# Wireless World

ELECTRONICS, RADIO, TELEVISION

CONTENTS

**APRIL 1964**





VOLUME 70 No. 4
PRICE: 2s 6d.

FIFTY-FOURTH YEAR
OF PUBLICATION

*Managing Director:* W. E. Miller, M.A.
Iliffe Electrical Publications Ltd., Dorset House, Stamford Street, London, S.E.1

*Please address to Editor, Advertisement Manager or Publisher as appropriate*



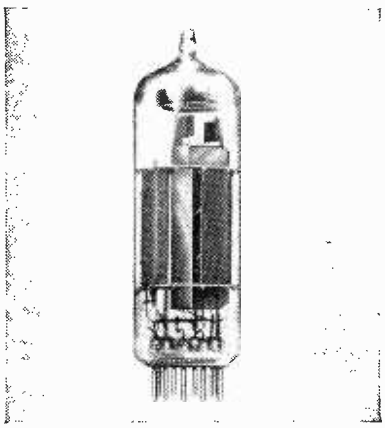
*PUBLISHED MONTHLY* (4th Monday of preceding month). *Telephone:* Waterloo 3333 (70 lines) *Telegrams:* "Ethaworld London Telex." *Cables:* "Ethaworld, London, S.E.1." *Annual Subscriptions: Home* £2 0s 0d, *Overseas* £2 5s 0d. *Canada and U.S.A.* $6.50. Second-class mail privileges authorised at New York, N.Y. BRANCH OFFICES: *BIRMINGHAM:* King Edward House, New Street, 2. *Telephone:* Midland 7191. *BRISTOL:* 11, Marsh Street, 1. *Telephone:* Bristol 21491/2. *COVENTRY:* 8-10, Corporation Street. *Telephone:* Coventry 25210. *GLASGOW:* 123, Hope Street, C.2. *Telephone:* Central 1265-6. *MANCHESTER:* 260, Deansgate, 3. *Telephone:* Blackfriars 4412. NEW YORK OFFICE: U.S.A.: 111, Broadway, 6. *Telephone:* Digby 9-1197.

# MULLARD TEN-PIN VALVE PFL200 DOUBLE PENTODE

## *Complementary characteristics allow economic full-performance designs*

**DEVELOPED by Mullard to meet the needs of the latest dual-standard television receivers, the PFL200 is a video valve of unique construction. A novel feature in its design is the use of a 10-pin B10B valve base. This new base—the decal base—makes possible the inclusion of two completely separate pentode systems in one envelope.**

The pentodes in the PFL200 are dissimilar, and have been given complementary electrical characteristics which makes possible the design of exceptionally economic full-performance television receivers. Particular care has been taken in the pinning and in the screening between the two sections of the valve to provide independence of operation. The PFL200 'L' section is designed to operate as a high-gain video output pentode capable of producing a large output voltage across a low-value anode load resistor. To achieve high gain, which also permits the application of negative feedback, a frame-grid control grid has been used, and this gives the valve a slope of 21mA/V at 30mA.



Note has been taken in the design of the 'L' section of the increasing popularity of high-level contrast control circuits in which the contrast-control potentiometer is placed in the anode circuit of the video output valve. Care has also been taken in the valve design to permit screen-grid dissipation limits that allow for short term overloading. This can arise when the u.h.f. tuner in a dual-standard television receiver operating from a signal having negative modulation (BBC-2) is switched so that neither video signal nor noise is present to provide bias for the grid of the video putput valve.

The 'F' section of the PFL200 is a voltage-amplifying medium-slope pentode designed principally for application as a synchronising pulse separator. For this application the valve has been designed to provide adequate current at a low anode voltage, and care has been taken to reduce to a minimum the feedback capacitance from the anode of the 'F' section to other electrodes in the double valve.

# PY88 BOOSTER DIODE

## for dual-standard television receivers

The PY88 is a Mullard television booster diode now to be encountered in the line timebase circuits of switchable receivers, especially in conjunction with the Mullard PL500 line output pentode.

Because of the excellent insulation between the heater and cathode, the PY88 has a high heater-to-cathode voltage rating of 6.6kV. The peak and average anode current ratings of the valve are also high—550 and 200mA respectively—but to achieve these it has been necessary to increase the heater voltage from the 19V required with the PY800 Mullard booster diode to 30V.

With its improved ratings, the PY88 is thus well equipped to meet the more stringent booster diode requirements of 625-line operation, and the valve is particularly suitable for stabilised timebase circuits using the PL500 high-output line pentode.

# PL500 LINE OUTPUT PENTODE

## Consistency of Performance

It is important in dual-standard television receivers to ensure that the performance of the line timebase does not deteriorate when the receiver is switched from one line standard to another.

Most of the functions of the line timebase are critical in application so that consistency of performance must be achieved, despite the fact that the energy requirements for 625-line operation are roughly half as great again as those of 405-line operation. In many new dual-standard receivers, this task of ensuring comparable performance has been simplified by utilising the new Mullard line output pentode, type PL500. This new valve has improved ratings compared with valves previously recommended for 405-line operation. In particular, an exceptionally high ratio of anode current to screen-grid current is achieved by the 'cavitrap' anode. Because of the improved current ratio, the PL500 is capable of delivering greater deflection power, which helps to prevent any significant change in performance between the two line standards.

MVE3222

7WW—112 FOR FURTHER DETAILS.

# Wireless World

VOL 70 NO 4 APRIL 1964

## Electronics and Radio

THE British Institution of Radio Engineers will in future be known as the Institution of Electronic and Radio Engineers. We congratulate the Institution on having received the Royal assent to its plea for a change of title, though some of us may regret that it is no longer openly proclaimed to be British. The right of a member to describe himself as a "*Chartered* Electronic and Radio Engineer" nevertheless conveys to all whom it may concern that this is essentially a British qualification.

In some other respects, however, there is room for ambiguity. It is not clear whether the member's description derives from his qualifications or is just simply a reflection of the new title. The Institution has established a distinction between electronics and radio, so a client seeking the services of one of its corporate members and reading his description would be entitled to assume that he was competent in both branches. Will a candidate for membership be expected in future to satisfy the Council that he is fit to practise outside as well as inside the field of communications? Will he be as competent at designing a computer as he has shown himself, say, in establishing a point-to-point communications link? The same sort of question could be asked of the "Chartered Electrical Engineer," but he would be more difficult to pin down because he does not describe himself as a "Chartered Generation, Transmission and Utilization Engineer."

These are the sort of problems which are giving concern to the Engineering Institutions Joint Council which is in process of making a thorough examination of the engineering profession as a whole, of the interplay of different disciplines and of divergencies and convergencies of interest. No doubt it has considered the possibility of establishing a single qualification "Chartered Engineer" to cover the requirements of professional integrity and basic knowledge, and this would be a good thing if it could be supplemented (in parentheses) by all those subjects in which the individual had proved his technical competence. We might then start to subdivide subjects and to recognize the fact that with the growth of knowledge few men are ever likely to be competent in the whole field of engineering, or for that matter of either electronics *or* radio.

## He That Hath Ears . . .

LORD Kelvin's dictum, that until you can measure a thing and express it in numbers your knowledge is of a meagre and unsatisfactory kind, has found support from recent correspondence in this journal on the subject of quality. Certainly many of the factors contributing to "hi fi" can be given numbers either by physical measurement or by subjective judgment and statistical analysis, but not all. We have still much to learn about the relative importance of single factors when they are presented to us in mixtures of continuously varying proportions—as they are during the performance of a musical work. At this stage most of us take a breather, either by enjoying the music, switching off the noise or, if we can't, moving into the next room.

The International Audio Festival and Fair, held this year in the Russell Hotel, London, from 2nd to 5th April, is the ideal place for any or all of these activities—listening to technical argument, enjoying good sound, or retreating to the bar! We think that those who are fortunate enough to be able to find the time to visit this gathering and have been wise enough to apply to their dealer (or to us) for complimentary tickets in advance will find more than enough to interest them in the new generation of transistor power amplifiers, new concepts of loudspeaker design and all the many other aspects of audio science and art.

# GROOVE DEFORMATION IN GRAMOPHONE RECORDS

By D. A. BARLOW, M.Sc., Assoc.I.E.R.E.

IT is well known that the elastic limit of a vinyl record, loaded by a pickup stylus, is exceeded with a load of only a few milligrams. Some years ago, in a discussion on a paper by Professor Hunt[1,2] the author pointed out that there was a critical load of much higher value, below which all plastic deformation of the record material under the stylus would be below the surface, the surface itself being still elastic. As the grooves would thus be virtually undamaged at this relatively high load, this would be a desirable and practical condition for pickup operation. From a consideration of the stress system, the limiting load for this region was estimated at about $\frac{1}{2}$gm on a 1-thou radius stylus. Further work[3] confirmed that this was of the right order. With existing techniques, it might just have been possible to construct a pickup to work within this limit, but with the advent of stereo and the need for a smaller radius stylus to reduce tracing distortion to tolerable limits, the possibility of constructing a pickup to work within this range became more remote.

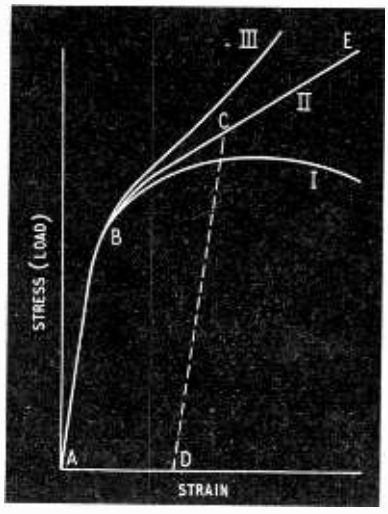



*Fig. 1. Stress-strain curves under different conditions.*

Recently, there have been a number of references to pickups working within the elastic range. Thus it has been said that the boundary between elastic and plastic deformation is $1\frac{1}{2}$ gm on a $\frac{1}{2}$-thou radius stylus, and more surprising still, that certain pickups with 2 and even 3 gm on a $\frac{1}{2}$-thou radius stylus operate within the elastic limit of the record material. As the limiting elastic load for vinyl is so very low, the surface elastic—subsurface plastic limit is doubtless intended. The evidence and arguments offered in support of these figures are unreliable, incorrect, or non-existent. There is evidently a great deal of confusion on the subject, so that a further review might be useful.

## Behaviour of a Material Under Stress

The behaviour of a material under simple stress will first be described, before considering the complex stress system under a stylus.

When a material is loaded in simple tension and the load or nominal stress (load/original cross-sectional area) is plotted against the extension, a curve similar to I, Fig. 1 is obtained, the exact shape depending on the particular material. A-B is the elastic region where the material obeys Hooke's Law and extension or strain is proportional to load; when the specimen is unloaded it returns to its original size and shape unchanged and the slope of this portion of the curve gives Young's modulus. If the true stress (load/current cross-sectional area) is taken, a curve similar to II, Fig. 1, is obtained and this gives a better indication of the behaviour of the material. The difference between nominal and true stress in the elastic range is small. At B, yielding occurs, sometimes with irregularities in the curve, such as an upper and lower yield with some materials which are not strictly homogeneous on a micro scale; deformation continues as the true stress is raised, B-C-E. If the testpiece is unloaded at some point C, it springs back, C-D, with the same Young's modulus as previously. Point C represents the new increased yield stress of the now work-hardened material; note that if the material is re-loaded with the same load corresponding to point C, no further plastic deformation takes place. At E, fracture occurs when ductility is exhausted and the material is incapable of further deformation under the prevailing stress system. (Brittle materials show little or no plastic deformation before fracture). During tensile deformation, the load or nominal stress reaches a maximum and may then decrease to fracture due to thinning, whereas the true stress increases to fracture, indicating that the material is continuously work-hardening. Vinyl work-hardens due to the orientation of the molecular chains in the direction of stress so as best to resist that stress. This orientation occurs suddenly in a tensile testpiece as a neck which travels the gauge length at constant load; this process occurs with many plastics and is known as cold drawing and is used to produce high strength fibres from the original extruded filament (which is largely of random orientation).

The corresponding load/strain curve for simple compression is shown in III, Fig. 1. As deformation proceeds, the cross-sectional area increases, so that the load required for deformation to continue increases rapidly. The true stress/strain curve in compression is similar to that in tension for most materials, although in some plastics, the properties in compression are rather higher than in tension.

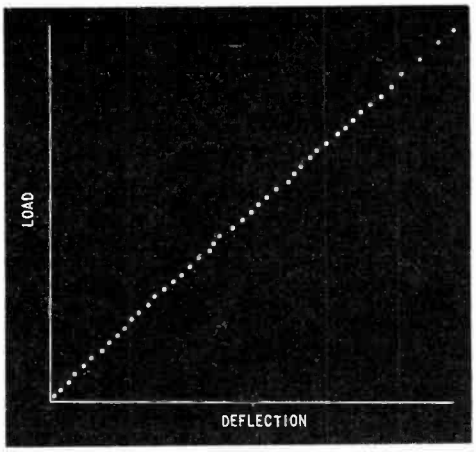



*Fig. 2. Load-deflection curve for vinyl cantilever.*

When the elastic limit of a material is exceeded and the load is maintained, creep or slow continuing deformation occurs over a period of time, although in some cases it is extremely small. Values obtained therefore depend to some extent on the speed of loading. Materials with poor elastic properties have no true elastic limit and creep at all stresses and show poor agreement with Hooke's Law. On unloading they do not spring back completely; they exhibit mechanical hysteresis and creep back or recover gradually. Typical examples of this behaviour are lead, plasticized plastics, and most rubbers. Vinyl records consist of vinyl chloride co-polymerized with about 16% of vinyl acetate to assist the flow of the material in the mould, together with small quantities of pigments, inhibitors to reduce decomposition at moulding temperatures and other additions. There are no added fillers or external plasticizers, so that the elastic properties are good, with a definite yield stress and Young's modulus and low creep. Fig. 2 shows a load/deflection curve for a strip of vinyl record loaded as a cantilever. The modulus is well-defined and decreases very little with increasing load, even when the yield stress of the outer layers is approached.

## Deformation Under a Spherical Indenter

When a hard rigid spherical indenter is first pressed into a flat surface, elastic deformation takes place and the material is as yet undamaged; this is the range covered by the well-known Hertz equations. As the load is increased, the criterion of yield is reached and plastic deformation (in addition to the elastic deformation) occurs; on releasing the load, the elastic deformation only is released. The stress system under the indenter consists of axial and circumferential compression and radial tension, and yielding occurs under this condition when the mean pressure over the area of contact is equal to about 1.1 times the simple tensile or compressive yield stress. The mean pressure under a hard rigid indenter is given by the Hertz equation:—

$$p_m = 0.386 \sqrt[3]{(E/1-\nu^2)^2 \; W/R^2}$$

where E is Young's modulus = 300 kg/mm$^2$

$\nu$ is Poissons' ratio = 0.35

W is applied load (gm)

R is radius of indenter = 1 thou

Under these conditions, with a yield stress of 4.5 kgm/mm$^2$ the yield load for a 1-thou radius stylus is about 12 mgm. The point at which yielding takes place is below the surface at a distance equal to half the radius of the circle of contact. This radius is given by the Hertz equation:—

$a = 2.356 \; Rp_m/E/(1-\nu^2) = 0.86\mu$ under the above conditions.

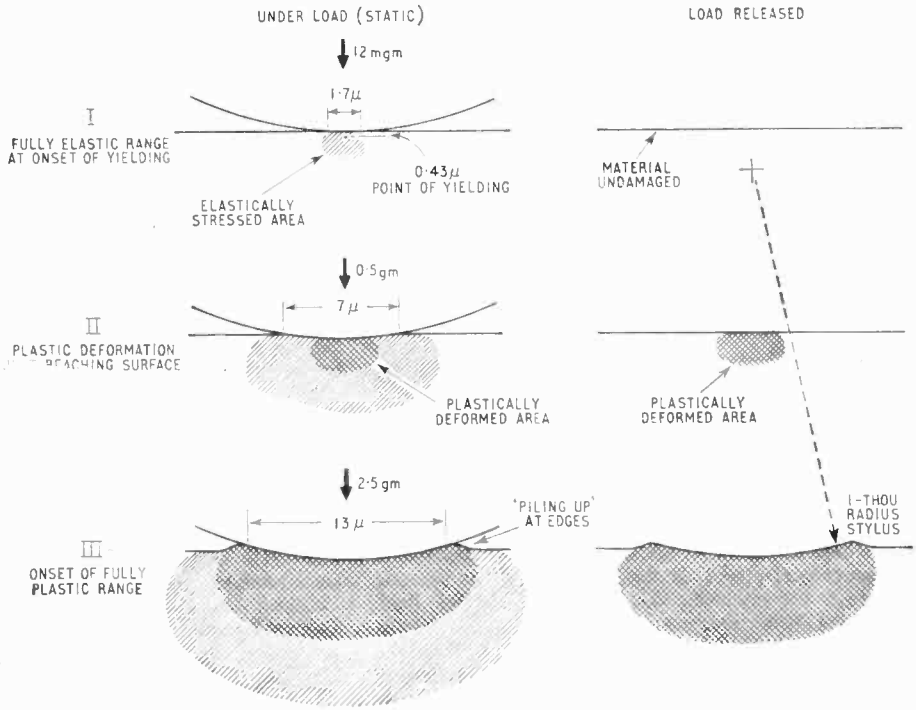



*Fig. 3. Critical indentation loads.*

With further increase in load, elastic distortion of the surface continues and yielding beneath the surface spreads until eventually it reaches the surface. The limiting load for this condition cannot be calculated but can be determined by observation. From static tests[3] this is about 0.5 gm for a 1-thou radius indenter. Further increase in load increases the plastically deformed zone until all the material in contact with the indenter is in the plastic range. The onset of this condition cannot be calculated but begins at about 2.5 gm on a 1-thou radius indenter, when the impression shows "piling up" of material at the edges for most materials, including vinyl. With further increase in load, the plastic zone continues to increase and the mean contact pressure remains approximately constant at 2.8 times the yield stress and no further change in the stress

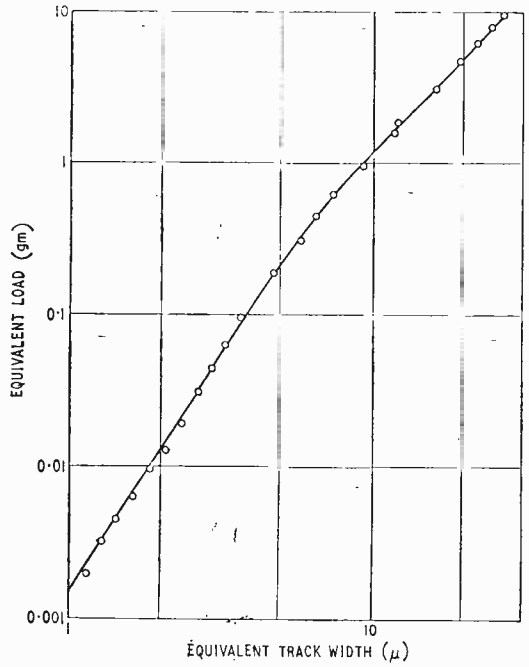



*Fig. 4. Equivalent load v. equivalent track width for 1-thou radius stylus.*

system takes place. There are thus four régimes of deformation under a spherical indenter:—

1. The fully elastic range.
2. The (surface elastic)/(sub-surface plastic) range.
3. The (surface partly plastic)/(sub-surface plastic) range.
4. The fully plastic range.

These are illustrated in Fig. 3 to scale, together with the effect of releasing the load. I shows the fully elastic range at the moment of yielding, II shows plastic deformation just reaching the surface, and III shows the onset of the fully plastic range. In régime 2, the sub-surface plastic deformation may cause very slight elastic distortion of the surface to remain on releasing the load. When the load is released from indentations in the partly plastic range, spring-back takes place, resulting in considerable shallowing of the impression, the (permanent) radius of which may be several times greater than that of the indenter; the width of the impression is almost unaffected. In the fully plastic range, spring-back is usually small compared with the plastic deformation. As the plastic deformation is local and non-uniform, the material is unable to spring back to a completely stress-free condition, so that residual internal stresses remain in the material, but as they do not affect the deformation they may be ignored.

A log-log plot of load *v.* diameter of impression or (total) track width, taken from the previous indentation tests, is given in Fig. 4. In the fully elastic range, the slope of the curve is 3, as given by the Hertz equations; with further loading the slope decreases until, in the fully plastic range, it reaches a final value usually between 2.5 and 2. If the slope is exactly 2, the mean contact pressure is, of course, constant. This occurs with materials where the elastic deformation is small compared with the plastic and which do not work-harden but yield at a constant true stress. "Plasticene" and heavily cold-worked metals approximate to this. As described previously, vinyl work-hardens and the final slope is 2.1.

## Principle of Geometrical Similarity

It is obvious that with different sized indenters, if conditions are geometrically similar, the contact pressure is the same and the material is stressed to exactly the same condition in each case. This is illustrated in Fig. 5. This is pure geometry and is quite independent of the material or of the régime of deformation or of the Hertz or any other equations. It means that the stress conditions in the record material with, say, a 1-thou radius stylus and a playing weight of 4 gm are exactly similar to those obtaining with a $\frac{1}{2}$-thou radius stylus and a playing weight of 1 gm. Of course, if in a practical case in reducing the stylus radius from 1 to $\frac{1}{2}$ thou some other criterion is taken as a basis for design, then some other weight may be indicated as acceptable for the $\frac{1}{2}$-thou radius stylus, although the record material will not then be in the same condition as previously and its frictional (and perhaps fatigue) life may be affected.

The principle of geometric similarity is axiomatic to the whole of the physical world and there is only one condition under which it does not apply, *viz.*, inhomogeneity of the material. This could take the form of either a size or surface effect. Hunt[1] has actually proposed a size effect, but it has no foundation in fact[2]. A harder surface to the plastic is conceivable as a result of polishing or working the surface in some way; material suppliers consider that a harder surface is unlikely to result from moulding conditions—indeed with some plastics such as nylon, the moulded surface may even be softer than the interior. In the previous identation tests the absence of a size or surface effect was shown by means of diamond pyramid hardness tests over a wide range of loads. The impressions from a pyramid are all geometrically similar and have the same stress system regardless of the size or the load used, so that the same hardness value or load/(area of impression) was obtained in each case, down to the lowest practical load of 1 gm. Further proof of the absence of a size or surface effect down to lower loads is given by the "Talysurf" machine, in which a diamond stylus of 0.1-thou radius is dragged over the surface under a

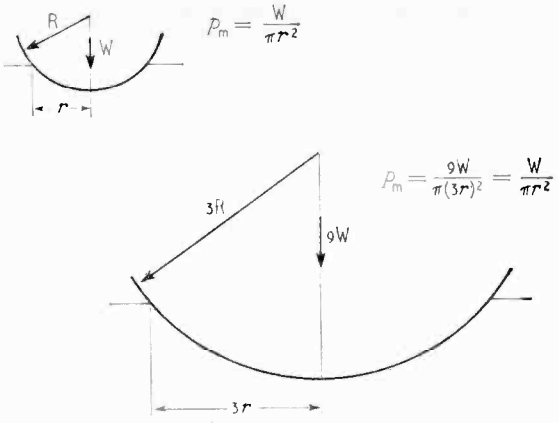



*Fig. 5. Principle of geometric similarity.*

load of 0.11 gm, and thus works in the fully plastic range. This is equivalent to a load of 11 gm on a 1-thou radius stylus or 17.1 kgm on a 1-mm radius indenter, which from the previous indentation tests gave a track width of 1.2 mm. The "Talysurf" should thus give a track width of 3/, and this was found to be the case, Fig. 6.

## Static v. Dynamic Tests

So far, static or slow speed tests have been considered whereas the record groove moves at considerable speeds under the sylus. Materials with fairly good elastic properties like vinyl, show a small increase in yield stress (and modulus) in the speed range of interest; the very low yield stress of materials with poor elastic properties may increase considerably at high speeds. It has been suggested that there is a "surf board" action such that friction on the advancing edge of the track tends to lift the indenter; this is the textbook case of the block moving up the plane, when friction acts down the plane and has no lifting effect. It can be readily shown that the static and dynamic track widths on vinyl are of a similar order by allowing a pickup to rest on a blank portion of a record while the turntable is rotating, and again while it is rotated slowly by hand. (Care must be taken to adjust the lateral bias so that the pickup gives a slow spiral, so that several revolutions may be allowed for the pickup to settle down to a steady condition.) The tracks so obtained are readily visible with the naked eye and will be seen to be of similar width. This is shown in Fig. 7 for a load of $1\frac{1}{2}$ gm on a 1-thou radius stylus. Further confirmation is hardly needed, but nevertheless tests with a diamond indenter were carried out, using a large scale to give accurate and consistent results.

## Dynamic Tests

A diamond indenter of 1 mm radius was used on a lever arm pivoted in precision ball bearings and mounted on the saddle of a lathe. Thick discs of vinyl record compound (slow-cooled to avoid residual stresses) with the as-moulded surface untouched were mounted on the lathe faceplate, and the loads applied for various numbers of revolutions, representing the effect of repeated playing. The track widths were measured by means of a microscope with a graticule eyepiece. The loads used ranged from 0.4-25 kgm, corresponding to 0.25-17 gm on a 1-thou radius stylus or 0.06-4 gm on a $\frac{1}{2}$-thou radius stylus. The speeds used were 5, 10, and 18 in/sec., covering the range used by $16\frac{2}{3}$, $33\frac{1}{3}$ and 45 r.p.m. records. It could conceivably be argued that if the indenter radius is increased for test purposes by a factor $x$, the linear record speed should also be increased by a factor $x$. This would give absurdly high speeds, higher than the speed of sound in vinyl, with quite moderate sized indenters. In playing a record, an elastic + plastic wavefront is being propagated through the material. The velocity of propagation is the important thing and must be similar in each case, i.e., actual velocities must be used.

For single loadings, the total and plastic track widths were determined by the method used previously, of applying a very thin (1,000 Å.U.) grease film to the surface; the track width in the grease gives the total contact area, and by dissolving off the grease in a suitable solvent, such as alcohol or light petroleum, the plastic track only is left. The total track widths on repeated loading were readily visible, even at low loads, due to the burnishing action and frictional damage. In determining the plastic track widths on repeated loading, the surfaces were lubricated with a copious supply of mineral oil to prevent frictional damage, which would have obscured the plastic tracks. The oil was then washed off and the surface examined.

In examining the surface for plastic tracks, the track edges are well defined at the higher loads and are readily visible under the microscope, although care must be taken to avoid including the piled up edges in measurements of track width. At lower loads, near the limiting case, the impressions are

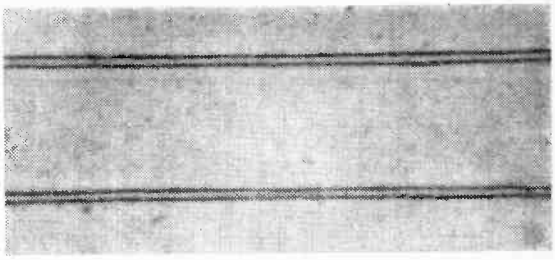


*Fig. 6. "Talysurf" tracks on vinyl. (X350)*

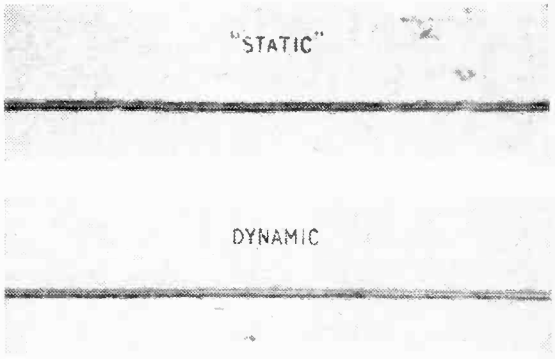



*Fig. 7. "Static" and dynamic (14in/sec) tracks on vinyl from $1\frac{1}{2}$-gm pickup with $\frac{1}{2}$-thou radius stylus. (X108)*

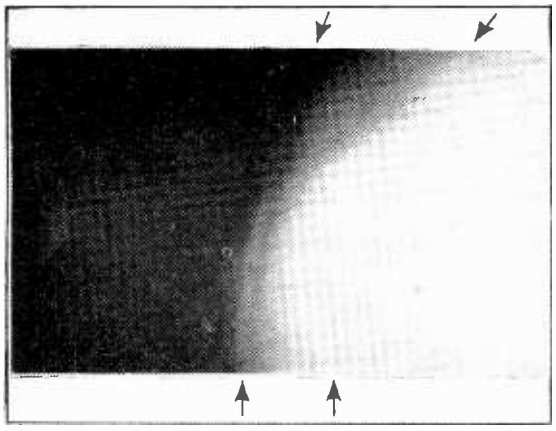


*Fig. 8. Typical plastic track on vinyl from 1-mm radius indenter at equivalent load of 1.38 gm on 1-thou radius stylus at 2-3in/sec. (X23)*

shallow with gently rounded edges. These tracks are easily detected by the naked eye by tilting the specimen and observing the edge of the moving image of the light source as it crosses the tracks. This is done automatically whenever one examines anything in detail. This is in effect a form of vertical illumination, yet no manipulation of the vertical illuminator and light source would show up these tracks under the microscope, even when they were as wide as 0.13 mm. Fig. 8 shows typical plastic tracks at an equivalent load of 1.38 gm on a 1-thou radius stylus, at speeds between 2 and 3 in/sec. The tracks are visible at the edge of the image of the lamp and are, of course, much more pronounced to the naked eye than on a reproduced photograph, yet the "Talysurf" machine failed to detect them. Small-scale tests using microscope or "Talysurf" machine are therefore useless in detecting plastic tracks.

Results are plotted in Fig. 9.

## Discussion of Results

Considering first the total track widths (continuous line), it will be seen that the dynamic tracks are rather narrower than the "static" ones, but there is no dramatic reduction in track width under dynamic conditions. In the fully plastic range, the mean reductions in track width compared with the static condition are 11%, 13% and 14% at 5, 10 and 18 in/sec, respectively, corresponding to yield stress increases of 26%, 33% and 35%. The ratio between the extremes of record speed used here is 3·6 : 1 and is about 100 : 1 between the lowest speed and the "static" speed. From manufacturers' limited data on p.v.c. and vinyl co-polymer, these yield stress increases are of the order to be expected.

The limiting load for the fully plastic condition increases from about 2·5 gm static to about 3·5 gm under dynamic conditions as shown by the appearance of piling up at the edge of the tracks. This limiting load will be roughly proportional to the yield stress of the material.

The effect of repeated playing is to increase the track width slightly each time, the bulk of the deformation occurring on the first playing, as described previously. The present tests may be more severe than actual repeated playing in that there is usually a considerable interval between each playing, when some recovery might take place. However, a spot check at 2·34 gm at 10 in/sec. with 12 hours rest after each 5 revolutions showed no difference from the continuous test.

The plastic track widths are indicated by the dotted line; owing to the gently rounded edges as

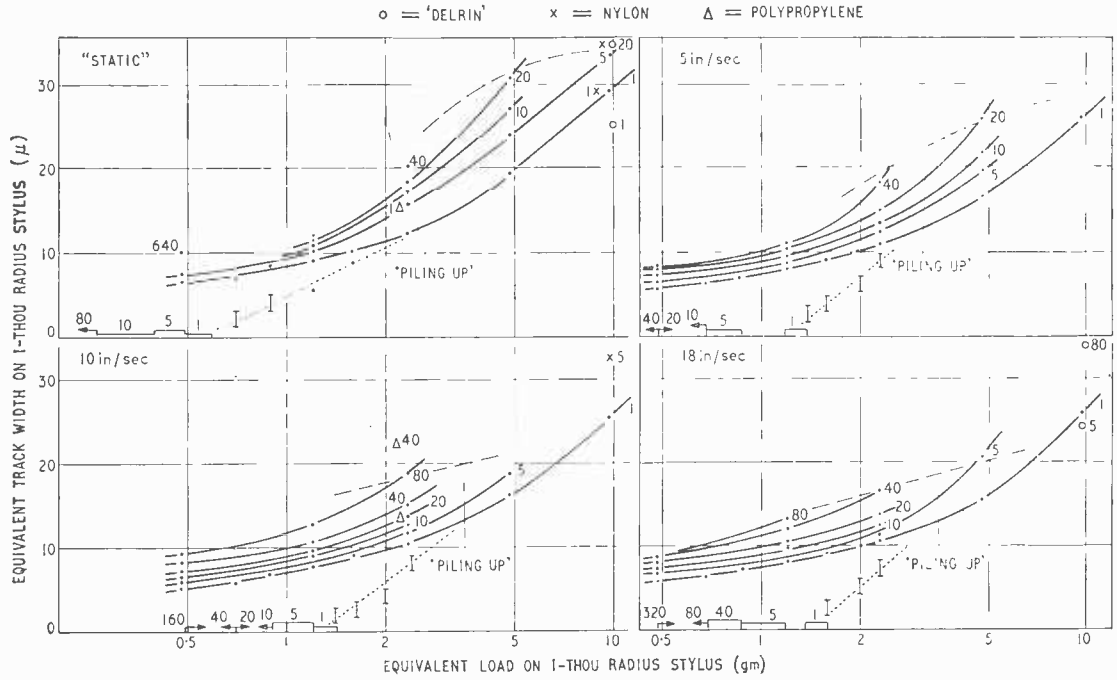



*Fig. 9. Indentation test results.*

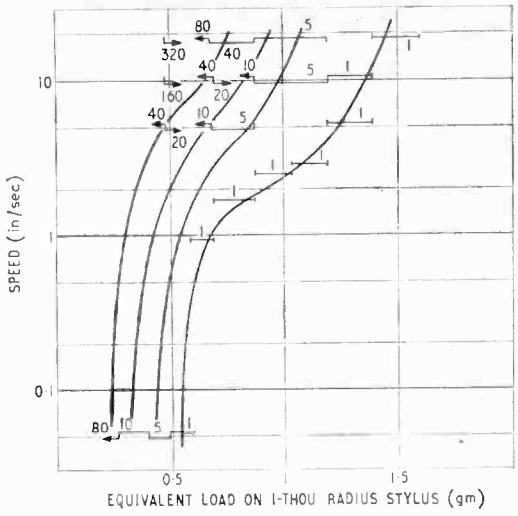



*Fig. 10. Effect of speed on limiting load for all plastic deformation sub-surface.*

described above, the exact widths are uncertain and these have been plotted as bars rather than points.

