuit layout.

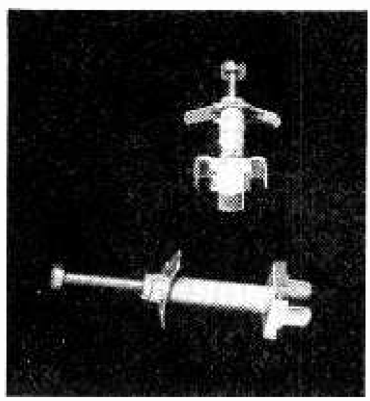
110° scanning coils made their appearance at this year's show. Elac were exhibiting a scanning yoke and Plessey were showing a complete set of components—yoke, line and frame output transformers. The Plessey line scan components require only 17W of h.t. power to give full scanning at 16kV e.h.t. and Elac claim less than 2% barrel and pincushion distortion for their yoke.

Manufacturers*: A.B. Metal Products (T); Sidney Bird (T); Brayhead Products (T); Ekco Plastics (M); Electro Acoustic Industries (D, F); Goodmans Industries (F); Long and Hambly (M); James Neill (F); Plessey (D, ST, F, W, T); Thermoplastics, Ltd. (M); Whiteley Electrical Radio (D, ST, F, W).

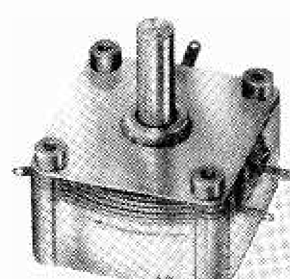
***Abbreviations:** D, deflection coils; F, focus, ion trap and picture shift magnets; M, masks; ST, scan transformers; T, tuners (v.h.f. heads); W, width and linearity controls.



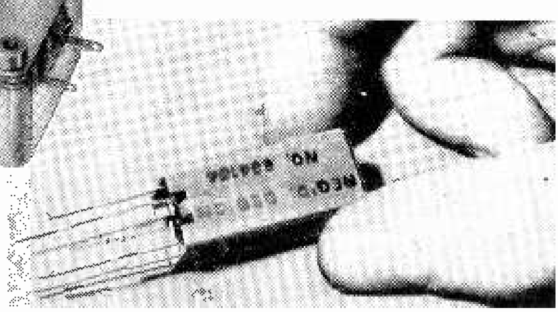
Plessey 110° scan-coil assembly. The frame coil is of the toroidal type and the two small bar magnets above and below the coils correct for pincushion distortion.



London Electrical Manufacturing Company's ceramic miniature trimmers for printed circuit use (about actual size).



Above: Ardente sub-miniature two-gang tuning capacitor (actual size.)



Weymouth miniature i.f. transformer.

Aerials and Accessories.—J-Beam were showing (from their Sky-Beam division) a set of aerials for use in the 460 to 480Mc/s mobile communications band, including end-fed dipoles for main and mobile stations and a double stacked slot directional array with a claimed gain of 14.5dB over a reference dipole. This is designed for sector coverage i.e., "looking" up a valley, or along an inhabited strip of coastline.

Television aerials, as at last year's exhibition, seem to be static as far as electrical design is concerned. Wolsey have adopted a wing-nut element clamp which enables them to supply their aerials in a pre-assembled but "collapsed" state. Antiference were showing a new loft aerial for Bands I and III. This consists of a low frequency "V" dipole with telescopic elements and a Band III Yagi-type array. One of the "V" elements can be rotated, making possible the use of the combined aerial in locations where the B.B.C. and I.T.A. transmitters are not co-sited.

J-Beam—well known for their end-fed and skeleton slot aerials—are producing a new range of "conventional" types—one of these, the "Twinbeam" was on show. This is a Band I "H" with a Band III Yagi-type array attached which can be rotated, carrying the Band III reflector with it.

Among the new aerial accessories shown were the "Belling-Lee" range of diplexers and a triplexer all of which use printed circuit construction, the TV diplexers (including a waterproof type for outside use) passing Band II signals through the Band I section. One diplexer (L1360) combines or separates television and f.m. signals.

A cable-to-mast strap was shown by Permanoid. This is a tough Nylon strap, saw-toothed on the inside surface. One end carries a moulding to hold the cable and a slot through which the toothed section is passed, so locking the strap and cable to the mast.

Manufacturers*: Antiference (TA, AS); Belling and Lee (TS, AS, D); Egen (AS); J-Beam (TA, CA); K.L.G. Sparking Plugs (TA); Permanoid (Arrell) (TA, AS); Wolsey (TA, AS, D).
***Abbreviations:** TA, domestic aerials; CA, communications aerials; AS, accessories; D, distribution amplifiers and equipment.

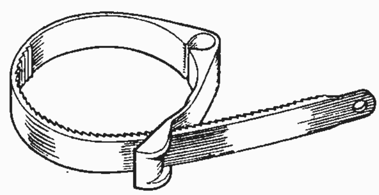
Switches.—Flexibility of switching arrangements is a feature of a miniature rotary switch by Ardente which measures only $\frac{3}{4}$in across. It is available with up to 4 banks and up to 6-way operation. The spacing between banks can be varied for ease of wiring, and screening plates can be fitted. Wave changing in receivers is one possible application.

The probable trend away from mains switches on volume controls (because of hum trouble) was reflected in a push-button mains switch for separate use displayed by Egen. Its operating stroke is $\frac{7}{16}$in and the shaft can be supplied in any length. Also intended for mains operation, a new N.S.F. rotary switch is basically a wafer type but with a special contact system for high currents up to 5 amps (or 10 amps at 30V d.c.). The rotor contacts are coil-spring loaded and have V-shaped ends. This firm has introduced a new type of locating mechanism for rotary switches which gives extremely positive action. It uses a fixed spring-loaded ball and a rotary corrugated plate. N.S.F. also showed an example of dual concentric spindles for rotary switches, making possible two independent switches in one assembly.

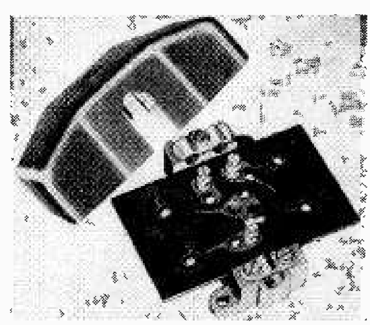
Key switches of unusual design by Henry and Thomas are notable for the low capacitance of less than 2·5pF between the gold-plated contacts (5pF between contacts and frame). Foolproof operation is obtained by providing two parallel paths for each circuit, and there is sealing (to 1·36 atmospheres) between the lever and the body.

Manufacturers*: A.B. Metal Products (K, T, P, R, SL); Ardente (R); B.E.R.C.O. (R, ST); Bulgin (K, T, M, P, R, SL, ST, TH); Diamond H (T, R); Egen (P, R); Henry and Thomas (K, T); Magnetic Devices (P); N.S.F. (K, T, P, R, SL); Painton (T, P, R, ST); Plessey (K, T, P, R, SL); Siemens Edison Swan (TH); S.T.C. (TH); T.M.C. (K, T); Walter (T, P, R, SL, ST); Whiteley (K, P, R, SL, ST).
***Abbreviations:** K, Key; T, lever or toggle; M, micro; P, push-button; R, rotary; SL, slide; ST, stud; TH, thermal delay.

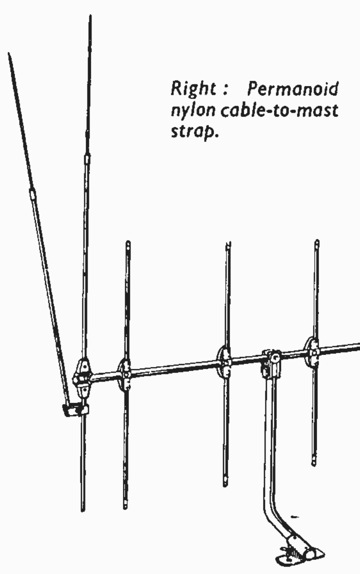
Relays.—High-speed operation and long-life are the main features of an unusual relay shown by Plessey in which the contacts consist of two magnetic reeds sealed inside a glass tube. The reeds are brought together by a solenoid, surrounding the glass tube, which applies a longitudinal magnetic field so that the two reed ends at the 0·005—0·01in contact gap become mutually attracting N and S poles. Several of the sealed tubes (which normally contain dry air but can be evacuated or filled with inert gas) can be inserted in a common operating coil. The "make" time is 0·8 millisecond and the release time better than 0·5 milli-



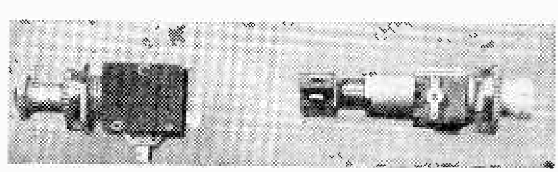
Right: Permanoid nylon cable-to-mast strap.



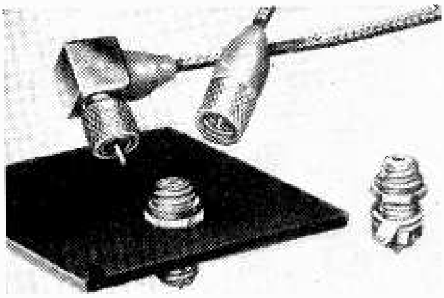
Right: "Belling-Lee" printed circuit TV/f.m. diplexer. The fixed tuning capacitors are concealed by the printed circuit board.



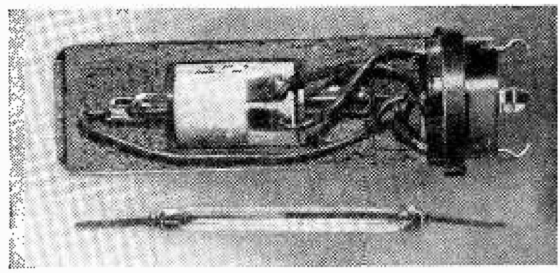
Left: Antiference HL523 band I/III loft aerial (f.m. elements can be fitted to this aerial).



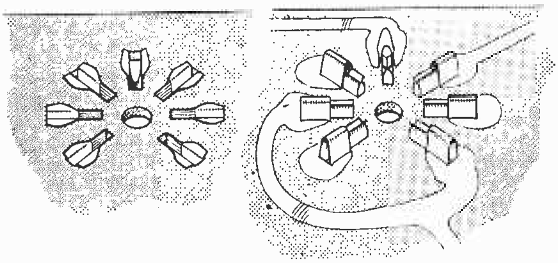
Bulgin switches incorporating signal lamps.



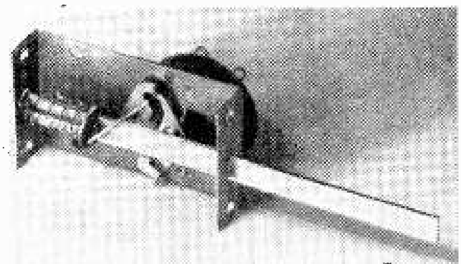
Belling and Lee miniature plugs and sockets.



Plessey sealed reed relay (with reed tube below).



Siemens Edison Swan printed-circuit valve sockets.



Egen push-button mains switch.

second. The normal "make" action can be changed to a "break" action by means of a biasing permanent magnet, while changeover actions can be achieved from pairs of reed tubes suitably biased and simultaneously energized.

Manufacturers: Diamond H; Electro Methods; Magnetic Devices; N.S.F.; Oliver Pell; Plessey, S.T.C.; Thorn, T.M.C.

Chassis Fittings.—Valveholders for printed circuits can now be dispensed with altogether as a result of a new development by Siemens Edison Swan. This is a valve-pin socket which locks directly into a hole cut in the printed circuit board (see sketch). It can be dip-soldered without affecting the contact area of the socket, and mechanical strain imposed by valve insertion and withdrawal is confined to the locked portion and not transferred to the soldered joint. The socket, which is made of beryllium copper alloy and silver-plated, can be used in other configurations besides valveholders—wherever it is necessary to insert small pins, plugs or component wire ends, in fact.

Another recently introduced connecting device was a subminiature coaxial plug and socket shown by Belling and Lee. The plug is less than ¼in in diameter and is suitable for 50-Ω subminiature coaxial cable. It is retained in position by a knurled nut which screws on to the socket in the printed-circuit board. P.T.F.E. insulation is used and all contact surfaces (which are naturally small) are gold-plated for low-resistance connection.

Widney Dorlec have greatly simplified their prefabricated cabinet design by a system in which the 12 screws originally required for each corner assembly are replaced by 3 bolts. The heads of the bolts are held in channels now incorporated in the main frame sections, and these channels also serve as a convenient means of attaching internal fittings like brackets and hinges.

Holders for two of the latest "glassware" bases were noted. Siemens Edison Swan had a B8F valveholder for transmitting valves, with air spacing to permit forced air cooling of the valve envelope and an incorporated by-pass capacitor between screen grid and earth. McMurdo were showing a B8H holder for the new 110° television c.r. tubes. This is like an octal base but with a somewhat larger spigot hole.

Combined switches and signal lamps were seen on the Bulgin stand—the lamps being incorporated in the press buttons. One type has a push-pull action. Another is actually an operating mechanism and lamp which can be coupled to existing Bulgin switches, and is available for either momentary contact or locking action.

Stratton were showing a new Eddystone tuning capacitor drive and dial assembly which is notable for its smooth action. It has a 110:1 reduction drive using double anti-backlash gears, operating a 500-division logging scale and blank scales for user calibration. The dial measures about 7in × 3in.

Manufacturers*: Antiference (CPS); Bakelite (P); Belling and Lee (CPS, T, F, J, V); B.E.R.C.O. (DL, K); Brayhead (EFC); Bulgin (V, EFC, CPS, DL, ES, T, F, J, K); Carr Fastener (EFC, CPS, T, F, V); H. Clarke (T); Colvern (RPS); Cosmocord (K); Creators (EFC, G, T); Egen (CPS); Electro Methods (CPS, T); Electronic Components (CPS, DL); Fortiphone (CPS); Goodmans (CR); Hallam, Sleigh and Cheston (CR); Harwin (EFC, CPS, T); Hasset and Harper (CR, EFC, ES); Hellermann (EFC, G, T, K); Imhof (CR); Insulating Components (DL, P, T, V); Jackson (DL, DR); K.L.G. (T); Long and Hambly (G); Lustraphone (EFC); McMurdo (V, CPS); Mica and Micanite (EFC, T, V); Morganite (CPS); Mullard (CR); N.S.F. (CPS); Painton (CPS, DL, T, K); Permanoid (CPS); Plessey (CR, CPS, DR, T, P, F, K, V); Power Controls (CPS, T); Salter (EFC); Siemens Edison Swan (CPS, T, V); Simmonds (EFC); Spear (EFC, CPS); Standard Insulator (EFC, G); Stocko (EFC, T); Stratton (CR, CPS, DL, DR, K); Suflex (ES); T.C.C. (P); Telcon (CPS); Thermo-Plastics (CR, DL, ES, T); Thorn (P); T.M.C. (J); Tucker (EFC, G); Tufnol (T); Walter (P); Weymouth (DL, T, K); Whiteley (CR, CPS, T, K, V); Wimbledon (CR, EFC, DL, ES); Wingrove and Rogers (DR, T); Wolsey (CPS).

***Abbreviations:** CPS, connectors, plugs and sockets; CR, cabinets, racks and chassis; DL, dials; DR, drives; EFC, eyelets, fasteners and clips; ES, escutcheons; F, fuseholders; G, grommets; J, jacks; K, knobs; P, printed circuits; T, terminals and tagboards; V, valveholders.

Glassware.—An interesting numerical indicator tube of the glow-discharge type made by S.T.C. has 10 wire cathodes shaped to form the numerals 0-9 and a common anode consisting of two wire meshes at top and bottom. Each cathode is brought out to a particular pin on the duodecal base, and a striking voltage

(200V) applied to the pin produces a glow discharge around the shaped wire inside the tube.

A range of corona voltage stabilizers made by the M-O Valve Company covers voltages from 350V to 2000V. These tubes are particularly suitable for high-voltage low-current supplies for Geiger counters, photomultipliers and cathode-ray devices. The stabilized voltage in most of the types is constant to within ±0.25% for ±10% changes in tube current at 250μA. Striking voltages are about 50V higher than operating voltages. M-O also displayed a new low-noise triode for v.h.f. operation, the VX3519. It has a noise factor of only 1.4dB at 45Mc/s.

Peak currents as high as 33 amps can be passed by a new radar transmitting diode shown by Siemens Edison Swan. Designed to work up to 25kV p.i.v., it features the unusual construction of twelve diode units, with their anodes commoned, arranged in a circle inside the envelope. This firm also had a new 14-inch rectangular c.r. tube, the CME1402, with 90° deflection angle and electrostatic focusing.

Manufacturers*: Cathodeon (Q); Ferranti (CC, IT, M, R, T); M-O (CC, IT, M, PC, R, T); Mullard (CC, IT, M, PC, R, T); Salford (Q); Siemens Edison Swan (CC, IT, PC, R, T); S.T.C. (CC, IT, M, Q, R, R).

***Abbreviations:** CC, cold cathode; IT, industrial and transmitting; M, microwave; PC, photocells; Q, quartz crystals; R, receiving; T, cathode-ray tubes.

Semiconductors. — Many new transistors made their appearance this year, and outstanding amongst them were silicon types capable of working at temperatures up to 150°C. Mullard had three p-n-p alloyed junction types. The OC200 a.f. transistor is similar to the well-known OC71 germanium type, with a typical current gain of 20. The OC201 h.f. type has a cut-off frequency of greater than 2Mc/s and a current gain of 30, while the OC202 has the high current gain of 50 and a cut-off frequency greater than 4Mc/s. All three are notable for their low bottoming point, permitting operation from voltages as small as 1.2V, and their low collector-base leakage current of only 10mμA.

Texas Instruments, exhibiting for the first time, displayed a whole range of n-p-n grown junction silicon transistors. Some of these were medium-power types (4 watts collector dissipation) suitable for audio or servo amplifiers. Higher power types will provide an output of 15 watts at 100°C in Class-B push-pull circuits, while a grown-diffused tetrode can be used in r.f. and i.f. amplifiers at frequencies up to 30Mc/s.

Silicon power rectifiers with diffused junctions are produced by both Texas and Ferranti. As an example of the capabilities of these devices, Ferranti showed an aircraft rectifier containing 36 of their ZR32 diodes arranged in a 6-phase half-wave circuit which delivers up to 1000 amps in a volume of only about 9in × 6in × 6in.

Amongst new germanium transistors Siemens Edison Swan and S.T.C. were showing symmetrical types intended for switching applications. In these the collector and emitter are interchangeable in function and have identical characteristics. S.T.C. also had a new range of audio and low-frequency transistors, while G.E.C. displayed some medium-power types (600mW dissipation) with cut-off frequencies of 750-950kc/s. Incidentally, the G.E.C. type GET6 is now outstanding for its very low noise factor of 3dB at 1kc/s. Last and definitely least—in size—are the Mullard OC57, OC58 and OC59 transistors. These are intended for hearing aids and measure only 0.16in long by 0.12in in diameter. They have current gains of 50, 70 and 100 respectively.

Manufacturers*: Ferranti (D); G.E.C. (D, TR); M-O (D, TR); Mullard (D, TR, TH); Newmarket (TR); Salford (D, MR); Siemens Edison Swan (D, TR); S.T.C. (D, MR, TR, TH); Texas (D, TR); Thorn (TR); Westinghouse (D, MR).

***Abbreviations:** D, diodes; MR, metal rectifiers; TH, thermistors; TR, transistors.

Materials:—Some interesting trends in new uses and improvements of existing materials were seen. For instance the Technograph stand featured developments in the many aspects of printed wiring and circuits. One of these was the roller coating of circuit plate with solder, prior to the insertion of components. This coating—only 5.10^{-4}in thick—helps to eliminate dry joints. Another item on this stand was a printed thermocouple panel on a Terylene sheet base. This can be placed in intimate contact with a surface under investigation, or stacked easily to make a thermopile. Parts of the new Avo Multi-minor were also shown. These use printed cupronickel shunts with small "trimming" bars which are cut, during calibration of the meter, to give the correct resistance.

Aero Research were showing a new hardener for use with Araldite "F" resin. This extends considerably the temperature at which the electrical and mechanical properties of the resin are retained, being satisfactory up to about 250°C.

