# Wireless World

ELECTRONICS, RADIO, TELEVISION

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

*Editor:* F. L. DEVEREUX, B.Sc.

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## JANUARY-DECEMBER 1959

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## *In This Issue*



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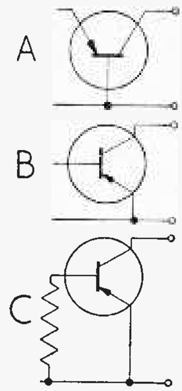
# Transistor Breakdown with Inductive Load

The maximum permissible collector voltage of a transistor is usually specified under three sets of conditions:

A: Minimum collector breakdown in grounded base with open circuit emitter;

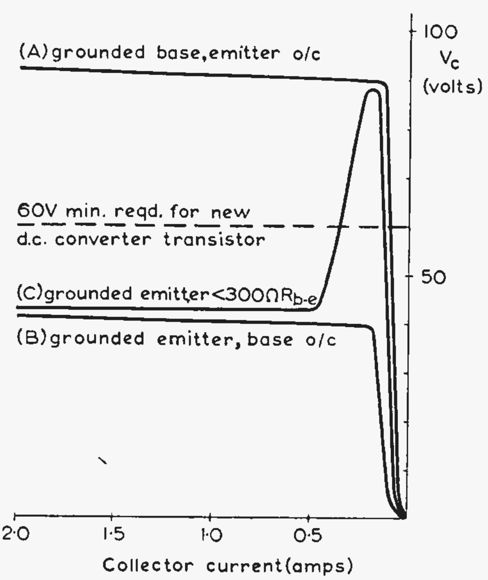
B: Minimum collector breakdown in grounded emitter with open circuit base;

C: A more realistic specification — grounded emitter with base connected to ground through a resistance or impedance of less than some given value.




When transistors are used with resistive collector loads, these cut-off conditions normally represent the position of greatest voltage stress on the device, and they adequately protect the application. As the current increases, the voltage across the transistor goes down, and it is possible to draw all normal load lines and still remain within the transistor requirements—whether expressly stated or implied.

Sometimes, however, an inductive load is used with the transistor in grounded emitter. If the transistor has been fully driven on its base to, say, 2 amps collector current and is then suddenly cut off, current continues to flow in the collector. The voltage across the inductance rises in such a direction that this current is maintained, and the transistor is subjected to a condition of *high voltage and high current* which is never met with in ordinary resistive or theoretical transformer applications.




The graph shows three curves of collector voltage plotted against collector current: Curve 'A' (for condition 'A' above) represents a normal diode breakdown; the transistor softens at, say, 90V.

Curve 'B' (for condition 'B') represents normal avalanche breakdown with the transistor softening at 40V. Curve 'C' shows that with condition 'C' the breakdown voltage at low currents remains nearly that of the collector by itself, as in curve 'A'; but as soon as additional drive current is applied to give higher collector currents, the breakdown voltage rapidly falls, and at about ½ amp is only a little greater than that of curve 'B'.

Thus, if a transistor operated under condition 'C' is passing 2 amps into an inductive load connected to a 24V accumulator, and is suddenly cut off so that the voltage across the transistor rises above its breakdown value of 40V, then the internal dissipation will be 80W. Such a peak dissipation is destructive. At 6 amps (and it is usually peak currents such as this which occur immediately before switch-off) the dissipation is 240W.

TO OBTAIN GOOD LIFE THE TRANSISTOR MUST NOT BE OPERATED EVEN UNDER TRANSIENT CONDITIONS ABOVE THIS REGION OF HIGH CURRENT AND VOLTAGE BREAKDOWN.

Where a power transistor is used in a driven circuit to close a relay or contactor, or to operate servomechanisms, a diode (with or without a series resistance) can be connected across the inductive collector load and will prevent the inductive peak voltage from reaching the transistor. In d.c. converter circuits, however, it is very difficult for the circuit designer to ensure that the peak voltages on the transistor remain low. Designers of d.c. converters and similar inductive circuits should ensure that the switch-off voltage at high current does not exceed the maximum permissible value for the type of transistor which they propose using.

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*Transistors need to have these characteristics specified in their data. Future Mullard data sheets will make limit values on this parameter available to the circuit designer.*

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# Quantity and Quality

ACTION to meet this country's present and future needs in scientific and technical manpower has rightly been directed first to what might be termed the logistics of the problem. From this point of view the situation is promising. As Mr. Geoffrey Lloyd, the Minister of Education, has put it*: "The years immediately ahead are of special importance, for there will be coming out of the schools the largest age groups of young people for over thirty years. This is a once-for-all opportunity for remedying our shortages of skilled manpower." The Government is fully alive to its responsibilities and has voted hundreds of millions of pounds for the building of new schools and technical colleges, and the re-vitalization of the old. It has appointed committees and councils to establish more certificates and diplomas and to open up new routes to technical qualification. Due consideration has been given to the possibility of transfer from one course of study to another, so that everyone has the chance of finishing an approved course even though it may be above or below the standard at first thought to be possible.

There seems little doubt that the numbers of students successfully completing the various specified courses will be adequate. The quantities will be there, but what of the quality?

The final arbiters of that quality will be the customers who buy the goods our industry exports; the intermediate judges will be the employers who recruit staff from the colleges or send their apprentices there to acquire theoretical training. Therefore (again quoting the Minister of Education) ". . . the development programme for the technical colleges does not depend only on the efforts of the Government and local authorities; it needs the full backing and support of industry and commerce."

This means that employers must be prepared to make the effort and find the time to collaborate with local technical colleges to narrow the gap which tradition has established between the academic and the workaday worlds, and to find ways and means of developing the qualities of mind which lead to original thought and sound judgment. In particular to decide such questions as how wide the basic training should be; and, if there is also to be specialization, how narrow and how deep? The limitations of human capacity enforce a compromise, but just where the line should be drawn must depend on circumstances and will change with time. In our view the trend must inevitably be towards greater specialization so that at least someone in a team *knows* when the rest have only a vague idea.

Professor E. E. Zepler in his Presidential Address last November to the British Institution of Radio Engineers had this to say:

". . . Such is the expansion of knowledge in almost every field of technology that it is quite a hopeless task to cover fully even one branch of engineering. This is a fact that can no longer be overlooked. Divergence of opinion can only exist as to what should be stressed most, general knowledge or depth of understanding. My own opinion is that it is the latter we should aim at above all things, and we should not be dismayed if, in the process, we find that larger parts of the subject are not adequately covered. There are plenty of books from which the student can acquire a general knowledge, but the ability to think for himself critically and objectively, that is something which he will best learn from lectures and tutorials and this, therefore, should be the foremost aim of inspired teaching. . . . The first duty of a university to a student is to 'teach how to think'. . . . The method of thinking, the fundamental treatment and the mathematical approach are often surprisingly similar in different branches of science, so that mastery of one subject is a large step towards mastery in others."

To those who fear that specialization may lead to narrow-mindedness we cannot do better than quote the words of Lord Adrian, Master of Trinity College and Vice-Chancellor of Cambridge University who said at last year's Annual Dinner of the Institution of Electrical Engineers:

"But personally I have never found that the subject a man takes makes very much difference to his range of interests; it can be as wide or as narrow as you please, whether the man is doing hydrodynamics or Anglo-Saxon. I do not think we can widen interest by force. We can do something by guile. Colleges and universities cannot help allowing all the faculties to mix up out of school hours, and we are glad to let them do it because it means that the chemist may sit next door to the law student in hall and talk to him about poetry. Sometimes they do not talk at all and when they do it may be about rugby or the Bank Rate; but at least they can share their views with people in a different line of work so they will not seem quite so odd when they get out into an industrial concern."

* Ministry of Education Pamphlet "Britain's Future and Technical Education."



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# Stereophonic Record Pickups

## PRINCIPLES OF CURRENT DESIGNS

*By* F. OAKES*, A.M.I.E.E., A.M.Brit.I.R E., *and* D. V. CHARLESWORTH*

ALTHOUGH the principles of two-channel stereophonic sound reproduction have been known for some considerable time, acceptable recordings on disc, and suitable pickup mechanisms to recover stereo information from the disc, have only recently become commercially available. The recovery of stereo information, i.e., the conversion of a combined mechanical signal into two separate electrical signals, can be carried out in a number of different ways, and a variety of pickup mechanisms have been developed, incorporating many ingenious ideas to fulfil this function.

* Ferguson Radio Corporation.

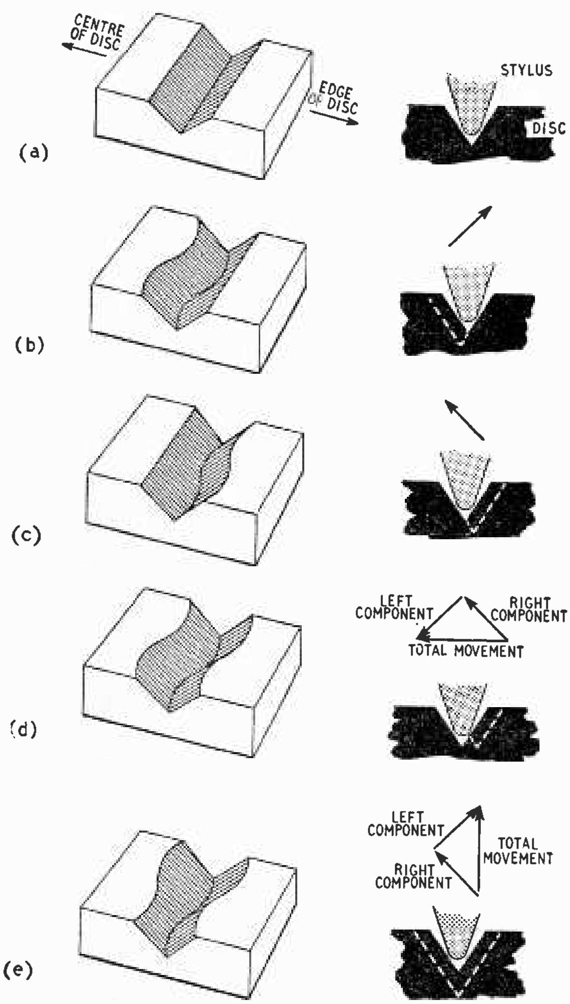


*Fig. 1. The 45-45 recording system. (a) No modulation, (b) left-hand channel only modulated, (c) right-hand channel only modulated, (d) both channels modulated in phase and with equal amplitudes, (e) both channels modulated with opposite phases and equal amplitudes.*

**Basic Principles.**—The fundamental problem of two-channel stereophonic reproduction lies in the storage and recovery of two sets of information. Each of the two sets corresponds to one channel of the system. With tape, the solution is comparatively simple. Two separate tracks are simultaneously recorded on the same tape. They are played back simultaneously although otherwise independently. Synchronism is thus ensured and simplicity maintained at the expense of using twice the area of tape as compared with single-channel recording. On disc, matters are more complicated, because the two channels have to be recorded in a single groove.

With single-channel recordings the groove is modulated in one direction only. A lateral cut is used, resulting in a groove of constant depth and width (disregarding second order effects). To store the information content of both channels in a single groove, an additional degree of freedom is required. This can be obtained by the use of vertical as well as horizontal excursions of the cut; in other words, by recording one channel laterally and the other in a hill-and-dale fashion. The pickup stylus will move laterally if information is recorded on the lateral channel only; it will move up and down if information is recorded only on the other channel. The main disadvantage of this method is its asymmetry with respect to the two channels. For instance, the vertical rumble component is usually considerably in excess of the horizontal component. The pickup tracing geometry will also have different effects on the horizontally and vertically modulated channels. To avoid these asymmetries, a different method, called the "45-45 system," has been adopted as standard practice for most two-channel stereo-disc recordings. This system accommodates the two-channel information in a single groove in such a manner that symmetry is preserved with respect to the two channels, the modulations of the groove being at +45° to a vertical tangential plane for one channel and at −45° for the other. The phases are so arranged that with the channels in phase and of equal amplitude a lateral modulation of the groove is obtained, whereas a vertical modulation results from out-of-phase signals. This system is illustrated in Figs. 1 (a) to 1 (e).

The following facts can be observed when studying these illustrations:

(a) When the groove is unmodulated its width (at the record surface) and depth are constant, and the stylus exploring the groove is stationary.

(b) When only the left-hand channel is modu-



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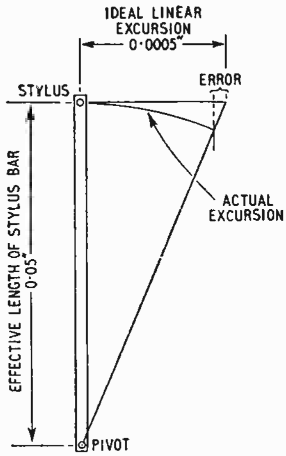


*Fig. 2. Errors incurred by non-rectilinear excursions of the stylus. With the dimensions shown the error is less than 0.01% of the excursion.*

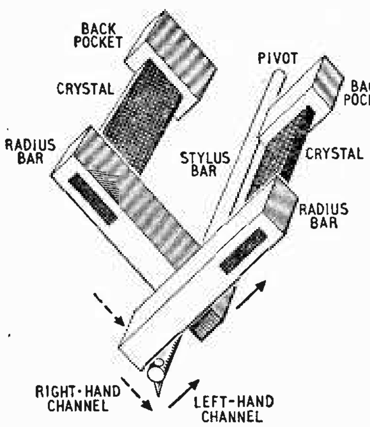


*Fig. 3. Mechanical component resolution using separate radius bars.*

lated, width and depth of the groove vary and the stylus moves along a line at $-45°$ to the vertical.

(c) When only the right-hand channel is modulated, width and depth of the groove vary, and the stylus moves along a line at $+45°$ to the vertical.

(d) When both channels are modulated in phase and equal amplitude, width and depth of the groove are constant and the stylus moves laterally, exactly as on an ordinary single-channel disc.

(e) When both channels are modulated 180° out of phase and equal amplitude, width and depth of the groove vary, and the stylus moves in a vertical direction.

Normally, combined modulations of both channels are present, and the stylus moves in a plane at right angles and radially disposed with respect to the disc surface; its movement cannot be restricted to a single line as in an ordinary lateral pickup (ignoring pinch-effect).

Thus, it can be seen how the individual information contents of the two channels are combined in a single groove, and transmitted to a single stylus exploring this groove. In order to separate the two sets of audio information, the planar movement of the stylus has to be resolved into two linear components, each corresponding to the appropriate modulation component.

**Mechanical Component Resolution.**—For accurate mechanical resolution of a two-dimensional movement into two one-dimensional, independent components, a complicated mechanical device comprising a number of precision-made moving members might appear to be necessary. In the case of the stereophonic pickup, however, the small amplitude of the excursions which the stylus has to trace, make it possible to reduce this difficulty. Considering a bar held at one end and carrying a stylus on the other, it can be understood that the stylus will not move in a plane but in a curved surface as a stereo record groove is explored. The excursions, however, are of the order of only 0.001in peak-to-peak or less, and from Fig. 2 it can be seen that to trace an excursion of 0.001in the stylus bar length need only be of the order of 0.05in to render the error between an ideal planar excursion and the actual curved excursion of its movable end negligible.

A simple but effective system for the resolution of stylus-movement into the two stereo components can therefore be based on the principle shown in Fig. 3. Here, the stylus is fixed to one end of a stylus bar which is parallel to a tangent of the record groove at the point of contact and pivots or flexes round its other end. As the groove is explored, the stylus and stylus bar move, moving also the radius bars which are held against the stylus bar by the reaction of the playing weight. If the stylus moves in a $-45°$ direction only, i.e., parallel to the right radius bar, only the left radius bar will move—and vice versa. For a horizontal stylus movement, the two radius bars flex both clockwise or both anti-clockwise simultaneously, for a vertical movement one will move clockwise while the other moves anti-clockwise. In this way, the combined motion of the stylus is resolved into two components corresponding to the two individual channels. The excursions are small compared with the lengths of the radius and stylus bars, they will therefore have an almost exactly linear relationship to the appropriate components of the stylus movement, and the accuracy of resolution will be high.

As the combined mechanical movement is resolved into two appropriate mechanical components, these must in turn be converted into appropriate electrical signals. This can be done by using Rochelle salt crystals. If these are of the so-called "twister" type, they will give a voltage output proportional to the amount of mechanical twist applied. In the mechanism described, one end of such a crystal is embedded in one radius arm of the structure shown in Fig. 3 and one end of a second crystal in the other radius arm. The other end of each crystal

*Fig. 4. Garrard stereo pickup with part of one crystal cover removed*



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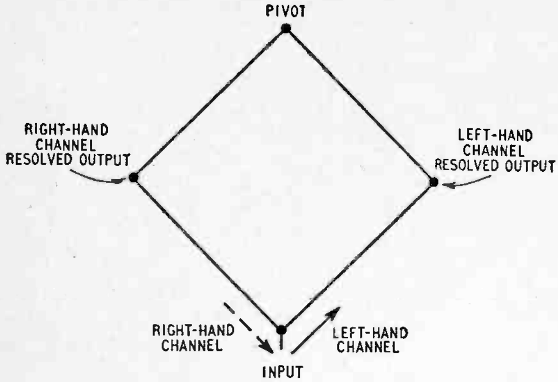


*Fig. 5. Diamond structure resolver.*

is held rigidly. When the radius arms are flexed, the crystals are twisted, and appropriate electrical signals are generated. This principle provides the basic method for the Garrard pickup, a photograph of which is shown in Fig. 4.

Another method of resolution into two rectilinear components is the diamond structure shown in Fig. 5. This is formed by four rigid members joined together flexibly, and pivoting about one corner. If the corner opposite the pivot is moved in the plane in which the diamond structure lies, the two remaining points will also move, but in such a manner that a $+45°/-45°$ resolution of the initial movement is obtained. This can be seen by imagining the bottom moving point displaced by a small amount in the direction of the arrow drawn as a broken line. Such a movement will cause the bottom right arm to swivel round the right corner leaving the top right arm stationary. The bottom left arm on the other hand will move along its axis and will cause the top left arm to swivel round the top pivot point. In other words, a movement due to modulation in the right-hand channel will cause the top left arm to swivel but will leave the top right arm stationary. For a modulation in the left-hand channel, as shown by the solid line arrow, an analogous process will ensue, with the functions of the left and right sides exchanged. A vertical upward movement of the bottom moving point is seen to cause a clockwise movement of the top left and an anti-clockwise movement of the top right arm. A horizontal or sideways movement will cause both top arms to rotate in similar directions. If amplitudes are small, a composite movement of the bottom moving point will thus be resolved into two linear movements of the elbow points, or into two swivel-movements of the two top arms, so that the resolved movements are linearly proportional to the $+45°$ and $-45°$ components of the initial composite movement.

This is one of the classical methods for mechanical resolution into two components, and several pickups are based upon it. As an example, the arrangement of the Acos pickup is shown in Fig. 6. A photograph of the actual device is shown in Fig. 7. The diamond-shaped resolver is made of a resilient plastic material, and the ends of the piezoelectric crystals are embedded in the upper arms. The notch at the bottom accepts the stylus bar where the movement is transmitted from the stylus to the mechanical resolver. The plastic re-

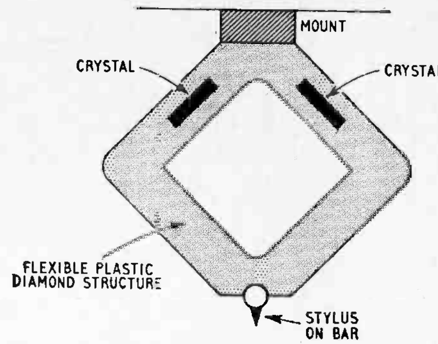


*Fig. 6. Acos diamond structure resolver.*

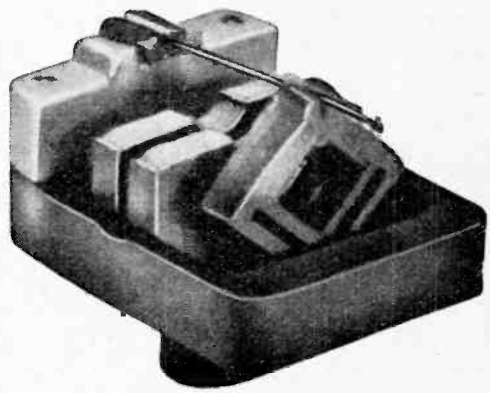

*Fig. 7. Acos stereo pickup with cover removed.*

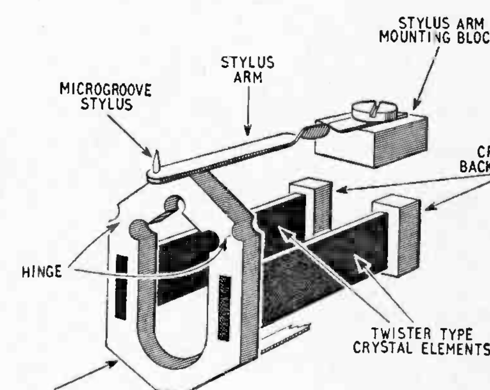


*Fig. 8. Schematic diagram of B.S.R. turn-over pickup.*

solver is distorted by the movement applied at this point, but the excursions are sufficiently small to keep the non-linearities introduced to a negligible magnitude, allowing only the linear components to contribute materially to the resolved output, twisting the two crystals. The electrical outputs are therefore again proportional to the appropriate components of the groove modulation.

An elaboration of this principle is used by B.S.R. for the design of a turn-over pickup to play 78 r.p.m. single-channel coarse-groove records on one side, and both single-channel and stereophonic microgroove records on the other side. Fig. 8 shows a



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schematic diagram of the working parts. In the position shown, the pickup is in the 78 r.p.m. position, and lateral only modulation will twist both crystals simultaneously as the stylus moves from side to side. If the pickup is inverted, it will resolve the stylus movement in a manner very similar to that of the diamond-structure. A photograph of the B.S.R. cartridge is shown in Fig. 9.

The methods described above are basically two-dimensional in that the resolution of a planar movement is carried out within this same plane. An interesting three-dimensional method is shown in Fig. 10. Resolution is carried out in planes at right angles to the original plane of movement. The structure illustrated can be regarded as a corner cut from a cube-shaped box pivoted at the corner point P. If the input point A is moved in a plane parallel to the BPC plane, resolved outputs can be obtained from points B and C. (It must be realised that the excursions of the input point are actually confined to a spherical surface, but for the small excursions under consideration, this can be regarded as equivalent to the tangential plane at the point A). Various kinds of input movements and their resolution are indicated by the various arrows in Fig. 10. For instance, a movement at a +45° slope to the verticals corresponding to the arrow drawn as a solid line and a right-hand channel only modulation, will rock the structure about its PC edge keeping C stationary, but moving B by the same amount at 45° to the B-C axis in a horizontal plane, as the input point A is moved in the vertical plane.

This principle is embodied in the Columbia Broadcasting System (C.B.S.) stereo pickup shown schematically in Fig. 11. The stylus is carried by a bar which is made flexible so that the effective stylus pivot point is not the point at which the stylus bar is clamped (P′), but at P say. Two wing-shaped metal vanes are attached to the bar for transmission of the output forces to piezoelectric crystals. The dotted lines indicate the structure in Fig. 10 from which the functions of the device can be derived. A photograph of the C.B.S. cartridge is shown in Fig. 12.

A similar principle can be used to obtain resolution of the composite stylus movement into appropriate voltage outputs by means of the moving-coil principle. Fig. 13 shows two coils of wire at right angles to each other and attached to a stylus bar going through the line of intersection of the planes in which the two coils are situated. The assembly is placed in a magnetic field parallel to the stylus bar, pivoted at the centre point P, and so oriented that the stylus bar, lying along the Z axis, is parallel

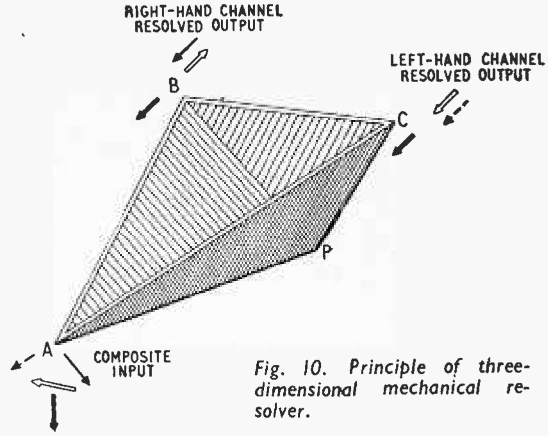

*Fig. 10. Principle of three-dimensional mechanical resolver.*

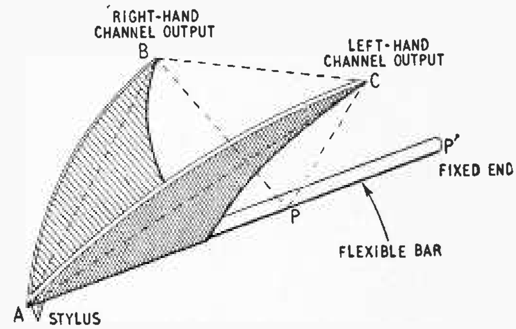

*Fig. 11. Schematic drawing of C.B.S. practical three-dimensional resolver.*

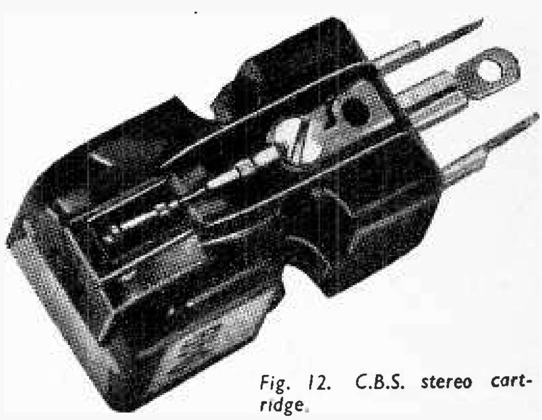
*Fig. 12. C.B.S. stereo cartridge.*

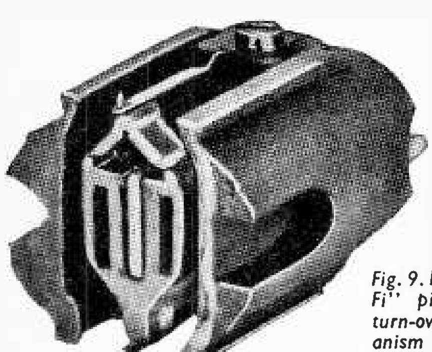
*Fig. 9. B.S.R. "Ful-Fi" pickup with turn-over mechanism and front removed.*

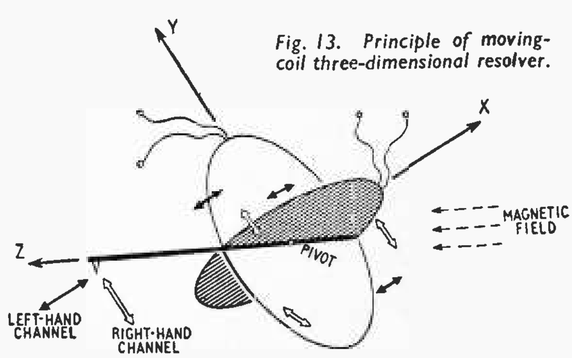

*Fig. 13. Principle of moving-coil three-dimensional resolver.*



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with the record groove at the point of contact. The coils, lying in the ZX and ZY planes, respectively, are at 45° to the vertical, as shown. If, for instance, only the right-hand channel is modulated, the Y coil rotates about the X axis but in its own plane as indicated by the arrows, whilst the X coil also rotates about the X axis, but leaving and re-entering its original plane. Thus, only the X coil will cut lines of magnetic force, and only the X coil will give a voltage output. In this way, the composite movement of the stylus produces an appropriately resolved stereo voltage signal at the output terminals. A schematic drawing of such a moving-coil pickup made by the Fairchild Recording Equipment Corporation is shown in Fig. 14.

A completely different approach has been made in designing the Tannoy "Vari-Twin" stereophonic pickup which is a variable-reluctance device. The principle of operation can be understood from Fig. 15. The stylus bar completes an individual magnetic circuit with each of the four pole pieces. A small movement of the stylus bar in the direction of the flux lines will therefore increase the air gap of one and decrease the air gap of the other magnetic circuit in this particular direction. Such a movement will be at right angles to the flux lines of the two remaining magnetic circuits and will leave their air gaps virtually unchanged. If the windings are so connected that the e.m.f.'s introduced by a movement in the direction of flux for one pair constituting one channel add, then the second-order gap changes due to the movement at right angles will produce e.m.f.'s of opposite sign, so that the errors tend to cancel out. Movement of the stylus bar in the A direction produces e.m.f.'s in coils 1 and 3 with the following polarities:—coil 1: F+, G−; coil 3: F−, G+. Similarly, movement in the B direction produces e.m.f.'s in coils 2 and 4 with the following polarities:—coil 2: F+, G−; coil 4: F−, G+. Thus movement of the stylus bar in the A-direction will result in an output from terminal 3, in the B direction in an output from terminal 1. A composite movement will be resolved and appropriate voltages produced at terminals 1 and 3, terminal 2 being earthed. When playing single-channel fine-groove records, terminal 3 is earthed and the output obtained from terminal 1. A photograph of the Tannoy cartridge is shown in Fig. 16.

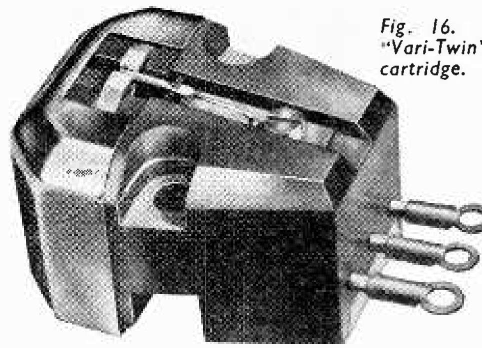
*Fig. 16. Tannoy "Vari-Twin" stereo cartridge.*

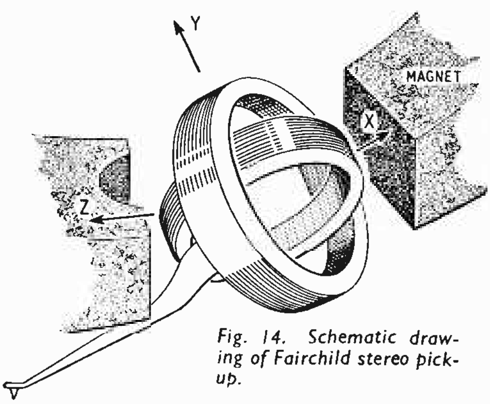

*Fig. 14. Schematic drawing of Fairchild stereo pickup.*

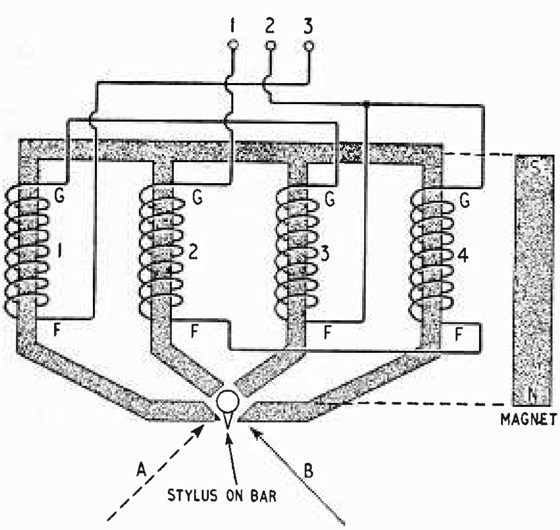

*Fig. 15. Principle of Tannoy variable-reluctance stereo pickup.*

Apart from fulfilling the function of resolving the mechanical input and converting it into appropriate electrical voltages, the mechanisms discussed above must be of such construction and weight as to be able to track the groove faithfully and without causing damage to the record. This means that the stylus assembly mass must be small, and its compliance must be large. The stylus should be so dimensioned that it rides on the walls of the groove without touching the bottom. Ideally, the stylus should have a tip radius between 0.0005 and 0.0006in, but up to 0.00075in radii are used for compromise styli to play stereo as well as single-channel fine-groove gramophone records. The groove angle is nominally 90° and the bottom of the groove radius about 0.0001in. The modulation is normally so arranged that the right-hand sound channel corresponds to the groove wall which faces the axis of the disc.

The performance which is obtainable with stereophonic records and pickups is not quite up to the standard of the best single-channel records at the present time. But although there is still room for improvement, the results achieved are most encouraging. In spite of the lesser fidelity, a far greater impression of realism is, in our opinion, achieved by the use of stereophonic reproduction, making worth while the effort and ingenuity that has been set to work to bring this new venture in sound reproduction within reach of the general public.

The authors are indebted to the manufacturers of the pickups, the mechanisms of which are described, for their assistance in providing material for the preparation of this article.



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# JAPAN'S RADIO INDUSTRY

THE recent announcement that Japanese transistor receivers are now permitted to be imported into this country has re-focused attention on the rapidly growing radio and electronics industry in Japan. A five-year plan for the industry, drawn up by the Ministry of International Trade and Industry, envisaged a total production of £195M in 1958 increasing to £446M in 1962.

During the five years over 13M sound receivers are to be manufactured, of which about 50 per cent. will be for export. The value of sound receivers produced during the period is planned to increase from £28M in 1958 to £46M in 1962. Transistor receivers form about 40 per cent. of the overall total. Japan produced 5.5m. transistors in 1957 and it is expected that the 1958 figure will be over 14M, rising by 1962 to some 70M.

There are, at present, something over a million television receivers in use in Japan. The industry's output for 1958 was expected to be just under a million receivers, and during the five-year period just under 7M. The plan provides for an overseas market of over 600,000 television sets during the period. The output of cathode-ray tubes is to go up from £13.5M to £34M. It is interesting to note that of all the figures quoted in the five-year plan only one, for radar, shows no increase, remaining at just under £500,000 for each of the five years.

To foster the export of radio and electronic equipment the Ministry waives the tax on income from exported goods and grants funds for the survey of overseas markets.

*The first consignment of Japanese transistor portables imported by Winter Trading Co. on arrival by B.O.A.C. at London Airport.*

# Testing Multi-wire Cables

A SMALL portable test set for "vetting" multi-wire cables *in situ*, or prior to installation, was demonstrated recently by de Havilland Propellers. Designed initially for testing cable looms in aircraft the possibility of it having applications wherever multi-wire cables were in use subsequently became apparent. Many such cables are employed in radio and radar installations at airports, in vehicles and elsewhere. Testing is carried out from one end of the cable but access is necessary to the remote end where the cable has to be fitted with a special adaptor. If the conductors of the cable have different destinations at the remote end the tester can still be used provided all leads are joined to a common point, such as earth.

The cable to be vetted is joined to the test set by a multi-way connector and testing is initiated by press-button switches, one for insulation test and another for continuity check. The unit selects each core of the cable in turn, applies a test voltage and samples the current, if any, flowing in it.

A transistor d.c. to a.c. convertor generates a 1-kc/s square wave which is rectified and provides 500 volts d.c. for insulation test and h.t. for two cold-cathode trigger tubes (Z803U), also a low-voltage current for continuity testing.

One Z803U is used as a timer for pulsing the selector mechanism and the other for sampling the current flowing in the cores under test. This current flows through a resistor and the volts dropped across it are applied to the trigger tube. If the insulation resistance is below a predetermined value (normally less than 2.5MΩ), the voltage across the source resistor will rise to a value sufficient to trip the sampler trigger tube which then energizes a relay and stops the selector mechanism. The identification letter of the faulty core which brought the testing sequence to rest is illuminated and can be seen through one of the inspection windows.