The limiting loads for all plastic deformation to be sub-surface are indicated, no tracks being visible at the lower load and tracks being just visible at the higher load. Thus at say, 10 in/sec. for one playing, the limiting load is between 1·19 and 1·38gm for a 1-thou radius stylus. It will be seen that with repeated playing at this load, tracks will eventually appear, as with plastic deformation just below the surface, only a little creep on reloading is needed to cause yielding to reach the surface. The limiting loads show a small increase with increase of record speed, but a considerable increase over the static limit (0·48-0·58 gm). The limiting load will not be very dependent on modulus (which in any case is less dependent on speed than the yield stress), but will be almost proportional to the cube of the yield stress; the increases over the static value are of this order. The effect of speed on the limiting load for sub-surface plastic deformation is plotted in Fig. 10, which also includes speeds intermediate between record speeds and the static condition.

The change of limiting elastic load under dynamic conditions can be calculated, knowing the increase in yield stress and modulus. From manufacturers' data on vinyl co-polymer, the modulus will increase by about 4·5-6·5%, giving limiting loads of 22, 25 and 26 mg.

## Commercial Pickups

For a 3-gm pickup with ½-thou radius stylus to operate with all plastic deformation under the surface, the dynamic limiting load will be some 34 times higher than the static load. Even if this limit is proportional to the cube of the yield stress, the latter must increase by a factor of 3·24. At a rate of straining of 12,000%/sec, the yield stress of unplasticized p.v.c. is increased by a factor of 2; this strain rate is hardly likely to be reached at record speeds, as special methods, usually ballistic, are necessary to attain such high rates of strain. Further, it is well known that at the highest attainable strain rates of up to $10^7$%/sec, in armourplate and explosive tests, the yield stress of a wide variety of materials is only increased by a factor of 3.

It is worth considering just how severe the loading is from a pickup supposedly working "within the elastic limit." 3 gm on a ½-thou radius stylus is equivalent to 12 gm on 1 thou—as high or higher than cheap monophonic equipment—and equivalent to 75 gm on 2½-thou, or 108 gm on a 3-thou radius stylus—almost as high as the loading from an acoustic gramophone, which used a record material with twice the hardness of vinyl. (The rapid deterioration of these records was of course due to other causes.)

It is evident that there is no commercial stereo pickup which operates within the elastic range or the sub-surface plastic range or the partly plastic range, even on first playing—all work well into the fully plastic range; a few monophonic pickups, because of their 1-thou radius styli, work in the partly plastic range of unmodulated grooves. Of course, this does not mean that the audible results are not extremely pleasing. There have been claims that certain pickups will track at 1 gm and even less, but examination of the actual pickup constants shows that this cannot possibly be the case except perhaps on certain records specially selected for low modulation and absence of warping. The damage that can result in attempting to operate a pickup at less than its properly designed tracking load has been shown by Bayliff[1].

## Conclusions

There is nothing unusual about the deformation of record material, nor are there any special effects in record grooves, such as size or skin effects or special dispensations in favour of pickup designers.

## Acknowledgements

The author wishes to thank Messrs. British Geon Ltd., D. & O. E. Industries Ltd., Imperial Chemical Industries Ltd. Paints Division and Plastics Division for much information and samples.

## APPENDIX

### A note on the frictional properties of record materials

During the loading tests, it was found that at first a burnished track was produced, then pickup would begin at one edge or the centre of the trace, eventually spreading over the whole area. With further repetitions, considerable frictional damage occurred, in the form of welding of the vinyl to the diamond followed by plucking out of particles of vinyl. Eventually, a shower of particles was produced with gross destruction of the surface. Fig. 11. This limit on the number of repetitions is indicated by the broken line in Fig. 9. Under static conditions, an equivalent load of 17 gm on a 1-thou radius stylus (4.25 gm on a ½-thou stylus), gave such severe welding after only 3 revolutions that vinyl was removed as a continuous but almost fragmented ribbon, resembling the swarf from a rather brittle material cut with a tool with little top rake. Photomicrographs by Watts[8] show a rough surface to the tracks left by the stylus on vinyl (and on shellac and lacquer likewise), and severe playing will give a shower of detritus from the damaged groove[6], although the record may still sound very good. The noise produced by the roughness of the earlier damage would be super-

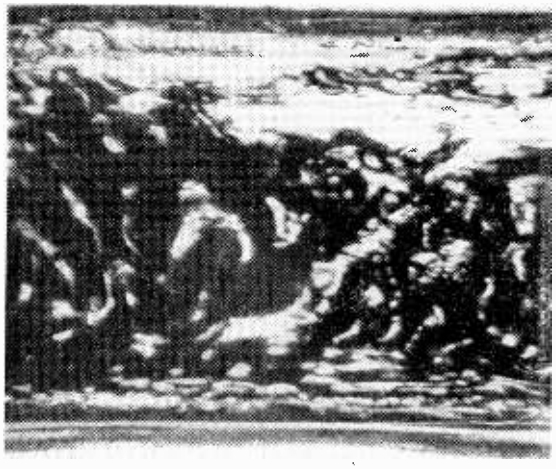


*Fig. 11. Severe frictional damage from 1-mm radius indenter at equivalent load of 4.78 gm on 1-thou radius stylus after 5 revolutions at 14in/sec. (X57)*

sonic; the later gross damage is delayed in record grooves by the lubricants which are added to the mix. These are small amounts of waxes or stearates which do not mix with the vinyl but are distributed throughout as globules; the globule size is sub-microscopic but is relatively large to a stylus. As the lubricant film breaks down, it is probably replenished by the exuding of further lubricant from below the surface. On a larger scale, this exudation may be insufficient over the greater migration distances involved, and in continuous tests there would be little time for this to happen between loadings, although in the comparison test on the effect of 12 hours rest after every 5 revolutions, there was no reduction in frictional damage. A comparison test on a blank portion of a record known to resist frictional damage by the pickup, gave severe damage with the large indenter. The damage was no more severe in a comparison test on a record from which the lubricant had been omitted. As replenishment of lubricant appears more effective with smaller styli, it would account for the best stereo pickups perhaps giving a longer record life (as judged by noise level) than would have been expected from comparison with monophonic records. The need for adding a lubricant is well-known to manufacturers of record compounds, and it may not be an exaggeration to say that the whole of the gramophone industry is dependent on as little as 0.1% of wax added to the record mix.

Boundary lubricants such as waxes, stearates, etc., are effective up to their melting point. In this case, the softening range of the record is 100-120°C so that there is no advantage in lubricants having a much higher melting point than this. It would appear unlikely, therefore, that more effective lubricants will be found, unless perhaps they are more strongly polar. These would be more strongly absorbed onto the vinyl surface and their life would be extended; as the shear strength of the lubricant film is of the same order as that of the vinyl, the reduction in coefficient of friction is unlikely to be more than about 30%. This absorbed film of lubricant is unlikely to be wiped off during normal use of a record, but it might perhaps be advantageous to add lubricant judiciously after say, every 20-200 playings, depending on the playing weight. For this purpose, a dilute solution of a suitable wax stearate, higher alcohol, etc., in a suitable grade of alcohol could be wiped on to the record and allowed to dry. This amount of lubricant should be insufficient to act as an adhesive for dust.

**Indenter Material:**—In initial trial indentations, a hardened steel ball was used as an indenter and frictional damage to the vinyl occurred. This was assumed to be a characteristic of steel, but later with the diamond, even greater damage occurred and this was repeated in further check tests. Most materials suffer less frictional damage in contact with diamond than with steel, but the reverse is true for vinyl; for a given amount of frictional damage, about twice as many revolutions are required for a steel indenter as for a diamond. The implication that we should go back to steel needles is doubtless impractical due to the high rate of wear of the steel. A comparison with a (synthetic) ruby indenter showed slightly less damage than with the diamond.

**Comparison with other Plastics:**—Vinyl is not notable for its frictional characteristics, but other plastics are. P.t.f.e. is too soft, too expensive, and difficult to process. Polythene is too soft but polypropylene has been proposed, although it is not as hard as vinyl. Polyformaldehyde (" Delrin ") and nylon are both hard and have quite good frictional properties.

A comparison test with nylon A100 (the hardest grade) showed very little frictional damage even after 320 revolutions at 9.75 gm, although it was no harder than vinyl, Fig. 9. " Delrin " was harder and showed even less frictional damage after 500 revolutions at this load; it is also less affected by moisture and has a higher fatigue strength than nylon. Polypropylene after 640 revolutions at 2.34 gm showed still less frictional damage, with a small quantity of very fine detritus; being softer than vinyl, the loads would have to be reduced to $\frac{1}{2}$ or $\frac{2}{3}$ for similar plastic deformation to vinyl.

**Fatigue.**—Fatigue failure and frictional damage are obviously impossible to separate in the present case. Any fatigue failure of the vinyl would be obscured by the severe frictional damage. With the other plastics, cross-hatching or fine transverse cracks were observed after a considerable number of revolutions and these may have been fatigue cracks which did not spread.

### REFERENCES


1. Hunt, F. V., *J.A.E.S.*, Vol. 3, No. 1, Jan. 1955.
2. Barlow, D. A., *J.A.E.S.*, Vol. 4, No. 3, July 1956.
3. Barlow, D. A., *J.A.E.S.*, Vol. 6, No. 4, Oct. 1958.
4. Bayliff, R. W., *Proc. I.E.E.*, Vol. 109, Pt. B, No. 45, May 1962.
5. Briggs, G. A., " Sound Reproduction," 3rd. edn., 1953 (Wharfedale Wireless Works), pp. 271, 305, 319.
6. Watts, C. E., "Hi-Fi Year Book," 1957 (Miles Henslow publications Ltd.), p. 5.


## THIS MONTH'S EXHIBITIONS

**LONDON**

April 21-25 — Olympia
**Church & School Equipment Exhibition**
(CASEX, Crown House, Morden, Surrey)

April 2-5 — Hotel Russell
**International Audio Festival & Fair**
(C. Rex-Hassan, 42 Manchester Street, W.1)

**OVERSEAS**

April 1-12 — Barcelona
**British Industrial Fair**
(British Overseas Fairs, 21 Tothill Street, London, S.W.1)

April 26-May 5 — Hanover
**Hanover Fair**
(U.K. agents Schenkers Ltd., 13 Finsbury Square, London, E.C.2)

# AUDIO FAIR PREVIEW

THE 1964 International Audio Festival and Fair (to give it its full title) opens at the Hotel Russell, London, W.C.1, on April 2nd for four consecutive days. To whet the appetites of readers who are able to attend, and for that matter those unable to do so, we give in the following few pages a foretaste of some of the fare to be offered. We hope this preview will be a useful guide to the new audio equipment being shown by manufacturers. The information has been supplied by exhibitors in response to our request, although it must be stressed that some manufacturers have withheld information until the Fair opens.

As will be seen from the following list of exhibitors a considerable number of them are from overseas. At the end of the reports on the overseas companies we give the name and address of the U.K. agents.

The reports are arranged alphabetically under trade names. Where this bears no relation to the title of the firm the trade name is given in square brackets after the manufacturers' name in the list of exhibitors.

Most of the record number of nearly 90 exhibitors will have demonstration rooms in addition to their stands. Also the B.B.C. will be giving live demonstrations of Zenith-G.E. stereophony transmissions from the Wrotham station.

The Fair will open each day at 11.0 but admission on the first day until 4.0 is restricted to invited guests. It will close at 9.0 (Sunday 8.0). Tickets (admitting two) are available from exhibitors, dealers or the editorial office of *Wireless World* and applicants are asked to send a stamped addressed envelope.

### A.K.G.

Among the well-known series of microphones made by Akustische und Kino-Geräte G.m.b.H., of Vienna, to be seen and demonstrated at the show will be the new DX11 which incorporates a reverberation element, amplifier and battery. Reverberation is optional and can be varied from approximately 1 sec to 2 secs. Another new microphone is the D501 which can be switched from cardioid to omni-directional operation. Among the versions of the D19 is one with a built-in switch.

*Agents:—Politechna (London) Ltd., 3 Percy Street, London, W.1.*

### AGFA

The current range of Agfa recording tapes on a wide variety of bases are to be shown this year.

*Agfa Ltd., Deer Park Road, Wimbledon Factory Estate, London, S.W.19.*

### AKAI

A number of Akai (Japan) tape recorders will be shown, including two new models. The Model 707 is a two-speed recorder, 7½ and 3¾in/sec with a frequency response at 7½in/sec of 30 to 12,000 c/s ± 3dB. The Model 903 is also a two-speed recorder but has two-input mixing facilities. "Semi-professional" and professional recorders will be shown.

*Agents:—Pullin Optical Co. Ltd., Ellis House, Aintree Road, Perivale, Greenford, Middlesex.*

### AMPEX

Two new audio tape recorders are being featured by Ampex. One, the E65, is designed specially for educational use. The other, the UST4, which is imported from Chicago, is a portable stereo recorder.

*Ampex Great Britain Ltd., 72 Berkeley Avenue, Reading, Berks.*

### ARMSTRONG

A number of recently-introduced equipments will be included in the Armstrong display. These include the Model 220 stereo power amplifier and Model 225 stereo pre-amplifier, tuner (f.m. and a.m./f.m.) units, an integrated stereo amplifier and pre-amplifier and tuner-amplifiers.

*Armstrong Audio Ltd., Warlters Road, Holloway, London, N.7.*

### BEYER

The Beyer range of German microphones and headsets are to be shown and demonstrated this year. A number of additional microphones to the current range are to be featured.

*Agents:—Fi-Cord International Ltd., 40a Dover Street, London, W.1.*

### BRAUN

Several items from the range of this West German company will be seen for the first time in the U.K. al-

## LIST OF EXHIBITORS

A.K.G. (*Austria*)
Acoustical Manufacturing [Quad]
Agfa
Akai Electrical Co. (*Japan*)
*Amateur Tape Recording*
Ampex Great Britain
Armstrong Audio
*Audio & Record Review*

B.A.S.F. Chemicals
Beyer Elektrotechnische (*Germany*)
Boosey & Hawkes [Jordan-Watts]
Braun Electric (*Germany*)
Brenell Engineering Co.
Brown, S. G.
Butoba Schwarzwalder (*Germany*)

Celestion
Celsa Electric Co.
Clairtone Sound Corp. (*Canada*)
Clarke & Smith Mfg. Co.

Decca Radio & Television Co.
Decca Record Co.
Derritron Radio [Chapman]
Design Furniture

E.M.I. Tape
Elcom Northampton
Elektroimpex [Qualiton] (*Hungary*)

Fane Acoustics
Fed. of Brit. Tape Recording Clubs
Ferrograph Co.
Fi-Cord International

G.K.D.
Garrard Engineering
Gevaert
Goldring Mfg. Co.
Goodmans Industries
*Gramophone*
Grampian Reproducers
Grundig Great Britain

*Hi-Fi News*

K.E.F. Electronics
Kelly Acoustics
Kodak

Lansing Sound Inc. (*U.S.A.*)
Leak, H. J. & Co.
Loewe Opta (*Germany*)
Long Playing Record Library
Lowther Manufacturing Co.
Lustraphone
Luxor Industri Aktiebolag (*Sweden*)

M.S.S. Recording Co.
Metro-Sound Manufacturing Co.
Minnesota Mining & Mfg. [Scotch]
Mullard

Ortofon A/S (*Denmark*)

Peto Scott Electrical Insts.
Philips Electrical
Pioneer Electronic Corp. (*Japan*)
Planet Projects
Pye

Radford Electronics
Record Housing
*Records & Recording*
Reslosound
Revox-Studer (*Switzerland*)
Richard Allan Radio
Rogers Developments

S.M.E.
S.T.C.
Sherwood Electronic (*U.S.A.*)
Shure Electronics
Sony Corporation (*Japan*)
Stuzzi Radiotechnischer (*Austria*)
Sugden, A. R. [Connoisseur]

Tandbergs Radiofabrikk (*Norway*)
Tannoy Products
*Tape Recording Magazine*
Telefunken A. G. (*Germany*)
Thorens S. A. (*Switzerland*)
Trio Corporation (*Japan*)
Truvox

Vitavox
Vortexion

Wharfedale Wireless Works
Whiteley Electrical Radio Co.
Williman, K. H., & Co.
Wilson Stereo Library
*Wireless & Electrical Trader*
*Wireless World*
Worden Audio Developments

Zonal Film

though previously exhibited on the Continent. Among them is the CSV10 stereo amplifier and associated PCS45 record player, and the TC20 stereo record player which incorporates an f.m./m.w./l.w. receiver (speakers are separate). Also to be shown for the first time in this country is the L80 loudspeaker which includes a Leak woofer and a Kelly ribbon tweeter.

*Agents:—Argelane Ltd., 251 Brompton Road, London, S.W.3.*

### BRENELL

The range of tape recording equipment that will be shown includes mono and stereo tape decks, tape decks with separate record and playback amplifiers, complete tape recorders and tape decks that will accommodate 10½ in diameter spools. In addition, the Brenell Mk5 Series 2 amplifier can be examined. This can be used as a recording amplifier, replay pre-amplifier or as a complete replay amplifier into a 15 ohm speaker. Facilities include switched frequency correction for 4 speeds, microphone and radio input sockets and monitoring of input signals on headphones.

*Brenell Engineering Co. Ltd., 1a Doughty Street, London, W.C.1.*

### BROWN

A wide variety of microphones, headphones and component parts will constitute the display by the Communications Division of S. G. Brown. At the Fair particular emphasis is being placed on what is called the "Diplomat Personal Auditorium." This headset and control unit for listening to stereo records provides independent control of sound level for each earpiece.

*S. G. Brown Ltd., King George's Avenue, Watford, Herts.*

### ERYAN AMPLIFIERS

Two transistor amplifiers from Bryan Amplifiers Ltd., of Hale, Cheshire, are to be shown on Stand 73 this year. The Model 400 is a mains-driven 15-watt per channel stereo unit with a distortion factor of less than 0.25% at 10 watts; signal-to-noise ratio of −60dB. Tape recorder take-off points at 100 mV, independent of volume control setting, are incorporated.

*Agents:—Tellux Ltd., Avenue Works, Colchester Road, Romford, Essex.*

### BUTOBA

Three twin-track, two-speed transistor tape recorders are to be shown this year. The wow and flutter characteristics of the senior model, the MT5, are 0.11% at 3¾ in/sec and 0.16% at 1⅞ in/sec. All three machines are battery operated and manufactured in Germany.

*Agents:—Denham & Morley Ltd., Denmore House, 173-175 Cleveland Street, London, W.1.*

### CELESTION

A new range of loudspeakers, known as the Studio Series, are to be shown for the first time at this year's show. Foremost in the range are the CX1512 (standard model) and the CX2012 (de-luxe model). Both models are full-range coaxial units of 12 in diameter and capable of handling 15 and 20 watts respectively. The cross-over frequency of both speakers is 4 kc/s.

*Celestion Ltd., Ferry Works, Thames Ditton, Surrey.*

### CHAPMAN

This trade name is still used by the company which was Chapman Reproducers and is now part of the Derritron Group. The range of Chapman equipment to be seen will include several tuners and three amplifiers. One tuner, the FM1005, covers from 16-2,000 metres (a.m.) as well as the f.m. band, and has an output of approx. 250 mV.

*Derritron Radio Limited, 24 Upper Brook Street, London, W.1.*

### CLAIRTONE

Described as a completely new concept in sound is the Project G stereo radiogram produced by the Clairtone Corporation of Canada. As will be seen from the photograph it has a sphere at either end of the cabinet and in these are housed the loudspeakers. The spheres are rotatable through 340°. It has an output of 45 watts per channel.

*Agents:—Argelane Ltd., 251 Brompton Road, London, S.W.3.*

### CLARKE & SMITH

Two additions to the range of equipment are to be shown. The Model 658 Mk II a.m./f.m. tuner with an improved specification will be demonstrated, together with established amplifiers and a compact new loudspeaker system, the 619. Transistor tape recorders will also be shown.

*Clarke & Smith Manufacturing Co. Ltd., Melbourne Works, Wallington, Surrey.*

### CONNOISSEUR

One of the main exhibits of sound reproducing and recording equipment to be shown this year is a new pick-up arm with a detachable head shell. Known as the SAU1, it will accept any standard cartridge with ½in fixing centres; including their own Type SCU1 stereo cartridge. Other items to be displayed for the first time include a new range of speaker enclosures designed for omnidirectional sound distribution.

*A. R. Sugden & Co. (Engineers) Ltd., Market Street, Brighouse, Yorks.*

### DESIGN FURNITURE

Cabinets for equipment housing and record storage will be shown. Most of the furniture will be available in walnut, sapele, mahogany or teak. Four new designs will be exhibited.

*Design Furniture Ltd., Calthorpe Manor, Dashwood Terrace, Banbury, Oxford.*

### E.M.I.

Tape, film and disc sound recording media are to be shown. The sprocketed magnetic recording Emifilm is available in 16, 17.5 and 35mm stock, the latter being obtainable either fully coated, centre coated or striped. Several professional tape recorders of E.M.I. Electronics, including the portable stereo TR52, will be demonstrated.

*E.M.I. Tape Ltd., Hayes, Middx.*

### ELCOM

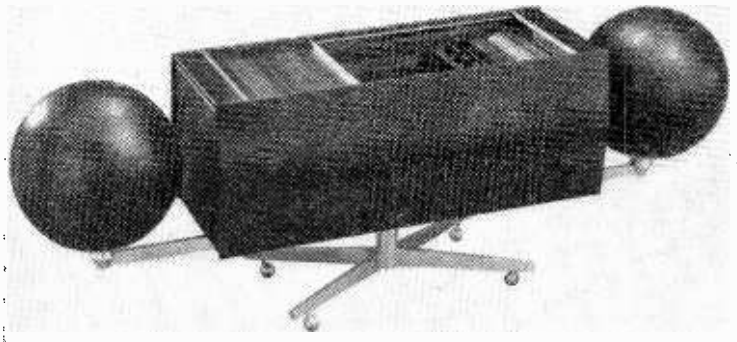
A new range of transistor equipment will be exhibited. Intended mainly for professional use many of the units and components shown could well find their way into the home of the connoisseur. Mixers, microphone amplifiers, talk-back amplifiers, attenuators, switches, connectors, plugs and sockets will be shown.

*Elcom (Northampton) Ltd., Weedon Road Industrial Estate, Northampton.*

### FERROGRAPH

In addition to their own domestic, "semi-professional" and industrial tape recorders, Ferrograph will be showing a selection from the range of components produced by their subsidiaries Wright & Weaire and Rendar Instruments.

*Ferrograph Co. Ltd., 84 Blackfriars Road, London, S.E.1.*



*Clairtone "Project G" stereo radiogramophone. The 18in spheres housing the loudspeakers are rotatable through 340°.*

#### FI-CORD

A new rechargeable battery unit for the Fi-Cord 202 tape recorder is to be shown along with two other recent Fi-Cord releases—a portable amplifier-speaker unit and a transistor mixing unit. The Fi-Cord recording system is to be demonstrated.

*Fi-Cord International Ltd., 40a Dover Street, London, W.1.*

#### G.K.D.

Cabinets designed for Leak and Quad audio equipment are among those to be shown by this company. In one of them—the Chiltern—the radio and audio units are fitted in a hinged drawer so that when closed the controls are concealed.

*G.K.D. Ltd., King Street, Houghton Regis, Dunstable, Beds.*

#### GARRARD

Among the Garrard range of products to be seen this year is a battery operated version of the Autoslim range of turntables. Other items to be shown include the Garrard Laboratory Series of auto turntables, a high-quality transcription motor and a low-mass stereo pickup arm.

*Garrard Engineering Ltd., Newcastle Street, Swindon, Wilts.*

#### GEVAERT

The complete range of Gevasonor recording tapes will be on display, including the TrP triple-play tape.

*Gevaert Ltd., Great West Road, Brentford, Middlesex.*

#### GOLDRING

Turntables, pickup arms, cartridges and replacement styli will be exhibited The three Goldring "Lenco" transcription turntables on show feature a vertical drive system and variable speed adjustment from 30 to 80 r.p.m. and from 15 to 18 r.p.m. A new pickup arm will be demonstrated that will permit balancing in all planes irrespective of which cartridge is fitted.

*Goldring Manufacturing Company (Great Britain) Ltd., 486 High Road, Leytonstone, London, E.11.*

#### GOODMANS

Four new products will be shown and demonstrated, the Eleganzia II, the Maxim, the Audion 91 and the Triaxion 1220C. The Eleganzia II is a loudspeaker and enclosure assembly only $6\frac{1}{4}$ in deep. The system is rated as 15W over a frequency range of 35 to 15,000 c/s. The Maxim has a frequency range of 45 to 20,000 c/s and measures only $10\frac{1}{2} \times 5\frac{1}{2} \times 7\frac{1}{4}$ in. Two loudspeakers were developed especially for this small cabinet.

*Goodmans Industries Ltd., Axiom Works, Lancelot Road, Wembley, Middlesex.*

#### GRAMPIAN

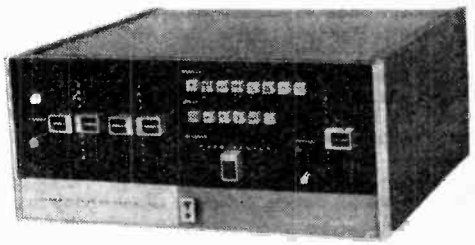
In addition to microphones, microphone accessories and loudspeakers, a range of reverberation and tremolo units for use with guitars and other inputs is now in production.

*Grampian Reproducers Ltd., Hanworth Trading Estate, Feltham, Middlesex.*

*Left: Grundig SV50 stereo power and control amplifier.*

*Below: Lansing SG520 control unit using slider controls and illuminated buttons.*

*A new version of the A.K.G. D19 microphone which incorporates an on-off switch.*



#### GRUNDIG

The v.h.f./medium-wave tuner (RT50) to be introduced to the U.K. at the Fair incorporates a decoder stage for f.m. stereo broadcasts. The associated stereo amplifier (SV50) has for each channel a two-stage microphone pre-amplifier, seven-stage audio amplifier, four-stage push-pull driver and transformerless output. Grundig will also be exhibiting and demonstrating their range of tape recorders and loudspeakers.

*Grundig (Great Britain) Ltd., Newlands Park, Sydenham, London, S.E.26*

#### JORDAN-WATTS

Claimed to be a new concept in loudspeaker design, the Jordan-Watts modular loudspeaker system will be introduced. Each unit has a power handling capacity of 12W r.m.s. and is intended to operate either singly or in multiples according to the acoustic power required. Each unit is square in shape to enable stacking of a number of units.

*Boosey & Hawkes Ltd., Sonorous Works, Deansbrook Road, Edgware, Middlesex.*

#### KEF

In addition to the established range of speakers and enclosures, a Standard version of the Duette will be introduced. The unit is electrically identical to the de luxe model, but has a simpler and cheaper cabinet. Further demonstrations of stereophony with artificial reverberation will be given.

*KEF Electronics Ltd., Tovil, Maidstone, Kent.*

#### KELLY

An extended range of loudspeakers is to be shown and will include four 12in and one 15in l.f. drive units and a ribbon loudspeaker.

*Kelly Acoustics Ltd., Romagna, Bycullah Avenue, Enfield, Middlesex.*

#### KODAK

Kodak, who are exhibiting for the first time at this year's show, are to display and demonstrate the range of magnetic sound recording tapes they import from their French associate company Kodak-Pathé.

*Kodak Ltd., Kodak House, Kingsway, London, W.C.2.*

#### LANSING

A wide range of the American Lansing loudspeakers will be on show for the first time. The two main features of the display will be the Model SG520 control unit—a comprehensive instrument using linear slider controls and illuminated buttons—and the Paragon stereo loudspeaker which, among other claims to fame, is nearly nine feet long.

*Agents:—Ad. Auriema Ltd., Inpectron House, 125 Gunnersbury Lane, London, W.3.*

#### LEAK

A new integrated pre-amplifier and amplifier using transistors will be introduced. Known as the "Stereo 30" the equipment provides 10W per channel into a 15Ω load and 15W per channel into a 4Ω load. The

weight is 14lbs and the unit may be used free-standing (table top, bookcase, etc.) or panel mounted. Other exhibits will include established Leak tuners and "Sandwich" loudspeakers.

*H. J. Leak & Co. Ltd., Brunel Road, Westway Factory Estate, London, W.3.*

### LOEWE OPTA

Tape recorders, radiograms and associated accessories manufactured by Loewe Opta of Germany will be exhibited. The Optacord 414 will be shown together with the 414 D1A which, besides having an identical performance to the Type 414 enables the recorder to be synchronized to transparency projectors which have automatic slide changing facilities.

*Agents:—Highgate Acoustics, 71-73 Great Portland Street, London, W.1.*

### LONG PLAYING RECORD LIBRARY

Books published by L.P.R.L. will be available. These include "A Guide To The Bargain Classics," "The Stereo Record Guide" (in three volumes) and "The L.P.R.L. Classical Catalogue and Handbook."

*Long Playing Record Library Ltd., Squires Gate Station Approach, Blackpool, Lancs.*

### LOWTHER

A new f.m. receiver and an f.m. tuner are to be shown. The receiver employs a transistor f.m. section and a 12-watt valve amplifier. The tuner, which covers the range 87-101 Mc/s, can be fitted with a transistor multiplex adaptor. Other products include a range of speaker enclosures, drive units and power amplifiers.

*The Lowther Manufacturing Company, Lowther House, St. Mark's Road, Bromley, Kent.*

### LUSTRAPHONE

In addition to the range of amplifiers, mixers, transformers, microphones and stands, the company will show their new combined microphone/transmitter to operate with the Radiomic seen last year.

*Lustraphone Ltd., St. George's Works, Regent's Park Road, London, N.W.1.*

### LUXOR

These Swedish-made tape recorders, record players and loudspeakers are being shown at the Audio Fair for the first time. The five tape recorders on show will include two 4-track models. One of the two record players—the ESL514—is battery operated. Loudspeakers range from 2-in to 14-in diameter.

*Agents:—Britimpex Ltd., 16-22 Great Russell Street, London, W.C.1.*

### M.S.S.

This year the M.S.S. Recording Company are to show a film which illustrates the production processes involved in the manufacture of their "Mastertape" magnetic recording tape.

*M.S.S. Recording Company Ltd., Poyle Trading Estate, Colnbrook, Slough, Bucks.*

### METRO-SOUND

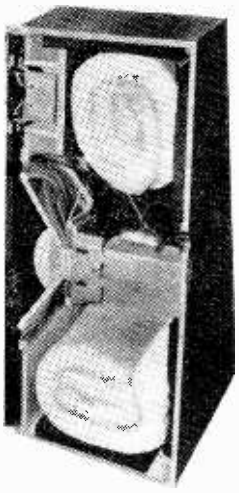
The display will include speakers, record-players, tape accessories and styli. New this year are the MI and MII bookshelf speakers with 12-in and 5-in units or 13 × 8-in and 3-in units respectively The Classic stereo reproducer consists of a Garrard AT6 motor, with two separate bookshelf speakers.

*Metro-Sound Manufacturing Co. Ltd., Bridge Works, Wallace Road, Canonbury, London, N.1.*

### MULLARD

Components of specific interest to audio equipment manufacturers and home constructors will be shown. These will include transistors suited to audio-amplifier applications, capacitors, silicon junction rectifiers and thermionic valves. Design data for stereophonic amplifiers, tape recorders and an oscilloscope will be available, free of charge.

*Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.*



Section through Leak "Sandwich" loudspeaker.

### ORTOFON

A range of pickup arms and cartridges, amplifiers, speakers and arm controls will be seen, the latest introduction being the SPU/GT stereo cartridge with an elliptical diamond stylus. The Hi-Jack hydraulic arm-lowering device will be shown.

*Agents:—Metro-Sound Sales Ltd., Bridge Works, Wallace Road, Canonbury, London, N.1.*

### PHILIPS

An addition to the range of Philips tape recorders is the new two-speed ($1\frac{7}{8}$ and $3\frac{3}{4}$in/sec) four-track EL3548. It has a signal-to-noise ratio of better than 40dB and a frequency response of 60-13,000c/s at $3\frac{3}{4}$in/sec. Philips studio equipment, including the EL3564 console tape recorder and the EL3624 disc record-playing console (both to be seen for the first time in the U.K.) will be demonstrated by Peto Scott.

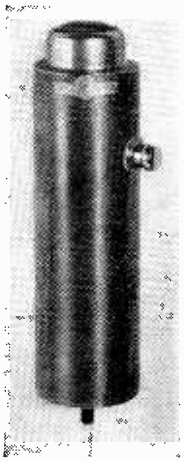
*Philips Electrical Limited, Century House, Shaftesbury Avenue, London, W.C.2.*

### PIONEER

A completely new range of tuner units and amplifiers, manufactured by the Pioneer Electronic Corporation, of Japan, are being exhibited for the first time at this year's show. A number of these tuner units and amplifiers are combined and contain multiplex circuits. Other items to be shown include a multiplex adaptor, a reverberation amplifier unit and a pair of lightweight stereo headphones.

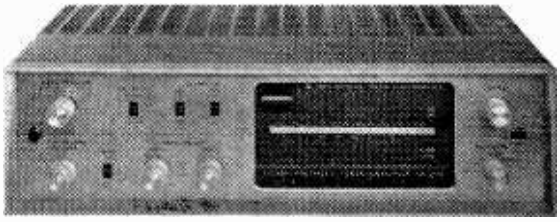
*Agents:—C. E. Hammond & Co. Ltd., 90 High Street, Eton, Windsor, Berks.*

(*Continued on page 171*)



Philips new two-speed four-track tape recorder, the EL3548.

Lustraphone D59/RT microphone/transmitter unit for use with the firm's Radiomic system.



*Known as Model SM-G205 this Pioneer Electronic Corporation stereo outfit covers the medium-wave and f.m. bands and has an output of 12 watts per channel.*

### PLANET

In addition to their U1 series of tape decks, which employ Bruno Woelke heads, Planet will be displaying a deck complete with stereo recording and replay amplifiers.

*Planet Projects Limited, Goodman Works, Belvue Road, Northolt, Middx.*

### QUAD

Quad electrostatic loudspeakers will be shown together with the Quad II power amplifier, the Quad 22 stereo control unit and two tuner units. The f.m. unit can be operated over the frequency range 87.5 to 108Mc/s. The European version of the a.m. tuner has a coverage of 5.8 to 18.5Mc/s. on the short waveband and 2070 to 800m and 588 to 185m on the long and medium wavebands respectively.