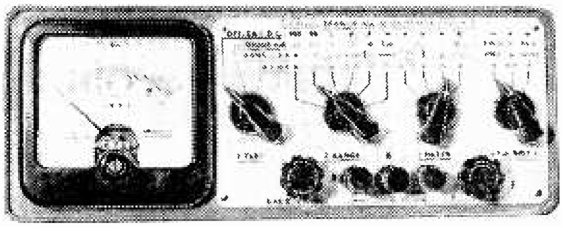
The base of the modern all-glass valve has to conform to rigid dimensional tolerances. Sintered glass preforms (Mansol (Great Britain), Ltd.) provide a means of satisfying these requirements. The glass is crushed to a fine powder, mixed with a binder and pressed to the shape required. After baking at a low temperature to set the binder the preform is strong enough to withstand normal handling. When the valve or assembly has been fitted to the base, the whole is fired at a temperature sufficient just to fuse the glass. Bases produced in this way have great dimensional accuracy and a high resistance to thermal shock.

The purity of a magnetic alloy is one of the factors limiting its performance. By melting the constituents in a vacuum contamination from atmospheric sources is prevented. A vacuum-melted alloy—Supermendur—was shown by the Telegraph Construction and Maintenance Company. Supermendur gives a μmax value about ten times that for Permendur, and it has the high Curie point of 880°C, making it useful as a magnetic alloy at temperatures up to about 800°C.

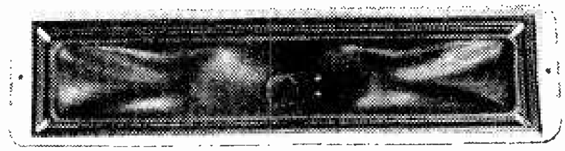
James Neill exhibited resin-bonded magnets. These use, as far as is possible, mass-produced, highly efficient cast magnets to which magnetically soft pole pieces are attached with an Araldite bonding resin, so overcoming the difficulties associated with producing and magnetizing complex shapes in the magnetic material itself. Shear strengths up to two tons/in² are claimed for this bonding process.

Swift, Levick have succeeded in producing large sections of Columax. They quoted the example of a magnet for nuclear resonance experiments; the system consisted of two sets of four quadrant segments of Columax forming magnetic discs 14in in diameter by 1½in thick. This magnet produces a field ten inches in diameter in a 1.38in gap with a uniformity of field better than one part in 10^5.

Manufacturers*: Aero Research (IM); Anglo American Vulcanized Fibre (IM); Bakelite (IM); Geo. Bray (CE); B. I. Callender's (C, S, W); Clarke (IM, IS, PC); Connollys (C, IM, W); Cosmocord (IM); Creators (IM); Darwins (M); Duratube (CW); Ekco (IM); Enanlon (IM); English Electric (L); Enthoven (S); Ferranti (F); Fine Wires (W); Formica (IM); Fortiphone (C); Hellermann (IM, PC, RP); Henley's (C, IM, W); Insulating Components and Materials (IM, PC); K.L.G. Sparking Plugs (IM); Langley London (IM); Linton and Hurst (L); Lion Electronic Developments (IM); London Electric Wire and Smiths (W); Long and



Levell transistor test set TM1 shown by Ardente.



Richard Allan $10\times2\frac{5}{8}$-in "slot" loudspeaker.

Hambly (IM, RP); Magnetic and Electrical Alloys (L, M); Mansol (IM); Marrison and Catherall (L, M); Mica and Micanite Supplies (IM); Micanite and Insulators (IM); Minnesota Mining (IM); Mullard (M, DC, F); Multicore (S); Murex (M, RM); Mycalex (IM); James Neill (M); Permanoid (C, IM, W); Plessey (IM, M, CE); Salford (DC, M); Scott (L); Shell Chemicals (IM); Siemens Edison Swan (IM); Sims (C, W); Standard Insulator (RP); S.T.C. (M); Steatite (CE), Suflex (IM, W); Swift, Levick (M); Symons (IM); T.C.C. (PC); Technical Ceramics (PE); Technograph (PC); Telcon (L); Telegraph Construction and Maintenance (C, DC, IM, L, M, RM, W); Telephone Mfg. (DC); Thermo-Plastics (IM); Tufnol (IM); Vactite (W); Wandleside (C, W); Whiteley (L, M, PC); Wiggin (RM).

***Abbreviations:** C, cables; CE, ceramics; DC, dust cores; F, ferrites; IM, insulating materials; L, core laminations and strip; M, magnets and magnetic alloys; PC, printed circuits; PE, piezo-electric ceramics; RM, refractory metals; RP, rubber parts; S, solder; W, bare or covered wires.

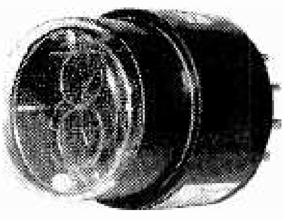
Audio Equipment:—Many items were also seen at the Audio Fair and are discussed in our report on that exhibition.

Remote control over a short distance can be carried out using sound generated at a frequency around 15 kc/s, and a small crystal microphone insert suitable for such work was shown by Cosmocord (the MIC41).

A fully tropicalized turnover moving iron cartridge with a high output was shown by Goldring. A version especially suitable for use with transistors will deliver 80μW into a 1,000Ω load. Another new turnover variable reluctance cartridge for manufacturers also shown by Goldring has a lateral compliance not less than 5×10^{-6} cm/dyne, the effective mass at the sapphire stylus tip being 2 mgm.

A v.h.f./f.m. "front-end" for set manufacturers shown by Plessey and Brayhead is designed around a single ECC85 or UCC85 double triode, one section being used as a neutralized r.f. amplifier and the other as a mixer-oscillator with i.f. feedback. The high overall gain of 58dB has been achieved.

For use with battery record players, a new motor shown by E.M.I. consumes 100mA from a 6 to 9V supply at the designed working torque of 4 gm-cm. 78 r.p.m. can be reached with a 12-in record in only 1 sec. A twin contact centrifugal governor is used.

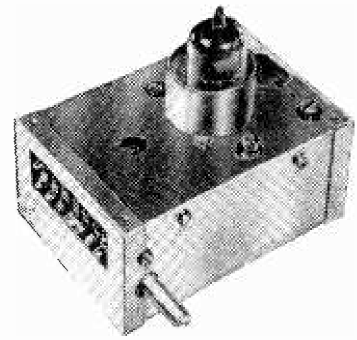


S.T.C. numerical indicator tube.

For maximum realism the best position for the loudspeaker in a television receiver is at the front, near the picture, particularly if someone is speaking. If the cabinet is not to be greatly enlarged this necessitates an elongated rectangular speaker shape. Cone break-up tends to occur at a lower frequency and with more unpleasant audible effects in such elongated speakers, and is often due to the stresses set up at the corners. In the Richard Allan $10\times2\frac{5}{8}$in "slot" rectangular speaker these stresses are relieved by holes cut in the cone at its corners. Cone break up is inhibited by the peculiar cross section adopted for the cone, which contains a number of shallow depressions and protuberances. Another way of inhibiting cone break up is to use a narrower apex angle than usual. This was exemplified in $8\times2\frac{3}{8}$in elliptical and rectangular speakers shown by Goodmans and Plessey respectively. Some space can also be saved by reducing the structure supporting the speaker cone to its absolute minimum, for example, at the cone edge. A new range of speakers in which this is done was shown by Goodmans.

A new $2\frac{1}{2}$in tweeter using a p.v.c. cone to smooth out the response through its self-damping was shown by E.M.I. An inner aluminium portion has been used in loudspeaker cones to inhibit break-up and extend the high-frequency response. In the E.M.I. standard range of elliptical speakers this portion extends as far as about one-third of the way to the edge.

Manufacturers: *Loudspeakers:*—Richard Allan; E.M.I.; Electro-Acoustic Industries; Goodmans; Plessey; Reslosound; Reproducers and Amplifiers; Rola Celestion; Truvox; Vitavox; Whiteley Electrical.
Magnetic Tape:—Minnesota Mining and Manufacturing Co.
Pickups and Microphones:—Ardente; Collaro; Cosmocord; Fortiphone; Garrard; Goldring; Lustraphone; Simon; Technical Ceramics; Vitavox; Walter; Whiteley Electrical.
Tape Recorders:—Collaro; Simon; Truvox; Walter.
Turntables:—Collaro; Garrard; Goldring.



Plessey-Brayhead v.h.f./f.m. "front end."

Test Equipment:—The compact p-n-p and n-p-n transistor tester (Type TM1) made by Levell Electronics, of Edgware, was shown on the Ardente stand as an example of the use of their miniature components. Transistor gains (at 1kc/s) and collector cut-off currents can be measured, and also diode forward resistances and reverse currents. Ranges for measuring a.c. voltage and current, d.c. voltage, and resistance are also provided. A simple "go/no-go" transistor gain and collector cut-off current tester was shown by Parmeko.

A portable television signal generator similar to their 405D but for 625 lines was shown by Waveforms. Simultaneous vision and f.m. sound signals with a constant carrier frequency difference of 5.5Mc/s may be obtained on Bands I or III or also over the i.f. band from 31.5 to 40Mc/s. Also shown by Waveforms was their model 302, a new portable oscilloscope similar to their 301 but with a frequency response extended down to d.c.

Manufacturers: British Physical Laboratories; Lion Electronic Developments; Measuring Instruments (Pullin); Siemens Edison Swan; Taylor; Victoria Instruments; Waveforms.

Transistor Miniature Tape Recorder

THE STUZZI MAGNETTE

SEVERAL electronic and mechanical features of interest are to be found in this Austrian tape recorder, which is being imported into this country. Taking the electronics first, a transformerless single-ended, push-pull output stage can give up to 350mW in the 32-Ω, 4-in internal loudspeaker; two OC308 transistors being used. When recording, these same two transistors provide the 40kc/s bias and erase supplies through a transformer feeding the record/replay head and the low-loss ferrite erase head. The bias is also rectified to produce the 60-V h.t. supply required for the DM71 level indicator.

The output varies by less than ±3dB from 80 to 9,000 or 4,000c/s at the alternative tape speeds of 3¾ or 1⅞in/sec respectively. The good contact between the tape and the record/replay head implied by this high frequency response is obtained without the use of a pressure pad.

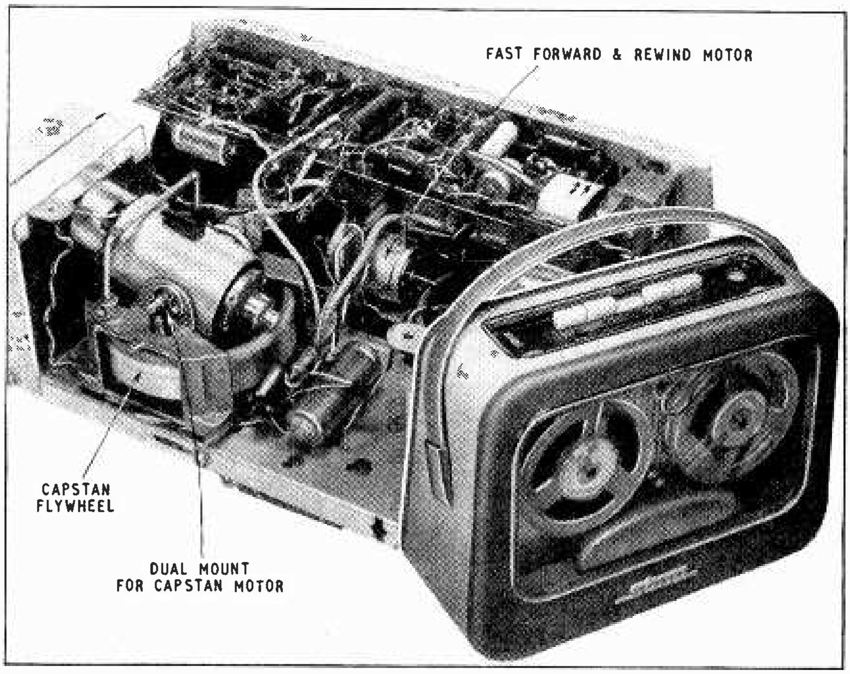
The capstan motor is pivoted by two trunnions located in either of two pairs of slots in the supporting base. The motor is shifted from one pair to the other by linkages attached to the speed change control. In this way, either of the two edges of the stepped diameter end of the rotating motor shaft are made to bear on the capstan flywheel rim. The capstan also drives the take-up reel by means of a spring belt which slips at the small diameter capstan drive shaft, thus giving the required tape tension. A revolution counter is driven from the supply reel.

The other end of the capstan motor shaft drives a contact switch centrifugal speed regulator. This intermittently joins the base and collector of an OC302 transistor, and thus shorts out a 100Ω resistor connected between the collector and emitter and in series with the 9V supply to the motor. In this way, the average voltage on the motor is kept at the required level of 5V and the speed remains constant to within 2% as the battery supply falls from 9 to 5V. The contact current is very low and long contact life is thus ensured.

Fast forward and rewind of 400ft of tape (up to 4-in diameter reels can be used) takes about two minutes using a separate motor. This is fed from the same 9V supply as the capstan motor. Two additional 4½V supplies in series are used for the amplifier and oscillator. Normal flashlamp batteries are suitable for all the supplies. Their life will generally be about 30 hours or more, so that the running costs are about a penny an hour or less.

An indication of when the amplifier and oscillator battery supply is running down is provided by the DM71 level indicator which will cease to glow when its h.t. supply becomes too low. An electromechanical indicator shows when the motor battery supply needs replacing. This consists of four white vanes (shaped like a cross) which rotate to indicate the current through the capstan motor. When this current is held correctly by the centrifugal regulator, these vanes show in a similarly cross-shaped viewing hole. If the battery voltage falls so far that the regulator is no longer able to hold the motor current to its correct value, these vanes will at first vibrate, and later rotate away from the viewing hole.

The dimensions of this recorder are only 11 × 8 × 4½-in and its weight is 7 lb (with batteries). It is imported into this country by Recording Devices, Ltd., 95, Villiers Road, London, N.W.2, and costs 69 guineas.



Interior of "Magnette" showing mechanical tape drive arrangements and (inset) the complete recorder.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents.

"Hi-Fi" and Stereophony

THERE seems to be a revival of interest in stereophonic sound and this brings back the memory of our first experiments in the subject in the 1920s.

Working in conjunction with the late Capt. A. G. D. West of the B.B.C. we fitted up one transmission from the Opera House, Covent Garden, for stereophonic work.

The two radiators were 2LO and Daventry. How many heard the result, aside from ourselves, I have no record, but to our own receiving arrangements it was fairly satisfactory.

Two microphones spaced a foot or so apart were fixed on the edge of the stage by the footlights at the Opera House and their output ran via two amplifying systems to the two transmitters.

It had previously been noted in earlier non-radiating tests with spaced microphones that, when receiving with two telephone earpieces, movement to the right or left was clearly defined but that in the main the sounds came from the back or the top of one's head.

I believe it was Mr. W. J. Picken who remarked to me on hearing someone walking across the microphone room that it sounded as though someone was walking over his grave.

When using two loudspeakers the effect vanished as the sounds were, of course, being put artificially in front of one.

However, a new effect was noted during the opera transmission. The microphones were, as I stated, placed by the footlights and they were between the stage and the orchestra. With a soprano singing on the stage and the orchestra accompanying her I noted at once that with telephone reception she seemed to be in front of me, but the orchestra sounded behind. Male voices, however, joined the orchestra, so that the effect was in some way due to frequency. West and I had many discussions as to the reasons for these curious effects.

Many obstacles of course are in the way of "hi-fi" and stereophonic sound for normal house use, particularly from radio transmissions. Rooms are not large enough and many wives and neighbours object to the volume of sound necessary for correct effects. The question of sound strength and correct quality was pretty thoroughly thrashed out many years ago—after Harvey Fletcher had published his monumental work on "Speech and Hearing" (Macmillan, 1929), and correcting devices for all strengths were worked out. But then, as now, quality and naturalness were the worry of only a very small percentage of the population.

Nearly everybody in those days, and very probably now, was content with the sound of his own loudspeaker (listen to some of those baby portables) and, however bad it really was, thought it better than his neighbour's.

I know that sometimes I was rather startled by the sort of sound that was acceptable to musical people.

On one occasion the late Mr. Percy Pitt, the then well-known operatic conductor, came over to my rooms in Marconi House to hear some rather lengthy musical piece being played at the Opera House.

At the time I had available only a very bad amplifier and loudspeaker, with the result that there was a lot of distortion.

Mr. Pitt opened his musical score and followed carefully the whole programme with a very satisfied air. Rather fearfully I apologised for the bad quality, to me it was a dreadful blasting effect, but all Mr. Pitt said was "Very excellent, couldn't be better." To him, apparently, as long as the notes were right and he could distinguish the instruments everything was satisfactory.

In many communications I had both by letter and personally with the late Edwin H. Armstrong I urged him to put programmes out stereophonically in his f.m. system, which was "hi-fi" to a great extent, and shortly before his unfortunate death he was starting to do this with his newly developed duplex f.m. system.

This would of course have both simplified transmission and reception—particularly the latter.

But I am rather afraid that radio stereophony with its duplication of most parts including land lines and radio links will not be generally acceptable to the powers.

The surprisingly commercial success of modern high quality gramophone records, however, does give a possible field with comparatively simple apparatus. The difficulty still remains however that until records are produced people will not buy the play-offs and until the play-offs are installed there will be no sale for the records.

It has, however, so often been wrongly said that something won't work or succeed, that I am now only looking at the difficulties and not trying to prophesy failure. The race must go on.

Southgate, London, N.14. H. J. ROUND.

Fixed or Free Stereophony

UNFORTUNATELY the enthusiasm shown by Mr. J. R. P. Bridge for "Free Grid's" binaural headphones is a little premature, since there is a fatal objection to the system.

When listening to music, one is constantly making small unconscious movements of the head, and the resulting changes in phase and intensity at the two ears are accepted as a natural corollary. Similar movements have very disconcerting consequences when wearing headphones, since the whole orchestra and concert hall appear to move also. This may seem a trivial objection, but even the most perfect binaural system soon becomes tiresomely unnatural as a result. A solution would be to sit with one's head in a clamp, but this rather limits the personal mobility which Mr. Bridge thinks desirable!

However, there is an answer, but only for those to whom *any* degree of complexity is justified in the search for perfection. A detection system is required which will register every movement of the listener's head relative to some fixed point in the listening room. This operates a servo-mechanism which continuously adjusts the intensity and time delay of the signals into each earphone in accordance with what would obtain in a free field, and the direction of the apparent sound source remains fixed as a result.

The cost and inconvenience of providing such a set-up for several persons at one time would be much greater than the installation of two conventional loudspeakers, so the present stereophonic compromise is perhaps best after all.

London, S.E.24. H. J. F. CRABBE.

Defining Electronics

THE May editorial draws attention to the problem of defining electronics.

Electronics seems to me to have three characteristics.

(1) It is a study of electric circuits.

(2) Although the inputs and outputs of the circuits may be responsive to, or feed into mechanical, optical, thermal or other physical apparatus the electronic aspect relates to the circuits themselves.

(3) The electric currents are considered primarily with regard to their information content. This is true of a public address system, of a radar installation, of data processing, of counting and measuring equipment and every other application. Efficiency is considered in terms of information lost and of false information (noise) introduced.

Electro-mechanical automatic telephone exchanges do not satisfy the second requirement: a simple telephone circuit has little circuit to study apart from the electro-mechanical devices of microphone and receiver. Valves and transistors, the most typical components of electronic equipment, often have energy-efficiencies lower than those acceptable in power engineering: but they enable information to be transferred and distributed without the introduction of too much noise.

Such a definition would remove from the subject the use of metal rectifiers for electric traction, and the use of valves for the conversion of a.c. to d.c. and *vice versa*, except in so far as they may be controlled by information such as the difference between the actual and the desired voltage output. Cannot these be made gifts to power engineering; just as the power engineer developed the transformer before the electronics engineer required it?

London, S.E.18. N. F. SHEPPARD.

Licence Reminders

UNDER the heading "Bureaucratic Bumbledom" "Free Grid" comments in your May issue on the "impertinent request" contained in the annual reminder for renewal of wireless licences. The wording on reminders sent out before April was not, perhaps, in the happiest terms and the phrasing of the request is one of thousands of forms used in the Post Office which have been under consideration over the past year.

I think that "Free Grid" will agree that the rephrasing now in use is an improvement. It says "To save our bothering you again with reminders, please give the reason below IF YOU ARE NOT RENEWING YOUR LICENCE. Then kindly re-address this card as overleaf and repost it. You don't need a stamp."

Your correspondent wonders why the Postmaster General wants to know the reason for non-renewal. If we printed these reasons on the reminder, as he says, few would read them, so the reminder would become bigger in size, and more costly to print for little purpose.

In brief the reasons are that the Postmaster General has an obligation to see that people do not use wireless sets without licences and, indeed, if a check was not made an unfair hardship would rest on those of us who pay our way. If this check was not made, in part, by answers received from reminder cards a tremendous number of personal enquiries would be necessary, with consequent waste of time and money. When we know that people are no longer using sets we can delete their names from our records and we can also help those who, acting under a misunderstanding, have made themselves liable in law.