On successfully completing a test sequence the mechanism stops and an indicator lamp, which was illuminated when the testing commenced, is extinguished. Re-starting the test sequence is effected by a third press-button switch.

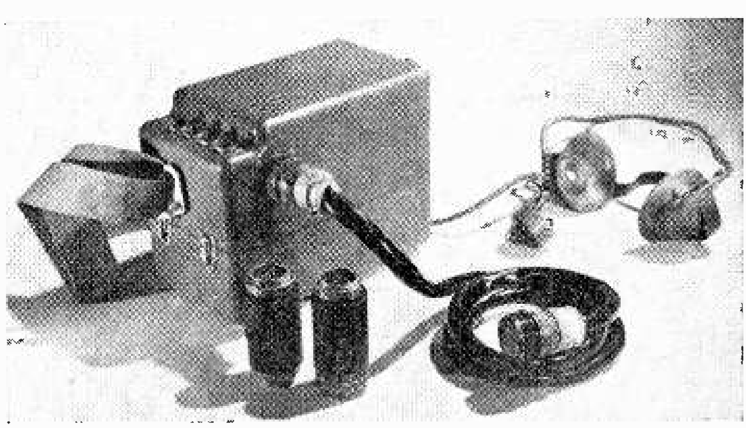
Continuity testing is carried out in a similar way except that the *absence* of current through the source resistor is made to trip the trigger tube.

Two transistor speech amplifiers are incorporated and used to provide two-way telephone communication between the ends of the cable, a useful facility when testing very long cables.

In portable form operating power is provided by a 24-volt unspillable accumulator housed in a container clipped on to the base of the main unit. This gives 16 hours of operation on a single charge. At fixed sites where a.c. is available the battery unit can be replaced by a mains unit of the same size.

A test sequence covers 25 conductors but a larger number can be handled by means of special adaptors.

The equipment measures 11in × 6in × 8½in, weighs 19 lb and is made by de Havilland Propellers Ltd., Hatfield, Herts.



*Automatic multi-wire cable tester (de Havilland).*



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# LEARNING MACHINES

## NEW ERA OF CONTROL SYSTEMS FORESHADOWED AT N.P.L. SYMPOSIUM

IN certain aspects the symposium held recently at the National Physical Laboratory on "The Mechanization of Thought Processes" had links with the Electronic Computer Exhibition (reviewed on page 17 of this issue). But broadly speaking the machines which formed the real centre of interest at Teddington were totally different from those on show at Olympia. The electronic computer is capable of doing arithmetic at incredibly high speeds, but it is a passive slave whose actions have to be determined in advance by a human programmer. The jargon word for it, borrowed from philosophy, is "deterministic." By contrast, the machines described at Teddington were capable of solving problems which the designers themselves could not solve. As distinct from the "deterministic" computers they worked on "probabilistic" principles, rather as human beings do when making intelligent guesses.

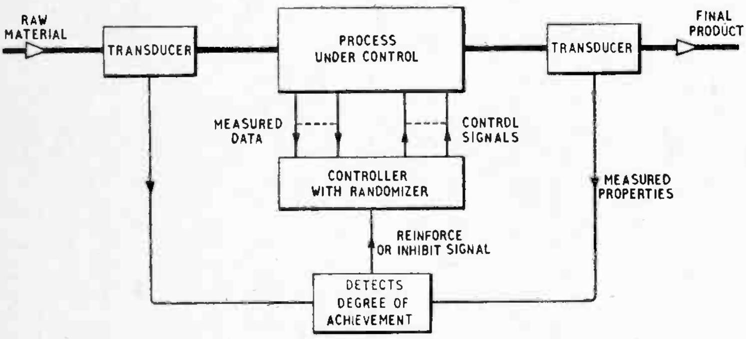
The main practical interest in these "intelligent" machines is the possibilities they seem to offer of new and advanced forms of process control in industry, as well as automatic piloting in aircraft and so on. In particular, the ones known as "learning machines" have the advantage over existing control systems of being able to profit from past experience by a trial-and-error method of working. As a result they should be capable of controlling industrial or other processes which do not lend themselves to precise mathematical analysis.

In essence the mode of operation of the learning machine is to tentatively try various patterns of control action in a random fashion and to reinforce those which give satisfactory results and inhibit those which give unsatisfactory results.

An outline illustration of how this would work in practice was given at the symposium by A. M. Andrew in his paper "Learning Machines." The block diagram shows the essentials of a continuous-process industrial control system with raw materials flowing in on the left and the final product emerging on the right. Variables such as temperatures, pressures and flow-rates are regularly monitored and the information is used by the "controller" to make suitable corrections to the process. The transducer on the right measures to what extent the final product has the desired properties (which might be, say, quality or quantity).

So far this is quite conventional, but the "controller" also contains a "randomizer," the purpose of which is to try different methods of interpreting the measured information. More precisely it varies the values of the mathematical functions by which the controlling signals are related to the monitoring signals.

When the final product tends towards the desired properties as a result of a fortuitous trial by the "randomizer," the transducer on the right causes a signal to be sent to the "controller" which reinforces the control action leading to this result. If the product tends in the other direction because of an unlucky random trial, an inhibiting signal is sent to reduce the control action giving rise to the unwanted tendency. This "approval" or "disapproval," as it were, of the randomly selected control patterns may also be made partly a function of the raw material properties, as indicated by the transducer on the left.




*Block diagram of an industrial process controlled by a learning machine*

Thus the learning system adjusts itself, not, as in a conventional control system, by using predetermined functions of the physical variables, but by using any convenient functions which lead to optimum conditions in the final product.

The terms "reinforce" and "inhibit" used in the foregoing are just convenient words to describe the processes concerned. Dr. Andrew suggests several different methods of instrumenting them in his paper. Some are based on the conditional probability computer described briefly in our September, 1958, issue (p.439). The method here is to discover on a statistical basis what patterns of control action (applied to some of the computer inputs) are associated with goal-achievement signals from the final-product transducer (applied to another input). This type of computer, however, works on a two-state "yes-no" principle and is not really suitable for continuously varying quantities.

A more straightforward method of association, which Dr. Andrew is hoping to use in practice, is based on correlation computing*. Here the idea is to making running correlations between the degree of goal-achievement in the final product and the values of the random mathematical functions tenta-

* See "Recovering Hidden Signals" by James Franklin, in *Wireless World*, March 1955 issue, for background to this technique.



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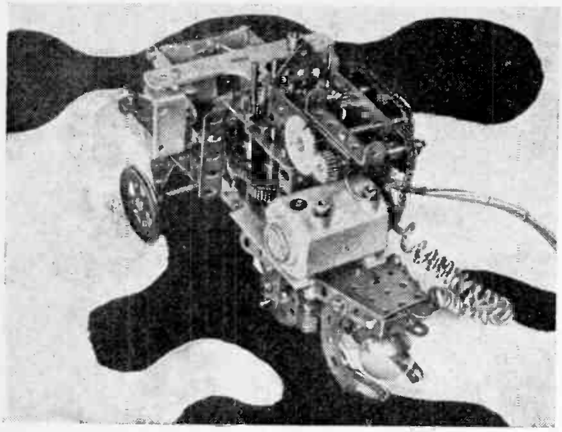

*An "intelligent" mechanical tortoise following a boundary by means of a learning machine (connected to the wires leading off to the right)*

tively tried out in the "controller" of the block diagram. If there is a positive correlation between the variation of one of these values and the variation in the final goal-achievement then the learning system increases the value concerned (i.e. reinforcement). Conversely if there is negative correlation the learning machine decreases the value (inhibition).

As was mentioned in the September, 1958, issue the conditional probability computer has been demonstrated, purely for illustrative purposes, as the "brain" of a mechanical tortoise which follows a complicated boundary between black and white areas (see picture). Here the learning system forms associations between the "black" or "white" signals the tortoise picks up from its photo-electric receptors and the corresponding signals indicating the "right" or "left" movements which it makes to regain the boundary. As in the industrial process control system, the correct associations are formed by applying reinforcing or inhibiting signals to the control patterns according to the degree of goal-achievement (in this case, regaining the boundary). Thus the tortoise can learn different patterns of association between its sensory perceptions and its motor activity. As a result it can cope with situations such as reversal of the positions of the black and white areas or reversal of the steering linkage.

Similar flexibility of action is achieved by this type of learning machine in another sphere of "intelligent" automation—the recognition of patterns. This will have practical application in devices for translating, say, hand-written characters into speech or print, speech into typescript, or similar visual or acoustic stimuli into mechanical activity. The great problem in pattern recognition is to be able to imitate the human faculty of recognizing patterns even if badly distorted or placed in unfamiliar positions or circumstances. Most people can recognize ∀ in a normal line of type as being an A upside-down, but a character-recognizing machine working on purely "deterministic" principles† would, with all due respect, be completely lost. Not so a "learning" character recognizer of the kind now being developed by W. K. Taylor‡ at University College, London. Here the general principle is that the machine learns to classify various distorted or unfamiliar versions of the patterns with the normal forms, so that on the occasions when a distorted or unfamiliar version is presented to the recognizer it still gives the correct output signal.

The machine uses a matrix of photomultipliers as an "eye" to analyze the pattern presented into small black and white areas. The learning mechanism itself, based on a study of the octopus, consists of 30 electronic units which are really analogues of nerve cells. These are connected together to permit an action corresponding to the "facilitation of synapses" which is thought to be a possible basis for learning in animals and humans. It simply means that certain junctions between nerve cells have their ability to transmit nerve impulses increased by the process of learning, and the pattern of these "facilitated" transmission paths is a stored representation of what is learned—a memory.

Such a learning machine as this is already too cumbersome for practical character recognition—not to mention the new version with 4,000 model nerve cells which Dr. Taylor is now building. But once a pattern of transmission paths has been learned for a particular character-recognizing application, this can be built into a much simpler machine as a permanent and static "memory."

A small machine of this kind, which can be considered as a "frozen" version of the learning machine, with no powers of self-improvement, was described by Dr. Taylor in his paper "Automatic Control by Visual Signals." Instead of the photomultiplier "eye" it uses a television-type scanning system, but it does not, like certain other character recognizers, analyze the picture elements on a two-state basis which says that each one is either "black" or "white." It preserves the analogue nature of the picture elements, containing as they do varying proportions of black and white, right up to the final stages of the recognition process. This is claimed to give improved results because the output signal produced by a distorted character is only reduced in approximate proportion to the amount of distortion and still remains active unless the pattern has a new significance or reaches 100% distortion.

Incidentally, those purists who object to anthropomorphic terms being applied to mechanical devices would have been highly shocked at this symposium. Words like "thinking," "learning," "intelligence," "memory," "recognition" were bandied about quite freely by scientists who (some might think) ought to have known better. It was probably Dr. A. M. Uttley (Superintendent of the Control Mechanisms and Electronics Division of the N.P.L.) who set the tone of the occasion. He remarked right at the beginning that if we allow such terms as "flying" applied to aeroplanes there was no reason to object to "thinking" applied to certain other machines. Somebody else by way of support, whispered "calculating"—no doubt remembering the electronic computing machines at Olympia.

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**"Data Processing"** is the self-explanatory title of a new non-technical quarterly for management and executives being issued by our publishers. In the first issue, to be published in January, the emphasis is on electronic computers. A year's subscription (4 issues) is £4.

† "Reading by Electronics," *Wireless World*, April 1957 issue.
‡ See "The Nuffield Foundation Thirteenth Report," Oxford University Press (1958), page 2.



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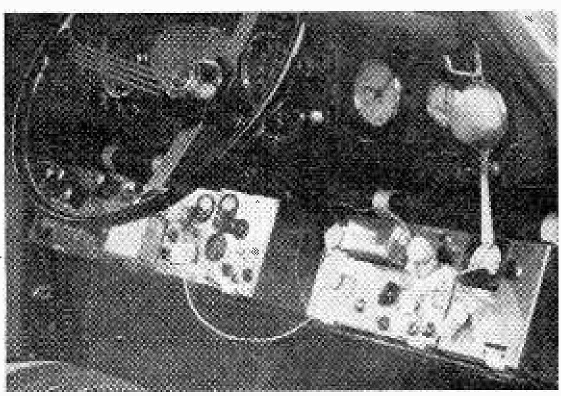
# Radio Hobbies Exhibition

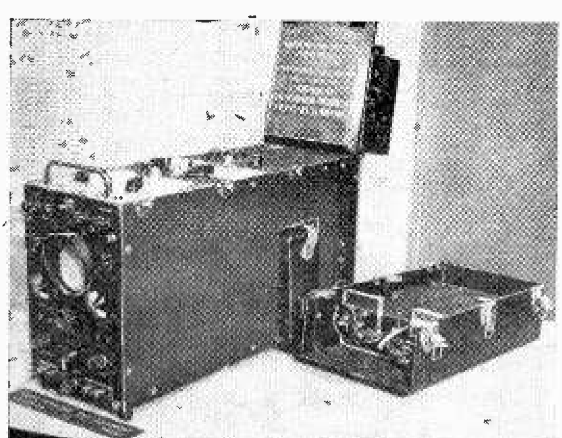
## Wide Field Covered by Amateur and Commercial Exhibits

THE R.S.G.B. stands held some examples of equipment showing an exceptionally high degree of craftsmanship. The winner of the Silver Plaque Award for the most outstanding piece of amateur-built equipment in the show was K. R. Clarke (G3KRC); for a set of unit-constructed test equipment comprising: $2\frac{1}{2}$ in. c.r.o. with pushpull $x$ and $y$ amplifiers and a crystal calibrator, sine-wave oscillator (3c/s to 300kc/s), a.m./f.m. signal generator with crystal check, valve voltmeter, r.c. bridge, 22-range multi-meter, and power supplies for the individual units, all dovetailed together to occupy a volume only 13in × 7in × 20in.

The item which caught our eye in the Mobile Group's display was C. H. L. Edwards's (G8TL) multi-band equipment. This is made up of beautifully-engineered units, the 160m to 10m transmitter and receiver being fitted with plug-in pre-aligned coil boxes for each band. The transmitter uses a Tesla oscillator (this resembles a Colpitt's with the feedback taken from a capacitive potentiometer in one leg of the capacitive network across the coil) which gives good frequency stability: the power unit utilizes separate motor-generators for receiver and transmitter and it includes an a.c. power pack.



*C. H. L. Edwards's mobile equipment in position in his car. (Since this photograph was taken the microphone has been fitted to a floor stand so that it can be swung out of the way when not in use.)*



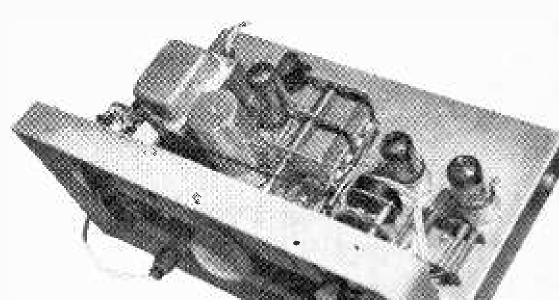
*Silver Plaque Award winning entry—K. R. Clarke's unit-constructed test equipment. R.C. bridge is at rear and plaque conceals valve voltmeter.*

The V.H.F./U.H.F. Group caters for amateurs with interests mainly in the allocations above 30Mc/s. Two items noticed here were H. F. Smith's (G2DD) neat and small transmitter/receiver with plug-in "front-end" and transmitter sections and a 3-cm test bench (D. Hayter, G3JHM). The receiver section of G2DD's gear is a triple superhet, the i.f.s being 28-32Mc/s (tunable), 7.3Mc/s and 465kc/s, and it includes a noise limiter.

The Armed Services were represented—the Royal Navy by the Royal Naval Reserve, the Army by two Royal Signals Regiments (one regular, the other T.A.) and a club station, and the R.A.F. by the Royal Air Force Amateur Radio Society. An attraction to potential recruits to the R.N.R. is the fact that a modified CR100 receiver fitted with a small (5-W) transmitter is loaned to ratings who qualify as an "Operator 2nd Class" so that training may be carried out at home.

On the R.A.F.A.R.S. stand was a self-contained s.s.b. exciter built by J. B. Smith (G3HSR) for the headquarters station, G8FC. This exciter uses the outphasing method of modulation and the output stage (829B double tetrode) can provide up to 100-W output with an external power supply (25W with internal power supply). G3IRS (like G8FC, from R.A.F. Locking) was operating on two metres at the exhibition as G3IRS/A. With a 150-W output, this station, near Weston-super-Mare, works a regular schedule with PE1PL (Holland)—350 miles away.

The field of television was represented by the British Amateur Television Club and Bush Radio, Ltd. The B.A.T.C. were producing some excellent pictures with a camera made by J. Jull (G3MHZ). This is fitted with a lens turret and uses a 1-in



*Jason a.f. oscillator. Twin gang capacitor forms tuning element in Wien-bridge circuit.*



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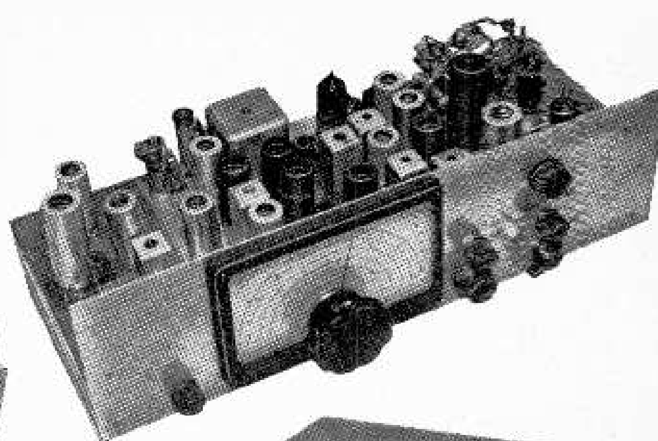
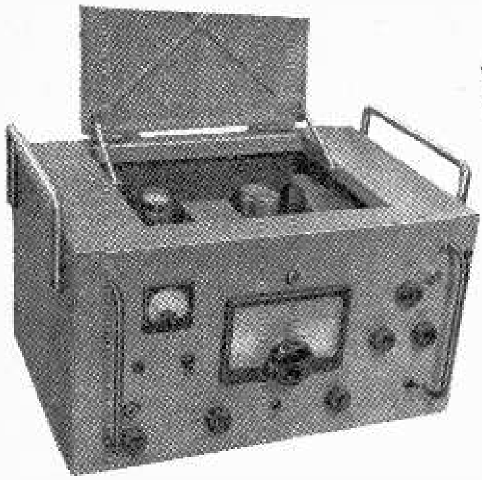
*Right: H. F. Smith's small transmitter/receiver. Left-hand chassis (slightly darker) is receiver "front-end"; right-hand unit (to right of Belling-Lee socket) is transmitter.*





*S.S.B. exciter built for G8FC (R.A.F.A.R.S.) by J. B. Smith. 9Mc/s crystal oscillator beats with v.f.o. to cover amateur bands.*

*DX100 (Heathkit) 15-valve 100-W transmitter for amateur bands. The Modulator uses a pair of KT88s in the a.f. output stage.*

Staticon tube: the camera timebases are used also for the "electronic viewfinder"—an MW13/35 tube mounted on the camera. Several improvements have been made in the Bush receivers, one being "balanced-waveform" dynamic convergence. Previously convergence adjustments were difficult because altering the convergence waveform changed its mean level and this upset static convergence. The balanced-waveform principle utilizes a waveform which is held symmetrical about a mean level: an alteration occurring in the current waveform does not change this level so that the mean current through the deflector coils, and thus the static convergence, is not affected.

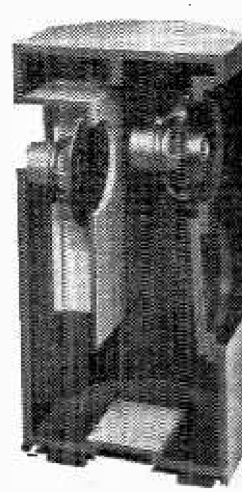
Those who prefer to make up equipment from a kit of parts were given a wide choice at the exhibition. Jason were showing several new instrument kits including a valve voltmeter, an f.m. "wobbulator" and an a.f. oscillator. The a.f. oscillator is a capacitance-tuned Wien bridge with a cathode-follower output and a squarer (cathode-coupled flip-flop). This, like most of the Jason equipment, is housed in a very neat grey-green case having a surround which projects far enough to protect the front panel and controls.

On the Heathkits stand (Daystrom, Ltd.), equipment shown included a 2×8-W stereo amplifier, a loudspeaker enclosure and two transmitters. One of these, the DX100, gives a nominal 100-W output on telephony in the 160m to 10m amateur bands. A Clapp v.f.o. is used with provision for crystal operation and a s.s.b. adapter: band selection is accomplished by a single knob.

On the Stentorian stand a 300-mW transistor amplifier was producing an impressive volume. This is designed to cover the range 100-7,000c/s and it uses a pushpull OC72s to feed directly a 30-Ω loudspeaker. The audio input required for full output is about 0.3V and the amplifier is available either as a "wired" printed-circuit board requiring only the fitting of the four transistors or as the board alone. Another kit which would be suitable for the beginner is the Cossor 701K f.m. receiver. This, complete with a 10in×6in loudspeaker, costs £15 15s and takes about 10 hours to assemble. A spare piece of printed-circuit board is included for the constructor to practice soldering.

## G.E.C. "Octagonal Periphonic"

*Introduced at the Northern Audio Fair by the G.E.C., the "Octagonal Periphonic" loudspeaker system illustrated here has had its cabinet vertically cut in half to show the loudspeaker positions and interior construction. A rectangular pipe, together with the port at the back near the top of the pipe and cabinet, provide an air load at low frequencies for the speakers. As in the original "Periphonic" system, a considerable reduction in second harmonic distortion at low frequencies is obtained by mounting the two speakers front to back and, in addition, connecting them out of phase.*





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# WORLD OF WIRELESS

## *TV in Orkneys*

TEMPORARY transmitters having been installed at the sites of the two proposed B.B.C. television stations in N.E. Scotland, the stations are being brought into service before Christmas. The Caithness station at Thrumster, near Wick, came into service in Channel 1 on December 15th. The Orkney station at Netherbutton was scheduled to open a week later in Channel 5. Both transmissions are vertically polarized.

The Thrumster station will receive its programmes by radio from the Meldrum station. The programme for the Orkneys transmitter will eventually be picked up direct from the Thrumster station, but while this transmitter is operating on low-power it has been necessary to set up a microwave relay station to convey the programme from Thrumster to the Orkneys.

The temporary stations will serve Kirkwall and Wick and their immediate surroundings, but the permanent transmitters, due for completion by next autumn, will serve almost the whole 43,000 population of the Orkney Islands and Caithness.

A temporary v.h.f. sound transmitter operating on 93.7 Mc/s has also been installed at the Netherbutton site.

## *Physical Society Exhibition*

AS already announced, the Physical Society's forty-third exhibition of scientific instruments and apparatus opens at the Royal Horticultural Society's Halls, Westminster, on January 19th for four days. Tickets are obtainable free from exhibitors or the Society.

*ANGELA FIRMAN who, at 18, recently obtained the P.M.G.'s first class certificate in radiotelegraphy after studying at the North Eastern School of Wireless Telegraphy, Bridlington, may now serve as a marine radio officer. Although she is the only woman in the U.K. to hold a valid first class certificate she is not the first to do so; Mrs. G. M. Bond (née Vale) obtained one in 1948 from the Colwyn Bay Wireless College.*

A large number of universities, hospital physics departments and research organizations are participating in the Exhibition in addition to the manufacturers listed in our last issue. Incidentally, it is regretted that two manufacturers in our field were omitted from the list: Advance Components and Decca Radar. By invitation of the Society, a collection of instruments from Swedish universities and research organizations is being shown.

Readers unable to visit the show may like to obtain the Exhibition Handbook, which is a valuable book of reference on scientific instruments and is available from the Society (1, Lowther Gardens, London, S.W.7) at 6s (postage 1s 8d).

## *Student Exchange*

THE eleventh annual report of the International Association for the Exchange of Students for Technical Experience records that 5,394 students were exchanged between 24 member countries during the summer vacation last year. This brings the total since the scheme was introduced to nearly 40,000.

Germany heads the list of countries, having sent 998 students abroad last year and received 1,023 from other countries. From the U.K. 774 students went abroad and we received 829.

Although in the report radio and electronic engineering is covered under the heading electrical engineering, it is obvious from the list of companies accepting students both in this country and abroad, that many of the 855 "electricals" (which was the second highest category in the table of "Academic Spheres of Influence") are taking light-current engineering.

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**Welsh V.H.F.**—The opening of two new stations at Llanddona, Anglesey, and Llangollen, Denbigh., on December 20th brings the coverage of the B.B.C. v.h.f. sound service to approximately 92% of the population of Wales. Llanddona, replacing the temporary v.h.f. transmitter at Penmon, radiates on 89.6, 91.8 and 94 Mc/s, with an e.r.p. of 2kW. Llangollen's carriers are 88.9, 91.1 and 93.3 Mc/s and its e.r.p. 6kW. The B.B.C. now has 17 permanent v.h.f. sound broadcasting stations in use, all of which use vertical polarization.

**Space Research.**—The International Council of Scientific Unions has set up a Committee on Space Research (COSPAR). Seven countries, including the U.S.S.R., and the U.S.A., and a number of international bodies were represented at its first meeting in London in November, at which Professor H. S. W. Massey, of University College, London, was elected to the executive committee.

**A.T.E.C.**—A council, to be known as the Air Transport Electronics Council, has been formed with representatives from the E.E.A., the Society of British Aircraft Constructors, B.O.A.C., B.E.A., and British Independent Air Transport Association. Its aim is the "standardization of civil aircraft radio equipment and systems installations and to promote development of systems for future air operating requirements." J. S. Simpson, of International Aeradio, has been appointed secretary of the Council, which has offices at 37, Park Street, London, W.1 (Tel.: Hyde Park 5024).



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**Marine Radio Telephony.**—The third station providing a v.h.f. radio-telephone link between U.K. subscribers and ships comes into service in January. It will operate from the Niton, Isle of Wight, station and will cover ships within a radius of about 50 miles from St. Catherine's Point. The frequencies to be employed are 156.8Mc/s (calling) and a two-frequency traffic channel using 161.85Mc/s for transmission and 157.25Mc/s for reception. Similar facilities are already provided in the Firth of Clyde and from North Foreland and further services are planned for the areas covered by the stations at Lands End and Mablethorpe (Humber).

**Mullard Amateur Award.**—A yearly award of equipment or books to the value of £25 is being presented by Mullard to the U.K. member of the R.S.G.B. who has "through the medium of amateur radio during the preceding calendar year rendered outstanding personal service to the community by his own endeavours or by his own example of fortitude and courage." Nominations for the award, to be presented in April, must be submitted by three members of the society in January.

**R.S.G.B. Report** for the year ended last June, presented at the annual meeting on December 12th, records for the second successive year an increase in membership. The increase was 600, giving a total membership of 9,095. At the end of last June there were 8,190 amateur sound licences in force in the U.K. and the holders of 5,898 were members of the society.

**R.A.F. Signals.**—The status of No. 90 Signals Group has been raised to Command level and will in future be known as Signals Command with its headquarters at Medmenham, Bucks. The present Air Officer Commanding, A.V-M. L. Dalton-Morris, is continuing in command of the formation.

**Twenty-first Annual Dinner** of the Royal Flying Corps Wireless Operators Old Comrades Association will be held in London on March 14th. Details are obtainable from E. J. F. C. Hogg, 57, Hendham Road, London, S.W.17.

**I.T.A. in the North East.**—Full-power test signals have been radiated from the Burnhope, Co. Durham, station of I.T.A. since the beginning of December in preparation of the start of programme transmissions on January 15th. The transmitter, operating in Channel 8, has an e.r.p. of 100 kW to the N.E. and S.E., 70 kW to the East and 20 kW towards the West.

**Receiving Licences.**—New combined television and sound licences issued in the U.K. in October numbered 147,979 bringing the total to 8,571,491. Sound-only licences are now down to 6,159,192 (including 360,286 for car radio), giving an overall total of 14,730,683.

**Indian Receiving Licences.**—Changes in the administration of broadcast receiving licences were introduced in India at the beginning of November. A licence is needed for each set in a household and it is now necessary to present a licence in order to buy a set. The counterfoil of the licence is retained by the dealer. A licence is now transferable with a set.

**London U.H.F. Group.**—The annual dinner of the Group will be held at the Bedford Corner Hotel, Tottenham Court Road, W.1, on Saturday, January 31st.

**TV Photographic Competition.**—*Amateur Photographer* is organizing a competition for end-of-tube television photographs. Half-plate prints of six different subjects showing the full screen mask and made from 35mm negatives taken during December and January must be submitted. Details of the competition were given in the November 26th issue of *Amateur Photographer* and instructions for posting will be given in the February 4th issue of that journal.

**"Medium-Wave News"** is the title of a duplicated four-page news sheet prepared by a group of medium-wave DX enthusiasts. It is published by Bernard Brown, 196, Abbey Street, Derby, and costs 4s for the six monthly issues (November to April).

**Jodrell Bank.**—An appeal for £150,000 to meet the deficit on the cost of the radio telescope at Jodrell Bank, estimated at some £680,000, has been launched by Manchester University. The telescope forms part of the University's Jodrell Bank Experimental Station, of which Professor A. C. B. Lovell (Professor of Radio Astronomy at the University) is director.

**Medical Electronics Group** has been formed within the Brit.I.R.E. with W. J. Perkins as chairman. The first of the five meetings to be held during the present session will be on January 23rd, at which Dr. A. V. Hill, C.H., F.R.S., Emeritus Professor of Physiology at University College, will be the speaker.

**Brit.I.R.E. Council.**—As already announced, Professor E. E. Zepler is the new president of the Brit.I.R.E. Newly elected vice-presidents are A.V-M. C. P. Brown and Col. G. W. Raby. Other new members of the Council are A. A. Dyson, H. F. Schwarz, Professor D. G. Tucker, Dr. T. B. Tomlinson and Major P. A. Worsnop.

**Paris Components Show.**—The dates of the Paris Components Show, announced in our last issue, have been changed from March to February 20th to 24th.

**E.I.B.A.**—Donations from a number of radio and electronics firms are acknowledged in the report and accounts of the Electrical Industries Benevolent Association for 1957 just published. The Radio Industry Council gave £500; the Radio Industries Club (London) £420; and the B.B.C. £105. The income of the Association, which was formed in 1908 to assist directly or indirectly any deserving or necessitous persons (excluding manual workers) in the electrical industry, increased by nearly £10,000 compared with the previous year.

**New Radio College.**—Opened in the spring of 1958 as a training college for Merchant Navy radio officers, R.M.S. *Wray Castle* at Ambleside, Westmorland, has been given recognition by the Post Office for the training of candidates for the P.M.G.'s certificate. The principals are R. S. Tomlinson and A. W. Wood, who are also principals of the College of International Marine Radiotelegraphic Communication, Manchester, and the chief instructor is F. M. Webber. The marine radio equipment for the college was supplied by Siemens Edison Swan.

**Presentation of Technical Information.**—Among the advanced courses in electrical and mechanical engineering outlined in the syllabus for the 1958/59 session issued by the Manchester and District Advisory Council for Further Education is one of eight lectures on the presentation of technical information. It will be given at the Manchester College of Science and Technology on Tuesday and Wednesday evenings from February 17th.

**Audio Lectures.**—A course of 12 lectures on sound recording and reproduction begins at the Southall Technical College, Middlesex, on Monday, January 12th at 7.0 (fee £1).

**Control Engineering.**—A course of 10 evening lectures on linear and non-linear servo-controlled systems will be given on Wednesdays from January 21st at the South East London Technical College, Lewisham, S.E.4 (fee £1).

**Industrial Electronics.**—A six-months' full-time course in industrial electronics for mechanical engineers begins at the South East London Technical College on January 5th (fee £17).

**I.G.Y. Juvenile Lectures.**—The opening lecture in the series of six on the International Geophysical Year being given during the Christmas holiday at the Royal Institution will be on the ionosphere and the I.G.Y. It will be presented by J. A. Ratcliffe, F.R.S., of Cavendish Laboratory, on December 30th. The third lecture, on the exploration of the upper atmosphere, will be given on January 3rd by Dr. R. L. F. Boyd, of University College.

**Radio Hobbies Exhibition.**—Nearly 10,000 people visited the Exhibition during its four-day run at the R.H.S. Hall, London, S.W.1.



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# Personalities

**G. G. Gouriet,** A.M.I.E.E., has left the B.B.C., where he has been head of the television group in the Research Department for some years, to become a director of Wayne Kerr Laboratories, Ltd. He joined the B.B.C. Engineering Division in 1937 and after five years in the Operations and Maintenance Department transferred to the Research Department. Initially he was concerned with transmission problems, including the study of modulation systems which led to the decision to adopt f.m. for the B.B.C. v.h.f. service, but since 1946 he has specialized in television research. Mr. Gouriet, who is 41, has undertaken considerable research and investigation into colour transmission systems and recently delivered a lecture on the subject to the Royal Institution. His interests, however, lie in the broader field of communications embracing information theory, measurement and control problems. He received one of the R.I.C.'s technical writing prizes in 1954 for his article on spectrum equalization in our sister journal *Wireless Engineer* (now *Electronic & Radio Engineer*).

*G. G. GOURIET.*

*W. J. BRAY.*

**W. J. Bray,** M.Sc.(Eng.), M.I.E.E., who, as announced last month, was recently appointed staff engineer in charge of the Inland Radio Branch of the Post Office Engineering Department, has been elected International Chairman of Study Group IX of the International Radio Consultative Committee (C.C.I.R.), in succession to **H. Stanesby,** who has resigned following a reorganization of work in the Engineering Department of the Post Office. This Study Group of the C.C.I.R. is concerned with standardization of line-of-sight and tropospheric-scatter radio-relay systems. The Post Office branch, of which Mr. Bray is now in charge, is responsible for the planning and provision of radio-relay systems and mobile radio systems, and for broadcasting and radio interference matters.

**Dr. T. S. Moss,** of the Radio Department of R.A.E., who has carried out much original experimental and theoretical work on the properties of semiconductors, and **P. R. Wallis,** B.Sc., A.M.I.E.E., of the Admiralty Signal and Radar Establishment, where he has been responsible for much of the development of radar techniques for guided weapons, have been promoted senior principal scientific officers in the Scientific Civil Service.

**D. J. Davis,** who since his demobilization in 1945 has been technical sales engineer with Avo, Ltd., has joined British Physical Laboratories as sales manager. He succeeds **D. G. Ashton Davies,** who has joined E.M.I. Electronics.

**C. L. Richards,** B.Sc., A.C.G.I., A.M.I.E.E., for the past nine years with E.M.I., where recently he has been associated with computer design, has joined Painton & Co., of Northampton, as chief engineer. Mr. Richards joined Philips in 1932, and after two years went to Eindhoven, Holland, where for five years he was in charge of the television receiver design laboratory. He returned to England in 1939 and for ten years was head of the Philips Television and Radio Set Development Laboratory in this country.

*C. L. RICHARDS.*

**E. V. D. Glazier,** Ph.D.(Eng.), B.Sc., A.M.I.E.E., Director of Scientific Research (Electronics and Guided Weapons) in the Ministry of Supply, since 1957, was recently promoted to the rank of deputy chief scientific officer in the Scientific Civil Service. Dr. Glazier, who was born in 1912, received his early training in electrical and mechanical engineering in industry, and joined the Post Office in 1933. For the ensuing nine years he was engaged on the development of telephone systems. In 1942 he was transferred to the Signals Research and Development Establishment. He became head of the Line Communication Group in 1946 and in 1950 he was put in charge of the Research Division at S.R.D.E., Christchurch. He is secretary of the Radar and Signals Board of the Minister's Advisory Council on Scientific Research and Technical Development.

