Wireless World

ELECTRONICS, RADIO, TELEVISION

OCTOBER 1962

VOLUME 68 No. 10

PRICE: 2s 6d.

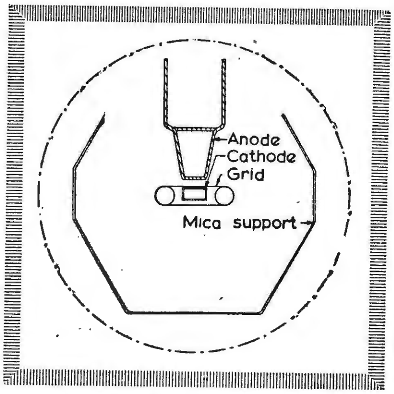
FIFTY-SECOND YEAR
OF PUBLICATION

Chairman: H. S. Pocock, M.I.E.E.
Managing Director: W. E. Miller, M.A. M.Brit.I.R.E.
Iliffe Electrical Publications Ltd., Dorset House, Stamford Street, London, S.E.1

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

PUBLISHED MONTHLY (4th Monday of preceding month). *Telephone:* Waterloo 3333 (70 lines). *Telegrams:* " Ethaworld, London, Telex." *Cables:* " Ethaworld, London, S.E.1." *Annual Subscriptions: Home and Overseas,* £2 0s. 0d. *Canada and U.S.A.* $5.50. Second-class mail privileges authorized at New York, N.Y. BRANCH OFFICES: *BIRMINGHAM:* King Edward House, New Street, 2. *Telephone:* Midland 7191. *COVENTRY:* 8-10, Corporation Street. *Telephone:* Coventry 25210. *GLASGOW:* 62, Buchanan Street, C.1. *Telephone:* Central 1265-6. *MANCHESTER:* 260, Deansgate, 3. *Telephone:* Blackfriars 4412. NEW YORK OFFICE: *U.S.A.:* 111, Broadway, 6. *Telephone:* Digby 9-1197.

MULLARD TRIODES FOR UHF TELEVISION TUNERS



FOLLOWING the publication of the Report of the Committee on Broadcasting—the Pilkington Report—the Government has undertaken to implement, amongst other things, the Committee's recommendations on the extension of television broadcasting and the change of line standard.

Both these items will involve television broadcasting at ultra high frequencies, and to utilise the new facilities, future television sets must be capable of receiving these u.h.f. transmissions as well as the present v.h.f. transmissions.

In readiness for this position, Mullard have introduced two high-frequency triodes — the PC86 and the PC88—which have been developed specifically for operation in Bands IV and V. The PC88 is designed as a u.h.f. r.f. amplifier, and the PC86 as a self-oscillating mixer. Both valves use frame grids: the accuracy and rigidity of this construction enable a very small spacing to be used between the anode and grid, so that the necessary high value of mutual conductance is achieved. To reduce grid-lead inductance, the grid of the PC88 is specially connected to five base pins, and that of the PC86 to three. To improve the stability of the PC88 further, the valve capacitances are minimised by the use of the single-sided structure illustrated in the figure.

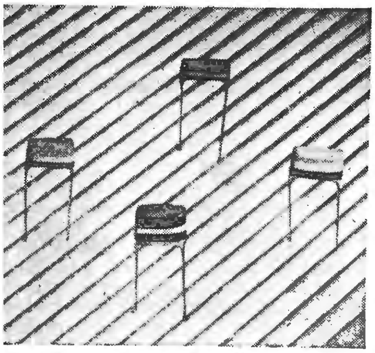
WHAT'S NEW IN THE NEW SETS

These articles describe the latest Mullard developments for entertainment equipment

The PC86 and PC88 have already appeared in several receivers, marketed in anticipation of the Report, which can be switched between u.h.f. and v.h.f. operation. Without doubt, they will both be encountered more frequently as more and more receivers are produced which require valves capable of operating at ultra high frequencies.

New Technique for PY33 Cathode Coating

The cathode of the Mullard PY33 mains rectifier is manufactured by a technique which produces the new pressed-powder coating. Normal emissive oxides are used, but the coating is prepared in such a way that the oxides are in a very dense form and a hard shiny surface is achieved. The internal resistance of the coating produced by the new process is low, which reduces local heating, and the smooth surface is free from high spots. Consequently, the likelihood of flashover occurring is minimised, and the damage suffered by the coating even if flashover does occur is much less than with conventional cathodes. Also, because of the toughness of the coating, particles are unlikely to become detached from the surface, and sputtering is less likely to occur. With these improvements it has been possible to reduce the spacing between electrodes, with a resultant increase in output voltage.



MINIATURE FOIL CAPACITORS

MULLARD have recently introduced a range of four miniature foil capacitors which is now being used frequently in portable transistor receivers. The four values of capacitance are 0·01, 0·022, 0·047 and 0·1μF, which are the values most frequently encountered in the i.f. stages of these portables. The tolerance on these values is ±20%. The d.c. voltage rating of the miniature capacitors is 30V, and the working temperature range is −40 to +85°C. The loss factor—the measure of the "goodness" of a capacitor—will not be greater than 0·015, and this is a marked improvement on the types which the Mullard components have superseded.

The winding is coated with an insulating lacquer, which allows close packing on printed-wiring boards. This, together with the smallness of the Mullard components, leads to the economy of space so vital in modern receivers.

MVE 1538

Wireless World

VOL 68 NO 10 OCTOBER 1962

After the Show

IN spite of reduced floor space and a total attendance " lower than the best," to borrow a phrase from the stock-market reporters, the atmosphere of this year's National Radio Exhibition was no less cheerful and optimistic than on previous occasions. Before a show opens there is always a good deal of gloom and pessimistic talk among those most intimately concerned in its preparation. This sometimes communicates itself to journalists who for a time believe that there cannot possibly be anything to talk about in the new sets which has not already been said before. The first round of the stands usually tends to fix this illusion, but by digging a little deeper and running to earth the designer, either in the trade demonstration room, or at his desk at the works, there is invariably something of interest to report and eventually a trend to be discerned.

But the atmosphere and spirit of a show is determined ultimately not by those who run it or attend it in a professional capacity but by the people who take the trouble voluntarily to travel there and pay for admission. As far as our observation goes the Show this year was as much a family affair as it has ever been. With the teenage members hived off into a compact and intermittently vocal group round the B.B.C.'s stage and autograph area, father and mother were free to wander at leisure from stand to stand and see for themselves the new styling and technical improvements about which they had read beforehand. We gained a clear impression that the majority of visitors came with an interest in sound and television broadcasting heightened by the Pilkington Report, that they had formulated questions to ask about 625 lines, colour, and stereo broadcasting and that they were going quietly about the business of finding and sifting answers. Nowhere was this more apparent than in the B.B.C. and I.T.A. information centres. Bush Radio kept a check on the number of visitors to their stands and state that of the 350,620 visitors who passed through the turnstiles during the 10 days of the Show, 128,277 spent some time in their demonstration room, 72,739 passed through the main stand, and that 12,062 firm inquiries were made at their information desk. The question " Who says the Radio Show is losing its appeal? " which concludes their report is obviously intended to be rhetorical. We have no doubt that comparable results could have been produced by any of the leading firms in the industry.

May we also record our appreciation of the time given by senior technical executives of several leading firms who were still in attendance when we had occasion to return to the Show during the last days to check facts. There is often a tendency to taper off after the first feverish activity of pre-view and opening days, and this is to be observed not only here but at the Continental shows. But this year at Earls Court latecomers had little cause for complaint.

By anticipating, more than a year ago, the findings of the Pilkington Committee on the future technical basis of television, and in carefully preparing dual-standard receiver designs, the set manufacturers are off to a flying start in television, but they seem to have been caught unawares by the B.B.C.'s announcement that single-radio-channel stereo sound broadcast tests were to start during the Show period and would continue for 10 weeks. Officially these tests are experimental and do not constitute a service, but public interest was stimulated and we received many inquiries as to where the necessary adapters or receivers could be bought. Mullard were quick off the mark with circuit information and an article in this issue should enable readers " skilled in the art " to make up a decoder in good time to sample at least some part of the current series of transmissions.

No doubt the industry as a whole is now sitting up and taking notice. We hope so, for some of their Continental competitors are in production and selling sets where there is already a market in America. The F.C.C. endorsement of the Zenith-GE system was published in the spring of 1961. As there was no European station radiating this type of signal the German firm of Körting, for example, built its own transmitter, developed and put into quantity production a transistor adapter, and has been exporting it to America since August 1961. This inversion—namely, export sales as a preparation for the supply of a future home market—is one which might well merit closer examination by our radio industry.

DIRECT VOLTAGE TRIGGER CIRCUIT

IMPROVED VERSION WITH PRECISION TRIGGER LEVELS

By T. K. HEMINGWAY,* B.Sc., and J. WILLIS,* B.Sc.

THE type of trigger circuit discussed here has two stable states and changes over from one to the other and back again in response to changes in an input direct voltage. Ideally the transition should be rapid, and the circuit should not dither when the input voltage approaches the threshold, nor should it respond to ripple components on the input voltage. These latter requirements are often met by including some hysteresis in the circuit action; that is to say, once the circuit has been triggered one way the input must be turned back some finite amount before the circuit changes back. The input-output relationship for the circuit will then be of the general form shown in Fig. 1. For increasing input voltage, the output voltage follows the path ABCDE, changeover occurring at CD, while subsequent reduction of the input

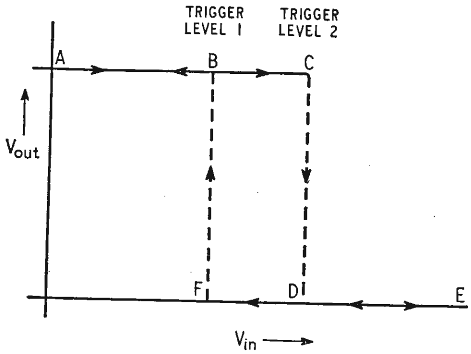


Fig. 1. Input-output curve for trigger with hysteresis.