London, E.C.1. T. A. O'BRIEN,
Public Relations Officer,
General Post Office.

CLUB NEWS

Barnet.—The inaugural meeting of the Barnet and District Radio Club was held on March 25th. Meetings are to be held on the last Tuesday of each month at the headquarters, No. 1374 Squadron, Air Training Corps, Gloucester Road, New Barnet. Sec.: E. W. Brett (G3LUY), 28 Edward House, Edward Road, New Barnet.

Bexleyheath.—The North Kent Radio Society is planning the formation of an instructional section with special instruction for the many "beginners" among the Society's 50 members. The club meets on alternate Thursdays at 7.30 at the Congregational Hall, Chapel Road. Next meeting on June 12th. Sec.: D. W. Wooderson (G3HKX), 39 Woolwich Road, Bexleyheath.

Birmingham.—"I. G. Y. Research" is the title of the talk to be given to members of the Slade Radio Society by D. Ramsden, of the electron physics department of Birmingham University, on June 6th. Meetings are held on alternate Fridays at 7.45 at the Church House, High Street, Erdington. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Bradford.—At the June 3rd meeting of the Bradford Amateur Radio Society, H. D. Kitchin will speak about experimental colour television. The subject to be covered at the meeting on the 17th is radio and television interference. Meetings are held on alternate Tuesdays at 7.30 at Cambridge House, 66 Little Horton Lane, Bradford. Sec.: D. M. Pratt (G3KEP), 27, Woodlands Grove, Cottingley, Bingley.

Downham.—Ravensbourne Amateur Radio Club now holds meetings on alternate Wednesday evenings at Durham Hill School, Downham. G. V. Haylock (G2DHV), hon. secretary of the British 2-Call Club, is chairman of the Ravensbourne Club, which operates station G3HEV. Sec.: J. Wilshaw, 4, Station Road, Bromley, Kent.

Harlow.—A mobile rally has been arranged by the Harlow and District Radio Society for June 22nd at Magdalen Laver Village Hall, Nr. Harlow. Station calls and frequencies are G3ERN (1,980 kc/s) and G3JMA (144.8 Mc/s). Sec.: A. T. White, The Chestnuts, Fyefield, Ongar, Essex.

Ringwood.—The recently formed Ringwood and District Radio Club meets every Wednesday and the last Friday of each month at 7.0 at 23 Merryweather Estate, Ringwood. Sec.: K. Cutler, 19 Pardys Hill, Hurn, Christchurch, Hants.

Stockport-Manchester Rally.—The joint rally of the Stockport Radio Society and the South Manchester Radio Club mentioned last month has been postponed until Sunday, July 13th. It will be held at Capesthorne, Cheshire. Particulars from Charles M. Denny (G6DN), 18 Willoughby Avenue, Didsbury, Manchester, 20.

Worthing.—Meetings of the Worthing and District Amateur Radio Club are held on the second Monday of each month at 8.0 at the Adult Education Centre, Union Place. Sec.: J. R. Tootill, 113 Kings Road, Lancing, Sussex.

THIS MONTH'S EXHIBITIONS AND CONFERENCES

The address of the organizers or the U.K. representatives is given in brackets.

International Conference on Solid State Physics in Electronics and Telecommunications, Brussels, Belgium .... June 2-7
(Société Belge de Physique, 18 rue de Phillipeville, Loveral, Belgium.)

Armed Forces Communications and Electronics Association Convention and Exhibition, Washington, D.C., U.S.A. .. June 4-6
(A.F.C.E.A., 1624 Eye St. N.W., Washington 6, D.C., U.S.A.)

International Automation Exposition and Congress, New York, U.S.A. .... June 9-13
(Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, U.S.A.)

International Congress and Exhibition of Electronics and Atomic Energy, Rome, Italy .... June 16-30
(Agents: Auger and Turner, 40 Gerrard St., London, W.1.)

French Components Show, Paris, France .... June 20-26
(S.N.I.R., 23 rue de Lubeck, Paris 16.)

Air Transportation Conference, Buffalo, U.S.A. .. June 25-27
(American I.E.E., 33 W. 39th St., N.Y.18, U.S.A.)

ELECTRONS AND HEAT

SOME VITAL STATISTICS

By "CATHODE RAY"

THE fact that it took us the last four *Wireless World* months to graduate from the usual over-simplified theory of electrical conduction to the more sophisticated one favoured by modern science explains why elementary books—and some of the not-so-elementary—don't make the attempt. But since we have done so, and I hope succeeded, it would be a pity not to exploit our achievement by following it up.

Although we ought to know better by now than to try to imagine the unimaginable, nevertheless we probably have formed a mental picture of the atomic structure of a crystalline substance. When a single atom occupied the full field of our mental view we could see how hazy and unsubstantial it was. But a cumulus cloud appears quite solid and clear-cut from a distance, and now that we step back far enough to take in a multitude of atoms they all look remarkably like spheres; not billiard balls again, certainly, but perhaps tennis balls—new woolly ones, packed closely in three-dimensional array like a wholesale export order. Of course we know that in spite of appearances they are far from solid really, for nearly all their mass is concentrated in the inconceivably small and dense nucleus at the centre; the rest is very nearly empty space, its apparent cloudiness representing only the whirl of equally small electrons. These are not the only ones; each atom has a small number of valency electrons, which are so loosely attached that they seem to belong to the array as a whole rather than to any particular atom, and may be pictured as a faint mistiness of the spaces between.

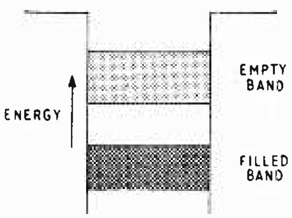


Fig. 1. Energy-level diagram for an insulator, in which the valency electrons fully occupy all the energy levels within reach.

We know that in spite of the apparent vagueness of the electrons they are governed by strict rules. In each atom they are arranged in a definite energy pattern, with no two exactly the same. Those with the lowest energies are (on the average) nearest the nucleus. The valency electrons, being farthest out, have the greatest energies, but not enough to let them escape clean away. Instead of being confined within very narrow bands like the others, their energies are distributed over wide bands made up of innumerable levels. But, like the other electrons, no more than two (spinning in opposite rotations) can be at any one level at the same time.

There are as many levels in each band as there are atoms in the crystal, so if there are two valency electrons per atom they fill all the levels in their band. This state of affairs is often shown as in Fig. 1, which, let me repeat, is purely an energy diagram. All the lower levels, not shown, are chock-full with the non-valency electrons. Any reasonable e.m.f. applied to the crystal amounts to only a very little per atom—insufficient to give any electron in the filled band enough energy to excite it into the empty band. And because the filled band *is* filled, no electron can rise unless another falls to make room, the net rise therefore being always nil. So the electrons are not in a position to receive any energy from the e.m.f. In other words there is no electric current, and the material is classed as an insulator—notwithstanding that its valency electrons are free to roam around it, *at random*. As a matter of fact, " roam " is perhaps hardly the word; if you take the trouble to work out the velocity an electron must have to amount to several eV (electron-volts) of kinetic energy you will find it is of the order of hundreds of miles per second! But on the average all movements in any direction are cancelled out by equal movements in the opposite direction.

Fig. 2 shows equivalent diagrams for conductors. In (a) there is only one valency electron per atom, so only half the places in the band are filled. At absolute zero temperature (0°K)—which is what we have been assuming so far—they are settled down in the lowest-energy places as shown, all ready to accept the small amounts of energy represented by rises within the band. Such increases of energy are manifested by movement towards the positive pole. Fig. 2(b) represents a metal such as zinc, which has two valency electrons per atom; these fill its band, but because the next higher band overlaps there are again plenty of vacant levels within reach. In our prime material for electrical conductors—copper—both conditions exist at the same time, so we are not surprised that its conductivity is particularly good.

That is as far as we got last time, and you may have been wondering why copper—or any other conductor—has any resistance at all. You have probably learnt that when quite a strong electric current is flowing the net speed of the electrons composing it is only a small fraction of an inch per

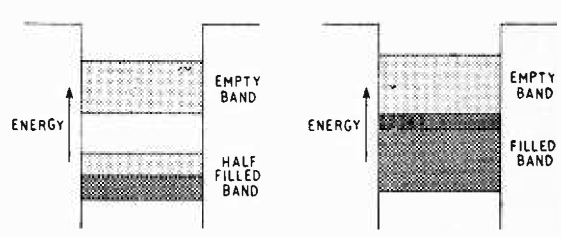


Fig. 2. If valency electrons have direct access to vacant energy levels for either or both of these reasons, the material is a good conductor (i.e., a metal).

second. Now to give an electron a speed of 1 mm/sec, say, the e.m.f. required is less than 3 micro-micromicro-volts, which suggests negligible resistance. What is more to the point, no e.m.f. at all is needed to maintain this or any other speed once it has been started—provided that there are no obstructions.

The elementary explanations tell us that the solid metal is full of obstructions—the atoms—and the free electrons are continually bumping into them, losing the energy the e.m.f. has given them, as heat, and having to start all over again, so that is why their average speed as a current is so small. The awkward thing for this explanation is that the atoms are there to be bumped into whatever the temperature, so the resistance should be constant. If anything, it should fall as the metal is heated, making it expand and so presumably relieving the congestion a little. In fact, however, the resistance of pure metals begins at or near zero at 0°K and increases pretty steadily as the temperature rises. Authorities try to talk them-

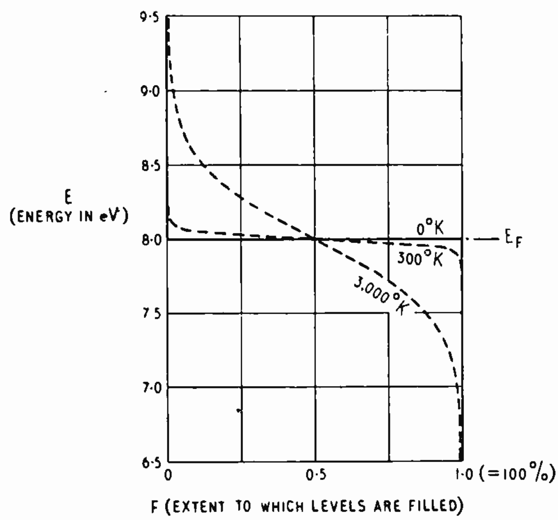


Fig. 3. Fermi distribution function plotted for three different temperatures, showing how only the highest-energy levels in Figs 1 and 2 are appreciably disturbed even by quite fierce heat.

selves out of this by saying that to raise the temperature of anything means giving it heat—a form of energy—and this makes the atoms (by which they mean the parts that are not mobile) vibrate. On the basis of the picture of resistance previously supplied, it is not at all clear why merely vibrating should make the atoms obstruct electron flow 100 times more at 400°K than at 20°K, but that is one of the places where the unconvincingness of the simple theory made people look for something better.

Wave mechanics is the something better. Unfortunately, although it accounts for resistance mathematically, it doesn't give us a clear mental picture of what is going on. That is because it is obliged to depart from the idea of electrons as just small particles and credit them with a wavelike nature. Such waves can be propagated freely through a structure which is exactly periodic, such as a perfect crystal at 0°K; in other words, under the influence of an e.m.f. the valency electrons can flow through the solid without resistance. But when the spacing of the atoms is thrown into irregularity by heat vibration there is an interference between the electron waves and the atoms whereby the electrons are continually having to give up the extra energy supplied to them by the e.m.f. This energy appears as heat, as the cat knows when it makes for the electric fire. The dissipation of this heat brings the electrons down to lower energy levels, so they don't all get stuck at the top of the band as one might have feared on first looking at Fig. 2. The irregularity, and hence the resistance, increases with temperature; which agrees with experience.

The resistance of substances that are not good conductors *falls* with temperature, usually very steeply. Their resistance, being so great, is hardly accounted for at all by the heat vibration of the atoms. But of course heat supplies energy to the electrons as well. It used to be supposed that the electrons in an atom began with no energy at all at absolute zero, and all shared the increase as the temperature was raised. But this led to conclusions at variance with experimental results. Nowadays, our energy-level diagrams and Pauli's principle show where the supposition was wrong and why the experiments turn out the way they do.

The Fermi Curve

Let us begin at 0°K, with the valency or " free " electrons distributed in the energy diagram like water in a well. Below the surface—which represents the highest occupied energy level—all levels are completely filled; above it there are no electrons at all. This condition is represented by the full line in Fig. 3, which shows that up to a certain level (marked E_F) all the energy levels are 100% filled, and above it they are all completely empty. Note that although the temperature is zero they all have quite considerable energy, for true zero energy (as distinct from our arbitrary zero at the well's mouth in previous diagrams) is right below the minimum of the scale shown. As regards kinetic energy, they are reckoned to start with zero at the bottom level, and work up to several eV at the surface.

Now impart a little heat. The nearest unoccupied levels are above the surface, so the only electrons in a position to receive small gifts of energy are those at or near the surface. Those near the bottom hardly have a chance, any more than drops of water at the bottom of the ocean are likely to spring up through the surface when they are gently stirred. This condition is represented by the first dotted line, which shows that levels just above E_F are partly filled with electrons drawn from levels just below, which are therefore incompletely filled. Practically half of those right at the surface are raised just above it, but the proportion falls off very rapidly as the energy distance from the surface increases. The chance of an electron being raised far does exist, but at low temperatures it is very small indeed. It is like the chance of winning a big prize with a small stake—only still slimmer.

At high temperatures the energy is such that a

(*Continued on page 281*)

few electrons are raised from fairly low levels and some are raised well above E_F. The number of electrons involved in even a small piece of stuff is so enormous that one is not interested in the doings of any particular individuals but only in their averages. There is a tendency nowadays, fostered by the lay Press, to think of statistics as something to do with individuals; but in scientific matters they concern only calculations in which individuals are ignored. For instance, no one can be sure of the result of fairly tossing a coin, or even half a dozen; but the result of a million throws can be predicted with considerable accuracy. That is because purely random events follow *statistical* laws.

By making assumptions based on the principles we have been studying, two scientists named Fermi and Dirac independently calculated how energy would on the average be distributed among the free electrons in a solid. The result of their effort, called Fermi-Dirac statistics, is expressed by

$$F = \frac{1}{\exp^{*}\left\{\frac{E-E_F}{kT}\right\} + 1}$$

where F is the filling factor at energy level E, k is Boltzmann's constant (which we ran into when considering the related subject of circuit noise) equal to 8.6×10^{-5} eV/deg, and T is the absolute temperature (°K). The curves in Fig. 3 were plotted from this equation for T = 0, 300° (= 80°F), and 3,000°. E_F is not necessarily at the 8eV level; it differs according to the material, but 8eV is typical of a metal. Wherever it is, it is called the Fermi level.

All this may seem to be getting highly involved and far from the subject, but actually it concerns it very closely, as you will see if you go back to Fig. 1. So far as ordinary electric fields are concerned, any clear gap between filled and empty band is a complete barrier, so at 0°K the material (if pure) is a perfect insulator. But at any other temperature some electrons have enough heat energy to take them across the gap. If the gap is large and the temperature low, the number is fantastically small. Suppose the gap is 2eV; then even at 300°K, which is a warm summer temperature in Britain, the proportion of electrons able to cross it is only 1 in 7.8×10^{35}, or about 1 per ten million cubic yards of material! So it would be no good trying to measure the leakage with a Megger! But if the gap were 0.1eV the odds would shorten startlingly to 1 electron in 9,700, which represents considerable conductivity. At 3,000°F, even the 2eV gap is crossed by 1 in 44,600, which would be enough to ruin it as an insulator even if it could stand such a temperature without going up in smoke.

These Fermi-Dirac calculations† agree very well with the steep decrease in the resistance of insulators and semi-conductors as the temperature is raised. Some materials such as diamond remain good insulators up to quite high temperatures, and one can guess that they have large energy gaps. Pure silicon conducts very little at room temperature, but much more than a good insulator should, so its gap is presumably less. Germanium is a middling conductor at room temperature. And tin, of course, conducts quite well. Note that all four of these materials are elements in the same column of the Periodic Table, since all have four valency electrons per atom; they were mentioned in order of increasing atomic number, and evidently decreasing energy gap. The reason why silicon transistors are better than germanium for working at high temperatures is now clear: the energy gap in germanium atoms is narrow enough to allow too many uncontrolled electrons to cross it with the assistance of heat energy from about 60°C (333°K) upwards. For comparison with Figs. 1 and 2, Fig. 4 is the energy-level diagram for a semi-conductor (strictly, as we shall see later, an *intrinsic* semi-conductor); the gap is narrow enough to be crossed by an appreciable number of electrons with the aid of moderate heat.

It would be quite wrong to interpret a Fermi curve as representing a static situation. Electrons that have been given excess energy tend to get rid of it again at once—well, after about a hundredth of a microsecond—whether that excess was conferred by radiation or electron bombardment or heat. A little piece of hot stuff left out in the cold cools down. The man in the street (provided he didn't misunderstand altogether the nature of the subject under

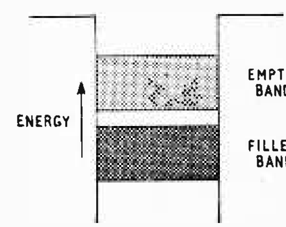


Fig. 4. Energy-band diagram for an intrinsic semi-conductor, in which the gap is about 1eV or less, so can be crossed by a small proportion of electrons if they are stimulated by heat or other external source of energy.

discussion) would probably greet such a statement with mock incredulity, but would he be able to explain why it doesn't stay hot? Each Fermi curve represents a constant temperature, but in order to maintain anything at a constant temperature—even a very low temperature—it is necessary to keep on supplying it with heat to push its electrons up to higher energy levels at the same rate as they are dropping back. Even an object in a uniformly cold room is in a continual state of turmoil, receiving heat energy from its surroundings and giving it back. Consequently the room is full of heat energy in transit—radiated energy—even though by domestic standards it would be judged cold. The Fermi curve for that temperature shows that most of the energy transitions are very small—electron-millivolts rather than volts—and by use of the quantum law ($E=hf$) we know that this means the radiation frequencies are low; far down in the infra-red. If the room were a furnace at a uniform temperature of 3,000°K, Fig. 3 shows us that an appreciable number of the transitions would be of the order of electron-volts and therefore in the visible part of the spectrum. Our man in the street would again consider it excessively obvious that things in such a furnace should be white-hot, but again would he be able to explain why? Indeed, it was a great puzzle to

* "exp x" is a more convenient way of writing e^x when x is a rather elaborate expression as here.

† The figures just given are obtained by calculating the area below the appropriate Fermi curve in Fig. 3 above an E level higher than E_F by the amount of the gap mentioned, in comparison with the total area below E_F. According to the full theory, the energy bands below E_F hold progressively fewer electrons, so the area below E_F was calculated as equivalent to the full width extending only 5eV downwards.

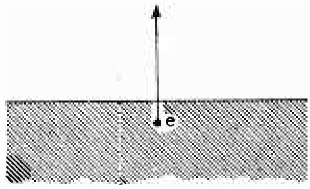


Fig. 5. An electron has the greatest chance of being emitted if the velocity given to it by heat is at right angles to the surface, as here.

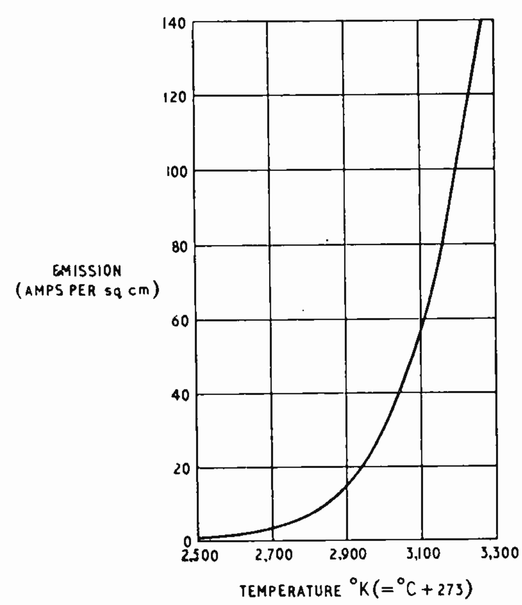
scientists up to the turn of the century, for the frequency distribution of radiation under the conditions of heat balance we have been considering couldn't be accounted for by nineteenth-century physics. It was, in fact, mainly this difficulty that led Planck to break away with his startling quantum theory.

If you are thinking this is going right off our subject just as we were getting warm with the mention of transistors, you could hardly be more wrong. Transistors are all very fine, but we are likely to need thermionic valves and cathode-ray tubes for quite a while yet. And what use would they be without emission?