**A. V. Olorenshaw,** B.Sc.(Eng.), who was until a few months ago sales manager of Wayne Kerr Laboratories Ltd., has become a director of Metrix Instruments Ltd., of Surbiton, Surrey, which was formed a few months ago to handle Continental instruments.

**S. C. Heward,** B.Eng., A.M.I.E.E., who has been with Marconi's since 1937 when he joined them as an installation engineer, is appointed manager of the Associated Companies Division. He will be responsible, within the export department, for technical liaison with the overseas associates of the company.

**G. T. Kelsey,** O.B.E., Marconi's London representative for the past 18 months, is appointed manager of the company's London office. For some years prior to joining Marconi's eight years ago as assistant to the manager of the radar division, he was with E.M.I. In recognition of his war-time services in the Radar Branch of the R.A.F., he was appointed an O.B.E.

*S. C. HEWARD.*

*G. T. KELSEY.*

**E. G. Parramore,** Plessey's representative in Amsterdam, has been honoured by Queen Juliana of the Netherlands with the Knighthood of the Order of Orange-Nassau in recognition of his distinguished services to the Netherlands aircraft industry. Before joining Plessey in 1956, he was for three years director of the Hunter Aircraft Construction Office in The Hague.

**J. E. Attew,** A.M.Brit.I.R.E., until recently with Peto Scott where he was engineer in charge of television transmission equipment, has joined the video division of Epsylon Industries as chief project engineer. He was recently appointed a member of the Brit.I.R.E. committee to organize the 1959 convention which will be devoted to techniques and applications of television.

**Gordon L. Ball,** B.E., Grad.I.E.E., has been appointed general sales manager of Wayne Kerr Laboratories in succession to A. V. Olorenshaw. Throughout the war he served in the Royal Canadian Signals Corps in which he held a commission as Captain. After the war he studied at McGill University where he obtained his Bachelor of Engineering degree. Since settling in this country in 1950 he has been sales manager of the components division of the Plessey Company.

## OUR AUTHORS

**Francis Oakes,** A.M.I.E.E., A.M.Brit.I.R.E., a frequent contributor to *Wireless World*, who with **D. V. Charlesworth** writes on stereo pickups in this issue, is engineer in charge of Ferguson's radio and transistor applications laboratories. He has been with Ferguson's for some years, prior to which he was assistant chief of the electronics laboratory of the Morgan Crucible Co. D. V. Charlesworth is senior development engineer in Ferguson's radio laboratory where for several years he has specialized in the design of audio equipment.

**C. Speight,** who writes on the Miller sweep circuit in this issue, is on the staff of the U.K. Atomic Energy Authority but the article is the result of research and development carried out privately. He is 20.

**P. R. Keller,** B.Sc., A.M.I.E.E., who with L. K. Wheeler writes in this issue on automatic error correction in telegraph systems, is in charge of the section formed by Marconi's in 1956 to develop error-correcting telegraph equipment. Soon after joining Marconi's in 1944 he was appointed to the design and development division for work on radar and marine communication equipment. From 1950 to 1956 he was chief of the Established Designs Section, V.H.F. Develoment Group, responsible for the planning and development of v.h.f. systems and the design of associated equipment.

*P. R. KELLER* *L. K. WHEELER*

**L. K. Wheeler,** B.Sc.(Eng.), A.M.I.E.E., co-author of "Automatic Error Correction," joined the Post Office Engineering Department in 1933 and has been at the Research Station since 1937 where he is now assistant staff engineer in charge of the Telegraph Section. He is a U.K. representative in two of the Study Groups of the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.).

## OBITUARY

**Stephen Butterworth,** O.B.E., who died recently at the age of 73, was an outstanding mathematician and one of the leading scientists in the Admiralty Research Laboratory, where he served from 1921 until retiring in 1945. The results of much of his work cannot be published and his contributions in the application of science to naval problems are, therefore, largely unknown. For his part in providing the answer to the German magnetic mine he received an award from the Royal Commission on Awards to Inventors. His work on electric filters is perpetuated by the association of his name with a particular type of response. Older readers of *Wireless World* will recall his work on coil design in the mid-1920s which contributed to the development of the famous "Everyman Four" receiver in 1926.

# News from the Industry

**Siemens Edison Swan** is being divided into three divisions: cables, telecommunications and radio and electronic components under a long-term reorganization scheme of the A.E.I. group, of which it is a member. The divisions will be controlled, respectively, by J. S. A. Bunting, W. G. Patterson, and J. W. Ridgeway, who will each hold appointments on the board of A.E.I. Divisional Management Co., Ltd. The telecommunications division which begins operation on January 1st will have F. G. Pheazey as chief engineer. The radio and electronics division will not come into operation until January, 1960.

**Racal Engineering,** of Bracknell, Berks., have formed an instrument division with its own development laboratories under N. Elson, chief engineer. It includes a special projects section which will "design, manufacture and install digital or non-digital instrumentation schemes." The sales manager of the new division is I. H. M. Campbell.

**G.E.C.** announce organizational changes covering the production and sale of valves and semiconductors. The responsibility for the sale of all non-domestic valves and cathode-ray tubes, as well as for the photocells, barretters, neon indicators, etc., which have hitherto been handled by the Valve and Electronics Department of the G.E.C., will be taken over by the M.O. Valve Co., Ltd. Domestic valves and tubes will continue to be sold direct to retailers by the G.E.C. Radio Division. The company's semiconductor business will in future be operated from the semiconductor factory at Hazel Grove, Stockport, Cheshire. G. A. Marriott, director of M.O. Valve Co., will direct overall sales policy for both the M.O. Valve Co. and the new Semiconductor Division. A. H. Howe has been appointed general manager of M.O. Valves. C. F. Machin, previously chief engineer in the semiconductor department at the G.E.C. Research Laboratories, is general manager at Hazel Grove, with B. R. Bettridge as commercial manager.



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**B.I.C.C.-Telcon Link.**—The B.I. Callender's Cables Group, which includes among its 15 or so members B.I. Callender's Construction Co., T.C.C., and United Insulator Co., has made an offer to acquire the Telegraph Construction and Maintenance Co., which has itself a number of subsidiaries including Magnetic and Electrical Alloys and Telcon Telecommunications. In association with Automatic Telephone and Electric Co., B.I.C.C. also controls British Telecommunications Research, Ltd.

**Solartron.**—The report of the Solartron group of companies for the year ended last June records that the year's trading profit is up by some 80 per cent on the previous year. Equipment to the value of £1.43M was sold during the year, twice the volume of two years ago. Exports accounted for over a third of the year's business.

**K.G. (Holdings), Ltd.**, of which Bonochord, Tellux, Perihel and W.S. Electronics are subsidiaries, made a record trading profit during last year. The profit before taxation was £189,226 compared with £145,901 the previous year.

**Radio and Television Trust, Ltd.**, of which Airmec is the only operating subsidiary, had a trading profit before taxation of £104,769 last year, compared with £77,464 in the preceding year. Radio and Television Trust is itself a subsidiary of Crompton Parkinson, Ltd.

**Millett Levens.**—With the purchase of a controlling interest in the Millett Levens Group, which includes Printed Circuits, Ltd., and Millett, Levens (Engravers), Ltd., of Borehamwood, Herts., the London Electric Wire Company and Smiths, Ltd., announce the appointment of the following directors: E. L. Wildy (chairman), L. Levens and P. Millett (joint managing directors), K. W. Marten and D. R. Cornwell.

**Marconi's** are supplying two 100-kW twin-channel transmitters employing evaporation cooling to the B.B.C. for installation in the Rampisham, Dorset, station which is used for the overseas service.

**E.M.I. Electronics** are supplying nine Vidicon camera channels (Type 201) to the B.B.C. for use in interview studios. The camera, which employs printed circuits, is considerably lighter than its predecessors.

**B & K Laboratories, Ltd.**, announce the formation of a new company, B & K Electronic Services, Ltd., at Union Street, London, S.E.1, which will carry out the re-alignment and calibration of instruments, particularly to American factory specification, on a contract basis.

**Change of Name.**—Newmarket Transistor Co., Ltd., announce that the name of the company has been changed to Newmarket Transistors, Ltd.

**B.T.H. and Metrovick.**—The London district office of B.T.H. is no longer at Crown House, Aldwych, but at 33, Grosvenor Place, S.W.1 (Tel.: Belgravia 7011), the new headquarters of Associated Electrical Industries. Similarly, the London office of Metropolitan-Vickers has been transferred from St. Paul's Churchyard to the same address.

**Metrix Instruments, Ltd.**, which commenced trading in February, has transferred its offices to 54, Victoria Road, Surbiton, Surrey (Tel.: Elmbridge 2776). In addition to handling equipment manufactured by Metrix, of France, the company are the sole U.K. agents for Metrawatt A.G., Nuremberg; Lemouzy, Paris; and Rochar, France.

**Beam-Echo, Limited,** makers of Avantic sound reproducing equipment, who are now in the Thorn Electrical Industries Group, have moved their factory to Essex Works, Essex Place, Newhaven, Sussex. Their offices are now at 13 South Molton Street, London, W.1 (Tel.: Mayfair 1039).

**Shockley Transistor Corp.** has been formed as a subsidiary of Beckman Instruments Inc. Since 1956 Dr. William Shockley has been directing the company's Shockley Semiconductor Laboratory at Palo Alto, Cal., from which the new corporation has grown.

**A communal aerial system** has been installed for the occupants of the 221 flats in 15 adjacent blocks erected by the Dover (Kent) Corporation. It provides outlets for Bands I, II, and III in each flat. The carrier of the local channel 2 transmitter is converted to channel 1 for distribution (to obviate spurious pickup on receiver wiring) and channel 9 is converted to channel 5 to minimize cable losses. The system was installed by B.A.A. Smye-Rumsby, of Dover and Folkestone.

**Pye Telecommunications, Ltd.**, have developed new ground equipment for I.L.S. (Instrument Landing System) and this was used at the recent demonstration of "no hands" landing reported on p. 579 of last December's issue.

**Marconi Instruments, Ltd.**, are staging an exhibition of their telecommunication measurement equipment at the Waldorf Hotel, Aldwych, London, W.C.2, from January 19th to 24th. Tickets can be obtained from their London Office, Marconi House, Strand, W.C.2. (Tel.: Covent Garden 1234.)

**McMurdo Instrument Company** have received Inter-Service Quality Approval for their "Red Range" connectors and for their 9-, 18-, 26- and 34-way "Micronectors."

**Tape Recorders (Electronics), Ltd.**, of Tottenham, London, N.17, have been appointed sole distributors for the U.K. for Sonocolor magnetic recording tape which is made on the Continent.

## OVERSEAS TRADE

**Exports** of British radio equipment of all kinds reached their highest monthly level in October. The provisional figure of just under £4.2M brings the total for the first ten months of the year to £36.75M. The month's exports of capital goods were to the value of over £1.5M. The October exports of valves (£536,000) were a record.

**Test equipment** to be used in the maintenance of radio-telephones employed by the police, fire, ambulance and other services has been ordered from Marconi Instruments by the Telecommunications Administration of Malaya. The order includes thirty v.h.f. signal generators, and the same number of transmitter and receiver output test sets.

**Bulgaria's** new television station to serve the capital and its environs will have studio, film scanning and transmission equipment supplied by Pye. They are also supplying a mobile unit for the station, which is planned to be brought into service early in 1959.

**Industrial television** equipment similar to that being supplied for the nuclear power station under construction at Bradwell, Essex, has been ordered from Pye for the first Italian nuclear power station at Latina.

**Oryx** miniature soldering irons are now being distributed in Canada exclusively by Len Finkler & Co., 1794, Avenue Road, Toronto, 12, Ontario.

**France.**—Equipments Industriels, of 1 rue Monticelli, Paris, 14, are interested in representing United Kingdom manufacturers of scientific instruments for industrial control, analysis and research.

**Sweden.**—A. B. Teleinvest, of Rosenlundsgatan 8, Gothenburg, wish to represent U.K. manufacturers of miniature components for guided missiles and also printed circuits.



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# ELECTRONIC COMPUTER EXHIBITION

## New Developments in Digital Circuitry and Input/Output Equipment

THE recent Electronic Computer Exhibition held at Olympia marks the end of the first decade of computer development in Great Britain. In these ten years the digital computer has emerged from the chrysalis of university and Government laboratories to become a fully developed and engineered commercial product. There are now over a hundred working installations in this country. Of these the greater proportion consists of "scientific" computers, for the era of business data processing is only just getting under way (with the notable exception of Lyons Electronic Office, operating successfully since 1953).

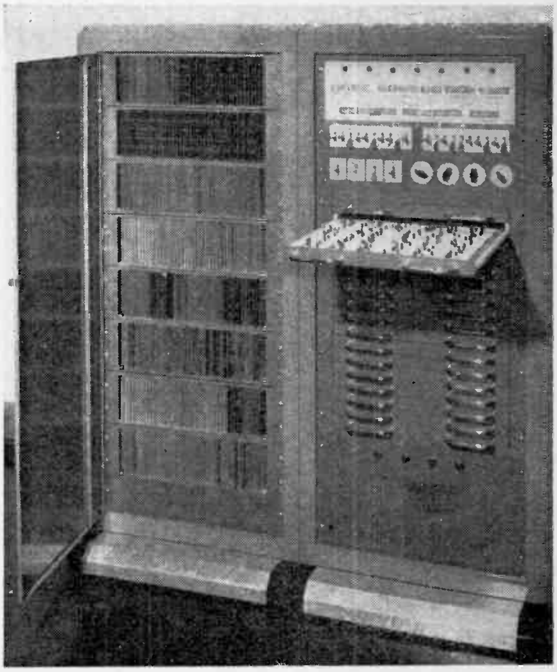
From the electronic engineering point of view it is, of course, the thermionic-valve computer which has now reached the state of a reliable commercial product. A great deal of money has been spent on research and, although everybody knows that transistors are the ideal components for digital computer circuitry, it is likely that the valve machine—for which regular production lines have now been set up —will continue to dominate the market for a good many years to come. This situation may eventually be modified now that several transistor computers have been developed and put on view at the Exhibition. But, even so, the valve computer will have the advantage of lower price for some considerable time.

There is probably no need to remind readers of this journal of the advantages of the transistor for use in the large masses required for digital computers. Being small, it makes possible machines of greatly reduced size. Requiring no heater, it reduces the problem of cooling, avoids the danger of heat affecting other components, simplifies the power supplies, and generally allows the components to be packed tighter together. As for reliability, this is a slightly unknown factor, but it is likely that the transistor will prove at least as reliable as the valve and probably longer-lived.

The main limitation of the transistor so far has been its slow speed of response compared with the valve. In the past this has restricted its operation to pulse repetition frequencies up to about 100kc/s, whereas a good many valve computers work at p.r.fs of several megacycles. Some of the latest transistor machines to be developed are using high-frequency alloyed-junction transistors of the OC44 and 45 types, and these are now making possible pulse rates in the range of 100kc/s-1 Mc/s. When surface-barrier, micro-alloy and other advanced high-frequency types find their way into the computing field the pulse rates will rival those of valve computers and probably exceed them. Indeed, once the problem of obtaining high speed of response is solved (as it will be) the transistor will show a distinct advantage over the valve, because of its inherently low input and output impedances, which will reduce the effects of circuit capacitance on fast pulse rise times.

For some applications where high-speed computing is not required the present available l.f. transistors are quite adequate. An example of this occurs in the exciting new sphere of process control by computers, which manufacturers of data processing equipment and control gear are just beginning to explore jointly. The idea is that the computer is incorporated directly into the control system, taking its input in turn from various measuring transducers distributed about the industrial plant (via analogue/digital converters) and giving outputs which are used to actuate servo-mechanisms for controlling the plant.

Two machines intended for this type of work were shown at the Exhibition. One, made by Ferranti, is being currently investigated as a possible means for the control of boilers during start-up and shut-down operations. A National-Elliott machine is to be used in a data processing and information system for application to a nuclear



*Ferranti process control computer with plug-in printed-circuit cards on the left and control panel and programme trays on the right.*



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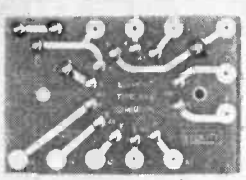
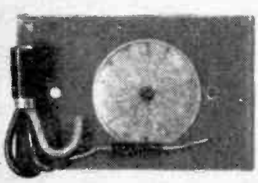
reactor of the U.K.A.E.A. Both are stored-programmed computers and are quite small, as can be seen from the illustrations. The significant point is, though, that the sampling of measurement points in the industrial control system is not done so rapidly that the computing has to be performed in a continuous high-speed stream. In fact, there are pauses between each burst of computing which could possibly be used for other work. As a result the machines have been designed to work in the serial mode (pulses representing binary digits by their relative positions in time), and it is not necessary for the pulse rate, which determines the speed of computing in the serial mode, to be unduly high. Thus, although these machines are operating in what is known as "real time," the "real time" is, in fact, rather slow.

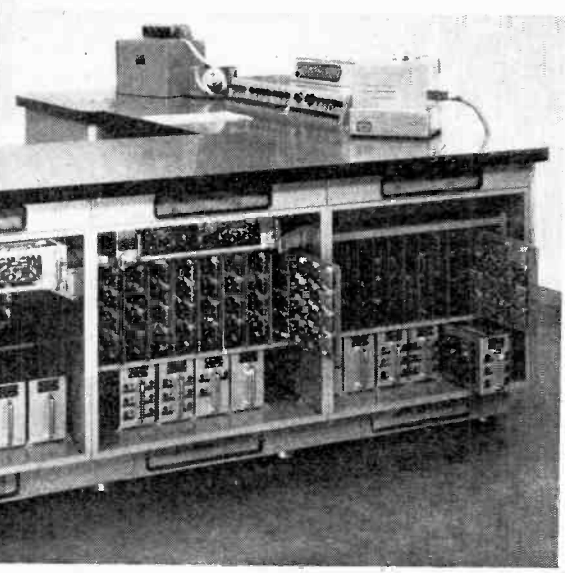
The Ferranti computer actually has a p.r.f. of 500kc/s, and performs addition, subtraction, and other simple operations such as transfer of numbers in 24$\mu$sec. More complex operations take longer. The length of the numbers, or "word length," is 10 binary digits (or 20 optional). Each step or instruction in the stored programme consists of a pattern of wiring connections and these patterns are set up by hand as rows of plugs in plug-boards, which are held in trays on the right-hand side of the machine (see picture). Altogether 500 programme steps are available and the computer scans them in turn. They are "single-address" instructions, that is, each instruction specifies in coded form the "address" or storage location of the next number to be transferred into the accumulating register in which the arithmetic operation is to be performed. The instruction also specifies in coded form what arithmetic operation is to be performed. When this is completed the computer automatically selects the next instruction in the plug-board programme.

*Magnetic-core matrix store (Mullard) used in many computers for immediate-access storage. The box contains a stack of matrix planes.*

The storage locations referred to are provided by a storage system of the magnetic-core matrix type* using tiny ferrite cores with rectangular hysteresis loops. This has a capacity of 256 numbers of 10 binary digits each, and the interesting point about it is that the windings driving the cores from one state of remanent magnetization to the other are energized by power transistors of the new OC23 type. Transistors hitherto available have not had the required combination of high collector current output and high alpha cut-off frequency necessary for this work, but the OC23 will deliver pulses of about 1 amp and has a cut-off frequency of 2.5Mc/s.







*National-Elliott 802 desk type computer with covers removed to show printed-circuit boards and the core matrix store (black box). Inset is a basic computing element of the machine, with transistor, core and resistor.*

Logical circuitry in the computer is similar to the larger "Pegasus" valve machine made by Ferranti. It is based on "OR" and "NOT" gate-type circuits formed by semiconductor diodes and transistor inverters. The two-state elements used extensively in binary digital computers to provide short-term storage registers are formed by transistor Eccles-Jordan trigger

* See "Magnetism in Materials" by D. H. Martin, *Wireless World*, April, 1958, issue.



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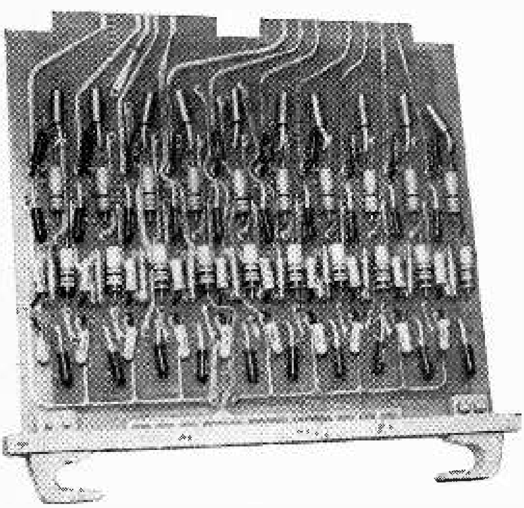
circuits. For this kind of operation the OC44 transistor is used. Pulse rise times are about 50m$\mu$sec. The computer works on power supplies of +6V, −6V and −24V and its total consumption is only 250 watts.

In the National-Elliott 802 machine the digit pulse rate is 166.5kc/s and the "word length" is 33 binary digits. Addition, subtraction and 46 other orders are performed in 612$\mu$sec each. It is again a "single-address" machine, but the programme of instructions is normally fed in by punched paper tape to be held in the magnetic-core matrix store (1,020 words capacity).

The logical circuitry is based on "OR" and "NOT" elements as before, but here two-state magnetic ferrite cores with various sets of input windings and a single output winding are used instead of the diode circuits. According to the logical pattern of input digit pulses applied to the input windings, each core is set into one state or



*Plug-in printed-circuit card for the Emidec 1100 magnetic-core/transistor computer.*

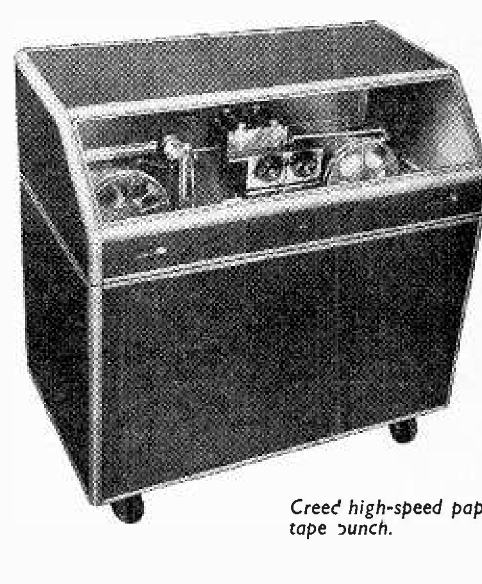
the other, corresponding to "0" or "1" in binary notation, by the coincident magnetic fields. This happens in the first 3-$\mu$sec half of the 6-$\mu$sec digit-pulse period. A so-called "shift" or "trigger" pulse is then applied to an additional input winding in the second 3-$\mu$sec half of the digit-pulse period, and the effect of this is either to switch the core or leave it as it is—depending on how it has been set by the original digit pulse inputs. As a result of this action the output winding either produces a pulse or a space (absence of a pulse), and this is where the transistor enters the picture—to amplify, regenerate and pass on the output pulse to another winding on another core.

Thus the magnetic-core/transistor circuits operate in two phases—the "set" phase, when the cores are switched into one state or the other, "0" or "1," by the input signals, and the "shift" phase, when the information on this state is made to appear at the output. The action is of necessity slower than the diode logical circuits, where all the switching occurs instantaneously, and in any case it is limited by the time-constant of the windings and magnetic core, which normally only allow operation at p.r.fs up to about 100kc/s. Hence the slower calculating speed of this machine compared with the Ferranti computer.

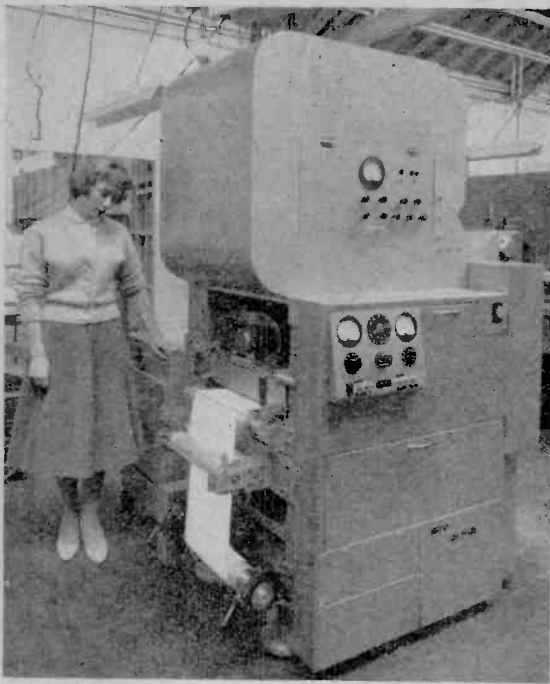
In spite of this inherent speed limitation the magnetic-core/transistor combination is likely to prove very popular as a circuit element in digital computers. The magnetic cores, as well as being small and robust, have a life which is probably infinite for all practical purposes, and while they are holding binary information by one state of remanent magnetization or the other they are not consuming power. Since they are inherently slow it is possible to use relatively inexpensive a.f. transistors for switching them, and in the National-Elliott 802 machine the ubiquitous OC72 performs this function. A basic computing element of magnetic core, transistor and one resistor mounted on a printed circuit is illustrated on page 18.

The speed of operation of magnetic-core/transistor computing circuits can be increased by working in the parallel mode instead of the serial mode. This means that all the digits of, say, a 32-digit number appear as pulses or spaces on 32 wires simultaneously, instead of in a time sequence on just one wire. Such a technique has been adopted in the Emidec 1100 digital computer shown by E.M.I. Electronics, a somewhat larger machine than those mentioned previously. The computer uses magnetic cores in combination with OC72 a.f. transistors and OC41, 42 and 45 high-frequency types. It has a high-speed "immediate access" magnetic-core matrix store (1,024 words capacity) driven by OC23 transistors, together with supplementary magnetic-drum stores each holding 16,384 words. These drums "write" and "read" digital information in sequential form, so special "serializer" and "parallelizer" circuits have to be placed between them and the parallel computing circuits. The word length, incidentally, is 36 binary digits, and numbers are transferred to and from the electro-mechanical input and output units in 6 lots of 6 binary digits. Instructions are of the two-address type.

Although the basic pulse rate of the Emidec 1100 is even lower than that of the National-Elliott 802 (actually 112kc/s) the speed of computing, owing to the parallel mode of operation, is a good deal



*Creed high-speed paper tape punch.*



*Xerographic high-speed output printer made by Rank Precision Industries. The electronic equipment is housed in a separate cabinet.*

faster. Addition, subtraction and other similar operations take about 120μsec, in fact. This speed is necessary, however, where it is not in the National-Elliott, because the Emidec is intended for entirely different applications. Moreover, the speed has to be paid for in the greater complexity of equipment necessary with parallel operation. The size of the Emidec machine is considerably smaller than that of equivalent valve machines and the power consumption of the computer proper is only 2kW—incidentally, it runs off car batteries!

E.M.I. Electronics were also showing a very much faster machine, the Emidec 2400, which uses diodes and h.f. transistors for the logical circuits and operates at the high pulse rate of 1Mc/s Magnetic cores are only present in the matrix store. Another, somewhat uncommon, quick-access store in the machine (64 words capacity) is formed by combinations of capacitors and diodes. Again, instructions are of the two-address type and the machine operates in the parallel mode. But the average time for addition and similar operations in this computer is only 0.6μsec—about 200 times faster than the Emidec magnetic-core/transistor machine.

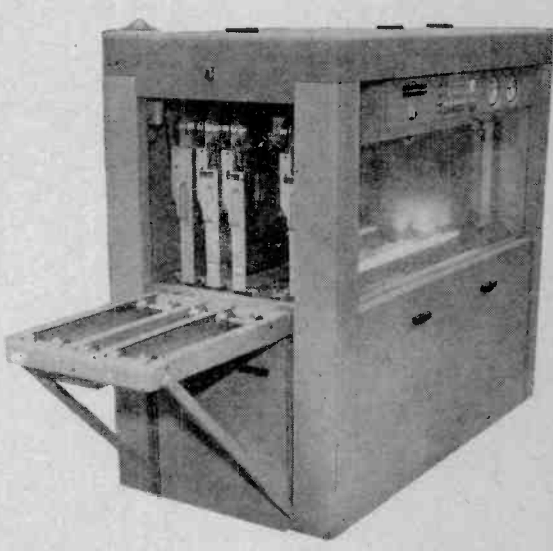
Such high speeds of operation are now becoming quite common in digital computers. They have raised the very difficult problem, which is always being quoted nowadays, that the electro-mechanical output equipment cannot keep up with the electronic speed of the computing circuits and is, in fact, causing a "bottleneck" in the production of computed results. Output equipment usually consists of card punches, paper tape punches, line-at-a-time printers, or electric typewriters, and in practice various combinations of these are used.

Great efforts are being made to remove the "bottleneck" by developing existing types of equipment and inventing new kinds. At the Exhibition one of the most outstanding examples of development in existing methods was the Creed 3000 high-speed paper tape punch. This operates at 300 characters a second (a character being a row of holes across the tape), which is about ten times as fast as most of the tape punches currently available. To achieve such a high speed, start-stop operation has been confined to very light parts, the movements of which have been kept very small. Heavier components are arranged to have continuous smooth motions. Higher grade materials are used, tolerances are closer and the lubrication has been improved over previous machines.

Amongst the more unconventional output devices, a machine which is beginning to establish itself very firmly is the Powers-Samas "Samastronic" page printer. This has abandoned the conventional method of printing from type founts and uses reciprocating styli to build up the letters and figures from patterns of inked dots. As a result it can print on a page at the rate of 300 lines per minute with 140 characters in each line—compared with the 100 lines a minute or so of some of the more conventional page printers. A storage system holds the necessary information for constructing 50 different characters and these are called up automatically by code signals fed in from punched cards.

Probably the most spectacular of the high-speed computer output devices on show was the "Xeronic" page printer demonstrated by Rank Precision Industries (see picture). This dispenses altogether with mechanical methods of making marks on paper, but records photographically, by the dry xerographic process, characters "written" on the screen of a c.r. tube. It can print at the staggeringly high speed of 1,500 lines a minute with 128 characters in each line on 13-inch wide paper, and is being developed to work up to 3,000 lines a minute.

The machine is a combination of an existing xerographic copying machine called the "Copyflo" (made by Rank-Xerox, Ltd.) and an electronic



*High-speed endless-loop magnetic-tape unit demonstrated by S.T.C. Three tape magazines are shown in the frame but five can be fitted.*



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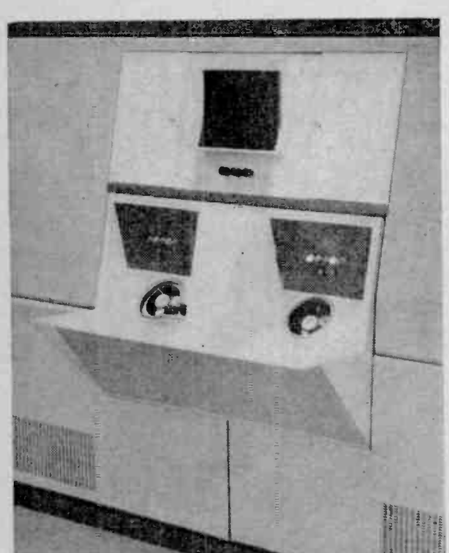
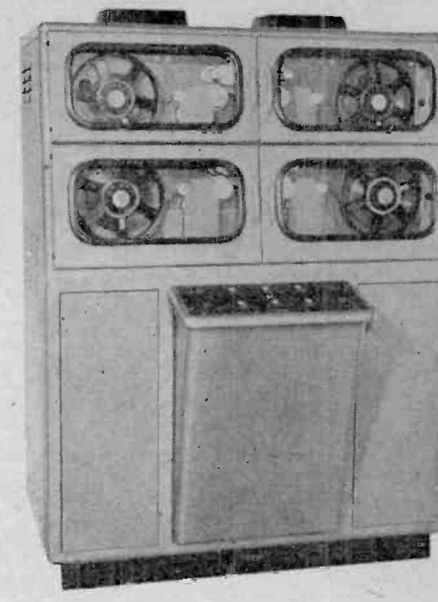
character-generating equipment which is housed in a separate cabinet (except for the c.r. tube). Special c.r. tubes have been developed in the U.S.A. which form characters by passing the electron beam through "stencils" and focusing the resulting patterns on to the screen, but these are rather expensive items. The interesting point about the Xeronic machine is that it uses a normal instrument-type c.r. tube and the characters are formed rather like Lissajous figures by applying deflection signals to the X and Y plates. These deflection signals are produced by applying suitable waveforms to passive networks, and the results displayed on the screen (capital letters) are of excellent quality and clarity.

Other electronic circuits are used to decode the binary input signals which specify the required characters and also to decode input instructions relating to the layout of the printed data. These layout instructions include such functions as horizontal and vertical tabulation, line feed (equivalent to carriage return on a typewriter), spacing and stopping, and selection of forms and headings as may be required for bills, invoices and so on. Tabulation can be pre-set manually by a plug-board, while the size of the characters printed can be varied by adjusting the gain controls of the deflection amplifiers. Transistors are used extensively throughout the machine.

The actual xerographic process of recording the characters displayed on the c.r. tube is centred around a large rotating drum with a coating of selenium. To begin with the drum surface receives an electrostatic charge from a wire grid, and this is retained as long as the drum is in darkness. Next the images from the c.r.t. are focused on the drum, and these modify the charge on the selenium to form a charge pattern corresponding to the characters displayed. The resultant electrostatic image is "developed" by showering over the drum thermo-plastic powder which has been charged oppositely to the pattern of characters on the selenium so that it adheres to the electrostatic image. After this the powder image is transferred by application of another electrostatic charge to the band of 13-inch paper, which is in continuous contact with the face of the drum and moving at the same speed. Finally the powder image is fused permanently to the paper by passing under a heating element. At the end of the process the drum is cleaned and is then ready for further recording action.



*Control desk of the Solartron ERA character recognizer, which reads documents such as till rolls at up to 300 characters/sec. (See "Wireless World," April, 1957).*



*Decca magnetic-tape storage equipment using two ½-inch tapes running at 100 inches/sec. The capacity is 23 million binary digits on each 2,400-ft tape.*

At the Exhibition the Xeronic printer was shown operating from an input from a high speed endless-loop tape machine displayed by S.T.C. This machine runs at 100 inches per second and information is stored in blocks in several parallel tracks at a packing density of 250 binary digits to the inch. In this application each block (containing a maximum of 500 binary digits) was transferred serially to a "staticizer" or static store, after which each character of 5 binary digits was transmitted in parallel form over a 5-wire line to the printer. The tape transport mechanism was automatically controlled by the paper feed of the Xeronic machine.

Speeds of 100 inches/sec are now quite common for magnetic tape storage systems. One machine displayed by E.M.I. Electronics runs at 200 inches/sec, stops and starts in less than 5 milliseconds and reverses in less than 7 milliseconds. This rapid type of operation is necessary to reduce the access time to information which, by the very nature of magnetic tape, has to be stored in sequential fashion. Most of the machines developed recently have two driving capstans rotating continuously in opposite directions and the tape is "sucked" rapidly into contact with either one or the other by a vacuum system under the control of switching signals from the computer. Two tape loops or "reservoirs" between the capstans and the spools isolate the tape drive from the inertia of the heavy spools, and the "reservoirs" are kept filled with constant lengths of tape by a servo system controlling the spool drive motors. To avoid wear the tape runs out of contact with the reading/writing heads.