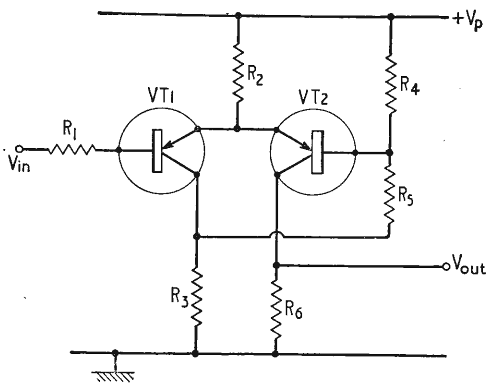
voltage means that the path followed is EDFBA, changeover now occurring at FB. (The dotted lines CD and FB imply that the output voltage moves rapidly and irreversibly through these regions.)

The best known direct voltage trigger circuit is that published by Schmitt in 1938. Schmitt used thermionic valves, of course, but this circuit has a direct transistor analogue (Fig. 2). A circuit of this kind can be designed to have any desired amount of hysteresis and is satisfactory for some applications, but it has a number of disadvantages where a precise action is required. For example, the trigger levels depend directly on the values of R_2, R_3, R_4 and R_5, and on the supply voltage V_p and less directly on R_1 and the parameters of the two transistors (principally V_{eb}, g_m† beta and $I_{co} + I_{eo}$). Neither trigger level can be set accurately at earth level. The output is basically a current change of a few milliamps in the collector of VT2.

These difficulties are to a large extent avoided in the circuit of Fig. 3. The circuit action may be explained as follows. Suppose that the base of VT1 is held at well below earth potential; then the whole of the current I_2 will flow through R_2 into VT1 emitter, and VT2 will be cut off. VT3, with zero potential between emitter and base, will also be cut off, and thus the base of VT2 will be at earth potential (neglecting the effect of leakage currents for the moment). As VT1 base is gradually made more positive, the point is eventually reached where current begins to be diverted from VT1 into VT2 emitter. This current then flows through R_3, producing a voltage drop which eventually turns VT3 on. When this happens, current flows into the collector of VT3, pulling down the base potential of VT2, so that VT2 is turned harder on. A cumulative action thus results, at the end of which VT1 is cut off, VT2 is conducting normally, and VT3 is bottomed. The new base potential of VT2 is now very nearly $-V_n\ R_4/(R_4 + R_5)$, and the input voltage must be lowered to near this value before triggering in the reverse direction can take place. If we arrange that the drop across R_3 just turns VT3 on when I_2 divides equally between VT1 and VT2, the circuit will trigger when VT1 and VT2 bases are within some tens of millivolts of each other. (After the change-over, the current in VT3 base will be almost $I_2/2$, and this is made large enough to keep VT3 bottomed.)

The two trigger levels for the circuit are thus very nearly earth potential and $-V_n\ R_4/(R_4 + R_5)$. None of the component values affects the first level much, and the second level is fixed largely by V_n and the ratio of two resistors. The output resistance of the circuit can be quite low; in one state it is the bottomed resistance of VT3 in parallel with $(R_4 + R_5)$, and in the other simply $(R_4 + R_5)$. (Note that in the latter state the trigger level will be affected if any

Fig. 2. Transistor version of Schmitt trigger circuit.



* English Electric Aviation Ltd

† g is defined as $1/[r_e + r_b(1-\alpha)]$ where r_e r_b and α are T-equivalent circuit parameters.

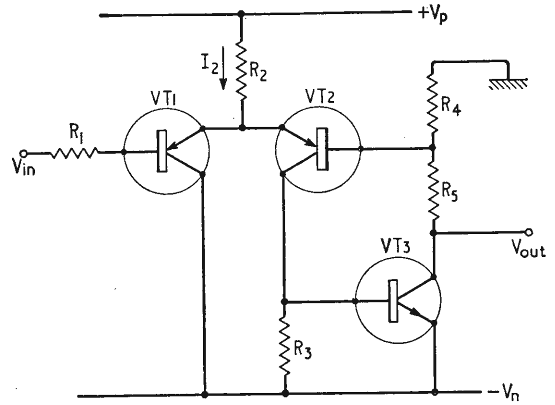


Fig. 3. Improved direct voltage trigger circuit with defined trigger levels.

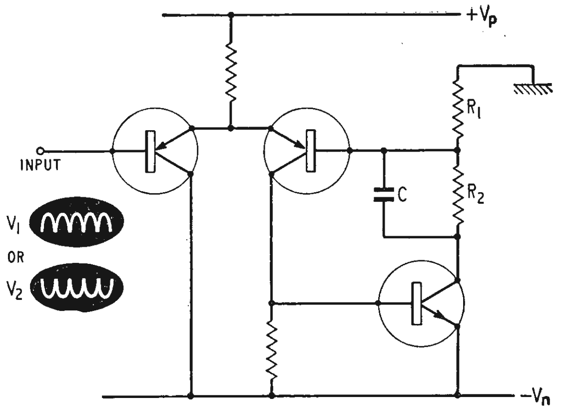


Fig. 5. Trigger circuit for operation on peaks of phase-sensitive detector output.

current flows in the output lead, though simply shunting the output to earth does not matter.)

To minimize the (second order) effects of temperature change on trigger levels, the circuit conditions at the instant of changeover should be decided like those of a d.c. amplifier. Thus, for minimum change of trigger level:

(a) Balance the emitter-base voltage of VT1 and VT2 by using similar transistors in thermal contact, and keeping collector dissipation low.

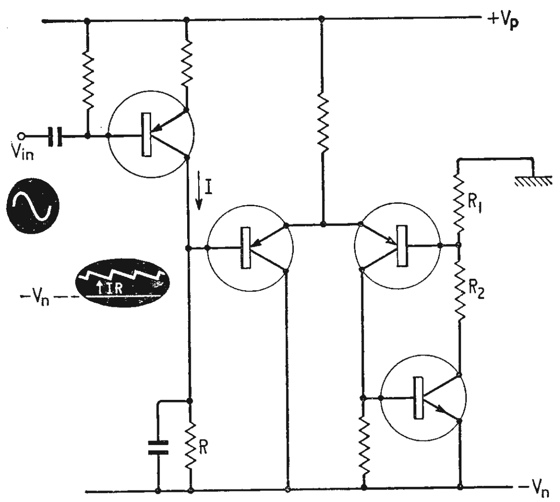
(b) Keep down voltage changes in base circuits due to base currents. The base circuit resistance should be small, and the transistors chosen should have small leakage currents and high values of beta at low emitter current (so that the base current is small).

(c) Ensure that VT3 cannot be turned on due to leakage currents from VT2 and VT3 flowing through R_3. Some bias across R_3 may be required.

The advantages of the circuit of Fig. 3 are, then, that the trigger levels are well defined and easily set to any desired value, including earth; the output resistance is low; and there is no restriction (apart from voltage ratings) on the range of values of V_{in}.

The circuit has a number of applications of which two will be mentioned here.

Fig. 4. Trigger circuit driven from detector.



The first is useful in detecting when the level of an alternating signal has exceeded a critical value. This is illustrated in Fig. 4 where the first transistor acts as a detector, the partly smoothed output of which is coupled to the trigger circuit. By making the hysteresis in the trigger circuit larger than the peak-to-peak ripple voltage at the collector of the first transistor, the imperfect smoothing does not cause continual retriggering. Another useful feature is that the ratio of the two signal input levels corresponding to the two triggering levels is independent of the supply voltage, as shown in the Appendix.

The second application arises when a conventional phase-sensitive-detector is being used to determine whether two signals are in phase or in antiphase. The output waveform of such a detector (Fig. 5) is of the form V_1, representing, for example, in-phase signals or V_2 representing antiphase signals. The waveform is then usually smoothed to give a positive d.c. level for V_1, negative for V_2.

When the inevitable time lag introduced by the smoothing is a problem, the unsmoothed output can be connected directly to the trigger circuit (Fig. 5). The d.c. level at the first base and the values of R_1, R_2, and V_n are such that the circuit triggers forward near the peak of V_1 and back near the peak of V_2.

Thus the circuit is now quick to respond to sudden changes from in-phase to antiphase phase-sensitive detector inputs but is able to ignore the ripple content.

APPENDIX

Trigger level 1 is given by

$$I_1R - V_n = 0$$

$$\therefore \quad I_1 = \frac{V_n}{R} \quad \ldots \quad (1)$$

Trigger level 2 is given by

$$I_2R - V_n = -\frac{R_1}{R_1 + R_2} V_n$$

$$\therefore \quad I_2 = \frac{R_2}{R_1 + R_2} \cdot \frac{V_n}{R} \quad \ldots \quad (2)$$

From (1) and (2)

$$\frac{I_1}{I_2} = \frac{R_1 + R_2}{R_2}$$

$$\therefore \quad \frac{V_{n1}}{V_{n2}} = \frac{R_1 + R_2}{R_2}$$

MICROWAVE VALVES

FOURTH INTERNATIONAL CONGRESS HELD AT SCHEVENINGEN (THE HAGUE)

ABOUT five hundred representatives of some 16 countries spent a superbly organized five days at the seaside resort of Scheveningen at the latest of this series of international conferences. Its predecessors have been held at two-yearly intervals since 1956 in Paris, London and Munich; there was certainly no sign of any slackening of interest in the problems of microwave tubes, though naturally the emphasis is gradually shifting with the years. In a wide-ranging introductory lecture, Dr. Casimir, of the Philips Research Laboratories, suggested that the typical characteristic of microwave work was the use of apparatus of dimensions comparable to wavelength. Thus if anyone chose to make a klystron for a wavelength of 30 metres with cavities of dimensions comparable with those of the grandiose Kursaal, in which the lecture was being delivered, it would surely be regarded as a microwave tube in spite of its size. When, later in the conference, a description was given by A. J. Monk of the 6-metre-long, 4½-ton travelling wave tube for 100MW pulse output at 400 Mc/s now being developed in England at the Services Electronics Research Laboratory, Harlow, the example did not seem quite so fanciful.