It should be clear by now that if the temperature is high enough, and the Fermi level not too far down the "well," an appreciable number of electrons will get right away from the atoms. That is to say they will be released from the material and able to soar through space on their own. This is precisely what is designed to happen at the surface of a heated cathode. What is done with those electrons after they have been emitted we all know. We know, too, that the emission increases very rapidly with the temperature of the emitter—the cathode. Does Fermi help us here? As a TV interviewee would say, he does indeed. But a little thought is required.

One might suppose, for example that all one had to do was to use the formula to calculate the proportion of electrons which receive sufficient extra energy

Fig. 6. Showing how steeply the emission of electrons increases with quite a small rise in temperature. This is a theoretical curve; in practice the emission is less, but the curve has the same shape.



to cross a gap equal to the depth of the Fermi surface from the top of the well. (This gap is better known in scientific circles as the "work function," denoted by ϕ.) The fallacy is the quite wrong assumption that the energy given by heat to an electron would necessarily give it velocity perpendicular to the surface, as in Fig. 5. There is no reason why it should aim in this direction more than any other. Those moving at an angle to the perpendicular need a higher velocity to carry them into the open against the potential barrier at the surface. One can picture the piece of solid as a level "Dodg'em" car arena, with sloping banks (their height representing ϕ) all round the boundary. The cars are dashing about in all directions, and whenever they reach the boundary they are reflected back by the slope. But if someone turns up the voltage of the supply to the cars (representing heating the solid) some of them may get up enough speed to charge right up the bank and fly out of the arena. Clearly those approaching the bank at right angles are most likely to do so.

To derive from Fermi statistics an equation for the number of electrons leaving a surface at temperature T°K is not so easy as it might look; the result known as the Dushman (or sometimes Richardson-Dushman) equation is:

$$I = \frac{AT^2}{\exp \frac{\phi}{kT}} \quad \text{(or } AT^2e^{-\phi/kT}\text{)}$$

where I is the emission current in amps per sq. cm. A is a hold-all for a collection of fundamental constants; it is equal to 120. In practice the current is less, and is often very much less, because even a single layer of impurity atoms at the surface creates an additional impediment. The important thing to notice is that the exp ϕ/kT factor is the same as in the original Fermi function (ϕ being the gap between the Fermi level and outer space), and it is this factor that dominates the situation, representing such a large change of emission for a small change in temperature that T^2 makes very little difference. The work function, ϕ, varies from about 1.8eV for caesium to 5 for nickel. Tungsten has quite a high ϕ—about 4.5—so it has to be heated to about 3,000°K for a useful emission; see Fig. 6. That is why tungsten filaments are run white-hot. You can see from the equation that if ϕ is halved the cathode temperature required is also halved (and the power needed to heat the cathode is much more than halved), so you may be wondering why tungsten is ever chosen. Although many other metals have lower ϕ, advantage cannot be taken of this because they would melt even at the lower temperature required for emission. However, certain oxide coatings reduce ϕ considerably, and make possible the low temperatures at which the cathodes of receiving valves are run. But they are too delicate for large transmitting valves.

As we have seen, heat is not the only way of imparting energy to electrons. One can do it with radiation. Using the by-now-familiar quantum relationship between energy and frequency, we can easily calculate the lowest frequency the radiation must have to provide enough energy to overcome ϕ. Take tungsten, with its $\phi = 4.5$eV. The frequency having at least this amount of energy is $\phi/h = 4{\cdot}5/(4.13 \times 10^{-15})$ c/s = 1,090 MMc/s. This is well above the highest visible frequency, so ultra-violet radiation is needed to extract any electrons from tungsten.

Other Causes of Emission

The corresponding figure for caesium is 436 MMc/s, which is just about the lowest visible frequency. So light of any colour has enough energy to stimulate emission from caesium; hence the use of this metal for cathode surfaces in photo-cells.

Radiation having higher frequency than the bare minimum ejects the electrons with greater violence. You may remember it was the contradiction between this fact and the wave theory of light that I quoted at the beginning of this series (February issue) as an example of the need for the quantum theory. Planck introduced that theory mainly on other grounds, and it was Einstein who a few years later carried it a step farther with the idea that not only was radiation confined to quantities which were multiples of hf but that it actually consisted of what are now called photons. On this theory, raising the frequency of a given amount of radiated energy means dividing it into fewer but more energetic photons.

Although it follows that a photo-emitter will respond to radiation of any frequency above the minimum, in practice the range is restricted by whatever material is used to keep out the air (which would obstruct the emitted electrons). Usually it is glass, which is opaque to ultra-violet rays: if the cell is to be used for them, quartz is substituted.

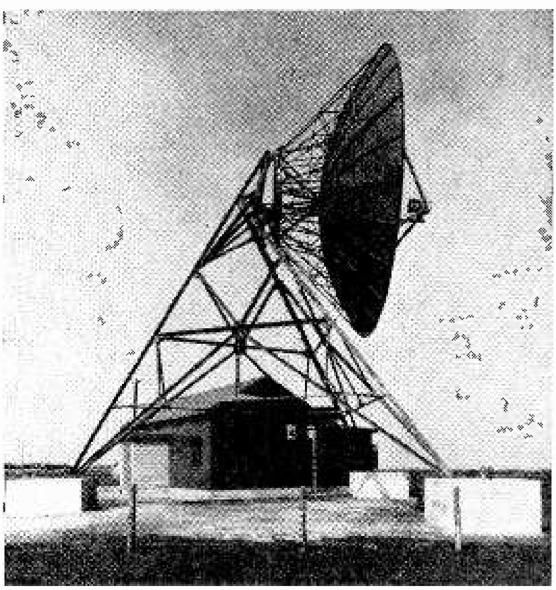
Photo-emission is much more complicated than the foregoing outline would suggest; in particular, even now the authorities maintain a discreet silence on exactly how some of the most-used cells work—those with compound surfaces, some of which are sensitive well into the infra-red.

Another energy giver is a fast-moving electron, and you are probably familiar with secondary emission in valves, cathode-ray tubes and electron multipliers. Although it is true that electrons begin to be knocked out when surfaces are bombarded by electrons having approximately the same order of energy as that needed to overcome ϕ (say 5eV), the whole business is even more complicated than photo-emission. For one thing, you hardly expect to make a nail fly out of a piece of wood by hammering it inwards. But electrons do just that if they are hit hard enough. Less intense bombardment will extract secondary electrons if it strikes a more glancing blow. And there are all the complications due to surface impurities—intentional or otherwise. So I don't intend to enlarge on this, or on the fourth and last kind of emission—field emission, in which electrons are extracted from a metal by the brute force of an intense electric field.

Having raced at a rather undignified pace through the applications of electron energy in what may be called the glassware branch of electronics, we can now—or rather next month—go back to where we left off with semi-conductors and take up that story. Don't forget all about Fermi statistics in the meantime.

U.K. TROPOSPHERIC SCATTER SYSTEMS

MULTI-CHANNEL tropospheric scatter systems can satisfactorily provide a point-to-point transmission of signals over distances of 200 miles or more as compared with the 40-mile average of direct-beam systems. Although in some cases it may be more expensive, the tropospheric scatter method holds out great possibilities over routes where intermediate repeater stations are impracticable, as over desert or long expanses of water.



Aerial and transmitting building of the tropospheric scatter station built by Marconi's at Start Point. The aerial is 30ft in diameter.

For some years now Marconi engineers have had an experimental tropospheric scatter system operating between Bromley in Essex and Catterick in Yorkshire, mainly for analysis of the transmission characteristics and to provide data for systems planning.

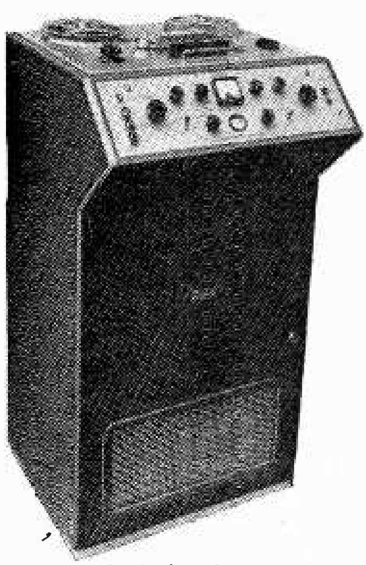
A multi-channel radio link has now been inaugurated between Start Point, Devon, and Galleywood, Essex, a distance of just over 200 miles. This operates on a frequency of 858Mc/s and is single-way with the transmitter situated at Start Point and the receiver at Galleywood. At present the equipment is designed for a maximum of 60 simultaneous telephone channels, but later television pictures will be transmitted over the link to ascertain whether an acceptable standard of quality can be realized.

The Start Point transmitter employs a water-cooled four-cavity klystron developing an output power of 10kW. The associated aerial system, a 30-ft diameter paraboloid "dish" excited by a horn radiator, is mounted with its centre 35ft above ground level. This aerial has a gain of 36dB over a dipole at 858Mc/s and thus provides an effective radiated power of the order of 40 megawatts in the direction of maximum intensity.

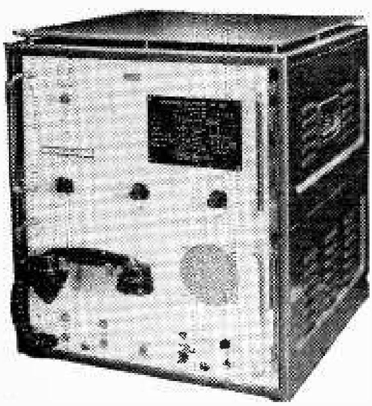
The receiving equipment at Galleywood is of the dual diversity type employing two dish aerials each of 30ft diameter and spaced 100ft apart. This method does much to counteract the effects of rapid fading of the signals which is a characteristic of tropospheric scatter propagation.

Instruments, Electronics

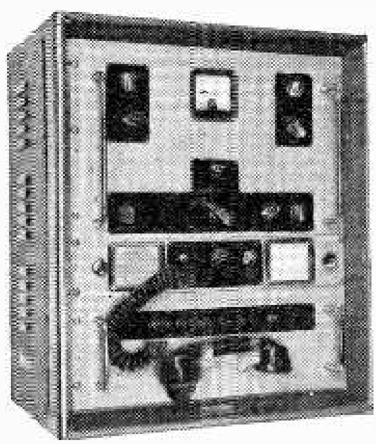
THINGS SEEN AT THE INTERNATIONAL EXHIBITION



Muirhead facsimile picture tape recorder.



Racal TRA55 60-watt transmitter-receiver, showing the simplicity of controls.



Redifon GR400 60-watt transmitter-receiver, using a novel form of transistorized modulator.

AT THE conclusion of last year's first I.E.A. exhibition there was general agreement that it had fully justified its existence and could usefully supplement older established functions in this sphere.

This year the scope of the exhibition has been extended, and the strong support which has been forthcoming from Continental and American firms and their agents has established its international character. Not the least welcome difference from last year is the significant increase in the number of firms exhibiting communications equipment, from which electronics borrowed many of its methods and to which it has paid back many new ideas.

Communications

Perhaps the most important item in this field at the exhibition could be reported colloquially in two words —"Fax taped."

The tape-recording of facsimile picture transmissions might seem to be an easy process because the range of frequencies handled is no more than the normal communications audio range. In actual practice the difficulties are manifest mainly as tape "drop-outs," wander in play-back speed and tape's terrible twins —wow and flutter.

Muirhead's facsimile picture recorder registers on standard ¼in magnetic tape at 7½in/sec, the output from a facsimile transmitter (rotating drum equipment) and enables it to be stored until conditions are suitable for transmission. To overcome "drop-out" and very-low-frequency equalization problems the 0 to 3kc/s picture information is used to frequency-modulate a 5-kc/s carrier, deviating it by ±4.9kc/s. This is recorded on a half-tape-width track, the other track carrying a 1000-c/s reference tone generated by an internal oscillator which is also used to drive the capstan motor. On play-back the f.m. carrier is subjected to a high degree of amplitude limiting, which overcomes "drop-out" problems, and the 1kc/s reference tone is compared with that of the local oscillator driving the capstan motor, a.f.c. being applied to the oscillator to maintain tape speed at its correct value. Wow and flutter are taken care of by the use of a tape-deck of the highest professional quality. Reproduction of the recorded picture was in fact, indistinguishable from a direct transmission between two conventional facsimile machines.

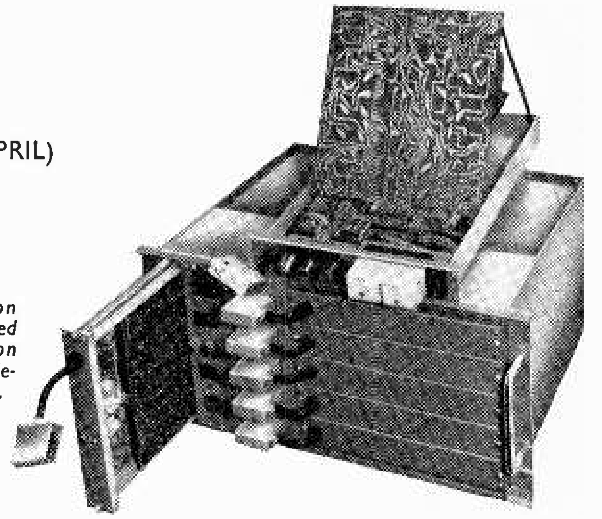
R/T and c.w. transmission and receiving equipment was well represented. Miniaturization—as in all electronics—was a prominent feature. One example of this was a 3-watt u.h.f. transmitter receiver (D103) on the W.S. Electronics stand. The D103 is designed for use direct from the aircraft 28V main supply, or from an independent 24V emergency battery. The amplitude-modulated crystal-controlled transmitter provides two channels within 1Mc/s of each other in the 238 to 248Mc/s band. Speech clipping is provided and the "transmit" side tone is taken from a crystal diode detector loose-coupled to the aerial socket, giving a valuable pre-flight and in-flight check of transmitter serviceability.

Another miniature equipment in rather a different class was shown by Microwave Instruments. This is the RT10 transmitter-receiver for marine use, providing ten crystal-controlled channels (including the 2.182Mc/s distress frequency) in the 1.6 to 3.8Mc/s band. Only four valves are used in the transmitter which obtains its power supplies (and provides those for the receiver) from a 12 or 24V d.c. supply by vibrator pack. The receiver has a ferrite rod mounted on the top of the cabinet for d.f. and covers 150kc/s to 4.0Mc/s with a break for the i.f. It uses 1.4V valves and can be operated from dry batteries when not used with the transmitter. The transmitter output claimed is seven watts, and the power input is about 45 watts. Weight 21lb. Overall dimensions 15in × 8⅞in × 8½in.

Siemens Edison Swan had on show a transistorized telephone carrier system junction unit primarily designed for use with multi-channel radio links. A master crystal oscillator running at 16kc/s is the basic timing unit for all five channels, con-

and Automation

HELD IN LONDON AT OLYMPIA (16-25 APRIL)



Siemens Edison Swan transistorized carrier junction equipment for telephone radio links.

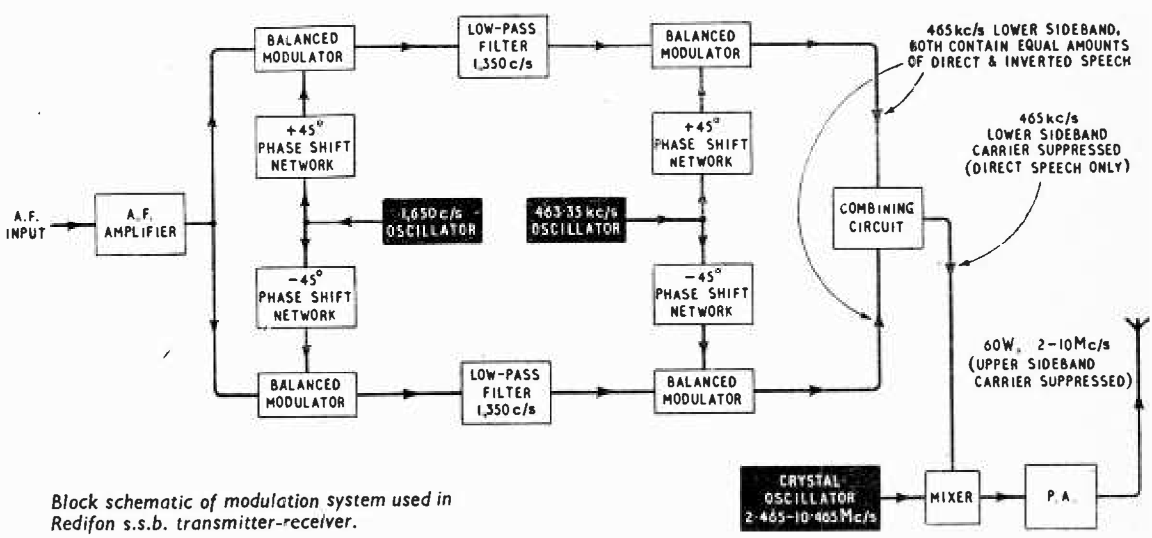
trolling the frequency of the 4-kc/s spaced carriers and the out-of-band signalling circuits for each channel. The unit is suitable for rack mounting in the standard 19in rack, and the complete five-channel equipment is 8¾in high. Power consumption is only 7½ watts from a.c. mains, or a 24V d.c. supply.

Two firms—Racal and Redifon—had on show broadly similar transmitter-receivers. These equipments have so many similarities that the common features are listed for both units. Both give 60W output, single sideband suppressed carrier a.m. radio telephony or c.w.; provide four crystal controlled frequencies in the 3 to 12Mc/s band; can be matched into a coaxial-line-fed or open wire radiator; run from a.c. supplies of 100-125V and 200-250V at a nominal frequency of 50c/s, and consume about 300W whilst transmitting; use the same output valves —Mullard QV06/20 (or the American equivalent). Even the cubic content of the case (within a few per cent) is the same. It is only by probing deeply into these two equipments, in fact into the modulator sections, that a difference can be found.

Racal TRA55: This employs the "filter" method of single-sideband suppressed-carrier generation. In this a balanced modulator (push-pull to a.f., push-push to r.f.) is used to generate a double-sideband suppressed carrier signal on a basic frequency of 1.4Mc/s. This is then passed into a crystal filter which attenuates the unwanted sideband by about 50dB.

The s.s.b. signal so obtained is passed to a second balanced modulator where it is brought to the r.f. required by mixing with the output from a master crystal oscillator. All the crystals on which the transmitted frequency depends are kept at constant temperature in a small oven to ensure frequency stability. On "receive" the incoming signal is amplified at r.f., converted to 1.4-Mc/s i.f. and passed through the filter, then into a "product" or heterodyne detector (after suitable amplification). About 20dB of speech clipping is provided in the modulator a.f. amplifier and the number of controls has been reduced to a minimum so that the equipment can be used by non-technical personnel.

Redifon GR400: Here a radical departure from the well-known methods of s.s.b. transmission generation occurs (see diag.). The extremes of the audio band are limited to 300 to 3300c/s. The outputs from the first balanced modulators consist of two "sidebands" of 0 to 1350c/s and 1950 to 4950c/s with a 90° phase difference between them. The 1950 to 4950c/s band is removed by an LC filter, leaving the 0 to 1350c/s band which is passed on to a second pair of balanced modulators, fed from a 463.35kc/s oscillator. The radio frequency outputs from the second pair of balanced modulators are thus lower side bands of a 465kc/s carrier (which is never generated) containing equal amounts of direct and inverted modulation (direct and inverted in frequency



Block schematic of modulation system used in Redifon s.s.b. transmitter-receiver.

spectrum), with a 90° phase separation. These outputs are combined in such a way that the inverted spectrum cancels out, leaving a 465 kc/s lower sideband suppressed carrier signal. It will be seen that, at every stage, if a breakdown or tampering with preset adjustments occurs, the unwanted sideband cannot be generated—a carrier is produced in the middle of the channel in use, and not in another user's channel space. On "receive" the modulator chain converts the signal back into a.f. information.

Obviously a modulator of this type, with many stages, would use a considerable amount of power for valve heaters alone. This problem is overcome completely by using transistors throughout. The a.f. amplifier and output stage, microphone amplifier and modulator all use transistors. (8 of OC71, 5 of OC45 and one V15/30P.) A development modulator, using thermionic valves, consumes about 30W of input power—the transistor modulator in the GR400 consumes only one hundredth of this amount—roughly $\frac{1}{3}$ watt.

Industrial Electronics

As automation in industry increases so does the ingenuity of some workers in trying to obtain spuriously high counts of work done. This, explained Burndept, was the problem they had to overcome in designing a new press output counter. With an optical device oil and dust can interrupt the light beam and prevent correct operation. So a new method of producing a pulse to work the counting mechanism had to be found.