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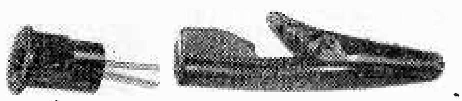
# Manufacturers' Products

## NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

### *Insulated Crocodile Clip*

A PLASTIC crocodile clip with a completely insulated brass insert forming a serrated wire grip in the jaws and terminating at the rear of the clip in a socket for a single-



*Insulated crocodile clip with socket for a plug (Creators, Ltd.).*

stem cable plug is obtainable from Creators, Ltd., Sheerwater, Woking, Surrey. Made of polystyrene it measures 2in long, costs 1s and is available in either red or black plastic.

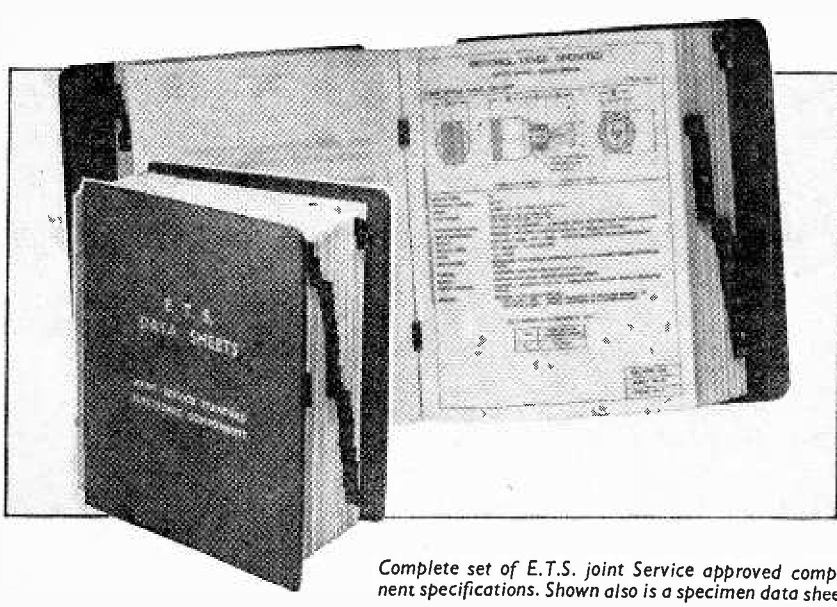
### *Joint Service Component Specifications*

IT is a requirement that all electronic equipment destined for Service use shall employ only type-approved components. What is an approved type is not always easy to decide although official documents such as the DEF5000 series of joint Service type-approved component specifications, and the earlier issues of the Radio Components Standardization Committee, do give the answers if one has the time and patience to delve deep enough into them.

A short cut to the essential facts required by design engineers of Service types of electronic equipment is now provided by a series of abridged joint Service approved component data sheets obtainable from H. W. Davies, Ltd., 1, Newman Road, Bromley, Kent. They are compiled by Electronic Technical Services (E.T.S.), an associated company, with the permission of H.M.S.O., because the E.T.S. series is derived from the official DEF5000 series of component specifications and the various documents issued by the R.C.S.C.

E.T.S. data are presented in a clear and concise manner and up to the present time some 500 loose-leaf data sheets have been issued. They are enclosed in a sturdy loose-leaf binder, well indexed for quick reference and the complete set of data sheets costs £15 15s 0d. When amendments are made to the official parent specifications new E.T.S. sheets are issued to replace the original or earlier ones and the familiar practice of having a lot of separate amendment slips to cope with is avoided.

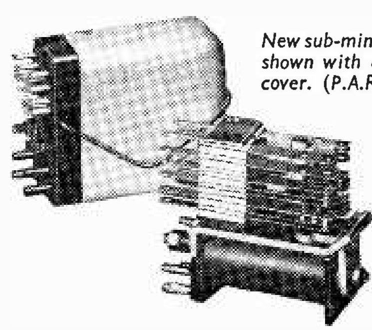
An additional £1 11s 0d is charged to cover amendment sheets issued to date and there is a fee of about 30s per annum to cover the supply of future amendments.



*Complete set of E.T.S. joint Service approved component specifications. Shown also is a specimen data sheet.*

### *Sub-miniature "3000"-type Relay*

A NEW Mark III version of the tiny P3 relay, which is a sub-miniature version of the well-known G.P.O. "3000"-type, has been introduced by P.A.R., Ltd., of Nottingham and obtainable from the distributors, D.



*New sub-miniature P3 relay shown with and without a cover. (P.A.R. Ltd.)*

Robinson and Company, 717, London Road, Hounslow, Middlesex.

The new P3 can now be obtained fitted with heavy duty contacts rated at 5A at 240V a.c. or 24V d.c. The action can be make or break and moderately heavy inductive loads can be switched. Alternative contacts can be fitted for high-duty change-over action, with make before break if required. It seems to be a useful general-purpose relay of the right size for miniaturized equipment.

Up to six sets of contacts of mixed type can be fitted and a special feature of the design is that it is suitable for mounting on printed circuit boards.

The operating coil can be wound to have any resistance up to 9,000Ω, single or double wound, or slugged, and it requires as little as $\frac{1}{10}$ watt to operate it with one "make" contact only and about $1\frac{1}{2}$ watts for six sets of change-over contacts. With the maximum number of contacts the overall dimensions come within $1.7 \times 1.5 \times 0.765$in.

# 110° SCANNING

## SHORT C.R. TUBES BRING NEW PROBLEMS IN TELEVISION SET DESIGN

*The Pye PV110 17-inch transportable receiver with 110° cathode-ray tube.*

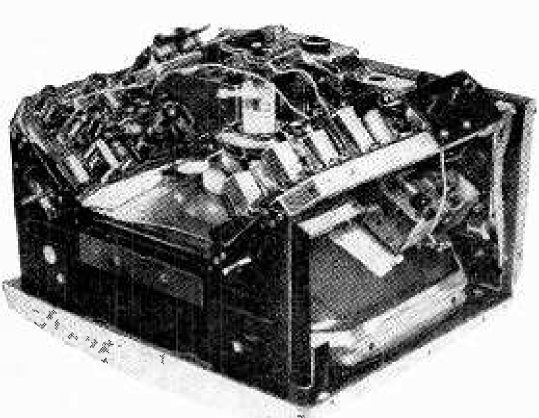
THE first of the long-awaited 110° television sets has now arrived on the British market—a 17-inch transportable made by Pye. As can be seen from the illustrations, the use of a 110° c.r. tube achieves a considerable reduction in cabinet depth, and in fact this dimension is only 13¼ inches overall (the height being 15 inches and width 17½ inches).

In general the 17-inch tube with a 110° deflection angle is about 3 inches shorter than the equivalent tube with a 90° angle. This particular c.r.t. is the C17/6A made by Cathodeon, a subsidiary of Pye. It has a rectangular screen of 5:4 aspect ratio (slightly increasing the picture area over 4:3 tubes but cutting the picture sides a little) and a narrow neck of 1⅛in diameter which makes possible the greater deflection sensitivity required to scan the 110° angle. The electron gun is a tetrode type with an electrostatic focusing electrode, and the final anode operates at 16 kV. It is a straight gun and no ion trap is required. At present the 6.3V tube heater takes a current of 0.6A, which means that it cannot be included in the series heater chain and a special transformer has to be provided. In later models of the set a series-heater tube will be used.

Conforming to the modern tendency with transportable receivers, the cabinet plays a very minor role in the construction of the set. It is merely a decorative cover enclosing the metal frame into which the set is built. A moulded plastic mask-cum-filter-screen covers the front of the tube, giving protection and improving the picture contrast when room lighting is on.

The two main problems in the design of such 110° receivers are (a) obtaining sufficient scanning power to deflect the c.r.t. electron beam through the wider angle, and (b) getting the circuitry into the reduced space resulting from the use of the shorter tube. Taking the electrical problem (a) first, this is a matter necessitating very careful design of the line and frame output stages, transformers and deflection coils. A PL81 valve is used for the line output and a PL84 for the frame output. Several improvements in the line output transformer are obtained by a technique known as "d.c. cancellation" applied to the ferrite core. The direct-current anode supply to the line output valve passes through a section of the transformer winding in the normal manner but it also has to pass through another section of winding in the opposite direction. The magnetic fields produced by the d.c. in the two sections therefore tend to cancel, and this reduces the magnetic loading on the core.

*Back view of the Pye receiver with cabinet removed, showing how the tuner unit is mounted and the easy accessibility to the printed circuit boards.*



Apart from slightly increasing the transformer efficiency, this technique largely eliminates the time-base whistle which would otherwise be extremely annoying in such a high power scanning system. The transformer leakage inductance is tuned on the "third harmonic" principle,* which, as well as mitigating line scan ringing, reduces the peak voltage on the line output valve and PY81 efficiency diode and so leads to higher efficiency by allowing higher turns ratios.

The anode load of the PL81 line output valve is arranged so that the anode is driven hard into the "knee" of the anode voltage current characteristic. This, in conjunction with a carefully chosen screen grid resistor, makes the scan amplitude largely independent of the valve's characteristics. Moreover the amplitude does not change appreciably with reasonable mains voltage variations. There is no line scan amplitude control as this is considered a source of wastage of scan power.

In the frame scan output stage improved efficiency in the output transformer is obtained by the use of a grain-oriented low-loss steel for the cored laminations (called "Unisil" and made by The Steel Company of Wales).

The deflector coil assembly is characterised by a pronounced flare at one end of the windings, which

* See "Overcoming Line Scan Ringing." By K. G. Beauchamp. *Wireless World*, September, 1957.



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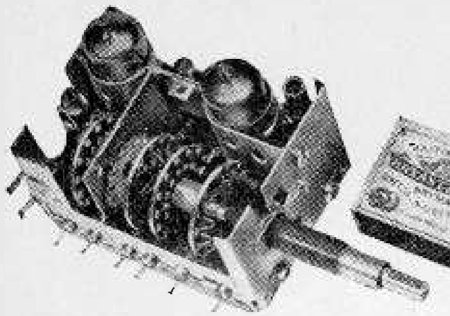

*The incremental inductance tuner of the Pye set, with cover removed to show the small switch wafers with coils mounted on them.*

allows the coils to extend a good distance up the cone of the tube. This is done so that the centre of deflection of the assembly can be as close to the screen as is necessary to avoid interruption of the beam by the end of the tube neck at the extremities of the 110° scan. Another reason for extending the windings as far as possible up the cone is to lengthen the distance in which the electron beam is affected by the magnetic field and so reduce the scanning current requirements. The coils extend as far back in the other direction as is practicable in a short-neck tube, and even overlap the final anode cylinder slightly.

The so-called "cosine" distribution of winding cross-section is used on the deflection coils to give uniformity of focusing all over the screen (which, of course, is particularly difficult to obtain with large deflection angles). This technique is well known for producing slight concavities in the sides of the raster ("pincushion" distortion) but correction is applied by small permanent magnets attached to the assembly. Toroidal frame coils are used, and thermistors are connected in series and incorporated in the assembly to correct the resistance changes caused by heating which would otherwise affect the picture height.

On the question of mechanical design, the main problem, as mentioned earlier, has been to find sufficient space for the circuitry around the short neck of the tube. Transistors are the obvious answer but this is a thing for the future. Meanwhile Pye's have worked out a neat form of construction based on two vertical printed-circuit panels on each side of the neck. When the cover is removed from the set both sides of these can be reached easily for servicing purposes. Power and e.h.t. supplies are arranged separately at the bottom of the chassis.

One of the largest circuit sub-assemblies in any television set is the tuner unit. Here the designers have saved a great deal of space by introducing a new miniature incremental inductance tuner (made by H.D.F., Ltd., of Lowestoft) which measures only $3\frac{1}{2}$in × $2\frac{1}{2}$in × $2\frac{1}{2}$in. It is situated between the back of the signal-frequency printed circuit and the tube cone. The four rotating coil switching wafers are of small diameter (actually $1\frac{1}{4}$in) and the coils are mounted on them and rotate with them (as distinct from previous Pye incremental inductance tuners in which the coils were connected to the fixed contacts of conventional wafer switches). Some of the Band-III inductance increments are just formed by conductors joining the switch contacts and are fabricated by printed circuit technique. The tuner circuit is the widely accepted arrangement of PCC84 cascode r.f. amplifier and PCF80 mixer/oscillator.

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# Audio-Frequency Spectrometer

THE Danish Brüel and Kjær Type 2110 uses 30 filters to divide the frequency range from 35c/s to 35,000c/s into $\frac{1}{3}$-octave bands. The rejection an octave away from the centre frequency is 52dB for those bands with centre frequencies between 160c/s and 16kc/s, and at least 36dB for the other bands. By paralleling the filter inputs and pre-loading their outputs so that there is no significant change in loading when the output amplifier is switched in, the filter ringing time can be made short enough to allow the input amplitudes in all the 30 pass bands to be recorded in 20 seconds. The total gain of the input and output amplifiers can be varied in 10dB steps up to a maximum of 100dB, and no attenuation is produced by the filters in their pass band. Four alternative standard frequency-weighting networks are available, and the instrument can also be operated as an amplifier with a response flat within $\pm 0.5$dB from 2c/s to 35,000c/s. The maximum sensitivity is $100\mu$V input at high impedance for a full-scale meter deflection, amplifier noise corresponding to an input of $15\mu$V (open circuited) under these conditions. The sensitivity can be checked using a built-in reference voltage. The peak, arithmetical mean, or r.m.s. value of the input signal can be measured; the r.m.s. error being kept to within 0.5dB for signals with crest values up to 5 by approximating the required square-law curve with straight-line portions. Other facilities include a polarizing potential variable between 150 and 250V for condenser incrophone inputs, and an output with an impedance of less than 50Ω for feeding a recorder. In this country the instrument is available from B. & K. Laboratories, Ltd., at 4, Tilney Street, Park Lane, London, W.1., and costs £426 10s.

*Brüel and Kjær audio-frequency spectrometer Type 2110.*



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## "BELLING-LEE" NOTES

*The First of a new Series*

### CONTACTS

We set out to write something which we hope will be informative to many and perhaps act as a refresher to those who might consider themselves more profound.

Our chosen subject—contact resistance as applied to those components which we manufacture in vast numbers, terminals, plugs sockets, etc.

Within an hour we found that many books had been written on the subject, big fat tomes full of formulae, and we nearly gave up. But surely we can put on paper an essay of a few hundred words to remind ourselves and others of the various factors that are involved.

First of all, just what is a contact? It would appear to be a series of points of contact rather than an area. If we examine a flat surface under a microscope it looks like a ploughed field, infinitesimal scratches caused by rollers or cutting tools being the furrows. The ridges form the high spots and here and there the high spots are higher, therefore if two such surfaces are placed face to face, contact will be "here and there," only the highest spots touch, theoretically a minimum of three. If the two surfaces are ground and polished, it only requires a higher magnification to confirm this.

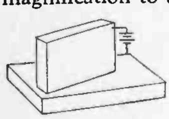


Fig. 1

Fig. 2

Figure 1 is intended to indicate a block of metal resting upon another. The contact surface is *not* the area of the adjacent faces, but contact will probably be made as shown in Figure 2, at about three points. It is not generally appreciated that when two pieces of metal touch—even lightly—the physical distortion caused by the breaking down of these points, generates heat and constitutes a minute hot weld, which is in fact broken when the two pieces are drawn apart.

Let us be quite clear about this, the condition exists between the coins in your pocket, and the heat so generated is measurable. In fact the friction between sliding solids is considered to be largely due to the breaking down of these minute welds. If sufficient pressure is applied to distort some of the higher points, then more points will touch and a better contact will result. Figure 3 shows the same theory applied to a plug and socket. Even if the plug is a tight fit in a socket, contact may only be made through a few high points. But the mass of metal around the contact points is important as it carries away the heat.

Fig. 3

The resistance at the point of contact depends upon the conductivity of the materials, and the cleanliness of the surfaces, i.e., absence of oxides, sulphides or other corrosions. That is why a wiping surface is desirable in switchwork. If the resistance at the point of contact is high, and if current is passing, heat will be generated and the higher the resistance the greater will be the heat. At this point it is worth a word of warning not to get involved with the current carrying capacity of the connector; this is another question to be dealt with later. Local heating of a resilient contact spring might cause annealing and loss of springiness, may be more heat, and any appreciable rise in temperature at the point of contact will tend to increase the formation of oxides, but this will not be very important once contact has been made. Where resilience exists, such as with a plug or socket, the normal operation ensures a wiping action which cleans such deposits.

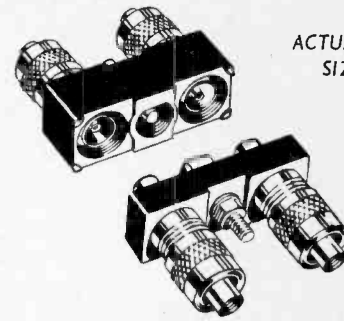
Phosphor bronze is a good spring material of fairly high conductivity, but in its natural state is apt to form a bad conducting surface. The silver-plating of contact surfaces is favoured because silver is a highly conductive material, and the normal tarnish of silver is not an oxide but a sulphide, and is conductive. But badly tarnished silver can be difficult to solder with fluxes that are safe to use. Where components designed to carry very small currents are expected to have an indefinite or very long "shelf-life," gold is plated on top of the silver, not because of better conductivity but because of its ability to withstand corrosion. It is interesting to remember here that with a very thin deposit of gold (known as a flash and may be only a micron (0.00004in.) thick) there will be "migration" of corrosive agents through the gold to the silver and the gold will appear to vanish in a comparatively short time. The gold deposit must be substantial and of the order of 0/.0002 or 0/.0003ins., if a long life is required.

Most high conductivity materials are soft, therefore silver or gold is often plated onto harder metals; beryllium copper is the exception, it is frequently used for sockets because it can be hardened and is ideal for the purpose; it is not essential to plate it but we do offer sockets in this material silver or gold plated. Where a gold or silver plated plug is being plugged into a beryllium copper socket, great care must be taken to ensure that the socket is free from burrs which would quickly scrape away the softer material. This would result in impaired contact, to say nothing of the possibility of metallic particles finding their way where they are not wanted.

Advertisement of
BELLING & LEE LTD.
Great Cambridge Rd., Enfield, Middx.
*Written 18th November, 1958.*

## "BELLING-LEE"
## MINIATURE COAXIAL UNITORS

ACTUAL SIZE



## *The Domino with a difference*

These Unitors are designed to be used in conjunction with our series of 'Domino' Unitors, and may be mounted with them in two- or three-way shrouds.

Each Unitor carries two miniature coaxial connectors which are of similar design to the plug and free socket of the L.1417 series and can be interconnected with them.

The brass shrouds (L.1404, L.1405 and L.1406) for mounting one, two or three Unitors, are each available for either flush or surface mounting.

Each Unitor is polarised by means of a flat on the locating spigot, so that the two coaxial ways cannot be accidentally interchanged.

**ELECTRICAL DATA**

*D.C. breakdown voltage at these pressures:*

| Atmospheric | 70 mm mercury | 10 mm. mercury | 2 mm. mercury |
|---|---|---|---|
| 3750 V | 1000 V | 500 V | 460 V |

These figures relate to the voltage between the two-way shroud (L.1405) and one outer conductor. The Unitor was not loaded with cable.

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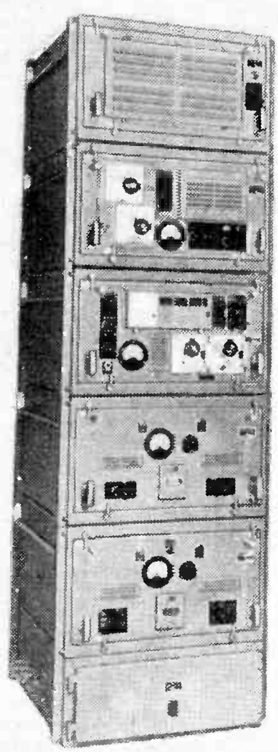

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# What Makes Currents Flow?

## Divertissement on an Original Theme by G. S. Ohm

By "CATHODE RAY"

AFTER a whole year of grinding through atomic theory, wave mechanics, Pauli exclusion, Heisenberg uncertainty, Fermi levels, phase and group velocity, dispersion, etc., regular readers (if any are left) will be thinking that if even Christmas brings no let-up the last hope of a return to the good old days when "Cathode Ray" stood for the simple things of life will have to be abandoned. Well, here we have a nice seasonable question, almost fit for a quiz game during the period of intellectual torpor following the Christmas dinner. I promise to make allowances for such circumstances, by discussing the matter in terms which at other seasons might be considered an insult to the intelligence.

So, for a start, let us understand that the currents in question are electric currents. And we won't bother much about the details of what electric currents are, or even whisper the word "hole," but will just regard an electric current as a movement of electric charges.

Until quite recently I wouldn't have thought that the title question would provide enough material for even a Christmas-length article. Surely a current is driven by an e.m.f.? The very name—electromotive force—signifies that. If pressed, one might admit that an alternative and perhaps more strictly correct answer would be "an electric field." But wouldn't that be a bit of a quibble—like insisting that a Christmas balloon was not burst by the pressure but by the pressure per square inch? One would know what to do with anyone who took that sort of line at a party—and I don't mean political party.

The reason for the matter cropping up now is that recently more than one learned authority has at least given the impression that currents are driven by electric charges. K. C. Johnson, for example, on p.429 of last September issue wrote that the properties of semiconductors "are most easily understood by considering the electric fields applied, and the densities of mobile charges present as causes, and the currents that flow as an effect." It is true that electric fields are named first among the causes, and earlier he said outright that "electric fields make mobile charges move." Are "the densities of mobile charges" an alternative cause, or what?

Then P. Hammond chose the exalted medium of an I.E.E. Monograph (No. 286, on "Electromagnetic Energy Transfer") in which to make quite an issue of the importance of electric charges, alleging that their role in electrical engineering was commonly ignored. Discussing Ohm's law, he pointed out a difficulty. "What is the origin of the electric force E on the current in the wire at a place considerably distant from the terminals of the battery? Clearly E can arise only from electric charges." By "electric force E" Mr. Hammond does not mean electromotive force, which unfortunately is also denoted by E, but electric field strength. This, of course, is reckoned in volts per metre, whereas e.m.f. is just volts.

If Mr. Hammond will forgive my saying so, experience has taught me to beware of the word "clearly." Too often it is used to pull a fast one. I don't suggest that that was the intention in this case, but I for one am not at all clear whether the statement so prefixed was meant to be universal, or confined to the particular circuit under discussion (a wire connected to the terminals of a battery). Farther on, with reference to the same circuit, we read that Ohm failed to see that a charge "provided the source of the necessary electric force"; and "only a minute amount of charge is required to cause the current to flow. Nevertheless, a total absence of electric charge would also mean the cessation of current flow. The necessity for this charge distribution is hardly ever mentioned in the textbooks." And elsewhere* "the existence of a charge distribution to drive the current, which was recognized by Ohm, is almost always ignored.

I found all this rather disturbing, for it seemed to mean that electric currents were not driven, as I had supposed, by e.m.fs but by electric charges.

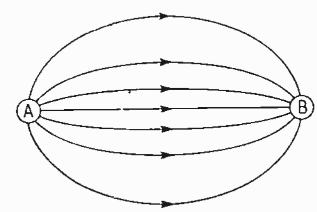


*Fig. 1. If electrons are transferred from A to B, A becomes positively charged, B negatively charged, and the resulting electric field is conventionally represented by the lines of force as shown.*

Since early youth I had believed that electric currents and the separation of electric charges were both due to e.m.fs. Nor had I been conscious that the charges were being ignored. For all I know they may be ignored in books about d.c. and 50-c/s electrical machinery, where the presence of charges is generally of only academic interest, but they certainly are not and cannot be in (for example) *Wireless World*.

But that is by the way. The question is "What makes (electric) currents flow?"

If you take a quantity of electrons from a place A (Fig. 1) and dump them at another place B, then the surplus of electrons at B constitutes what we call a negative electric charge. The atoms which were robbed to provide those electrons are no longer electrically neutral; their unbalanced protons are a positive charge. A mechanical force of attraction appears between these opposite charges at A and B, and (to conceal our ignorance) we say that there is an electric field in the space between. This is shown in the usual way by drawing a number of thin lines between A and B, with arrow heads pointing from + to −. Let us assume that A and B are well insulated from one another, for otherwise the attraction would soon pull the electrons back to A and

*Journal I.E.E.*, June 1958, p. 296.



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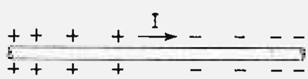
restore the original uncharged or neutral state. I say electrons, because the positive charges at A are parts of the atoms themselves and cannot normally move unless A moves as a whole. Even that could happen if it were free to move; for example, if A and B were charged objects floating on a pool of oil, for they would be drawn towards one another like magnets. But let us assume that A and B are fixed.

However, there might be a few stray charges in the space; electrons, say. Being negative they would be repelled from B and attracted to A. The direction along which this force acts on them is the direction in which a line of force passing through that point would have to be drawn to make the diagram correct. In other words, the lines of force show the directions along which small free positive charges would be pulled by the field. (Electrons, being negative, move along the same line in the opposite direction.) Incidentally, don't fall into the trap of thinking that a free electron would actually follow its line of force all the way to A. On a curved line

*Fig. 2. When a current I is driven along a wire, charges become distributed along it as roughly shown here.*




(a)

(b)

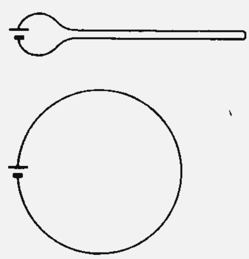


*Fig. 3. The amounts of charge distributed depend very largely on the shape of the circuit; in (a) for example they would be far more than in (b).*

the electron's inertia makes it swing out, like a stone pulled along a sheet of ice by a string held by a boy running in a curved path. The direction in which it moves is not always the same as the direction in which it is being pulled, as shown by the string or the line of force.

Since an electric current consists of electric charges in motion, one could say that a current was being caused in the space between A and B by the electric field (or force) there. And because the electric field is in this case caused by the charges at A and B, one could say (and presumably Messrs. Johnson and Hammond do say) that the current was being caused by those charges. But since that is a cause once removed they could hardly object if I were to look at the cause twice removed and say the current was being caused by whatever it was that created those charges by moving electrons from A to B. The usual "whatever it was" is, of course, an e.m.f. You yourself even might claim to be the cause, as the switcher-on of the e.m.f. And so on.

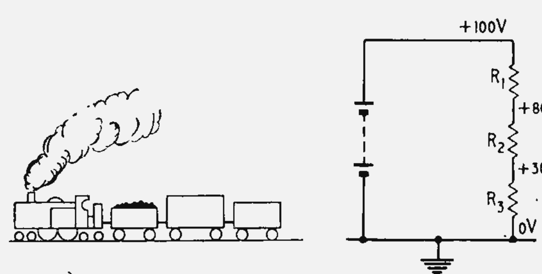
This is developing into something very like those lengthy arguments (now for the season in abeyance) put forward by expensive legal gentlemen in the High Courts: was the regretted death of Mr. X in a motor accident caused by the neglect of Mr. Y, the mechanic who forgot to replace the nut on the steering gear, or by Mr. Z, his employer, for engaging such a clot? But seeing that in our case there are no damages to pay (unless Johnson or Hammond sue me for libel), wouldn't it be best to decide that the cause of electric currents is just a matter of opinion, according to the way of looking at it? Then Johnson is right, Hammond is right, I'm right, you're right, everybody is right, so all will have prizes as in a caucus race.

Well, I'm awfully sorry to stop such a delightful solution being carried unanimously, but if we are to understand that there is always what the lawyers call an unbroken chain of causation from e.m.f. through charges and electric field to electric current, I must be a spoil-sport and object. Let us consider one of Mr. Hammond's own examples: a straight length of conductor — a piece of wire, say — as in Fig. 2, carrying current. Let us suppose the current is flowing from left to right, as shown. Then it is quite true, as he says, that there will be charges on the wire, the left hand being positive with regard to the right, and the density of the charges changing gradually, as I have tried to show. Mr. Hammond would, I think, say that these charges are needed to provide the uniform electric field to make the current flow along the uniformly resistant wire. I would say that there is an e.m.f. somewhere to make the current flow against the resistance of the wire, and it sets up a potential difference between the ends of the wire and (because the wire's resistance is uniformly distributed along it) between any two points along it. Now any two places between which there is a difference of potential must necessarily have become charged according to their capacitance, in accordance with the "Ohm's law of electrostatics":

$$Q=VC$$

where Q is the amount of charge, V the p.d. and C the capacitance.

Hammond—and apparently Johnson—find it helpful to look on the charge distributed along a wire or any circuit as the apportioner of the electric field strengths throughout its length so as to ensure (under d.c. conditions) the same current throughout. Mr. Hammond points out that the amount and distribution of the charge along a circuit varies drastically with the shape the circuit is bent into, all else including the strength of current being constant. Even this doesn't shake his faith in the idea of the two things being related as cause and effect, though he confesses to being amazed that the current should remain constant in spite of the extensive changes of charge. I (and I imagine most of you) are not amazed, because the resistance R (or conductance G) and the e.m.f. and p.d. are assumed to be unaffected by the bending about, so we expect




(a) (b)

*Fig. 4. A train (a) provides an interesting analogy with an electrical circuit (b).*



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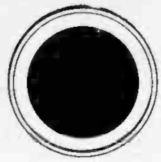

*Fig. 5. In the circuit formed by a wire ring around a core carrying a varying magnetic flux, a current flows without any difference of potential or accumulation of charge.*

the current to remain constant in accordance with

$$I = VG$$

I have written G instead of the more familiar 1/R to help comparison with the previous equation. Both equations apply to the whole wire circuit or to any part of it. Both I and Q are directly proportional to V, but whereas I depends on G (which is not affected by the bending) Q depends on C (which is). *Wireless World* readers at least are familiar with the self-capacitance of circuits and would need no reminder that if the wire were arranged as in Fig. 3(a) it would have much greater capacitance and would therefore have much greater charges accumulated along it than if it were opened out as at (b). Surely it is more natural to regard Q as a parallel result of V than a cause of I?

We have seen that Johnson admits "electric fields applied" as causes of currents, and Hammond implies that there are causes other than charges when he goes on to consider the wire in Fig. 2 with a magnetic field sweeping past it, as in the usual sort of revolving-field power-station generator. There is then an induced "electric force" throughout the length of the wire, sufficient to overcome the small resistance to the flow of current and produce in addition a relatively large voltage between the ends of the wire, capable of making the same current flow through the resistance of an external circuit. To do this, the right-hand end must be positive. So the charge distribution must be of opposite sign to that shown in Fig. 2, and usually much more intense. If one were to consider the charges as the cause of the current flow one would expect it to flow in the opposite direction and be much stronger! Why, then, so much emphasis on them in the case of no induced e.m.f.? Surely it is not only unnatural but confusing to introduce the idea of charges causing currents?

We may find it instructive to join engine spotters by the side of the railway line and consider a short goods train as it passes; Fig. 4(a). The whole train is going at the same speed. What makes it go? Wouldn't you be surprised if one of your young companions replied "Each wagon is made to go by the stretching of the couplings between it and the rest of the train"?

Yet that seems a fair equivalent of the concept advocated by the writers quoted. Fig. 4(b) shows the electrical analogue: the whole circuit is the train, the resistors are the wagons, the e.m.f. of the battery is the motive force of the engine, the speed of the train is the current strength, the voltages at the circuit junctions are the tensions in the couplings, and the charges accumulated are the stretchings of those couplings. To my simple mind, the train and the current are made to go by the engine and the battery respectively (or their motive forces, if you want to be fussy).

The tension is greatest just behind the engine, and falls off to zero at the back end of the train. Similarly the voltages, marked at (b), decrease from a maximum at the battery end of the chain of resistors to zero at the earthed end. The speed of any one wagon depends on the difference between the tensions at its front and rear couplings, and on its frictional resistance; and of course the tensions throughout the train adjust themselves so that it all moves at the same speed. The couplings stretch to an extent depending on the tensions and their own compliances. Would anyone suggest that it is the stretching that makes the train go? Work out the analogy in Fig. 4(b)!

Reversing the battery reverses the signs of all the voltages and reversing the engine makes all the tensions negative, which means that they would be compressions.

The effect of an e.m.f. distributed along the circuit itself, as in the generator wire, is represented by running the train on a slope. It is then possible for the tensions in Fig. 4(a) to change to compressions, the trucks driving the engine against its brakes. (This may be contrary to good railway practice, but no matter!) With one particular gradient, and the right relationships between weight and friction of the wagons, it is possible for the train to be running along without coupling stresses or strains anywhere. Similarly (and this is the trump card) you can have current flowing in a circuit without any potential differences or accumlated charges. Fig. 5 depicts a uniform wire forming a closed circle around an iron core through which magnetic flux is changing at a uniform rate. A considerable current is likely to flow around the wire, but the whole circuit will be at the same potential, so there will be no surface charge redistribution.

What makes the current flow? Redistribution of charges? Or is it no accident if they are often ignored?

## CLUB NEWS

**Barnet.**—R. G. Shears (G8KW), managing director of K. W. Electronics, will be the speaker at the meeting of the Barnet and District Radio Club at 8.0 on January 27th. Lecture meetings are held on the last Tuesday of each month at the Red Lion Hotel, High Barnet, and morse and instructional meetings on the second Tuesday at the A.T.C. Headquarters, Gloucester Road, New Barnet.

**Bexleyheath.**—At the January 22nd meeting of the North Kent Radio Society E. C. Hasted (G3BHF) will talk on power-pack design. Meetings are held fortnightly at 7 30 at the Congregational Hall, Bexleyheath.

**Bradford.**—Mobile operation will be dealt with by J. J. Platt (G2VO) at the January 13th meeting of the Bradford Amateur Radio Society. Meetings are held fortnightly at 7.30 at Cambridge House, Little Horton Lane, Bradford, 5.

**Cleckheaton.**—Bridge circuits will be discussed by S. Marsden at the meeting of the Spen Valley Amateur Radio Society on January 21st. The guest speaker at the Club's annual dinner on January 24th will be I. C. I. Lamb, engineer-in-charge of the I.T.A. station at Emley Moor.

**Manchester.**—A talk on the conversion of Government surplus equipment will be given to members of the South Manchester Radio Club by F. Nicholls (G3MAX) on January 9th. The club meets each Friday at 7.30 at Ladybarn House, 17, Mauldeth Road, Manchester, 20.

**Prestatyn.**—"Looking Back" is the title of the talk being given by F. G. Southworth (GW2CCU) at the January 8th meeting of the Flintshire Radio Society. The club meets on the first Monday of each month at 7.30 at the Railway Hotel.

**South Kensington.**—J. Lank, chief development officer of T.C.C., will speak on capacitor techniques and peculiarities at the January 5th meeting of the Civil Service Radio Society The meeting will be held in the Science Museum Lecture Hall at 6.0.

**Wellingborough.**—"The lighter side of TV servicing" is the title of the talk being given by F. Wright, of Rushden, at the January 22nd meeting of the Wellingborough and District Radio and Television Society at 7.30 at Silver Street Club Room.



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# Automatic Error Correction

## Repetition Methods in Multiplex Radio Teleprinters

**By P. R. KELLER,* B.Sc., A.M.I.E.E. and L. K. WHEELER,† B.Sc.(Eng.), A.M.I.E.E.**

NO doubt readers will be generally familiar with the fact that a very large part of telegraph communication is effected by means of the teleprinter and that the mode of signalling is by a binary code, each character signal comprising five information units (giving 32 permutations) preceded by one unit that sets the printing receiver in operation, and succeeded by an element of one to one and a half units minimum duration to permit the receiver to come to rest. Thus synchronism has to be maintained only over the period of a character permutation, and the effect of speed differences between transmitter and receiver is not cumulative.