The trends of fashion are indicated by the distribution of subject matter between the 21 sessions.

A vestigial half-session on diodes and grid-controlled tubes, one and a half sessions on klystrons and two each on travelling-wave tubes, crossed-field devices and parametric devices, represented the main stream of development. The specialist disciplines which back up this development provided one session on slow-wave structures, one on electron-beam waves, two on noise, three on the formation and focusing of electron beams, and two on constructional and cathode technology. Future possibilities were indicated by two sessions on "tubes of special design", on which unfailing ingenuity continues to be exercised, one on gas-discharge devices, revitalized by the general growth of interest in plasma physics, and one on masers, an inevitable incursion from "quantum electronics".

Low Noise Gun Design

A fascinating feature of international conferences is the way in which the apparently confused pattern of activities in all parts of the world somehow crystallizes into recognizable new trends and ways of thinking. Among these may be mentioned the increasing use of hollow electron beams of high perveance in klystrons and travelling-wave tubes, the beams often being derived from "magnetron" guns in which the cathode and anode are cylindrical or conical, coaxial with the focusing magnetic field. The proper design of such guns is still a matter of debate, but successful results have been obtained at all power levels from megawatt klystrons to travelling-wave tubes with a few watts output. The noise behaviour of such guns was variously reported: some workers have found the high values typical of crossed-field guns, others behaviour as good as that of conventional travelling-wave-tube guns. There is a link here both with the crossed-field and the low-noise art, in both of which experimental results and theory are inadequately correlated. Crossed-field devices continue to provide very large powers at high efficiency, both as amplifiers and backward wave oscillators, but the spurious phenomena inherited from the magnetron remain as a rather confused picture—however, new crossed-field gun designs related to the "magnetron" hollow beam guns have recently given striking improvements. At the other extreme of low noise, travelling-wave tubes using guns with a low-velocity drift region and scrupulous care in construction, particularly of the cathode surface, continue to improve in noise figure —2.6dB, falling to 1.7dB with liquid nitrogen cooling, was quoted for tubes in the 200-4000 Mc/s range by Israelsen and Peter of Watkins-Johnson. These seem to be the lowest figures available for broad-band amplifiers, and provide quite a challenge to the electron-beam parametric amplifier which at first seemed to be in the lead. There seems to be no satisfactory theory for this low-noise behaviour as yet. A further piece in the jigsaw was provided by Klüver of the Bell Telephone Laboratories; he has made a crossed-field parametric amplifier at 2,000 Mc/s with a noise figure of 5dB, and an implication of a beam noise temperature of only 10-20°K in spite of its crossed-field character.

Thus, to summarize, the excessive noise often encountered in crossed-field devices, and the very low noise obtained elsewhere, all seem to depend on very delicate considerations in the electron gun, which seem likely to be elucidated very soon.

A further feature of the study of electron beams was the number of very careful experiments being done on the detailed behaviour of practical beams: higher frequency and power travelling-wave tubes require beams of increasing perveance and convergence which are carefully focused. Very detailed studies are being made in the U.S., France and Japan. The high-frequency waves which can propagate on such beams are also receiving both theoretical and experimental attention.

Parametric Amplifiers

It is the coupling of such waves to cavities and slow-wave structures which forms the basis of the well-known microwave tubes; most of the newer ideas result from an extension of these interaction processes to more general types of wave motion. Thus, in the degenerate quadrupole amplifier (see for example p. 393 of our August 1960 issue), fast cyclotron waves on a beam are excited and the noise removed in Cuccia couplers, and low-noise parametric amplification follows on the application of a pump signal at twice the signal frequency. It has been appreciated for some time that non-degenerate operation (pump frequency no longer twice signal frequency) would be desirable; Adler of Zenith described the arrangement necessary so that a signal at 400 Mc/s could be amplified by a 2,000 Mc/s pump, giving a 2dB noise figure with the (1,600 Mc/s) idler load at room temperature, and 1.3dB with it cooled in liquid nitrogen. Further insight into parametric coupling was provided by Sturrock of Stanford University and Davis of G.E.C., who showed that "beam refrigeration" (reduction of slow-wave noise prior to normal travelling-wave amplification) could be accomplished parametrically. Japanese, British and American workers also described various "d.-c. pumped" parametric amplifiers in which multi-helix or ring circuits at different d.c. potentials round the beam provide a further type of amplification process. An ingenious proposal by Shing Mao and Siegman of Stanford was to use continuous helices to excite cyclotron waves, amplify them by "d.c. pumping" and couple out the amplified wave: it was suggested that the required helix sizes were larger than for conventional travelling-wave tubes.

Plasma Devices

A further class of device which is generally desirable for higher frequencies is one in which there is no mechanical slow-wave structure. One type includes a stationary plasma, usually in the presence of a magnetic field permeated by an electron beam. Over certain frequency ranges microwave signals propagating through the plasma can be amplified by travelling-wave processes—overall gains of 30dB or more have been reported. In most cases, however, slow-wave structures were used to couple the signals in and out: Ferrari of G.E.C. was able to avoid this, though the coupling losses were still rather high. He formed the plasma by collisions with the electron beam, rather than by a separate discharge, reducing the noise considerably. For very high frequencies, high plasma densities are needed: St. John of Microwave Associates indicated how plasmas suitable for millimetre wavelengths might be obtained.

Cyclotron Resonance Devices

Devices without slow-wave structure can also be made by using beams with periodic motion which can be coupled to plain waveguides or transmission lines. Some of these depend on cyclotron resonance in a magnetic field: Stevenson of G.E.C. indicated how power can be generated at the resonance frequency and Ono of Tokyo University showed how this might be extended to harmonics of the resonance frequency. A related proposal by Thompson and Dain of English Electric involved exciting a beam at cyclotron resonance in a Cuccia coupler and passing it through a magnetron block to generate power at as much as ten times the cyclotron frequency. Considerable success was reported with the "Ubitron" by Phillips of G.E.: this has a beam modulated by permanent magnets and gives amplification along a waveguide. Peak outputs were reported of more than a megawatt at 10cm with 13dB gain and 10% efficiency: at 2cm the gain and efficiency were rather lower.

A final mention should be made of "quantum electronics". Travelling-wave masers were described by Walling of Mullard—careful magnetic-field shaping has given 60 Mc/s bandwidth with 38dB gain at 3,025 Mc/s—and by Weibel—the use of iron-doped rutile for a millimetre-wave maser was proposed. The mixing of optical maser outputs in non-linear resistors to produce (difference frequency) sub-millimetre radiation was discussed by Fontana of Stanford. McMurty described a broadband detector (for a microwave modulated laser beam) in which a photo-cathode was followed by a conventional helix travelling-wave amplifier.

This account indicates some of the novel ideas which attracted attention at the Conference. It does not do justice to the large quantity of detailed work on development of existing devices, which will, no doubt, find due recognition in the manufacturers' catalogues.

"Permanent Magnets and Magnetism"

THEORY, MATERIALS, DESIGN, MANUFACTURE AND APPLICATIONS

THIS new Iliffe book is the first fully comprehensive treatise on the subject to be published in this country. It has been written by a team of authors, each an expert in his own field, under the editorship of Dr. D. Hadfield.

An introductory chapter by Professor E. da C. Andrade discusses the early history of the subject. This is followed by a chapter by Dr. McCaig on Magnetic Units and Definitions. This includes a useful explanation of the relationship between the m.k.s. and c.g.s. systems (although this book is written primarily in the m.k.s. system, the corresponding equivalent relationships in the c.g.s. system are given throughout). Two following chapters discuss the theory of permanent magnetism; the first, by Professor F. Brailsford, mainly from the point of view of atomic theory; and the second, also by Dr. McCaig, primarily from the point of view of domains.

The rest of the book deals with the subject from a practical point of view. J. F. Hinsley contributes a chapter on the Classification and Properties of Permanent Magnet Materials, a valuable feature of which is the 27 tables of properties of the main commercial materials. This leads to a chapter by Dr. A. Edwards on Magnet Design and Selection of Material for a wide variety of applications; and the many and varied applications as such are fully described in the following chapter by F. G. Tyack. The Manufacture of Permanent Magnets is discussed by J. C. Williamson, and F. Knight describes the various methods of magnetization and de-magnetization. The important subject of Magnetic Stability is next discussed by J. E. Gould.

After an account of the development of the industry by Dr. A. G. Clegg, two final chapters by Dr. K. Hoselitz and Professor W. Sucksmith discuss respectively Current Research and Development and future trends.

This book should prove of great value to a wide variety of people; to students, to designers, to manufacturers, and to users. With 556 pages and costing 105s, it is published by Iliffe Books Ltd., of Dorset House, Stamford Street, London, S.E.1.

Sine v Square Waveform

IS SINE WAVE INPUT REALLY NECESSARY?

By V. VALCHERA*

THE advancement in power transistor design has led to the development of highly efficient transistorised d.c. to a.c. converters, which for ease of identification we shall refer to as "transverters."

Transverters providing a square waveform are very frequently used as stand-by a.c. sources in the event of a power failure, for operating v.h.f. transmitter/receiver equipment or automation control gear and, in mobile laboratories such as are frequently used by car manufacturers for the scientific development of their cars, the square waveform transverter is usually the source of all the electrical energy requirements for operating oscilloscopes, heat and vibration recorders, television cameras, etc.

These transverters convert a direct voltage of up to 50V to a.c. The transistors used in them operate as highly efficient switches, alternating the d.c. supply across a transformer primary at a pre-determined frequency, and the resultant a.c. output takes the form of a "square" wave as shown in Fig. 1.

Although the waveform is normally termed "square," this is not quite correct. The tops of the waveform have a decided slope, shown slightly exaggerated in Fig. 1, which is primarily caused by the inductive effects of the associated transformer. Units producing a square waveform have a very high conversion efficiency and very low output impedance, outputs of up to 65W from 12V or 24V batteries being obtainable.