*Acoustical Manufacturing Co. Ltd., Huntingdon.*

### QUALITON

A stereo amplifier, known as the AE 211, is to be shown by Elektroimpex the Hungarian trading company for telecommunications equipment. The output of the amplifier is 14 watts and the frequency coverage is 20-20,000 c/s; with either 15dB boost or cut at the bass and treble ends of the range.

*Agents:—David & Co. Shipping Ltd., 70 Brewer Street, London, W.1.*

### RADFORD

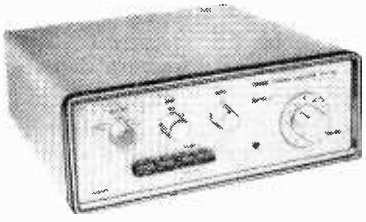
Existing products and prototypes of equipment to be manufactured later in 1964 will be demonstrated. As well as showing amplifiers, pre-amplifiers, loudspeakers and turntable equipment, kits, transformers and laboratory test equipment will be exhibited.

*Radford Electronics Ltd., Ashton Vale Estate, Bristol, 3, Glos.*

### RECORD HOUSING

The " Lowline " range of equipment cabinets is augmented this year by a new speaker cabinet and a compact cabinet for turntable and control units. The " Folded-Horn 8-in Enclosure " is designed on the Voigt principle to take an 8-in speaker, while the " Lowline One " equipment cabinet is intended for the smaller installation.

*Record Housing, Brook Road, London, N.22.*



*Type SC4-10 transistor integrated amplifier and pre-amplifier manufactured by Radford.*

### RESLO

Three new microphones are among the wide range to be shown by Reslosound. They are the Pencil Dynamic (P.D.) stand type, the M.P.D., which is a smaller version of the P.D. for use with a neck attachment, and a professional type ribbon microphone (SR1).

*Reslosound Ltd., 24 Upper Brook Street, London, W.1.*

### REVOX

The latest Revox tape recorder, the 736, is to make its first appearance at the show. Two and four track versions of the 736 are to be demonstrated in both stereo and mono modes. The record/replay characteristics of this Swiss machine conform to the latest C.C.I.R. standards. A feature of the 736 is the inclusion of a 6-watt mono monitoring amplifier.

*Agents:—C. E. Hammond & Co. Ltd., 90 High Street, Eton, Windsor, Berks.*

### RICHARD ALLAN

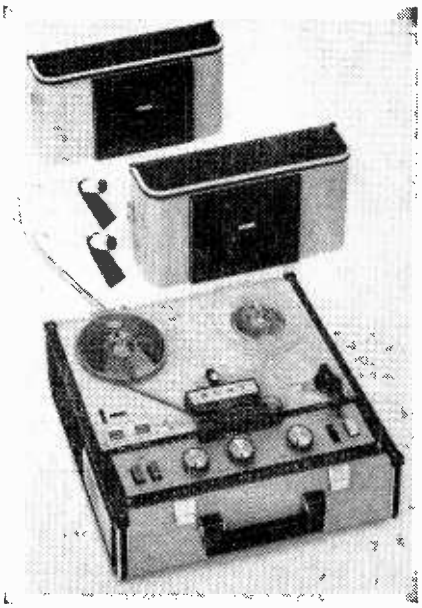
A new range of loudspeakers is announced, using ceramic magnets and shallow cones for mounting in the modern, slim type of enclosure. Units ranging from the 4-in 410T tweeter to the C915 15-in, 20-W unit will be on show, with three new two-way and three-way enclosures.

*Richard Allan Radio Ltd., Bafflette House, Batley, Yorks.*

### S.M.E.

Although the Series II pickup arms are unchanged from those of last year, they will be available with the amplifier connecting lead as a standard pack. The arms will be shown together with a number of accessories which include balance weights, adaptors for Decca heads and a plinth to increase height of pickup when used with deep turntable units.

*S.M.E. Ltd., Steyning, Sussex.*



*Called the Sony 200, this machine has two speeds and full four-track facilities. The pair of loudspeakers form the lid when the recorder is not in use.*

### S.T.C.

Microphones and earphones will form the main part of the exhibit. New products to be shown include the 4114 and 4118 omnidirectional microphones offering good performance at low cost, the 4113 unidirectional type which covers the full audio range of frequencies and gives improved performance in the presence of vibration, and the 4115 ribbon microphone designed for work in noisy surroundings. Stereo earphones will also be shown.

*Standard Telephones & Cables Ltd., (Electro-mechanical Division), West Road, Temple Fields, Harlow, Essex.*

### SCOTCH

The full range of magnetic sound recording tapes manufactured by the 3M Company will be shown and demonstrated together with a number of accessories.

*Minnesota Mining & Manufacturing Co. Ltd., 3M House, Wigmore Street, London, W.1.*

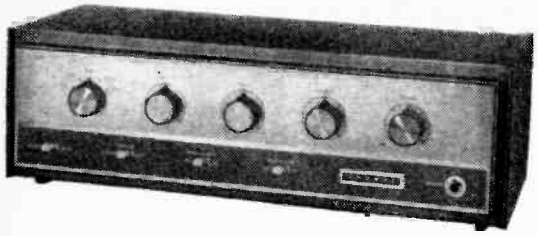
### SHERWOOD

A new version of the S5500 stereo amplifier introduced at last year's Fair is to be shown by the agents of this Chicago firm. Version III has an output of 28 watts r.m.s. per channel. Also on show will be a transistor stereo amplifier (S9300) which has a 15-watt per channel output.

*Agents:—Audioson Ltd., Orchard House, Orchard Street, London, W.1.*

### SHURE

A stereo pickup (M.44) with a retracting stylus working at an inclination



*Truvox stereo amplifier (transistor).*

from vertical of 15 is to be shown. It has a compliance of $25 \times 10^{-6}$ cm/dync (playing weight $1\frac{1}{4}$ gm) and channel separation > 25dB is claimed.

*Shure Electronics, Ltd., 84 Blackfriars Road, London, S.E.1.*

### SONY

Two new tape recorders and a stereo tape deck and associated amplifier have been added to the Sony range of Japanese recording equipment. Both tape recorders, which are to be seen for the first time, are twin-speed, four-track machines and the Model 600 is fitted with transistor pre-amplifiers. A large range of accessories are also to be shown.

*Agents:—Tellux Ltd., Avenue Works, Colchester Road, Romford, Essex.*

### STUZZI

Several new instruments from this Austrian firm will be introduced, which combine radio, tape recording and, in one case, sound reproduction. The 802FM is a combination of 2-speed tape recorder and f.m. tuner, and may be used either for radio listening or radio recording, or both. The 502 is similar, but uses an a.m. long- and medium-wave tuner. The Disc-Corder is a transistor unit comprising a battery-powered tape recorder, a radio and 45 r.p.m. record-player.

*Agents:—Recording Devices Ltd., 44 Southern Row, London, W.10.*

### TANDBERG

Two-track and four-track versions of the 6 and 7 Series of Tandberg tape recorders are to be shown this year. These Norwegian machines are fitted with three-speed motors and have sound-on-sound facilities. The Tandberg range of language laboratory equipment is also to be displayed.

*Agents:—Elstone Electronics Ltd., Edward Street, Leeds 2, Yorks.*

### TANNOY

Loudspeakers, enclosures and magnetic cartridges will be among the products exhibited. The Mk. II magnetic mono cartridge will be available in two forms, a turnover cartridge and "single play" cartridge. The stereo version the "Vari-Twin" Mk. II magnetic cartridge, will also be shown. This has an output of 7mV per channel into an impedance of 100kΩ.

*Tannoy Products Ltd., Norwood Road, West Norwood, London, S.E.27.*

### TELEFUNKEN

The main feature of the display will be the new M.300 battery/mains tape recorder. Specifically intended for portable working, the tape transport is claimed to give constant-speed drive even when the recorder is being swung by its handle. Frequency response is up to 13kc/s at the single speed of $3\frac{3}{4}$in per sec.

*Agents:—Welmec Corporation Ltd., 27 Chancery Lane, London, W.C.2.*

### THORENS

Among the range of turntables and pickup arms being shown by this Swiss firm will be the very unusual TD224 transcription-quality automatic record changer, which has only one record at a time on the turntable.

*Agents:—Metro-Sound (Sales) Ltd., Bridge Works, Wallace Road, Canonbury, London, N.1.*

### TRIO

Several new additions to the Japanese Trio range of equipment are to be shown this year. These include an a.m. f.m. multiplex stereo tuner, a f.m. stereo receiver, an a.m./f.m. stereo receiver with multiplex facilities, a combined stereo pre-amplifier and 12 watt amplifier, and a multiplex adaptor.

*Agents:—Winter Trading Co. Ltd., 95-99 Ladbroke Grove, London, W.11.*

### TRUVOX

The full range of Truvox tape recorders will be shown. In addition, a transistor amplifier will be introduced. Designated Type TSA100, the stereo amplifier has a transformerless, 10W per channel output (15Ω). A number of input sockets permit amplification of signals from tuners, tape heads and recorder and from a large number of pickup cartridges. The company also hope to introduce a stereo loudspeaker system.

*Truvox Ltd., Neasden Lane, London, N.W.10.*

### VITAVOX

Examples from the range of microphones, speakers and loud-hailers will be presented together with a demonstration of loudspeakers developed for use in cinemas.

*Vitavox Ltd., Westmoreland Road, London, N.W.9.*

### VORTEXION

Tape recorders, mixer units and high power amplifiers will be the principal equipments on show. Two microphones will also be included in the exhibits, the Type M8 ribbon microphone and a moving coil cardoid microphone with a back to front discrimination of 15dB.

*Vortexion Ltd., 257/263 The Broadway, Wimbledon, London, S.W.19.*

### WHARFEDALE

Apart from the established range of loudspeakers, enclosures and transformers some new speaker units and crossover networks will be shown. The HS/400/3 crossover unit is a three-way separator with cross-over frequencies at 400 and 3,000 c/s. The new loudspeakers are the Types 8in Bronze/RS/DD and 10in Bronze/RS/DD. These are intended to reproduce a wide range of frequencies at a comparatively low price.

*Wharfedale Wireless Works Ltd., Idle, Bradford, Yorks.*

### WHITELEY

A wide range of Stentorian loudspeakers (from $1\frac{3}{4}$ to 18in dia.), v.h.f. tuners, amplifiers and cabinet kits are to be exhibited and demonstrated. The WB12 amplifier has been redesigned and its associated control unit provides facilities for feeding stereo or mono inputs from tape, disc or radio.

*Whiteley Electrical Radio Co. Ltd., Victoria Street, Mansfield, Notts.*

### WILLIMAN

This company is exclusively engaged in the export of British audio equipment and will be demonstrating equipment of some of the companies they represent. Products will include tuners, amplifiers, pickup arms, tape decks and loudspeaker units.

*K. H. Williman & Co., Blackford House, Sutton, Surrey.*

### WILSON STEREO LIBRARY

The "Stereo Index" which contains over 200 pages of information on stereo recordings of all syles (drama, serious music, jazz etc.) will be on sale. The index will give information on records issued up to Easter 1964.

*Wilson Stereo Library Ltd., 463 Streatham High Road, Streatham, London, S.W.16.*

### WORDEN

A transistor stereo control unit and complementary power amplifiers are among the items to be shown. Other products include an articulated pick-up arm with a shell headpiece which will accommodate any cartridge having a $\frac{1}{2}$in mounting centre, and a loudspeaker enclosure fitted with a 10-in Wharfedale speaker.

*Worden Audio Developments Ltd., 54 Chepstow Road, London, W.2.*

### ZONAL FILM

A range of recording tapes and accessories will be exhibited.

*Zonal Film (Magnetic Coatings) Ltd., Zonal House, Heron Trading Estate, Westfields Road, London, W.3.*

# MANUFACTURERS' PRODUCTS

## NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

### Magnetizer

A PORTABLE, mains-powered magnetizing unit has been developed by Hirst Electronic, Crawley, Sussex, for producing relatively small magnets. It is envisaged that the magnetizer, Type MC/1, will be used mainly for the production of magnets for use in thermostats, small motors and loudspeakers and relays. The output of the instrument is fixed at 40 joules. The dimensions are $10\times6\times6\frac{1}{4}$in, the weight 12lb and the magnetizer costs £40.

7WW 301 for further details

### Insulation Testers

FOUR new insulation testers have been introduced by the Instrument Division of Evershed and Vignoles, Chiswick, London. The range has been designated the Major "Megger" testers, and all are multi-voltage instruments, three of the range also having continuity-testing facilities. The insulation test voltages are 100, 250, 500 and 1,000V, d.c. Instruments No. 70154 and No. 70155 have insulation-measurement ranges from 0 to 200MΩ, the former having a continuity range from 0 to 100Ω and the latter from 0 to 10,000Ω. Tester Type 70157 has an insulation range of 0 to 100MΩ and a continuity range of 0 to 500Ω. The other instrument in the range, Type 70156, has an insulation range of 0 to 2,000MΩ. Test leads are provided with all the instruments. The terminals can accommodate most standard types of cable terminations. The upper sections of the instrument cases are constructed from aluminium, stove enamelled in a resin based finish. The lower section is made from pressed steel. A leather case can be supplied for each instrument in the range at an extra cost.

7WW 302 for further details

### Automatic Range Changing

USERS of digital voltmeters, Types DM2001 Mk2 and DM2020 manufactured by Digital Measurements Ltd., Mytchett, Hants, can add automatic ranging facilities with the Type DM2053 automatic ranging unit. This unit, when coupled with the digital voltmeter, enables the instrument to select automatically the range which provides optimum resolution for the applied input voltage. In addition input attenuators and filters, which duplicate those in the voltmeter, are provided. Remote control of the equipment is also provided. The new unit can be rack mounted and the dimensions are $19\times1\frac{1}{2}\times12\frac{1}{2}$in. A case to take both ranging unit and voltmeter is available.

7WW 303 for further details

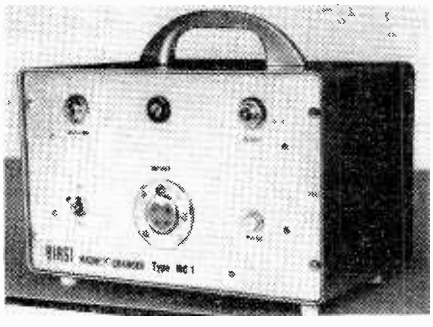
### E.H.T. Unit

INTENDED for incorporation with other equipment, the Beulah e.h.t. unit provides a variable direct voltage from 8 to 12kV. The unit uses an r.f. source which is well screened. At 12kV the maximum current available is 500μA. An h.t. supply of 250V, 30mA is required together with an l.t. supply of 6.3V (a.c.) at 0.9A. The unit weighs $4\frac{1}{2}$lb and the dimensions are $7\frac{1}{4}\times5\times7$in. The price for single units is £14 10s. The address of the manufacturer is Beulah Electronics, Hamilton Road, London, S.E.27.

7WW 304 for further details

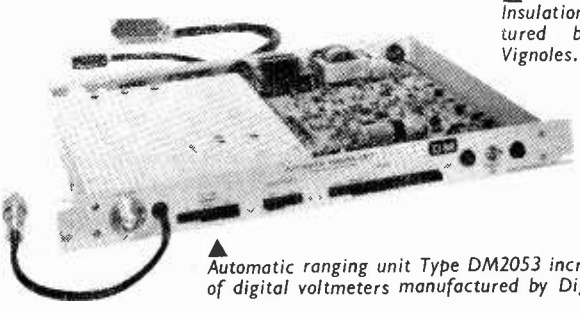
### Instrumentation Tape Recorder

A TRANSPORTABLE, battery- or mains-powered tape recorder for instrumentation work is announced by Precision Instrument Company of California. Designated the P1-6100, two, four or eight channel versions are available. Transistors are used throughout and an interesting feature is that of being able to expand or compress time on a 100:10:1 ratio basis. Thus, a 9-hour process when recorded can be reproduced in 9 minutes. The tape speeds are 37.5, 3.75 and 0.375in/sec; $\frac{1}{4}$-in magnetic tape is used. The instrument can be operated in a horizontal or vertical position and can be powered from alternating mains supplies of 105 to



▲ *Portable mains-powered magnetizing unit by Hirst Electronic.*

▲ *Insulation tester manufactured by Evershed and Vignoles.*



▲ *Automatic ranging unit Type DM2053 increases the versatility of digital voltmeters manufactured by Digital Measurements.*

230V or from two 12V batteries. Record, playback and erase facilities are available in both tape directions and the tape speed is servo controlled to within 0.5%. F.m. recording can be achieved over a frequency range of z.f. to 10kc/s. The 2-channel version costs $3,950, the 8-channel $6,500. Precision Instruments are represented in the U.K. by T. D. Dalzell of Cannon Hill, Bray, Berkshire.

7WW 305 for further details

### Ten-pin Valve

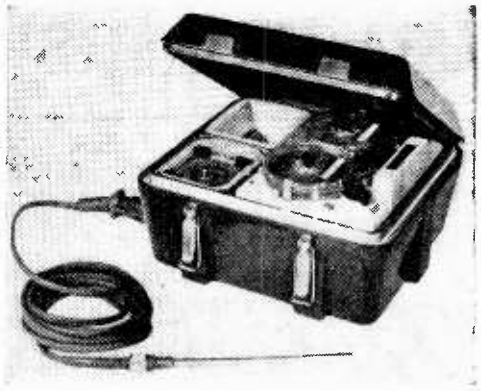
TWO pentode valves in one envelope is a feature of a new Mullard valve, the Type PFL200. Intended mainly for television receiver applications, one pentode system can be used as a high-gain video output stage. The "F" section may be used as a medium-slope voltage amplifier in sync separator or a.g.c. stages, etc. The valve, which has ten pins, requires a base which has the same diameter as the familiar B9A base, the new base being designated B10B or "decal" base. The "L" section is designed so that a large output voltage can be produced across a low value anode load resistor. To achieve high gain and thus allow the application of negative feedback, a frame-grid control grid has been used, the valve having a slope of 21mA/V at 30mA.

7WW 306 for further details

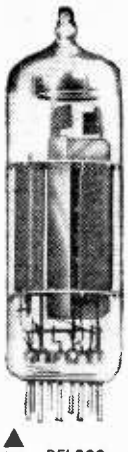
### Data Logging

A PORTABLE logging system for sampling data and recording it at pre-set intervals can be obtained from Dobbie McInnes (Electronics) Ltd., Guildford, Surrey. The instrument is powered by battery and is housed in a watertight container. Thus it can be left unattended outdoors if required. (At the standard recording rate the logger can be left for one year without replacement of tape cassette or battery.) The equipment, which uses transistor circuitry, consists of an analogue-to-digital converter, precision clock mechanism, a $\frac{1}{4}$in magnetic tape recording unit and a battery power supply. The converter changes analogue voltage or resistance variations into digital pulses suitable for recording on the tape. The tape is only in motion when a reading is being taken, but each reading is separated from the next by a small length of blank tape. External transducers are available for many applications. These include measurement of temperature, pressure, strains, rainfall, wind speed and direction, depth of water, etc. The equipment can be used over a temperature range of $-10$ to $+30$°C but the use of a second channel for temperature monitoring so that corrections to zero drift due to temperature changes can be made, permits the equipment to be used over the range $-30$ to $+75$°C. Readings may be made at a rate of one per minute in steps down to one every 12 hours. An alternative unit allows readings at a rate of one every 30 seconds to 3 per second. The whole instrument measures $12 \times 13 \times 5\frac{1}{4}$in and weighs 23lb. Users of the equipment who do not possess translation facilities to enable the recorded data to be automatically analysed by computers, etc., will be able to make use of translation facilities provided by the manufacturers at London, Glasgow and certain overseas agents.

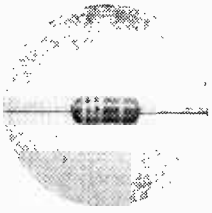
7WW 307 for further details



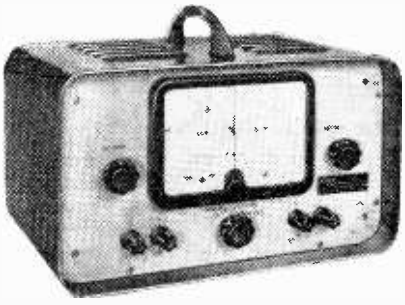
▲ *Dobbie McInnes data logging equipment with case opened.*



▲ *Type PFL200 valve manufactured by Mullard for use in television receivers.*



▲ *Resistor from the Electrosil TR5 range.*



*Scoba resistor and capacitor component comparator.* ▶

### Metal-oxide Resistors

AN unusual feature of the TR5 range of tin-oxide resistors, manufactured by Electrosil, Sunderland, is that any one component may be used in $\frac{1}{8}$, $\frac{1}{4}$ and $\frac{1}{2}$W applications. If a resistor is used as a $\frac{1}{8}$W component the stability (2000 hours at 70°C) can be expected to be within 0.5%. When used as $\frac{1}{4}$ and $\frac{1}{2}$W components the stabilities are within 1% and 2% respectively. Resistors from this

**INFORMATION SERVICE FOR PROFESSIONAL READERS**

To expedite requests for further information on products appearing in the editorial and advertisement pages of *Wireless World* each month, a sheet of reader service cards is included in this issue. The cards will be found between advertisement pages 48 and 51.

We invite readers to make use of these cards for all inquiries dealing with specific products. Many editorial items and all advertisements are coded with a number, prefixed by 7WW, and it is then necessary only to enter the number(s) on the card.

Readers will appreciate the advantage of being able to fold out the sheet of cards, enabling them to make entries while studying the editorial and advertisement pages.

Postage is free in the U.K., but cards must be stamped if posted overseas. This service will enable professional readers to obtain the additional information they require quickly and easily.

range are 0.375in long and have a diameter of 0.15in. Resistance values are available from 10Ω to 120kΩ. The maximum direct voltage that may be applied to resistors in the TR5 range is 350V. Other ranges of "triple rated" resistors are being manufactured. The TR4 range will have ratings of $\frac{1}{16}$, $\frac{1}{8}$ and $\frac{1}{4}$W and the TR6 range will be rated at $\frac{1}{4}$, $\frac{1}{2}$, and 1W.

7WW 308 for further details

## Component Comparator

THE first of a new range of "go/no-go" instruments which will be available from Aero Electronics, Horley, Surrey, is the Scoba resistor and capacitor component comparator. The instrument is direct reading over the range ±20% with an accuracy of ±5% of full scale. The comparator is basically an a.c. bridge (50c/s). The meter is calibrated in percentage deviation of value of the component under test from that of the standard. The range of the equipment is from 100Ω to 50MΩ and from 100pF to over 12μF. Two pairs of terminals, one for the standard component and one for the unknown, are provided on the front panel.

7WW 309 for further details

## Klystron Power Supply

THREE separate direct voltages are available from the Type LS502 klystron power supply manufactured by Allied Electronics, Upper Richmond Road, Putney, London, S.W.15. The supplies are individually and continuously variable from 0 to 10V (5A), 0 to 1kV (10mA) and 0 to 5kV at 150mA. The 1 and 5kV outputs are stabilized. Other features include an overload warning device, pilot lights to show which supplies are switched on and six meters so that the voltage and current at each output can be indicated. The equipment is housed in a free-standing rack fitted with castors.

7WW 310 for further details

## Oscilloscope Kit

AN OSCILLOSCOPE using a 5in cathode ray tube and with a $y$ amplifier bandwidth of 3c/s to 5Mc/s is available in kit form, or assembled, from Daystrom Ltd., Gloucester. The Heathkit Model I0-12U oscilloscope is a single-trace instrument and the vertical sensitivity is 10mV (r.m.s.) per cm at lkc/s. The rise-time is quoted as 0.08μsec or less and the overshoot as 10% or less. The sensitivity of the horizontal channel at lkc/s is 50mV per cm and the frequency response is lc/s to 400kc/s (within 3dB). Between lc/s and 200 kc/s the frequency response is flat to within 1dB. The timebase extends from 10c/s to 500kc/s in 5 steps. Other facilities include a 1V peak-to-peak voltage calibration, provision for $z$ modulation and a selector switch which permits synchronizing with either positive or negative signal pulses (internally), external signals or at the mains frequency.

The use of printed boards and a pre-formed cable harness facilitates construction. The kit of parts costs £32 12s 6d. If the oscilloscope is required assembled and ready for use the cost is £41 10s.

7WW 311 for further details

## Wire-wound Resistors

TWO new types of wire-wound resistors have been added to the Series G101 "Precistors" manufactured by Electrothermal Engineering, Neville Road, London, E.7. The tags of both types are anchored securely and protrude from the underside of the moulded body of the component. The Type 3505T is a $\frac{1}{4}$W resistor, the other type being a $\frac{1}{2}$W and designated Type 3507T. The values available are from 0.1Ω to 1MΩ ($\frac{1}{4}$W) and from 0.1Ω to 2MΩ ($\frac{1}{2}$W). Tolerances are from 0.1% to 0.01% dependent on value; the stability is better than ±0.02%. Maximum working voltages are 550V ($\frac{1}{4}$W) and 750V ($\frac{1}{2}$W).

7WW 312 for further details

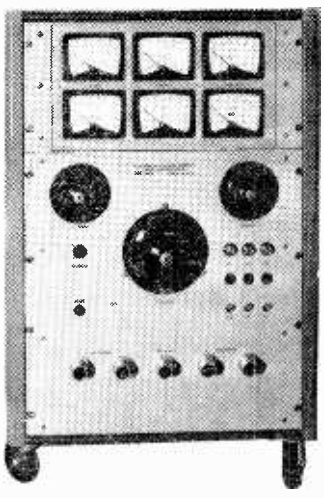
## Electronic Counter

FREQUENCY measurements up to 20Mc/s may be made with the counter Type 3135 manufactured by P.E.K. Electronic, Tettnang, Württ, Germany. The gating circuits can be controlled by hand-operated switches on the front panel of the instrument or by pulses −4 to −10V in amplitude. Eight meters are used for readout presentation. Transistors are used throughout the instrument which may be powered from a 220V alternating mains supply or from a 6V battery. The instrument may be used over a temperature range of 10 to 45°C. The weight of the counter is 13kgm and the dimensions are 430 × 200 × 180mm.

7WW 313 for further details

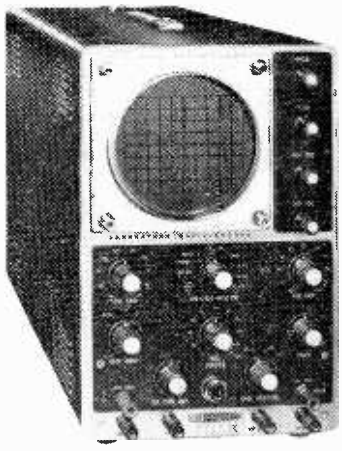
## Low-temperature Oven

A NEW low-temperature oven (Type I. 3/105) with a capacity of 5.6 cubic feet is available from Griffin

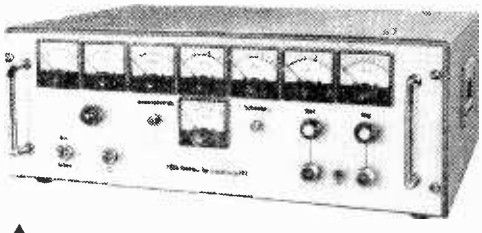


▲ *Klystron power supply Type LS502 (Allied Electronics).*

▲ *½W resistor from the Electrothermal "Precistor" range.*



▲ *Model 10-12U general-purpose oscilloscope.*



▲ *Counter Type 3135 manufactured by P.E.K. Electronic.*

and George, Wembley, Middlesex. Besides thermostatic temperature control, the oven has a toughened glass interior door and four non-tip sliding shelves; these can be adjusted to give shelf height variations. The maximum temperature that can be obtained is +105°C. At 37°C the maximum temperature variation is 0.8°C and the temperature drift over 72 hours is within 0.4°C.

7WW 314 for further details

### Tape Head Cleaning

AN often-neglected task is the removal of oxide deposits from tape recorder heads. To facilitate this duty, Tape Recorder Maintenance of Kennington Road, London, S.E.11, have introduced a brush which has an angled "blade." This is sufficiently small to slip into the majority of tape channels without removing cover plates. The angle and stiffness of the bristle is claimed to enable efficient removal of deposits without scoring the heads. The brushes cost 4s 3d each.

7WW 315 for further details

### Voltage Stabilizers

THE BTR range of mains voltage stabilizers manufactured by Claude Lyons, Hoddesdon, Herts, has been increased so that three basic types are available for 240V operation and three for 115V operation. For the 240V models, the operating voltage can be set as required from 200 to 254V and the output current ratings are 2A in the case of the Type BTR-2, 5A (BTR-5) and 13A (BTR-13). For 115V models, the operating voltage is adjustable from 100 to 127V and the current ratings are 3.5A (BTR-L4), 9A (BTR-L9) and 23A (BTR-L23). All models provide three alternative input ranges selected by a link, these being −15% to +5%, ±10% or −5% to +15% relative to the set operating voltage. Each model can be provided with filters but without these they have a total distortion of less than 7%, and output accuracy of ±0.3% at any load current from zero to full load. They are unaffected by frequency variations from 45 to 65c/s. When filters are provided the total distortion, at the frequency of the filter, is below 2.5%.

7WW 316 for further details

### Recording Heads

MAGNETIC recording heads for professional applications are available to customer specification through a new design and manufacturing service announced by Mullard. Recording heads for tape, magnetic discs and drums can be supplied for either single-track or multi-track applications in video tape recorders, computers and professional audio-frequency recording equipment. In place of the conventional laminated-metal construction a ferrite is used and they will work up to 10Mc/s.

By moulding glass in the gap between the pole pieces a sharply defined gap is obtained and wear of the ferrite at the pole pieces is very much reduced. Gap sizes of down to 1 micrometre (micron) can be supplied. Other advantages claimed for the heads include lower power losses, less head noise and a life-expectancy increase of 10 times that of more conventional heads.

7WW 317 for further details

### Plastic Labels

A NEW tool has been added to the range of Dymo Tapewriters manufactured by Hellerman Equipment, Crawley, Sussex. Designated Type M1054, it can produce labels up to 10 feet in length on plastic tape $\frac{3}{8}$in wide. The characters are selected by a dial; on squeezing the handle the character is embossed on the tape. A choice of eleven colours is available, although the letters appear white. The labels so produced have an adhesive-coated backing protected by a plastic strip which has to be peeled off immediately prior to sticking down the label. The machine costs £8 12s 6d.

7WW 318 for further details

### Thermal Delay Switch

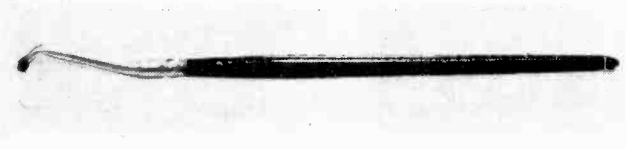
THE latest addition to the range of STC thermal delay switches is the Type SS110/1D. It consists of two separate switches mounted in a common glass envelope. Each unit provides a maximum closing delay time of 110 seconds. The switches can be used independently or in conjunction with one another when it is possible to obtain a delay of approximately 240 seconds. The delay is virtually independent of heater voltage variation and ambient temperature. The heater of each switch requires a 6.3V supply. The contact ratings (maximum) are, on make, 100V at 1A a.c. and 220V at 1A d.c.

7WW 319 for further details

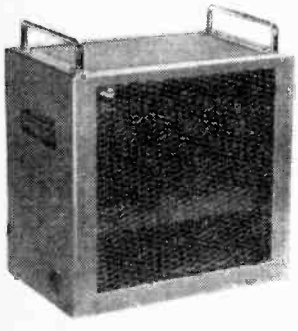
### Decade Resistance Boxes

A NUMBER of interesting features are to be found in two new decade resistance boxes that are available from Muirhead and Co., Beckenham, Kent. The new boxes, Types K-114 and K-115 are smaller than those previously available from the company and the use of improved resistance wire has resulted in higher accuracies and lower temperature coefficients. The resistors are non-reactively wound in single-layer windings on flat Mycalex cards. Four- and five-dial boxes are available, the maximum resistance being 111,110Ω. The accuracy over most of the range is within ±0.05%. Silver studs and silver-graphite wipers are features of the miniature rotary switches used in the boxes. The metal cases ensure adequate

(*Continued on page* 177)



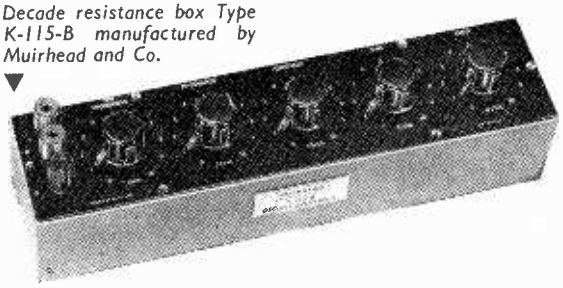
▲ *Brush for cleaning tape heads. (Available from Tape Recorder Maintenance.)*



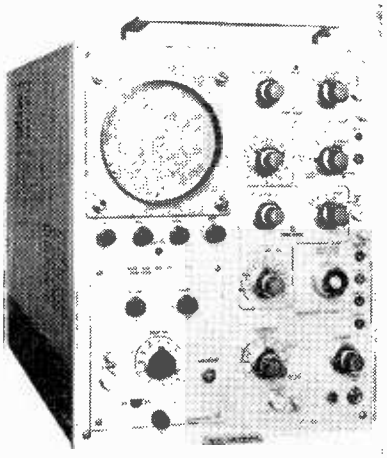
▲ *Dymo Tapewriter Type M1054 uses $\frac{3}{8}$in wide plastic tape to produce embossed labels up to 10ft in length.*

◀ *Voltage stabilizer Type BTR-13 from the new range of Claude Lyons stabilizers.*

Decade resistance box Type K-115-B manufactured by Muirhead and Co.



▲ Oryx 6V soldering iron.



▲ Solartron oscilloscope Type CD.1220 with wide-band, single-trace y amplifier.

▲ U.h.f. triode valve Type STC7298.

▲ Goodmans "5in Inverted" slim loudspeaker.

screening and a terminal enables the screen to be connected to either of the resistance terminals or to any point of the circuit to which the box may be connected. The terminals are so designed that the portion which clamps the lead does not rotate as the head is screwed down.