In certain instances communication by teleprinter over radio links can be successful during appreciable periods, but there are great variations in propagation characteristics and, although refinement in methods of signal modulation and detection (including diversity) may be employed to ameliorate these, there may be periods in which noise and fading still prevent reliable communication. In the event of falsified signal elements direct teleprinter operation suffers in two ways. It is obvious that if one or more of the five information units is incorrectly received a wrong character will be printed, since all the permutations are significant (i.e. there is no redundancy in the code). But, if the start or stop element is affected, the relative phase of the transmitter and receiver is upset and an error in one character can result in falsification of succeeding characters even though the elements of these are unmutilated in transmission. The second of these troubles can be overcome by using synchronous transmission (i.e. the telegraph transmitting and receiving apparatuses run continuously, instead of on a start-stop basis, and are closely controlled in speed and phase by special means). The effects of the first type of error still remain, however, and various ways have been used to minimize them.

* Marconi's Wireless Telegraph Co., Ltd.
† Post Office Research Station.

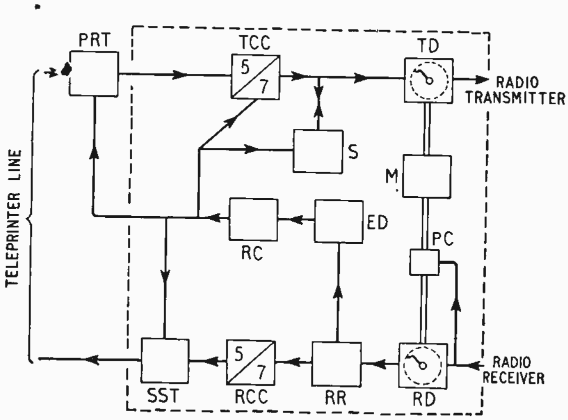


*Fig. 1. Van Duuren system of error correction by automatic repetition.*

**Message Protection.**—The simplest form of message protection is by multiple transmission (which could be called "time diversity") and comparison of the various received versions. Variations of this method, in which the signals of the multiple transmissions are automatically compared element by element and the most probable result accepted, have also been used, but it is obvious that these ways are very uneconomical in the exploitation of the transmission capacity.

The most usual method now employed, the application of which is steadily increasing, is the use of a protective or error-detecting code. The use of such a code alone, of course, indicates only that a mutilation has occurred during transmission, but it removes any misapprehension as to the accuracy of the received message, particularly when it is encoded in "secret language". (The use of error-detection to permit automatic correction is explained later.) The fundamental property is that the number of units in the code allows more permutations than are required for the number of information symbols to be conveyed (i.e. the code has redundancy). This permits the choice of permutations to represent symbols so that they have some common characteristic (e.g. the number of units of one kind in all used permutations can be made odd, even or the same). Hence, if a permutation without this predetermined characteristic is received, it is certainly an error. There is always, of course, some probability that compensating errors in the units will occur and cause "undetectable errors". This probability decreases as redundancy is increased with properly designed codes, but inevitably the number of detected errors will increase. "Self-correcting" codes are also known which enable wrong signal elements to be identified and reversed, but these require a greater measure of redundancy and are generally regarded as uneconomical for ordinary telegraph applications.

In the 1930s Moore and Mathes introduced for use with the R.C.A. synchronous multiplex system a 7-unit code in which each of the characters was represented by permutations comprising three marking and four spacing elements. This enabled errors to be indicated by a distinctive symbol on the record printed by special 7-unit printers. Van Duuren (of the Netherlands P.T.T.) adapted this basic code-form and extended its usefulness by reallocating the permutations amongst the information symbols so that an automatic translation from and to the International Alphabet No. 2, used for teleprinters, was facilitated. The teleprinter code has 32 permuta-



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tions and the 7-unit protective code has 35 permutations available. Two of the excess permutations can be used for signalling the teleprinter line conditions of continuous mark, the condition during a pause in the message, and continuous space, which is used as a clearing signal in teleprinter exchange systems.

**Error-correction by Automatic Repetition.**—Van Duuren also conceived the idea of error-correction by repetition of the faulty permutation from the transmitter when an error is detected by the receiver. The basic outline of his "teleprinter over radio (TOR)" system, which provides a means for reliable communication between teleprinter systems over a radio circuit, is shown in Fig. 1. The teleprinter signals are received by a receiving reperforator-retransmitter (PRT) which records them on a perforated tape which is then read into the TOR at the correct time interval. The code signal is presented in parallel form to the code-converter (TCC) which comprises a relay switching system. The resultant 7-unit code permutations are transmitted sequentially by a mechanical distributor (TD) driven by a synchronous motor (M) fed from a stable-frequency source of power. The 7-unit permutations are also stored for a period (as will be explained later) as charges on a bank of capacitors, a series of banks (S) being switched in sequence by relays so that several characters may be stored.

The received signals are registered as groups of 7 units on relays (RR) via the receiving distributor (RD) which is driven from the synchronous motor (M) through a phase-correcting mechanism (PC) controlled by the signals. The register (RR) is connected to the receiving code converter (RCC) and also to the error-detector (ED) which is a form of Wheatstone bridge that is in balance if the received code permutation has the correct ratio of marking to spacing elements. If the signal is correct, the code-converter emits the corresponding 5-unit permutation to a start-stop transmitter (SST) that adds start and stop elements and sends the signal to the teleprinter.

If, however, the 7-unit combination is incorrect, the repetition control circuits (RC) stop the read-out to the teleprinter and the input from the tape reader. (It is not necessary for the teleprinter to stop sending as the perforated tape accommodates the overrun.) The error signal (which will be termed RQ), for which the 35th permutation is used, is sent back to the distant station followed in sequence by the symbols in the store. At the distant station the receipt of the RQ causes a similar train of events. (It will now be obvious that the number of symbols stored must be sufficient to cover the time for transmission in both directions plus the time taken to register a complete permutation.) The characters repeated from the store are transmitted, and, if the one previously faulty is now received satisfactorily, full communication in both directions is restored, but, if it is still incorrect the repetition cycle is repeated.

**Multiplex operation.**—Generally, it is possible to operate the radio channel at higher speeds than are required to accommodate one teleprinter channel, and time-division multiplexing is employed to cater for two or four teleprinter channels. The limit is set by multi-path effects on the radio link. The apparatus is usually built on a two-channel basis, symbols from channels A and B being transmitted alternately. The polarity of signals in one channel is inverted so that it is impossible to obtain through transmission unless the channels are phased correctly; this prevents the possibility of misrouting. Four-channel transmission is usually effected by combining two two-channel equipments so that the signal elements are interleaved in time, the element unit period being reduced to half the former value.

**Standardization.**—Other allocations of the 7-unit code have been devised with various advantages, but a modification of the original one is recommended by the C.C.I.T.T. which has also standardized the speed of operation. The code is shown in Table I and the speeds in Table II. (One baud is one elementary information unit per second.)

**Improvement in Error Rate.**—It is difficult to give a precise figure for the improvement in communication brought about by the introduction of automatic repetition on detection of error (ARQ)

TABLE I

| FIGURES | LETTERS | INTERNATIONAL TELEGRAPH ALPHABET No. 2 | 7-UNIT CODE |
|---|---|---|---|
| – | A | ● ● ○ ○ ○ | ○ ○ ● ● ○ ● ○ |
| ? | B | ● ○ ○ ● ● | ○ ○ ● ● ○ ○ ● |
| : | C | ○ ● ● ● ○ | ● ○ ○ ● ● ○ ○ |
| | D | ● ○ ○ ● ○ | ○ ○ ● ● ● ○ ○ |
| 3 | E | ● ○ ○ ○ ○ | ○ ● ● ● ○ ○ ○ |
| % | F | ● ○ ● ● ○ | ○ ○ ● ○ ○ ● ● |
| @ | G | ○ ● ○ ● ● | ● ● ○ ○ ○ ○ ● |
| £ | H | ○ ○ ● ○ ● | ● ○ ● ○ ○ ● ○ |
| 8 | I | ○ ● ● ○ ○ | ● ● ● ○ ○ ○ ○ |
| BELL | J | ● ● ○ ● ○ | ○ ● ○ ○ ○ ● ● |
| ( | K | ● ● ● ● ○ | ○ ○ ○ ● ○ ● ● |
| ) | L | ○ ● ○ ○ ● | ● ● ○ ○ ○ ● ○ |
| . | M | ○ ○ ● ● ● | ● ○ ● ○ ○ ○ ● |
| , | N | ○ ○ ● ● ○ | ● ○ ● ○ ● ○ ○ |
| 9 | O | ○ ○ ○ ● ● | ● ○ ○ ○ ● ● ○ |
| 0 | P | ○ ● ● ○ ● | ● ○ ○ ● ○ ● ○ |
| 1 | Q | ● ● ● ○ ● | ○ ○ ○ ● ● ○ ● |
| 4 | R | ○ ● ○ ● ○ | ● ● ○ ○ ● ○ ○ |
| ' | S | ● ○ ● ○ ○ | ○ ● ○ ● ○ ● ○ |
| 5 | T | ○ ○ ○ ○ ● | ● ○ ○ ○ ● ○ ● |
| 7 | U | ● ● ● ○ ○ | ○ ● ● ○ ○ ● ○ |
| = | V | ○ ● ● ● ● | ● ○ ○ ● ○ ○ ● |
| 2 | W | ● ● ○ ○ ● | ○ ● ○ ○ ● ○ ● |
| / | X | ● ○ ● ● ● | ○ ○ ● ○ ● ● ○ |
| 6 | Y | ● ○ ● ○ ● | ○ ○ ● ○ ● ○ ● |
| + | Z | ● ○ ○ ○ ● | ○ ● ● ○ ○ ○ ● |
| CARRIAGE RETURN | | ○ ○ ○ ● ○ | ● ○ ○ ○ ○ ● ● |
| LINE FEED | | ○ ● ○ ○ ○ | ● ○ ● ● ○ ○ ○ |
| FIGURE SHIFT | | ● ● ○ ● ● | ○ ● ○ ○ ● ● ○ |
| LETTER SHIFT | | ● ● ● ● ● | ○ ○ ○ ● ● ● ○ |
| SPACE | | ○ ○ ● ○ ○ | ● ● ○ ● ○ ○ ○ |
| UNPERFORATED TAPE | | ○ ○ ○ ○ ○ | ○ ○ ○ ○ ● ● ● |
| RQ SIGNAL | | | ○ ● ● ○ ● ○ ○ |
| * IDLE SIGNAL $\alpha$ | | | ○ ● ○ ● ○ ○ ● |
| Ø IDLE SIGNAL $\beta$ | | | ○ ● ○ ● ● ○ ○ |

* CORRESPONDS TO CONTINUOUS START POLARITY (TELEX CLEANING SIGNAL)
Ø CORRESPONDS TO CONTINUOUS STOP POLARITY (TELEX CALLING SIGNAL)

TABLE II

| Teleprinter Modulation Rate | 7-unit Multiplex Modulation Rate | |
|---|---|---|
| | 2-channel | 4-channel |
| 50 bauds<br>*45.45 bauds | 96 bauds<br>85 5/7 bauds | 192 bauds<br>171 3/7 bauds |

* This is not part of the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) recommendation for operation on International circuits, but is proposed by the International Radio Consulative Committee (C.C.I.R.) for use when American speed is acceptable to both parties.



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systems, because of the infinite variability of conditions encountered in transmission. However, in a circuit which without protection would produce one error per hundred characters printed it would not be unusual for the rate to be reduced to one per ten thousand characters printed. The operation of such a system, of course, necessitates a return circuit, and if this is similarly affected, the time taken to dispose of messages would be increased by about eight per cent in the above example; but, in the absence of automatic repetition, the additional load placed on the circuit and operators by messages of verification would render commercial operation impossible. It is particularly important in Telex services, in which the subscribers are in direct communication, for the printed copy to be as "clean" as possible, because there is no opportunity before delivery for scrutiny and clearing of obvious errors due to faulty transmission.

**Electronic Equipment.**—Following the success of the original electromechanical apparatus, engineers in several countries have considered the design of analogous electronic apparatus. One design, evolved by the Post Office Research Station, and revised in co-operation with Marconi's Wireless Telegraph Co., Ltd., has been engineered by this firm for production, and is being marketed under the name "Autoplex"†. Although it will be obvious to those familiar with electronic techniques that the functions of the various parts of the apparatus could be performed by a variety of different circuit elements, the above design will be briefly described as a typical electronic equipment.

† Regd. trade mark.

The simplified block diagram of an Autoplex two-channel time-division error-correcting terminal equipment is shown in Fig. 2. In this system the storage of transmitted characters precedes the coder, thus permitting the use of common translation equipment.

This equipment uses cold-cathode tubes for all frequency dividers, distributors, registers, storage and counting stages, but the block diagrams are appropriate to alternative circuit elements. Cold cathode tubes offer the advantages of low power consumption and heat dissipation (little or no standby power is required, according to type), long life, reliability, and visual indication of their on/off condition. The last advantage is an important point in servicing.

**Timing Circuits.**—Referring to Fig. 2, the transmitter and receiver element distributors are driven from a high-stability 9.6 kc/s crystal oscillator via ring-counter frequency dividers. By switch selection of the scale of division the equipment can operate at aggregate speeds of 85.5/7, 96 or 100 bauds.

The timing equipment is shown in more detail in

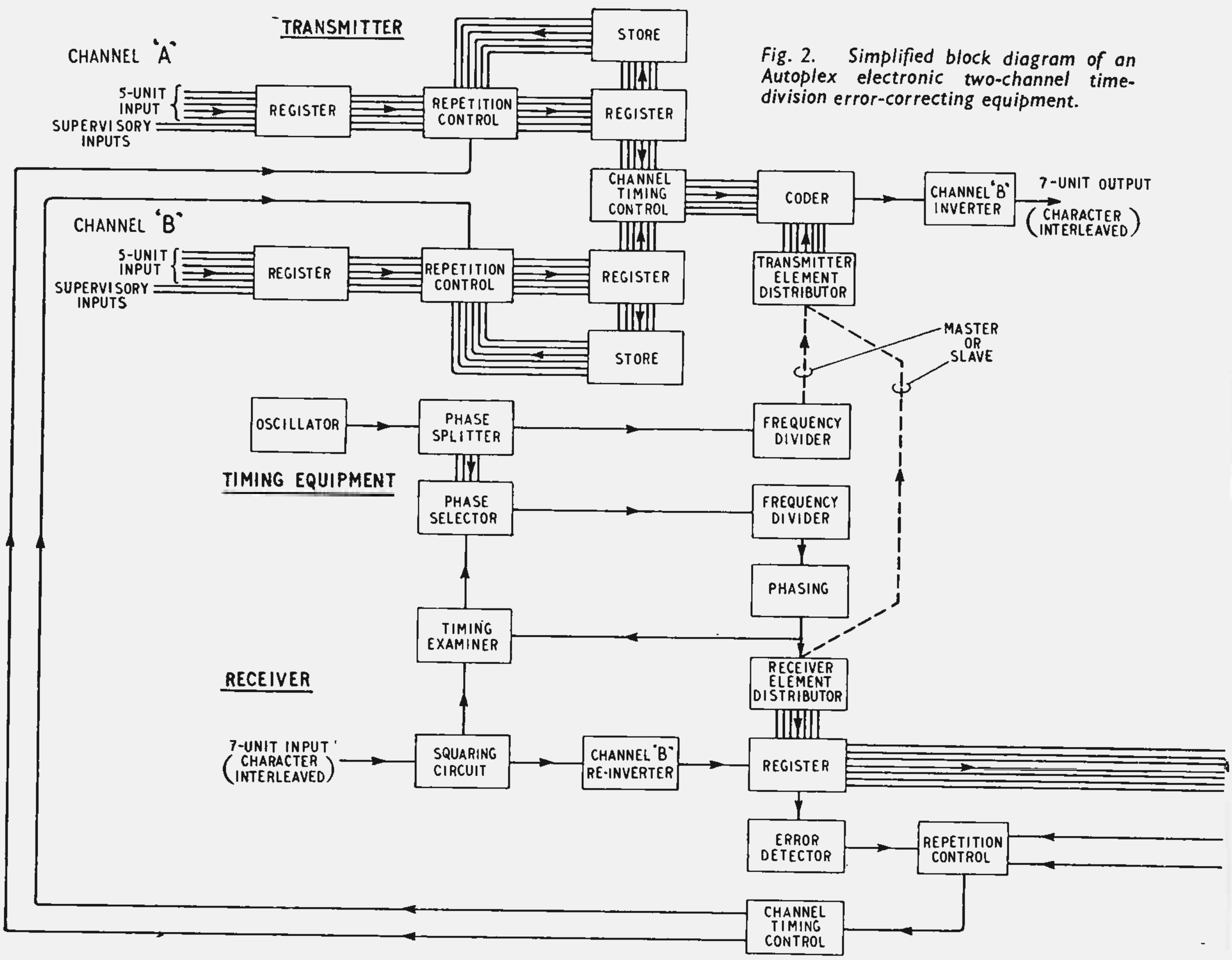


*Fig. 2. Simplified block diagram of an Autoplex electronic two-channel time-division error-correcting equipment.*



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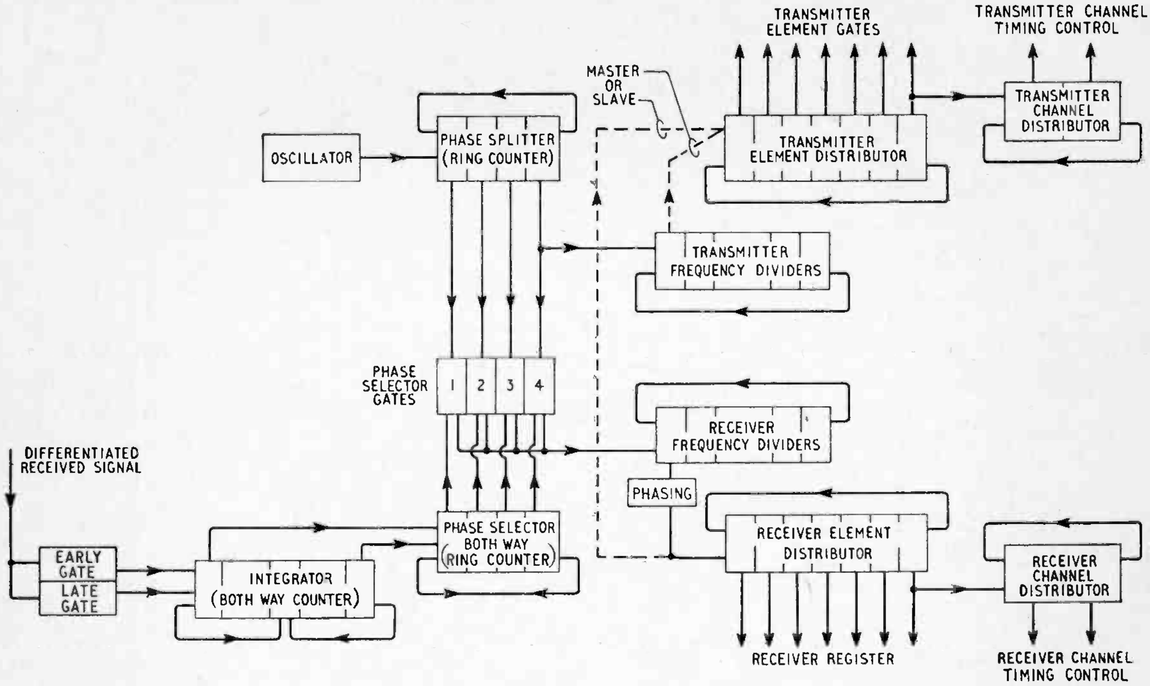
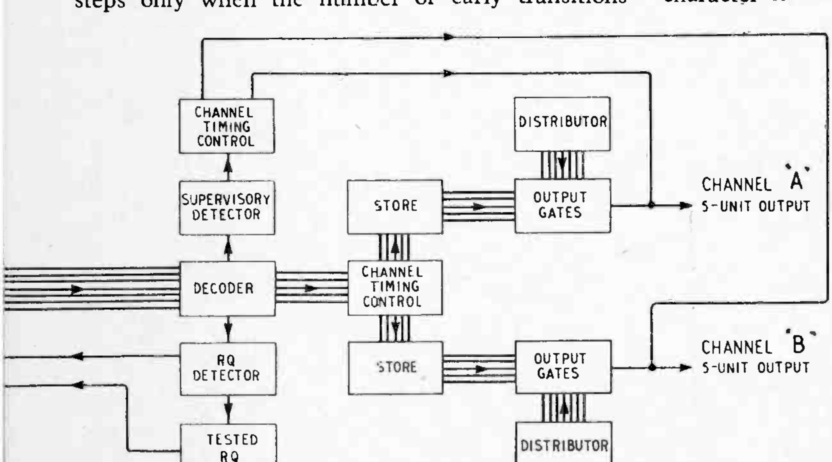



*Fig. 3. Detailed block diagram of timing equipment in the Autoplex.*

Fig. 3. Synchronism is achieved by applying continual correction to the timing of the receiver distributors, and at one terminal (the slave station) the transmitter element distributor is locked in a specific phase relationship to the receiver distributor. The timing examiner compares the relative timing of the transitions of the incoming aggregate signal with the drive pulses to the receiver element distributor. Early transitions step the phase selector counter to advance the phase of the drive to the receiver frequency divider via the phase selector gates. Late transitions cause the phase of the drive to the frequency dividers to be retarded. To prevent unnecessary changes of phase when the aggregate signal is time distorted due to multi-path propagation it is desirable to include an integrating device (both-way counter) so that the phase selector steps only when the number of early transitions exceeds the number of lates (or vice-versa) by a specific number.

**Transmitter Circuits.**—Referring to Fig. 2, 5-unit characters or supervisory signals to be transmitted over the system are registered at the inputs of the channels. Since 35 different signals have to be presented to the coder, and there are only 32 permutations in 5-unit code, the first register acts as a simple coder and provides a 6-wire output to a further register. In the 6-unit code a mark is added as the sixth element to normal characters, and supervisory signals are formed by permutations in which the sixth element is space. The channel timing control, driven by the transmitter channel distributor (see Fig. 3), causes characters from the two 6-unit registers to be passed in turn to the coder where the translation to 7-unit code is effected. As each character is transmitted over the system it is also passed to a shifting store which normally accommodates 3 characters, which are discarded in turn if a repetition is not required. In the Autoplex equipment the coder is of the decode-recode type, the first half breaking down the 6-wire input to the 35-wire form, and the second half forming the 7-wire output. This type of coder does not require that there be a logical relationship between the 5-unit and 7-unit codes. Servicing is simplified by the provision of test points at the 35-wire stage. A typical section of the coder (translation for character "A") is shown in Fig. 4. Five pairs of input terminals are provided,



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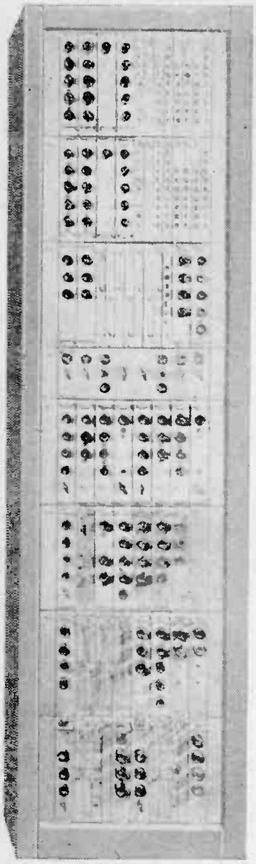

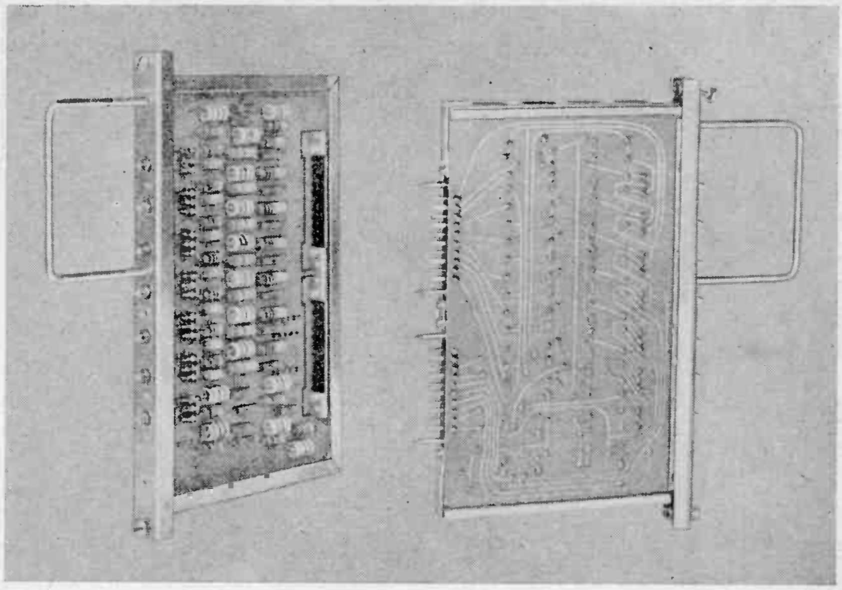

*Above: Typical unit of the Autoplex.*

*Left: The Autoplex electronic error-correcting equipment for teleprinters.*

each pair indicating the condition of one of the elements of the 5-unit character. One terminal (the upper) of each pair is positive on mark and earth on space, the other (lower) is positive on space and earth on mark. The test point for the character "A" is connected via 5 rectifiers to 5 input terminals as shown, and can only go positive if the input signal is MMSSS. Point "A" going positive applies a positive potential to output terminals, 3, 4 and 7 giving the 7-unit permutation SSMMSMS at the output.

The output of the coder is converted by the transmitter element distributor to a sequential aggregate signal which is passed to the radio transmitter. The output drive stage includes a circuit which inverts the elements of channel B characters.

**Receiver Circuits.**—The elements of the incoming aggregate signal to the receiver are examined at their nominal mid-instants, and registered in the correct sequence by means of the receiver distributor, the elements of channel B characters being automatically re-inverted. The 7-wire output of the register is applied to the decoder for translation to 5-unit code. As each character is registered, the number of mark elements is counted by the error detector unit, and if acceptable (3 marks) the decoder output is transferred to the appropriate channel store. The 5-unit signal is read out of store sequentially via output gates by a distributor operating at the required speed of 50 or 45.45 bauds. Start and stop elements are added, and the composite output is passed to the receiving printer. If a supervisory signal is received, continuous start or stop polarity is applied to the output wire.

**Repetition Circuits.**—If the error detector indicates an incorrect mark element count, or the decoder detects the RQ combination, a repetition cycle is initiated on the appropriate channel. In this period (4 characters for 3-character storage) continuous stop polarity is normally applied to the receiver channel output wire to hold the printer. In the transmitter, the input character stepping device is stopped to permit the transmission of the RQ signal followed by a repetition of the characters in the channel store. As these characters are transmitted, they are automatically stored again in case a further repetition is required. At the end of repetition cycling normal traffic is resumed. The repetition cycle is shown in Fig. 5. Character C transmitted in the master-slave direction on channel A is falsified in transmission and detected as an error.

(*Continued on page* 33)

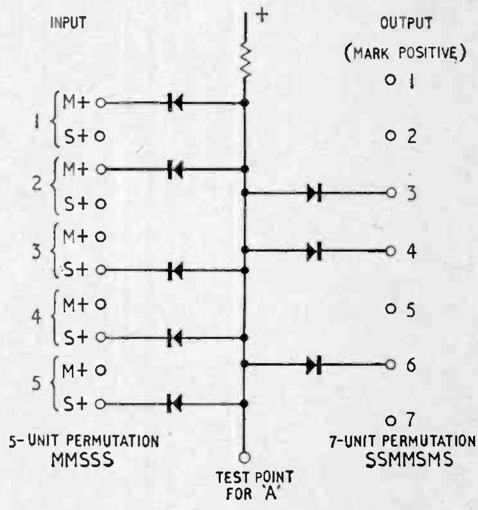


*Fig. 4. Translation of the character "A" in the coder.*



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The channel A receive printer at the slave station is stopped for 4 character periods, and, at the first opportunity following the receipt of the error, channel A transmission is interrupted in the slave-master direction to send the repetition request (RQ signal) followed by 3 characters from storage (M, N and O). Receipt of the RQ signal at the master station initiates a repetition of the stored characters C, D and E. It can be seen from the diagram that any further errors in either direction during the period of the repetition cycle will be rejected.

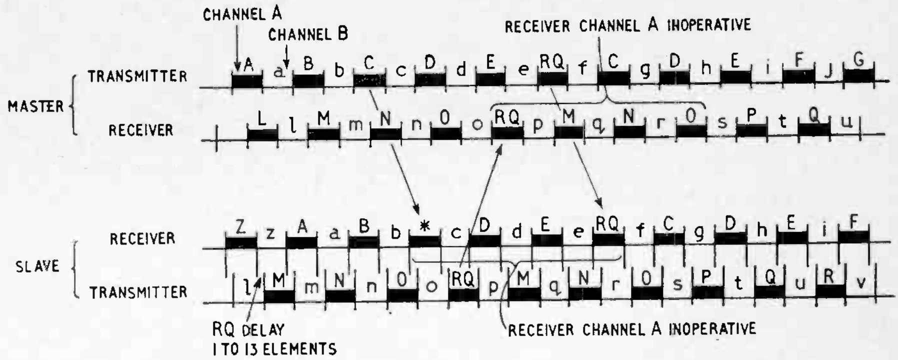



*Fig. 5. Repetition cycle after error detection in the Autoplex.*

**Other Facilities.**—A "tested RQ" facility can be provided to give some protection against undetectable errors. During a repetition cycle one of the received characters should be the RQ signal. If this is not detected owing to bad propagation conditions which may cause transpositions and undetectable errors, the repetition is ignored and another repetition cycle requested.

As an alternative to error correction by repetition, or when no return circuit is available, an error indication facility is provided. On detecting an error, the 5-space combination is transmitted on the start-stop output wire causing a special error symbol to be printed on a suitably modified teleprinter.

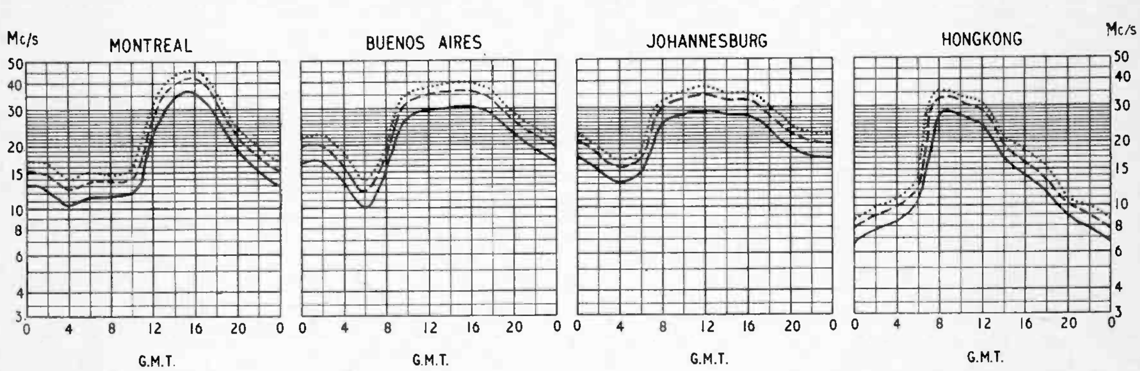
Out of phase operation may be recognized when in a specific period of repetition cycling the RQ signal is not detected. Phasing is accomplished by omitting a drive pulse to the receiver distributor not more than once per repetition cycle until the RQ signal is recognized on each channel. Each drive pulse omitted has the effect of shifting the receiver examination circuits relative to the signal by a step of one element. This action can be manually controlled or automatic.

**Ancillary Equipment.**—The basic error correcting equipment is generally designed for a 5-wire simultaneous input to the transmitter channel units. A 5-wire tape reader is then used when the information to be transmitted is prepared on perforated tape.

Adaptors are necessary when the input is sequential from a remote auto-transmitter or from the Telex network. If the remote auto-transmitter is driven by release pulses from the main equipment a simple sequential-to-simultaneous converter unit with one character storage is required. For connection to Telex or a free-running auto-transmitter where the rate of reception and clearance of characters may differ, a converter with buffer storage for several thousand characters (which may be, for example, in the form of a loop of perforated tape) is required. Another ancillary item is a channel subdivider unit to permit the input characters to a channel to be derived in turn from a number of remote auto-transmitters, and also to allow the output to be distributed in turn to a number of remote printers.

## SHORT-WAVE CONDITIONS

*Prediction for January*




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

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

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

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

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



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# Miller Sweep Circuit

## A Very Linear Timebase Using a Puckle Flyback Circuit

By C. S. SPEIGHT

THE Miller and Puckle timebases are often considered as being two distinct approaches to the problem of obtaining a linear sweep. The variations on the basic Miller-integrator circuit nearly all involve the use of the suppressor grid of a pentode as the switching electrode and they differ mainly in the method of generation of the switching pulse; whereas the Puckle timebase varies in the type of sweep-generating circuit used. A plain resistor-capacitor combination will suffice for some purposes; but for more linear sweeps a pentode is commonly used to produce a constant-current discharge from the capacitor by making use of the high " $r_a$ " of a pentode. The linearity of output from such a circuit is still not very good and difficulties arise in calibrating the sweep speed and stabilizing it against variations in valve characteristics, etc.

However it is possible to combine the linear sweep characteristics of the Miller circuit with the Puckle recharging circuit to produce a timebase which is simple and yet superior to the more usual Miller-transitron circuit in almost every respect.

Some advantages of such a circuit may be listed as follows:—

1. The Miller integrator operates with an infinite load during the sweep period so ensuring an extremely high degree of linearity.

2. The current recharging the sweep capacitor may be high compared with the discharge current. This means that the ratio of sweep period to flyback period can be made very much better than in the Miller-transitron in which a compromise is made between a high stage gain without feedback (high anode load) and a high recharge current (low anode load).

3. The use of suppressor and screen grids as switching electrodes can be avoided, resulting in a high loop gain and fast transition from one condition to the other. Thus the circuit lends itself to high-speed applications.

4. The initiation of the sweep and flyback periods is independent of the parameters of the sweep circuit. The amplitude of the sawtooth is therefore independent of sweep speed and can be controlled accurately.

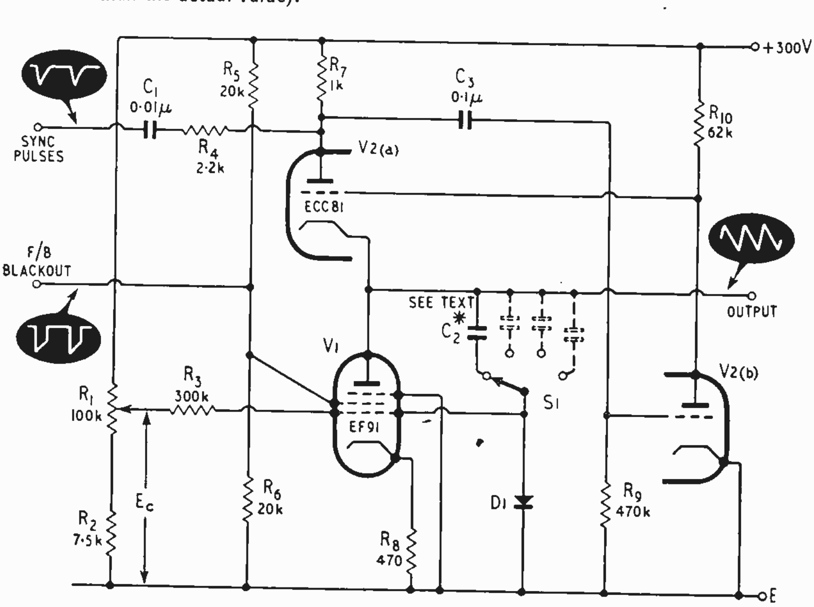
5. The initial " fast " region or " Miller step " associated with nearly all adaptations of the Miller circuit, can be eliminated almost completely. This is made possible by allowing the control grid voltage of the sweep valve to change only one or two volts during the transition from flyback to sweep.