Most a.c. equipment designed to operate from a sine wave source will function quite satisfactorily from a square or rectangular waveform, such as that obtained from transverters. However, in order to obtain optimum results the effects of the square waveform on the operation of the equipment should really be considered at the design stage, although in most cases identical results to sine wave working can be obtained, with no modification whatsoever, or by minor alterations. There are very few cases where it is impossible to operate equipment from a square waveform. In terms of electrical energy, there is very little to choose between sine waves and square waves; the differences only become apparent when the two waveforms are applied to equipment in which energy is converted from electrical to mechanical, as in an a.c. motor, or rectified. Most a.c. motors operate equally well on a square and sine waveform, but there are certain types which may suffer from a slight loss of power. This can usually be overcome by adding a 2 to 4μF capacitor across the supply, incidentally improving the power factor.

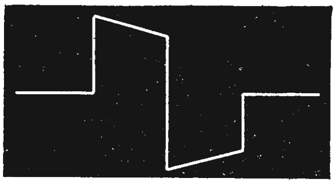


Fig. 1. Typical waveform from square wave transverter.

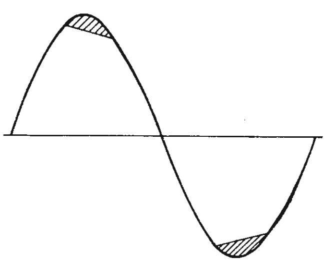


Fig. 2. If sine wave obtained from high impedance source, rectifier circuit clips peaks.

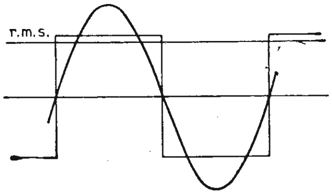


Fig. 3. Relative amplitudes of sine-wave and equivalent square-wave.

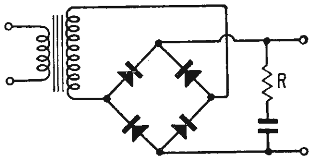


Fig. 4. R reduces output to r.m.s. value of input on both square and sine. Level is restored by increasing input volts.

Each piece of equipment is designed to obtain the best possible results using the characteristic features of a sinusoidal waveform. For example, in rectifier circuits it is quite usual to obtain a direct voltage higher than the r.m.s. value of the a.c. This is achieved by using a combination of low forward-resistance rectifiers and high-value reservoir capacitors. When operating such circuits from a square waveform, the resultant d.c. will be slightly lower than that obtained from a sine wave whose r.m.s. amplitude is equal to the peak square wave. In most cases the loss of a little voltage will not affect performance. However, in some types of laboratory equipment, stabilized d.c. supplies are employed, where it is imperative that the unstabilized direct voltage should be well above the stabilized level.

At first glance, it would appear that if the square

---

* Valradio Ltd.

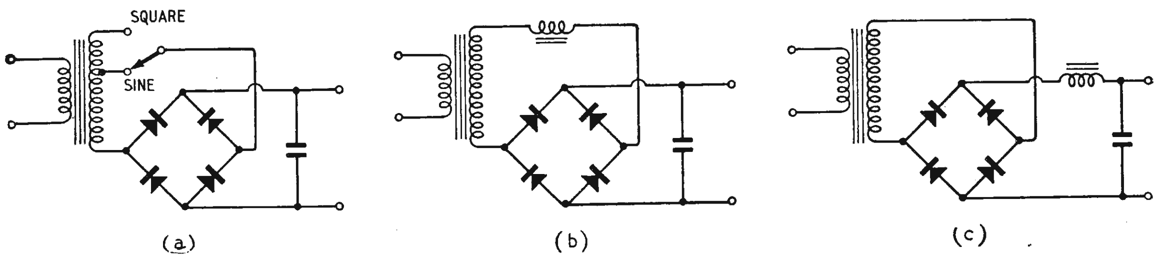


Fig. 5. Alternative methods of compensation. Choke-input filter tends to equalize rectified levels.

wave were converted to sine wave, the difficulties of low rectified output could be overcome. Unfortunately, this is not the case. While it is relatively easy to obtain a sine wave, the process results in a much higher output impedance, which would cause a rectifier/condenser circuit to clip the waveform as shown in Fig. 2, the effect being a reduction in voltage output.

The ideal solution is for the equipment to be designed so that the rectified output is equal to or slightly less than the r.m.s. value of the a.c. and increasing the applied a.c. by about 15%. This can be achieved by reducing the value of the reservoir capacitor or inserting a resistor in series with the capacitor (Fig. 4). Alternative methods are shown in Fig. 5. Advantages of these modifications are lower peak current, improved rectifier reliability and reduction in the heat developed in the supply transformer.

Any increase in alternating voltage to compensate for the loss suffered in square wave operation involves over-running a.c. devices such as valve heaters and motor windings. This is of no consequence in the case of motors, where the increase will offset the slight loss of power on square wave, and will restore the power consumption to its original rating. Heater dissipation, however, must be maintained within the valve manufacturers' limits and if the applied a.c. is increased, it may be necessary to introduce a small resistor in the heater circuits. Where a separate heater transformer is used, the primary can be set to a higher voltage tap. Besides the normal tappings on the equipment transformers most transverters incorporate a range of tappings providing output voltages above and below the nominal rating.

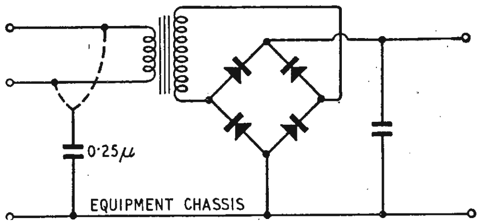


Fig. 6. Hum-bucking circuit.

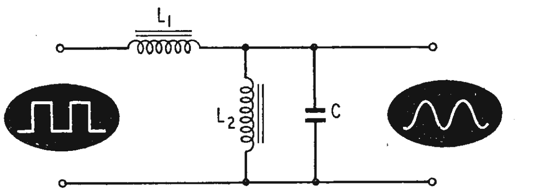


Fig. 7. When sine-wave essential, filter of this type can be used.

The 50 c/s square waveform obtained from transverters contains significant output at frequencies up to about 1,000 c/s. Amplifying equipment which is likely to be operated from a square waveform supply should be effectively screened at these frequencies. Most transverters at present on the market incorporate some form of suppression of the higher harmonics; however, it is important to remember that the radiation range increases with frequency, so that the interaction between two transformers spaced, say, 10in apart, is negligible at 50 c/s but may be considerable at 1,000 c/s. One very effective way of eliminating stray hum pick up is by the hum-bucking action of the circuit shown in Fig. 6. The action of this circuit is to feed into the "earthy" side of the amplifier a slight amount of hum which is in antiphase to the picked-up hum.

In the rare cases where a sine wave is absolutely necessary a suitable filter can be interposed between the transverter and the equipment. The circuit of such a filter is shown in Fig. 7.

Values for 150W sine wave filter of Fig. 7:

L_1 = 1 H
L_2 = 1 H
C = 10μF

Winding data:

L_1 = 850 turns × 20 s.w.g. en. copper wire, wound on 1¼in stack of No. 136 laminations inserted choke fashion. Gap .03in.

L_2 = 800 turns of 22 s.w.g. en. copper wire, wound on 1¼in stack of No. 78 laminations, interleaved.

Detection of Nuclear Explosions

DURING the high-altitude test over Johnston Island in July, engineers of Cable & Wireless at Singapore attempted to detect the explosion using their back-scatter equipment. It consists of an h.f. communications transmitter to which is applied a train of audio pulses on one sideband of a frequency around 14 Mc/s and is used to locate the range at which transmitted energy reaches the earth's surface. With a pulse repetition of 10 per second it should be possible to detect an echo out to a range of 15,000 km. Normally there are echoes due to energy being scattered when the ionospherically propagated waves strike the ground, but these seldom exceed ranges of 5,000 km. However, 20 min after the explosion a clear echo was received from a range of 9,300 km—close to the point of the explosion. It remained for only 10 minutes.

ELECTRONICS AT FARNBOROUGH

THE period of the light-hearted attitude to flying ended long ago, and regular services in foul weather are now *de rigueur*. Landings at night or in fog with several million pounds worth of aircraft and hundreds of passengers are not noticeably comic, and "playing it by ear" is strictly for the birds.

Automatic landing has long ranked with wins on the pools and profit-making airlines as being desirable, but hardly realistic. However, due to the sterling work of the Blind Landing Experimental Unit, the two latest types of aircraft to emerge have gone a long way towards this ideal, and it is hoped to have them certificated for automatic landing in 1966.

The equipment installed in the VC10 has been developed by Elliott Brothers in co-operation with S.T.C. and Marconi. Bendix PB-20 autopilots are used, with comparison monitoring, and Standard Telephones STR-40 frequency-modulated radio altimeters. The glide-slope receivers are Marconi AD260, while the autoflare control computer is an Elliott monitored type. This complete equipment is suitable for autoflare only, that is, it is effective in controlling the aircraft's attitude in pitch down to touch down. Information is supplied by the I.L.S. glide-slope system to the autopilot, which directs the approach path from interception by I.L.S. down to about 150ft. Below this height, I.L.S. glide-slope guidance becomes less accurate, and a "memory" system is used. A detailed plot of the pitch behaviour from 2,000ft to 50ft is stored and used to operate the autopilot from 150ft to the beginning of flare-out at 50ft. At this point, a radio altimeter takes control of the pitch axis of the autopilot, rate of descent being now proportional to height, so that the approach is exponential.

Autoflare having been proven, it is then proposed to bring into operation automatic control in all three axes, when the system will be completely automatic and weather-independent. Although the electronics for the whole system is well understood, the autoflare stage is to be operated first because the system of azimuth guidance is yet to be decided. The two protagonists are the B.L.E.U./Murphy leader cable system in which two signal-carrying cables run parallel to the runway, receivers operating the azimuth computers, and the later, more accurate type of Pye I.L.S. localizer.

Some indication of the magnitude of reliability required (the figure for maximum risk is 1×10^{-7}) is given by the fact that an airline operating ten intercontinental aircraft should have not more than one fatal accident in 1500 years during the landing phase, a period of flight during which 40 per cent of all accidents have occurred during the last ten years.