The piece-part is removed from the mandrel and blown down a glass tube by compressed air. This tube passes through a box containing the sensing element, which is a coil wound round the tube. In the top of the box, which can be locked to prevent unauthorized tampering, is a crystal oscillator, using the coil as the second tuned circuit. The oscillator is operated on the "knee" of the valve curve, so that the passage of the object through the coil causes a large anode current pulse. To prevent scrap material thrown into the tube producing a spurious count this pulse is applied to a flip-flop with a paralysis time equivalent to the minimum interval between two successive articles when the press is operating at maximum speed.

A versatile counter which can also be used as a frequency meter, chronometer, pulse frequency divider and pulse delay generator was shown on the Racal stand. Using transistor-driven magnetic-core counter circuits, it is extremely compact (13in × 9in × 12in) and displays its results on four of the new numerical indicator tubes (see page 273). As a totalizer the instrument will count up to 9999 then reset to zero and carry on in this manner indefinitely. Frequency is measured by counting cycles over a period of time which can be set from 1msec to 10 seconds in 1-msec steps. Used as a chronometer the equipment counts units of time between "start" and "stop" signals applied to it. Any input frequency up to 10kc/s can be divided by any factor from 2 to 10,000. For pulse delay purposes the required delay is set up on the instrument, the initial pulse is applied to the "start" terminal and after the delay interval an output pulse is produced.

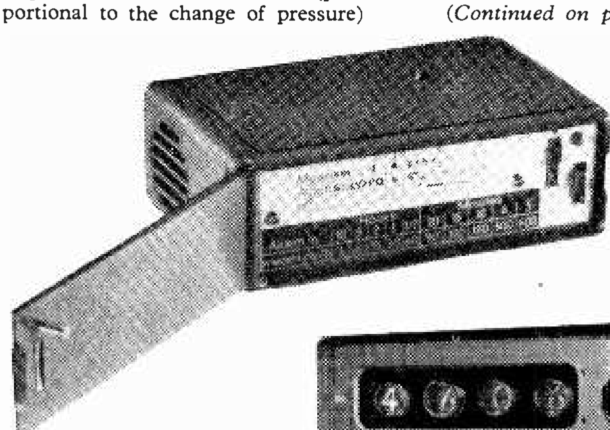
Kelvin-Hughes exhibited what is almost a model servo-system on a "force/balance" type of aneroid pressure-indicating device in which the pressure capsules are coupled to a pivoted beam and are balanced by a spring in tension. The end of this beam is used as the moving element in a differential transformer. When a change in pressure occurs the beam is deflected, causing an out-of-balance signal from the transformer, which, after passing through a transistorized amplifier is used to drive a motor geared to a lead screw. The balancing spring is attached to this screw so that the beam is returned to its original position, the angular displacement of the lead screw (proportional to the change of pressure) giving an indication on a dial geared directly to this spindle, or arranged as a remote repeater.

Another item commendable for its neatness on the Kelvin-Hughes stand was a miniature slip-ring assembly primarily designed for carrying leads to sensing devices on a rotating member. Only $1\frac{1}{4}$in long and using a spindle 0.2in in diameter, this slip ring assembly provides 22 separate contacts capable of withstanding a flash-test of 1kV between adjacent sections. Other types with a smaller diameter spindle and fewer contacts are available.

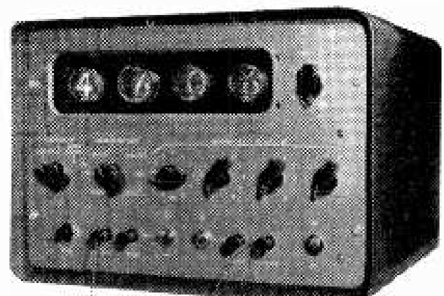
Thickness gauges using radiation sources are well known, but worthy of note in this field is a set of three gauges produced by Ekco for use with their N565 indicator (this is a large-scale valve voltmeter using "chopper" technique and providing an input impedance of $10^{10}\Omega$). In each instrument, the radiation passing through the specimen impinges on a phosphor screen, the scintillations being detected by a photomultiplier tube. The tube's output is applied directly to the indicator.

Between the end of the range of materials light enough to be measured by α techniques and dense enough to be measured by β techniques there is a gap. This gap in the nucleonic "ruler" has now been filled by one of the Ekco gauges using strontium 90 as a source of β radiation to excite Bremsstrahlung for use as the measuring radiation, allowing the measurement of metal films between 0.02in and one inch thick. Each of these Ekco gauges in-

(*Continued on page* 287)



Above: Integrating personal dosimeter ("Monitor") by Radiatron.

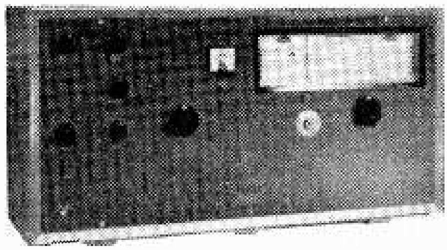


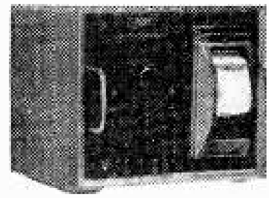
Racal counter/chronometer using transistors and magnetic cores.

corporates an automatic standardization feature. Variations in the high voltage supply and temperature can cause inaccurate results, so, after a predetermined interval (usually five minutes) operation of the gauge is stopped for ten seconds or so, and the head is exposed to radiation from a standard source. Servo-mechanisms then make adjustments to the gauge circuits to correct any drift which may have occurred.

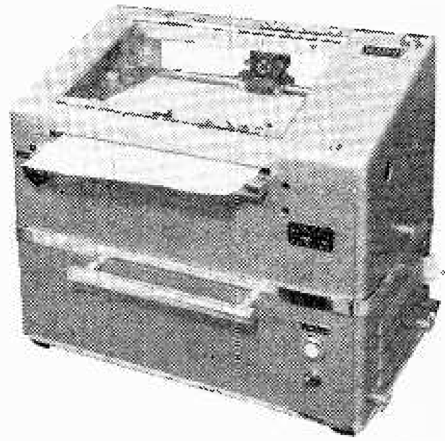
Personal safety in the presence of radiation is a factor receiving ever-increasing attention. A personal dosimeter giving audible warning when the danger level has been reached was shown by Radiatron under the name "Monitor." This instrument, of German origin, uses the current passed by an ionization chamber to charge an electrostatic relay. When this relay has charged to a sufficient potential to close, an audible warning is set off. It will be seen that an integrating action is achieved which sounds a warning when the total dose exceeds 30 milliröntgens—the maximum allowable weekly dose under the present regulations. The high voltage for the ionization chamber is developed by a transistor oscillator and stored on a capacitor. The equipment is powered by a small rechargeable battery, and it is supplied complete with a small β radiation source for calibration and testing. The weight is 350 grammes and the measurements are about $4\frac{1}{4}$in × $2\frac{3}{4}$in × $1\frac{1}{2}$in overall.

Chemical analysis was represented by a wide range of electronic instruments in which the electronics in many cases only amounted to a standard detector, like a photocell or radiation counter, coupled to a standard measuring or indicating instrument. There were, however, other instruments in which electronics played a more essential part. A nuclear magnetic resonance spectrometer shown by Fairey Aviation was one interesting example. Although this method of analysis (see May issue, p. 219) is now about twelve years old, the Fairey spectrometer is interesting because it takes the form of a very compact bench-type instrument designed with an eye to incorporation in process control systems. Hitherto such apparatus has been somewhat bulky and essentially for laboratory use. The compactness of the Fairey instrument is mainly the result of using a small permanent magnet with 4-inch diameter poles, a pole gap of 0.72inch and a field of just under 4,200 gauss. This is incorporated in the main body of the instrument and samples for analysis are inserted through an opening in the front control panel. The output signal, representing the absorption which occurs at resonance for particular atomic nuclei, is displayed on a separate pen recorder, the chart movement of which is linked to the magnetic field sweep system. In the prototype machine on show the resolution of the spectrometer was about 5 in 10^7 but the production model is stated to be capable of 1 in 10^7.





Fairey nuclear magnetic resonance spectrometer.



Right: Sefram galvanometer recorder.

Measuring and Test Instruments

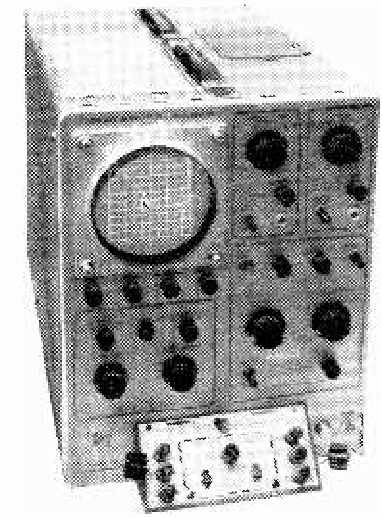
Current and Voltage Measuring Equipment.—The high possible overload factor of 30,000 in galvanometers with sensitivities as high as 1.6×10^{-3} μA/mm is a feature of several ranges of Sefram instruments shown on the French C.O.M.E.F. manufacturers society stand and imported into this country by Dobbie McInnes. An important part of the design is the suspension of the coil in liquid of the same mean density.

A galvanometer recorder which records on an 8-in-wide paper chart the deflections of an external mirror galvanometer was also shown by Sefram. Called the Photodyne, it is essentially a light-spot follower device and uses a high-performance servo system capable of an acceleration up to 13ft/sec/sec and a writing speed up to 24 inches/sec. The light spot movement is followed by a differential photoconductive cell on a carriage which conveys the recording pen and ink reservoir. This carriage slides along a rail transversely across the paper chart. The output from the cell is amplified and controls a servo motor which drives the carriage in such a way that any difference in output between the two halves of the cell is reduced to zero—in other words the photoconductive cell is kept centred on the moving light spot. By means of this instrument it is possible to record voltages down to 20μV and currents down to 0.01μA at full-scale deflection.

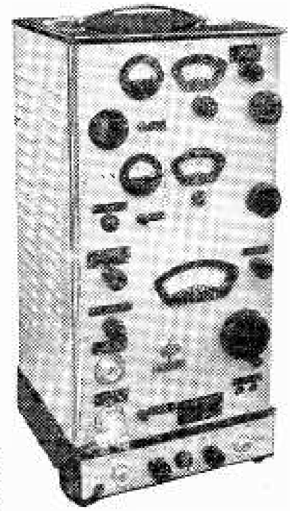
In the Racal digital test meter SA75 the time taken for a highly accurate ramp waveform to reach the level of the input voltage is crystal counted. The peak ramp voltage is also compared with a standard, the difference being fed back to give the correct rate of rise regardless of drifts in the ramp circuit component values.

Two inputs are provided in the Metrix E.R.I.C. multi-meter(S), one, with an input resistance of $10^{14}\Omega$, providing unit gain impedance conversion, is used basically for voltage measurements; the other, with a very low input resistance and providing a current gain of up to 10^6 times, is used basically for current measurements down to 10^{-13}A. The output impedance is also very low so that

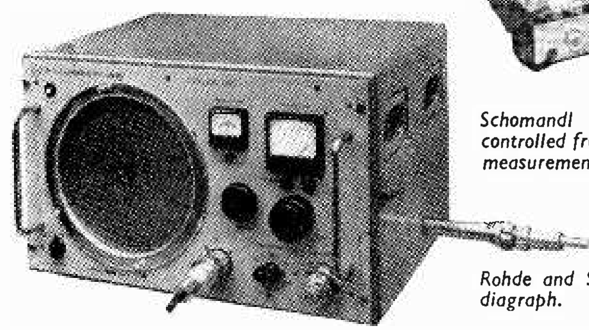
Agents in U.K. for foreign instruments: (A), Aveley Electric, Ltd., 15-16, Ayron Rd., Aveley Industrial Estate, South Ockendon, Essex; (L), Livingston Laboratories, Ltd., Retcar St., London, N.19; (S), Solartron Electronic Group, Ltd. (Merchandising Division), Queens Rd., Thames Ditton, Surrey; (W), Wykeham and Co., Ltd., 17-19, Cockspur St., London, S.W.1.



Left: Tektronix (L) 575 transistor curve tracer.



Schomandl (S) FDI crystal controlled frequency meter for measurements up to 920Mc/s.



Rohde and Schwarz (A) Z-g diagraph.

an ordinary milliameter or recorder indicator can be used.

Impedance Bridges.—Measurements are made in terms of magnitude and phase angle by comparison solely with resistances in the Radiometer(L) GB6. The magnitude is measured by equalizing the a.c. voltages across the unknown impedance and a variable resistor in two of the arms; and the phase by equalizing the voltages across a bridge diagonal and a variable fraction of one of the two other 500Ω arms.

The British Physical Laboratories CB181, working on the principle described by Lynch in *Proc.I.E.E., Part B*, for July 1957, measures capacities at 1Mc/s against changes in a standard in a method which is independent of strays at either capacity terminal. A 100kc/s bridge for checking ceramic capacitors according to R.C.S. 133B was also shown by B.P.L. (C.B.171).

Sources and detectors are now available for the Wayne-Kerr tapped transformer v.h.f. (5-250Mc/s) admittance bridges, the source outputs being compensated for changing bridge insertion loss and detector sensitivity over the bridges' ranges.

Audio and R.F. Oscillators.—Sine waves in the very wide range of 10c/s to 30Mc/s are obtained in the Wandel and Goltermann(S) MG-64 using an RC and LC oscillator below and above 1Mc/s respectively. An example of a number of small-size generators with an upper limit of about 1Mc/s is the American Waveforms(L) 510B for the sine waves. Sine or square waves, or square pulses as short as 0.25μsec at frequencies from 15c/s to 200kc/s may be obtained from the versatile Philips GM2314.

More specialized instruments shown included the E.M.I. S.R.O. 2A motorized sweep oscillator source for vibration generators covering up to any of five decades from 1c/s to 100kc/s; and the Radiometer(L) HO12W for measuring sound distribution. This latter is a b.f.o. with fundamental frequencies at about 200kc/s producing sine waves up to 40kc/s which can be frequency modulated. The output can be "clicklessly" disconnected at a speed of 600dB/sec for reverberation time measurements.

V.h.f. Signal Generators.—The wide range of 10kc/s to 110Mc/s is available in the Radiometer(L) MS111 (for a.m.). An output constant within ±3dB is obtained without any continuous level control because of the small frequency variation of 1.2 to 1 in each sub-range. In the Airmec 204 (for a.m. or f.m.) the ranges from 20Mc/s to 320Mc/s are obtained by frequency doubling, whereas the range from 1 to 20Mc/s is obtained by mixing the 40 to 80Mc/s output with a fixed frequency. In the Advance 60 (also for a.m. or f.m.) the frequency range of 4Mc/s to 230Mc/s is obtained by amplification from a Colpitts oscillator.

Crystal-controlled Decade Generators.—Very high accuracies can, of course, be achieved in such devices. In the Schomandl(S) units a variable frequency oscillator is phase locked to a single 100kc/s crystal at frequencies separated by a fixed interval. Frequencies which are not phase locked are obtained using an additional continuously tuneable oscillator. In the FD3 the fundamental frequency range extends to 1,000Mc/s and harmonics are usable up to 30kMc/s. An unknown frequency may be measured by mixing with the standard, beats being indicated aurally or by magic eye.

In the Rohde and Schwarz(A) XZB frequencies are obtained at intervals of 1kc/s from a 100kc/s crystal by multiplication, division and addition; intermediate frequencies being obtained using a continuously tuneable oscillator. The fundamental frequency range extends up to 30Mc/s and harmonics up to the 20th are usable. A meter shows the difference between the standard and an unknown frequency to an accuracy of ±2% for differences between 10c/s and 300kc/s. The order of a harmonic being used may be found by measuring the change in the frequency difference for a known change in the fundamental.

In the Gertsch(L) FM-3 the fundamental range of 20 to 40Mc/s is obtained from the harmonics of a 1Mc/s crystal oscillator and a very accurate (±0.02%) 1 to 2Mc/s oscillator. Harmonics up to at least the 25th are usable.

Frequency Response Displays.—A mechanically swept b.f.o. transmitter and associated receiver are used in the Siemens(W) 3K211 to give a plot of the frequency response of a network from 200 to 6,000c/s on a long persistence c.r.t. Automatic alternate comparison with a standard is also possible, and phase differences may be revealed by comparison with half the complex sum of the standard and unknown. The horizontal sweep is obtained directly from the received frequency, so that an external transmitter can be used at the end of a long line.

A similar type of display of the r.f. response is given on an 11×8-in c.r.t. in the Rohde and Schwarz "Polyskop"(A). In this case, the frequency sweeping and switching are obtained from the mains supply. The frequency range is 0.5 to 400Mc/s and the sweep width from ±0.2 to ±50Mc/s.

Phase and Reflection-coefficient Display.—Microwave techniques are applied from 30 to 300Mc/s in the Rohde and Schwarz(A) Z-g diagraph type ZDU. The reflection coefficient is found by comparing at an i.f. of 10.3Mc/s samples of the power (obtained from directional couplers) in two lines, one line being terminated by the unknown impedance and the other a standard representing unity reflection coefficient. The reflection coefficient is shown on a circular chart by radial deflection of the light spot from a mirror galvanometer. The phase of the reflected signal is measured by limiting the standard and unknown i.f. outputs and applying them to the opposite ends of another line shaped as a nearly complete circle. Standing waves are produced in this line with a minimum position determined by the phase angle. This minimum is measured by a rotating probe which is mechanically coupled to the chart so that the light spot then indicates the correct phase as an angle. The local oscillator follows small variations in the input frequency so this need not be especially stable.

Transistor Testers.—Pulses with a duty cycle of one in ten are used in the Marconi TF1272 to allow non-destructive overload current and voltage measurements to be made simultaneously. In the new Microcell 108 a variable frequency (1kc/s to 3Mc/s oscillator is provided for measurement of the grounded-emitter current gain cut-off frequency. About the same size as and looking rather like an ordinary oscilloscope, the Tektronix(L) 575 allows the display from zero of literally almost any two transistor parameters against variable steps in a third. The display may be limited by a number of alternative load-lines.

Oscilloscopes.—An inexpensive storage oscilloscope shown by Wandel and Goltermann(S) uses crystalline potassium chloride on a mica film backed by a semiconductor as the storage screen inside the cathode-ray tube. The electron beam converts potassium ions into atoms which form blue colour centres which can remain visible for days. The trace can be erased within 20 secs by the heating action of current passed through the semiconductor. The frequency range is 0 to 10kc/s.

A number of Tektronix(L) oscilloscopes were shown. The 536 is used for tracing the relationship between two inputs, and so has no time base. The X and Y d.c. amplifiers have a rise time of 35mμsec and a relative phase shift of not more than one degree at 15Mc/s. The 551 is a double beam d.c. oscilloscope with the fast rise time of 12mμsec and the wide sweep rate range of 0.02μsec/cm to 12sec/cm. The wide variety of triggering arrangements include an automatic setting for signals from 60c/s to 2Mc/s. A feature of the 535 is the possibility of delaying the sweep from 1μsec to 0.1sec, with a time jitter of less than 1 part in 20,000, to examine part of a complex signal.

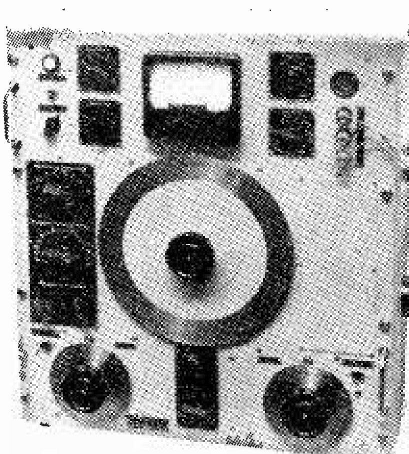
Oscilloscopes developed especially for testing television transmission equipment were shown by Faraday Electronic Instruments and Marconi. In the Marconi TF1277 the time base can be triggered by the frame sync pulse and delayed to permit examination of individual lines. It can also be expanded up to 50 times. Parts of the waveform away from the zero level can be linearly magnified (windowing) to enable the black level stability to be measured to within ±1 per cent of peak white. Differential facilities enable hum to be measured as low as 54dB down on the peak signal. Hum on the earthy side of unbalanced input signals is automatically rejected by the same amount; and its effect may be still further reduced by clamping the input signal at the black level or sync bottom.

Microwave Equipment.—Wideband 3cm reflected power display equipment was shown by the G.E.C. The frequency of a "Carcinotron" backward wave oscillator is swept using the mains supply from 20Mc/s up to 7,500 to 11,000Mc/s as required; its output being stabilized by sampling a fraction from a directional coupler and feeding it back to the "Carcinotron" grid. The power reflected from the unknown impedance is sampled from another coupler. The display is calibrated by viewing a standard mismatch. Similar equipment is available in coaxial line for the 2,400 to 4,000Mc/s band.