**Free-running Linear Timebase**—The circuit for a general purpose timebase incorporating the above features is given in Fig. 1. Only two valves are used: V1 is the Miller sweep valve, V2 is the Puckle " multivibrator." $R_1$ and $S_1$ form the fine and coarse speed controls.

The operation of the circuit is most easily seen by starting during the sweep period. V2(b) is conducting heavily ($I_a \approx 4$mA), its anode potential being given by the point at which the load line and the " $V_g = 0$ " curve intersect. The anode potential of V1 is more positive than that of V2(b); therefore V2(a) is held cut-off. The charging current, flowing through $R_3$ into the sweep capacitor $C_2$, provides the total anode current of V1, which is constant because the grid voltage is required only to change sufficiently to maintain this current at reduced anode voltage.

Therefore the rate of fall of voltage at V1 anode is constant until only a few volts exist between the grid and cathode of V2(a); which then starts to conduct. The drop in anode potential is transferred by $C_3$ to the grid of V2(b) where it reduces the anode current so allowing V2(b)'s anode potential to rise. Since V2(b) anode is directly coupled to V2(a) grid, the current is further increased in V2(a). A cumulative action occurs limited by V2(b) being cut-off and V2(a) forced into heavy conduction; thus the sweep capacitor, $C_2$, recharges through the diode action in

*Fig. 1. Free-running linear timebase. (The mark-space ratio of the waveforms shown is less than the actual value).*



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V2(a) (grid and cathode), $R_{10}$ and $D_1$. The anode voltage of V1 rises until the current in V2(a) can no longer produce sufficient voltage across $R_7$ to maintain V2(b) cut-off; then V2(b)'s anode potential falls which reduces the current in V2(a) still further. Again a cumulative action occurs, this time limited by the return of V1 and V2 to their original conditions, thus allowing the sweep to start once more. It follows that the lower limit of sweep voltage is determined by the anode potential of V2(b) when conducting and hence by $R_{10}$. The upper limit is determined mainly by the value of $R_7$, the " $r_a$ " of V2(a) and the grid base of V2(b). If the value of $R_7$ is too low; the flyback will end too soon and the loop gain will be low; if it is too high the sweep will not start until $C_3$ has discharged through $R_9$. (This occurs if the circuit components are so chosen that the circuit finds a " stable " condition, with V2(a) running at " $V_g = 0$," with anode current equal to that of V1.)

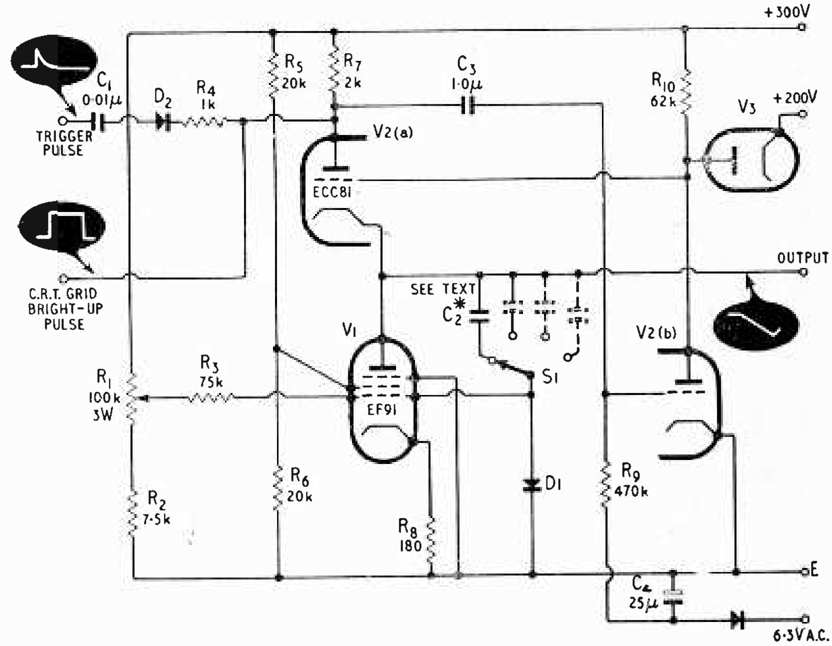


*Fig. 2. Adaptation of the free-running circuit to provide triggered (single-shot) high-speed timebase.*

$R_8$ is introduced to limit the current drawn by the pentode during flyback to about 4mA, the grid potential being limited to h.t. negative by the diode $D_1$. The latter should have a back resistance of at least 1M$\Omega$ at a reverse voltage of about 5 volts, and a forward current rating of at least 20mA under pulsed conditions. (Most point contact germanium diodes satisfy this requirement.)

Values of sweep capacity are not given since they are best left to suit individual requirements. An approximate formula for obtaining the value of $C_2$, in terms of the minimum sweep duration required on that range, may be obtained from:—

$$C = \frac{it}{V}$$

(where the symbols have their usual meaning).

Substituting $i = 1$mA, $V = 150$ volts.

$$C_2 \approx \frac{7t}{10^6}$$

(C is in farads and $t$ is in seconds.)

Values of $C_2$ between 15pF and 0.1$\mu$F have been found suitable, providing a range of speeds from 2$\mu$sec to about 0.2 sec. (As the stray capacity is likely to be of the order of 15pF, the lower limit will be something over 2$\mu$sec.)

The flyback-blanking pulse is taken from V1 screen and synchronization is effected by injecting negative pulses into V1(b) grid (via $C_1$, $R_3$, $C_3$). The amplitude of these pulses may be as small as 0.25V to produce synchronization because they are amplified and reversed in polarity by V2(b) before they are applied to the grid of the cut-off valve V2(a).

**Linearity**—Although the cathode current of V1 does increase slightly throughout the charging period, the change in voltage developed at the cathode is negligible due to the low value of $R_8$. And, because the screen current is less than 5% of the current drain through $R_5$ and $R_6$, the screen potential is also substantially constant throughout the same period.

The change in grid voltage is given by :—

$$\Delta V_g = \frac{\Delta V_a}{\mu} \quad \left\{ \begin{array}{l} \text{where } \Delta V_a \text{ is amplitude of} \\ \text{saw-tooth at V1 anode and } \mu \text{ is} \\ \text{amplification factor of V1.} \end{array} \right.$$

Change in charging current is therefore:—

$$\frac{\Delta V_g}{R_3} = \frac{\Delta V_a}{R_3 \mu} \text{ (assuming } E_c \text{ is constant)}$$

Non-linearity (%) is:—

$$\left[\frac{\Delta V_a}{\mu R_3} \div \frac{E_c - V_g}{R_3}\right] . 100 \approx \frac{\Delta V_a}{\mu E_c} . 100$$

substituting:

$\Delta V_a$ = 150 volts, $\mu$ = 7,000 (typical value for EF91)

$E_c$ = 300 volts (max. value)

$$\text{Non-linearity} = \frac{150}{7{,}000} \times \frac{100}{300} \approx 0.007\%$$

Although output impedance of a Miller circuit can be shown to be as low as that of the cathode-follower ($Z_{out} \approx 1/g_m$) the use of this advantage of the circuit by feeding the output into resistive loads which are low compared with the " $r_a$ " of the valve must result in a loss of linearity. This arises from the fact that the anode current of the sweep valve and hence the grid potential, has to change appreciably during the sweep period to reproduce the saw-tooth across the load. Consequently the charging current $(E_c - V_g)/R_3$ cannot be constant. Therefore, if this circuit is to feed a device having an input impedance of such a value that it would shunt the





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" $r_a$ " of the Miller valve ( $\approx 1M\Omega$) to any appreciable extent, it is desirable that a cathode-follower should be used to isolate this impedance from the Miller valve. This is especially so if a paraphase amplifier is used, where the combined effect of stray capacitance and the input impedance of the amplifier could spoil the inherent good linea ity of the sweep circuit. An amplifier with a high degree of negative feedback is recommended: the anode-follower operating with a gain of one would be a suitable circuit. Usually, for oscilloscope work, the linearity of the tube is the limiting factor and for most purposes the sweep may be regarded as perfectly linear.

**High-speed Triggered Timebase.**—The circuit of Fig. 1 may be made mono-stable by returning the " earthy " end of $R_8$ to a negative potential, as in Fig. 2.

Normally V2(b) is cut-off by the 9 volts or so across $C_4$: its anode potential is limited by the diode, V3. V2(a) behaves as a cathode follower maintaining 200 volts across V1. The anode current in V1, and hence in V2(a), is limited by $R_8$ to about 7mA. The grid potential of V1 is slightly above earth due to the current flowing through $R_3$ and through the diode between V1 grid and earth.

A positive pulse is applied to V2(b) grid, via $C_1$, $D_2$, $R_4$ and $C_3$, to trigger the timebase. If the amplitude is sufficient to cause V2(b) to conduct, an amplified negative pulse will appear at its anode and therefore at V2(a) grid where it reduces the current in the valve. The resulting positive pulse at V2(a) anode adds to the pulse that initiated the process and once the loop gain exceeds one the action is cumulative, limited by V2(a) cutting-off. V2(b) is then conducting heavily and the sweep starts. The anode potential of V1 falls linearly and from this point the action is the same as that occurring in the free-running circuit, except that at the end of the flyback, the voltage across $R_7$ is not allowed to fall to such a value that V2(b) can conduct (the value of $R_7$ is therefore increased from $1k\Omega$ to $2k\Omega$.).

It will be seen from Fig. 2 that the maximum charging current flowing through $R_3$ is equal to 300/75 = 4mA (1mA in Fig. 1). The expression for $C_2$ will have to be modified accordingly:—

$$C_2 = \frac{7t}{10^6} \cdot 0.25.$$

This increase in current is a desirable feature of a high-speed timebase; because there is a limit to the minimum value of sweep condenser (about 15pF), and the greater the charging current—the higher the upper limit of sweep speed. The increase has been made possible at the expense of recovery time, as compared with the free running timebase.

The same remarks as before, concerning linearity, apply to the triggered timebase; but several other points may require clarification.

At high speeds, it is generally more difficult to produce the beam brightening pulse than to initiate the sweep. To brighten the trace a definite excursion of voltage in (ideally) zero time is required, whilst sweep-initiation requires only a finite rate-of-change of voltage. For this reason the bright-up waveform is taken from the same current path as the sweep waveform (see Fig. 2). so that the beam is " turned on " at the same time as the sweep.

The semi-conductor diode, $D_2$, is inserted between $C_1$ and $R_4$ to reduce the possibility of any negative pulses which may appear after the main triggering pulse affecting the state of conduction of V2(a). Without this diode the circuit may be used to give the time integral of a pulse.

The amplitude of triggering pulse should be greater than 10V to ensure consistent results, and, if necessary, it should be passed through a differentiating circuit to reduce the pulse duration to something less than that of the sweep. Apart from this restriction the shape of the pulse is not critical.

No particular valve is quoted for V3, as practically any small thermionic diode will give the required forward current of about 2mA, and the voltage across the valve at this current is not critical.

**Conclusions**—The two circuits given are meant to be of a general nature and are easily adapted to specific applications. For example, by limiting the end of the sweep with a diode connected to " catch " V2(b) anode (Fig. 2), an accurate pulse-delay circuit is formed (the sweep duration depends only on the charging current, the limits of sweep and the sweep capacitor).

In applications where a higher ratio of sweep-to-flyback duration is required (that of the existing circuit is as high as 30 : 1 when $E_c$ is at its minimum) the value of $R_3$ may be increased and a strapped ECC91 could take the place of V2(a). The latter modification also increases the amplitude of the output. Should this prove a desirable feature the value of $R_7$ and $R_{10}$ may be increased to $1.5k\Omega$ and $100k\Omega$ respectively.

Usually this is not worthwhile for use as a c.r.t. timebase because this usually necessitates the use of a paraphase amplifier which effectively doubles the output.

The circuit of Fig. 1 has been used in a general purpose oscilloscope and has proved very satisfactory, producing an almost-ideal saw-tooth. It is difficult to say whether the linearity estimated for this circuit is realized in practice due to the difficulty in detecting such a small percentage (0.007%), but examination of the grid waveform at a deflection sensitivity of 0.5V/cm revealed no change in voltage throughout the sweep period. Assuming that the change was just undetectable (about 0.05 volts) the percentage non-linearity would still be 0.017%, which represents, to all intents and purposes, a perfectly linear sweep.

## Electronic Velocity Analyser

IT is surprising that in these days of comprehensive instrumentation it is still difficult to measure accurately some transient events. One of these is velocity measurement. "EVA," developed by Marconi's W/T Co., Ltd., is designed to do this automatically, giving a highly accurate continuous record of velocity against time on a paper strip. It is a small portable instrument using X-band Doppler radar to provide the information. The range of the basic equipment is 600 ft on targets of at least $\frac{1}{3}$ sq. metre radar reflecting area. The use of a superhet receiver will nearly double this and even greater ranges can be achieved by modifications to the aerial system and transmitter.

The lowest speed range is 2 to 80 m.p.h. This can be extended virtually as far as is desired by the use of ancillary units, for instance, a 60 kc/s oscillator and detector extends the range to 3000 ft/sec. The equipment is thus equally suitable for measuring braking performance of cars or the speed attained by guided missiles. In this latter application the use of "EVA" saves the processing and correlation of many thousands of readings.



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# LETTERS TO THE EDITOR

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

## *Raster*

I AM pleasantly surprised to find on reading "Free Grid's" contribution in the December issue that even I should be able to help him.

As far as I can recollect the word Raster was first used in connection with television by Baron von Ardenne when in 1934 or 1935 he made his first cathode ray tube television receiver which worked with 180 lines. At least he was the first person from whom I heard the expression. It is basically German for the screen used in half-tone printing and is a logical choice of word for what it is intended to describe. We ought in English to refer to a "screen" of so many lines.

May I take this opportunity of thanking "Free Grid" for much constructive amusement which I have obtained from him for well over 30 years.

Taplow, Bucks. H. C. SPENCER.

## *Rigidity of Loudspeaker Diaphragms*

FOR the same reasons as given by Mr. D. A. Barlow in his article in the Dec. 1958 issue, I started work three years ago on devising and perfecting a light and stiff cone material. On the pure chemistry side I had the collaboration of an American chemist, Mr. H. J. Luth. The outcome of that work was briefly mentioned in my "Audio Design Handbook" (Gernsback, New York, 1958) on page 158 where I write—"This material [has] a core of cellular material which is left in an unimpregnated condition so far as the air cells are concerned, but the bonding material is allowed to penetrate the fibres to form a hard lattice-work frame. On the outer surfaces a complete skin is formed of the very hard bonding material".

I submit that, although I didn't call the new cone construction a "sandwich", this invention does give practical effect to Mr. Barlow's needs, for speakers incorporating the principle have been on sale in the U.S. for some 16 months. They work extremely well in centrally-heated American homes but hygroscopy tests in my English laboratories showed them to be susceptible to damp atmosphere, and a good deal of work has had to be done to make them "waterproof". Of course all paper-coned speakers are hygroscopic to some extent, but adopting a stiff cone results in many complications, among which is the aggravation of any inherent defects in the system. What is good for paper cones is not necessarily good for stiff cones.

In contrast to Mr Barlow's expectation that a speaker of the type he mentions could only act over a narrow band of frequencies, experience has proved that it is quite possible to get from a single unit a smooth and very good response from 10 to 15,000c/s, beyond which I do not think it is really necessary to go. The mechanics of a stiff cone do not seem to conform to what has hitherto been accepted as conventional theoretical speaker design. More on this point cannot be given in a short letter.

Exton, Southampton. H. A. HARTLEY.

## *Stereo Under Fire*

I FEEL it necessary to cross swords with Mr. G. A. Briggs, of Wharfedale Wireless Works, Ltd., over his letter on stereo in the November issue.

As long ago as 30 years, a leading firm in whose employ I used to be, tried out stereo on disc. Due to the soft disc material and heavy pickups, it was obviously not practicable in those days, but it does prove that the idea is not a new-fangled gimmick.

Stereo not only largely overcomes the lack of perspective and sound source positioning, but also for some reason as yet unexplained technically, appears to give a much greater dynamic range than is in effect the case, and appears to show up the higher frequencies to a more marked extent than does a single-channel system.

There is one other point to be considered, and that is that many people can hear little above 9kc/s, and "hi-fi" to these people sounds no better than anything else. Stereo, with its added presence and spatial effect will be a great step forward in enjoyment of music and plays to these millions of people

Whilst agreeing wholeheartedly with Mr. Briggs' contentions concerning pickups. I cannot agree with his idea that stereo has been launched too soon, as from my earlier remarks it would appear to be about 30 years overdue.

West Drayton, Middlesex. R. W. BRYANT.

IT seems to me that amongst all the talk about "stereo" sound, one point seems to have been overlooked. This is that what goes under the name of "stereo", or "3D" sound, is neither solid nor three-dimensional. It has only one dimension—width. It has neither height nor front-to-back depth. One can hear a train come in from one side and go out the other side, but one could not hear the angle of approach or recession; neither could one hear a rocket and know that it was going up at an angle of 75° over one's head.

Not of course that one particularly wants to do so, but I only mention these points to underline my contention that "stereo" is a misnomer.

Birmingham, 28. ROBERT G HASELER.

## *Disc Stereo*

MAY I reply briefly to some of the points raised in your December issue?

I agree with "Free Grid" that for technicians and writers no new development can be launched too soon, but I had in mind the general public and those who supply them with equipment. Most people in the industry now agree that the launching of stereo discs before reasonable supplies of compatible pickups were available was an unwise step to take. Even at the time of writing, six months after the fiasco at the London Audio Fair, high-class stereo heads are unobtainable in the dealers' shops. I have obtained interesting specimens from the U.S.A., Denmark and Germany, but this does not help the man in the street.

I also agree with Mr. H. C. Rylatt that the playing conditions at the Radio Show were abnormal. The point is, however, that stereo pickups were overcome by the heat and humidity when "monaural" types carried on without wilting, so it would be foolish to scrap the more reliable type.

As regards performance, some writers are claiming that a stereo head is better than a "mono" type on single-channel discs. This is unlikely, because whatever you do in the design of a stereo head you can do better and more easily in the simpler type. To make a fair test, the two pickups should be mounted to play the same record groove, and be connected through a switch to the same two amplifiers and loudspeakers. As the stereo output—type for type—will be about 6 dB down, the volume control must be turned up when switching to the stereo pickup In all our tests to date, the "mono" pickup gives more top, cleaner bass and better definition, but this (apart from h.f. response) would not apply to the playing of stereo discs.

In conclusion may I say that I am all in favour of good stereo, but, as Mr. B. Wallace points out, we can-



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not go on ignoring solo items indefinitely. What I object to is any assumption that second-rate stereo will or should replace first-class single channel working.

Idle, Bradford. G. A. BRIGGS,
Wharfedale Wireless Works, Ltd.

## *Printed Circuits*

IN extolling the virtues of the printed circuit, unit constructed TV your contributor "Diallist" indicates that he is rather out of touch with modern TV servicing conditions. Any reputable dealer of to-day, if he is to stay in business, must endeavour to have a faulty set back at his customer's house in working order within 24 hours of the original complaint being made. Given good engineers and no printed circuits this can nearly always be achieved. With the printed circuit units, however, the engineer must first definitely locate the fault and decide which unit is to blame. This is not always such an easy matter (e.g. many a poor frame lock has been traced to the video output stage).

Assuming that he guesses right the dealer must then apply to the manufacturer for a new unit, and judging from past experience, he will be very lucky if he gets it within a week. Meanwhile the faulty set must take up precious space in the workshop, and, to save his sanity, the dealer will probably have to lend the customer a set to keep him quiet.

I am sure that most engineers will agree that the only advantage of the printed circuit is that it cheapens production. Otherwise they are a necessary evil and to suggest that they are an aid to service is nonsense.

I understand that in the U.S. the better quality TV receivers are advertised as "definitely containing no printed circuits", and that surely speaks for itself.

London, N.W.6. A. G. TUCKER.

## *Unbiased Valves*

"FREE GRID" avers that the word "valve" has come to mean a one-way device by common usage. As a civil engineer I wish to refute his suggestion. Valves have been in use for centuries to control the flow of fluids, i.e., liquids and gases. Of the many types available only one is intended to restrict the flow to one direction, viz., the reflux or non-return valve. Since in many hydraulic systems, e.g., water supply, flow is normally in one direction only under the influence of gravity or pumps (c.f. batteries or generators) the design of some types of valve has naturally tended to produce devices either intolerant of reverse pressures due to selective provision of machined faces, or incapable of functioning under reverse pressures as in the case of the ball valve in the cistern in the attic, or the common domestic tap, in which a loose plug is screwed down on to its seat against the normal flow.

Just because these valves have been specialized for use in one-way systems, it is not necessarily correct to class them as one-way devices.

The simplest types of valve are functionally two-state devices (albeit imperfect in action when changing over), being normally kept fully open or closed, e.g., sluice, gate and barrel valves which are very poor as flow rate controls having an exponential characteristic. They are the "switches" of the plumbing world. Reflux valves are the "diodes" (fortunately not normally subjected to a.c. which is anathema to the water engineer, being transient in character and potentially disastrous in effect, and known as "water-hammer"). Servo-operated valves are the "triodes", further electrode equivalents not being necessary.

It is, of course, dangerous to press an analogy too far. If "Free Grid" wishes to learn a little more about valves I suggest that he pays a visit to the Institution of Civil Engineers, where he can read a most interesting paper entitled "Control of Flow by Gates and Valves", by Horace Denton Morgan, M.Sc.(Eng.), M.I.C.E., in *Proc. Inst. C.E.*, Vol. 7, p. 537, dated April 9, 1957. After which I look to him for a definition of the phrase "common usage".

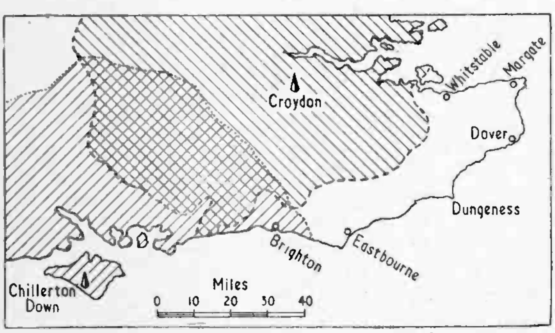
Newbridge, Midlothian. JAMES M. HOY.

# I.T.A. NATIONAL COVERAGE

WITH the opening of the Burnhope, Co. Durham, station in January and the East Anglian and N. Ireland transmitters towards the end of the year, the I.T.A. will then be covering over 90 per cent of the U.K. population. The Authority's ultimate plans for a nation-wide coverage call for stations for a further three major service areas, each with populations large enough to support an independent programme company, and a number of satellites serving areas too small to "make financially possible the operation of independent companies."

The three major areas to be covered are S.W. England, N.E. Scotland and the Solway and it is hoped to bring the stations into service not later than the winter of 1960-61. S.W. England cannot be covered by only one Band III transmitter, as is done by the B.B.C.'s Band I station (North Hessary Tor), and it is, therefore, planned to build two stations, one in Devon and the other in Cornwall, both being operated by the same programme company.

*The proposed Dover station is planned to serve the area outside the present I.T.A. coverage in S.E. England.*




The first of the proposed satellites will be built near Dover and will come into service next winter. As already mentioned, these satellites are being introduced for an economic rather than a technical reason and will not, therefore, operate with the fly power one has come to consider to be the output of such stations; in fact, the Dover transmitter will have an e.r.p. of about 100kW in one direction. Satellites are also being considered for the Berwick area, W. Wales, Inverness, the Channel Islands and the Isle of Man, and possibly along the W. Coast of Scotland.

It is now certain that, despite the inconvenience, delay and expense involved in re-designing at the P.M.G.'s instigation the topmast of the B.B.C.'s tower at Crystal Palace in order to accommodate the I.T.A.'s London aerial, the Authority will not be using it. It intends to build its own tower at Croydon to replace the temporary 200-ft mast and to use a more efficient aerial, thereby improving the overall coverage of the London station. The I.T.A. is also planning the installation of a taller mast at Lichfield.

The completion of these plans by 1961 is expected to extend the I.T.A.'s service to something like 99 per cent of the population using only four of the eight channels in Band III. It still remains to be seen who will be given the other four channels.



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# THE "THIRD METHOD" By J. F. H. ASPINWALL*

## A New System of S.S.B. Generation

An amplitude-modulated radio-frequency signal consists of a carrier radio frequency and two bands of frequencies at the sides of the carrier. These sidebands are caused by the addition and subtraction of the audio frequency to and from the carrier frequency, e.g. a carrier frequency ($f_0$) amplitude modulated by a 1,000 c/s audio tone will produce at the output of the modulator three frequencies (1) $f_0$ c/s, (2) $f_0 + 1{,}000$ c/s, (3) $f_0 - 1{,}000$ c/s, the latter two frequencies being the upper and lower sidebands respectively.

**The "Filter" Method.** In the "conventional" method of single-sideband generation, a carrier radio frequency and the audio-frequency signal are applied to a balanced modulator. The carrier frequency is balanced out of the output leaving only the sum and difference frequencies, i.e., the upper and lower sidebands.

With the aid of a complex filter one of these two sidebands is eliminated leaving a single-sideband signal for further amplification and transmission. The difficulties of this method are, in the main, the design, manufacture and, for commercial purposes, cost of suitable stable filters to operate at radio frequencies with high discrimination, and the care necessary to prevent breakthrough across the filter.

In this method of single sideband production, a downward shift of 1% in the filter pass band will, for a carrier frequency of, say 100 kc/s (a frequency commonly used for single sideband production), give a change in position of 1,000 c/s. This would mean that the filter would move part of its pass band over to the unwanted sideband. Assuming that the modulation frequency band required to be passed is 300 to 3,000 c/s, then the filter would pass frequencies up to 700 c/s in both sidebands and frequencies up to only 2,000 c/s in the upper sideband. Fig. 1 illustrates the vast change in operation which would occur for a change of only 1% in filter characteristic. This gives some idea of the stability required from a single-sideband filter operating at low radio frequencies. It also indicates why the lower frequencies of 50 kc/s or even 25 kc/s are used as carrier frequencies when using filters in the conventional method of single sideband production.

**The "Out-phasing" Method.**—Another method of single sideband generation, which is popular with amateurs because it does not require a complex and expensive filter, is the "out-phasing" method.

The audio input signal is applied to two broadband, a.f. phase-shift networks. These networks advance and retard the phase of the whole of the required audio spectrum by approximately plus and minus 45°. The audio-frequency outputs from the two networks thus have a relative phase shift of approximately 90°. The two audio outputs are applied separately to two balanced modulators. The r.f. carrier applied to these modulators is also in phase quadrature having passed through simple phase shift circuits giving plus and minus 45° phase shifts.

The resultant phases of the sideband outputs from these two modulators are such that, when combined, two of the sidebands add together and the other two subtract and cancel, thus leaving a single sideband output (Fig. 2). This method suffers from the disadvantage that unless the amplitudes are identical and the relative phase shifts are exactly 90°, the cancellation of the unwanted sideband is not complete: thus 1° of error in the phase shift gives an unwanted-sideband level of approximately −40 dB; 2° of error gives approximately −35 dB, 3° approximately −30 dB, etc. In practice it is difficult to design and build 45° phase shift networks to work over the broad audio frequency band required for speech which give this high degree of constancy of

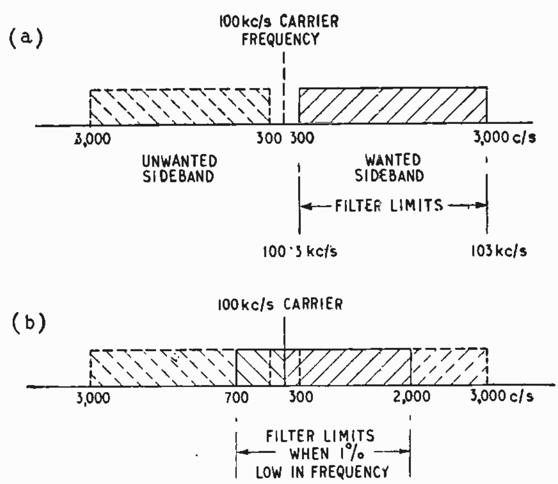


*Fig. 1. (a) Diagram showing pass and rejection bands of filter for eliminating unwanted sideband in "filter"-type s.s.b. generator. (b) Effect of 1% drift (low) in pass band of filter.*

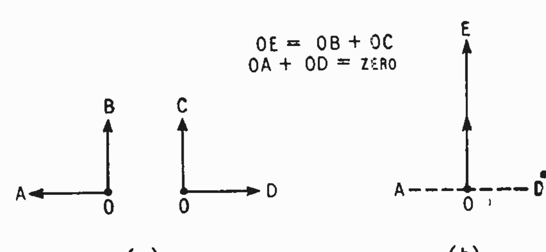


*Fig. 2. (a) Outputs from modulators in "out-phasing"-type s.s.b. generator. OA, OB, OC and OD and sideband outputs (carrier suppressed by modulators) from modulators. Upper and lower sideband outputs are in phase quadrature to each other and the unwanted sidebands are 180° out of phase. (b) Combining the output results in OA cancelling OD and OB reinforcing OC, so giving a s.s.b. signal.*

*Communications Laboratory, Redifon, Ltd.



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attenuation and accuracy of phase shift. A compromise system is often used, which gives about 2° of phase-shift error at some frequencies, using high-stability close-tolerance components. This gives an unwanted sideband level of about −30dB to −35 dB which could interfere with users of the other sideband. Some equipments use filters after this type of s.s.b. generator to reduce the unwanted sideband still further. In this case the system is a combination of the conventional filter system and the phasing system and may suffer from some of the disadvantages and complications of both.

Another disadvantage of the out-phasing system is that the balanced modulators have to be balanced very accurately: they must be sufficiently stable to remain balanced for long periods of time if fully suppressed carrier operation is required. If even a small amount of carrier should appear it could cause interference with an operator using the "other" sideband of the channel, especially if he were using an automatic frequency-control system.

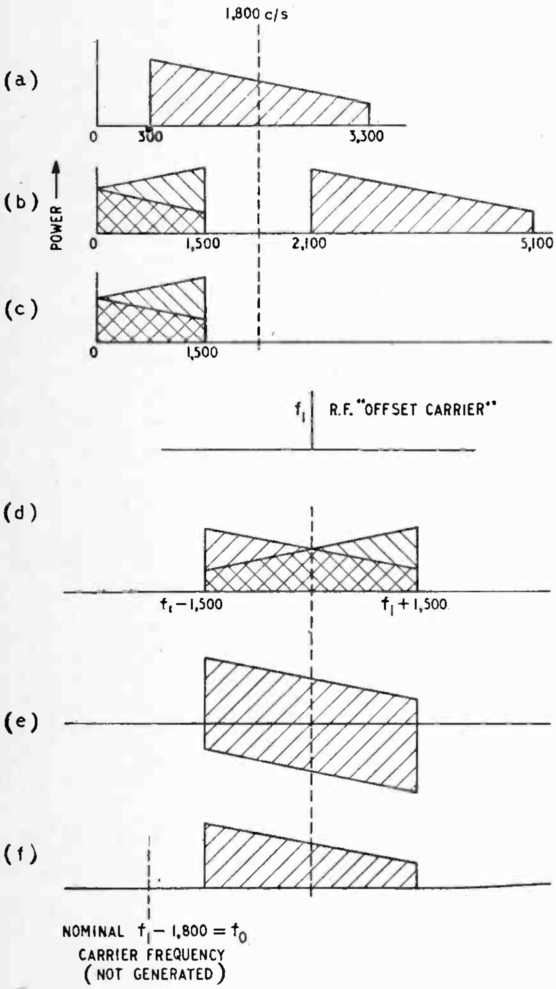


*Fig. 3. (a) Power/frequency spectrum of audio input to modulator. (b) Audio modulator output, nominal (suppressed) carrier frequency 1,800c/s. Note the "folding" of the lower sideband. (c) Output from low-pass filter, cut-off frequency 1,500c/s. (d) Output from first modulator chain (chain "B" in Fig. 5). (e) Output from second modulator chain (chain "A" in Fig. 5). (f) Sum of outputs of modulator chains "A" and "B" gives a single-sideband signal with nominal carrier frequency $f_0$, 1,800c/s below $f_1$, the r.f. carrier. Note that $f_0$ is not generated. N.B. The power/frequency spectra shown apply only to speech.*

From the foregoing brief description, it will be seen that these first two methods rely on balancing out the unwanted products of a.m.—the carrier and the unwanted sideband, both of which, although undesired, are still generated.

A different and logical approach to the problem is to avoid generating the carrier or the unwanted sideband altogether. This approach is used in a method now known as the "Third Method" of single-sideband generation which was described by D. K. Weaver in the *Proceedings of the I.R.E.* for December, 1956.

In the following discussion, production of the upper sideband only will be considered for simplicity. The same general principles naturally can be applied to the generation of the lower sideband.

**The "Third Method"**—Consider the radio frequency spectrum to be occupied by the wanted sideband, say 3,000 c/s wide. It will be seen that this same spectrum could be occupied by a "carrier" frequency $f_1$ placed centrally in the wanted-sideband spectrum, and two "sidebands" each extending over half the width of the wanted sideband spectrum (double cross-hatched part of Fig. 3(d)). These two "sidebands" would be produced by modulating the "carrier" $f_1$, with audio frequencies of up to half the width of the wanted sideband, i.e. audio frequencies of up to 1,500 c/s.

Thus it is possible by modulating the offset "carrier" frequency $f_1$ with audio frequencies ranging from 0 c/s to 1,500 c/s to produce a frequency spectrum which will occupy only the wanted sideband width. At this stage we are considering only how to "fill" the required spectrum and restrict the radiated bandwidth. How this bandwidth is "filled" with the correct intelligence will be described later.

It is a relatively simple matter to produce a low-pass audio filter to pass 0 c/s to 1,500 c/s and attenuate rapidly above 1,500 c/s. The attenuation can be made as high as may be required with quite-wide-tolerance components. The stability of the filter need not be particularly good as, for example, a downward change of 1% in the filter pass band will only alter the width of the radiated sideband by a total of $2 \times 1\% \times 1{,}500 = 30$ c/s. The position of the sideband will remain unaltered because it is symmetrical about the fixed "offset carrier" frequency $f_1$.

Comparing this result with the result of the 1% drift in the "filter" method, it will be seen that the filter problem using the "third method" is greatly simplified, as it is easier and more logical to restrict the bandwidth to that of the audio spectrum at audio frequencies rather than at radio frequencies.

Having now produced a radio frequency spectrum which, by reason of the audio filter, cannot be any wider than 3,000 c/s, the problem is how to produce the correct intelligence in this spectrum.