Equipment used in automatic landing includes the radio altimeter, and the Elliott/Bendix AN/APN-141 is remarkable from two points of view. First, it is a true radar equipment, using nanosecond pulses. Freedom from vibration troubles, which often cause spurious modulation in the f.m. variety, is achieved, and aircraft attitude is not critical. Secondly, the whole equipment (with the exception of the oscillator) incorporates what Elliotts call "solid-state reliability." This can mean many things to many people, and it is taken to mean that all signal-switching is carried out by semiconductor gates which only require the application of d.c. command levels. The only moving parts are the control switches and meters. The old problem of the "disappearing gremlin," the "fault" that clears up on the way from the aircraft to the servicing bay, is avoided by the liberal use of self-check circuits for all functions.

When the aircraft has landed, one may think that the pilot's problems revert to those of a rather expensive lorry-driver, but this is not quite so. Many large aircraft have restricted speed during ground handling, and in any case even with the wheels rolling, the pilot is still at a considerable altitude, and speed estimation can be difficult, especially in poor visibility. A taxispeed indicator is, therefore, required, and Smiths have a neat solution. A sensing unit is mounted on a fixed part of the undercarriage and magnets fixed to the wheel rim. The gap between detector and magnets is 0·1in and current pulses are produced when the wheel rotates. Pulse integration gives a d.c. output which is proportional to the rolling radius of the wheel and which is fed to a meter calibrated in knots.

The development of VTOL aircraft will eventually lead to the disappearance of airfields as they are now known, and landings will have to be made on sites which, to take full advantage of VTOL capabilities, will be in cities and, therefore, probably surrounded by obstructions. The R.A.E. are studying the problem, and a possible solution was shown in model form. A computer store is supplied with a selection of landing profiles, taking into account direction of approach, loading, aircraft type, etc., any of which can be selected by the Controller. Microwave interferometers disposed about the site measure phase-slips between aerials and thereby continuously determine the direction-cosines of the slant lines to the airborne beacons. The direction-cosines are fed to the computer and difference signals extracted when these differ from the stored profile. The difference signals are transmitted to the aircraft, over a link which could be multiplexed to cope with up to ten aircraft, and processed by an airborne computer, which then feeds the autopilot.

Navaids and A.T.C.

The squabble between Americans and Europeans on the system of navigation and traffic control to be used as standard continues. The Americans insist on using VORTAC, which is a combination of VOR and the distance measuring part of TACAN, while the system to be evaluated by Eurocontrol is HARCO (Hyperbolic ARea COverage), proposed jointly by Decca, CSF (Compagnie générale de télégraphie Sans Fil) and Telefunken. HARCO is a development of DECCA, which means that, as about 60% of Eurocontrol is already covered, only five more chains will complete the area. The airborne equipment consists of one of two types of

Ferranti Moving Map pictorial navigation display for use with inertial or doppler navigators.

receiver—Type A for fast transports and Type B for slower, lighter aircraft. Both are transistorized and the Type A provides a digital output which can be used for a data link system and to provide an input for Omnitrac. The latter is required to perform the conversion of hyperbolic co-ordinates into Cartesian co-ordinates, so that ordinary charts can be used instead of the distorted kind necessary for hyperbolic systems. The Mk. 3 Flight Log, which completes the system, has a digital track on the edge of the map, which enables photo-electric sensors in combination with Omnitrac to set the pen automatically. The system is capable of extension into auto-navigation by direct coupling of Omnitrac to the autopilot or by remote-sensing both a prepared track and the Flight Log trace optically, comparing the two and correcting via the autopilot. In this way, for instance, curved tracks could be followed.

Both I.C.A.O. and Eurocontrol require the use of a pictorial display for the navigation system, and one form is the Ferranti Moving Map. Flight maps are reproduced on 35mm colour film which is projected on to a ground glass screen between the pilot's and co-pilot's positions. Information from Doppler or inertial navigators is used to move the film and film carriage in two axes so that a fixed point on the screen is always over the aircraft's position on the map. Track-stabilized or north-stabilized modes of operation are used in which the top of the screen corresponds to either the aircraft's heading direction or to north, a switch selecting the required mode. It is also possible to offset the position marker to show as much of the future track as may be required.

The Marconi p.p.i. shown last year has been developed and transistorized, and the principle of alpha-numeric display is now used in two units—the S.3001 radar display and the S.3101 tabular display. The S.3101 is intended mainly for use in Air Traffic Control centres to present the findings of a computer in a quickly assimilable form. 50,000 characters per second may be written, this high speed making it possible to use the display for on-line working. Two sets of deflection coils are used in order to satisfy the conflicting requirements of high-speed deflection and full screen deflection. The main deflection coils are driven by a low-frequency saw-tooth to provide what could be described as a raster, although this is not visible. The individual characters are formed by deflecting the spot to the intersections of a 4×4 matrix, the deflection being obtained by a character-generator fed by a ferrite store. Deflection from one character to the next is performed by superimposing on the main sawtooth a high-frequency signal which aids the main one during the flyback and cancels it during the sweep. The sum of the two provides the required staircase waveform.

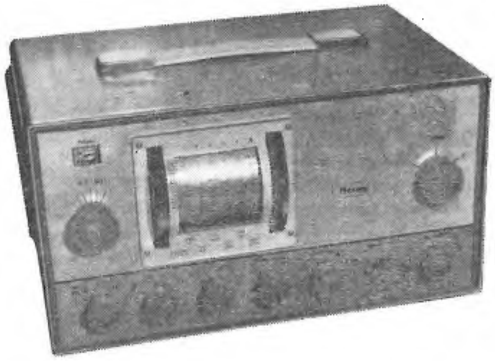
Test and Measurement

A second method of defeating the "disappearing gremlin" is adopted by Hawker-Siddely Aviation. It is estimated that 50% of units removed from aircraft are serviceable and that removal, which entails holding spare units for replacement, could be reduced by automatically checking electrical and electronic equipment *in situ*. The Tape-controlled Recording and Automatic Check-out Equipment (TRACE) consists of signal sources and a measuring system, which are switched to the required channels, and a control system. The use of analogue-to-digital converters in the measuring unit enable the use of digital computers to analyse results in order to establish fault patterns and trends. Programming is by punched tape.

With the introduction of power supply units using transistors instead of rotary transformers, designers have been made sharply aware of the devastation caused by transients on supply lines. Suppressors have become imperative and W.S. Electronics have introduced a device for checking them. A direct voltage equal to the transient to be simulated is applied to the collector of a series regulator, and a signal similar in shape to the transient impressed on the base. The output is now a transient of accurately known size and shape (steep leading edge, exponential decay).

Communications

Completely transistorized communications receivers are still fairly thin on the ground, but Plessey were showing a neat little double-superhet for the range 550kc/s to 30Mc/s, in 6 ranges. Tuning is by a 40-in film scale, and a tunnel diode crystal calibrator offers a setting accuracy of 0.1%. H.t. to the first oscillator and crystal calibrator is Zener-stabilized, which means that the internal batteries will give a useful life of 50 hours. Plessey have also developed a combined u.h.f./v.h.f. transceiver for use in military aircraft flying into civil aerodromes; normally, military communications are in the u.h.f. band, while v.h.f. is used for civil aircraft.



Plessey transistor communications receiver for mains or battery operation. Sensitivity is 5μV for 250mW audio output. Total scale length (550kc/s-30Mc/s) is 18ft.

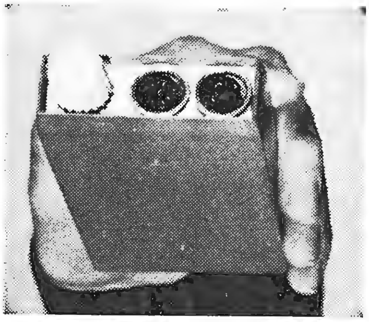
On the subject of communications, we feel that Tannoy deserve recognition for the magnificent public-address equipment used for the Show, where the combined problems of crowd dispersal and jet noise are indeed formidable. A total of 8kW was fed to six groups of 500W line-source units and 170 separate reproducers, and synchronism over 1,000yd was achieved by delaying the signal by up to 2½ seconds in a separated-head tape record/playback unit.

Telemetry and Recording

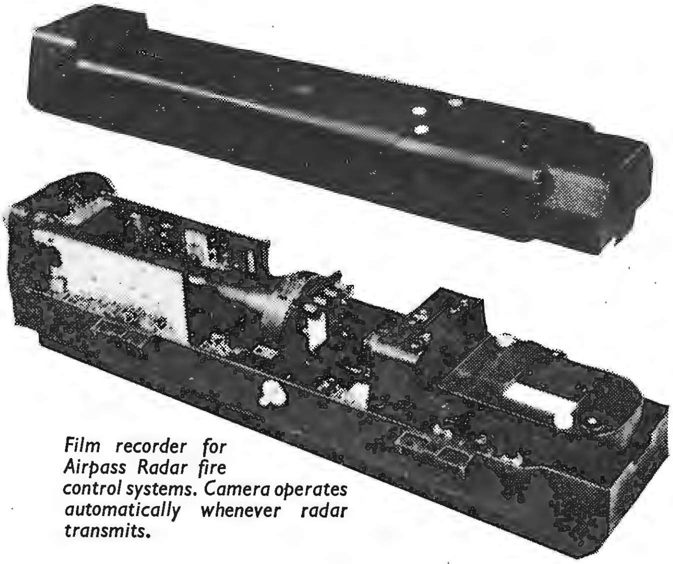
Radio telemetering equipment which has been extensively used in missile development was shown by E.M.I. The typical sender is capable of telemetering information on up to 21 variables by means of an f.m./a.m. time-multiplex system. The physical parameter to be measured (pressure, vibration, etc.) is converted to a voltage or, by means of permeability variation, made to alter the inductance of a coil, and used to frequency-modulate a subcarrier oscillator working between 130kc/s and 160kc/s. A 24-contact motorized switch selects the channels, one of which is used to synchronize the receiver, which de-multiplexes in real time. The f.m. oscillator is then used to amplitude-modulate the carrier oscillator which works at about 450Mc/s.