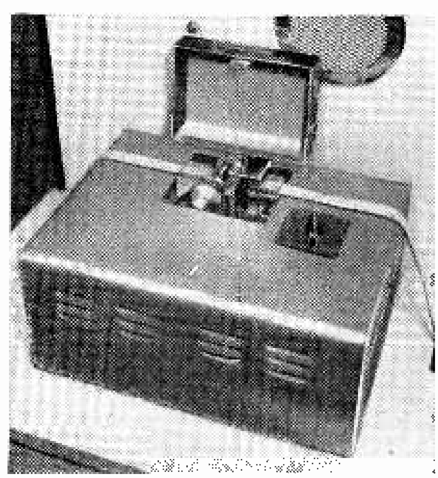
A comprehensive power and frequency measuring radar test set (SGM122) and high-speed oscilloscope (SGM120/01) were part of a very wide range of wideband equipment for 3cm shown by Philips.

Computers

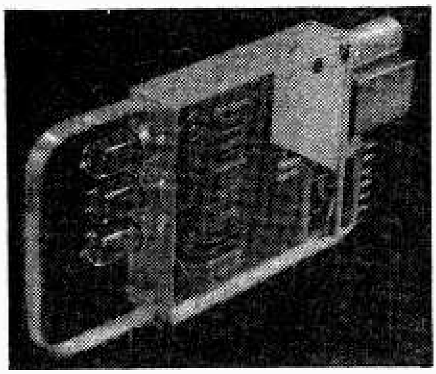
Digital input/output mechanisms were represented by two new developments—a punched paper tape reader by Metrovick and a fast serial print-out machine by Hollerith. The Metrovick tape reader uses phototransistors for sensing the rows of holes across 5-channel paper tape and operates at speeds up to 250 rows per second. It has a novel type



Radiometer(S) HO12W b.f.o for sound distribution and reverberation time measurements.



Metrovick punched paper tape reader.



Plug-in d.c. amplifier from Short analogue computer.

of drive mechanism based on continuously rotating rollers and brake blocks, controlled by a moving-coil actuator. This actuator is in turn controlled through a transistor amplifier from the sprocket holes on the tape and from "read" pulses from the computer.

In the Hollerith experimental print-out mechanism the letters or numbers are formed in sequence on a narrow moving paper tape by means of electromagnetically-operated styli, each of which makes a dot through inked ribbon at a particular place in a rectangular frame. There are 35 styli in 7 x 5 formation, and by selecting suitable combinations of these any characters can be built up from the patterns of dots. The selection for particular characters is done electronically by a selenium-diode coding matrix, which sends signals to thyratrons operating the styli electromagnets. Each stylus can be operated in 3 milliseconds, and a printing speed of 160 characters per second is possible. The paper tape moves at up to 20 inches per second.

A digital differential analyser shown by the Royal Aircraft Establishment is intended to be used for simulation work on control systems in the same way as an analogue computer, but has the greater accuracy of a digital machine. It also makes possible the precise repetition of results. The basic element is a device which performs approximate integration by finite differences—roughly analogous to the principle of totalling squares on graph paper underneath a curve. Several such integrators are required for solving differential equations, and each integrator has storage registers associated with it for holding the running totals of increments which occur in the process. There is, however, only a single computing circuit, which is used in turn by the integrators as it would be too expensive to provide one for each. Because all the quantities are handled as pulse counts the digital differential analyser can generate functions of any variable and not merely functions of time as in the time-dependent analogue machine. The example on show was actually a slow computer using electromechanical relays, but it demonstrated the principle of a fast electronic version being built by R.A.E.

Analogue computing equipments are tending towards greater simplicity and cheapness to cater for the growing market of educational establishments and small firms who cannot afford large and expensive general-purpose computers. Firms are beginning to realize, in fact, that there is no point in trying to produce a truly general-purpose machine since most users' requirements are specialized or restricted to a certain field. The tendency, therefore, has been to manufacture either small desk-type machines of limited capabilities or separate computing elements from which complete equipments can be assembled on the "build-it-yourself" principle. Both Elliott and Short Brothers were showing desk-type d.c. analogue machines, the first with ten operational amplifiers and the second with four, while Solartron displayed a whole range of computing units, including d.c. amplifiers, linear and non-linear computing elements, multipliers, function generators, power and reference supplies, digital voltmeters and control and patch panels. Newcomers to the field are Airmec, who showed a console-type machine intended for the same market, and E.M.I., whose bench-size computer is based on experience gained with control-system simulators for guided weapons. Printed circuits were a common feature of practically all the machines on show, and the system of making d.c. amplifiers as flat plug-in units, like books in a bookshelf, has become almost universal.

Materials and Components

The good electrical properties of some organic polymers (polyethylene, polystyrene, etc.) make them almost indispensible in modern electronics apart from their myriad other uses. All these polymers have, however, an outstanding disadvantage—they melt or become soft enough to "creep" at relatively low temperatures. Improvements have been made in the case of polythene by lengthening the molecule, but only to the extent that polythene is now available which will withstand a temperature of about 100°C without deterioration. The polymer type of insulant obviously has many advantages from the manufacturing point of view and a polymer which possesses reasonable electrical properties up to 500°C or so is a very valuable material indeed.

Phosphorus - nitrogen polymers with a volume resisivity of 10^8 ohm-cm at 450°C and a permittivity of 7.0 at 1Mc/s and 25°C were shown by the Royal Radar Establishment, Malvern, on the Ministry of Supply stand.

These inorganic compounds fall into two main groups—cyclic polymers of phosphonitrillic chloride and linear types. Most of these polymers have limiting temperatures in the range 500°C to 800°C. A typical linear polymer starts its life as phosphoryl chloride ($POCl_3$). This is converted to magnesium diamidophosphate, which, when heated to 600°C, polymerises, forming magnesium polyphosphate. Sodium diamidophosphate polymerises during a vacuum-drying process at 200°C. (This work was carried out by the Plessey Co., Ltd., under contract to R.R.E., Malvern.)

James A. Jobling were showing pressed glass preforms under the name "Multiform" and metallic oxide film resistors to RCS (provisional) 114. The technique of making glass preforms is mentioned in the review of the R.E.C.M.F. exhibition—it is sufficient to say here that they have many advantages over moulded glass shapes when used as bases and electrode supports for valves and cathode-ray tubes. The metallic oxide film resistors are made by coating a tin compound on to a "Pyrex" brand glass rod. This coating is fused into the glass surface forming a stannic oxide resistance element and a spiral cut is made in the fused surface until the required resistance value is obtained. Heavily silver-plated brass end caps are fitted and fired to silver bands on the end of the element, and the whole is coated with a moisture-resistant silicone varnish and baked. The noise level is comparable with a wire-wound resistor and long-term stability and initial accuracy are good.

Jobling are also producing a special dielectric glass for capacitors required to work at high temperatures.

London Audio Fair

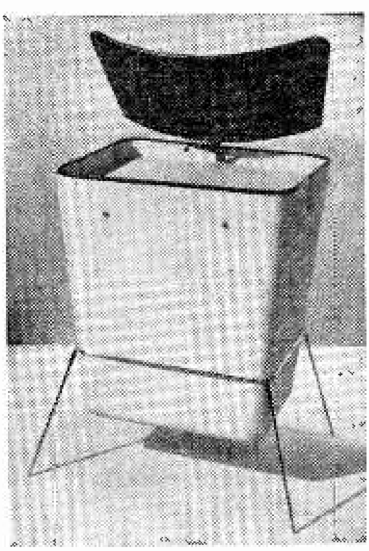
RECENT TRENDS IN SOUND REPRODUCTION

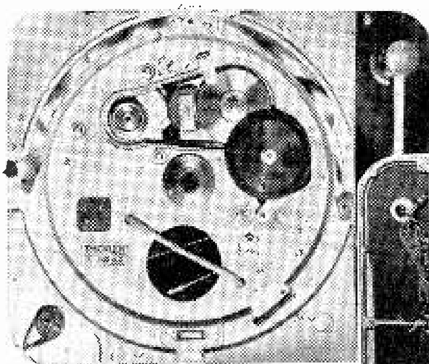
DEMONSTRATIONS of two-channel stereophonic records using the 45/45 system were the main feature of this year's fair. The quality of reproduction was very variable, both as regards the stereophonic definition achieved and the distortions in each individual channel.

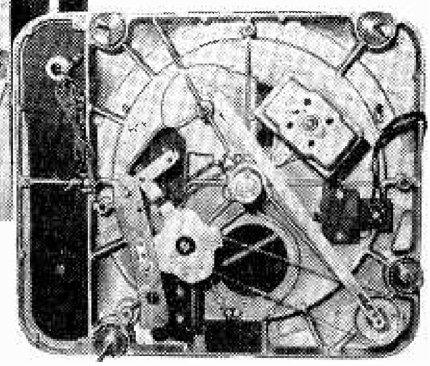
Pickups—Most manufacturers were showing new models for stereophonic records, though often only in a prototype form. These were usually designed to play 45/45 records directly, instead of using a vertical/lateral pickup and adding and subtracting the two outputs to convert them to the outputs which would be obtained with a similar 45/45 pickup.

A design method for stereo pickups, which can be used with all types of transducer, is to couple the stylus to the two transducers by two links which can swing at right angles to their length. These links are positioned at right angles to each other and parallel to the two record modulation directions. Modulation in one of the two directions should then move only one transducer owing to the transverse freedom of the connecting link to the other transducer. This method was used in the Cosmocord and Burne-Jones crystal

CQ Q-flex loudspeaker with flexing walls.







Thorens TD124 record player (shown by Lowther). Top view (left) with turntable removed and (below) underside.

pickups, and also the Westrex moving-coil pickup.

For variable reluctance stereo pickups an alternative design method is possible. If the two magnet gap systems are at right angles and parallel to the two modulation directions, the moving-iron elements may be directly joined to the stylus. Modulation in one of the two directions will then alter the length in only one of the gap systems since the moving-iron element in the other gap system moves at right angles to the gap length. This method was used in the Tannoy and Goldring pickups.

A somewhat similar method is possible with moving-coil pickups where the two magnetic fields in which the two coils move are at right angles to each other. In this case, modulation in one of the two directions moves one coil at right angles to the magnetic field (inducing an output voltage), and moves the other coil parallel to the magnetic field (which does not produce any output).

The Tan II version of the Burne-Jones arm uses new point contact bearings. The pedestal mounting for the two fixed pivots has also been modified so that the maximum tracking weight now occurs at the innermost grooves where the recorded accelerations are generally greatest. The small change in tracking weight as the pickup moves across the record arises because the vertical moment of the arm and head about the suspension alters owing to the relative movement of the two linked rods.

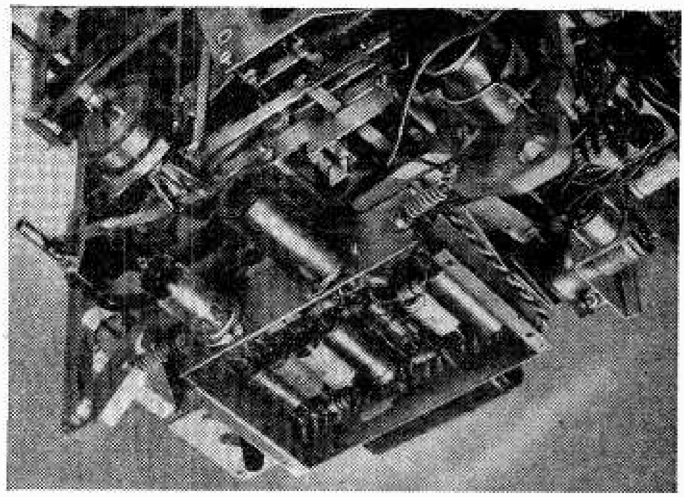
Loudspeakers — A uniform polar response in a horizontal plane was generally favoured for stereophonic reproduction.

A reduction of the space or at least the floor area taken up by a loudspeaker is desirable if two are being used as in stereophony. If the cabinet is made taller its volume need not be decreased so much. This latter approach was adopted by Whiteley in their new square column speaker with four reflex ports at the bottom. In this system the speaker faces up towards a diffuser. An example of the more usual overall reduction in cabinet dimensions was a very small resistively-loaded reflex cabinet shown by Pamphonic.

Cabinet vibration is generally considered a serious disadvantage in a loudspeaker system. It is, however, deliberately used in the CQ Q-flex (shown outside the fair) to give increased radiation and sound source size at low frequencies. This, it is claimed, gives greater loading on the speaker and acoustic damping. An asymmetrical cabinet is used as its structural resonances are more numerous. The 9×5-in elliptical speaker and two 4-in diameter tweeters radiate upwards on to an adjustable diffuser.

Turntables and Records—There are several unusual features in the Swiss Thorens TD124 turntable shown by Lowther. The four-speed stepped pulley is not on the motor shaft but driven from it by a rubber belt. This further reduces motor vibrations which might otherwise be transferred via the stepped pulley and rubber idler wheel to the turntable. The turntable is an 11½-lb cast-iron main flywheel which is covered by an aluminium top. This top can be raised and stopped to change the record while the iron turntable continues to rotate underneath. The weight of the iron turntable being much greater than that of the top, the correct speed is reached almost immediately the top is lowered again. A magnetic eddy current break can give speed variations of up to ±3%. The braking action is varied by a movable iron vane. Major changes of speed can be obtained by adjusting the magnet position.

There are a number of useful test frequencies on an American Sound Corporation record now being pressed in this country for distribution by the *Gramophone Record Review*. For example, a repeated glide tone from 300 to 20 c/s with markers every 50 c/s is designed for locating panel resonances and adjusting ports in loudspeaker reflex cabinets. A maximum-level glide tone from 20 kc/s to 20 c/s is useful for finding pickup resonances; whereas a normal-level glide tone from 15 kc/s to 20 c/s can be used to match loudspeakers in multi-speaker systems and also to locate any resonances in them. Residual noise can be checked from a 1,000-c/s tone recorded at 0.007 cm/sec. The advice given of using the record at dealers to reveal faults in equipment being considered for purchase is likely to lead to many surprises.

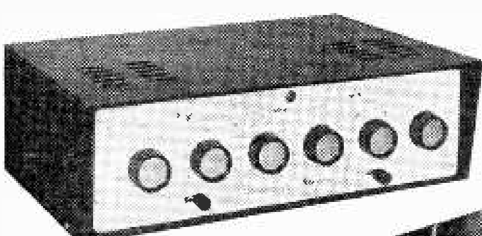


Part of interior of the Simon SP/4 tape recorder showing anti-vibration mounting of low level valve stages.

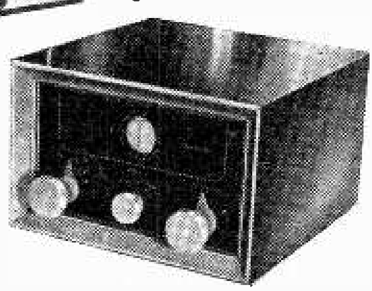
Tape Recorders and Accessories—In an exhibition where probably most of the visitors are not professionally engaged in sound recording, it is surprising how many mixers are shown. New models were exhibited by Associated Electronic Engineers (Astronic), Spectone, Grundig and Lustraphone, the last being a transistor model.

A one-inch diameter cathode-ray tube is used to provide indication of the peak recording level and also the bias and erase voltages in the Audiomaster Tape Adaptor. A push-pull oscillator is used. Owing to the cancellation of even harmonic distortion, such oscillators produce an almost pure a.c. signal with very little d.c. component, and thus reduce the noise level on the tape. The use of such oscillators in tape recording is becoming more popular, even to some extent in relatively inexpensive models such as the Sonomag 46 (which uses the latest Motek deck). This model also illustrates another trend in the tape recorders shown; the provision of 1⅞ in/sec as the slowest of three speeds.

In the new Telefunken 65X series (demonstrated near the fair by Welmec), the response is claimed to be only 4dB down at 8000 and 14,000 c/s for tape speeds of 1⅞ and 3¾ in/sec respectively. The braking action on these recorders is sufficiently gentle to permit the use of tape of half the standard thickness. 1,200 ft of such tape is accommodated on the 5-in diameter reels available.



Left: Pamphonic 3000 stereophonic combined amplifier and pre-amplifier.



Below: Audiomaster tape oscillator, recording compensation and level indicating unit.

A new high-quality tape recorder shown by Simon has a push-pull oscillator. The bass and treble tone controls can be used either while recording or replaying. Independent mixing is possible from three inputs, one of these being for a 30-ohm microphone. The revolution counter is actuated by the rotation of one of the two tape guides, rather than more usually by the rotation of one of the spools. Thus the indication of the length of tape traversed is given directly.

If an in-line stereophonic tape head is to be used for the reproduction of standard dual-track, single-channel recordings, the crosstalk requirements are much more stringent than for stereophonic recordings. This is because with such single channels the other tape track will probably be recorded with quite different and possibly higher-level material. The low crosstalk figure of 50dB quoted for the Reflectograph head (now manufactured by Multimusic) suggests that this, in fact, could also be used for such single channels.

Pre-amplifiers and Amplifiers—A number of two-channel amplifiers for stereophony were already shown at last year's exhibitions. The only essential differences from two separate units lie, of course, in the control ganging, channel switching and balancing arrangements. The channel balancing control seems to be generally placed at the front where it provides yet another knob to be mismanaged by the unskilled. An exception was noticed in the

Astronic A1434 where the adjustment range was ±6dB. A similar range was provided in most other models, though in some cases it was infinite. While an infinite adjustment caters for the use of amplifiers or loudspeakers of widely differing sensitivities in the two channels, the fine adjustments of a few dB which are required for units of nominally the same sensitivity are then more difficult to make, and dissimilar units could be allowed for by a large fixed and small variable adjustment.

Useful two-channel switching arrangements, seen for example in the Dulci pre-amplifier, allow selection of either channel (possibly to be fed to both loudspeakers); or the addition of both channels, which would be required for playing ordinary single channel records with a 45/45 two-channel pickup. Two other useful switches on the Pamphonic 3000 allow the phase of one of the channels to be reversed with respect to the other, or alternatively the two channels to be interchanged. Thus two likely mistakes in connecting units together can be corrected with a minimum of difficulty.

The amount of data supplied on the various exhibits was if anything even more variable than usual. For example, we collected a tape-recorder leaflet which did not even give the possible tape speeds. On the other hand, the data given on the very comprehensive new Astronic A1432 control unit include graphs of the frequency responses given by the various controls, signal-to-noise ratios even for the highest sensitivity inputs, and the required input and output voltages and impedances. These last data are of course very important for considering the interconnection of different units.

The ear of course must be the final judge, but as usual the crowds almost completely prevented any relaxed listening. Relaxed viewing was, however, quite possible owing to the welcome continuation (not a new trend!) of the use of programme sellers who were very "easy on the eye".

SELECTIVE PAGING

Radio System Using Amplitude and Frequency Modulation

A NOVEL u.h.f. paging system by means of which people in any part of a building having one of the special receivers can be called individually and confidentially has been introduced by the Page Boy Company, a division of Cotterill-Ginn, Ltd., 13, Suffolk Street, London, S.W.1. As the block schematic diagram shows, the installation consists of four items; i.e., radiator supply unit, modulator, r.f. unit and pocket receiver. One or more modulators can be included to enable selected executives of the company or organization to call personally individual members of the staff.

Radiation takes place on a frequency of 465Mc/s, the u.h.f. carrier being amplitude modulated by a supersonic frequency which in turn is frequency modulated by a calling tone or by speech. The number of independent receivers in the system is governed by the product of the number of a.f. calling tones employed and the number of supersonic coding frequencies in the range 25kc/s to 50kc/s that can be used. The maximum number with the present equipment is 144, provided by 24 coding frequencies and 6 calling tones.

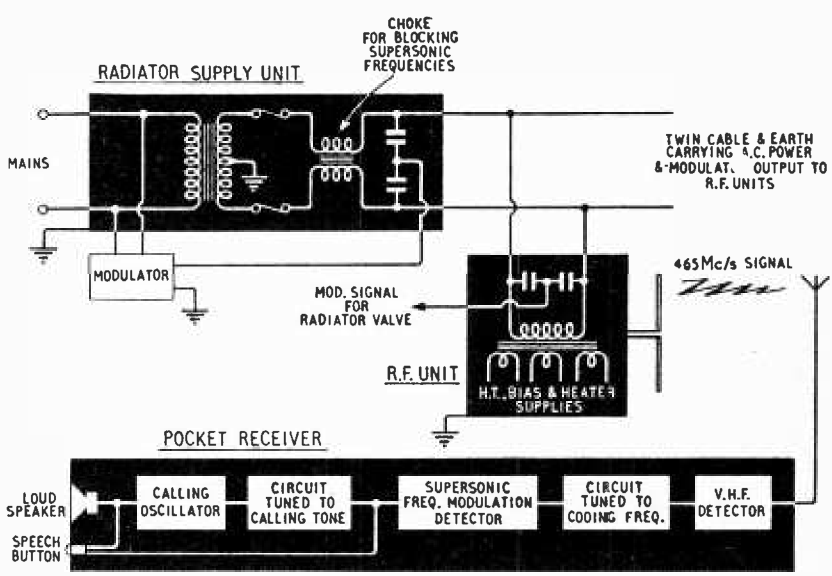
The r.f. units are simple, self-oscillating, push-pull stages with h.t. rectifiers and the oscillators are normally held quiescent by a large negative grid bias. Application of the supersonic modulation cancels the bias on positive peaks and pulses of r.f. are radiated on which is superimposed either the selective calling tone or speech. The effective range is stated to be 40 to 50 yds.