7WW 320 for further details

## Soldering Iron

MEASURING only 5½in long, and weighing 4gm, a new Oryx soldering iron is available for 6V working (5W). The $\frac{1}{16}$in tip is interchangeable without the need for fixing screws or rivets, etc. The iron is distributed by W. Greenwood Electronic, Finchley Road, London, and it is claimed that it will heat up to 320°C within 18sec. The retail price is 27s 6d.

7WW 321 for further details

## Oscilloscope

TWO timebases are provided in the new Solartron oscilloscope Type CD.1220. Timebase "A" has a range of 0.1$\mu$sec/cm to 12sec/cm while timebase "B" has a range of 2$\mu$sec/cm to 1sec/cm. This latter unit may be used to delay the former by 2$\mu$sec to 10sec (both can be expanded up to 5 times). The $x$ amplifier has a bandwidth of z.f. (zero frequency) to 150kc/s (−3dB) with a maximum sensitivity of 200mV/cm. The oscilloscope is sold without a $y$ amplifier but provision is made for plug-in units, two of which are immediately available. The single trace unit, Type CX.1256, has a bandwidth of z.f. to 40Mc/s with a sensitivity of 50mV/cm to 50V/cm. The dual trace unit, Type CX.1257 (sensitivity 50mV/cm to 50V/cm), has a bandwidth of z.f. to 24Mc/s. The main oscilloscope costs £545, the single trace unit £50 and the dual trace unit £100.

7WW 322 for further details

## U.H.F. Triode

A HIGH-SLOPE triode valve, which can be used as a unilateral replacement for the 2C39A, is announced by S.T.C. (Valve Division, Paignton, Devon). Designated the Type STC7298, it is more rugged than the 2C39A triode and the distributed inductance and capacitance of the grid/cathode and grid/anode configurations are more tightly controlled. Applications include use as a power amplifier, oscillator or frequency multiplier at frequencies up to 3,000Mc/s. The cathode is indirectly heated, the filament voltage being 6.0V (1A). The valve conforms to the U.S.A. JAN-7289 specification.

7WW 323 for further details

## Slim Loudspeaker

A NUMBER of slim loudspeakers, particularly suited to the domestic radio and car wireless industries, are available from Goodmans Industries, Wembley, Middlesex. The slimmest of these loudspeakers is the Type 5in Inverted which is only $1\frac{1}{16}$in when measured from back to front. Several alternative magnet systems and voice coil impedances can be supplied.

7WW 324 for further details

## U.H.F. Pre-amplifier

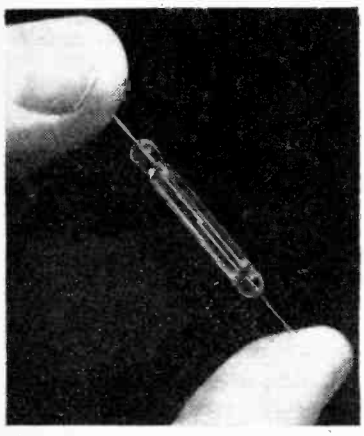
WOULD-BE viewers of the forthcoming BBC.2 programmes in weak signal areas may find a considerable improvement in reception by the use of the Labgear (Cromwell Road, Cambridge) masthead u.h.f. amplifier. Transistors are used and the power supply to the unit can be made via the coaxial downlead. The gain is approximately 14dB (Channels 23-33) and both input and output impedances are nominally 75Ω. The amplifier is housed in a cylindrical plastic case with a diameter of 3¼in and 1¾in deep. The cost is £5 5s. Two optional power units are available, a mains power unit (£3 15s) and a battery power unit (17s 6d).

7WW 325 for further details

# RECENT TECHNICAL DEVELOPMENTS

### Remanent Magnetic Alloy

The highest value of remanent induction of any magnetic material is claimed for a new member of the cobalt-iron-vanadium family of alloys —Remendur. It has been developed by the Bell Telephone Laboratories for use in switching applications, one of which being the "ferreed," which is a reed relay used for cross-point switching in electronic telephone exchanges. The new material possesses



*One application of Remendur is as pole-piece for the "ferreed" switch. Plates of Remendur are mounted parallel to the reeds, outside the glass; the whole is surrounded by a switching coil, the Remendur providing "hold" conditions after switching by a pulse.*

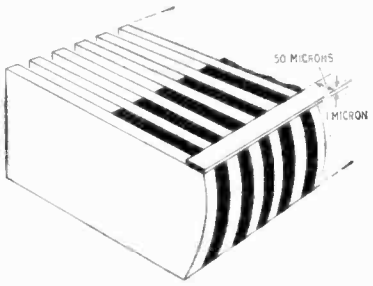
several mechanical and electrical advantages over the ferrites used for switching. A square hysteresis loop is combined with a temperature-stable coercive force, which is controllable between 20 and 60 oersteds to give remanence values of 16,000 to 21,500 gauss. Mechanically, the alloy is sufficiently malleable and ductile to be formed into ribbon and fine wire, and its coefficient of expansion is similar to that of glass.

### Delay Line

One factor which may possibly affect the current controversy on colour television systems is the cost of receivers. The delay line used in SECAM has been a fairly costly item, chiefly due to the special type of glass used and close dimensional tolerances required. The French firm C.S.F. have now developed a line made in mild steel which is driven in shear by two lead zirco-titanate ceramic transducers. The steel used for the bar presents no supply or price problems, and machining need not be extremely precise. Quantity production price has been estimated at £1 per line.

### Magnetic Recording Head

A magnetic head specifically designed for the recording of up to 40 tracks on conventional quarter-inch tape was described by Dr. J. C. Barton and C. T. Stockel in the January 1964 issue of "The Radio and Electronic Engineer"—the journal of the I.E.R.E. It was pointed out that the conventional method, in which the tape is passed across the gap in a magnetic circuit is very inefficient, as the greatest field strength is concentrated between the faces of the gap, only the fringing field being important in magnetizing the tape. In the method described, the conventional magnetic circuit is abolished, and the magnetic field round a current-carrying conductor is used. A stack of silver and mica sheets are clamped together, the end of the resulting block being shaped and polished to the requisite convex form, and the conductor—a wire—is soldered across the end of the block in a direction perpendicular to the plane of the sheets of silver and mica. The silver sheets are taken in pairs, a current being passed "up" one and "down" the other, passing through a small length of the wire in the process. To overcome the




*Recording head due to Dr. J. C. Barton and C. T. Stockel. Tape moves across curved end of block in direction parallel to sheets of material.*

problem of wear (although the wire can be faired in to the head contour by epoxy resin) an alternative form of conductor has been developed. This is a strip of evaporated silver set edge-on to the tape at the corner of the head. The inductance of the heads so obtained is less than 1nH (less than the lead inductances) and each element has a resistance of about 20mΩ.

### High-speed Facsimile

An experimental data transmission system for black and white facsimile has been designed by Bell Telephone Laboratories. It is capable of transmitting up to sixteen $11 \times 8\frac{1}{2}$in pages per minute at 100 lines per inch definition over a channel of 240kc/s bandwidth. In normal methods of transmission the scanning process produces voltages which are opposite in polarity for black and white areas of the page. In this way, a certain amount of redundant information must be transmitted and the channel is not used efficiently. In the new method, advantage is taken of the fact that only relatively infrequently does the scanner encounter a sudden change between black and white, and if only the *changes* are transmitted, bandwidth is saved. Also, the pulses are fairly infrequent, and while keeping the transmitted power to a reasonable level, the pulses can be made larger and signal-to-noise ratio improved. The pulses are used to modulate a carrier for transmission to a remote office, and after demodulation are used to trigger a bistable flip-flop, whose output is a replica of the voltages obtained by the scanner.

### I.L.S. MONITORING

On page 133 of the previous issue under the title "I.L.S. Monitoring" we described a precision instrument for the measurement of modulation characteristics which has been developed by Wayne Kerr Laboratories Ltd., in conjunction with R.A.E. In our report we attributed this development to Dawe Instruments and we offer our sincere apologies to both firms for any embarrassment which this error may have caused.

A POSSIBLE SOLUTION USING TORSION-WIRE SUSPENSION

# PICKUP ARM PROBLEMS

By JOHN K. MURRAY, Assoc. I.E.R.E.

TO anybody about to purchase a gramophone pick-up the author would always advise, "Buy the best you can possibly afford, and you will remain pleased with it in the years to come."

Following his own good advice, he recently bought what he regarded as the best stereo pickup cartridge available, and was then faced with the inescapable fact that he could not afford the sort of arm that would do it justice. This led to serious thoughts regarding the construction of an arm in the home workshop and, while thinking about the relative advantages of knife edges versus miniature ball races, and springs versus counterweights, it was thought worth while to list the virtues that the ideal pickup arm should possess. These were his conclusions:—

1. Friction in both vertical and horizonal planes should be negligible.

2. Groove jumping and record damage due to mechanical shock from any direction should not occur.

3. It should not be necessary to level the turntable. Ideally the system should be capable of playing a record in any position.

4. The system should be capable of playing warped records—the pickup should not only stay in the record groove but should track stereo records correctly without audible distortion.

In order to follow the reasoning behind the evolution of an arm which almost, if not entirely, meets the above requirements, let us consider the limitations of the more common pickup arms.

Item 1 is met, fairly easily, by using a knife edge or miniature ball races for vertical motion, and ball races for horizontal motion. Knife edges are, however, unsuitable for use in mobile or portable equipment, and do not take kindly to vertical shock.

Item 2 raises the question, "What happens when the pickup jumps grooves?" A moment's thought reveals that, at the instant of impact, it is not the pickup head that moves. In fact, due to its inertia, the head tends to stay still, and it is the record that moves relative to a stationary pickup head.

If the moving parts, consisting of the head and arm assembly, could be dynamically balanced in all planes, then acceleration due to shocks from any direction would cause no relative movement between head and groove. This, of course, necessitates the use of a rather elaborate counterweight system, which should be adjusted so that perfect dynamic balance is obtained. Such a system would, however, require a spring to provide the downward tracking pressure, as no out-of-balance component could be permitted.

The use of a dynamically balanced system satisfies the requirements of shock immunity and provides freedom from levelling problems. Unfortunately, it doubles the inertia of the moving system and so makes the task of tracking warped records even more difficult. In order to track warped or buckled records, it is essential to have very low friction bearings and a pickup arm system with low mass. Since this mass includes the counterweights, any reduction in head mass will enable a twofold improvement to be achieved. These remarks also apply to eccentric records which, fortunately, are not often encountered nowadays, thanks to improved manufacturing techniques.

Since badly buckled records are the exception rather than the rule, a compromise solution to the problem was found by deliberately increasing the tracking pressure as the head is raised above its normal playing position. As the crest of a buckled part of the record lifts the stylus the spring providing the downward tracking pressure is extended to a greater degree and the tracking pressure increases.

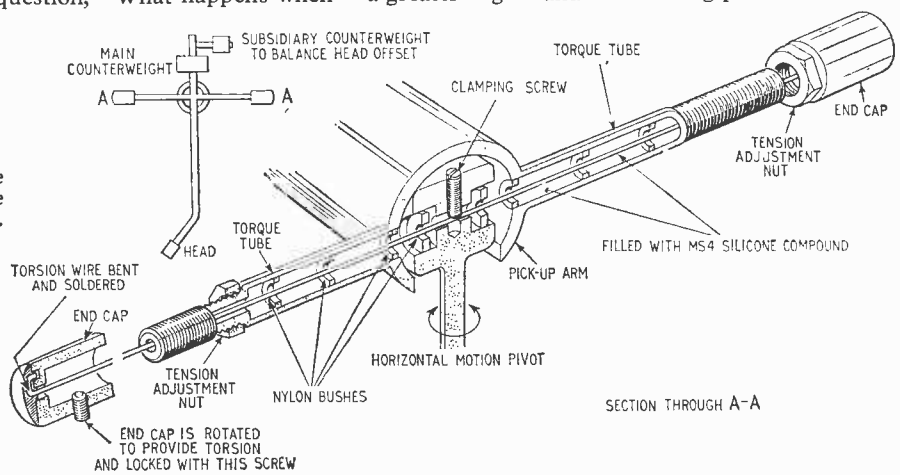



*Fig. 1. Torsion wire mounted so that the anchorage is at the centre.*

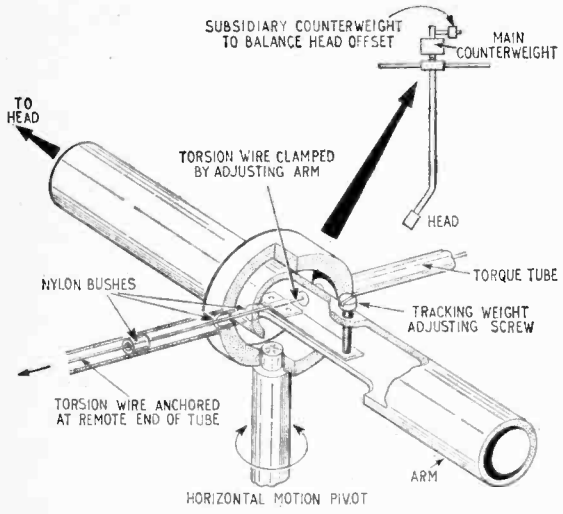



*Fig. 2. In this method of mounting, vertical motion twists the centre relative to the ends.*

This may be made to offset the disadvantages of increased inertia due to the use of counterweights, when playing buckled records; it cannot, of course, produce any improvement in the case of eccentric records.

In passing, it might be worth mentioning that this is the exact opposite of the problem encountered by manufacturers of auto-changers, who go to great lengths to maintain reasonably constant tracking pressure, regardless of the height of the pickup head. This is a very real problem when playing the top record in a pile of eight. The dynamically balanced system could still be used with an auto-changer, if provision were made for raising the pickup arm pivot and spring anchorage every time a record dropped on to the turntable.

A practical pickup arm was evolved as a result of the foregoing considerations and a torsion wire suspension* was chosen. This method of suspension provides virtually frictionless vertical motion and a convenient method of applying the downward tracking pressure. The torsion wire may be mounted in either of two ways:—

(a) The two ends of the wire may be twisted with respect to a fixed anchorage at the centre (Fig. 1).

(b) The pickup arm may be attached to the centre of the wire, so that vertical motion twists the centre relative to the ends (Fig. 2).

## Practical Details

The construction details of importance are the use of torque tubes to contain the torsion wire, and the use of nylon bushes. The torque tubes are filled with M.S.4 compound (Midland Silicones Ltd.) to damp any tendency of the torsion wire to resonate. The wire passes through nylon bushes whose centre holes are large enough not to touch the wire in normal usage. These bushes serve the dual function of retaining the silicone compound, and as safety bearings in the event of violent mechanical shock.

*Provisional Patent No. 29319/63.

In case any readers wish to experiment along similar lines, the following details may be of interest.

**Torsion Wire:** This should be approximately $4\frac{1}{2}$in long and should be made of piano wire or similar high-tensile steel. The diameter of the wire is quite important, as this governs the increase in tracking weight as the pickup head is raised above its normal playing position; a diameter of 0.028in (22 s.w.g.) was used in the experimental model.

**Torque Tubes:** The original torque tubes were made out of $\frac{3}{16}$in brass tubing with a bore of $\frac{1}{8}$in. The torque-tube material and dimensions are not, of course, important to the functioning of the pickup. Brass is easily worked, it is quite strong enough for the purpose, and the diameter chosen enables 2 B.A. threads to be cut for the tension adjustors.

**Nylon Bushes:** With the exception of the inner pair of bushes which have a bore of $\frac{3}{32}$in, all the others have an internal diameter of $\frac{1}{16}$in. These holes should be drilled first, before adjusting the outside diameter to be a push fit in the torque tube. Having inserted the bushes in the tube, once again, pass the drill through the bushes to ensure that they are still the same diameter. Each bush should be approximately $\frac{1}{8}$in long.

## Performance

During a demonstration of this arm at the author's home, a visitor brought a badly warped and heavily modulated disc which had proved to be unplayable on a number of record players. This arm, however, tracked the disc perfectly at $1\frac{1}{2}$ gm. No audible difference in quality was noticeable when the same record was played with a pile of three florins placed under one edge.

A transcription turntable and the "development model" of this arm were installed in a portable carrying case some 12 months ago and have withstood many bumpy miles in the back of an estate car, without mishap.

## Acknowledgement

The author would like to express his thanks to Marconi Instruments Ltd., St. Albans, holders of the provisional patent, for permission to publish the constructional details of the pickup arm.

# CLUB NEWS

**Bradford.**—D. M. Pratt (G3KEP) is talking to members of the Bradford Radio Society about simple transmitters on April 7th at 7.30 at 66 Little Horton Lane, Bradford 5.

**Halifax.**—"Medium-wave DX'ing" is the title of the talk to be given by D. Howell to members of the Northern Heights Amateur Radio Society on April 29th at 7.30 at the Sportsman Inn, Ogden.

**Heckmondwike.**—The April meetings of the Spen Valley Amateur Radio Society include a talk on "Telstar" by H. Tomlinson (16th) and another on amateur radio gear by J. H. Withers (30th). Meetings are held at 7.15 at the Grammar School.

**North Midland Mobile Rally.**—This event, organized jointly by the Midland and Stoke-on-Trent Amateur Radio Societies, will take place in Trentham Gardens, near Stoke-on-Trent, on 19th April. An exhibition is being staged in conjunction with the Rally. Details are available from R. Yates (G3NGL/T), 28 Daimler Road, Birmingham 14.

# WORLD OF WIRELESS

## Reliability

COMMENTING on recent criticisms of the cost of servicing military equipment and the reliability of electronic equipment in general, the Electronic Engineering Association states that critics should look beyond the "engineering." It stresses that one of the root causes of "unreliability" is the Government's insistence on "competitive tendering," and adds "the purchase of complex electronic equipment, even with a detailed specification, just on the basis of cheapness is not conducive to long reliability." The Association suggests that it would be more sensible if the Government asked for tenders on the basis of "initial cost plus servicing for life. . . . The one fact on reliability which cannot be repeated too often is that increased reliability costs money, and that buying the cheapest equipment available will only tend to lead to increased servicing costs."

## WWV Propagation Forecasts

PROPAGATION forecasts, previously broadcast by the American standard-frequency transmitter WWV at 19½ and 49½ minutes past each hour, are now transmitted every five minutes. A forecast follows the station announcement at 4½ minutes past the hour, and is repeated every five minutes thereafter. Given in morse, the forecasts consist of the letter N, W or U, followed by a figure. The letters apply to the following propagation conditions at the time of transmission: W—ionospheric disturbance in progress or expected; U—unstable conditions, but communication possible with high power; and N—conditions normal, no warning necessary.

The expected propagation conditions during the subsequent 12 hours are indicated by the following figures: 1—impossible; 2—very poor; 3—poor; 4—fair to poor; 5—fair; 6—fair-to-good; 7—good; 8—very good; and 9—excellent.

The forecasts, which are intended primarily for transatlantic high-frequency circuits, are broadcast from six transmitters near Beltsville, Maryland, on the following frequencies (e.r.p. in kW is shown in parentheses):—2.5 Mc/s (1); 5 Mc/s (8); 10 Mc/s (9); 15 Mc/s (9); 20 Mc/s (1); and 25 Mc/s (0.1).

Trans-Pacific propagation forecasts continue to be broadcast by WWVH, at Puunene, Hawaii, at 9 and 39 minutes past each hour on 5, 10 and 15 Mc/s.

## Aeronautical Radio Conference

THE first session of the Aeronautical Radio Conference, whose task is to draw up a new world-wide plan for high-frequency long-range communications for aircraft flying on national and international air routes, closed recently after having met for four weeks in Geneva. This session has been concerned with determining the operational and technical principles to be used in the preparation of the new plan, and has produced a 135-page report containing its findings.

On the basis of the findings, the telecommunication administrations of I.T.U. member countries will, before the second session of the conference which is to take place early next year, submit statistics of flight activity to the International Frequency Registration Board; the permanent organ of the I.T.U. dealing with the registration of radio frequencies throughout the world. The existing aeronautical h.f. allocations were drawn up at the last Aeronautical Radio Conference, which was held in Geneva in 1948-49.

## Automatic Landings

THE introduction of the Trident aircraft on some of B.E.A.'s regular passenger services this month sees a significant step forward in the development of automatic landing apparatus, as it will be used for all fine weather landings. Smiths Aviation Division, who, in collaboration with the Blind Landing Experimental Unit at Bedford, developed the R.A.F. "V" bomber automatic landing system, are responsible for the Trident installation. The Trident system is somewhat similar to the "V" bomber installations, which now have been operational for about five years; the main differences being that I.L.S. guidance information is used for the whole of the descent (whereas the military system uses a leader cable for the last half mile), and that the system is triplicated. Only two of the system's channels will be used initially for the fine-weather landings. The third channel will be connected before all-weather landings are attempted in about three years' time. Using the civil system, some 12,000 automatic landings in a number of different types of aircraft have been made without incident.

## A British Acoustical Society?

MOVES are on foot to co-ordinate the work of the Acoustics Group of the Institute of Physics & the Physical Society, the Society of Acoustic Technology and some specialist groups within the I.E.R.E. and the I.E.E. by the formation of a British Acoustical Society which could act for all professional interests in acoustics (building, engineering, medical, etc.) and could, for example, organize the International Congress on Acoustics when this country is called upon to act as host. Preliminary discussions have already been held under the auspices of the Royal Society.

---

**Educational Television Service.**—As a result of discussions between the Postmaster-General, the Ministry of Education and the Scottish Department of Education, two hundred and eighty-one schools in the Glasgow area are to receive a local educational television service. Programmes, which can be transmitted simultaneously on up to four different channels, will be relayed by a series of microwave and cable links from two studios located in the centre of Glasgow. The complete studio, transmission and reception equipment is being supplied by Pye. Some three hundred 27in television receivers have already been supplied. The scheme will start in September this year and cost the Department of Education an annual rental of about £40,000.

**BBC-2 Trade Transmissions.**—The nominal e.r.p. of the Channel-33 trade test transmissions from Crystal Palace has been increased to the full 500kW. The increased power will be maintained as far as possible throughout the trade tests which will continue until 20th April on the existing schedule: Mondays to Fridays 9 a.m. to 1 p.m. and 2 p.m. to 8 p.m.; Saturdays 9 a.m. to 8 p.m.

At the last **Radio Amateur's Examination**, held in December, 75% of the 506 candidates passed. In the previous year when 418 sat for the examination 70% were successful.

**Swedish Exhibition of British Components.**—The Radio and Electronic Component Manufacturers' Federation is to sponsor an exhibition of British components in the Ostermans Marmorhaller, Stockholm, from 13th to 16th October, 1964. The show, provisionally named The British Electronic Component and Instrument Exhibition, is the fifth in the series which the Federation has organized and will not be restricted to members of the R.E.C.M.F. Full details and application forms are available from Industrial Exhibitions Ltd., 9 Argyll Street, London, W.1.

The sixth annual **Aslib Electronics Group Conference** will take place at Ashridge College, Berkhamsted, on 5th-7th June. The conference will open on the Friday evening with a talk and demonstration on "stereophonic sound" by Dr. D. M. Manley. There will be two main sessions, one on "computers, mechanization and documentation," and another on "indexing and information retrieval." Further information can be obtained from the conference secretary, R. S. Lawrie, Chief Librarian, Sperry Gyroscope Company Ltd., Downshire Way, Bracknell, Berks.

Four of the **five British firms awarded gold medals** at the Leipzig Spring Fair for outstanding exhibits are in, or associated with, the electronics industry. Decca Radar received a medal for their D202 marine radar; Vacwell Engineering for an automated controller for checking transistors; Unicam Instruments for an infrared spectral photometer; and Slee Semiconductor Equipment for their micro-welding machines used in the production of semiconductors.

**Hearing Aid Imports.**—In answer to a Parliamentary question in the Commons recently as to how many hearing aids were imported, Mr. Heath, the Secretary of State for Industry, Trade and Regional Development, replied: "Details of quantity are not available, but, in the twelve months ended January, 1964, the total value of imports of hearing aids, including parts, was £632,083."

During the **Shakespeare Quatercentenary Festival** 22nd-25th April the Stratford-upon-Avon & District Radio Club will be operating a transmitting station with the specially assigned call-sign GB2WS. It will operate in the 20-, 40- and 80-metre bands after 17.00 GMT on the 22nd and from 08.00 to 17.00 on the other days. The station will use equipment lent by several manufacturers and a QSL card depicting Shakespeare's birthplace will be used to acknowledge contacts.

**Middle East Radio,** a new commercial medium-wave broadcasting station at Mansoura, near Port Said, Egypt, has begun testing and will be brought into regular service early in April. It is being operated on 818 kc/s, with a power of 500 kW, by the U.A.R. Broadcasting Corporation which has appointed Radio & Television Services (Middle East) Ltd., of London, as broadcasting consultants and also as international sales representatives.

**Valve and Tube Measurements.**—The first four parts of the I.E.C. Publication 151 "Measurements of the electrical properties of electronic tubes and valves" are now available from the B.S.I. Sales Branch, 2 Park Street, London, W.1. Part 1 deals with the measurement of electrode current (4s 6d); Part 2 with measuring heater or filament current (5s 8d); Part 3 with the measurement of equivalent input and output admittances (8s 6d); and Part 4 with methods of measuring noise factor (10s 2d). The first three parts outline the conditions to be followed in measurement, but do not give measuring methods. The methods described in Part 4 are based on current practice.

The first **facsimile newspaper transmission** in Europe has been inaugurated by Sweden's *Dagens Nyheter* using the British designed Muirhead system. The publishers are now printing the original in Stockholm and a facsimile in Jonkoping, 180 miles away. A whole page is proofed and placed on the transmitter and in 10 minutes a negative is received at the printing house, from which an offset litho plate is made ready for the press.

**M. of E. & A.?**—Last November the electronics industry was employing 276,400 compared with 268,000 in the aircraft industry. In his report to the council of the Electronic Engineering Association, Mr. Gregson the chairman suggests "that in view of the large growth of the electronics industry in recent years, the Ministry of Aviation might more appropriately be called the Ministry of Electronics and Aviation."

**I.F.R.B.**—The 1964 chairman of the International Frequency Registration Board, one of the four permanent organs of the International Telecommunication Union, is Mohamed Nazir Mirza, of Pakistan. Prior to joining the Board in 1959 he was director-general of the Pakistan Posts and Telegraphs.

**Academic Awards.**—The National Council for Technological Awards, set up in 1955 "to create and administer technological awards" has been replaced by the Council for National Academic Awards. This new council has been established on the lines recommended in the "Robbins Report" to carry on the pioneering work which the N.C.T.A. has done in the field of technology—including the introduction of the Dip. Tech. —and to extend that work into other disciplines of study. The chairman of the new council is Sir Harold Roxbee Cox who was chairman of the N.C.T.A.

**I.E.R.E.**—An Order in Council dated 26th February permits the amendments foreshadowed in our issue of December last (page 606) and for Brit.I.R.E. we must in future remember to write I.E.R.E. (Institution of Electronic and Radio Engineers). For further comment see page 159 of this issue.

**I.R.E.E. Australia.**—The word electronics has been added to the name of the Institution of Radio Engineers Australia which in future will be known as the Institution of Radio & Electronic Engineers Australia.

**B.E.A.M.A. in Nigeria.**—The British Electrical & Allied Manufacturers' Association has established an overseas committee in Nigeria. There are ten founder members and proposals have been made to elect a number of agent members and associate members. P. A. Lake, of British Insulated Callender's Cables Ltd., has been elected chairman of the new committee.

A course of seven **evening lectures** on "logic algebra and its application to system design" (Fee £2) is to start on 9th April at the Hendon College of Technology, The Burroughs, London, N.W.4. "Printed circuits" is the theme of another course of six evening lectures scheduled to start on 7th April (Fee £1).

**"Audio Techniques."**—This is the title of a course of six lectures to be given on Tuesday evenings from 21st April at Slough College Bucks. The lecturers are Dr. G. F. Dutton, G. Balmain, G. A. Cooksey, J. C. G. Gilbert, G. Pontzen and R. L. West. (Fee £1.)

**A radio and TV maintenance course** will be conducted at the Wesley Evening Institute, Wesley Road, London, N.W.10, on Mondays and Wednesdays for three months from 13th April. (Fee 12s 6d.)

# PERSONALITIES

**F. Neil Sutherland,** C.B.E., M.A., M.I.E.E., has been elected president of the Electronic Engineering Association in succession to **O. W. Humphreys,** C.B.E., B.Sc., F.Inst.P., M.I.E.E., vice-chairman of the General Electric Company, Mr. Sutherland, who is deputy chairman and managing director of the Marconi Company and is on the board of

*F. N. Sutherland*

several associated companies, joined Marconi's in 1947 from the parent company, English Electric, with which he had been associated since 1922. Mr. Sutherland was last year appointed as one of the representatives of the radio industry on the Television Advisory Committee.

**C. P. Fogg,** B.A., director of guided weapons (research and general) at the Ministry of Aviation has been appointed director general of electronics research and development at the M.o.A. Mr. Fogg, who is 49, joined the staff at the Bawdsey Research Station in 1937 and two years later was made a group leader responsible for research and development of radio receivers. He went to Malvern in 1945 and after taking charge of three divisions—working on transmitters, aerial test gear, and receivers and display—he became head of the ground radar department in 1956. Three years later he transferred to the M.o.A. headquarters to become director of guided weapons.

**Professor S. Gill,** B.A., a member of the research staff of Ferranti's computer department and part-time Professor of Automatic Data Processing at the Manchester College of Science and Technology, has been elected to the London University Chair of Computing Science, tenable at the Imperial College of Science and Technology.

**T. S. England,** Ph.D., B.Sc., A.M.I.E.E., F.Inst.P., head of the physics department at R.R.E., Malvern, has been appointed deputy director (equipment) at the Royal Aircraft Establishment, Farnborough. Dr. England, who is a graduate of Durham University, was head of airborne radar at R.R.E. from 1959 to 1961. Prior to this he had held several senior Civil Service positions, including those of superintendent circuits and electronics, and superintendent radar ballistics at T.R.E. (now R.R.E.).

**E. R. Ponsford,** deputy managing director and one of the founders of the Solartron Electronic Group, has been appointed managing director.

**W. D. H. Gregson,** elected on 26th February for the second year as chairman of the Electronic Engineering Association, has been with Ferranti Ltd. since 1946 and is now assistant general manager of the Company's factory in Edinburgh. He is 43 and received his technical training at Faraday House, London. At the beginning of the war Mr. Gregson was at the Admiralty Signals Research Establishment but later joined the R.A.F. In 1946 he was technical adviser to the R.A.F. delegation at the International Civil Aviation Conference in Paris.

*W. D. H. Gregson*

**Robert Telford,** B.A.(Cantab.), M.I.E.E., general manager and a director of the Marconi Company, is the new vice-chairman of the E.E.A. A graduate of Christ's College, Cambridge, Mr. Telford, who is 49, joined Marconi's in 1937 and three years later was appointed manager of the company's Hackbridge Works. In 1946 he became managing director of Marconi Brasileira, returning to this country in 1950 and being appointed general works manager at Chelmsford in 1953.

**G. C. Gifkins,** A.M.I.E.R.E., for many years a senior colour television development engineer with Murphy Radio, has been appointed manager of Rank-Bush Murphy Colourvision Engineering Services. Mr. Gifkins will be based at the Welwyn Garden City factory, and his duties will include technical liaison within the company on colour television development and research and technical help in arranging colour television training courses and literature for service engineers.

**Kenneth S. Phillips,** B.Sc.(Eng.), A.M.I.E.E., A.C.G.I., who for the past five years has held several sales management positions in the Philips organization, has been appointed general sales manager (home) of Automatic Telephone & Electric Company. Prior to joining Philips, Mr. Phillips spent twenty years with A.E.I. in engineering and sales management. **G. N. Reynolds,** who has been with A.T. & E. since 1937, has been appointed general sales manager (direct export).

**Captain L. S. Bennett,** C.B.E., B.Sc., R.N., who served for 19 years as an instructor officer in the Royal Navy until 1956 and for the past six years has been on the editorial staff of the I.E.E., has been appointed education officer of the Institution. He succeeds **G. F. Stewart,** B.Sc., A.M.I.E.E. Capt. Bennett served as Commander (L) in charge of power, communications and navigation aids in *H.M.S. Implacable,* was for three years assistant captain superintendent of the Admiralty Signal and Radar Establishment and for the last five years of his service was Senior Instructor Commander in the Naval Electrical School.

*Capt. L. S. Bennett*

**R. O. R. Chisholm,** A.M.I.E.R.E., has been awarded the 1963 Prince Philip Medal of the City & Guilds of London Institute. The medal, which is awarded annually and was introduced last year, is restricted to those who have "travelled the City and Guilds path," and is given "in recognition of outstanding promise or achievement in the promotion, theory or practice of science and technology." Mr. Chisholm gained

*R. O. R. Chisholm*

15 City and Guilds' certificates in radio and telecommunications engineering before receiving his full technological certificate in 1950. In the following year he won a diploma in electronics at University College, Southampton, and joined the British Aircraft Corporation in a junior position. Seven years later he was appointed chief electronics engineer in the guided weapons division of the Bristol works and is now the division's chief projects engineer. The medal is to be presented to Mr. Chisholm by His Royal Highness The Duke of Edinburgh on 25th March, at Buckingham Palace.

**I. G. Gardner** has become export manager of Marconi Instruments Ltd. Mr. Gardner joined Marconi Instruments in 1939 after serving with the Marconi International Marine Company as a wireless officer and became Marconi Instruments' chief of test in 1941; a position he held until 1946. He then undertook export duties, representing the Company's interests in the Middle and Far East. On his return to the U.K. in 1960 he was appointed manager of product research and two years later he became assistant commercial manager, a new post in which he was responsible for sales in Western Europe.

**R. H. Clarke** has been appointed chief engineer of Counting Instruments Ltd. of Boreham Wood, Herts. He was formerly principal mechanical engineer of the avionics group of Decca Radar Ltd.

**H. Barrell,** C.B.E., D.Sc., A.R.C.Sc., F.Inst.P., superintendent of the standards division of the National Physical Laboratory, has been appointed chairman of the B.S.I. Units and Symbols Standards Committee. Dr. Barrell joined the N.P.L. in 1923.