Where weight is not a serious problem, an airborne recorder can be used and Specto showed an instrument which overcomes the problem of speed fluctuations by using two contra-rotating flywheels, accelerations of 12g having no measurable effect on tape speed. The tape spools are mounted on a common axis to keep size within reasonable limits, and the whole instrument, together with pulse-code and frequency modulation facilities, is contained in about one cubic foot. By multiplexing, 224 channels are obtained in 8 tracks on ½-in tape. Channel bandwidth is 3c/s.

Exhibited at Farnborough

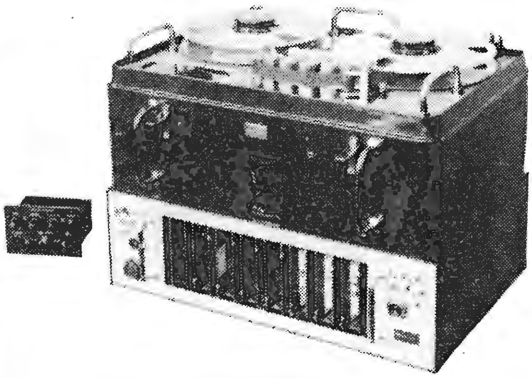


Pocket Intercommunication Amplifier by Amplivox for two-way or multi-way speech, It is particularly suited, together with boom microphone head set, for noisy situations.

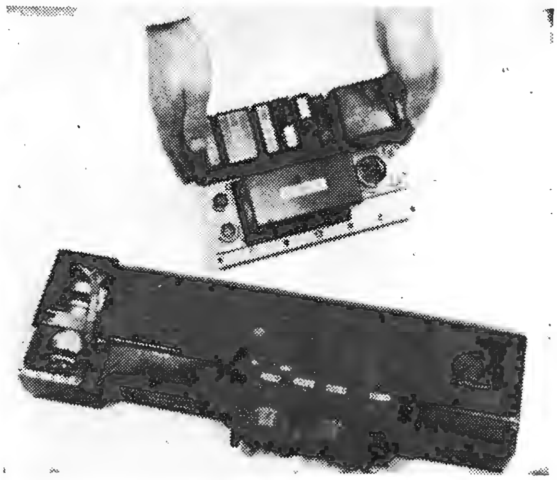


Film recorder for Airpass Radar fire control systems. Camera operates automatically whenever radar transmits.

Versatile transistorised radar display unit by Marconi can be used as plan position indicator with intertrace alphanumeric characters or as synthetic display for data handling.



Solartron instrumentation tape recorder.



Above—Missile telemetry senders by E.M.I. Electronics. F.m. sub carrier amplitude modulates transmitter working in the range 400-500 Mc/s.

Left—Precision approach radar for small, fast jet aircraft, the S.T.C. SLA 3/C.

TELSTAR REPORT

REVIEW OF TRANSMISSION TESTS

CONSIDERABLE publicity was given to the first intercontinental television transmissions *via* Telstar but some of the less spectacular "firsts" have passed almost unnoticed. The most recent was the joint experiment undertaken by the British National Physical Laboratory and the U.S. Naval Observatory to check the time standards of the two countries. The experiment involved the simultaneous transmission of precise time signals in both directions (from Andover, Maine, and Goonhilly, Cornwall). These signals were obtained from the quartz clocks installed at each station. The accuracy of time comparisons has previously been limited by variations and uncertainties in the time of propagation of signals transmitted by long and short waves *via* the ionosphere. The accuracy achieved during the 424th orbit of Telstar on August 25th was 10-20μsec compared with the previous 1-2msec. The result will provide the basis for better co-ordination between satellite tracking stations and in improving the accuracy of radio-navigation systems.

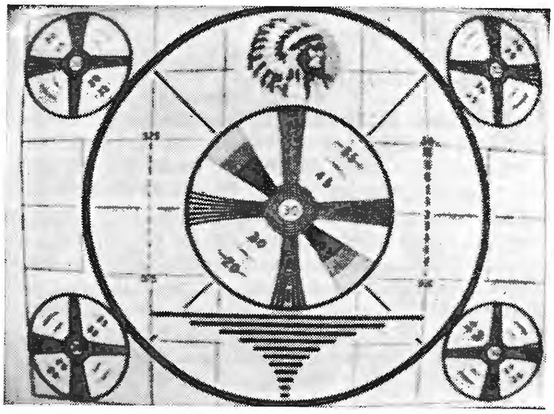
For the record we list below the various Telstar intercontinental experiments undertaken so far.

Television Tests.—A difficulty was encountered at Goonhilly on the initial attempts at transatlantic television reception during the earliest usable orbits (6 and 7) on July 10th due to a reversal of the direction of rotation of the wave polarization of the aerial relative to that of the satellite. This arose from an ambiguity in the accepted definition of the sense of rotation. Only a noisy picture was received. During these orbits the American transmissions were received satisfactorily at the French station at Pleumeur-Bodou in Brittany. The sense of polarization of the Goonhilly aerial having been reversed, excellent pictures were received from Andover, on orbit 15 and broadcast in the U.K. networks on July 11th. During the 16th orbit transmissions from Goonhilly were received at Andover and broadcast in the U.S.A.

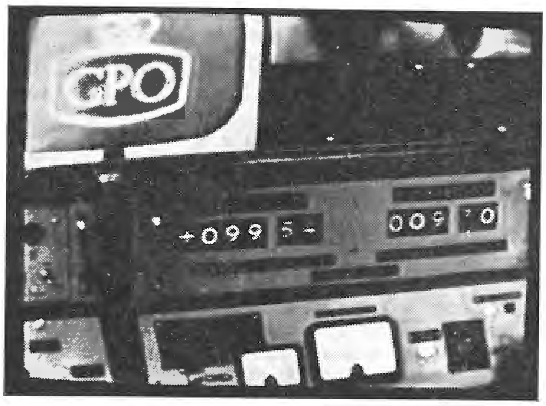
Telephony.—During the 24th orbit (July 12th) the first two-way telephony tests using 12 channels in each direction were made. Tests were carried out on the 43rd orbit (July 15th) to assess the ability of a communication satellite to transmit large numbers of telephone circuits. "White" noise was used to simulate 600 simultaneous one-way telephone conversations, gaps being left in the spectrum of the white noise (60 to 2,500 kc/s) in which unwanted noise and crosstalk could be measured. The results demonstrated that at least 600 telephone circuits, with a quality comparable with first-grade international circuits, should be possible by satellite.

Phototelegraphy.—During 12-channel telephony tests on July 14th one pair of channels was used to transmit facsimile pictures between London and New York.

Colour Television.—During the 60th and 61st orbits (July 16th) the first transmissions of colour television *via* a satellite were made from Goonhilly, with the co-operation of the Research and Designs Departments of the B.B.C. The signals, which were on 525-line N.T.S.C. standards, comprised captions, test cards and still pictures used to assess colour quality. The transmissions, which were made initially from Goonhilly to the Telstar satellite and back to Goonhilly, were also received at Andover who reported: "colour, good; picture quality, excellent." There was no perceptible deterioration of colour quality due to Doppler frequency shifts.



"Indian Head" test card as received at Goonhilly after transmission from Andover via Telstar.



Picture of control console at Goonhilly as received back at the station after retransmission by Telstar.

Transatlantic TV Programmes.—On July 23rd an 18-minute programme, comprising scenes transmitted by the Eurovision link from many European countries, was radiated from Goonhilly and received satisfactorily at Andover and broadcast throughout the United States. The picture monitors at Goonhilly showed no perceptible difference in quality between the incoming pictures from the Eurovision link and those transmitted by Telstar and received back at Goonhilly. On the same day a television programme from America was very successfully relayed by both the B.B.C. and I.T.A.

General Comments.—The results obtained from the Telstar demonstrations and tests to date have confirmed the expectation that communication satellites could provide high-quality stable circuits both for television and multi-channel telephony.

The performance of the G.P.O. station at Goonhilly, after the correction of the initial error in polarization, has been excellent in every respect. The satellite has been "acquired" by the aerial, often within one degree of the local horizon, and tracked with great accuracy throughout the periods of mutual visibility.

WORLD OF WIRELESS

Another Board

THE three U.K. associations representing the manufacturers of components, valves and semiconductors have formed a joint committee, to be known as the Electronic Industries Supply Board, to deal centrally with Government departments, industry and research organizations on problems of common interest. The associations are—the British Radio Valve Manufacturers' Association (B.V.A.); the Radio and Electronic Component Manufacturers' Federation (R.E.C.M.F.) and the Electronic Valve and Semi Conductor Manufacturers' Association (V.A.S.C.A.). The chairman is S. S. Eriks, K.B.E., managing director of Mullard Ltd., and the secretary is R. Kelf-Cohen, C.B., who is director and secretary of the Radio Industry Council.

The associations will continue to operate independently on most questions of policy, planning and development, but "when matters arise which are beyond the competence of one association, the Board will provide a single, integrated channel for discussion and negotiation."

Stereo Broadcasting

EXPERIMENTAL stereophonic broadcasts have been conducted by the B.B.C. for several years, but these have necessitated the use of two transmitters. Now the B.B.C. has started a new series of experiments, using the Zenith-GE system, in which a single transmitter is employed for both channels. The Wrotham Third Programme transmitter, radiating on 91·3 Mc/s with an e.r.p. of 120 kW, is being used.

The transmissions, which will continue for several weeks, are radiated at the following times:—

Midnight Tuesday-00.25 Wednesday.
Wednesday 10.50-11.10 a.m.
Midnight Wednesday-00.25 Thursday
Saturday 10.50-11.10 a.m.

Details of decoding circuits for the reception of these transmissions are given in this issue.

1963 Radio Shows

THE first international radio and television exhibition to be held in Paris is scheduled for next September. This is of particular interest in view of the discussions concerning the Common Market. The Paris components show, which will be held from February 8th to 12th, will again be international.