For speech reproduction to be intelligible, there is no necessity to reproduce frequencies below 300 c/s, so this gives a lower limit of frequency to transmit. As we have selected a sideband spec-

(*Continued on page 41*)



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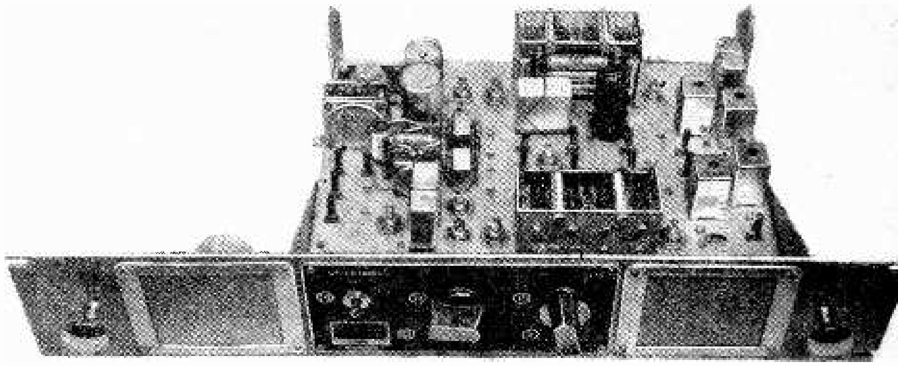
Transistorized modulator deck of the Redifon GR400 radio-telephone. The unit is 19in wide and $3\frac{1}{2}$in high.



trum 3,000 c/s wide, the upper-frequency limit therefore will represent 3,300 c/s. Therefore the arithmetical centre of this band, which is the offset "carrier" frequency $f_1$, represents a single sideband frequency corresponding to 1,800 c/s. It should be noted that $f_1$ is not the nominal carrier frequency ($f_o$) (which is not generated and lies 300 c/s below the bottom of the spectrum which has been generated).

1,800 c/s, therefore, is the centre of the transmitted audio spectrum. If the audio input can be "folded over" on itself about the centre frequency of 1,800 c/s, then all the necessary information can be contained in a spectrum of only 0-1,500 cycles, which can then pass through the filter to the r.f. modulator (Fig. 3(b)).

The audio input spectrum can be "folded over" about the centre frequency of 1,800 c/s by applying both it and a 1,800 c/s tone to a ring modulator. The ring modulator can be balanced so as to remove all the audio-input frequencies and the 1,800 c/s audio-carrier voltage from its output. The output will consist then of the sum frequencies of 1,800 c/s plus audio of 300 to 3,300 c/s, i.e. 2,100-5,100 c/s (which will be removed by the filter) and the difference frequencies between the audio and the 1,800 c/s. For input frequencies of 300 c/s up to 1,800 c/s, the difference frequencies will be 1,500 c/s down to zero so that the lower part of the input audio spectrum will be inverted and reduced in frequency. Input frequencies of 1,800 c/s up to 3,300 c/s will produce beat frequencies of zero up to 1,500 c/s. This is the same resultant spectrum as for the lower frequencies and hence the whole of the audio spectrum will have been "folded" in two and reduced in frequency (Fig. 3(c)).

This "folded" spectrum thus contains the original information in a bandwidth of only 1,500 c/s.

As shown earlier, the "folded" spectrum can be used to modulate the "offset carrier" $f_1$ where the spectrum will be "unfolded" to occupy the full single-sideband spectrum of 3,000 c/s.

However, an ambiguity was introduced in the first modulator when the original audio spectrum was "folded over." Any given frequency in the output spectrum of 0 to 1,500 c/s could have been produced by a tone either above or below the 1,800 c/s audio carrier frequency. Similarly, when one frequency in the 0 to 1,500 c/s spectrum is used to modulate the "offset carrier" $f_1$, two "sidebands" are produced which correspond to the two possible audio frequencies in the original speech band. In other words, the sideband produced in this manner will contain equal amounts of direct and "inverted" speech. It will be seen at this stage that the nominal carrier frequency could be 300 c/s below the bottom end of the sideband spectrum or 300 c/s above. In the latter case, the same spectrum could be considered to be the lower sideband of another nominal carrier frequency $f_o + 3,600$ c/s (Fig. 3(d)). In either case, the unwanted inverted-speech component must be removed.

We have already seen that the phasing method of single-sideband production generates two sets of sidebands, by means of two separate and differently phased modulator chains, and then adds them together giving cancellation of the unwanted sideband and reinforcement of the wanted sideband.

A similar approach to this is used in the "third method" of single sideband production where the "wanted sideband" is considered to be the final frequency in the s.s.b. spectrum which represents the original audio frequency.

The "image" frequency representing inverted speech in the output spectrum is considered to be the "unwanted sideband."

To produce cancellation of the inverted sideband the first audio modulator, filter and r.f. balanced modulator are duplicated.

A relative phase shift of 90° is introduced between the 1,800 c/s tones supplying audio carriers to the two audio modulators. This is achieved by simple r.c. circuits which advance the phase of the 1,800 c/s a.f. carrier by 45° for one modulator and retard the phase by 45° for the other modulator. Similarly the phase of the offset "carrier" frequency $f_1$ is advanced and retarded by 45° for the two separate r.f. modulators as in the phasing method. It will be noted that the 90° relative phase shifts in both cases are produced at fixed frequencies (as distinct from the whole audio spectrum) and so can be made exactly 90° without any compromise being necessary.

The effect of the two different-frequency phase shifts in the two modulator chains is to produce "sidebands" of the "offset carrier" of such a phase relationship, i.e. quadrature, that when combined the inverted spectrum cancels and the wanted direct spectrum is reinforced in a similar manner to the reinforcement of the "wanted"



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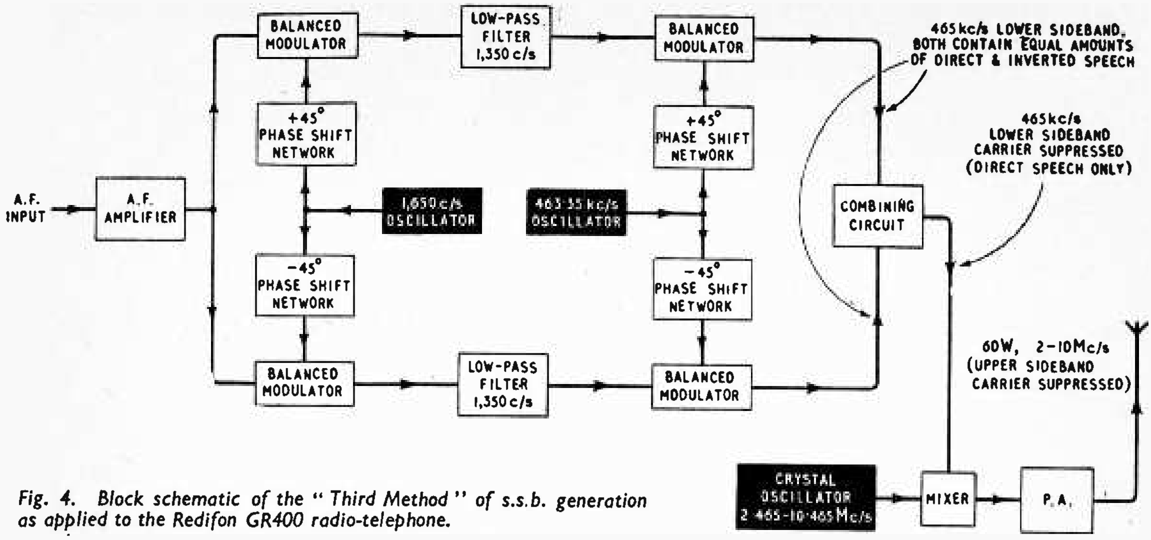


*Fig. 4. Block schematic of the " Third Method " of s.s.b. generation as applied to the Redifon GR400 radio-telephone.*

sideband in the phasing method of s.s.b. generation. (Fig. 3 (d, e and f).)

In this manner a true s.s.b. signal with fully suppressed carrier is produced. The s.s.b. signal may be developed at any required radio frequency, as filtering out of the unwanted sideband is not required at r.f. because none is generated.

If a " third method " s.s.b. generator is adjusted wrongly or suffers from tampering by unskilled personnel it cannot radiate outside its sideband spectrum. For instance, if the balance of the output modulators is disturbed then the " offset carrier " frequency $f_1$ will appear in the user's own spectrum as the equivalent of a sideband produced by an 1,800 c/s tone. The user will be the only person to suffer since this will give him a " whistle " in the centre of his own sideband spectrum.

Similarly, if the phasing or balance of the two channels is disturbed, the user again will be the only person to suffer since he will then produce a small amount of " inverted " speech entirely within his own sideband spectrum. Practical experiments have shown that removing completely the second modulator chain so that equal amounts of inverted and direct speech are produced does not render the signal unintelligible. The ear and brain cannot understand the meaningless " inverted " speech and thus tend to ignore it as an unwanted interference occurring at the same time as the intelligible direct speech.

This is a very useful feature of the " third method " since half of the generator can be damaged or a fault can occur in it; but in an emergency the equipment can still be used to produce an intelligible output.

The same system may be used in reverse for reception. A radio frequency will, if it is within 1,500 c/s of the " offset carrier " frequency $f_1$ produce an audio-frequency beat note which can be passed through the audio filters. If the radio frequency is more than 1,500 c/s away from $f_1$ then any beat note will be severely attenuated by the filters. The a.f. beat note of up to 1,500 c/s is then applied to the audio modulator whereupon the sum and difference frequencies between the a.f. beat note and the 1,800 c/s oscillator will be produced.

These two frequencies will represent a.f. " inverted " and direct speech. As in the generation of the s.s.b. signal, the addition of the outputs of the two modulator chains will, by reason of the phase shifts, give cancellation of the " inverted " speech and reinforcement of the direct speech.

When used for reception, the " third method " has the same advantages as when it is used for transmission. Any tampering or maladjustment of the circuits will not make the system unusable, it will merely produce either a whistle if the modulators are upset or a small amount of " inverted " speech; which, although perhaps annoying, does not make the signal unintelligible.

This method of single-sideband generation is used in the Redifon GR400 radio-telephone. In this equipment the s.s.b. generator and demodulator, together with the microphone and loudspeaker amplifiers, are combined into one small transistorized unit. In this case the audio oscillator operates at 1,650 c/s instead of 1,800 c/s and the low-pass filters cut off at 1,350 c/s instead of 1,500 c/s. This combination gives an audio frequency band 2,700 c/s wide centred on 1,650 c/s i.e. an a.f. spectrum of 300 to 3,000 c/s.

For convenience of switching radiated frequencies in the GR400 the s.s.b. generation and demodulation is performed at the fixed intermediate frequency of

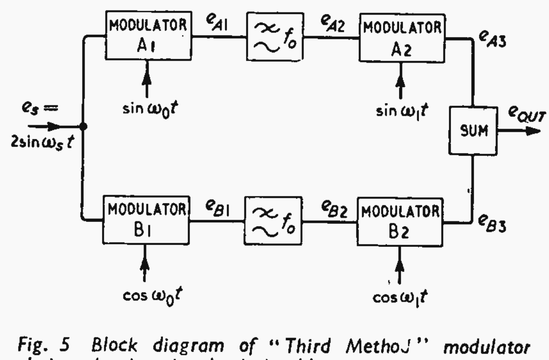


*Fig. 5 Block diagram of " Third Method " modulator chains, showing signal relationships.*



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465 kc/s. When transmitting the s.s.b. output is mixed with a local, switched crystal oscillator to give the required radiated frequencies. When used for reception the output from a normal 465 kc/s receiver i.f. amplifier is applied to the unit. Fig. 4 shows in block form the application of these principles to the GR400.

Using this method of s.s.b. generation and demodulation the Redifon GR400 radio-telephone can achieve an overall "link" distortion (from microphone input of one GR400, via the radio circuit, to the loudspeaker output of another GR400) of 5 to 6%, which is very reasonable for a radio-telephone. Intermodulation products produced in the transistorized s.s.b. generator using the "third method" are 35 to 40 dB down, the non-linearity being mainly in the transistor amplifiers.

For those who would like to look more closely at the method of operation of the "third method" the following analysis may help.

For convenience let the input signal be

$$e_s = 2\ \sin\omega_s t \quad \cdots \quad (1)$$

(see Fig. 3(a) and Fig. 5.)

∴ The outputs of modulators A1 and B1 are:—

$$e_{A1} = e_s \sin \omega_0 t \quad \cdots \quad (2)$$

$$e_{B1} = e_s \cos \omega_0 t \quad \cdots \quad (3)$$

respectively where $\omega_o = 2\pi f_o$ and $f_o$ is the frequency of the local audio oscillator.

Substituting (1) in (2) and (3)

$$e_{A1} = 2 \sin \omega_o t.\ \sin \omega_o t$$
$$= \cos (\omega_s - \omega_o)t - \cos (\omega_s + \omega_o)t \quad \cdots \quad (4)$$

and $e_{B1} = 2 \sin \omega_s t.\ \cos \omega_o t$

$$= \sin (\omega_s + \omega_o)t + \sin (\omega_s - \omega_o)t \quad \cdots \quad (5)$$

(see Fig. 3(b)).

$e_{A2} = e_{A1}$ less frequencies greater than $f_o$ because of the filter

$$\therefore e_{A2} = \cos\ (\omega_s - \omega_o)t \quad \cdots \quad (6)$$

Similarly $e_{B2} = \sin (\omega_s - \omega)t \quad \cdots \quad (7)$

(see Fig. 3(c)).

The output of modulators A2 and B2 respectively:—

$$e_{A3} = e_{A2} \sin \omega_1 t = \cos (\omega_s - \omega_o)t.\ \sin \omega_1 t$$
$$= \tfrac{1}{2} \sin\ (\omega_s - \omega_o + \omega_1)t - \tfrac{1}{2} \sin\ (\omega_s - \omega_o - \omega_1)t \quad \cdots \quad (8)$$

(see Fig. 3(e)).

$$e_{B3} = e_{B2} \cos\ \omega_1 t = \sin\ (\omega_s - \omega_o)t.\ \cos\ \omega_1 t$$
$$= \tfrac{1}{2} \sin\ (\omega_s - \omega_o + \omega_1)t + \tfrac{1}{2} \sin\ (\omega_s - \omega_o - \omega_1)t \quad \cdots \quad (9)$$

where $\omega_1 = 2\pi f_1$ and $f_1$ is the frequency of the local r.f. oscillator (see Fig. 3(d)).

But $e_{out} = e_{A3} + e_{B3} = (8) + (9)$

$$\therefore e_{out} = \sin (\omega_s - \omega_o + \omega_1)t \quad \cdots \quad (10)$$

(see Fig. 3(f)).

It should be noted that the nominal carrier frequency is represented by $\omega_1 - \omega_o$. (This frequency is not generated; therefore it cannot appear in the output.)

# Commercial Literature

**Constructors' Components and Accessories,** a 100-page catalogue of over 4,000 items produced by well-known manufacturers. Available from Home Radio (Mitcham), 187, London Road, Mitcham, Surrey, price 2s including postage.

**Cable-Makers' , Instrumentation,** including capacitance monitors, wire temperature indicator, high-voltage test sets, an analogue computer, etc. (13 main groups of instruments altogether). Brief details on a leaflet from the Addison Electric Company, Bosworth Road, London, W.10.

**B.A. Spanners,** double-ended, in chrome alloy steel, available singly or as sets in plastic wallets. Leaflet from Thos. Smith and Sons of Saltley, Saltley Mill, Birmingham, 8.

**Automatic Synchronous Clock** suitable for elapsed time measurements, etc., as an alternative to the more expensive process timers. Automatic reset is incorporated, and models are available with dials ranging from 0-30 seconds to 0-120 hours. Leaflet from the Electrical Remote Control Co., The Fairway, Bush Fair, Harlow, Essex.

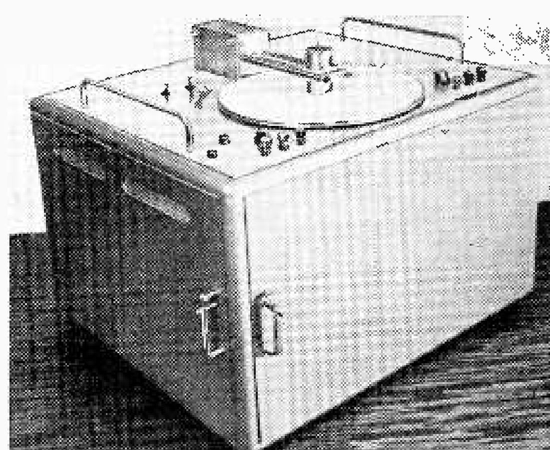
**Marine Radar Simulator.**—Systems are built up from three basic units—an operator's control box (mounted on the p.p.i.) and two types of instructor's racks of equipment. Simulation facilities for "own ship," up to five target ships, coastlines, tide effect, noise and clutter, etc., and three types of display. Brochure from Ultra Electric, Western Avenue, London, W.3.

**Pocket Valve Data** booklet of Mullard types, with characteristics, base connections and equivalents. Includes semiconductors and c.r. tubes. From Mullard, Ltd., Mullard House, Torrington Place, London, W.C.1.

**Magnetic-Tape Data Recorder** with six tape speeds ($1\tfrac{7}{8}$ to 60 inches/sec), up to 14 tracks (on 1-inch tape) and frequency response of 100c/s to 130kc/s (at 60 inches/sec) on direct recording. For digital recording the p.r.f. can be up to 10kc/s, using the non-return-to-zero method. Recording by p.d.m. and f.m. carrier can also be used. Brochure on the FR-100A from the Ampex Corporation, 934, Charter Street, Redwood City, California, U.S.A.

**pH Meter,** self-contained, of the potentiometric type, requiring no special skill in operation. An electrometer valve is used and the accuracy is 0.05pH unit. Total range: 0-14pH units. Leaflet from the Doran Instrument Co., Stroud, Glos. Also leaflets on a thermo-couple potentiometer (range 2mV) and resistance boxes and bridges.

**Magnetic Tape Containers** in the form of "books" bound in red and black imitation leather, measuring 10in × $7\tfrac{1}{2}$in × $1\tfrac{1}{4}$in. Also racks for six of the "book" containers. Leaflet from the MSS Recording Company, Colnbrook, Bucks.



*Automation in automation design is made possible by the Automatic Nyquist Diagram Plotter for servo-mechanisms manufactured by Servo Consultants Ltd., of 17, Woodfield Road, London, W.8. The output of an electro-mechanical frequency generator is fed into the servo-mechanism, the output of which feeds both an amplifier and phase detector. These in turn feed two servo-systems which automatically plot the phase and amplitude of the servo-mechanism from 0.25c/s to 100c/s.*



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# GUIDE TO EUROPEAN BAND II STATIONS

THERE are now well over 800 f.m. sound broadcasting stations in Europe operating in Band II, and these are listed below. Following the carrier frequency in Mc/s we give, where known, the max. e.r.p. in kW, the station location and a symbol for the country (see abbreviations at foot of page). Where a station is operated by an organization other than the national broadcasting authority this is indicated in brackets. There are no U.S.S.R. stations in Band II. The Soviet broadcasting service uses the upper part of Band I and adjacent channels.

| | | | |
|---|---|---|---|
| 87.60 | | Poitiers (A.F.N.) | F |
| | 80 | Berlin* | G |
| | 0.5 | Geislingen | G |
| | 100 | Oldenburg | G |
| | 0.1 | Tegernseer Tal | G |
| | 25 | Witthoh-Hegau | G |
| | 3 | Würzburg | G |
| | | M. Morello | Sd |
| | | M. Sagne | Sd |
| | | Vaberg | Sw |
| 87.70 | | Ljubljana | Y |
| 87.80 | 50 | Caen | F |
| | | Metz (A.F.N.) | F |
| | | Austagder | No |
| | | Hovdefjell | No |
| 87.90 | 0.1 | Stubnerkogel | A |
| | | Pic du Midi | F |
| | 7.5 | Blauen | G |
| | 40 | Heidelberg | G |
| | 0.1 | Landshut | G |
| | 100 | Langenberg | G |
| | 0.5 | Lubeck | G |
| | 0.5 | Ulm-Wilhelmsburg | G |
| | | M. Creo | I |
| | | M. Vergine | I |
| | | Teramo | I |
| | | Rabat | M |
| | 1.5 | Celerina | Sd |
| | 60 | Oestersund | Sw |
| 88.00 | | Dijon | F |
| | | Sogn | No |
| 88.10 | | Aalborg | D |
| | | M. Venda | I |
| | 60 | N. Hessary Tor | U |
| | 120 | Sandale | U |
| 88.20 | | Sonnwendstein | A |
| | 100 | Harz | G |
| | 12 | Raichberg | G |
| | 5 | Scharteberg | G |
| | 15 | Irnsum | Ne |
| | 1 | Leuk-Feschel | Sd |
| 88.30 | | Taivalkoski | Fd |
| | 0.5 | Lindau | G |
| | | Jerusalem | Is |
| | | Borgo, Val di Taro | I |
| | | M. Conero | I |
| | | M. St. Angelo | I |
| | | Sondrio | I |
| | | Spoleto | I |
| | 120 | Sutton-Coldfield | U |
| 88.50 | 0.3 | Innsbruck | A |
| | 9 | Gelbelsee | G |
| | | Fueino | I |
| | | M. Scuro | I |
| | | M. Serra | I |
| | | Noto | I |
| | | Trapani | I |
| | 60 | Pontop Pike | U |
| | 60 | Rowridge | U |
| | | Maribor | Y |
| | | Pohorje | Y |
| 88.53 | 55 | Feldberg-Taunas | G |
| 88.54 | 50 | Hamburg | G |
| 88.60 | | Paganella | I |
| 88.70 | | Pomarico | I |
| | 60 | Blaen-Plwy | U |
| | 60 | Meldrum | U |
| 88.80 | 50 | St. Pölten | A |
| | 60 | Berlin | G |
| | 18 | Burgstall | G |
| | 2 | Göttingen | G |
| | 15 | Lingen | G |
| | 4.5 | Mühlacker | G |
| | 17 | Kristiansand | No |
| 88.85 | 0.1 | Bad Mergentheim | G |
| | 0.5 | Braunschweig | G |
| 88.90 | 10 | Mikkeli | Fd |
| | | M. Favone | I |
| | | M. Limbara | I |
| (88.90) | | Maranza | I |
| | | Pantelleria | I |
| | | Luxembourg | L |
| | 6 | Llangollen | U |
| 89.00 | | Bordighera | I |
| | | La Spezia | I |
| | | M. Venda | I |
| | | Polcevera | I |
| 89.05 | 3 | Traunstein | G |
| 89.10 | 50 | Aalen | G |
| | 0.1 | Hochrhein | G |
| | 60 | Langenberg (B.F.N.) | G |
| | | Ascoli Piceno | I |
| | | Martina Franca | I |
| | | Sulmona | I |
| | 120 | Wrotham | U |
| 89.15 | 15 | Nordhelle (B.F.N.) | G |
| 89.20 | | Forssa | Fd |
| | | Schwerin | G |
| 89.25 | | Warsaw | P |
| 89.30 | | Jerusalem | Is |
| | | Alleghe | I |
| | | Courmayeur | I |
| | | Naples | I |
| | | Ogliastra | I |
| | 120 | Holme Moss | U |
| 89.35 | 60 | Kreuzberg | G |
| 89.36 | 50 | Bourges-Neuvy | F |
| 89.40 | 0.3 | Betzdorf | G |
| | 18 | Bremen | G |
| | 60 | Hornisgrinde | G |
| | 1 | Rotbühl | G |
| | | Borlänge | Sw |
| 89.50 | | Chaumont (A.F.N.) | F |
| | 3 | Tammisaari | Fd |
| | | Genoa | I |
| | | Gorizia | I |
| | | Marca Pusteria | I |
| | | Mione | I |
| | | M. Sambuco | I |
| 89.60 | | Alkmaar-Winkel | Ne |
| | 2 | Llanddona | U |
| | 6 | Rosemarkie | U |
| 89.69 | 90 | Hoher Meissner | G |
| 89.70 | 1 | Pfunder | A |
| | 150 | Metz-Luttange | F |
| | 0.5 | Berchtesgaden | G |
| | 0.5 | Bonn | G |
| | 0.5 | Hardberg | G |
| | 20 | Hühnerberg | G |
| | | Cascia | I |
| | | Garfagnana | I |
| | | Lagonegro | I |
| | | Rome | I |
| | | Stazzona | I |
| | 120 | Tacolneston | U |
| 89.74 | 0.5 | Würzberg | G |
| 89.75 | 0.5 | Cologne | G |
| 89.80 | | Dresden | G |
| | | Katowice | P |
| 89.90 | 0.8 | Baden-Baden | G |
| | | M. Venda | I |
| | | M. Soro | I |
| | | Teramo | I |
| | 120 | Kirk o' Shotts | U |
| 89.95 | 120 | Wenvoe | U |
| 90.00 | 90 | Verdun (A.F.N.) | F |
| | 10 | Berlin | G |
| | 3 | Coburg | G |
| | 25 | Haardtkop | G |
| | 15 | Heide | G |
| | 0.05 | Monschau | G |
| | 100 | Waldenburg | G |
| | 100 | Wendelstein | G |
| | | Casablanca | M |
| | | Oujda | M |
| 90.05 | 5 | Aachen | G |
| | | Novi Sad | Y |
| 90.10 | 18 | Koli | Fd |
| | 10 | Kristiina | Fd |
| | | Alcamo | I |
| (90.10) | | B. go Val Sugana | I |
| | | M. Argentario | I |
| | | Modica | I |
| | | Mondovi | I |
| | | M. Celentone | I |
| | | M. Creo | I |
| | | M. Vergine | I |
| | | Potenza | I |
| | 60 | Divis | U |
| 90.20 | | Vestjylland | D |
| | 100 | Langenberg | G |
| | | Oslo | No |
| | | Parede | P |
| 90.30 | | Orleans (A.F.N.) | F |
| | 0.5 | Bad Reichenhall | G |
| | 50 | Verden (B.F.N.) | G |
| | 25 | Weinbiet | G |
| | | Jerusalem | Is |
| | | M. Conero | I |
| | | Plose | I |
| | | Sassari | I |
| | | Spoleto | I |
| | 1 | Fadara | Sd |
| | 60 | N. Hessary Tor | U |
| | 120 | Sandale | U |
| 90.50 | 60 | Grünten | G |
| | | Fucino | I |
| | | M. Scuro | I |
| | | M. Serra | I |
| | | Noto | I |
| | | Trapani | I |
| | 120 | Sutton Coldfield | U |
| 90.60 | 2 | Kiel | G |
| | | Borgo, Val di Taro | I |
| | | Domodossola | I |
| | | Milan | I |
| | | Sondrio | I |
| | | Bjerkreim | No |
| 90.63 | 0.1 | Stubnerkogel | A |
| 90.65 | 100 | Teutoburger Wald | G |
| 90.70 | 10 | Tampere | Fd |
| | | M. Bignone | I |
| | | M. Serpeddi | I |
| | | Paganella | I |
| | | Pomarico | I |
| | | Terminillo | I |
| | 60 | Pontop Pike | U |
| | 60 | Rowridge | U |
| 90.80 | | Copenhagen | D |
| 90.85 | 15 | Bamberg | G |
| 90.90 | 5 | Hannover | G |
| | 9 | Hohe Linie | G |
| | 2.5 | Koblenz | G |
| | 5 | Münster | G |
| | 100 | Stuttgart | G |
| | | Bologna | I |
| | | M. Favone | I |
| | | Pantelleria | I |
| | | Gulen | No |
| | 12 | Steinkjer | No |
| | | Attinghausen | Sd |
| | 60 | Blaen-Plwyf | U |
| | 60 | Meldrum | U |
| 91.00 | 15 | Imatra | Fd |
| | | Marlow | G |
| | | Raum Jessen | G |
| 91.10 | | Mulhouse | F |
| | | Ascoli Piceno | I |
| | | Bellagio | I |
| | | Bordighera | I |
| | | Colle Visentin | I |
| | | Candoglia | I |
| | | Maranza | I |
| | | Martina Franca | I |
| | | Polcevera | I |
| | | Sulmona | I |
| | 6 | Llangollen | U |
| 91.20 | | Schoeckl | A |
| | 55 | Biedenkopf | G |
| | 0.5 | Geislingen | G |
| | 9 | Hohenpeissenberg | G |
| (91.20) | 10 | Oldenburg | G |
| | 19 | Potzberg | G |
| | 25 | Wittoh-Hegau | G |
| | | La Dole | Sd |
| | | Ovc | Sd |
| 91.30 | | Marseilles | F |
| | | Alleghe | I |
| | | Carrara | I |
| | | Naples | I |
| | | P. Badde Urbara | I |
| | | Trieste | I |
| | 120 | Wrotham | U |
| 91.50 | 50 | Caen | F |
| | | Toulouse | F |
| | 60 | Brodjacklriegel | G |
| | 3 | Bungsberg | G |
| | 40 | Heidelberg | G |
| | 0.25 | Kleve | G |
| | 0.5 | Ulm-Wilhemsburg | G |
| | | Brisighella | I |
| | | Gardone Val Trompia | I |
| | | M. Sambuco | I |
| | | Rovereto | I |
| | | Ladir | Sd |
| | 1 | St. Moritz | Sd |
| | 1 | Orebro | Sw |
| | | Ostersund | Sw |
| | 120 | Holme Moss | U |
| 91.53 | 2 | Bonn (B.F.N.) | G |
| 91.60 | 30 | Kuopio | Fd |
| | | Stulpe | G |
| 91.70 | | Aarhus | D |
| | | Cascia | I |
| | | Garfagnana | I |
| | | Lagonegro | I |
| | | Mione | I |
| | | Premeno | I |
| | | Rome | I |
| 91.80 | 0.5 | Bremerhaven | G |
| | 60 | Ochsenkopf | G |
| | 12 | Raichberg | G |
| | 6 | Eifel | G |
| | 0.5 | Siegen | G |
| | 15 | Hoogezand | Ne |
| | | Stord | No |
| | 2 | Llanddona | U |
| | 6 | Rosemarkie | U |
| 91.85 | 0.5 | Munich-Freimann | G |
| 91.90 | 40 | Helsinki | Fd |
| | | Genoa | I |
| | | Marca Pusteria | I |
| | | M. St. Angelo | I |
| | | M. Soro | I |
| | | Stazzono | I |
| | | Teramo | I |
| | 120 | Tacolneston | U |
| 92.00 | | Tel Aviv | Is |
| 92.10 | | Patscherkofel | A |
| | 0.25 | Berlin | G |
| | 5 | Hamburg | G |
| | | Alcamo | I |
| | | B. go Val Sugana | I |
| | | M. Argentario | I |
| | | M. Celentone | I |
| | | Modica | I |
| | | M. Vergine | I |
| | | Potenza | I |
| | | Turin | I |
| | | Rabat | M |
| | | Goteborg | Sw |
| | 120 | Kirk o' Shotts | U |
| | 120 | Wenvoe | U |
| 92.13 | 55 | Feldberg-Taunas | G |
| 92.20 | | Lille | F |
| | 10 | Jyväskylä | Fd |
| 92.30 | | Como | I |
| | | Asiago | I |

*B.B.C. European Service

(Continued on page 45)

**Abbreviations:** A, Austria; B, Belgium; C, Cyprus; D, Denmark; Fd, Finland; F, France; G, Germany East; G, Germany West; H, Hungary; Is, Israel; I, Italy; L, Luxembourg; M, Morocco; Ne, Netherlands; No, Norway; P, Poland; Pl, Portugal; R, Rumania; S, Spain; Sw, Sweden; Sd, Switzerland; U, United Kingdom; V, Vatican City; Y, Yugoslavia; A.F.N., American Forces Network; B.F.N., British Forces Network.