**Geoffrey N. Bowling,** B.Sc.(Eng.), A.M.I.E.E., is the new managing director of Brookdeal Electronics Ltd. and vice-chairman of the Company's subsidiary, Kenton Laboratories Ltd. Mr. Bowling obtained his degree and a post-graduate Diploma in Electronics at Southampton University. He spent the first few years of his electronics career in Australia before returning, in 1957, to take up an appointment with Southern Instruments Ltd. In 1962 he joined the Marconi International Marine Company as deputy technical manager, a post he held to the end of last year.

**R. John Halford,** B.Sc., has been appointed product sales manager of the newly-formed transducer and data products division of the Solartron Electronic Group. Mr. Halford, who is 30 and a physics graduate of London University, joined Solartron as sales engineer for data-logging systems in 1960.

## OUR AUTHORS

**Ogilvie M. Murray,** contributor of the article in this issue on the prediction and planning of television service areas, joined the Marconi Company as a student apprentice in 1955 at the age of 18. He is now employed in the Radio-wave Propagation Section of the Marconi Research Laboratories and is studying at the Mid-Essex Technical College, Chelmsford.

**John K. Murray,** Assoc.I.E.R.E., whose article on torsion wire suspension of pickup arms appears in this issue, spent six years in the Royal Signals before joining E.M.G. Handmade Gramophones Ltd. where he was chief test engineer. In 1955 he joined the staff of Marconi Instruments Ltd. as a technical author, preparing handbooks on oscilloscopes and pulse generators. He recently transferred to the design department.

**D. F. Bailey,** A.M.I.E.E., author of the article on page 204, began his career as a radar fitter in the R.A.F. For the past 14 years he has been in industry, including periods with Pullin on sonar design and Solartron on transistor instrumentation, and is now with Decca Radar as a senior engineer.

## OBITUARY

**Norman Preston Vincer-Minter,** who died on 11th March, aged 67, wrote under the pen name of "**Free Grid**" and contributed for nearly 34 years the "Unbiased" page of this journal.

Born in Newmarket, Suffolk, the son of the Rev. J. Vincer-Minter, it was intended that he should follow his father into the ministry and he received a classical education at King Edward VI School, Bury St. Edmunds, and Ardingley College. He had passed into Cambridge when the 1914-18 war broke out and he then saw service, first in the Army and later, after being invalided out, as a wireless operator in merchant ships sailing to S. America and to Russia. After the Armistice he served for a time in N. America under Capt. McCoy in an attempt, as he put it, to secure the repeal of the 18th amendment to the American Constitution.

Returning to a comparatively settled life in England he joined the staff of *Wireless World* in 1924 and contributed many constructional articles as well as taking charge of replies to readers' queries. But his mischievous spirit often sought outlet in ways which were a potential embarrassment to his more serious-minded colleagues, until the editor of the day had the inspiration of channelling his talents for iconoclasm into writing his own regular feature.

An open grid circuit, causing removal of bias and generally unpredictable behaviour, was a common circuit fault in the days of unreliable high resistances, and it was this that suggested the now famous pseudonym and title.

Vincer-Minter accepted the challenge with an enthusiasm which never flagged, and although he left the permanent staff to work as a freelance after the last war he continued regularly to send us his contributions, to sharpen our wits and to save us from pomposity. His last contribution went to press the day before he died.

# NEWS FROM INDUSTRY

Group profit, before taxation, of the **English Electric** group of companies in 1963, amounted to £8,218,000 and represented an increase of £1,888,000 on the previous year's results. In his address to the stockholders at the forty-fifth annual general meeting Lord Nelson, the company's chairman and chief executive, stated that the company's electronic interests accounted for more than a quarter of the whole turnover. The Marconi Company's turnover was the largest yet achieved and net profit was £812,158 as against £187,285 in 1962. More than half the equipment leaving Marconi factories was sent overseas and more than four-fifths of the output of the broadcasting division was exported. Lord Nelson referred to the fact that Marconi Instruments exported 50% of its output and that total orders for the year were 14% above the 1962 level. Turnover of the English Electric Valve Company rose to a new level. Profit, after taxation, of Marconi International Marine—an associate company of English Electric—showed a slight increase on the previous year's results at £315,625 (£311,912).

**The Telegraph Condenser Company** group profit on trading for 1963 totalled £403,224. This represents a drop of over £40,000 on the previous year's results and a drop of over £250,000 on the 1961 results. Profit for 1963, after taxation, amounted to £114,323 as against £131,987 in 1962.

After provision for income tax of $22,375,000, the consolidated earnings of the **Zenith Radio Corporation** amounted to $20,852,548 in 1963. This represents a profit increase of 6% ($1,214,480) on the previous year's results. Net consolidated sales for the year totalled $350M and are 12% up on 1962.

**Doppler** radar manufactured by Decca is to be fitted to the T.S.R.2 series of aircraft. This navigation equipment is to be used to measure the aircraft drift angle and relative ground speed.

**V.H.F. radiotelephone equipment** manufactured by A.T. & E. is to be used to extend the public telephone service to four small islands off the western and southern coasts of Ireland. These are: Inishmeane, Inishturk, Achillbeg and Long Island.

**Automation in Industry.**—"The number of computer systems now installed or on order in Britain must be something like 800," Mr. Edward Heath, the Secretary of State for Industry, Trade and Regional Development, said recently at a luncheon of the Electronic Engineering Association. Mr. Heath stated that the growth rate has accelerated over the last four years and "in the first nine months of 1963, the annual rate was nearly double that of 1962. But though the pace is swifter, it is still not fast enough. Our progress here will determine the speed of our whole economic advance." According to estimates by the American Diebold management consultancy, the number of computer installations in the United States totalled almost 16,000. About 5,000 of these were introduced last year.

**B.E.A.M.A. Directory.**—Coinciding with the news of the electrical industry's record export achievement of £360M during 1963, is the publication of the second edition of "The B.E.A.M.A. Directory". Planned on similar lines to the first edition, published in 1961, the new volume lists manufacturers' names, U.K. addresses and their overseas companies and agents, and includes a classified Buyers' Guide covering more than 1,000 items of electrical and allied equipment. A quick-reference cross-index system relates this section to the foreign language sections; in French, German, Portuguese, Spanish and Russian. Nearly 15,000 copies of the new volume, which cost £3, are being distributed to overseas buyers by the British Electrical and Allied Manufacturers' Association, of 36 & 38 Kingsway, London, W.C.2.

**Electro Mechanisms Ltd.**, of 218-221 Bedford Avenue, Slough, Bucks, announce a merger between their affiliated company Schaevitz Engineering of Pennsauken, New Jersey and the Bytrex Corporation of Massachusetts. As a result of this merger, Electro Mechanisms have the U.K. marketing rights of the range of Bytrex semiconductor strain gauges, transducers and instrumentation.

An order in excess of £26,000 has been placed with **Rank Cintel** for the supply of 16mm and 35mm film scanners to the Southern Television Centre, Southampton. This completes a further stage in Southern's 625-line conversion plans.

*Sir Lancelot*, the first vessel of a future fleet of logistic ships, whose task will be the movement of troops and vehicles, has been fitted with a comprehensive **radio installation** by the Marconi International Marine Company. In addition to the conventional communications, navigational and emergency radio equipment, the vessel is fitted with closed-circuit television. This is used to assist in navigation and beaching, observation of the bow and stern exits, and for (tele-ciné) entertainment. Observation of obstacles when beaching the vessel are made through a camera fitted with a narrow angle lens, mounted in the stem-head of the vessel. A range indicating system, projecting a pattern of illuminated lines into the stem-head camera lens, has been included for calculating the distance the vessel is from the beach when making a landing. Charts giving distance, plotted against camera angle, are provided. A complex intercom system, which includes four solid-state 100W amplifiers, has also been fitted.

The Marconi Company are to supply and install **six new I.T.A. television stations.** Installations at Caithness, Central Berkshire and Bedford are each to include four translators, four 500-watt amplifiers and associated equipment. The stations to be built at Dundee, Scarborough and the Isle of Man are to be equipped with dual translators, dual 500-W amplifiers and associated equipment. The six stations, which have been designed for unattended operation, are scheduled to come into service next year. The approximate value of the contract is in the region of £200,000.

Five classrooms in the recently-opened Riversdale Technical College at Liverpool have been equipped with **communications training equipment,** "designed to provide individual tuition facilities and to simulate seagoing reception conditions in the classroom." The installations were designed and engineered to the college's specification by Kenton Laboratories Ltd., a subsidiary of Brookdeal Electronics Ltd.

**Micro-miniature Welding.**—Under an arrangement with Hughes International (U.K.) Ltd., Hirst Electronic Ltd. are to act as the U.K. distributors for the range of precision micro-miniature welding equipment, manufactured by Hughes Aircraft Company, of California.

Under a recent Ministry of Aviation contract, Decca Radar Ltd. are to supply twelve 10-cm **airfield surveillance radars** to the Royal Air Force. Known as the AR-1, these high definition, 75-mile radars were introduced at the end of the last year. Delivery will be at the rate of one per month starting in June.

**Hawker Siddeley Dynamics** have formed an industrial electronics division. It will operate from the company's Coventry Works, Whitley. Mr. J. E. Dick has been appointed the division's chief engineer.

Freudenberg Incorporated, of 50 Rockefeller Plaza, New York, who represent a number of American companies have formed **B.F.I. Electronics Ltd.** to look after their British interests. This subsidiary company is operating under the management of A. Dunkley at Sinclair House, The Avenue, West Ealing, W.13 (Tel.: ALPerton 2113).

**W. L. Gore & Associates Inc.**, of Newark, Delaware, U.S.A., have appointed Albert L. Townsend, of 94 The Ridgeway, Waddon, Croydon, Surrey, as their U.K. representative. Wires and cables, and special harnesses are included in their range of products.

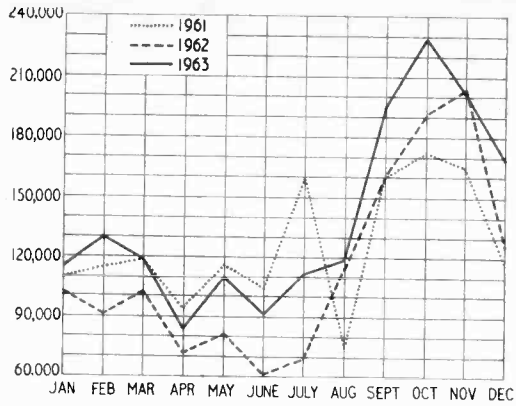
**C-E-I-R (U.K.) Limited** are moving their offices and computer service bureau from Turriff Building, Brentford, to 30-31 Newman Street, London, W.1.

**Jones and Stevens Ltd.**, manufacturers of fractional h.p. motors, fans, blowers and laboratory equipment, have moved to Henley Road, Berinsfield, Nr. Dorchester-on-Thames, Oxford. (Tel.: Clifton Hampden 404.)

**Langbourne Consultants Ltd.**, of which Langbourne Components forms the electronic and electrical components division, has moved to Langbourne House, 108-110 Shenley Road, Boreham Wood, Herts. (Tel.: ELStree 1137/8.)

**G. A. Stanley Palmer Ltd.** and associated companies, which include Emeco, and Electronics & Automation (London) Ltd., have moved to Elmbridge Works, Island Farm Avenue, West Molesey Trading Estate, East Molesey, Surrey.

**Chateau Productions Ltd.**, distributors of the Microkit condenser microphone, have moved to 4 Manchester Street, London, W.1. (Tel.: HUNter 2353.)




***Television** set despatches from British manufacturers to the home market last year, according to B.R.E.M.A. estimates, totalled 1,673,000 compared with 1,378,000 in 1962 and 1,509,000 in 1961. During 1963 radio receivers, including those for car installations, showed a slight increase on the previous year's results of 2% to 2,612,000. Radiograms reached the highest annual figure since 1957, at 248,000.*

## OVERSEAS NEWS

**Nigeria.**—An order, worth nearly £500,000, from Nigerian External Telecommunications Ltd. for equipment and services covering a major expansion of Nigeria's international communications has been received by the Marconi Company. It calls for the supply and installation of equipment for a new transmitting station at Ikorodu and for the expansion of facilities at the existing transmitting and receiving station at Ikoyi, which will become the new receiving station. And also to provide a u.h.f. radio link between the two sites. For the new transmitting station, Marconi's are supplying three 30kW h.f. transmitters, two 10kW h.f. transmitters, two 2.5kW m.f. transmitters for maritime services (to be manufactured by Redifon), twenty-six masts for aerial systems and two additional 3.5kW h.f. transmitters for the new direct radio circuits with other African States. Some of the existing transmitting equipment at Ikoyi will also be transferred to Ikorodu. The existing receiving station at Ikoyi will be equipped additionally with five h.f. receivers, four radiotelephone terminals and inter-station teleprinter equipment, plus a comprehensive range of monitoring and test facilities.

**India.**—Lakhmichand & Co., of 12 Western Breeze, Causeway Road, Bombay 1, have informed us that they are interested in acting as agents for British manufacturers of transistor radio receiver kits, components (including valves and transistors) and accessories such as magnetic tape, record changers, aerials, etc.

**Alma Components Ltd.**, precision resistor manufacturers of Diss, Norfolk, have appointed Electronic Research Laboratories (Pty.) Ltd., of Silbro House, 605 Jeppe Street, Johannesburg, as their official agents for South Africa.

**Japan.**—The Solartron Electronic Group, Farnborough, Hants, have appointed the Iwasaki Communication Apparatus Co. Ltd., of Tokyo, licensees for the manufacture of some of their oscilloscopes. Solartron have been exporting in relatively small quantities to Japan for the past eighteen months.

**Microwave Equipment for Canada.**—The Canadian General Electric Co., is to supply equipment for a new 6Gc/s microwave system to link Quebec and Rivière-du-Loup with existing Bell Telephone microwave routes. The equipment will be manufactured in this country by G.E.C. (Telecommunications) Ltd. at its Coventry factory.

**Radar Simulator Exports.**—The military systems and simulation division of the Solartron Electronic Group have recently received two orders for radar simulators for the training of air traffic controllers. The first comes from the Hong Kong government for installation at Kai Tak airport and the other from the Norweigian civil aviation authorities for use at the Fornebu airport, near Oslo.

Pye Telecommunications, of Cambridge, have received a contract, valued at about £250,000, for a fixed and mobile **radiotelephone network** to cover the whole of Denmark, from the Danish State Police.

**Marconi Instruments'** mobile showroom is on a three-month tour of industrial centres in Spain, Portugal, Yugoslavia and Germany. Since its acquisition in 1959, this mobile showroom has travelled more than 40,000 miles and visited eighteen European countries.

# LETTERS TO THE EDITOR

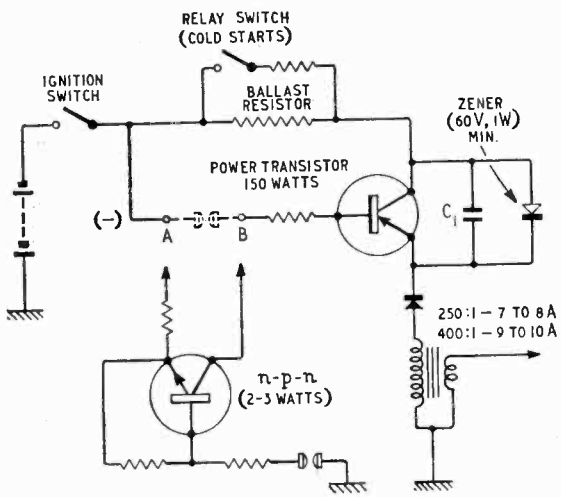
*The Editor does not necessarily endorse opinions expressed by his correspondents*

## Transistor Car Ignition System

MR. Willis's article in the March issue is the first reference in a British publication that I have seen concerning solid-state circuitry in cars.

However, the existing ignition coil limits the advantages to be gained by installing a semiconductor device. The use of power transistors with special 250 to 1 and 400 to 1 ratio, heavy-duty coils results in higher sparking voltage, less voltage decline at high engine speeds, greatly increased spark-plug life, much less plug fouling, improved petrol consumption, longer "peak-tuned" periods, easier cold-starts and quicker "warm-ups" together with longer contact breaker point life; all at the cost of the unit and an increased current consumption (about doubled). Surely, a big advance at a small price.

A simple circuit which can be used with insulated breaker points AB or, with a low-power n-p-n type




ransistor and earthed contact breakers is shown. The contact current would be about 0.5 amp.

The ballast resistor is shunted only during engine starting to ensure coil current constancy even though the battery voltage drops momentarily. The circuit can easily be converted for negative earthed cars, yet the circuit's time constant is not high; a drop of about one amp. can be expected from idling to 4000 and 5000 r.p.m. with a six-cylinder car.

Returning to Mr. Willis's less ambitious but commendable circuit, I note his reluctance to depend entirely upon the new system and suggest the shunting of capacitor $C_1$ with a suitable Zener diode to reduce substantially the chance of overloading and transistor burnout. (More than adequate, a Zener at 68 volts $\pm$ 10% rated 25 watts is advertised toward the back of *Wireless World* for about 7/6 and no doubt a high value within the tolerance could be obtained.) The value of $C_1$ could then be reduced.

I would finally suggest the situating of any "conventional"/"transistor" change-over switch in a relatively inaccessible place so that deliberate action rather than error is needed to cut out the new, efficient system. Deterioration of the "peak-tuned" condition would quickly result from change-over, thus losing the advantages gained.

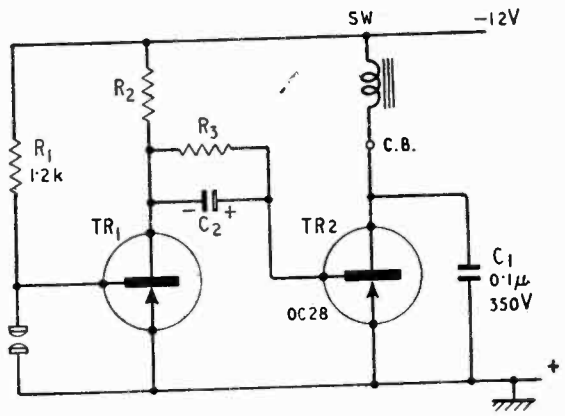
Using good quality components, a system can be reliable and trouble-free, in heat and cold alike.

Plymouth. R. W. TOWNSEND

[We take this opportunity of reiterating the author's warning that the peak voltage developed by the ignition coil primary should first be checked. Several readers have written suggesting the use of a Zener diode to limit the peak voltage across Tr2. If an ignition system other than the one referred to in the article is involved, the design may have to be revised *ab initio*.—ED.]

J. H. WILLIS'S statement (p.152, March issue) that the peak voltage on Tr2 (OC28) collector should not exceed 75 volts is in fact incorrect, as the OC28 can only be operated in the region $V_{ce} = -60$ to $-80$ volts if reverse bias is applied to the base, reverse *current* bias Mullards say. This is not possible with the circuit as published, so Mr. Willis is in danger of blowing up his OC28 (and thus *needing* the change over switch in Fig. 3.).

I would suggest the following modification:




$R_2$, $R_3$, $C_2$ to be chosen so that Tr2 base is positive until the peak voltage on Tr2 collector has subsided to below $-60$ volts. I would suggest for trial purposes $R_2 = R_3 = 47\Omega$, $C_2 = 10\mu F$ giving a time constant of 0.5 m sec.

Oxford. PETER W. TOMLINSON

*The author replies:*

I accept Mr. Tomlinson's correction and indeed I lost one OC28 after 2,000 miles of mixed short and long distance motoring. The replacement is working perfectly, but I will try out Mr. Tomlinson's modification as soon as possible.

J. H. WILLIS

ABOUT the only advantage which may be claimed for a "hybrid" ignition system of the general type shown by Mr. J. H. Willis in his article in your March 1964 issue, is the reduction of wear on the contact breakers.

In a "traditional" ignition system, secondary output voltage falls off at high speeds because as the rate of sparking increases, less time is available to build up magnetic flux in the ignition coil's winding. In any such

circuit as the one shown by Mr. Willis, the ratio of on-to-off time will still be governed by the original contact breaker and the best that may be hoped for, is that the additional devices in the circuit will have no adverse effects.

On the other hand, if dirt accumulates or humidity condenses on the contacts, the position with such a "transistorized" system will be even worse than with a "traditional" system. In fact, at the low voltage and current now existing across the contacts, there can be no reasonable hope of breaking through or of drying out the noxious film—which is what usually happens in a "traditional" system—unless the position is really hopeless or the car's battery is exhausted before the engine can be started. Wear of the "shoe" against the actuating cam is still exactly the same as in a "traditional" system and, apart from the extreme case in which the contacts refuse to open at all, the adverse effects of wear on the accuracy of timing as a function of rotary speed will also be still the same.

The foregoing reflects mainly on the method of synchronizing the electronic "spark generator" to the engine, and it is obvious that only the elimination of contact breakers will improve the position in these respects.

However, the point I wish to make is that simple circuits using transistors as switches are quite inadequate "spark generators," regardless of the method by which their action is synchronized to the engine's crankshaft. In fact a transistor which is "practicable" for the purpose at today's prices, has a $V_{ce}$ rating which is quite appreciably lower than the amplitude of the pulses which occur across the contact breakers in a "traditional" system. Mr. Willis's figure of 72V is fairly typical —and 4 to 6 times lower than the pulses across the primary of a typical "traditional" system. Obviously, a coil with a higher turns ratio between its primary and secondary windings is thus required, to achieve the same amplitude of secondary voltage as with the original system.

In addition to voltage a practical ignition system must also supply power. Perhaps the easiest way to visualize this requirement is to imagine a divider comprising the coil's secondary impedance in one arm, and a resistance in the other. The latter of course, simulates the load (which is normally a rather high resistance), as shunted when there is appreciable leakage through wet or fouled plugs, or humidity on the wiring harness, etc. (In fact, the standard method for measuring an ignition system's power output capabilities is to determine the lowest value of resistance shunted across a standardized gap, for which a spark of given length will still be obtained. The reciprocal of this value of resistance is the system's "usefulness," expressed in units of conductance ("S" or "siemens").)

Now if the coil's primary is wound with a smaller number of turns, a higher current will flow through it—and "trading voltage for current" has become little short of a slogan when discussing transistorized ignition systems. In practice, however, the current permissible through our "practicable" transistor is of the same order of magnitude as that flowing in a "traditional" system. The inductance of the primary winding of course decreases as the square of the number of turns, and eventually it is found that the energy stored, $\frac{1}{2}LI^2$, is practically the same as for a "traditional" system.

Thus, to achieve the required increase in turns ratio the number of secondary turns has to be increased. It will be obvious from the foregoing that—unfortunately—the "usefulness" of the system will decrease in inverse proportion to the number of turns in the secondary winding, following a square law. In practice, a simple transistorized system of the type being discussed will have a "usefulness" of about 1 $\mu$sec (and definitely below 3 $\mu$sec in the very best possible case)—and in practice it will actually prove inferior to a "traditional" system (having "usefulness" of from 5 to 10 $\mu$sec).

The recently introduced "GCS" or "gate-controlled switches," i.e., a variety of silicon controlled rectifiers which may be turned off at the gate, might appear to be a step towards a solution since the $V_{BO}$ ratings of these devices may easily be several hundred volts for several amperes of current, and thus the ignition coil may be wound with more reasonable numbers of turns. However, apart from device cost, practical experiments have confirmed that, again, the overall performance is at best equal to that of a "traditional" ignition system.

In summation, the performance of "simple" electronic systems is at best only slightly inferior to that of "traditional" systems of suitable characteristics and in good working order, on all counts except life expectancy of the contact breakers. Which, in my opinion, is only a minor advantage since anybody sufficiently interested in his car's performance to try and improve it by resorting to electronic ignition should certainly not find it an impossible nuisance to check on the status of his contact breakers twice a year or every 5,000 miles—which is sufficient preventive maintenance on any "traditional" ignition system of adequate quality.

According to my experience to date, the only "electronic" approach which will yield a significant improvement over the "traditional" ignition system is a capacitive storage and discharge system—i.e., one where energy is stored in a condenser to a level of $\frac{1}{2}CE^2$ at a comparatively high voltage obtained via an electronic inverter, and discharged by an s.c.r. into the primary of an ignition coil.

Such a "spark generator" can be used both in a "hybrid" system retaining the existing contact breakers for synchronizing purposes, and in "all electronic" systems using inductive pulses for the purpose. Even in the "hybrid" configuration, the switching speed is no longer dependent on the contact breaker's actuating time, but rather of the s.c.r's. firing characteristics. Whereas a mechanical contact breaker operates in the milliseconds or at least several hundred microseconds region, and s.c.r. operates in a few microseconds at worst: at par stored energy, the power output is accordingly very much greater. By suitable choice of the inverter's frequency and of other circuit parameters, the storage condenser can be charged to its rated level even at high repetition rates of firing and consequently the fall-off in secondary voltage is negligible to frequencies beyond the range of speeds of all but the more "extreme" engines. With coils of standard construction, peak voltages exceeding 17kV and "usefulness" exceeding 15 $\mu$sec can easily be achieved. These figures become 25 to 30kV and over 30 $\mu$sec respectively, if coils wound on cores presenting a closed magnetic path are substituted.

Obviously, even in its simplest form such a "spark generator" is much more of a "machine" than a straightforward transistorized switch and, regrettably, is also much more expensive.

It could be interesting to re-calculate costs on the basis of "automotive" quantities—we have already seen what happened to the price of silicon power rectifiers, as soon as these got to be used in cars' alternators.

Be that as it may, at least with such an ignition system an engine's performance will effectively improve—rather than remain what it was or possibly deteriorate.

Milan, Italy. ALESSIO GURVIZ

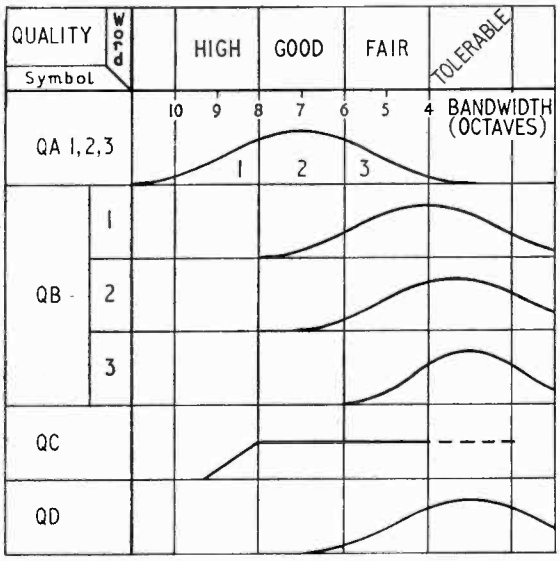
*The author replies:*

I have had no trouble with contact breaker film resistance, and in fact its operation in a 12-volt non-inductive circuit produces a cleaner make and break. This, I believe, contributes to the maintenance of accurate cylinder firing timing at high engine revolutions, and is the probable reason for the noticeable increase in maximum engine revolutions obtainable in my car with the transistors in use.

J. H. WILLIS

## Qualifying Quality

IT appears that, exceptionally, Homer, in the person of "Free Grid", has nodded. Some words have a dual use as have all numbers; they may be counting integers or




they may be the proximate indications of measurement. "Fidelity", "unique" and "pregnant" are members of the first class only. "Quality" and "accuracy" belong to the second class only. "Reproduction" may be assigned to one or other class only when its connotation is recognized. "R. = copy" may properly be qualified by an adjective which indicates degree or tolerance. Each "Old Master" painting is unique yet any reproduction of it may be excellent—or may be poor. Some adjectives, "faithful" as an instance, are absurd when strictly interpreted. However, long before the days of gramophones/phonographs the absurdity of "faithful reproduction" had ceased to be shocking or even noticeable in its application to copies of paintings. We're stuck with it! (*Pace*, Mr. Roddam.)

Perhaps we may follow the Editor and stick to "high-quality" in our own discussions. A good *and simple* scale of quality is not easy to find in the literature. The following is presented as a basis of discussion—but, please, let it stay simple.

Clean = little noticeable distortion
Balanced = follows the precept of Mr. H. F. Olson of which Mr. Royston reminds us in his letter—Jan. '64, p.71
Bandwidth { narrow = five to under six octaves; average = six to eight octaves; wide = over eight octaves

| Scale Symbol | Distortion and balance | Bandwidth Symbol | | |
|---|---|---|---|---|
| | | Narrow | Average | Wide |
| QA | Clean and balanced | 3 | 2 | 1 |
| QB | Not clean but balanced | 3 | 2 | 1 |
| | | State type/s and degree of distortion | | |
| QC | Clean but not balanced | State frequency limits: and suitability for named purpose | | |
| QD | Not clean, not balanced | Specify distortion and frequency limits. State suitability for named purpose. | | |

The quality scale symbols derived in the table are related to the convenient "measuring" words in the figure. Normal distributions are reasonable for all except QC, but it is not to be inferred that normal distribution has been proved. The price of cleanliness at extended bandwidth is high; but that is another, and unfinished, story.

Glasgow. W. GRANT

## Thermostatic Pickup Control

RECENT experience has convinced me that quality from my stereogram is displeasing when the house is cold, but recovers later in the evening as the room temperature rises. I attribute this to the fact that all pickup suspension materials, so far as I know, harden appreciably for quite modest falls of temperature, and that this must affect the performance. Even with central heating a temperature range of 45°F or less in the morning to 75°F later is accepted by most and it is obviously unreasonable to expect to have to light a fire for the benefit of the pickup.

This raises the following questions:—

1. Should not manufacturers (a) specify the design temperature; (b) the temperature range over which there is no audible effect; (c) provide a head weight-temperature table.

2. Would not a thermostatic control of head weight be a more rewarding field for experiment than chasing the last fraction of tracking error?

Greenford, Middlesex. S. D. SMITH

## Band II Sound Reproduction

YOUR correspondent, L. E. Smith, believes that he speaks for the small but important minority, the readers of the *W.W.*, in committing them to a readiness to sacrifice the lovers of organ music and presumably other minorities, in order that savings effected could be employed to extend the frequency response of the v.h.f. service thereby improving his enjoyment of Mozart.

As a reader of the *W.W.* since 1927, I am one who does not agree with him. I also would welcome the extra 2 kc/s when listening to the organ music of Clérambault and other great masters on some of the brilliant classical instruments, but never would I press for it at the expense of other minorities whose programmes do not interest me, and there are many such on the Third. I think that the B.B.C. deserve praise for catering for these minorities despite the fact that they have no yet been able to oblige me by moving the one half-hour weekly organ recital to a time later in the day when, my duties as an organist over, I could hear it as broadcast. This would be preferable to the hazards of depending on the amateur members of the family for a recording on tape.

If improvement of the line network requires money, I for one would be willing to pay more even though my use of it would be little, but I should feel that if I were able to enjoy thoroughly only one programme in the week, the cost would have been worth it. I would nevertheless rejoice in the fact that many were deriving much more enjoyment from their favourite programmes.

My suggestion for financing this would be by another fee. We have at present separate fees for sound and TV. Why not three rates?

(1) Sound (a.m. only) as at present, but do away with the separate fee for a fixed installation in a car.

(2) Sound (a.m. and f.m.). This at a higher rate to cover the additional line transmission costs which would be of advantage to the f.m. service only.

(3) Sound and TV which would cover all services.

Preston. FRANK BROADBENT

BEFORE your correspondence on this subject is pronounced closed, may I be permitted to add some observations concerning the quality of B.B.C. f.m. transmissions?

I have much sympathy with the B.B.C.'s views that extending and improving the coverage is desirable, and in this respect they deserve more support from listeners for the fine job they are doing. At the same time, I am very puzzled by certain aspects of the programme feed arrangements. My receiving site and equipment are such that I am frequently able to make instant comparisons between seven or eight groups of stations. Recordings of these have been made and played to friends

who all expressed some surprise that such frequency and phase distortions should exist.

Mr. Turner has explained the financial aspects very clearly and therefore I am wondering why the B.B.C. felt that the cost of a radio link for Rowridge for the Light and Third programmes was merited instead of G.P.O. lines? It is also something of a mystery as to how the Sutton Coldfield and Llangollen Light and Third programme feeds are virtually as good as those for Wrotham. Indeed, Llangollen is giving a better audio bandwidth than Wenvoe which, of course, serves a far larger population. Another interesting point is that the midland Home Service through Sutton Coldfield (on a programme from London) gives a better audio bandwidth than Norwich or Peterborough. In other words, some of the midland v.h.f. audience are getting a far superior bandwidth through Sutton Coldfield and its satellites than others.

In view of the above it is pertinent to ask why there is so sharp a decline in audio quality from Manchester northwards. Midland listeners get no better audio on north region programmes than London listeners, so there is something extremely one-sided about the programme feed arrangements somewhere. As a matter of interest, Holme Moss listeners seem about the worst off all round. Even their locally produced programmes exhibit an unpleasant "peakiness" at times.

Having listened to many hundreds of hours of European f.m. transmissions at my location, I can fully confirm the views expressed regarding Continental quality—the finest undoubtedly originating from Germany and Austria. Furthermore, the standard is maintained almost throughout the whole day's broadcasting.

A point not covered so far concerns programme circuit and transmission noise. It is unnecessary to turn the volume up to hear this even through Wrotham. Yet tune to one of the nearer Continental stations, Ruiselede, Lopik, etc., and there really is silence between programmes. Turn up the volume and it is likely that one's receiving equipment noise will become noticeable before that broadcast from these stations!

Instead of ordering further new studio equipment and extending transmission hours, might not the money be better spent on improving programme feeds, etc. I feel sure your readers would agree that if this could be done with a slightly increased licence fee it would be well worth paying. Then we might *all* be able to fully enjoy the B.B.C.'s many excellent productions.

Aylesbury, Bucks. A. H. UDEN

# PUBLIC ADDRESS EXHIBITION

THE 1964 exhibition of the Association of Public Address Engineers, held at the King's Head Hotel, Harrow-on-the-Hill, on the 4th and 5th March, was probably the most ambitious "show" yet presented by the Association. Besides a record number of exhibitors (41 taking up 69 stands), the B.B.C. provided, as a static exhibit, an outside-broadcast control vehicle and a number of lecture/demonstrations were provided throughout the exhibition. This last feature was intended to help improve the standard of p.a. presentation and the optimum deployment of equipment. Miss J. Coulson, E.M.I. Records Ltd., spoke on "Choosing the Right Music for the Job" this illustrated talk was repeated six times throughout the duration of the exhibition as was "Choosing the Right Microphone" by N. Bone, B.B.C. Engineering. Other talks were given on loudspeaker enclosures, delayed sound systems, microphones (including radio types), continuous tape players and closed circuit television.