Next year's German radio show—Funkausstellung—will be held in Berlin from August 30th to September 8th, but it will remain national in character.

At the time of going to press no announcement had been made regarding the London show for 1963.

U.H.F. Television Tests

WITH a view to obtaining more information about 625-line propagation in Bands IV and V, the B.B.C. has commenced a new series of field trials. The tests are being conducted from 10.30-17.00 and from 20.00-21.30 on Mondays to Fridays in Channel 44, using an existing aerial at the Crystal Palace (London) station. So that the problems of co-siting u.h.f. stations can be studied, simultaneous transmissions will also be radiated in Channel 34 early next year. The e.r.p. of both transmitters will be about 160 kW.

New I.E.E. Division Boards.—Elections to the boards of the Institution of Electrical Engineers' new divisions (electronics, science and general, and power), which replace the former specialized sections on October 1st, are announced.

Members of the electronics division board are J. A. Ratcliffe (chairman), G. G. Gouriet (deputy chairman), Dr. R. C. G. Williams and A. J. Young (vice-chairmen), W. Bamford, Dr. G. B. B. Chaplin, F. S. Barton, Professor A. L. Cullen, P. A. T. Bevan, Dr. E. V. D. Glazier, Dr. A. J. Biggs, W. C. Lister, B. W. S. Challans, W. S. Melville, G. Millington, Dr. J. A. Saxton, Dr. J. H. Mitchell, F. J. D. Taylor, J. Moir, T. B. D. Terroni, M. J. L. Pulling, C. Williams, W. S. Elliot and R. J. Halsey.

Science and general division board members are Dr. D. Taylor (chairman), Dr. J. R. Mortlock (deputy chairman), C. G. Garton and Professor J. M. Meek (vice-chairmen), Professor H. E. M. Barlow, H. W. French, G. S. Bosworth, C. A. Laws, Professor F. M. Bruce, A. C. Lynch, S. S. Carlisle, Dr. L. Rotherham, J. F. Coales, Dr. R. W. Sillars, Professor M. W. Humphry Davies, Professor R. A. Smith, Dr. L. Essen, Dr. J. S. Tait, R. H. Tizard, P. E. Trier, Dr. P. Vigoureux, S. E. Goodall and Dr. G. A. V. Sowter.

Malta Television.—A new television service which is being inaugurated in Malta on September 29th will use studio equipment designed and manufactured by Pye T.V.T. Ltd., of Cambridge, and supplied through Overseas Rediffusion Ltd., London, who have been responsible for the planning of the station. Pye equipment includes the latest image orthicon cameras, telecine, and video and audio mixers. Television transmissions will be on the 625-line standard.

South African Television Problematical.—Dr. Albert Hertzog, Minister of Post and Telegraphs, has informed parliament in Cape Town that it was not the government's intention to introduce television in South Africa at present. He thought the country might never have television, and certainly not for the next year or so.

Cabinet and Radio Accessory Show.—B.R.E.M.A. is to hold its sixth International Styling, Cabinet and Radio Accessory Exhibition at the Russell Hotel, Russell Square, London, W.C.1, from October 3rd to 5th. It is essentially a trade show of embellishments, cabinet materials, fabrics, ornamental controls, indoor aerials, etc., and admission is restricted by trade card.

Chicago Police Department has brought into operation an advanced design of communications centre which uses 27 radio frequencies, nine base transmitter locations and three "satellite" receiver stations to control 1,400 vehicles in a region of 224 square miles and serving a population of 3½M. The centre requires 300 people to operate it fully and is based on the principle of direct and complete integration of the police system with the public telephone system. This year some 1.6M police service calls are expected to be handled by the centre.

Brit.I.R.E. Convention 1963.—Next convention of the British Institution of Radio Engineers will have as its theme Electronics and Industrial Productivity, and will be held at the University of Southampton from April 16th-20th, 1963. Further details on application to the Secretary of the Convention Committee at 9 Bedford Square, W.C.1.

One-man Television Station.—A new educational television system, which can transmit programmes up to five miles and can be operated by one man, consists of a live pick-up TV camera, film and slide projection equipment, and a 50ft aerial mast. Designed by E.M.I. Electronics, the equipment enables a lecturer to teach a large number of students in his immediate locality by closed-circuit television and, at the same time, to reach more students in outlying schools by means of a low-power television transmitter.

Next I.C.A. Congress.—On page 495, which went to press earlier, we gave the venue (Liège) but omitted the year of the 5th I.C.A. Congress; it will be 1965.

Receiving Licences.—During July the number of U.K. combined television and radio licences increased by 55,960 bringing the total to 12,039,643. The latter figure compares with 6,642,742 registered television sets in operation in West Germany and in West Berlin on July 1st, an increase of 64,596 over the previous month.

Diagnostic uses of ultrasonics is the subject of a joint meeting of the three British radiological societies to be held in London on December 7th next. Ultrasonic surgery and diagnosis discussion groups have been arranged for December 5th and 6th by D. Gordon, West End Hospital for Neurology and Neurosurgery, 91 Dean Street, London, W.1.

Nine S.I.M.A. members are participating in an Instrument-Automation Conference and Exhibition which the Instrument Society of America is to hold in New York from October 15th to 19th. British firms exhibiting are Avo, Counting Instruments, Dawe Instruments, Newport Instruments (Scientific & Mobile), W. G. Pye & Co., Smiths Industrial Division, Stanton Instruments, W. F. Stanley & Co., and Wayne Kerr Laboratories.

City and Guilds of London Institute announce that following a major reorganization B. D. Hankin has been appointed director of the Institute with effect from October 1st. He succeeds Major General C. Lloyd, who was appointed director-general of the Institute earlier this year.

A 22-nation Asian Broadcasters' Conference, held recently at Kuala Lumpur, was told by the Malayan prime minister that he hoped their countries would become partners in a wide TV link-up of Asiavision. He said Thailand, the Philippines and Malaya had already decided to exchange radio and television programmes as well as technical and non-technical information and personnel. Taking part in the Conference were Burma, Taiwan, India, Indonesia, Japan, South Korea, Laos, Malaya, Pakistan, Philippines, Saudi Arabia, Thailand, Turkey, United Arab Republic, South Vietnam, Brunei, Hong Kong, North Borneo, Sarawak, Singapore, Australia and New Zealand. The Indian delegate, B. P. Bhatt, said although Asia had made great progress in broadcasting and receiving facilities in recent years, the number of sets per 100 people is now only 1·9—the lowest level of all the continents.

Satellite Communications.—The international conference on satellite communications originally planned by the I.E.E. for December will now be held from November 22nd to 28th at the Institution's headquarters, Savoy Place, London, W.C.2. Registration forms are available from the Institution.

C. S. "Mercury," described as the fastest cable laying ship in the world, was launched recently at the Birkenhead yards of Cammell Laird & Co. and has now joined the fleet of Cable & Wireless Ltd. An extensive radio system by Marconi Marine is fitted and nautical instruments and radar equipment have been provided by Kelvin Hughes and Decca.

Räo, a radio-astronomical research centre affiliated to Sweden's Gothenburg University, has been recommended as the base for Scandinavian tests with reception of signals from communications satellites of the Telstar type.

What They Say.—"Telstar, the 170-pound apple of the [American] electronics industry's eye"—*Electronic News*, New York.

"New Phase-Splitter": a correction—The h.t. decoupling resistor to the EF86 valve in Fig. 8 of this article (page 413 of the September issue) should be 220k and not 22 k.

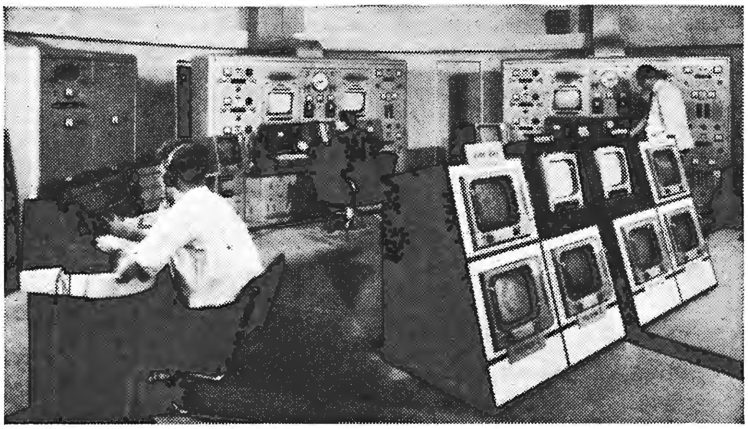
November Issue.—The November issue of *Wireless World* will not appear until October 29th, a week later than usual, due to a temporary re-arrangement of our printing schedule.

CLUB NEWS

Leamington.—A meeting will be held in the Oddfellows Hall, Warwick Street, Leamington Spa, at 8.0 p.m. on Friday, September 28th, with a view to forming an amateur radio and electronics society in the town. The convener of the meeting is N. K. Read, 86 Telford Avenue, Lillington, Leamington Spa.

Melton Mowbray.—A recorded lecture by N. Shires (G3BTM) on transmitter design and television interference will be given at the October 18th meeting of the Melton Mowbray Amateur Radio Society. The meeting will be held at the St. John Ambulance Hall, Asfordby Hill.

Birmingham.—C. N. Smart, until recently secretary of the Slade Radio Society, will describe a new transistorized d.f. receiver at the meeting of the club on October 19th. Meetings are held at 7.45 p.m. at the Church House, High Street, Erdington.



Radio Show Control Room.—*The distribution system at Earls Court, which provided 405/625-line monochrome pictures, 625-line colour, v.h.f. sound and an inductive medium- and long-wave service, was engineered and operated by E.M.I. Electronics.*

Personalities

John A. Ratcliffe, C.B.E., F.R.S., director of the D.S.I.R.'s Radio Research Station at Slough, is the first chairman of the I.E.E.'s new Electronics Division (see page 470) with effect from October 1st. Mr. Ratcliffe was born in 1902 and was educated at Giggleswick School and Sidney Sussex, Cambridge. Apart from the war years, he remained at Cambridge as a reader in physics until his appointment to the Radio Research Station in 1960. His first work on the subject which was to become his main interest, radio wave propagation, was done while he was still an undergraduate, when as a research student under Sir Edward Appleton he helped in the experiments which led to the discovery of the Appleton Layer in the ionosphere. From the beginning of the war Mr. Ratcliffe was closely concerned with the development of radar and, at the Telecommunications Research Establishment (now Royal Radar Establishment) at Malvern, he formed the Post-Design Service which was instrumental in converting the experimental radar into the equipment actually used by the R.A.F.