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## EUROPEAN BAND II STATIONS (Continued)

| | | | |
|---|---|---|---|
| (92.30) | | Cima Penegal | I |
| | | Gorizia | I |
| | | M. Conero | I |
| | | Sassari | I |
| | | Spoleto | I |
| | 60 | Divis | U |
| 92.40 | | Schmittenhöhe | A |
| | 0.5 | Göttingen | G |
| | 18 | Waldburg | G |
| | | Horby | Sw |
| | | Stockholm | Sw |
| 92.50 | 0.8 | Baden-Baden | G |
| | | Cortina | I |
| | | Fucino | I |
| | | Mondovi | I |
| | | M. Scuro | I |
| | | Noto | I |
| | | San Pellegrino | I |
| | | Trapani | I |
| | | Valle S. Giacomo | I |
| | | Porto | Pl |
| | 60 | N. Hessary Tor | U |
| | 120 | Sandale | U |
| 92.60 | | St. Germain-en-Laye (A.F.N.) | F |
| | | Stülpen | G |
| 92.67 | 0.1 | Buchen-Walldürn | G |
| 92.70 | | Lyon Mont-Pilat | F |
| | 50 | Aalen | G |
| | 0.07 | Hochrhein | G |
| | | M. Serpeddi | I |
| | | Paganella | I |
| | | Pomarico | I |
| | 120 | Sutton Coldfield | U |
| 92.72 | 0.05 | Wertheim | G |
| 92.80 | | Kemi | Fd |
| | | Berlin | G |
| | | Hälsingborg | Sw |
| | 6 | Douglas, | U |
| 92.90 | | M. Creo | I |
| | | M. Favone | I |
| | | M. Serra | I |
| | | Pantelleria | I |
| | | Villar Perosa | I |
| | | Madrid | S |
| | 60 | Pontop Pike | U |
| | 60 | Rowridge | U |
| | | Maribor | Y |
| 93.00 | 1 | Klagenfurt | A |
| | 10 | Pyramidenkogel | A |
| | 50 | Bourges-Neuvy | F |
| | 0.3 | Betzdorf/Westerw | G |
| | 15 | Flensburg | G |
| | 6 | Herford (B.F.N.) | G |
| | 60 | Hornisgrinde/Schw | G |
| | 0.5 | Kreuzeck | G |
| | 0.5 | Passau | G |
| | 1 | Leuk-Fesche' | Sd |
| | 0.5 | Schulz | Sd |
| | | Borlänge | Sw |
| 93.10 | 25 | Vaasa | Fd |
| | | Ascoli Piceno | I |
| | | Colle Visentin | I |
| | | Martina Franca | I |
| | | Sulmona | I |
| | 60 | Blaen-Plwyf | U |
| | 60 | Meldrum | U |
| 93.20 | 0.3 | Stuttgart | G |
| | | Bellagio | I |
| | | Candoglia | I |
| | | Courmayeur | I |
| | | La Spezia | I |
| | | M. Bignone | I |
| | | Malcesine | I |
| 93.30 | 1 | Pfunder | A |
| | | Aalborg | D |
| | | Bordeaux | F |
| | 150 | Metz-Luttange | F |
| | | Halle | G |
| | 2 | Dannenburg | G |
| | 0.5 | Hardberg | G |
| | 0.03 | Mainz | G |
| | 2.5 | Hoher Meissner | G |
| | 15 | Norden-Osterloog | G |
| | | Tel Aviv | Is |
| | | Alleghe | I |
| | | Naples | I |
| | | P. Badde Urbara | I |
| | | Voss | No |
| | 6 | Llangollen, | U |
| | | Vatican City | V |
| 93.40 | 0.5 | Cologne | G |
| 93.50 | | Aosta | I |
| | | Brisighella | I |
| | | Carrara | I |
| | | M. Sambuco | I |
| | | Plose | I |
| | | Sestriere | I |
| | | Trieste | I |
| | 15 | Mierlo | Ne |
| | | Tryvasshogda | No |
| | | Norrköping | Sw |
| | 120 | Wrotham | U |
| 93.60 | 10 | Berlin | G |
| | 25 | Haardtkopf | G |
| | 15 | Heide | G |
| | 3 | Osnabrück | G |
| | 100 | Waldenburg | G |
| | | Tel Aviv | Is |
| | | Bremanger | No |
| | | Varberg | Sw |
| 93.65 | 100 | Wendelstein | G |
| 93.70 | 10 | Tampere | Fd |
| | | Cascia | I |
| | | Garfagnana | I |
| | | Milan | I |
| | | Porretta Terme | I |
| | | Rome | I |
| | | Rovereto | I |
| | | Val Gardena | I |
| | 120 | Holme Moss | U |
| 93.90 | 18 | Dillberg | G |
| | 5 | Hannover | G |
| | 0.25 | Heidelberg (A.F.N.) | G |
| | 15 | Nordhelle | G |
| | | Bagni di Lucca | I |
| | | Bologna | I |
| | | M. St. Angelo | I |
| | | M. Soro | I |
| | | Pieve di Cadore | I |
| | | Val Venosta | I |
| | | Scheveningen | Ne |
| | 1 | Brigue | Sd |
| | 1.4 | Zeneggen | Sd |
| | | Gavle | Sw |
| 94.00 | | Toul (A.F.N.) | F |
| | | Ylivieska | Fd |
| | | Inselberg | G |
| | 2 | Llanddona | U |
| | 1 | Penmon | U |
| | 6 | Rosemarkie | U |
| 94.10 | 0.2 | Augsburg | G |
| | | Casentino | I |
| | | M. Faito | I |
| | | Potenza | I |
| | 120 | Tacolneston | U |
| | | Ljubljana | Y |
| 94.15 | 2 | Kiel | G |
| 94.20 | 18 | Pfaffenberg | G |
| | 100 | Teutoburger Wald | G |
| | | M. Penice | I |
| | 1 | Les Ordons | Sd |
| 94.30 | 50 | St. Pölten | A |
| | 10 | Turku | Fd |
| | | Alcamo | I |
| | | M. Argentario | I |
| | | Catanzaro | I |
| | | Lunigiana | I |
| | | Modica | I |
| | | Ogliastro | I |
| | | Pescara | I |
| | | S. Marcello Pistoiese | I |
| | | Marca Pusteria | I |
| | | Tel Aviv | Is |
| | | Lisbon | Pl |
| | 120 | Kirk o' Shotts | U |
| | 120 | Wenvoe | U |
| 94.40 | | B. go Val Sugana | I |
| | | M. Celentone | I |
| 94.45 | 15 | Bamberg | G |
| 94.50 | | Bornholm | D |
| | 2.5 | Koblenz | G |
| | 5 | Münster | G |
| | 100 | Stuttgart | G |
| | | Asiago | I |
| | | M. Beigua | I |
| | | Roseto Capo Spulico | I |
| | | Sassari | |
| | | Terminillo | I |
| | | Tolmezzo | |
| | 60 | Divis, | U |
| | | Orkneys | U |
| 94.60 | | Phalsbourg (A.F.N.) | F |
| | 40 | Helsinki | Fd |
| | 6 | Kristiina | Fd |
| | | Brocken (Harz) | G |
| | | Borås | Sw |
| 94.70 | | Cortina | I |
| | | M. Caccia | I |
| | | M. Lauro | I |
| | | M. Nerone | I |
| | | Mione | I |
| | | Stazzona | I |
| | 120 | Sandale | U |
| 94.80 | 1 | Salzburg | A |
| | 1 | Gotschnagrat | Sd |
| | 1.5 | Sool | Sd |
| 94.90 | 10 | Feldberg (A.F.N.) | G |
| | | Genoa | I |
| | | Lagonegro | I |
| | | Palermo | I |
| | | Plateau Rosa | I |
| | | Sezze | I |
| | | Terni | I |
| (94.90) | | Villar Perosa | I |
| | 15 | Hoogezand | Ne |
| 95.00 | | Strasbourg | F |
| 95.10 | | Sonderjylland | D |
| | | Agordo | I |
| | | Bolzano | I |
| | | Campo Imperatore | I |
| | | Golfo Salerno | I |
| | | S. Giuliana | I |
| | | S. Lucia | I |
| | | Udine | I |
| | | Valle Isarco | I |
| | 4 | Hulsberg | Ne |
| | 60 | Bantiger | Sd |
| | 0.5 | Schulz | Sd |
| | | Tarasp | Sd |
| 95.20 | 25 | Vaasa | Fd |
| | | Görlitz | G |
| | | Rheinsberg | G |
| | | Borgo, Val di Taro | I |
| | | Domodossola | I |
| | | Sondrio | I |
| 95.30 | | Benevento | I |
| | | Como | I |
| | | Gambarie | I |
| | | M. Limbara | I |
| | | S. Cerbone | I |
| 95.37 | 55 | Biedenkopf | G |
| 95.40 | 10 | Schockl | A |
| | | Brussels | B |
| | | Marseilles | F |
| | 100 | Oldenburg | G |
| | 19 | Potzberg | G |
| | 60 | Santis | Sd |
| 95.50 | 30 | Lahti | Fd |
| | | Brisighella | I |
| | | Campo Catino | I |
| | | Colle Visentin | I |
| | | Gardone Val Trompia | I |
| | | S. Antioco | I |
| 95.52 | 50 | Caen | F |
| 95.60 | | C. Spartivento | I |
| | | Maranza | I |
| | | Turin | I |
| 95.70 | 2.5 | Blauen | G |
| | 3 | Bungsberg | G |
| | 100 | Langenberg | G |
| | | M. Peglia | I |
| | | Madonna di Campiglio | I |
| | | Porretta Terme | I |
| | | S. Sofia | I |
| | | Val Gardena | I |
| | | Hälsingborg | Sw |
| | | Vasteras | Sw |
| 95.80 | 30 | Vienna-Kahlenberg | A |
| | | Nicosia (B.F.N.) | C |
| | | Dijon | F |
| | 10 | Savonlinna | Fd |
| 95.90 | | Aarhus | D |
| | | Bordighera | I |
| | | Crotone | I |
| | | M. Cammarata | I |
| | | Mugello | I |
| | | Polcevera | I |
| | | Rovereto | I |
| | | San Pellegrino | I |
| 96.00 | 18 | Linz | G |
| | | Munich (Ismanning) | G |
| | 12 | Raichberg | G |
| | 10 | Schaumberg | G |
| | 100 | Torfhaus (Harz) | G |
| | 1.5 | Würzberg | G |
| | 15 | Irnsum | Ne |
| | 0.75 | Gstaad | Sd |
| | | Ladir | Sd |
| 96.05 | 60 | Ochsenkop | G |
| 96.10 | 20 | Paris | F |
| | | Kotka | Fd |
| | | Bologna | I |
| | | Carrara | I |
| | | Casentino | I |
| | | M. Faito | I |
| | | M. Padric | I |
| | | Premeno | I |
| | | Valle S. Giacomo | I |
| | | Val Venosta | I |
| 96.20 | | Breda | Ne |
| 96.30 | 50 | Hamburg | G |
| | | Catanzaro | I |
| | | Mandovi | I |
| | | M. Serpedd | I |
| | | Pescara | I |
| | | Trieste | I |
| | | M. Morello | Sd |
| | 15 | Göteburg | Sw |
| | | Vatican City | V |
| 96.40 | | Leipzig | G |
| 96.50 | | Copenhagen | D |
| | | Asiago | I |
| | | Bagni di Lucca | I |
| | | Cima Penegal | I |
| | | M. Beigua | I |
| | | Malcesine | I |
| (96.50) | | Roseto Capo Spulico | I |
| | | Tolmezzo | I |
| 96.60 | 15 | Büttelberg | G |
| | 15 | Nordhelle | G |
| | | La Berra | Sd |
| | 1 | Stockholm | Sw |
| 96.70 | 18 | Rovaniemi | Fd |
| | | Marlow | G |
| | | Bellagio | I |
| | | Candoglia | I |
| | | Cortina | I |
| | | M. Caccia | I |
| | | M. Lauro | I |
| | | M. Nerone | I |
| 96.75 | 3 | Berlin* | G |
| 96.90 | | Nancy | F |
| | 18 | Bremen | G |
| | 0.25 | Werl† | G |
| | 18 | Wolfsheim | G |
| | | Lunigiana | I |
| | | S. Marcello Pistoiese | I |
| | | Sezze | I |
| | | Palermo | I |
| | | Plateau Rosa | I |
| | | Terni | I |
| | | Villa Perosa | I |
| | 1.5 | Celerina | Sd |
| | | St. Anton | Sd |
| | | Sundsvall | Sw |
| 97.00 | | Burg | G |
| 97.10 | | Agordo | I |
| | | Bolzano | I |
| | | Campo Imperatore | I |
| | | Golfo Salerno | I |
| | | S. Giuliana | I |
| | | S. Lucia | I |
| | | Udine | I |
| | | Valle Isarco | I |
| 97.20 | | Hengelo | Ne |
| | 50 | Markelo | Ne |
| | 1 | Gotschnagrat | Sd |
| | 0.7 | Niederhorn | Sd |
| | 1 | Sool | Sd |
| 97.23 | 0.1 | Stubnerkogel | A |
| 97.30 | | Dreux (A.F.N.) | F |
| | 3 | Pori | Fd |
| | | Helpterberg | G |
| | | Benevento | I |
| | | Campo Catino | I |
| | | Gambarie | I |
| | | S. Cerbone | I |
| | | P. Badde Urbara | I |
| 97.40 | | Sonnwendstein | A |
| | | M. Penice | I |
| 97.50 | | M. Bignone | I |
| | | Hulsberg | Ne |
| | 60 | Uetliberg | Sd |
| 97.60 | 10 | Pietarsaari | Fd |
| | | Sonneberg | G |
| | | Aosta | I |
| | | C. Spartivento | I |
| | | Sestriere | I |
| | | Lyngdal | No |
| 97.70 | | M. Peglia | I |
| | | Madonna di Campiglio | I |
| | | Pieve di Cadore | I |
| | | Porretta Terme | I |
| | | S. Antioco | I |
| | | S. Sofia | I |
| | | Val Gardena | I |
| | | Koper | Y |
| 97.75 | 3 | Kreuzberg | G |
| 97.80 | | Kanzelhohe | A |
| | 10 | Pyramidenkoge | A |
| | 0.5 | Flensburg | G |
| | 18 | Linz | G |
| | 1 | Les Ordons | Sd |
| 97.85 | 1.25 | Hannover | G |
| 97.90 | | Crotone | I |
| | | M. Cammarata | I |
| | | Mugello | I |
| 98.10 | | Bordeaux | F |
| | | Casentino | I |
| | | Gorizia | I |
| | | M. Faito | I |
| | | M. Padrio | I |
| | | Plose | I |
| | | Terminillo | I |
| 98.20 | 30 | Turku | Fd |
| | | Berlin | G |
| | | Turin | I |
| 98.30 | | Catanzaro | I |
| | | Como | I |
| | | Ogliastra | I |
| | | Pescara | I |
| | | Hengelo | Ne |
| | 50 | Markelo | Ne |
| 98.40 | 12 | Feldberg | G |
| | 15 | Pinneberg (B.F.N.) | G |
| | | Västeras | Sw |
| 98.45 | 5 | Aachen | G |

*French Forces.
†Canadian Forces.



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**EUROPEAN BAND II STATIONS (Continued)**

| | | | |
|---|---|---|---|
| 98.50 | | Bagni di Lucca | I |
| | | Domodossola | I |
| | | Malcesine | I |
| | | Roseto Capo Spulico | I |
| | | Coimbra | Pl |
| 98.70 | 18 | Dillberg | G |
| | 15 | Nordehelle | G |
| | | Gardone Val Trompia | I |
| | | M. Caccia | I |
| | | M. Lauro | I |
| | | M. Nerone | I |
| | | Val Venosta | I |
| | | Gavle | Sw |
| | 3 | Malmö | Sw |
| 98.90 | 1.5 | Saarbrücken | G |
| | | Cima Penegal | I |
| | | M. Beigua | I |
| | | Palermo | I |
| | | S. Marcello Pistoiese | I |
| (98.90) | | Sezze | I |
| | | Terni | I |
| 99.00 | | Salzburg | A |
| | 15 | Hannover (B.F.N.) | G |
| | | Basel | Sd |
| | | Gempen | Sd |
| 99.05 | 1 | Berlin (B.F.N.) | G |
| 99.10 | | Agordo | I |
| | | Campo Imperatore | I |
| | | Golfo Salerno | I |
| | | Lunigiana | I |
| | | Plateau Rosa | I |
| | | Premeno | I |
| | | S. Giuliana | I |
| | | S. Lucia | I |
| | | San Pellegrino | I |
| | | Tolmezzo | I |
| | | Valle S. Giacomo | I |
| | | Valle Isarco | I |
| | | Bucharest | R |
| 99.20 | | Vestjylland | D |
| (92.20) | | Breda | Ne |
| 99.30 | 1 | Linz | A |
| | | Bornholm | D |
| | 80 | Drachenberg (B.F.N.) | G |
| | 18 | Wolfsheim | G |
| | | Benevento | I |
| | | Gambarie | I |
| | | M. Limbara | I |
| | | S. Cerbone | I |
| | 1 | Fadara | Sd |
| | | Ravoire | Sd |
| 99.40 | | Kajaani | Fd |
| | 3 | Pori | Fd |
| | | La Spezia | I |
| | | Milan | I |
| 99.50 | | Karl Marx Stadt | G |
| | | Bolzano | I |
| | | Campo Catino | I |
| | | M. Padrio | I |
| | | S. Antioco | I |
| 99.60 | 100 | Teutoburger Wald | G |
| | | C. Spartivento | I |
| | 0.7 | Niederhorn | Sd |
| 99.70 | 10 | Kokkola | Fd |
| | | Aosta | I |
| | | M. Peglia | I |
| | | Madonna di Campiglio | I |
| | | Pieve di Cadore | I |
| | | S. Sofia | I |
| | | Sestriere | I |
| | | Udine | I |
| 99.80 | | Laon (A.F.N.) | F |
| 99.90 | 30 | Vienna-Kahlenberg | A |
| | | Sonderjylland | D |
| | 100 | Torfhaus (Harz | G |
| | | Crotone | I |
| | | M. Cammarata | I |
| | | M. Penice | I |
| | | Mugello | I |
| | 15 | Mierlo | Ne |

# JANUARY MEETINGS

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

**LONDON**

5th. I.E.E.—"The application of transistors to line communication equipment" by H. T. Prior, D. J. R. Chapman and A. A. M. Whithead at 5.30 at Savoy Place, W.C.2.

9th. Television Society.—"A television link with America?", a discussion at 7.0 at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.

9th. Radar & Electronics Association, Student Section.—"Television wire broadcasting" by K. A. Russell (British Relay Wireless) at 7.0 at the Norwood Technical College, Knight's Hill, S.E.27.

13th. I.E.E.—Discussion on "Education and training from the student's point of view" opened by two members of the London Graduate and Student Section at 6.30 at Savoy Place, W.C.2.

14th. Society of Instrument Technology.—Symposium on data storage media at 6.0 at Manson House, Portland Place, W.1.

16th. Institute of Navigation.—"Blind landing problems" by W. J. Charnley (Blind Landing Experimental Unit, R.A.E.) at 5.15 at The Royal Geographical Society, 1 Kensington Gore, S.W.7.

16th. B.S.R.A.—"Some further developments in loudspeakers" by A. R. Neve at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2.

19th. I.E.E.—"High-current-density thermionic emitters" by A. H. W. Beck at 5.30 at Savoy Place, W.C.2.

20th. I.E.E.—Discussion on "D.C. amplifiers" opened by K. Kandiah at 5.30 at Savoy Place, W.C.2.

21st. I.E.E.—"Dielectric materials—trends and prospects" by C. G. Garton at 5.30 at Savoy Place, W.C.2.

21st. Royal Society of Arts.—"Technical education: a prognosis" by the Right Hon. Lord Nathan (president, Association of Technical Institutions) at 2.30 at John Adam Street, W.C.2.

22nd. Television Society.—Fleming Memorial Lecture, "Modern optics in relation to television" by G. H. Cook (Taylor, Taylor & Hobson), at 7.0 at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.

26th. I.E.E.—Faraday Lecture on "Automation" by Dr. H. A. Thomas at 6.0 at the Royal Festival Hall.

26th. Radar and Electronics Association.—"Zeta: nuclear power and fusion" by Dr. D. W. Fry, deputy director, Harwell Atomic Energy Establishment, at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

27th. Society of Instrument Technology.—Symposium on flow measurement at 6.0 at Manson House, Portland Place, W.1.

28th. Brit.I.R.E.—"Speech recognition and the phonetic typewriter" by Professor D. B. Fry and P. Denes at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

29th-30th. I.E.E.—Convention on long-distance transmission by waveguide at Savoy Place, W.C.2. (All wishing to attend must register.)

30th. Women's Engineering Society.—"Some uses of electron beams in metallurgy" by Mrs. I. H. Hardwich at 7.0 at Hope House, 45 Great Peter Street, S.W.1.

**BOURNEMOUTH**

21st. I.E.E.—"Domestic high-fidelity reproduction" by J. Moir at 6.30 at the Grand Hotel.

**BRISTOL**

29th. Brit.I.R.E.—"Recent developments in printed and potted circuits" by H. G. Manfield at 7.0 at the School of Management Studies, Unity Street.

**CARDIFF**

14th. Brit.I.R.E.—"Computer control of machine tools" by H. Ogden at 6.30 at the College of Advanced Technology.

26th. I.E.E.—"A transatlantic telephone cable" by Sir Gordon Radley at 6.0 at the South Wales Institute of Engineers, Park Place.

**EDINBURGH**

7th. I.E.E.—"A new cathode-ray tube for monochrome and colour television" by Dr. D. Gabor, P. R. Stuart and P. G. Kalman at 7.0 at the Carlton Hotel, North Bridge.

**GLASGOW**

6th. I.E.E.—"A new cathode-ray tube for monochrome and colour television" by Dr. D. Gabor, P. R. Stuart and P. G. Kalman at 7.0 at Royal College of Science and Technology, George Street.

**GRANGEMOUTH**

29th. Society of Instrument Technology.—"Electronic weighing" by K. J. Railler at 7.0 at the Leapark Hotel.

**MALVERN**

12th. I.E.E.—"Electrostatic Loudspeakers" by P. J. Walker at 7.30 at the Winter Gardens.

29th. Brit.I.R.E.—"Industrial and underwater television" by B. V. Somes-Charlton at 7.0 at the Winter Gardens.

**MANCHESTER**

20th. I.E.E.—"The atomic clock" by Dr. L. Essen at 6.15 at the Engineers' Club, Albert Square.

**NEWCASTLE**

12th. Brit.I.R.E.—"The design and construction of an electronic digital computer" by R. W. Walker at 6.0 at the Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road.

19th. Institution of Production Engineers.—"Electronic computers and the production engineer" by P. V. Ellis at 7.0 at the Rutherford College of Technology, Northumberland Road.

**PORTSMOUTH**

7th. I.E.E.—"Ultrasonics in industry" by C. F. Brockelsby at 6.30 at C.E.G.B. Offices, 111, High Street.

**STOKE-ON-TRENT**

12th. Institution of Production Engineers.—"Electronic computer control of machine tools" by H. Ogden at 7.30 at the Grand Hotel, Hanley.

23rd. Association of Supervising Electrical Engineers.—"Electronics" by F. H. Fryer at 7.30 at the Grand Hotel, Hanley.

**WEYMOUTH**

30th. I.E.E.—"Radio observations on the artificial satellites" by Dr. R. L. F. Boyd at 6.30 at the South Dorset Technical College.

**WOLVERHAMPTON**

21st. Brit.I.R.E. — "Learning machines" by P. Huggins at 7.15 at the Wolverhampton and Staffordshire College of Technology, Wulfruna Street.



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# EXHIBITIONS AND CONFERENCES

## UNITED KINGDOM

**Physical Society's Exhibition,** Royal Horticultural Society's Halls, Victoria, London, S.W.1 .......... Jan. 19-22
(Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.)

**Convention on Long-Distance Transmission by Waveguide,** Savoy Place, London, W.C.2 .......... Jan. 29-30
(I.E.E., Savoy Place, London, W.C.2.)

**Television Equipment Exhibition,** Royal Hotel, London, W.C.1.... Mar. 3-5
(Television Society, 166 Shaftesbury Avenue, London, W.C.2.)

**Electrical Engineers' Exhibition,** Earls Court, London, S.W.5...... Mar. 17-21
(P. A. Thorogood, Museum House, Museum Street, London, W.C.1.)

**Audio Fair,** Russell Hotel, Russell Square, London, W.C.1.......... Apr. 2-5
(Audio Fairs Ltd., 42 Manchester Street, London, W.1.)

**Radio and Electronic Component Show,** Grosvenor House and Park Lane House, Park Lane, London, W.1 .......... Apr. 6-9
(R.E.C.M.F., 21 Tothill Street, London, S.W.1.)

**International Instruments Show,** Instrumentation Centre, Park Lane, London, W.1 .......... Apr. 6-10
(B. & K. Laboratories, 4 Tilney Street, London, W.1)

**Engineering, Marine, Welding and Nuclear Energy Exhibition,** Olympia, London, W.14 .......... Apr. 16-30
(F. W. Bridges & Sons, Grand Buildings, Trafalgar Square, London, W.C.2.)

**International Convention and Exhibition on Transistors,** Earls Court, London, S.W.5 .......... May 21-27
(I.E.E., Savoy Place, London, W.C.2.)

**International Plastics Exhibition and Convention,** Olympia, London, W.14 June 17-27
("British Plastics," Dorset House, Stamford Street, London, S.E.1.)

**British Computer Society's Conference,** Cambridge........... June 22-25
(British Computer Society, Finsbury Court, Finsbury Pavement, London, E.C.2.)

**Convention on Techniques and Applications of Television,** Cavendish Laboratory, Cambridge .......... July 1-5
(Brit. I.R.E., 9 Bedford Square, London, W.C.1.)

**National Radio and Television Show,** Earls Court, London, W.5 Aug. 26-Sept. 5
(R.I.C., 59 Russell Square, London, W.C.1.)

**Farnborough Air Show**..........Sept. 8-14
(Society of British Aircraft Constructors, 29 King Street, London, S.W.1.)

**Radio Hobbies Exhibition,** Royal Horticultural Hall, London, S.W.1 Nov. 25-28
(P. A. Thorogood, Museum House, Museum Street, London, W.C.1)

## OVERSEAS

**National Symposium on Reliability and Quality Control in Electronics,** Philadelphia .......... Jan. 12-14
(R. Brewer, G.E.C. Research Laboratories, Wembley, Middx.)

**Paris Components Show** (Salon International de la Pièce Détachée Electronique)
(S.N.I.R., 23 rue de Lubeck, Paris 16.) Feb. 20-24

**Stockholm Electronics Exhibition** .......... Mar. 21-30
(Industrial & Trade Fairs, Drury House, Russell Street, London, W.C.2.)

**I.R.E. National Convention,** New York..........Mar. 23-26
(E. K. Gannett, I.R.E., 1 East 79th Street, New York 21, N.Y., U.S.A.)

**Symposium of Millimetre Waves,** New York.............. Mar. 31-Apr. 2
(Polytechnic Institute of Brooklyn, 55 Johnson Street, Brooklyn 1, N.Y., U.S.A.)

**Interdisciplinary Conference on Self-Organizing Systems,** Chicago May 5-6
(Scott H. Cameron, Armour Research Foundation, Chicago 16, U.S.A.)

**British Trade Fair,** Lisbon, Portugal.......... May 29-June 14
(British Overseas Fairs Ltd., 21 Tothill Street, London, S.W.1.)

**International Conference on Information Processing,** Paris...... June 15-20
(B.C.A.C. Group B, c/o I.E.E., Savoy Place, London, W.C.2.)

**I.R.E. International Symposium on Circuit and Information Theory,** Los Angeles .......... June 16-18
(Richard A. Epstein, Jet Propulsion Laboratory, Pasadena, California, U.S.A.)

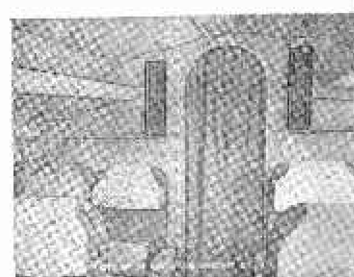
**International Chemistry Conference and Exhibition,** Paris...... June 16-30
(Conférence Internationale des Arts Chimiques, 28 rue Saint-Dominique, Paris 7.)

**International Congress on Acoustics,** Stuttgart .......... Sept. 1-8
(Dr. Ing. E. Zwicker, Breitscheidstr. 3, Stuttgart.)

Further details of the exhibitions and conferences are obtainable from the addresses in brackets.


Hong Kong to Hatfield

World record and sun beating Comet IV—pride of the British aircraft industry, ultimate in airline luxury—has built-in Trixadio Passenger Announcement System for the convenience of its transmondial travellers. Developed to meet the exacting needs of engineers who seek high quality, long service and realistic costs. Trix equipment is built with integrity—and the pioneering spirit which is constantly in search of perfection.



★ **The first completely transistorised Aircraft Passenger Announcement and music system.**

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# RANDOM RADIATIONS

By "DIALLIST"

## *Printed Circuits*

THANKS to the many letters that readers were kind enough to send me and to conversations with dealers and servicemen, I've been able to compile quite a dossier on the subject of printed circuits. Two points of importance emerge right away. The first is that the printed panel is perfectly sound in theory and can be made so in practice. The second is that printed panels used in some receivers are not always to be depended upon. Let's begin with the first point. Printed circuitry has proved to the hilt that if it is made up skilfully and from high-grade materials it can be entirely trustworthy: otherwise it wouldn't be so widely used in radar equipment as it is nowadays, or in guided missiles, artificial satellites and other apparatus in which reliability is a must. In the United States "*everything* electronic," as one reader puts it, "which can be printed is printed."

## *Special Short Courses?*

Some sound and television setmakers provide their own printed panels. A member of one well-known firm has sent me one of theirs, which is a beautiful example of good design and good workmanship applied to excellent materials. He tells me that his service department reports that faults in receivers using such panels are appreciably fewer in number than they were when conventional wiring was in use. Some dealers, I think, dislike printed panels because with them it's not always easy to isolate this or that for quick tests. Some, again, are too ready to diagnose that there is a fault in the printed connection when anything goes wrong. I've heard of three different cases in which sets were returned to manufacturers as suffering from some such trouble only for it to be discovered on testing that in each one of them the cause of the breakdown was, in fact, a "dud" valve! It would be a good idea if setmakers ran short courses for service department managers and servicemen on trouble-hunting in printed circuits. Perhaps some of them are already doing so.

## *Quality and Design*

And now for the other side of the picture, for everything in the garden is still far from being lovely. I'm told that not all setmakers produce their own printed panels and that, in addition to many firms of good repute, there are cheapjack firms ready to supply them at very low prices. Some of these concerns use poor materials and their workmanship is shoddy. Any maker who uses their products with the idea of lowering manufacturing costs is taking a big risk, for a few disgruntled customers who air their grievances to all and sundry can soon cancel out the effects of much expensive advertising. There's no doubt that printed panels are here to stay and it's up to setmakers to see that they don't get a bad name because of the indifferent quality of some of them. One reader raises an interesting point I hadn't thought of. Some makers use vertically-mounted panels with resistors, capacitors and so on fitted at right angles to them. As he says, this increases the leverage and it may possibly be one of the causes of those hairline cracks in conducting paths of which not a few people complain.

## *Out of Print!*

From Rotherham comes a letter from a home constructor which suggests yet another possibility to be guarded against. He intended to make up a rather expensive piece of apparatus from a published description. He acquired the parts one by one over a period and needed only the printed panel in order to get going at last. On sending for it, he learned that it was no longer available. To use his own words, "it was quite literally out of print." Setmakers will have to bear that sort of thing in mind. Most ordinary folk, I suppose, expect a television set to keep going for a good five years or so and a sound receiver for much longer than that. It will certainly be up to makers to keep stocks of printed panels for their various models for a good few years after they make their first appearance. Anyone who sent in a set for repairs after, say, three or four years and found that nothing could be done because it was impossible to replace a faulty panel would most certainly not be amused!

## *American Tube Rebuilding*

A RECENT issue of *Wireless Trader* contained a most interesting letter on the position of c.r.t. rebuilding firms in America. It was from W. C. Gase, general manager of the G. & S. Electronic Corporation, of Toledo, Ohio, one of the 65 firms who now undertake the work on the other side of the Herring Pond. In 1957 60% of all replaced c.r.t.s were rebuilds.


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The 1958 figure is expected to rise to 70% and, if so, the year's total of rebuilt tubes will be over 12,000,000. The method used is similar to that employed by at least one company over here. Each worn-out tube is opened and completely washed out, so that nothing remains of its old self but the glass bulb. When the job is finished the customer obtains what is to all intents and purposes a new tube, and this carries a twelve months' guarantee, in fact it is treated as such by the government who levy an excise on it. An important point is that all the major American valve manufacturers co-operate fully with the rebuilders, who are then able to buy from them all the parts and materials required—a very sound state of affairs from the public's point of view. The rebuilders require a dud tube for each rebuild supplied to a dealer.

## *The Amazing Transistor*

WHAT enormous strides have been made in the making of transistors both in this country and in America. When they first made their shy appearance a few years ago they were tiny things, usable at low frequencies only, not able to handle more than a few milliwatts and not very reliable. To-day, transistors are very different things. There are types which will work at 1,000 Mc/s and others have been developed which can handle hundreds of watts at audio frequencies. Perhaps most important of all, improved design and manufacturing processes now turn out transistors so reliable that it is claimed that there is no reason why they should not work continuously for a century or more.

## *Can You Beat This?*

Talking about long-service life reminds me that I heard the other day from a Stockport reader who tells me of an extraordinary experience that he has had with a 12-in c.r.t. in a TV set which he bought second-hand in February, 1953. The set is switched on at the start of Children's Hour and not switched off until bedtime every day, except when he and his family are away for their holiday. After 6,800 hours of use the emission had fallen off somewhat, so he boosted the heater voltage up gradually and maintained a good picture for a further 1,850 hours, when the heater burnt out. This gives a total of 8,650 hours of service, which is the longest TV tube life that I've ever heard of.


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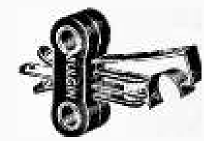

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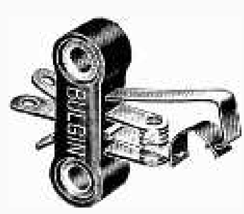

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|---|---|---|---|---|---|---|---|
| V. | S.690, S.691: A.* | S.695: A.* | V. | S690, S.691: A.* | S.695: A.* | | |
| 12 | 3 | 3 | 12 | 3 | 6 | 250 | 1 KV. (Across contacts & to E.) |
| 50 | 1 | 1 | 50 | 2 | 5 | | |
| 110 | 0.25 | 0.5 | 110 | 1.5 | 4 | | |
| 250 | 0.1 | 0.3 | 250 | 1.0 | 3 | | |

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**MECHANICAL DATA**

| List No. | Pre-travel allowable to user for longest life | Differential | Max. Over-travel, for longest life | Drive Force | Point of Drive, dim. from line of fixing crs. | Fixing crs. |
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## *Music Mucked Up*

ONE of the biggest disadvantages of stereo is the necessity of using two loudspeakers spaced several feet apart. Even when the B.B.C. start their single-channel experiments we shall still require these spaced loudspeakers, and I have for a long time wondered if there was any way of using one loudspeaker.

A suggestion has been made to me as to how this might be done. But before I set to work to turn the idea into practical form, I should value your comments. This does not necessarily mean that I shall take any notice of them, for I can never forget that if Marconi had listened to the scientific pundits in 1901, he would not have tried to bridge the Atlantic by wireless.

Briefly, the idea is to use one loudspeaker having a motor-driven moving baffle so that the sound would be directed alternately to the left and the right. There would also be a simple commutator working in conjunction with the baffle so that the leads from the left- or right-hand channel of the amplifier would be connected to the LS in synchrony with the movements of the baffle.

Thus the sound would be radiated from the loudspeaker in two channels like the arms of the letter V. The sound from the left-hand channel would obviously strike the left-hand wall of the room, and be deflected towards the listener's left ear. In a similar manner, the sound from the right-hand channel would reach the listener's right ear.

There are obviously a lot of snags, since the two reflecting walls would be unlikely to be equal in the matter of sound absorption, and a certain amount of juggling with curtains and cushions would be necessary to even things up. No doubt the music would be mucked up to a certain extent, but according to many musical critics that happens with conventional stereo anyway. It could, at any rate, be a new experience as broadcasting itself was in 1922. Who would have dreamt that the ghastly gurglings of 2LO 36 years ago would develop into the dulcet tones of Wrotham 1958?

## *Destaticizing Shavers*

NOWADAYS all-electric razors are suppressed to avoid interference with sound broadcasting and TV, but anybody who has had the same extensive experience of electric shavers as I have will know that some of them are better suppressed than others.

There is one particular make which I tried recently that was very troublesome although it contained all the usual suppressors. It occurred to me to try the effect of earthing the ironmongery of the comb and cutter, and this brought about such an amazing improvement that I wonder why its makers don't fit a three-pin plug.

I have often wondered why electric razors are fitted with two-pin plugs and no earth on the metal comb which is pressed to the face. It is true that all makes nowadays employ a non-metallic shaft to link the motor to the cutter, and so there is no danger of shock. But the metal casing of an electric fire is also isolated from the "live" parts and there is clearly no danger of shock while it remains in that condition. If it is desirable to earth the fire casing—as it certainly is—why not the metal comb of the shaver.

*Experience of electric shavers.*

Many years ago I did get a nasty shock from an electric razor due to my absent-mindedly plunging it into hot water in the basin as I—and many others—used to do with our old cut-throats. It has made me so nervous that nowadays I use a low-voltage razor run from a bell-transformer fitted under the bathroom floorboards, with the lead from the secondary winding running to a wall socket.

## *Car Radio*

Anybody who runs a car, be it a Rolls-Royce or the sort of contraption which takes me about on my lawful occasions, could not fail to be interested in the article on car radio design by F. Grimm in the November issue.

He seems to have covered every contingency, and I particularly admired the ingenuity displayed in getting rid of the last traces of ignition interference. He seemed, in fact, to be up to all the dodges except the one which I have always considered the only one to give 100 per cent results and that is to change over to a diesel engine.

## *Astral Advertising*

I MUST confess to feeling very uneasy in my mind about the continued successful launching of satellites, which bodes no good to humanity. I am not, of course, thinking of the possibility of their being used as H-bomb carriers. There is no real cause for worry about that for if they do drop nuclear bombs on us all our worries will be at an end and if they are not going to do so then there is no need to worry.

No, it is a far more real and subtle menace that disturbs my peace of mind, for it cannot be long before the big advertisers, who sponsor sound and television programmes in Luxembourg, the U.S.A. and elsewhere, realize their potentialities, and we may find ourselves defenceless before a fierce fusillade of astral advertising.

It may well be asked how a sustained programme could be transmitted as the satellites, travelling at 18,000 m.p.h., would only be within reliable radio range of a target like London for a matter of two or three minutes. Unfortunately it would be only too easy by adopting the technique used by the Germans in 1918 to send radio instructions from Berlin to their submarines operating around the Spanish coast.

The procedure of the astral advertisers, reduced to its simplest terms, would be as follows. A base would be established in any convenient spot. The satellite, complete with solar-charged batteries, tape recorders and other necessary apparatus would be "orbited" from its base so that it passed over the desired target areas in its circummondial gyrations.

As the satellite passed over its base, the previously recorded programmes and propaganda would be radioed up to it; the reproducer on earth and the satellite-borne recorder producer rotating at such a speed that an hour's programme could be compressed into the few minutes that the man-made moon was within range. Supposing the HQ of the advertising company were in mid-Pacific. Obviously the satellite would be over London in less than an hour when it would re-radio its programme back to earth at the same high speed.

Obviously anybody below wanting to receive these programmes would have to equip himself with a recorder-reproducer capable of receiving the incoming high-speed recordings, which, after reception, would play them back at ordinary speed. It is useless to say that people will not equip themselves with this special apparatus. Provided it is skilfully advertised people will buy anything.



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