Meandering through the exhibition halls the use of continuous play tape reproducers for equipment demonstrations indicated that the industry was fully alive to time and labour-saving methods of ulcer-free public address. Two new tape players were shown, the "Continuo" manufactured by B.T.S. Productions and the Series II automatic tape player manufactured by Sound Coverage Ltd. The former equipment used transistors and, if required, a paging facility can be included. The decks of both models use Garrard tape cassettes but the Sound Coverage player can be modified to take 7 in tape spools.

Trix Electronics showed a new horn manufactured from glass fibre. The lightness and durability of this material should indeed ease the load of the engineer whose life is committed to shinning up and down poles. Another new product of this company was the B66 p.a. system consisting of a transistor amplifier, battery powered, and a number of loudspeakers all enclosed in a cabinet measuring 37×6×5in. A microphone and one other source (tape recorder, pickup, etc.) can be plugged into the equipment.

With the knowledge that an increasing number of sports commentaries are being relayed via G.P.O. telephone lines to local hospitals, the Warren LPAI microphone amplifier of small overall dimensions provides a 600Ω output suitable for feeding into a Post Office line. The input impedance is suitable for 20 to 50Ω microphones. An internal dry battery powers the amplifiers and the controls are limited to an on/off switch and a pre-set gain adjustment. Another useful accessory manufactured by Warren Equipment was the LMU1 line coupling unit. This matches signals from a 600Ω line to the normal "gram" channel of a p.a. amplifier. Passive equalizing circuits permit adjustment for treble losses over the line and for attenuation of the low frequency content to balance reverberant speech.

A new range of transistor equipments consisting of mixers and amplifiers were exhibited by C. T. H. Electronics. In addition a loud hailer Type L.H.I. was demonstrated. This consisted of a hand-held speaker unit incorporating a 12W amplifier and a noise-cancelling microphone. The batteries are carried separately in order to reduce the weight of the hand-held apparatus.

Where vibration is a problem for microphone location the Shure Model S39A vibration-isolation stand may prove of great value. The stand accepts all Shure microphones and swivel adaptors. The cushioning is achieved by a heavy pad of foam rubber.

The Magneta 50W Type S84 amplifier was unusual in that the cabinet was constructed from glass fibre, the overall dimensions being 13×15×5½in. Using valves the amplifier provides 3 microphone inputs and a radio tuner or gramophone input. The frequency response is within ±1dB from 40 to 15,000 c/s. The output is suitable for 100 V line work at 200Ω. A mains power supply is required and the equipment weighs 23lb. Many other manufacturers showed equipment that had been modified since last year and a number of custom-built systems were demonstrated prior to installation. Many items exhibited were applicable to the audio world in general. The latest Westrex p.a. system consisted of 19-in, rack-mounted equipment to which units can be added at a later date. Panels already available include a mixer panel with 5 microphone inputs, an equalizer panel with three equalizer units each providing variable l.f. and h.f. equalization and a power amplifier.

## Predicting and Planning

# TELEVISION SERVICE AREAS

### A THEORETICAL METHOD PROVED IN PRACTICE

By O. M. MURRAY*

THE planning of service areas in any television band demands a great deal of care, for the building of even a modestly-powered station is a costly business and it is vital to have it in the best position. Failure to do so may result in an inefficiently-served area and a consequent partial wastage of an operational channel—and channels are in very short supply.

Because the thirteen channels available in Bands I and III are approaching saturation point in Britain (a situation which also applies in many countries abroad), additional services are having to be accommodated in the u.h.f. bands (IV and V). Although more channels are available in these bands the achievable station-coverage is, for technical reasons, appreciably less. To enable the best use to be made of these bands the channels must be assigned and the stations sited with the utmost care if co-channel interference is to be minimized and the desired service areas achieved.

All electromagnetic waves obey the same laws of diffraction, refraction and reflection, but in general the practical manifestations of these laws become more and more apparent with increase of frequency. It follows, therefore, that the planning of a v.h.f. service area is a more involved task than one concerning the lower frequency bands, whilst a u.h.f. service is more complex still. This is particularly apparent in towns where, at quasi-optical frequencies, individual buildings may well mask a particular receiving aerial or group of aerials whilst adjacent ones receive a perfectly acceptable signal. Such problems of detail obviously have to be considered on an *ad hoc* basis; the prediction of a service area is usually (but not invariably) confined to ensuring that an adequate signal strength reaches the general locality.

In order to underline the problems associated with the prediction of service areas, let us first consider briefly how the natural laws mentioned above affect the issues.

**Diffraction:**—The terrain to be covered is rarely topographically featureless and in any event there is the curvature of the earth's surface to allow for. Fig. 1 illustrates a hypothetical obstructed path. The diffraction loss becomes greater as the frequency and the height, *h*, increases and as the distance, *d*, between the closest obstruction and the receiver decreases.

Radio waves are also diffracted round the curvature of the earth and, although signal attenuation increases rapidly with distance beyond the horizon, care has to be taken in the geographical spacing of stations to ensure as far as possible that co-channel interference is avoided.

**Refraction:**—The normal decrease of atmospheric temperature, pressure and humidity with height is such that the refractive index of the troposphere also decreases. This causes electromagnetic waves to deviate from their normal path and to be bent slightly towards the earth. The amount of curvature increases with the gradient of the refractive index and this, in turn, depends upon the meteorological conditions. If such conditions are fluctuating, fading will occur and will be particularly evident around or somewhat beyond the optical horizon.

Certain meteorological conditions, particularly those associated with long periods of calm anticyclonic weather, can greatly increase the refractive index gradient and thereby cause co-channel interference[1, 2]. Should the tropospheric and ground waves be of comparable amplitudes, severe destructive fading of up to some 30 dB will occur whenever minor changes in the troposphere cause the relative phase to pass through the antiphase condition. This effect is less common within 30 miles of the station but at somewhat greater distances a tropospheric wave may swamp the ground wave.

An atmospheric discontinuity, if sufficiently intense, can act as a duct, trapping signals and propagating them over long distances with little more attenuation than would be suffered in free space.

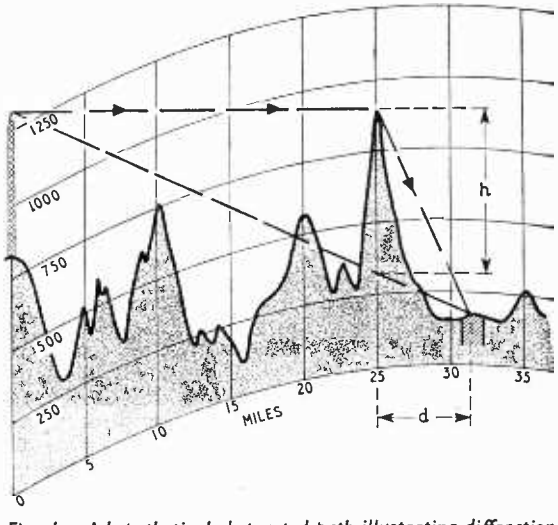



*Fig. 1. A hypothetical obstructed path illustrating diffraction.*

*The Marconi Company, Ltd.

This mode of propagation occurs in the Mediterranean area, particularly during calm summer weather; for example, Egyptian television programmes can often be viewed about 350 miles away.

**Reflection**:—Coherent reflections can occur from the ground and, assuming the co-efficient of reflection to be unity, these could double the resultant signal if the direct and reflected waves happen to be in phase, or affect it in ratio to the phase relationship through to a point of cancellation when the two waves are in anti-phase. The unity co-efficient never obtains in practice; nevertheless, very deep nulls are not uncommon, particularly with horizontally polarized waves over certain short sea paths. Vertical polarization produces much shallower nulls because of the lower co-efficient of reflection [3, 4].

These, then, are the main considerations when predicting and planning a given television service area. As was mentioned earlier, the problems of diffraction, refraction and reflection are accentuated with increasing frequency whilst the changes in performance of transmitting and receiving equipment as the operating frequency is raised must also be taken into account[5]. For example, the shorter the elements of the receiving dipole the lower the e.m.f. which will be induced in it by a signal of given strength (in volts/meter) and this is only partially offset by the increase in receiving aerial gain which is possible at the higher frequency. Added to this is the increased receiver noise experienced as the operating frequency is raised. It follows, therefore, that in order to maintain a specified minimum acceptable signal-to-noise ratio at the picture tube, the threshold of field-strength at the receiving aerial becomes higher as the operating frequency is increased. For a receiving aerial on an interference-free site (say, in a remote rural area) a comparison with Band I would place the threshold level at approximately 10 dB for Band III and 25-30 dB for Band V. These thresholds are, however, amended in practice because the bulk of the population live in towns where man-made interference often reaches a high level in Band I and a lower level in Band III but is seldom troublesome in Bands IV and V. Hence, for the vast majority, the threshold levels in Bands I and III are raised and the disparities reduced. All factors such as these must be taken into account at the planning stage.

In view of the onerous requirements and the complexities outlined above, one can readily visualize a small army of engineers roaming the countryside, taking field strength measurements from a pilot transmitter. It comes as something of a surprise to find that in fact the whole of the work can be carried out in an office by a relatively small number of people and in much less time than would be required for a pilot survey. Visits to the transmitting site or to the area are seldom necessary.

This does not mean to say that a carefully conducted pilot survey is not an excellent thing[6]. It is, in fact, ideal if cost is no object, but the trial erection of masts in order to establish the best site (remembering that masts of over 1,000ft in height are sometimes needed) is almost invariably out of the question. An alternative method, namely, that of supporting the pilot transmitter by means of a captive balloon, also presents several difficulties; the balloon has to be large if the transmitter is of adequate size to enable satisfactory measurements to be

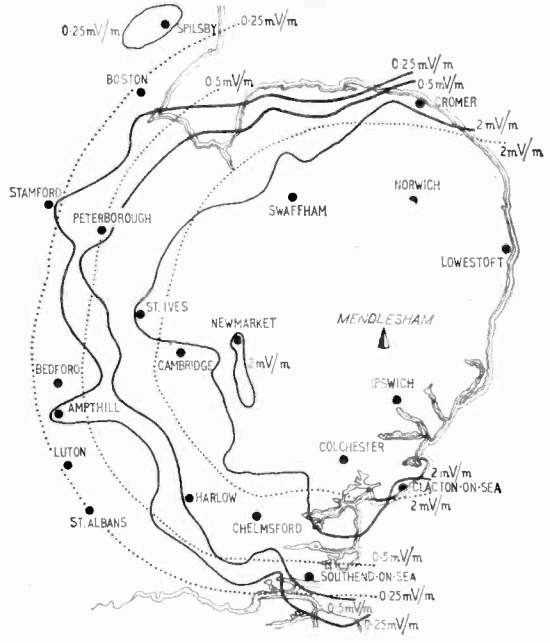



*Fig. 2. Comparison between forecast and measured service areas of the I.T.A. East Anglia station at Mendlesham (Band III, max. e.r.p. 200kW). The median field strength contours forecast by F.C.C. empirical curves are shown dotted.*

taken in the fringe areas and its manipulation is not easy except under the most favourable weather conditions.

A very rough preliminary impression of coverage can be obtained from sets of empirical curves published by C.C.I.R. and the U.S. Federal Communications Commission. These curves relate, for each television band, field-strength to distance from the transmitter for a fixed value of radiated power and for a range of transmitter aerial heights. They are, however, not suitable, nor are they intended, to give anything but a rough-and-ready approximation. Fig. 2 gives a comparison between the field strength contours forecast by F.C.C. empirical curves and actual measured contours for the I.T.A. Band III station at Mendlesham. It illustrates the danger of applying empirical curves to specific towns—in this case Cambridge which, according to the empirical curves, should be comfortably within the primary (2mV/m) area. In practice, because of an obstructing hill which the F.C.C. empirical curves could not take into account, Cambridge lies outside this contour. Apart from this, however, there is fairly good agreement between the contours. Fig. 3 gives a similar comparison for the I.T.A.'s Burnhope station. Here there is violent disagreement, particularly to the west of the station, because of the hilly nature of the area. It demonstrates quite clearly that any broadcasting authority which wholly relied for its information on empirical curves might have a rude awakening when the station came into operation.

A theoretical method of field strength prediction evolved at the Marconi Research Laboratories has in practice proved to be highly accurate. Under contract, the Laboratories have assisted in the planning of all the stations of the Independent Television Authority now in operation and have also done

a great deal of similar work for overseas broadcasting administrations. In nearly all cases the prediction work has been carried out solely on a theoretical basis.

## The Theoretical Method

The prime essential to the task is that detailed and reliable contour maps are available—preferably to the standard of 1 inch to 1 mile Ordnance Survey maps. From a preliminary study of these, experience will indicate a promising transmitting site—perhaps more than one. These are then individually investigated, the signal strength in the vicinity of each receiving locality being calculated from data derived from examination of the ground profile drawn between the trial transmitting site and the place to be served. The calculations are based on the fundamental principles of diffraction, refraction and reflection referred to earlier using, where appropriate, theoretical smooth earth propagation curves.[7]

The necessary ground profiles are drawn on the special form of graph paper shown in Fig. 1, on which the distance axis is curved to represent the effective curvature of the earth on a greatly exaggerated height scale for standard atmospheric refraction. (The latter is expressed as the ratio, designated $k$, of the effective earth's radius—i.e. one in which refraction is taken into account—to the true earth's radius. For overland paths in temperate climates $k$ is normally 4/3.) By this means it becomes possible to draw the curved ray paths more conveniently as straight lines and to enable the standard (i.e. median time) field strength to be calculated. Although no two profiles are exactly alike, the majority fall into one or other of the three following broad types:—

**(a) Obstructed Path.**—The diffraction loss over obstructing hills can be readily estimated from curves derived for the appropriate frequency from Fresnel's knife-edge theory in the normal practical condition where $h$ is small compared with $d$ (see Fig. 1). As very few hills resemble knife-edges, corrections have to be applied for rounded and irregular obstructions and for the special case when $h$ is not small compared with $d$. The magnitude of these important corrections and when to apply them can at present be determined only by experience based largely on the analysis of many actual measurements made over similar paths.

This process of calculating the diffraction loss has been extended to a succession of two or more obstructing peaks.[8]

**(b) Smooth Path.**—As stated earlier, in cases where a town is exposed to a coherent ground reflection in addition to the direct wave, reference is made to the appropriate curve in the Atlas of Ground Wave Propagation Curves, a comprehensive set of theoretical curves prepared by the C.C.I.R. for smooth earth paths. Paths which depart from the smooth earth condition over a significant part of their length must be considered on their merits and corrections inserted where appropriate.

**(c) Rough Optical Path.**—No major problems exist in the calculation of field strength over a path of this nature, provided that it is established that the terrain is rough enough to prevent the occurrence of coherent reflections and also that the signal path has adequate clearance above all the obstructions on the profile.

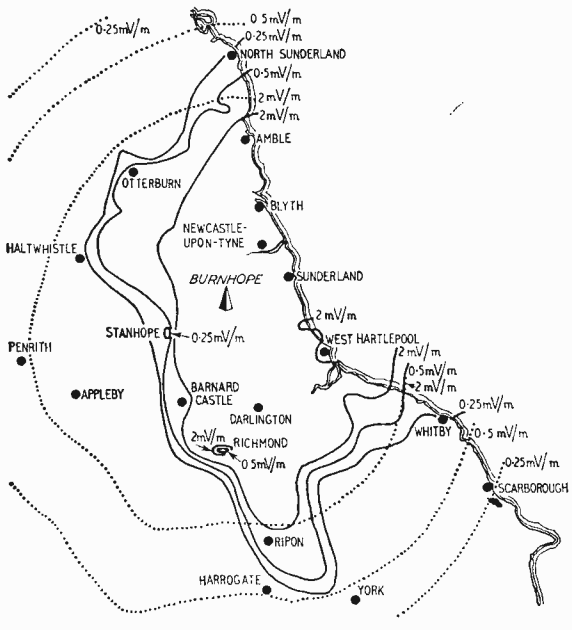



*Fig. 3. Comparison between forecast and measured service areas of the I.T.A. Burnhope station (Band III, max. e.r.p. 110kW). The median field strength contours forecast by F.C.C. empirical curves are shown dotted.*

## Preparation of Coverage Map

Let us suppose that a broadcasting authority wishes to know the best site and economic characteristics of a transmitting station required to give a service to a specified area, and, finally, to obtain a map showing in detail the likely coverage, grades of service and population served.

The first step, carried out with the aid of detailed contour maps and accumulated experience, is to select the best sites from the propagation point of view. Ground profiles are drawn to all important centres of population from each of the sites which, from an inspection of the map, seem promising. The average value of field strength is then calculated for each town, assuming some arbitrary value of radiated power. It is then an easy matter to determine the power needed along these radials in order to provide the desired grades of service. By making the calculations from a range of aerial heights, it becomes possible to find the economic height of the mast for each site.

This information is then referred to the authority which will, in turn, assess the sites from the point of view of the material considerations (accessibility, planning permission and so on). Out of these combined considerations will emerge an order of preference, and the site which is first choice will be subjected to a detailed prediction.

The basic coverage, in which co-channel interference is ignored, is determined first, and is derived from a large number of computations made for all the centres of sizable population and also for points selected along each profile in order to find the distance at which one grade of service merges into the next. These distances from the transmitter site, at which the cut-off of each grade may be expected to

occur, are then plotted on the appropriate radials on a map of the area. In order to obtain a sufficient number of cut-off points around the 360°, more profiles may have to be drawn along radials carefully chosen to yield the maximum amount of significant topographical information. Except in flat country there will inevitably be many pockets of a grade of service higher or lower than that which predominates, but it is neither practical nor desirable to show "island" contours except in cases where these enclose a relatively large population.

When all the points for each field strength contour have been plotted and joined, the resulting contours are likely to show violent irregularities. Some of these may arise from the limited number of radials employed, whereby undue weight has unwittingly been attached to cut-off points which, on closer inspection of the topographical map, can be seen to be no more than isolated hills. In such circumstances, a judicious smoothing of the contours carried out with reference to the topographical map will, in general, result in the presentation of a more realistic coverage.

Since the profiles are drawn on 4/3 Earth paper (i.e. median time) and the calculations made for each centre of population are averaged (i.e. 50% of the locations), the completed map shows grades of service to be expected in at least 50% of locations for at least 50% of the time.

## Co-channel Interference

So far, except for passing references, no attention has been paid to one very important aspect of the prediction—namely, the probability of the occasional occurrence of co-channel interference especially in fringe areas. In practice this is taken into account at an early stage in the preparation of a coverage map.

Co-channel interference can be divided into two categories, namely that produced by interaction between the respective ground waves of two stations operating on a common channel, and that which occurs as a result of special ionospheric or tropospheric modes of propagation whereby signals from a distant station can be received in the service area of a station which is on the same channel.

In cases where two stations are obliged to share a channel, basic planning will, in general, have ensured that their geographical spacing is sufficient to eliminate serious ground-wave interference. C.C.I.R. quote 45 dB as the minimum acceptable wanted-to-unwanted signal ratio at the input of the receiver. The minimum acceptable ratio at the viewer's aerial can often, however, be less than 45 dB by the amount of discrimination which the aerial is able to provide against the unwanted signal. If the channel allocations permit one station to radiate vertically and the other horizontally polarized waves, the aerial will discriminate against the unwanted polarization. If, on the other hand, the two stations use the same polarization, any directive properties the aerial may have will provide discrimination. In either case, the degree of discrimination depends on the aerial design and its environment, and may amount to as much as 20 dB or so.

If the channel allocation permits the carrier frequency of one signal to be off-set from that of the other by approximately $\frac{1}{3}$, $\frac{2}{3}$, $\frac{4}{3}$ or $\frac{5}{3}$ of the line frequency, the accommodation of the eye allows the minimum protection figure of 45 dB at the receiver input to be reduced to 35 dB for a 405-line system or to 30 dB for 625 lines. Furthermore, if the off-set can be held to within ± a few c/s by the use of very high stability r.f. drives at the transmitter, it is possible that these ratios can be reduced by a further 5 to 10 dB.

Other precautions against co-channel interference fall more within the direct province of the prediction and planning team. Under favourable topographical conditions it may be possible to site the proposed new station at one end of the service area and, by using a directional transmitting array, ensure that whilst the area to be served is "floodlit" the back-radiation toward the station which shares its channel is restricted. Again, a downward tilting of the radiation may be of value in limiting the range of ground-wave propagation.

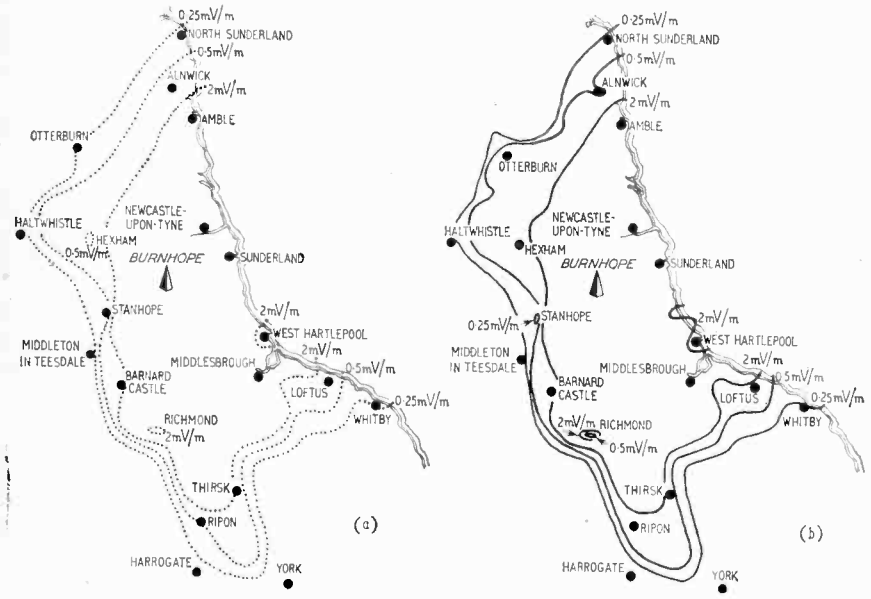



*Fig. 4. (a) Median field strength contours predicted by the Marconi method for the I.T.A. Burnhope station compared with the measured contours (b).*

With such combination of these and other methods as may be necessary, little or no significant co-channel interference from the ground wave should be experienced by the vast majority of viewers, provided that an efficient receiving aerial is used.

The second type of co-channel interference, namely that caused by certain abnormal meteorological conditions, is more difficult to guard against. Whereas the above methods of discrimination remain effective, the estimate of the actual strength of the signal which is likely to be exceeded for any given percentage of the time can be made only by using empirical curves derived from many measurements over similar terrain and in similar climatic conditions (or, where practicable, by a special long-term recording of field-strength over the path in question). From such curves for the band, e.r.p., distance and effective height of the proposed transmiting aerial, the value of field strength likely to be exceeded during 50%, 10% or 1% of the time can be estimated. For normal broadcast standards it is common practice to protect against the probability of co-channel interference for at least 99% of the time, based on a period of at least a year. This is done by taking the likelihood of its occurrence into account at the site-selection stage; it is conceivable that a site which is otherwise satisfactory might be rejected at this point on the grounds of a high degree of probability of tropospheric co-channel interference. (If the figure of 99% immunity seems unnecessarily high, it must be remembered that when the special meteorological conditions which give rise to this form of interference do occur they usually persist for days at a time and so, although infrequent, the trouble tends to be prolonged and, therefore, less readily tolerated.)

None of the television bands is exempt from this form of interference, but the propagation of signals via the troposphere tends to become more pronounced as the frequency is raised, particularly over flat ground and sea paths—a point to be borne very much in mind when planning services in Bands IV and V. Band I, while less susceptible to tropospheric propagation effects, is, however, prone to interference caused by sporadic reflections over distances of up to 1,400 miles via the E region of the ionosphere and also over many thousands of miles via the $F_2$ region at times of high sunspot activity. These effects are well known in Britain but can be much more severe in equatorial countries. Cross-polarization against ionospheric signals cannot, unfortunately, be counted upon since the polarization on arrival tends to be random.

## Final Choice of Site

It is hoped that enough has been said to show that the final choice of a transmitting site is by no means as straightforward a matter as selecting the highest hill and erecting a mast on its summit. On the contrary, a great number of parameters must be calculated and each weighed in relation to its importance.

In view of the complexity of a theoretical prediction, the question may be fairly raised as to how accurate it is in terms of an estimated coverage of population. The answer is best given in Fig. 4 comparing a typical prediction carried out for the I.T.A. station at Burnhope with the measured contours. Based on the published figures for the Administrative Areas, the total population within the predicted coverage was 2.66 million. After the station came into operation, a large number of field-strength measurements were made throughout the area and used to determine the true population coverage which was found to be 2.68 million.

## Acknowledgements

This article is published by permission of the Chief of Research of the Marconi Company Ltd. The author wishes to thank the Independent Television Authority for permission to reproduce the service area maps of its Burnhope and Mendlesham stations.

### REFERENCES

1. Booker, H. G., "Elements of Radio Meteorology: How Weather and Climate cause Unorthodox Radar Vision beyond the Geometrical Horizon." *Journ. I.E.E.*, March, 1946, Vol. 93, Part IIIA, p. 69.

2. Saxton, J. A., "The Propagation of Metre Waves beyond the Normal Horizon." *Proc. I.E.E.*, September 1951, Vol. 98, Part III, p. 360.

3. Quarta, P., "Propagation with Horizontal and Vertical Polarization over the Portofino-Monte Beigua and the Portofino-Monte S. Nicolao Paths." *Alta Frequenza*, October 1957, Vol. 26, p. 404.

4. Gough, M. W., "The Plane of Polarization as a Factor in V.H.F. and U.H.F. Broadcasting." *Marconi Review*, Second Quarter 1963, Vol. XXVI, No. 149, p. 117.

5. Swann, G. F., "The Field Strength required for the reception of Television in Bands I, III, IV and V." *Proc. I.E.E.*, November 1959, Vol. 106, Part B, No. 30, p. 541.

6. Isted, G. A., "Field Strength Surveys of V.H.F. and U.H.F. Broadcast and Television Service Areas." *Marconi Review*, Second Quarter 1963, Vol. XXVI, No. 149, p. 93.

7. Atlases of Ground Wave Propagation Curves for Frequencies between 30 and 300 Mc/s and between 30 and 10,000 Mc/s (International Telecommunication Union, Geneva).

8. Millington, G., Hewitt, R., and Immirzi, F. S., "Double Knife-Edge Diffraction in Field Strength Prediction." *Proc. I.E.E.*, September 1962, Vol. 109, Part C, No. 16, p. 419.

# Wireless World

# OSCILLOSCOPE

## 9.—WIDE-BAND Y AMPLIFIER—CONSTRUCTION

WE described, last month, most of the construction of the amplifier, and the further diagrams in this article will serve to illustrate the trickier points.

### Attenuator

The attenuator assembly is possibly the most complicated part of the unit, and is therefore allotted three illustrations. The photograph shows a general view of the construction, but Figs. 1 and 2 are included to show how the components are mounted. The aluminium bracket in Fig. 1 is mounted on the switch shaft with the Paxolin panel facing towards the rear of the amplifier. The 3-30pF bee-hive trimmers are held on the panel by their ears, the longer ones being bent to form solder tags. The earth connections are made to the bus-bar on $S_{1b}$, which in turn is connected to chassis. Short leads and neatness in wiring are worth a little trouble in this part of the circuit; odd little resonances have been known to cause peaks and suck-outs of quite alarming proportions even at frequencies as low as 5Mc/s.

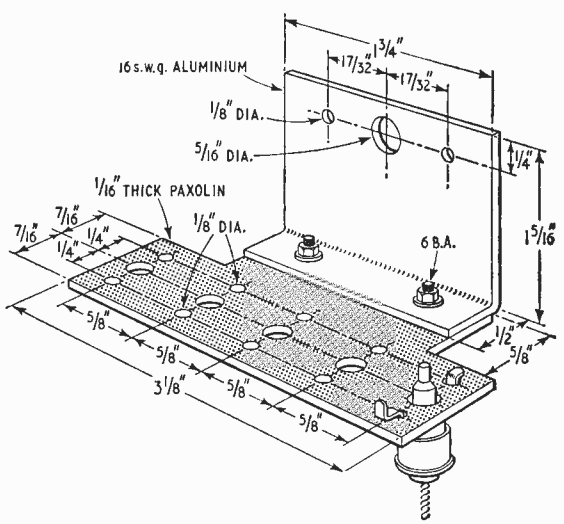
### Output Panel

This unit is a rather unfortunate necessity. The plugs and sockets chosen for the plug-in unit connections were perfectly adequate for the first types described, but when we came to use them for this amplifier, we found that the self-capacitance of the mated plug and socket, together with that of the wiring, gave us a response at 10Mc/s of about −6dB compared with the low-frequency response. To avoid this, we had to by-pass the existing connectors and use the device shown in Fig. 3. Constructors who have not yet built the oscilloscope may like to use lower capacitance connectors in place of the originals, but the self-capacitance of the wiring will remain, and may still be too great. We did not try this and can offer no guidance as to the results to be expected.

A virtue is made of necessity by mounting the series-compensation inductors $L_4$ and $L_5$ on the connector panel. This is of advantage in keeping the leads to the tube plates short. The operation is quite simple and reliable, and needs no expensive components. Fig. 4 of last month's article showed a Paxolin panel with two screws in it mounted on the rear of the amplifier unit. When the amplifier is pushed into position, the two screws, which carry the signal, protrude through the holes in the output panel (Fig. 3 this month) and make contact with the spring strip. The spring breaks contacts with the original output leads (A and B) and thereby disconnects their stray capacitance. The panel is mounted on the cross-bar of the main chassis.

### Attenuator Adjustment

The easiest way of setting up the trimmers $C_5$-$C_{11}$ is to look at the response to a square-wave on the screen. If a square-wave generator is not available, then the squarer part of the "Wireless World" audio signal generator (November and December 1963) fed by a convenient sine wave will be useful. The amplifier should be connected to the square-wave source by a short length of unscreened lead, and the trimmers adjusted for minimum overshoot and rounding of the corners of the waveform. The trimmers should be adjusted by a non-metallic tool, or at least the fingers should be removed after each adjustment to see the effect.




▲ *Fig. 1. Attenuator mounting bracket and trimmer panel.*

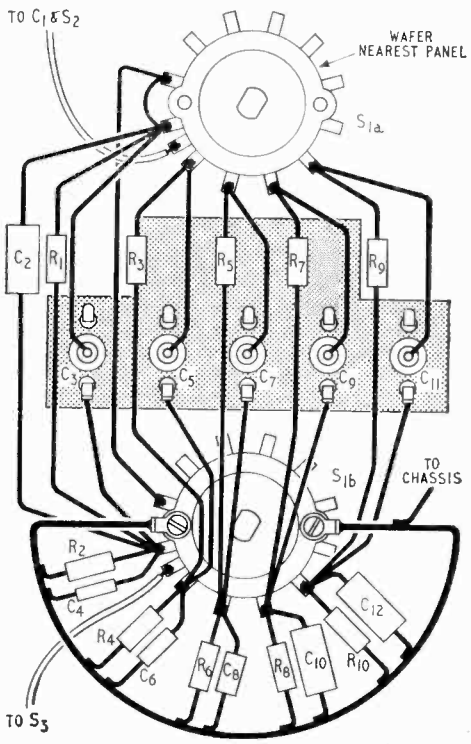



*Fig. 2. Attenuator switch and components, looking from rear of unit.*

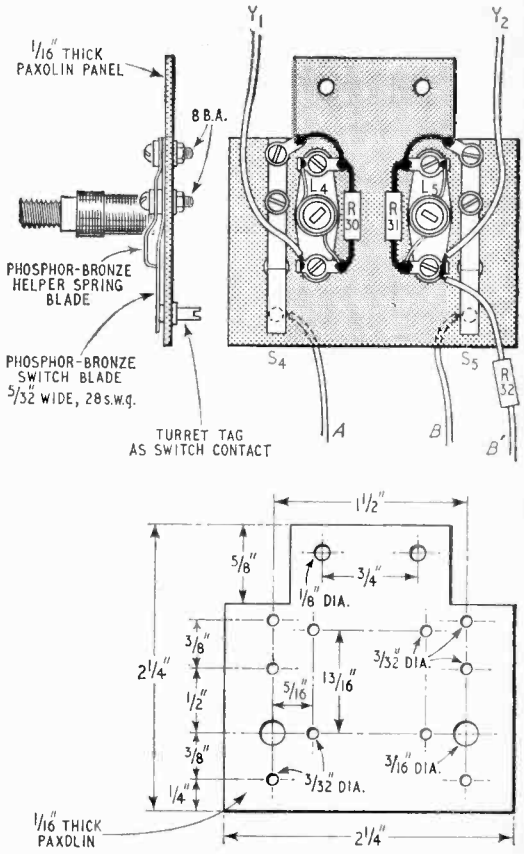


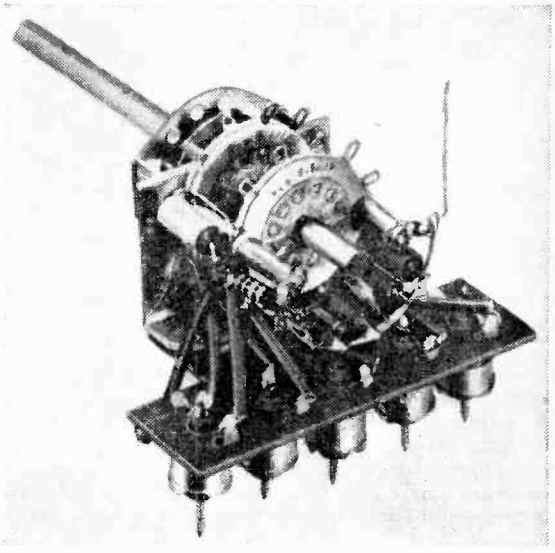

*Fig. 3. Output panel mounted in main unit between "TRIG. LEVEL" control and Trigger selector switch (Aug. 1963 issue).*

Alternatively, the calibrating waveform can be used. This is not a very good square wave, being derived from the heater waveform, but it is sufficient to give an indication of the attenuator compensation. It was, in fact, found so useful that we decided to bring the waveform out to the front panel, and this accounts for the hole "D" near the bottom left-hand corner of the panel in Fig. 3, which was not on the front-cover photograph. It is useful, in addition, for setting up the trimmer inside the high-impedance probe.