Pocket receivers, which measure only $5\frac{3}{4} \times 2\frac{3}{4} \times 1$in, employ printed circuits and transistors. The signal is received on a broadly-tuned aerial system and the sub-carrier is extracted by a silicon crystal detector. All the circuits, except the aerial, therefore have to deal only with the supersonic sub-carrier, the a.f. calling tone or the modulation. Some idea of the receiver layout can be gleaned from the block diagram.

A novel feature of the receiver is that the incoming calling tone is used to trip a quiescent audio oscillator, which provides the actual calling tone.

The receiver is powered by four "Deac" (nickel-cadmium) accumulator cells and when the receiver is not in use this battery is charged via a built-in germanium diode.

Block schematic diagram of the Page Boy selective calling system.



Measuring TV Aerial Performance

3.—Impedance Measurements

By *F. R. W. STRAFFORD**, *M.I.E.E.*

(Concluded from page 123 of March issue)

THE previous parts have shown that accurate and consistent measurement of aerial gain and directivity required an extensive site substantially free from reflections. The measurement of aerial impedance, and mismatch effects involving the feeder, does not require such onerous conditions and a smaller site, and the presence of reflecting objects, can, within certain tolerances, be permitted.

At television frequencies a simple and highly efficient aerial is the dipole (Fig. 10). The equivalent circuit (Fig. 10(b)) is a series combination of L, C and R. In the conventional receiver tuned circuit these parameters are substantially independent of frequency. Hence, a single measurement of the magnitude of each enables us to plot the impedance curve on the basis of simple calculation, and from this curve predict the effective bandwidth available for handling a desired range of signal frequencies. The dipole, on the other hand, displays marked variations of R (its radiation resistance) both as regards variation with frequency and with height above ground. The effect of the latter may also include the effect of neighbouring conducting, or partly conducting, obstacles such as buildings and personnel. If the aerial is erected about one wavelength above ground, and two or three wavelengths from reflecting objects, the terminal impedance measured between x and y (Fig. 10(a)) will be largely unaffected by these factors. But measurement of the dipole terminal impedance cannot be made without connection to the measuring apparatus, and this must be made through a length of low-loss feeder. This brings us to consider whether there is any point, other than academic, in measuring the terminal impedance because the feeder is always a practical requirement and in any event exercises a greater influence upon the actual impedance as viewed by the receiver input (or transmitter output) than the normal variations inherent in the aerial.

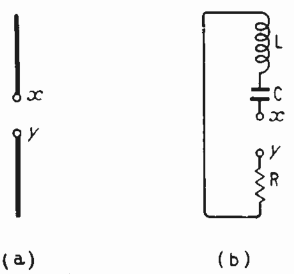


Fig. 10. The equivalent circuit of a half wave dipole (a) is shown in (b).

The general problem is shown in Fig. 11 where the aerial terminal impedance Z appears at the far end of a feeder of characteristic impedance Z_o and length x. The magnitude of the input impedance, Z_i, may be obtained from classical transmission-line theory and is given by the somewhat complicated expression:—

$$Z_i = \frac{Z_o(Z+Z_o \tan h\ Px)}{Z_o+Z-\tan h\ Px} \quad \ldots\ldots\ldots \quad (8)$$

where $P=a+jb$, a is the term due to the resistive losses of the feeder, and b is equal to $\frac{2\pi}{\lambda}$.

Providing that the feeder losses are low, say not more than 1dB, the expression may be simplified to:—

$$Z_i = \frac{Z_o\left(Z+jZ_o \tan\frac{2\pi x}{\lambda}\right)}{Z_o+jZ\tan\frac{2\pi x}{\lambda}} \quad \ldots\ldots\ldots\ldots\ldots \quad (9)$$

It is more convenient to put $\frac{2\pi x}{\lambda}$ in its angular form θ for as x is varied θ varies from 0 to 360 degrees.

So the expression to be studied is:—

$$Z_i = \frac{Z_o(Z+jZ_o \tan\theta)}{Z_o+jZ\tan\theta} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

This is a most fascinating expression and the reader may wish to interest himself in evaluating Z_i for the following conditions:— $Z=0$, $Z=\infty$, $\theta=0, \frac{\pi}{4}, \frac{\pi}{2}, \frac{3\pi}{2}$ and 2π.

Particular interest resides in the conditions when θ is respectively $\frac{(2n-1)\pi}{4}$ and $\frac{n\pi}{2}$. This corresponds to lengths, x, of feeder of *odd* quarter wavelengths,

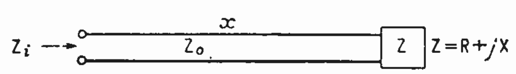


Fig. 11. Aerial feeder of characteristic impedance Z_0 terminated in an impedance Z.

or even *multiples* of half wavelengths. The following very interesting results are obtained:

Odd quarter wavelengths of feeder:—

$$Z_i = \frac{Z_o^2}{Z} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

Even half wavelengths of feeder:—

$$Z_i = Z \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

In the former case the influence of the characteristic impedance, Z_o, of the feeder is most marked, while in the half-wave multiple condition the feeder has no effect whatever on the input impedance. Use is

* Consulting radio and electronics engineer.

made of these two unique properties of the feeder. A quarter-wave feeder may be used deliberately to transform, or match, an aerial to its main feeder. For example (from equation (11)), if the characteristic impedance of the main feeder is Z_i, and that of the aerial is Z, then the impedance, Z_0, of a quarter-wave section to give perfect matching is given by $Z_o = \sqrt{Z.Z_i}$.

On the other hand, if the terminal impedance of the aerial is desired, the influence of the connecting feeder may be removed completely if it is one or more wavelengths long. If the terminal impedance is to be measured over a range of frequencies it is a tedious matter to cut the feeder to the correct length for each frequency. It is, of course, possible to calculate the terminal impedance, Z, from equation (10) but this is even more tedious.

Fortunately, a very elegant graphical method exists[1] whereby the impedance may be corrected for the length of feeder. That is to say, if Z_i is measured and the length of the line is known, the terminal value of Z may be obtained at a glance. The length of the line is, of course, not the physical length, but the electrical length which depends upon the type and amount of dielectric between the conductors. The electrical length is obtained by dividing the physical length by the square root of the effective dielectric constant of the insulator. The graphical method also permits the inclusion of the feeder loss to give greater accuracy.

It is beyond the scope of this article to try to explain the theory of the construction of the chart of which an example is shown in Fig. 12. In this chart the circles whose centres lie on the resistive component axis correspond to constant values of resistance, and the arcs of circles whose centres lie on an axis perpendicular to the resistance axis

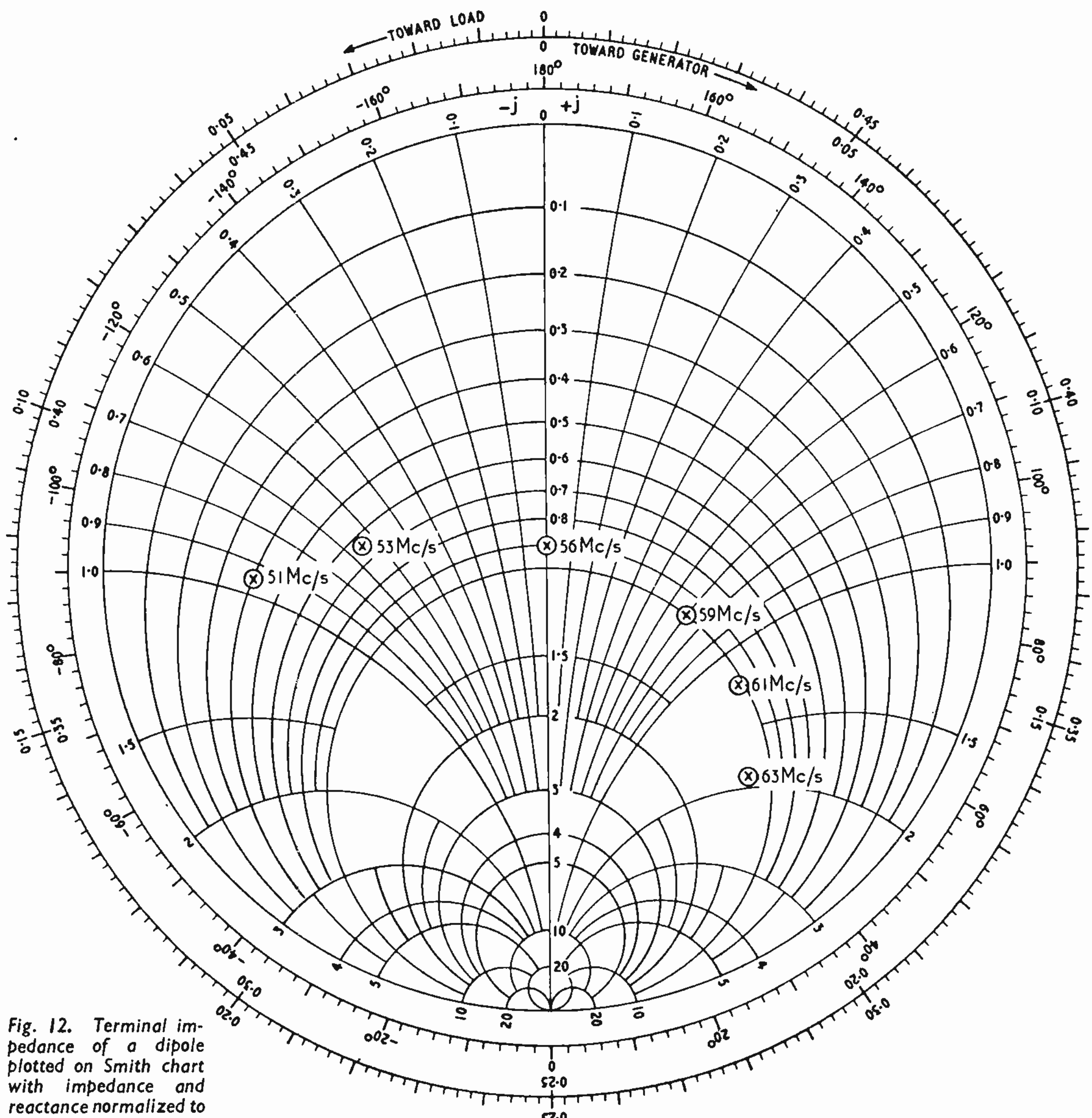


Fig. 12. Terminal impedance of a dipole plotted on Smith chart with impedance and reactance normalized to 75 ohms.

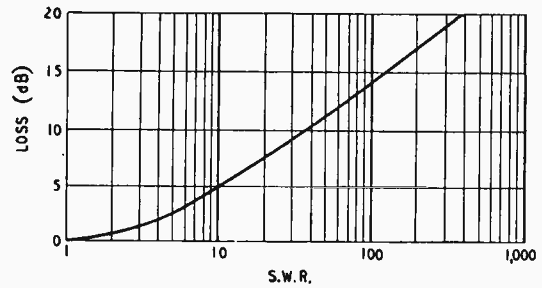


Fig. 13. Relationship between r.f. power loss and standing-wave ratio.

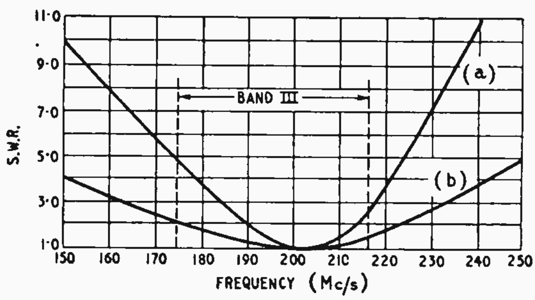


Fig. 14. Frequency/standing-wave ratio characteristics on Band III of (a) plain dipole, (b) folded dipole.

correspond to constant values of reactance, positive or negative. Thus the chart covers all values of impedance from zero to infinity and the position of a point corresponding to any given complex impedance may be found from the intersection of the resistance and reactance co-ordinates corresponding to the resistive and reactive components of the unknown impedance. The reader whose work entails much measurement of this kind will know how useful the Smith chart is. Also, how very difficult to explain to the uninitiated! A typical plot of the terminal impedance of a dipole is included in Fig. 12.

The characteristics were measured through a length of 75-ohm coaxial feeder and corrected for its effect at each frequency so that the true terminal impedance of the aerial was measured. The chart is normalized with respect to the feeder impedance so that each value must be multiplied by 75 ohms to obtain the resistance or reactance. For example, at 56Mc/s the dipole is resonant, the reactance is zero and the resistance 67.5 ohms. At 51Mc/s the reactance is 71 ohms (negative), and the resistance 30 ohms.

The need for measurement of aerial impedance is chiefly, if not wholly, concerned in practice with determining the loss of signal transfer due to the mismatch between the aerial and feeder impedances. Irrespective of the feeder length this mismatch loss may be determined by measuring Z_i on apparatus which gives the resistive and reactive components separately. If the terminal impedance of the aerial is not resistive, or not equal to the characteristic impedance of the feeder, a standing wave of voltage is set up by reflection. The reflection coefficient, K, which varies between zero and unity is related to the standing-wave ratio, σ, by the expression:—

$$\sigma = \frac{1+K}{1-K} \qquad (13)$$

The value of the reflection coefficient can be calculated from the known value of the feeder impedance, Z_o, and the measured input impedance, Z_i. It is much more desirable, however, to measure the admittance, Y_i, and most bridges or similar apparatus for this purpose measure directly the conductance G_i, and susceptance B_i, such that $Y_i = G_i + jB_i$.

In this case the characteristic impedance now becomes the characteristic conductance, G_o. If the admittance bridge measures G_i and B_i separately, then, independent of the feeder length, providing its losses are low, the reflection coefficient may be calculated from:—

$$K = \sqrt{\frac{(G_o - G_i)^2 + B_i^2}{(G_o - G_i)^2 - B_i^2}} \qquad (14)$$

from which the s.w.r. may be derived from equation (13).

Having obtained the s.w.r. the loss of signal power due to the mismatch may be obtained from the formula:—

$$\text{Loss in dB} = 10 \log_{10} \frac{(1+\sigma)^2}{4\sigma} \qquad (15)$$

This relationship is plotted in Fig. 13. It will be seen that a fairly moderate degree of mismatch is permissible before any serious reduction in power transfer takes place. A two-to-one mismatch

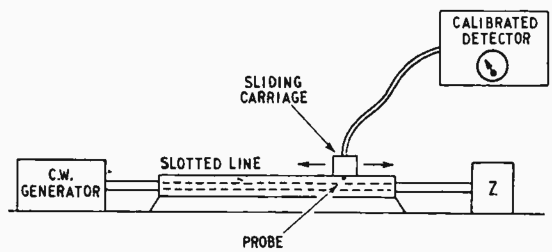


Fig. 15. Basic arrangement of a slotted line for standing-wave ratio measurement.

results in only 0.5dB loss of power. If the mismatch does not exceed four-to-one the power loss will not be greater than 2dB and is the sort of figure to be aimed at if a multi-channel TV aerial is being designed. Fig. 14(a) is a plot of the frequency/s.w.r. characteristics of a simple Band-III dipole working into a correctly terminated 75-ohm coaxial feeder. Curve (b) is the characteristic for a folded dipole working into a 300-ohm feeder as is standard practice in the U.S.A. The improvement is apparent and the long-lived 75-ohm feeder standard of this country does make it difficult to design really wide-band aerials so that rationalized stocks can be held to cater for the three channels already in use on Band III, bearing in mind that the remaining five are bound to be released one day.

If this curve (Fig. 14) is replotted as a curve of dB loss against frequency (with the aid of Fig. 13) the resultant is *not the variation of gain with frequency.* The directivity of most types of multi-element aerials varies considerably with frequency so that

(Continued on page 297)

the pick up might occur at a minimum several dB down from the major lobe response. On the other hand, the mismatch between aerial and feeder *is independent of the directivity*. Thus, while the s.w.r./frequency curve shows the power loss due to mismatch, no wider significance attaches to it, and it should be accompanied by a curve relating gain and frequency with the aerial fixed on the bearing for maximum gain at the design frequency.

The standing waves launched onto a feeder, due to mismatch, have their maximum and minimum amplitudes spaced exactly one quarter-wavelength apart successively along it. These are the electrical distances which, as previously explained, are related to the physical distances in terms of the magnitude of the di-electric (permittivity) constant of the feeder insulation.

The s.w.r. may be measured directly by the slotted-line technique[2] shown in Fig. 15 in which power at the desired frequency is fed into an air-spaced coaxial line carrying a longitudinal slot over most of its length. A sliding carriage, carrying a probe, which is capacitively coupled to the inner conductor, is used to explore the s.w.r. over the length of the line. The output from the probe is rectified and suitably displayed. The unknown impedance is connected through its own feeder to the remote end of the slotted line and the carriage is simply slid along to a maximum rectifier output, which is noted. The same process is repeated for a minimum output, from which the ratio is calculated after correcting for the non-linear characteristics of the rectifier. The latter need not be done if a standard signal generator is used as the source of power. The rectifier output is then maintained constant and the s.w.r. measured direct in terms of the attenuator settings on the signal generator. In this case, however, the latter should be capable of providing at least 0.5 volt into the slotted line as the pick up by the probe is small. It has to be loosely coupled or errors in the determination of s.w.r. will be present. Of course, the impedance of the slotted line has to be accurately matched to the feeder impedance and since the mechanics of its design necessitate an overall diameter of about 1.5in the input and output connections are gradually tapered down to the diameter of the feeders from the signal generator and to the unknown load impedance. The slotted-line technique is very well suited for Band-III measurements since the separation between successive maxima and minima is only about 16in at the lowest frequency. On the other hand, the separation at 45Mc/s is about 70in, and the design of an accurate slotted-line of this length involves many mechanical difficulties concerned with the accurate maintenance of coaxiality between the inner and outer members, and the constancy of spacing of the sliding probe in relationship to the inner member. For these reasons it is usual to employ the bridging, or similar null-producing techniques, for the purpose. If both bands, not forgetting Band II, are to be covered economically, bridging methods are to be preferred, since one bridge can cover all the frequencies involved.

Fig. 16 is a photograph of an arrangement for the measurement of the admittance of a typical Band-III TV aerial.

The General Radio admittance bridge is shown in the centre. The length of rigid coaxial feeder extending from the right hand of the meter is constructed so that its length may be varied. By this means the total feeder length may be maintained at an integral multiple of half-wavelengths between the instrument and the load so that the readings are independent of the feeder characteristics. The preliminary setting up consists of disconnecting the feeder from the aerial and adjusting the trombone to half extension. The output from the signal generator is adjusted to the centre of the frequency range of the measurements, and the conductance and susceptance arms of the bridge are set to zero, and the range multiplier to unity. Short pieces of feeder are cautiously snipped off until the bridge is balanced, as shown by a null reading on the detector to the right of the photograph. If one has overstepped the cutting process exact balance may be retrieved by slight adjustment of the trombone

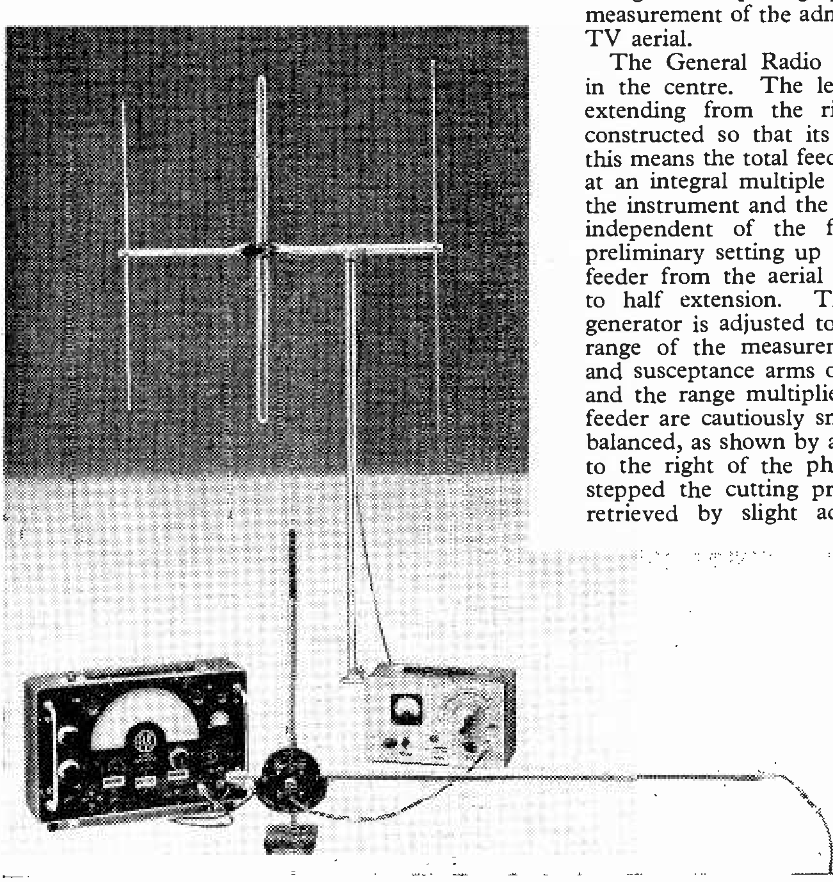


Fig. 16. Arrangement of equipment for measurement of admittance of typical Band-III aerial system. In practice the aerial is higher than shown and about 15ft away.

section. The aerial is reconnected and the bridge is balanced for the conductance and susceptance of the aerial. The frequency is changed, the aerial disconnected, while the trombone is readjusted for zero conductance and susceptance, and then reconnected for the next measurement. This somewhat tedious procedure is eliminated if the trombone technique is omitted and the Smith chart used, but quite a lot of tabulation is required prior to plotting the final result on the chart, since the true electrical length of the feeder must be known at each measurement frequency.