## Calibration

The 500mV peak-to-peak amplitude of the calibrating square wave must be set. To do this, we must again invoke the aid of the C.E.G.B and use the 50c/s heater waveform (unless the reader has built the audio signal generator). A potentiometer consisting of a 33kΩ and a 1kΩ resistor is connected across a source of 6.3V r.m.s., the output (across the 1kΩ resistor) being fed to the amplifier input, the attenuator being set to "100mV" and the "CAL/USE" switch to "USE." The gain control, $VR_1$, is set to give a convenient size and the amplifier switched to "CAL." The control which sets the calibrating voltage is $R_{17}$ (Fig 3 last month) and this should now be adjusted to give the same deflection as the 50c/s sine wave. This is all the calibration required. In use, the calibrating waveform is set to be between two graticule lines, so setting the scale

*Fig. 4. Completed attenuator assembly.*



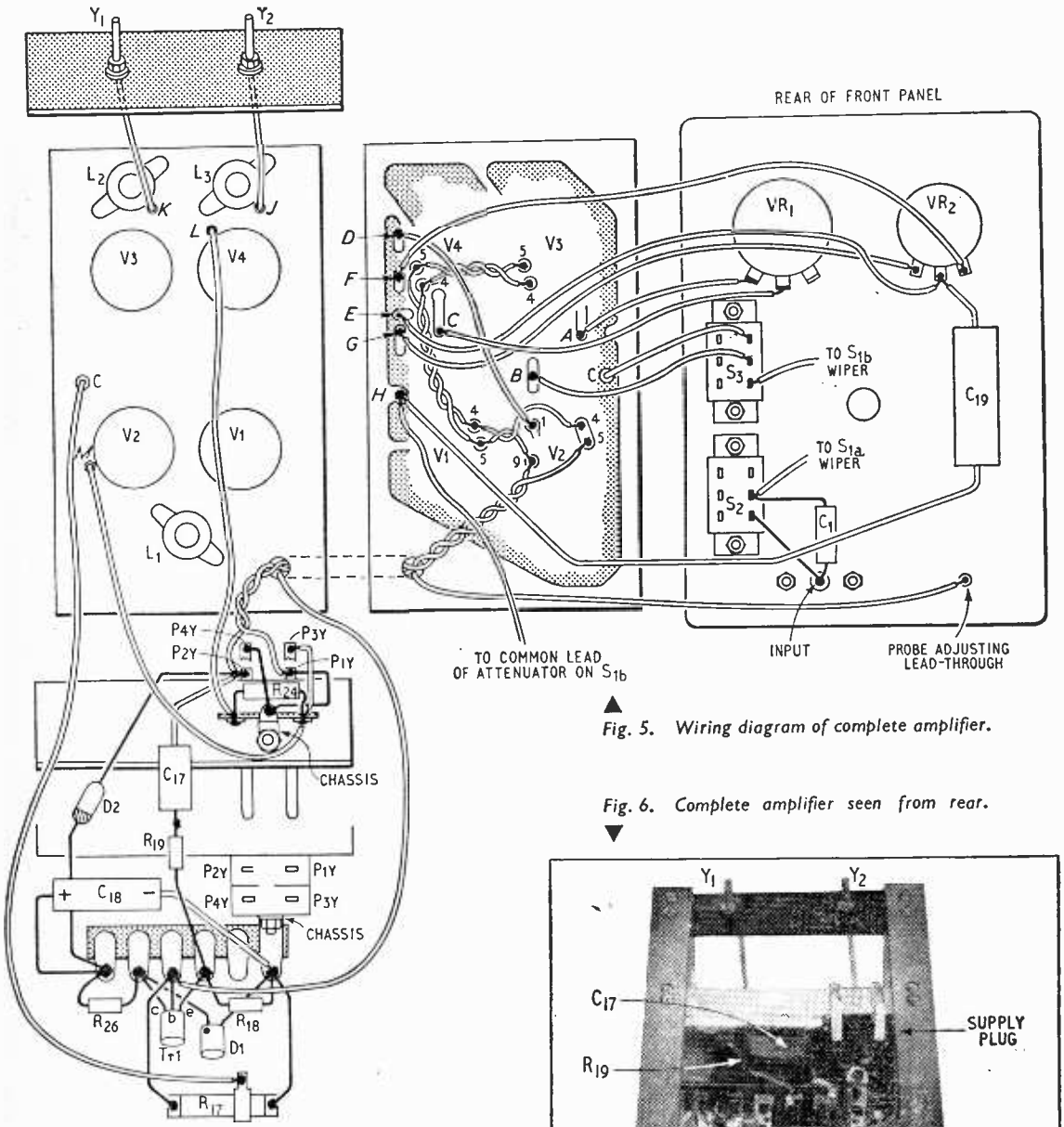
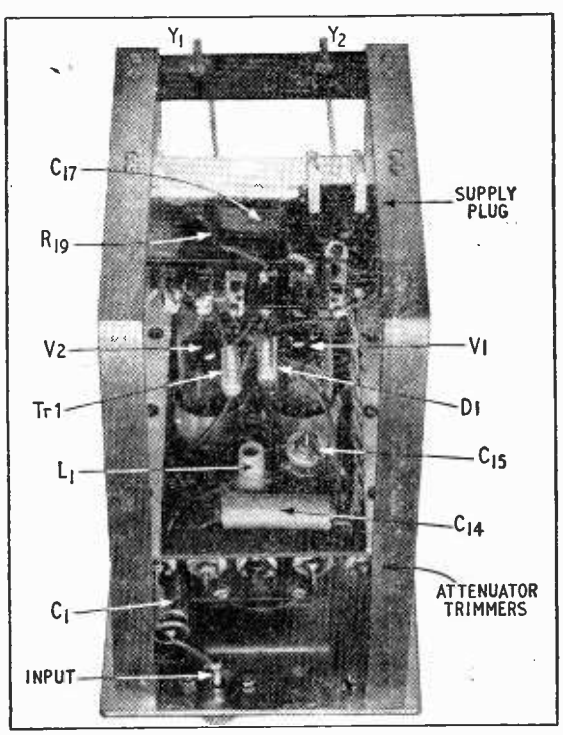



*Fig. 5. Wiring diagram of complete amplifier.*

*Fig. 6. Complete amplifier seen from rear.*




of the display. For instance, if the square wave is adjusted by the amplifier gain control to occupy 5 divisions, the whole screen corresponds to 1V and a picture taking up three divisions would be 300mV peak-to-peak.

## Conclusions

The amplifier we have described will enable observations and measurements to be made on most types of equipment that are of interest to the average reader. To extend the usefulness of the oscilloscope still further, we intend, in the near future, to describe a new time-base unit to provide both free-running and triggered operation, a high sweep speed and precision time measurement.

# Elements of Transistor Pulse Circuits

## 4.—TRANSISTOR MONOSTABLE MULTIVIBRATORS

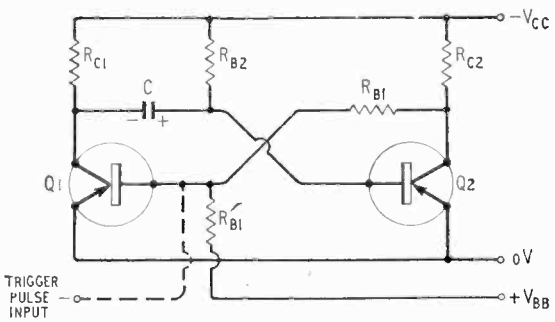
By T. D. TOWERS* M.B.E.

A "GALLUP POLL" conducted by the author on a small random cross section of electronic engineers brought out interesting facts about the monostable multivibrator. Everyone interviewed had *heard* of the circuit, but only 20% could have obtained a pass mark in an examination for the question "Describe in general terms the principle and uses of the monostable multivibrator." Moreover, only 5% (one lone engineer in the twenty canvassed) could actually do even a simple approximate design of a general-purpose monostable. Considering the importance of the circuit for generating, reshaping, stretching or delaying pulses, for gating other circuits and for frequency dividing, it is surprising how few engineers have a working knowledge of it. This article aims to fill this gap with particular reference to the modern transistor versions of the monostable multi (which have largely superseded the valve versions formerly used).

In cold scientific terms, a monostable multi is a two-state device with one permanently stable and one quasi-stable state. A suitable trigger pulse will induce a rapid transition from the stable to the quasi-stable state. The multi then remains in this second state for a predetermined time which is long compared with the time of transition between states. Finally it switches rapidly back to the stable state without any further external triggering. In another way, the circuit is said to "flip" on under a trigger pulse and "flop" off by itself after a time T which is essentially independent of the trigger pulse characteristics and is determined only by the RC time constant of the circuit itself.

Because it requires only a single trigger pulse to go through its cycle, the monostable multi is often referred to as a "one-shot," "single-step multi" or "univibrator." Because it produces a rectangular output pulse which can be used to gate other circuits, it is sometimes described as a "gating" multi. Again, the output pulse can be differentiated to give a pulse at its trailing edge which occurs at a preset time after the input trigger pulse, and the monostable is therefore often called a "delay" multi. The names are all suggestive of the uses to which the circuit is put.

*Fig. 39 Basic collector-coupled circuit.*




### Basic collector-coupled monostable multivibrator

Transistor monostable multis fall into two classes:

(a) *Collector-coupled*, where the cross-couplings are from collector to opposite base, and

(b) *Emitter-coupled*, where one cross coupling is from collector to base and the other is by feedback through an emitter resistor common to both stages.

The collector-coupled version is analogous to the valve anode-coupled multi, and the emitter-coupled to the valve cathode-coupled one.

The basic circuit of the first of these, the collector-coupled monostable multi, is shown in Fig. 39. In the absence of external excitation Q2 is held on by the base current through $R_{B2}$. Now when Q2 is on, its collector voltage is close to 0V, the transistor being bottomed. As a result, Q1 is held off by the network $R_{B1}$ and $R_{B1}'$ between 0V and $+V_{BB}$, the potential of the base of Q1 lying somewhere between 0V and $+V_{BB}$, depending on the ratio of $R_{B1}$ to $R_{B1}'$. If either transistor is triggered out of its stable state, regeneration can occur due to the overcoupled positive feedback in the circuit. The resulting astable state with Q1 on and Q2 off will exist for a time determined largely by the time constant $CR_{B2}$. The mechanism of this is relatively easy to follow. In the stable state with Q1 cut off, its collector is virtually up at the negative rail potential $-V_{CC}$. At the same time the base of the transistor Q2 is effectively at 0V (if we ignore the small base-emitter volts drop in that transistor). Thus the capacitor C is connected effectively between the negative rail, $-V_{CC}$ and the earth line at 0V, and as a result is charged up to $-V_{CC}$. When Q1 is pulsed on, its collector drops to 0V, carrying down the left hand side of the capacitor C to that level. The right hand side of C is consequently taken immediately to $+V_{CC}$ volts. This takes the base of Q2 positive and cuts off the transistor. C then begins to discharge through $R_{B2}$ and its right hand side gradually rises towards 0V with a time constant $CR_{B2}$. After C has discharged sufficiently, Q2 begins to conduct again and regeneration immediately sets in to turn Q2 rapidly on and Q1 rapidly off.

The resultant approximate waveshapes are shown in Fig. 40. The output can be taken from the collector of either transistor, but normally it is taken from the collector of Q2. The waveshapes show that the voltage output at the collector of Q2 is a negative going pulse.

*Newmarket Transistors Ltd.

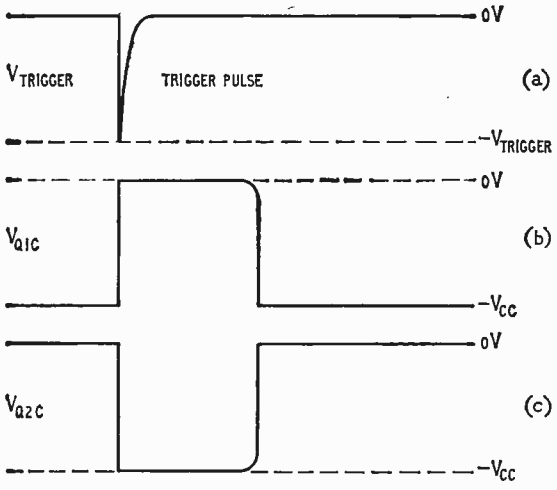



*Fig. 40 Waveforms of circuit of Fig. 39. Trigger pulse (a), $Q_1$ collector (b) and $Q_2$ collector (c).*

The precise design of a collector-coupled monostable multi can be complex, but the general lines can be covered with reference to Fig. 39. $V_{CC}$ is first selected equal to the output pulse voltage required. $R_{C2}$ is then chosen to give the output impedance required for the pulse. The transistor Q2 is selected with a collector-emitter voltage rating (at the full collector current, $V_{CC}/R_{C2}$) not less than $V_{CC}$. When the circuit is flipped on, the base of Q2 (connected to the right hand side of C) is carried to approximately $+V_{CC}$, and Q2 must have an emitter-base voltage rating not less than $V_{CC}$. Finally, since the base of Q2 switches to $+V_{CC}$ and its collector to $-V_{CC}$ when it is first switched off, Q2 must have a collector-base voltage rating not less than $2\times V_{CC}$. $R_{B2}$ is chosen sufficiently low in value to ensure that Q2 is well bottomed when switched on. To make this possible, $R_{B2}$ should be selected to give a base current of at least twice that required to bottom Q2, i.e., $R_{B2} = V_{CC}/2R_{C2}h_{FE}$. For reasons which cannot be gone into here, the $V_{BB}$ rail voltage should be selected not less than one-third of $V_{CC}$. $R_{B1}$ is normally selected to be not less than ten times $R_{C2}$ to ensure that it does not load $R_{C2}$ excessively. $R_{B1}'$ is then chosen to ensure that Q1 base goes more than 1V positive in the cut-off condition. For this it should not be greater than $(V_{BB}-1)R_{B1}$. The transistor Q1 is then selected with a collector-emitter voltage rating better than $-V_{CC}$, because its collector travels between 0V and $-V_{CC}$ and its emitter stays at 0V. In this case also, because there is no capacitive cross-coupling to the collector of Q2, the emitter voltage rating is unimportant, and provided it exceeds a few volts there should be no trouble. The collector-base voltage rating need not, as a result, be more than a few volts greater than $V_{CC}$. The current gain of Q1 should be selected so that the base drive provided by $R_{B1}$ will bottom the transistor in its on condition. $R_{C1}$ should not be of too great a value or it will adversely effect the recovery time of the circuit after pulsing. Very frequently $R_{C1}$ will be found approximately equal to $R_{C2}$, the circuit being symmetrical in this respect.

The length of the on-pulse is set in the main by the time constant $CR_{B2}$. An approximate formula for the pulse length time is:

$$T = 0.7CR_{B2} \quad .. \quad .. \quad .. \quad .. \quad (1)$$

For a rigorous treatment of the design of a collector-coupled monostable multi, readers are recommended to consult "Junction Transistors in Pulse Circuits," by P. A. Neeteson, Cleaver-Hume Press Ltd., 1959.

## Typical Medium-speed Collector-coupled Multivibrator

In Fig. 41 will be found the practical circuit of a 20$\mu$sec collector-coupled monostable multivibrator, based on the simple general design analysis given above. In the standby condition transistor Q1 is biased off and Q2 on. Q1 is triggered on by a pulse applied to its base through the 220pF, 1k$\Omega$ differentiating network. Diode D is connected so that only negative going pulses pass through to the base of Q1. The diode used, a NKT 149S1, is a diode-connected transistor with low hole-storage properties, but any good point-contact or gold-bonded germanium diode will do. Transistors Q1 and Q2 are standard alloy germanium r.f. switching transistors, with a minimum frequency cut-off of 8Mc/s. The NKT 125s were used in the circuit because they have a guaranteed minimum d.c. current gain of 50 at the 10mA level switched in this circuit, but any similar germanium alloy switching transistor with a typical $f_{hfe}$ of 15Mc/s would be suitable.

The circuit has been shown with separate positive

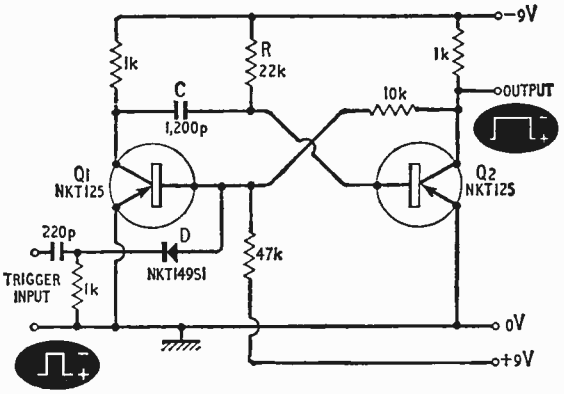



*Fig. 41 Typical medium-speed circuit, giving 20$\mu$sec pulse*

and negative d.c. supplies. A single-supply version can be obtained by connecting a 1,000-ohm resistor shunted by a 0.1$\mu$F from the 0V to +9V rail and connecting a single 18V supply between the +9V and −9V rails.

## Typical High-speed Monostable Multivibrator

A transistor requires a finite time to switch on and off, and special transistors have to be used when pulses narrower than a few microseconds are required. Fig. 42 illustrates a typical high-speed monostable capable of producing a narrow pulse of about half a microsecond duration. For these narrow pulses, a standard germanium alloy transistor would be useless and resort must be made to diffused-base transistors.

In the state before the monostable is triggered,

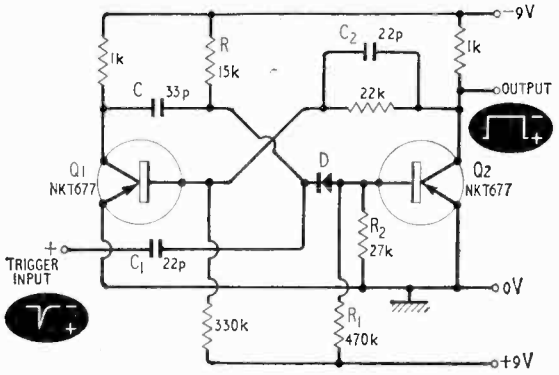



*Fig. 42 High-speed circuit for pulses down to 0.5μsec width.*

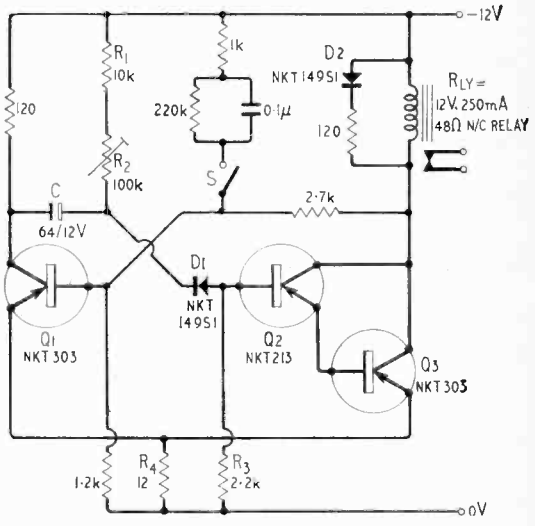
the right hand transistor Q2 is biased on by the current through the base resistor R and the forward biased diode D. At the same time Q1 is biased off by the 22kΩ, 330kΩ potentiometer across its base. On the application of a positive trigger pulse voltage to the input through $C_1$ across R, this voltage cuts off the diode D and causes Q2 to start switching off. Regenerative action through the cross-coupling resistor from the collector of Q2 to the base of Q1, tends to drive the latter transistor on, and the circuit flips into the quasi-stable state with Q1 on and Q2 off. During this state when the output pulse is being produced, the three capacitances C, $C_1$ and $C_D$ (the capacitance of the diode D) charge up with a time constant approximately $(C+C_1+C_D)R$, and the pulse length is $0.70(C+C_1+C_D)R$.

The purpose of the diode D is to protect the base-emitter junction of Q2 from exceeding its voltage rating which is of the order of 1V only (this being typical of the diffused-base type of germanium transistor). The diode D connected in series with the base of the transistor Q2 stops the positive signal up to 9V developed at the right hand side of the capacitor C during the quasi-stable state from being applied to the base of the transistor Q2. In this connection, an additional feature of the circuit not found in simpler circuits is the potentiometer network $R_1$, $R_2$ which maintains transistor Q2 emitter-base cut-off at a low voltage during the quasi-stable period. The other additional feature is the so-called "speed-up" or "commutating" capacitor $C_2$ across the 22kΩ cross-coupling resistor. The purpose of this, which will be examined in greater detail in a later article on the bistable multi, is to ensure a quasi-voltage initial drive to the base of Q1 when it is being turned on. This speeds up the transition between the stable and unstable states. The NKT 677 transistors used in the illustrative circuit are germanium alloy-diffused types with typical frequency cut-offs of 150Mc/s, voltage ratings greater than 20V and minimum current gains of the order of 50. The diode D can be any fast point-contact or gold-bonded germanium diode.

## Typical Low-speed Collector-coupled Multivibrator

Long-time-constant monostables present certain difficulties in design, particularly at high currents. This is because the timing resistor is also the resistor that provides the base drive for the normally-on transistor. For high currents, this base drive resistor must be low value. This then means that for a long output pulse the timing capacitor must be very large and in very large capacitors (which must be electrolytic) leakage currents tend to upset the timing constants. The practical circuit of Fig. 43 shows one method of getting round this difficulty. The particular circuit shown is designed to operate a high-current relay for the order of seconds to tens of seconds. It is basically a conventional collector-coupled monostable multi in which the timing is set by C, $R_1$ and $R_2$. When the switch S is open, the compound Darlington-pair transistor Q2-Q3 is held on by the base current through $R_1$ and $R_2$ and the relay $R_{LY}$ is held in. When the start switch S is closed, a negative pulse is applied to the base of Q2 and initiates a flip to the state where Q1 is hard on and Q2-Q3 cut off. C then discharges through $R_1$ and $R_2$ and eventually Q2-Q3 comes on again and Q1 cuts off to return to the stable state. The circuit is thus a timer which switches off a relay for a predetermined time given approximately by $T=0.7C(R_1+R_2)$. With the component values shown, this provides a relay switch-off time which can be varied from approximately 0.5 to 5.0 seconds. The resistor $R_3$ is designed to reduce leakage current in Q2-Q3 in the cut-off condition. The diode D1 is a blocking diode to cut $R_3$ out of the timing circuit, when the diode is reverse-biased during Q2-Q3 cut off. The feed network to the start switch, S, i.e. 1kΩ 220kΩ, and 0.1μF, is designed to provide an instantaneous sharp pulse for driving $Q_1$ on, but it has a sufficiently high d.c. resistance not to hold it on beyond the monostable pulse time if the starting switch $S_1$ is accidentally kept closed after starting the cycle. The diode D2 and the 120-ohm resistor in series with it are designed to clamp the collectors of Q2 and Q3 so that, on switch-off, the inductive switch-off voltage from the relay coil cannot take the collectors substantially above the −12V rail, thus protecting Q2-Q3 from breakdown due to excessive voltage. The 12-ohm resistor $R_4$ provides a stand-off voltage for the transistor bases and enables a single battery supply to be used. Because of the

*Fig. 43 Low-speed multivibrator driving a relay.*



low value of this resistance it is not necessary normally to decouple it. Q1 and Q3 are standard miniature intermediate power transistors operated in free air without being mounted on a heat sink. Q2 is a standard high gain audio transistor used in combination with Q3 to provide a composite very high gain transistor pair which enables reasonably high values of resistance to be used for $R_1$ and $R_2$. By using the composite transistor, values of $(R_1+R_2)$ at least ten times higher than with a single transistor can be used for any given pulse length and correspondingly lower timing capacitor values. Preset relay operation up to several minutes can be achieved with this arrangement.

## Emitter-coupled Multivibrators

The circuits described so far have been of one main category, collector-coupled monostables. The other main category is the emitter-coupled multivibrator. Fig. 44 illustrates the basic circuit of this. Here Q2 in the absence of external triggering, is normally conducting due to the base current supplied by $R_{B2}$. $R_E$ is chosen sufficiently high in value to ensure that the on current through Q2 and $R_E$ biases the emitter of Q1 more negative than the 0V, at which the base is held, and thus keeps Q1 cut off. A positive-going trigger pulse applied to the base of Q2 is followed by the emitters of both Q2 and Q1, until the emitter of Q1 goes positive with respective to its base. Q1 then begins to switch on, its collector voltage begins to drop towards 0V and this positive voltage drop is communicated back through C to the base of Q2 Regeneration sets in and the circuit switches rapidly into the condition where Q1 is cut-off and Q2 is hard on. Q2 is held off by the charge voltage across C, applied to its base. C discharges through $R_{B2}$ with a time constant $CR_{B2}$. The pulse duration before the circuit flops back to its original quiescent state is approximately $0.7CR_{B2}$. The result of all this is a

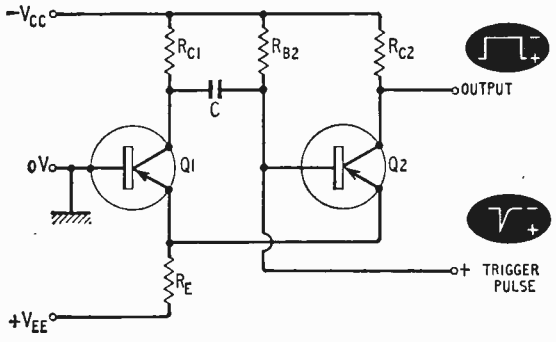



*Fig. 44 Basic emitter-coupled circuit.*

negative-going pulse output at the collector of Q2, of duration $0.7CR_{B2}$. The detailed design of this sort of circuit need not be gone into in full because it is very similar to that of the collector-coupled multivibrator given earlier. For a very full analysis, interested readers should consult " Transistor Circuit Analysis " by M. V. Joyce and K. K. Clarke, Addison-Wesley Publishing Co. Massachusetts, 1961.

## Complementary-symmetry Multivibrator

The circuits discussed so far have all used transistors of the same polarity. In the illustrations, they

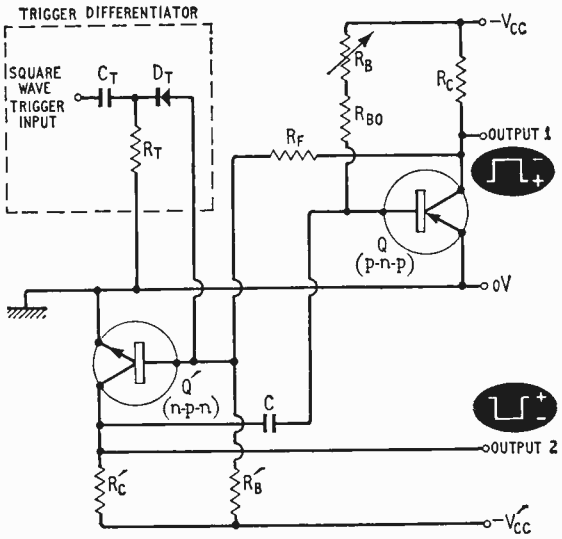



*Fig. 45 Complementary-symmetry multivibrator, using p-n-p and n-p-n transistors (both normally on).*

happen to have been p-n-p, but n-p-n could equally well have been used if available. The use of both types of transistor in combination makes possible a new family of switching circuits which have no valve equivalent. One form of the basic complementary symmetry monostable multi is shown in Fig. 45, where normally in the quiescent condition both transistors are switched hard on. The p-n-p transistor Q is held hard on by the base current through $R_{BO} + R_B$ ($R_{BO}$ is only a limiting resistor to guard against accidental short circuit of the base of Q to the negative rail if $R_B$ is reduced to zero.). With transistor Q switched on, its collector voltage is close to 0V. Under these conditions the n-p-n transistor Q′ is also held on, this time by the base current through $R_B'$, little current being deflected through $R_F$, since both ends of $R_F$ are close to 0V. When a negative trigger pulse is applied to the base of the n-p-n transistor, Q, it starts to switch off, and the voltage on its collector starts to move in the positive direction. This positive step is communicated through C to the base of Q, and tends to cut Q off, resulting in a negative step at the collector, which is communicated back through $R_F$ and aids the negative trigger pulse applied to the base of the Q′. Regeneration sets in and both transistors rapidly switch off. The circuit then relaxes, C charging up through $(R_{BO} + R_B + R_B')$ until eventually Q starts to switch on again and the circuit flops back into the quiescent condition with both transistors full on. The length of the pulse is set by the discharge time constant of C, and $(R_{BO} + R_B + R_B')$, and is given approximately by $0.7C(R_{BO} + R_B + R_B')$. $R_{BO} + R_B$ could be replaced by a single fixed resistor, if a variable pulse length is not wanted. The circuit is interesting in that it provides simultaneous outputs of opposite polarities at the transistor collectors, negative-going in Q and positive-going in Q′, each with reference to 0V.

For a 100μS, 6V pulse, typical values in this circuit would be $V_{CC} = V_{CC}' = 6V$; $R_C = R_C' = 4.7k\Omega$; $R_B' = R_{BO} + R_B = 47k\Omega$; Q = NKT 213; Q′ = NKT 713; $R_F = 47k\Omega$; C = .0015μF; $D_T$ =

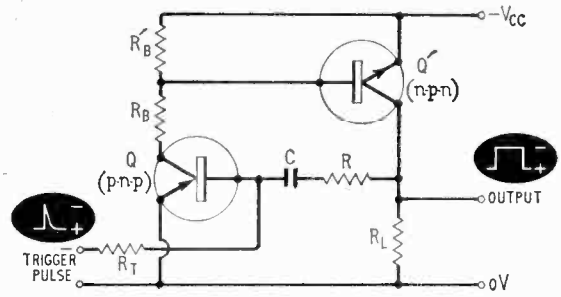



*Fig. 46 Alternative version of Fig. 45 with transistors normally off.*

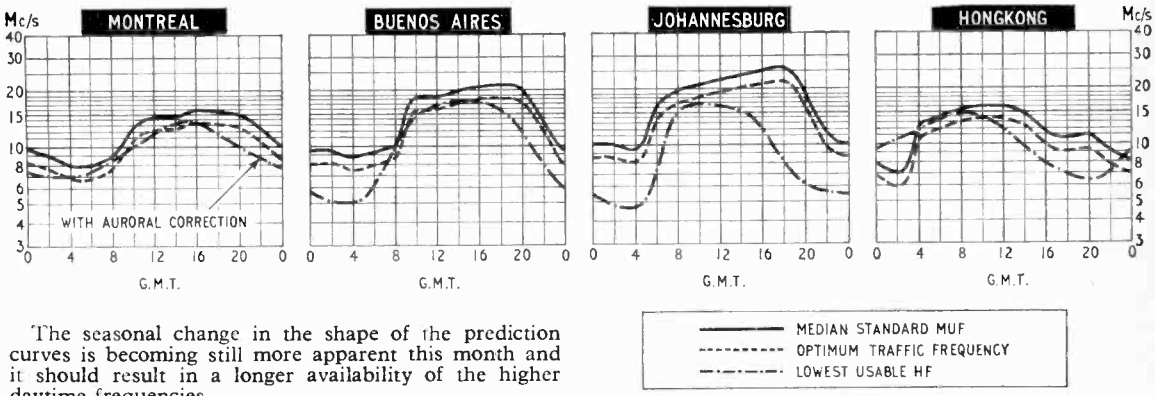
NKT149S1 (but any point contact or gold-bonded germanium diode is suitable); $C_T = .001\mu F$ and $R_T = 1k\Omega$. With a pulse length of $100\mu S$, the recovery time was found to be less than $20\mu S$ i.e., it was found possible to trigger the circuit up to a pulse repetition rate of 8kc/s.

The circuit of Fig. 45 has both transistors switched on during standby. For battery economy, a circuit where both transistors are cut off during standby is desirable. Fig. 46 gives the basic circuit of this alternative type. In the quiescent condition between pulses, with no current to the base of the p-n-p transistor Q, it is cut off, and its collector voltage is close to the negative rail, $-V_{CC}$. With no drive voltage to its base, the n-p-n transistor Q′ is also cut-off and the capacitor C is discharged. A negative trigger pulse applied to the base of Q through an isolating resistor $R_T$ will tend to drive it full on. Its collector voltage will then fall towards the positive rail. This carries the base of Q′ positive and tends to drive Q′ on. The collector voltage of Q′ then tends to go negative and this negative step is fed back through C and R to the base of Q, assisting the trigger pulse cumulatively until the whole circuit flips into the state where both Q and Q′ are held hard on. C then begins to charge through R during the relaxation (pulse) period until eventually Q begins to switch off again and the circuit flops back into the quiescent condition, with both transistors cut off. If the on pulse is chosen to be $T = CR_{eff}$, it can be shown that $R_{eff}$ is given approximately by $R_{eff} = 0.4\ h_{fe}h_{fe'} \times R$. The circuit has the disadvantage that the pulse time is highly dependent upon the transistor current gains, but it has the advantages that it requires no power effectively until triggered, that it can handle large load currents and can sustain long pulse periods with relatively small capacitor values. Because of the double current multiplication round the circuit loop, the timing capacitor C can be approximately $h_{fe}$ times smaller than would be necessary in a conventional monostable multivibrator using only one polarity of transistor.

## Conclusion

In this article we have taken a look at the monostable multivibrator in its transistor versions, because it is such a commonly used tool in pulse circuit work. It finds many applications in the generation of precise pulses, in reshaping pulse trains which have degenerated during transmission, in stretching narrow pulses into wider ones, in generating a time delay, in gating control circuits, and in frequency division (in the way described previously for an astable multivibrator). Most engineers find the monostable multi a satisfying circuit because so very frequently it turns out to perform almost exactly as designed theoretically and it is usually not difficult to "get working," once you understand the basic principle on which it works.

# H. F. PREDICTIONS — APRIL




The seasonal change in the shape of the prediction curves is becoming still more apparent this month and it should result in a longer availability of the higher daytime frequencies.

The curves show the median standard MUF, optimum traffic frequency and the lowest usable high frequency (LUF) for reception in this country. Unlike the MUF, the LUF is closely dependent upon such factors as transmitter power, aerials, local noise level and the type of modulation; it should generally be regarded with more diffidence than the MUF. The LUF curves shown are those drawn by Cable & Wireless, Ltd., for commercial telegraphy and they serve to give some idea of the period of the day for which communication can be expected.

# DIRECT-READING CAPACITANCE METER

## A PORTABLE TRANSISTOR INSTRUMENT POWERED BY BATTERIES

By D. F. BAILEY, A.M.I.E.E.

THE instrument described is a simple, transistor device which gives an instantaneous capacitance measurement on a linear scale. Three ranges are provided (1000 pF, 0.01$\mu$F and 0.1$\mu$F full scale) with a reasonably high degree of accuracy (3%). Useful measurements may also be made up to 1$\mu$F.

### Principle of Operation

Referring to Fig. 1 an internal oscillator of frequency $f$ c/s is used to actuate a switch. In one position of the switch a close-tolerance capacitor is charged through a defined reference voltage V. In the other position of the switch the capacitor discharges fully through a meter. Now the charge in the capacitor is $Q = CV$ coulomb and since the switch operates at $f(=1/t)$c/s the average meter current $I_m = Q/t = CVf$.

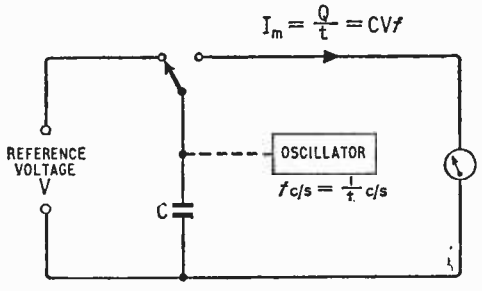



*Fig. 1. Simple circuit illustrating principle of operation.*

Hence $I_m$ is proportional to C, and V and $f$ are so arranged that Im is the full-scale deflection current with an internal standard in circuit. If the capacitor is now replaced by the unknown the instrument becomes a direct-capacitance comparator and thus, by suitable choice of internal standards, a direct-reading capacitance meter.

### Design Considerations

In the practical circuit (Fig. 2) the oscillator is a transistor multivibrator, the switch is a transistor while a Zener diode provides the reference voltage V. Range changing is effected by decade switching of the oscillator frequency.

In arriving at a final configuration the following are the major considerations:

(a) From $I_m = CVf$ it will be seen that the more sensitive the meter used the smaller the lowest value of capacitance that may be measured.

(b) The reference voltage and the switching frequency should be kept as high as possible. A high $Vf$ product permits either a low minimum-value capacitance range or alternatively the use of a cheaper and less sensitive meter should a higher value of minimum range be acceptable.

(c) In order to use relatively low-frequency transistors and yet produce a good switching waveform the maximum oscillator frequency should not exceed, say, 20 kc/s. This will be the wanted oscillator frequency on the lowest capacitance range. Adequate time must be available in the respective half cycles for charge and discharge of the capacitor.

(d) Stray capacitance in the measuring circuit sets an ultimate limit to the full-scale value of the lowest capacitance range. As will be shown later a figure of 100 pF full scale enables strays to be neglected.

(e) The highest capacitance that may be measured is limited both by the bulk of the internal standard and by pointer flutter caused by the meter movement following the low switching frequency. A maximum range of 0.1$\mu$F full scale demands a switching frequency in excess of 100 c/s, so that no trouble will be experienced here.

(f) The reference voltage, which is derived from a Zener diode, is limited by the available battery potential. This in turn is governed by the fact that the instrument is intended to be a small portable transistor device.

(g) In the interests of battery size and economy the current consumption should not exceed about 10 mA.

These factors lead to a choice of 3 full-scale capacitance ranges of 1000 pF, 0.01$\mu$F and 0.1$\mu$F. Values remain to be allocated to Im, V and $f$.

It was decided to design for a nominal 12 V supply while maintaining circuit performance down to a voltage of 8. This permits the use of two 6 V PP1 batteries with exceptionally long life or alternatively one PP3 9V battery with somewhat less life but with the advantage of extremely small size. Since measurements may be made rapidly the battery will, in general, receive only intermittent loading and the latter solution is perfectly adequate.

The 8 V minimum-supply figure fixes the maximum possible Zener potential at around 6 V. Hence the choice of an OAZ 203 (6.2 V).

A 50$\mu$A movement was available so it merely remained to calculate $f$ for the three ranges. Since, in practice, it is more convenient to shunt the meter than alter the oscillator frequency in order to calibrate against the internal standard capacitor, a figure of 75$\mu$A f.s.d. was used to calculate $f$.

With $I_m = 75\mu A$, $V = 6$ V, substitution in the equation $I_m = CVf$ yields:

$f = 125$ c/s for 0.1$\mu$F f.s.d.
$f = 1250$ c/s for 0.01$\mu$F f.s.d.
$f = 12.5$ kc/s for 1000 pF f.s.d.

**The Practical Circuit:**—Transistors Vt1 and Vt2 provide a unity mark-space ratio square wave of 12V

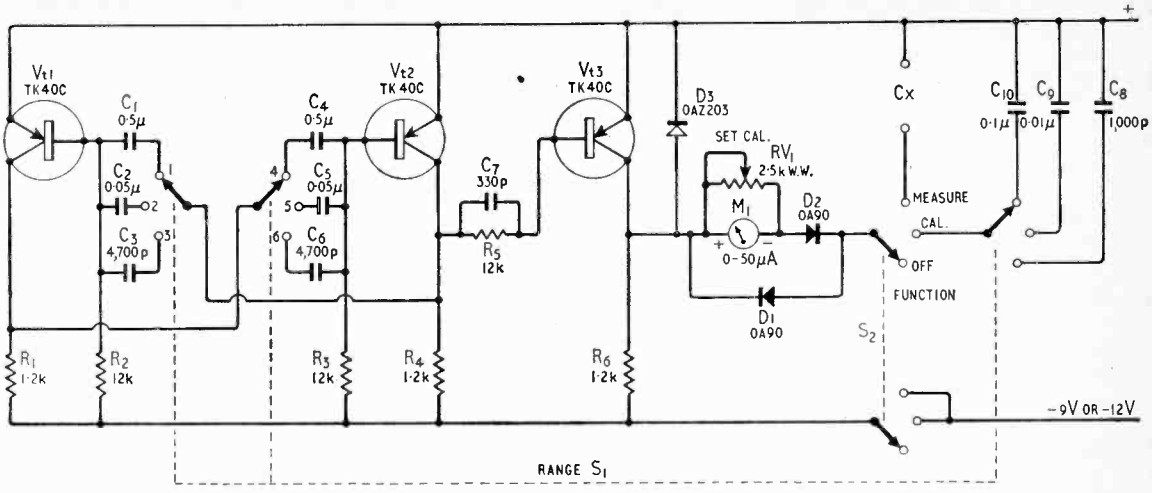



*Fig. 2. Practical circuit; all resistors are ±10% ¼W types. Capacitors $C_1$ to $C_7$ are ±20%, $C_8$, $C_9$ and $C_{10}$ are polystyrene ± 1% types.*

amplitude at a frequency of 125 c/s, 1250 c/s or 12.5 kc/s dependent on the range selected.

This square wave is used to switch Vt3 between the bottomed and the cut-off conditions. Vt3 collector swings from approximately zero potential when in the bottomed (on) condition to −6 V when Vt3 is cut off, the collector excursion being limited by the Zener diode D3.

When Vt3 is cut off the capacitor charges to −6 V via D1. When the transistor is bottomed the capacitor discharges via the meter, D2 and Vt3. The meter thus reads the average current $Q/t = CVf$.

Adjustment of the meter shunt $RV_1$ with the internal standard capacitor in circuit enables full-scale calibration to be set in the " CAL " position. Upon replacing the standard by the unknown in the " Cx " position a direct reading of capacitance is obtained.

**Multivibrator Vt1 & Vt2:**—These transistors form a conventional cross-coupled multivibrator with CR timing in the base circuits. An output impedance of 1.2 kΩ is adequately low to drive the succeeding switch stage " ON." In order to cut off the switch the multivibrator transistors must bottom when " ON." Hence the base resistors must be no greater than 1.2 kΩ × βminimum—12 kΩ will ensure heavy bottoming. Although only short-term frequency stability is required of the multivibrator, the timing mechanism merits some examination. From the waveform diagrams (Fig. 3) it will be seen that at the switching instant, the collector potential of the previously off transistor changes rapidly from −12 V to approximately zero (bottoming potential). Hence the base of the previously on transistor is driven positive by 12 V to +12 V approximately. This transistor is cut off while the timing capacitor recharges through the 12 kΩ base resistor the aiming potential being −12 V. However, when the base reaches a potential slightly negative with respect to the zero rail the off transistor conducts and completes the half cycle. Similar action ensues with the other transistor to complete the full cycle.

The time of each half cycle is thus the time of the exponential discharge $V = \hat{V}\left(1 - e^{-\frac{t}{CR}}\right)$. Here $\hat{V} = 24$ V and $V = 12$ V. Hence $e^{-\frac{t}{CR}} = 0.5$ and the time of each half cycle is approximately 0.7 CR. Since only the first half of the exponential is used, the threshold of conduction is quickly swept through which implies that the frequency is reasonably stable and independent of transistor characteristics. The capacitor values are chosen to give the desired oscillator frequencies. Component tolerances of 20% will suffice since meter sensitivity (unshunted) is a factor of 1.5 greater than the figure used in the frequency calculation.

**Switching Stage Vt3:**— This is alternately switched between bottoming and cut-off by Vt2. The collector resistor $R_6$ must not be so low that an

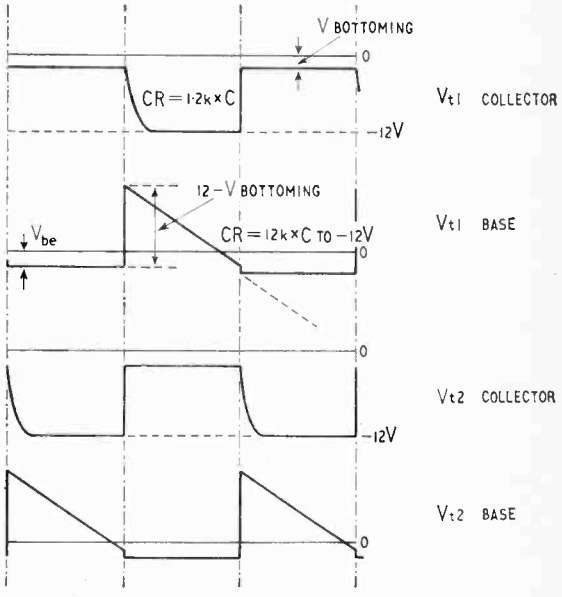



*Fig. 3. Waveform diagrams of the collectors and bases of transistors Vt1 and Vt2.*

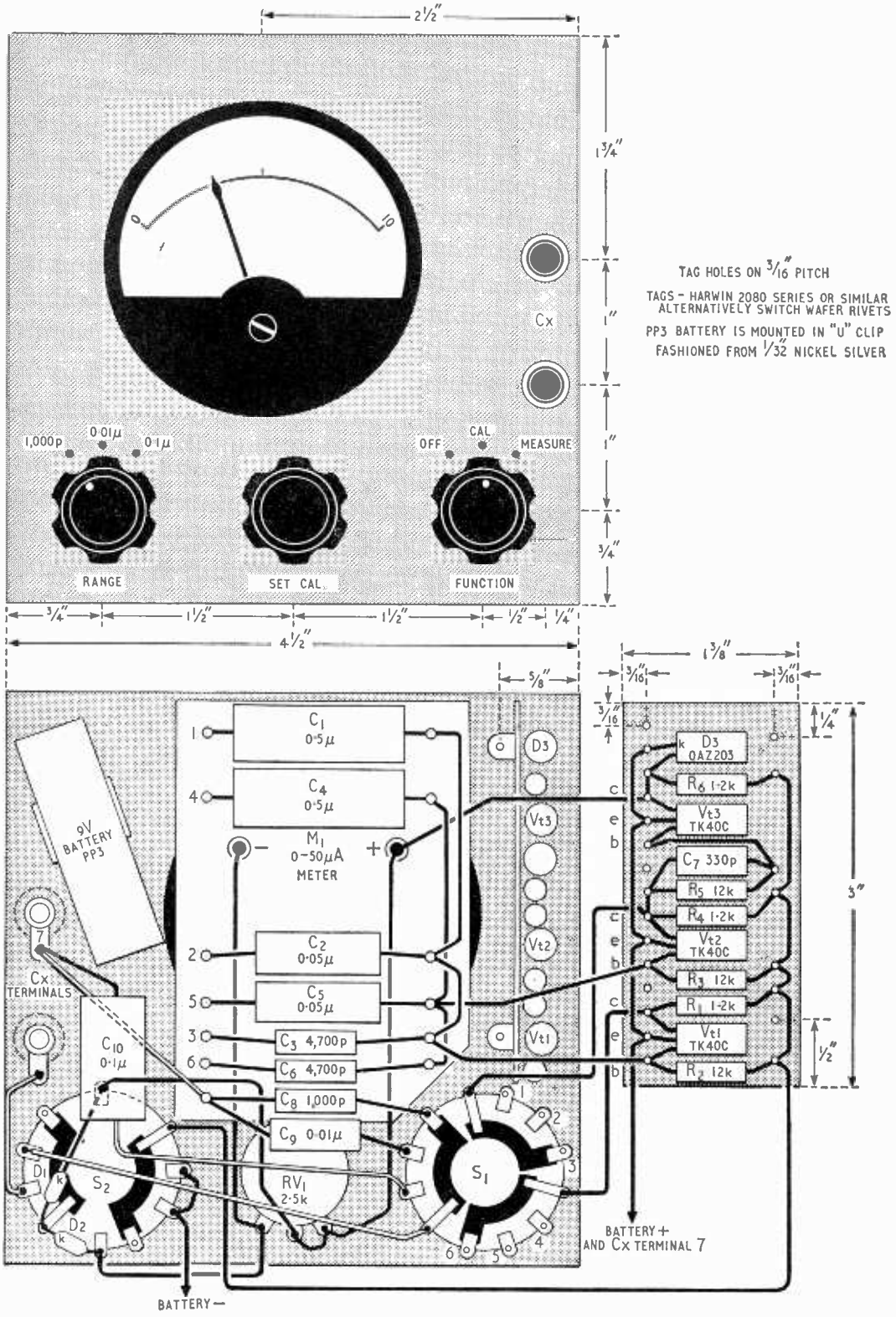



*Fig. 4. Layout and constructional details of the instrument. The tag boards are constructed from synthetic resin-bonded fibre sheets.*

excessive base drive is demanded to bottom the stage. On the other hand it must be low enough to ensure that the full-scale capacitance may be charged in a fraction of the half cycle available. The resistor current is then diverted through the Zener diode and this current must be sufficient to keep the diode above the knee of its I/V characteristic even at low-battery voltage. This is in order to keep a well-defined reference voltage and in the case of the OAZ 203 demands a current around 1-2 mA minimum. The capacitor will charge to the reference potential in a time somewhat less than $CR_{\mu}$sec since the aiming potential is twice the reference. This time is a small fraction (less than 5%) of the charging time available (one half cycle of the input).

A time of at least 5 CR must be allowed for the capacitor to discharge fully. The R in question is, at the commencement of discharge, substantially the resistance of the meter. However as discharge continues the current lowers and the diode D2 forward resistance increases and becomes more significant. The time constant of the capacitor and meter resistance is only about 2% of the discharge half-cycle period and is sufficiently short.

If no arrangements are made to drive Vt3 base positive when switching the transistor off, hole storage will cause the negative-going collector transition to be rather slow (greater than 10$\mu$sec). On the lowest capacitance range this represents a significant part of the charging half cycle (40$\mu$sec) so to ensure that there is no danger of incomplete charging the transition is speeded up by the addition of $C_7$.

The diodes D1 and D2 should have a low forward resistance (no more than a few hundred ohms) and a reverse resistance sufficiently high to avoid substantial diversion of charging current through the meter and discharge current away from the meter by the nominally non-conducting diode.

## Accuracy

The sources of error are:—

1. Standard capacitor tolerance: polystyrene types of $\pm 1\%$ have been used.
2. Meter linearity: this will be of the order of $\pm 1\%$ in a good quality movement.
3. On the lowest capacitance range the stray capacitance of the wiring from the junction of D1 and D2 via the switches to earth affects both the value of the standard in the " CAL " position and of the zero capacity in the " Cx " position. It is possible to get this capacitance down to less than 5 pF by short wiring (diodes wired direct to the switch wafer and a short lead from the function switch to " Cx " terminal, etc.).

An overall accuracy of $\pm 3\%$ is obtainable therefore except upon the lowest capacitance range where the zero error should be taken into account with readings below 300 pF.

## Construction

The whole instrument is conveniently constructed inside a plastic lunch box $4\frac{1}{2} \times 4\frac{1}{2} \times 1\frac{5}{8}$in deep (a PP3 9 V battery is used). With the exception of the diode and switch wiring mentioned above, layout is not critical. All multivibrator timing capacitors may be mounted on a tag board at the side of the meter, this board being mounted on the front panel by two small " L " brackets. If the lid is used as a chassis, accessibility is good, the box itself merely forming a cover.

## Operation

1. Switch to " CAL " and to the desired capacitance range.
2. Adjust " SET CAL " until the meter reads full scale.
3. Switch to " Cx " and connect unknown capacitor to " Cx " terminals.
4. Read value directly off meter scale.

On the 100 pF range, if steps 3 and 4 are carried out with the "Cx" terminals open circuit, the reading obtained will be the zero-error (stray) capacitance.

## Extension to 1$\mu$F

If on the 0.1$\mu$F range the " SET CAL " control is adjusted to give 0.1 f.s.d. in the " CAL " position then on switching to " Cx," the full-scale reading will represent 1$\mu$F. The charge time constant when measuring has a maximum value of $1.2\,k\Omega \times 1\mu F = 1.2$ msec. This is only 25% of the available time so almost complete charging should occur. Sufficient time is available for discharge since, although the capacitor has been increased by a factor of 10 the significant resistance (that of the meter) has been reduced by the same amount by shunting to calibrate.

It is rather more difficult to adjust the " SET CAL " control accurately however and a measurement accuracy of about 5% is probably realistic.

# Commercial Literature

The 1964 edition of the **Mullard Semiconductor Designers' Guide** for industrial and communication equipment is now available from the technical office of the industrial semiconductor division of Mullard Ltd., Mullard House, Torrington Place, London, W.C.1. Three new charts have been introduced in the transistor section. Full dimensional drawings and details are included.
**7WW 326 for further details**

**Computer Booklet.**—The Solartron Electronic Group of Farnborough, Hants, has published a booklet describing the various units in the Solartron 247 Analogue Computer System.
**7WW 327 for further details**

A leaflet describing a range of **small push-button switches** is now available from Highland Electronics Ltd., 26-28 Underwood Street, London, N.1. Dimensional drawings are included.
**7WW 328 for further details**

A booklet describing the **lubricants and greases** produced for electrical and mechanical applications is now obtainable from Electrolube Ltd., Oxford Avenue, Slough, Bucks.
**7WW 329 for further details**

A leaflet describing the Type 175A **50 Mc/s double trace oscilloscope** is available from Hewlett-Packard Ltd., of Dallas Road, Bedford.
**7WW 330 for further details**

Polyethylene terephthalate **(PET) capacitors** rated from 200 to 5,000 V d.c. working are described in a recent publication from the instrument division of E.M.I. Electronics Ltd., Hayes, Middx.
**7WW 331 for further details**

**A. T. & E. (Bridgnorth) Ltd.,** of Bridgnorth, Shropshire, has completely revised its radiotelephone and associated equipment catalogue.
**7WW 332 for further details**

# UNBIASED

By "FREE GRID"

## Electronics in 1888?

WE all know that warrant holders who supply goods of various kinds to the Royal household are permitted to use the words "By Appointment, etc." I have been very interested in examining a list of these Royal warrant holders who were appointed in the reign of Queen Victoria. I should say at once that I am indebted for this list to Mr. F. G. L. Beresford, of Ottery St. Mary, Devon, who tells me he has been reading my page since 17th Sept. 1930; obviously he is a man of stamina. He has sent me a cutting of an article from *The Times* of 31st January this year which somehow I had overlooked.

It appears that the Queen, or at any rate her advisers, appointed a medical galvanist and electrician as early as 1847. This is not so surprising as it looks at first sight, as according to Mellanby's "History of Electric Wiring," Trafalgar Square was lighted by electricity (arc lamps) as early as 1846, and, of course, medical treatment by galvanism—or in other words an electric current—dates back to a still earlier period.

The biggest surprise was to read of the appointment of an electronic engineer in 1888. At first I was inclined to doubt this as I cannot find any reference in the O.E.D. to the use of the word electronic before 1891. However, the O.E.D. itself was a mere seven-year-old stripling in 1891 as it first saw the light of day in 1884.

I think the truth of the matter is that Queen Victoria's electronic engineer of 1888 may have been a lamptrimmer whose duties were to replace gas mantles and trim oil lamps which were very probably still used in the servants' quarters. The reason why I think that the lamptrimmer may have been called by the fanciful title of electronic engineer is that we see the same sort of human vanity today when rat catchers call themselves rodent officers; dustmen, refuse operatives; office boys, management trainees and, of course, plumbers have been sanitary engineers for quite a long time.

It must not be forgotten that the primary meaning of the Greek word "electron" is "that which produces shining or glitter" and so it is not surprising that the ancient Greeks used the word to describe a whole host of things which glittered in the light. Among these were gold and silver, some alloys and, of course, amber. Thus "electrical properties" to the Greeks meant properties which produced shining or glittering. No doubt Queen Victoria's advisers knew all this, and it would not be surprising if they called her lamptrimmer an electronic engineer. I dealt with this whole question of the basic meaning of "electron" *in extenso* in the February 1960 issue of *Wireless World* and so will not labour it further here.

## South Bank Science

HAVING recently complained to the Editor about "Cathode Ray's" absence from the February issue, his re-appearance last month was as welcome as the flowers in Spring, and I feel I speak for all my fellow readers when I say that.

Maybe one day "Cathode Ray" may find time to produce a comprehensive textbook for us weaker brethren, not exactly on the lines of his famous "Second Thoughts on Radio Theory" but more like the "Latin without Lashes & Greek without Groans" which I recall from my schooldays.

I would myself try to fill in the gaps as his understudy when "Cathode Ray" is too busy to appear in person, but the Editor was quite severe when I suggested it, and reminded me that *W.W's* head office is situated on the south bank of the Thames and he feared that I might get the journal an undesirable reputation for what in current jargon might be termed "south bank" science. He reminded me that even in my own columns I had sometimes expressed unorthodox views which militated against any chance I might have had of receiving a tempting offer from the U.S.A.

I was glad to notice that "Cathode Ray" admitted in his article an instance of his furthering an error originally promulgated by more than one elementary textbook. To admit this fact makes him sound even more human than we know him to be. I, of course, have made (not furthered) errors through slip-shod reading of some of "Cathode Ray's" own writings. This admission on my part makes me bold enough to ask if he has not himself made a slight error in this article.

When mentioning (page 149, col. 1) what we used to call the precession of the equinoxes he gives us a figure of 27,000 years. Surely it is rather less than that, namely 25,800 years. Of course he may only be using round figures as we all do when we say a light-year is equal to six billion miles when it is actually rather less than that. The only reason I have for raising this trivial point is that I don't want "Cathode Ray" to be equated with me in this matter of south bank science.

## Reversing the Flow

RECENTLY I was very interested to read a letter to the Editor of *The Daily Telegraph* by L. Marsland Gander, the well-known radio columnist. He was writing on the subtle under-the-surface influence which, he says, the ladies exert in what has become known as the brain-drain down which so many of our eminent scientists are being sucked by the brain-starved American world of science.

Now as we all know many of these scientists eventually return to us, but this is not so very surprising when we remember that anything which goes down our drains, finds its way eventually to the sea, and is then evaporated and duly returned to us as rain. In contrast to the blaring trumpeting of each scientist's departure, his return is usually quiet and unheralded; in fact he "droppeth as the gentle rain from heaven," as Shakespeare so aptly puts it in Portia's famous speech.

I must congratulate Marsland Gander on his discovery that it is the scientists' wives who provide the drive in initiating their husbands' return just as the sun's evaporative power does in the case of the rain. Apparently the wives get very bored and discontented with the nerve-racking American way of life which is so different from ours.

The only thing I would like to suggest is that the Government starts a fund to send the wives over to the U.S.A. for a year on their own so that they could gain experience to enable them to discourage their husbands from going down the brain-drain.

## Data or Datæ?

AS I have mentioned previously in these columns, I have never made any claim to be a Latin or any other sort of scholar. In the matter of Latin, however, I did manage to scrape together sufficient knowledge of it to satisfy the examiners that I was a fit person to be allowed to pursue my studies at Cambridge. That is not saying much, however, as in 1914 the degree of knowledge required was so elementary that it has always surprised me that budding boffins jibbed at it, and as a result,

Latin is no longer required of intending Cantabs.

To me this seems a pity, as it tends to lead to such deplorable errors among even the most eminent of scientists when they use expressions from this ancient tongue. A notable instance of this occurred in a series of B.B.C. television lectures given in January and February by a scientist who more than once, used a singular verb after the word data.

I am raising the whole matter of this grammatical grotesquity—if I may coin a word—of the phrase "data is," as I think I have found an explanation of its prevalence. I think that scientists—the Cambridge-grown variety at any rate—owing to their being no longer "learned in Latin and grounded in Greek" as was once the case, fail to realize that data is indeed a plural word, and wrongly imagine it to be a singular noun of the first declension in which the customary suffix of the nominative case is "a," the plural being "ae." They are in good company as the first declension led to the undoing of Sir Winston Churchill as he tells us in his book "My Early Days."

To prove my theory correct I am keeping a sharp look-out for a case where a scientist wants to speak of a collection of various sets of data. I feel sure that instead of writing "All these data are" as he should do, he will write "All these datæ are."

## About Architects

LAST November I deplored the fact that new houses are being built without a mast on the roof, which I suggested should run down through the house to the foundations, to provide a strong support for the rather elongated horizontal aerials which some of us are going to need for satisfactory reception of BBC-2.

I have, however, received letters rebuking me for trying to usurp the functions of the architect, and also pointing out that such a mast would transmit strong vibrations to every floor of the house unless it were properly insulated in the mechanical sense, so that it would not transfer vibrations to the brickwork, etc.

I certainly don't want to offend the susceptibilities of architects, for whom I have a great respect, but surely it is their job and not mine to see to the practical aspects of suggestions which, from time to time, I throw out in these pages. Architects and their families are people who have to be handled with care. Long years ago I knew an architect's daughter whom I endeavoured to handle with great care, but she did not appreciate my efforts as she had all her plans for her future from foundations to finials cut and dried, and I didn't figure in them. Since then I have been wary of architects and their families but apparently I have put my foot in it again.

# APRIL MEETINGS

*Tickets are required for some meetings : readers are advised, therefore, to communicate with the secretary of the society concerned*

**LONDON**

1st. I.E.R.E.*—Short papers on "Pulse compression techniques in radar" at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

3rd. Institution of Electronics.—Full-day symposium on "Oscilloscopes" at Hendon College of Technology.

6th. I.E.E. Graduates.—"Digital does analogue" by M. R. Krick at 6.30 at Savoy Place, W.C.2.

7th. I.E.E.—"Electronic summation metering" by M. L. Done at 5.30 at Savoy Place, W.C.2.

8th-10th. I.E.E.—Conference on "Dielectric and insulating materials" at Savoy Place, W.C.2.

8th. Inst. Phys. & Phys. Soc.—London Acoustics Group annual general meeting at 5.15 followed by "Test conditions for industrial acoustical measurements" by Dr. A. J. King at Imperial College.

9th. I.E.E. & I.E.R.E.—Discussion on "Road and rail traffic control using computers" at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

13th. I.E.E. & I.E.R.E.—Colloquium on "Field-effect and other high-input-impedance devices and their applications" at 2.30 at Savoy Place, W.C.2.

13th. Television Society.—"Problems of recording colour signals on magnetic tape" by P. Rainger at 7.0 at the Faraday Room, I.E.E., Savoy Place, W.C.2.

15th. I.E.E.—"A new method of amplification using acoustic waves" by Dr. E. A. Ash at 5.30 at Savoy Place, W.C.2.

15th. I.E.R.E.—Symposium on "The operation of electronic equipment under conditions of severe electrical interference" at 10.30 a.m. at Birkbeck College, Malet Street, W.C.1.

16th. I.E.E.—Colloquium on "The design and use of cathode-ray tubes" at 9.30 a.m. at Savoy Place, W.C.2.

17th. B.S.R.A. — "Intermodulation and Doppler distortion in loudspeakers" by James Moir at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2.

20th. I.E.E.—"The application of oblique incidence sounding to long-distance communications problems" by P. A. C. Morris at 5.30 at Savoy Place, W.C.2.

21st. I.E.E. & I.E.R.E.—Colloquium on "Simulators for training purposes" at 2.30 at Savoy Place, W.C.2.

27th. I.E.E., British Computer Society and Society of Instrument Technology.—Discussion on "The choice between analogue and digital-computing techniques in engineering analysis and design" at 5.30 at Savoy Place, W.C.2.

28th. Society of Relay Engineers.—"Coaxial and multipair cables for television wire broadcasting" by J. D. S. Hinchliffe, and "The specification and testing of small radio-frequency cables" by B. W. Osborne at 2.30 at 21 Bloomsbury Street, W.C.1.

29th. I.E.E.—Colloquium on "Filter design" at 10.0 a.m. at Savoy Place, W.C.2.

*Institution of Electronic and Radio engineers, the new title of the Brit. I.R.E.

29th. I.E.E. & I.E.R.E. (Medical Electronics).—Discussion on "A practical approach to transistor circuits" at 6.0 at the London School of Hygiene, Keppel Street, W.C.1.

**BEDFORD**

20th. I.E.E.—"The Highgate Wood electronic telephone exchange" by H. F. Hesketh at 7.0 at the Bridge Hotel.

**BIRMINGHAM**

7th. I.E.E. & I.E.R.E.—One-day symposium on "Electronics in the automobile industry" at the University.

15th. Television Society.—"Transistorized television receivers" by P. L. Mothersole at 7.0 at the College of Advanced Technology, Gosta Green.

30th. I.E.R.E.—"Air traffic control" by Dr. D. H. Davies at 7.0 at the University.

**BRISTOL**

13th. I.E.E. and I.E.R.E.—"Some recent ionosphere researches" by J. A. Ratcliffe at 6.0 at the University.

23rd. Inst. Phys. & Phys. Soc. and I.E.R.E.—"Microwave spectroscopy and its applications" by Prof. D. J. E. Ingram at 7.0 at the College of Science and Technology.

27th. I.E.E.—"The principles and operation of large radio telescopes" by Dr. A. H. Hewish at 6.0 at the Technical College, Ashley Down.

**CAMBRIDGE**

6th. I.E.E. & R.Aero. Soc.—"Satellite communication" by D. Wray at 7.0 at the University Arms Hotel.

**CATTERICK**

7th. I.E.R.E.—"U.H.F. propagation and reception" by Dr. A. C. Roff at 6.0 at Catterick Camp.

28th. I.E.E. — "Discussion on "Studies in physical electronics for engineers" opened by E. C. Bell at 6.30 at Catterick Camp.

**CRANFIELD**

13th-16th.—Symposium on "Instrumentation and test techniques for manned high-speed flights" at the College of Aeronautics. (Organizer, M. A. Perry, Dept. of Flight, College of Aeronautics, Cranfield, Bucks.)

**EASTBOURNE**

26th-29th.—R.T.R.A. annual conference at Queen's Hotel.

**EDINBURGH**

3rd-5th. L.E.R.E. & I.E.E.—Symposium on "Microminiaturization" at Heriot-Watt College.

**EVESHAM**

3rd. I.E.R.E.—"Systems and receiver techniques for stereophonic broadcasting" by Dr. G. J. Phillips at 7.0 at B.B.C. Club, High Street.

**GLASGOW**

18th. R.S.G.B.—Scottish v.h.f. convention at 2.30 at Mill Hotel, Rutherglen.

**ISLE OF WIGHT**

24th. I.E.E.—"Magnetic tape recording" by W. Silvie at 6.30 at the Technical College, Hunnyhill, Newport.

**LEICESTER**

14th. Television Society.—"Colour television" by Dr. G. N. Patchett at 7.15 at the New Vaughan College, St. Nicholas Street.

**LIVERPOOL**

6th. I.E.E.—"Electronics—the expanding frontier" by Dr. R. C. G. Williams at 6.30 at the Royal Institution, Colquitt Street.

15th. I.E.R.E.—"The history of radio" by G. R. M. Garratt at 7.30 at the Walker Art Gallery.

23rd. I.E.E.—"Teaching machines" by Prof. H. Kay at 6.30 at the Royal Institution, Colquitt Street.

**MALVERN**

15th. I.E.R.E.—"Superconductors in instrumentation" by Dr. D. H. Parkinson at 7.0 at the Winter Gardens.

**MANCHESTER**

22nd. I.E.E.—"Electronics—the expanding frontier" by Dr. R. C. G. Williams at 6.15 at the Reynolds Hall, College of Science and Technology.

**NEWCASTLE-UPON-TYNE**

8th. I.E.R.E.—Annual general meeting of the North Eastern Section at 6.15 followed by "Electronic musical instruments" by K. A. Macfadyen at the Institute of Mining and Mechanical Engineers, Westgate Road.

**PORTSMOUTH**

8th. I.E.R.E.—Annual general meeting of the Southern Section at 6.30 followed by "A naval view of reliability" by Commander J. R. Young at Highbury Technical College, Cosham.

**PRESTON**

8th. I.E.E.—"The sun, the earth and radio" by J. A. Ratcliffe at 7.30 at the Harris College.

**READING**

7th. I.P.R.E.—"The principles and uses of lasers" by Dr. O. S. Heavens at 7.30 at the White Hart Hotel.

**REDHILL**

8th & 15th. I.E.E.—"Colour television" by R. N. Jackson at 7.30 at the Mullard Research Laboratories, Salfords.

**RUGBY**

7th. I.E.E.—"The colour performance of the SECAM colour television system" by G. B. Townsend at 6.30 at the College of Engineering Technology.

**OVERSEAS**

6th-8th. I.E.E.E.—Conference on "Nonlinear magnetics" in Washington, D.C., U.S.A.

13th-15th. I.E.E.E.—Symposium on "Microelectronics" in St Louis, Mo., U.S.A.

21st-23rd. I.E.E.E.—Computer conference in Washington, D.C., U.S.A.