REFERENCES

[1]Smith, P. H. "Transmission Line Calculator". *Electronics*, January 1939, Vol 12, p.29.

[2]Willis-Jackson, F. "High Frequency Transmission Lines" Monogram Series. Methuen.

Books Received

Glossary of Terms Used in High Vacuum Technology. British Standard 2951; 1958. Pp. 29. Price 7s 6d. British Standards Institution, 2, Park Street, London, W.1.

Proceedings of the XIIth General Assembly of U.R.S.I. (Boulder, Colorado, U.S.A., August 22nd-September 5th, 1957.) Volume XI, Part 1, Commission 1 on radio measurements and standards. Pp. 78. Price 100 Belgian Fr., 14s 6d, or $2. General Secretariat, U.R.S.I., 7, Place Emile Danco, Uccle-Bruxelles, Belgium.

Quality Amplifiers for A.C. Mains (Data Book No. 11) gives constructional data on seven amplifiers with tone controls, including two "Mullard" designs, and also compensation circuits useful in record reproduction. Pp. 64; Figs. 55. Price 4s 6d. Data Publications, Ltd., 57, Maida Vale, London, W.9.

Radio Upkeep and Repairs, by Alfred T. Witts. Eighth edition includes additional chapters on f.m. receivers, transistor circuits and printed circuits. Pp. 234; Figs. 174. Price 15s. Sir Isaac Pitman and Sons, Ltd., Parker Street, London, W.C.2.

Sound, by Alexander Efron. Elementary pictorial introduction to the physical and physiological bases of acoustics. Pp. 72; Figs. 62. Price $1.25. John F. Rider Pub., Inc., 116, West 14th Street, New York, 11. Obtainable in this country from Modern Book Co., 19-23, Praed Street, London, W.2. Price 9s 6d.

How Television Works, by W. A. Holm, non-mathematical treatment of transmission and reception starting from basic physical ideas extends to such details as pick-up and cathode ray tubes, aerials, types of sound and vision modulation including synchronizing wave-form, valve oscillators and pulse generators and receiver circuitry. Pp. 318; Figs. 246. Price 32s 6d. Cleaver-Hume Press, Ltd., 31, Wright's Lane, London, W.8.

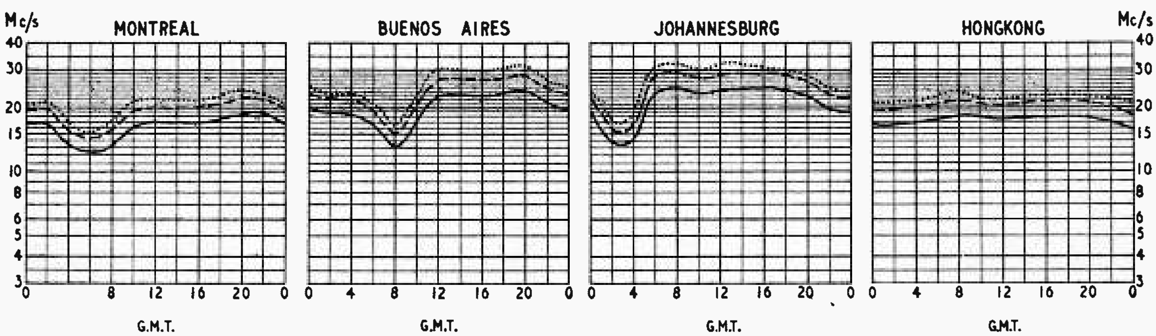
Techniques of Magnetic Recording, by Joel Tall, deals primarily with uses in such fields as the recording of sounds in nature, films and television, business and industry, medicine and education. Pp. 472; Figs. 112. Price 55s 6d. Macmillan Co., 10, South Audley Street, London, W.1.

The Sources of Invention, by John Jewkes, David Sawers and Richard Stillerman discusses development of inventions and also suitable conditions for their production. Fifty examples include the long-playing record, magnetic recording, radio, television, and the transistor. Pp. 428. Price 31s 6d. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2.

Frequency Modulated Radio, by K. R. Sturley, Ph.D. Second edition of this book on the principles of f.m. transmission and reception has additional material on the counter f.m. detector. Pp. 120; Figs. 78. Price 15s. George Newnes, Ltd., Southampton Street, London, W.C.2.

SHORT-WAVE CONDITIONS

Prediction for June



•••••••••• FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

———— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

THE full curves given here indicate the highest frequencies likely to be usuable at any time of the day or night for reliable communications over four long-distance paths from this country during June.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

MANUFACTURERS' PRODUCTS

Screened Transistor Coils

TINY screened coils for use in transistor receivers are now obtainable from Channel Electronic Industries, Ltd., Dunstan Road, Burnham-on-Sea, Somerset. They measure $\frac{5}{8}$in

Channel miniature, screened oscillator and i.f. coils for transistor receivers.

diameter at the base (slightly less at the top) and are $\frac{5}{8}$in high excluding fixing lugs and connecting pins. Windings are on low-loss moulded nylon formers with ferrite pot cores and Q values of 180 are claimed.

Three coils comprise the present range, Type 735 oscillator coil, Type 736 1st or 2nd i.f. transformer and Type 737 3rd i.f. transformer. They are primarily intended for use with transistors such as the Mullard OC44 and OC45 and Siemens XA101 and XA102 and for an intermediate frequency of 460 to 470kc/s. They cost 11s 3d each.

Miniature Soldering Iron

THERE are endless jobs that demand a really miniature soldering iron especially now that electronic equipments are becoming so much smaller due to the introduction of transistors. One that is described as "pencil size" and having a bit only $\frac{3}{32}$in diameter is obtainable from Antex, Ltd., 3, Tower Hill, London, E.C.3. Known as the "Precision" miniature soldering iron it is made for use on voltages of from 6V to 230V with the consumption ranging from 8 to 15 watts. Alternative bits of $\frac{5}{32}$in and $\frac{3}{16}$in diameter can be supplied, also bits of different length, five sizes in all available.

Because bits of soldering irons are expendable and must be replaced special care is taken to ensure that the worn out bit does not stick in its holder.

Despite its small size, it is only $6\frac{1}{2}$in long and weighs under 1oz, the electric heating element is fully insulated from the iron and is housed inside a steel tube approximately $\frac{1}{8}$in in diameter.

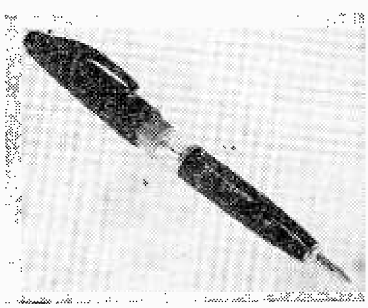
Special attention has been given to the cord grip in order to relieve the internal electrical connection of all cord strain and the lead and the element are readily replaced when

"Precision" miniature soldering iron for high- or low-voltage operation.

necessary. All irons are flash tested at 900V a.c., equivalent to 1,500V d.c. The price of the "Precision" iron is 25s for low-voltage (under 50V) models and 29s 6d for high-voltage models.

Neon Oscillator Probe

THE "Elge" Radio Pen is an elaboration of the usual neon test probe. Additional components are a 10MΩ resistor in series, and a 200 pF capacitor in parallel with the neon. The application of a d.c. voltage of a suitable polarity charges up the capacitor through the resistor until the neon flashes over and discharges the capacitor. This process is continually repeated resulting in an approximately sawtooth oscillatory output of 25V (peak-to-peak) across the neon. The time taken to charge the capacitor to the neon flashover voltage depends on the input voltage, so that



"Elge" Radio Pen.

a measure of the input in the range 90 to 300V can be obtained from the neon oscillation frequency which then ranges from 300c/s to 5Kc/s. In addition, the sawtooth oscillations can provide a signal source extending into the radio frequency region. An alternating voltage applied to the pen will produce a glow near both electrodes of the neon, and may be identified in this way. This probe is of Austrian origin, and distributed in this country by Mercia Enterprises, Ltd., Godiva House, Allesley Old Road, Coventry. It costs 24s.

RANDOM RADIATIONS

By "DIALLIST"

Rehabilitating C.R.T.s

IT'S GOOD to learn from the article in the May issue of *W.W.* and other sources that the business of giving a new lease of life to c.r. tubes, in which breakdowns are far commoner than they should be, is now being undertaken by firms employing highly skilled staffs, working in well-equipped factories. It has always seemed all wrong to me that such an expensive part of the television receiver should have to be scrapped because of such a fault as a grid-cathode short, or a burnt-out heater. Various firms have been in the business for some time, catering largely for maintenance concerns; but their work hasn't always been too good and, as the article in question pointed out, the term "reconditioning" was used to mean a number of different things. One of them, for instance, was (and probably still is) the treatment of a tube whose emission had become low by applying considerably more than the rated voltage to the heater for a spell—and that sort of reactivation is better done by the use of a booster transformer for the heater. But neither method is of much use if the cathode is in poor shape. The cathode-heater short, again, can be dealt with, if the set is worked from a.c. mains, by fitting an isolating transformer for the heater. But unless the bulb can be opened and new parts fitted a grid-cathode short spells disaster. I've no personal experience of the performance of tubes which have been expertly fitted with new cathodes and heaters and I'd be very glad to hear from any readers who have. Much must depend on the pumping. If that's well done and the phosphor is in good condition, I can't see any reason why the refitted tube shouldn't put up as good a show as a new one.

Why Valves?

WHEN Fleming brought out his diode it was natural that it should be called a valve, for its action on an electric current was similar to that of mechanical non-return valves on currents of water or steam in allowing one-way traffic only. De Forest's triode changed the whole picture. Traffic was still in one direction only, but that wasn't its main business: it could amplify and it could oscillate. But the idea that any electronic "bottle" was a valve had become so firmly rooted in this country that we call it and the far more complicated multi-electrode affairs which followed, and continue to follow, all valves. Even the magnetron sometimes gets the name. Americans call the whole lot tubes, hardly any better, for it isn't a bit descriptive and the shape of many of them is far from being tubular. The French are logical enough in using "valve" for the diode only; but they fall down rather in their term for other types, which is simply "lampe," bringing back memories of the old bright emitters of the early days. And they were bright, some of them. An early American word for the triode was Audion. I remember seeing in one of their wireless magazines of the time a picture of a man reading a book under a kind of chandelier, into which he'd built a wireless receiver, with its valves arranged in a ring round the outside. The caption was "Reading by Audion Light"! The word "condenser" is on the way out because it was such a complete misnomer. "Valve" is just as much a misnomer: can't we do something about that too? Any suggestions?

Rules of Thumb

SURPRISINGLY few useful rules of thumb came in from readers of *W.W.* in response to my request for some good ones. One of the best I've come across, though, was sent by L. F. Ivin, of the B.B.C. It concerns the reactance of small capacitors: "One hundred and sixty thousand ohms per micky-mike per megacycle"—the alliteration is rather attractive, isn't it? We'll take the case of a 100-puff capacitor at 10 Mc/s. Write down 160,000; knock off two noughts for the 100 puffs and one for the 10 Mc/s. That leaves 160Ω, which is right. And he has a better one than my "yard plus ten per cent" for the metre: A metre is 3 feet 3 inches and 3 eighths of an inch =39.375 in, which is correct within a "thou" or two. Any who have done any rifle shooting will remember the useful one: A minute is one inch at 100 yards, or one inch subtends an angle of one minute at 100 yards. Since there are 3,600 inches in 100 yards, this one is based on taking the approximate figure of 60° for the radian. One way of squaring any two-figure number in one's head which I find very handy is this: Simply bring the number to the nearest ten by adding (or subtracting) the amount needed, then multiply the number, plus (or minus, as the case may be) the same amount by this and add on the square of the number used to bring it to the nearest ten. Thus $87^2 = (87+3)(87-3)+3^2 = 84 \times 90 + 9 = 7{,}569$. In other words, $x^2 - y^2 = (x+y)(x-y)$.

Electricity Direct from Heat

SINCE the first announcement some months ago of promising results in the production of electricity directly from heat by American physicists using apparatus on the lines of the diode valve, some success has been achieved by other workers in that country. One is using thermocouple methods. At first blush that doesn't seem to be a line of approach likely to lead to worth-while results on a large scale, for the efficiency of the familiar thermocouple is very low indeed. It is, however, stated that great improvements have already been made in this and it is believed in some quarters that this method may eventually prove to be of practical use. Others are working on different forms of diode apparatus. In our own country some of the big shots in the nuclear energy field have said that experiments are coming along quite nicely; but no mention has been made of the methods tried. The problem of the direct generation of electricity from heat is bound to be solved sometime and I believe that it won't be so very long before an efficient practical system is evolved.

I.T.A. Sound on F.M.

MANY readers have kindly written to report the reception of I.T.A. sound on slightly mistuned f.m. receivers. Most of them, as I expected, live near I.T.A. transmitters, or in places where the Band III signal is strong. One whose home is some 11 miles from Croydon has a f.m. set whose i.f. is 11 Mc/s and with this he receives the I.T.A. signal by tuning to about 101 Mc/s. Thus the second harmonic of the oscillator is 2(101 − 11) = 180 Mc/s. The sound on 191.25 beats with this to give an i.f. of about 11 Mc/s. But how can a frequency-modulated set detect an amplitude-modulated signal? The accepted answer to that one is that rectification takes place in the first a.f. stage of the receiver. There are some queer and unexpected happenings in wireless, aren't there?

UNBIASED

By FREE GRID

Q. & A.

THERE was such a large number of readers who took the trouble to answer the various questions I have asked recently that I can only find space to deal with each item briefly but I should like to express my thanks to the many who wrote and for the appreciative remarks they made.

In the first place, a Canadian reader (Mr. Arthur Jackson, of Ontario) has, in my opinion, settled the question of why mains voltages are always in multiples of 11 instead of the more-to-be-expected 10. It was the fault of the gas companies which in their natural opposition to early electric lighting systems stressed the danger of shock and got a 100-volt legal limit imposed. Eventually the electricity companies got authority for a ten-per-cent error and then kept as closely as possible to the upper limit of 110 for obvious technical reasons. British exporters inflicted this voltage on the North American continent and so the 11 complex was started on its way. To my mind this seems the most feasible explanation of all.

With regard to the use of "I" as the symbol for current, several readers have pointed out to me that it signifies the intensity of the magnetic field caused by the current. To me this seems rather like measuring the gallons-per-minute going over Niagara by the intensity of the accompanying noise and then expressing it in gallons-per-minute instead of phons. I have always had an equal dislike for the use of "E" as the symbol for pressure because Electro-motive-force is such a clumsy expression; even the Gas Board doesn't talk of G.M.F.

Nobody told me why *x* is used as the symbol for an unknown quantity and so I shall have to guess the answer. Our old friend Descartes seems to have started this *x* business in 1637. There was once a theory that he took it from the word "xei," used by the Arabs to denote an unknown quantity. This is generally discounted nowadays on the ground that there is no evidence that he was acquainted with Arabic. However, he was most certainly "learned in Latin and grounded in Greek" and so my guess —repeat guess—is that he used the initial letter of the Greek word "xenon" which, as a secondary meaning, denotes "an unknown thing."

With regard to my query about car batteries, most readers mistook my query and rightly warned me not to invite an explosion by removing the charging lead without first switching off. I am still puzzled about what happens to the gas when we bowl along overcharging our batteries at 10 amps with the vents quite rightly screwed hard home.

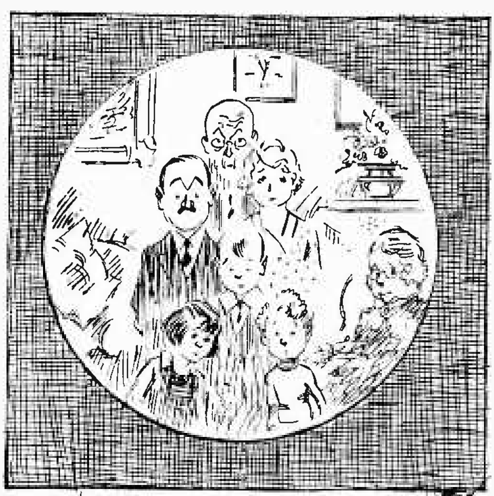
[" Free Grid ' is no doubt speaking for owners of those "horseless carriages" which are not fitted with compensated voltage control for the generator.—ED.]

Fiat Lux

I WAS very surprised to read in J. R. P. Bridge's letter (May issue) of the reasons why he objects to stereo listening. He says that "the wretched listener has to sit rooted to the same spot . . . ; this puts paid to listening while doing odd jobs, minding the baby, etc."

This seems to me to show that he is numbered among the "daily droolers" who are content to let the loudspeaker drool on all day as a mere background to other activities and he is probably quite oblivious of what is being churned out at any given moment. I know from my own experience of long years ago that bathing a bawling baby renders the listening centres of the brain quite unmoved by what a well-known musical critic has described as "the heavenly tenderness of the music of Mozart."

Apart from this, however, Mr. Bridge does not seem to appreciate that even with single-channel music one has to be rooted to the same spot or, at any rate, to the same local longitude to give the best effect. In other words most loudspeakers give only of their best to those who sit somewhere along the axis. In this respect it is very like a photographic lens in which, as is well known, the best definition is given at the centre and tends to fall off at the edges which is one of the reasons why our cameras are fitted with stops. I drew attention to this lens effect of the loudspeaker over a quarter of a century ago (16.12.32) and stressed the difficulties of ranging the family in line astern in front of the loudspeaker. I emphasized my point by the sketch reproduced herewith.



"Ranging the family in line astern"

The solution to the problem, if one must bath the baby to the accompaniment of Beecham's baton bashing in 3D, is obviously headphones as Mr. Bridge realizes. But I am astonished to learn that he thinks it necessary to wear headphones with long leads attached or alternatively to have a miniature "hi-fi" receiver clamped to each ear.

Has he never heard of the system used in certain theatres, lecture halls and hospital wards where the audio signals are fed to flat metal conductors running around the room under the wallpaper and conveyed thence to "wireless" headphones by induction?

Scientists in the Dock

CAN any psychologist tell me why it is that men of science are usually so very pessimistic concerning developments in their own field of activity, and frequently hostile to new developments.

I am moved to ask this question by a recent remark made by Sir John Cockcroft about Lord Rutherford, the pioneer of the atom age. According to Sir John, Lord Rutherford said that getting power from the atom was all moonshine. One can hardly imagine a more pessimistic—and also more false—prophecy from one so eminent in this particular branch of science.

It was just the same in 1901. Nothing but pessimistic head-wagging came from all the leading scientists of the day at Marconi's idea of bridging the Atlantic by wireless. Even after the triumph of December 12th in that year, the scientists took the line that a few esses didn't constitute wireless communication any more than one swallow made a summer.

In other branches of science things are much the same. It was the medical profession which was loudest in its denunciation of the introduction of anæsthetics over a century ago.

Another strange theory about men of science is this. Why is it that they are all highly appreciative of music but comparatively seldom of the other arts? Maybe it is because "Music hath charms to soothe the savage breast," and scientists are nothing if not ruthless. So perhaps music is a sort of antidote which keeps them on an even keel.