Denis Taylor, M.Sc., Ph.D., M.I.E.E., F.Inst.P., who was recently appointed co-ordinator of research and development for the Plessey group of companies, is to be the first chairman of the I.E.E.'s new Science and General Division. Educated at Hull Technical College, he graduated from London University (B.Sc.) in 1931. He gained his Master's degree for research in electromagnetic theory two years later and went to Croydon Polytechnic as senior lecturer in physics and radio engineering in 1937. On the outbreak of war, Dr. Taylor transferred to the Telecommunications Research Establishment at Malvern and in 1944 was attached for one year to the Royal Air Force, Far Eastern Forces. He returned to England as head of Electronics and Instrumentation Division at A.E.R.E., Harwell, where he stayed until joining Plessey Nucleonics Ltd. as director and general manager in 1957.

J. C. Heywood, B.Sc., A.I.M.E.E., has been appointed sales manager of both the digital systems and the aircraft equipment departments of Ferranti Ltd. Prior to his new position Mr. Heywood was sales manager of the company's electronics department, and was vice-chairman of the semiconductor management committee of V.A.S.C.A., and chairman of the standardization committee of the B.E.A.M.A. Semiconductor Section. **G. Hanson** B.Sc., succeeds Mr. Heywood as sales manager of the electronics department. He joined Ferranti Ltd. at Oldham in 1959 and acted as the senior technical sales consultant on semiconductors until June, 1961. He is a graduate of the Inst. P. & Phys. Soc.

J. C. Heywood

G. Hanson

J. A. Ratcliffe

Dr. D. Taylor

C. O. Stanley, C.B.E., chairman of the Pye Group of companies, who was recently elected president of B.R.E.M.A., has also been elected chairman of the Radio Industry Council in succession to **J. W. Ridgeway,** O.B.E., who has retired from the industry. **A. L. Sutherland** (Philips) continues as vice-chairman. Mr. Ridgeway who was chairman from 1960, was also chairman of the British Radio Valve Manufacturers' Association for 18 years until his recent retirement from the A.E.I. group. He joined Metrovick in 1929 and became manager of the Radio Division of A.E.I. in 1940.

James T. Kendall, M.A., Ph.D., M.I.E.E., has been appointed general manager of SGS Fairchild Ltd. Dr. Kendall will be responsible for setting up a manufacturing organization in the U.K. for the complete range of Fairchild semiconductor devices. Dr. Kendall's most recent appointment was that of managing director of Microwave & Semiconductor Devices, of Luton (reported in our January issue). Two other appointments are announced by SGS Fairchild. **C. Hayward** becomes production manager and **A. H. L. Wates** senior applications engineer. They were both at one time at the A.E.I. Research Laboratory in Rugby and latterly with Microwave & Semiconductor Devices Ltd.

R. J. Bailey, who since 1954 has been U.S. manager of Marconi Instruments and was later appointed vice-president of the English Electric Corporation in New York, which was formed to co-ordinate the American activities of the English Electric Group, is returning to M.I.'s main works at St. Albans. **W. A. Buck** succeeds him as manager of Marconi Instruments' organization in the U.S.A. Mr. Buck joined Marconi Instruments in 1954, and was posted to the U.S. office a year later. He was assistant U.S. manager for a number of years, before returning in June, 1960, to head office.

Iain W. Dick, since 1958 the Marconi Marine representative in S.E. Asia, has been appointed general manager of the Norsk Marconikompani, Oslo. After service in the R.A.F. as an instructor in air radio Mr. Dick was at the Glasgow Wireless College for a period before joining Marconi's seagoing radio staff. He transferred to the shore staff in 1955. **G. H. W. Johnson,** chief executive of the Norsk Marconikompani for the past two years, is returning to England to take up an appointment with Marconi Marine Company in Chelmsford, but will remain a member of the board of directors of the Norwegian company.

G. E. Spark has resigned his position as sales manager of the tape deck division of the Garrard Engineering & Manufacturing Co. Ltd. Mr. Spark, who joined Garrard in 1959, and was previously with M.S.S. Recording Co., has been appointed manager of Muzicord Ltd. **E. W. Mortimer** has been appointed to succeed Mr. Spark at Garrard.

L. C. Jesty, B.Sc., M.I.E.E., formerly manager of the Sylvania-Thorn Colour Television Laboratories, has joined the Westinghouse Corporation in the U.S.A. His address from September 1st is c/o Westinghouse Research and Development Center, Churchill Boro, Pittsburg 35, Pennsylvania. Educated at University College, Southampton, Mr. Jesty joined the G.E.C. Research Laboratories, Wembley, in 1927 and spent 18 years there before leaving to take up a position with Cintel Ltd. as head of the advanced development department. In 1949 he joined the Marconi Research Laboratories as chief of the television research group. Seven years later he joined the Thorn group.

H. C. Willson, chairman and managing director of Reproducers & Amplifiers Ltd., Wolverhampton, has retired from the board of the company, which he founded in 1930. Management of R & A is now in the hands of **T. D. Humphreys,** M.Brit.I.R.E., who joined the company in 1953 as general manager and was elected to the board in 1955.

Due to ill-health **W. F. Taylor,** O.B.E., has resigned his directorship of the Telegraph Condenser Co. Ltd. and has retired from executive duties after 36 years service with the company, latterly as sales director. As a result **E. Marland** has been appointed commercial manager, and **S. D. T. Henderson,** home sales manager of T.C.C.

E. B. Callick, B.Sc., A.M.I.E.E., has joined G. & E. Bradley Ltd. as technical director and chief engineer. Until recently Mr. Callick was chief engineer of the English Electric Valve Company.

Kennyth E. Harris, B.Sc., M.I.E.E., M.Brit.I.R.E., has been appointed to the board of A. C. Cossor Ltd. as technical director (electronics). Mr. Harris was with the G.P.O. from 1934 to 1939. During the war and until 1947 he was at the Telecommunications Research Establishment, Malvern, as technical officer and later senior and principal scientific officer. He was with Sir Robert Watson-Watt & Partners from 1947 until 1949 when he joined A. C. Cossor as research manager. He became director of research and development in 1953, technical director of Cossor Radar & Electronics Ltd. in 1957, and director and general manager in 1958.

K. E. Harris

OUR AUTHORS

W. R. Carter, B.Sc., and **A. T. Rawles,** who with **Dr. R. M. Gould** contributed the article on balloon supported v.l.f. aerials on page 502, are at the Admiralty Surface Weapons Establishment, Portsmouth, where for the past ten years or so they have been concerned primarily with the design and development of navigational aids. Dr. Gould was also at A.S.W.E. until recently emigrating to New Zealand to join the staff at Victoria University, Wellington.

V. Valchera, whose article on sine *versus* square waveform appears in this issue, started the company Valradio Ltd., the converter specialists, in 1935 at the age of 23. After war-time service in the Signals Branch of the R.A.F. he returned to the company. He is particularly interested in large-screen projection television receivers, which the company has been developing since 1949.

OBITUARY

S. M. Aisenstein, a pioneer of wireless and one of the world's foremost valve designers, has died at the age of 78. He retired in 1955 from the position of general manager of the English Electric Valve Company, which he had held since the company was formed in 1947. He was then retained as a consultant on vacuum physics by the English Electric Group. A native of Kiev, he formed a wireless company in Russia in 1907, in which has was associated with Isaac Shoenberg (now Sir Isaac) and Vladimir Zworykin. At Guglielmo Marconi's invitation Mr. Aisenstein came to England in 1908 and three years later the Russian company coalesced with the Marconi company. In 1922 he was appointed to a company established by Marconi's in Poland and three years later went to Czechoslovakia, where he set up a valve manufacturing company. Prior to the formation of the English Electric Valve Company, he was in charge of Marconi's valve laboratories.

Ralph Watson Hallows, T.D., M.A., M.I.E.E., who, under the nom de plume "Diallist," contributed the feature "Random Radiations" to *Wireless World* for over 25 years, died on August 18th at the age of 77. Major Hallows, who in addition to his regular contribution to *W.W.* also wrote under his own name, was author or joint author of a number of books including "Introduction to Valves," "The Oscilloscope at Work" and "Radar Simply Explained." He won a classical scholarship to Magdalene College, Cambridge, and it was not until later in life that he turned to electrical engineering. During the last war he was in the Royal Artillery and was for some time chief instructor (radar) at the 66th A.A. Group School.

Roy N. Wellington who died on August 20th, was managing director of Sound Sales Ltd., which he founded in 1930. He will be remembered by many readers as one of the pioneers of high-quality reproduction.

News From Industry

Cable & Wireless Ltd.—Group profit for the year to March 31st was higher by £134,820 at £4,575,282 as compared with the previous year. Total income for the year was £18.2M as against £17.5M previously. The C. & W. report, issued as a White Paper (Cmnd. 1797), gives a word of warning that a reduction in the level of profitability is expected in the "immediate future." This is attributed to the approaching obsolescence of a large part of the telegraph cable system and the impending transfer of ownership of the company's stations in a number of overseas countries.

General Electric Co. Ltd.—Sales in the year ended March 31st last totalled £135.1M as against £118.5M the previous year and group trading profits increased from £4.6M to £6.1M. In a review of the year's operations it is stated the group's share of the radio and television market increased and the combined turnover in G.E.C., Sobell and McMichael merchandise rose appreciably. G.E.C. (Electronics) trading in both civil and military electronic equipment improved over the previous year, and similarly profits and turnover of the G.E.C. (Telecommunications) Company and the M-O Valve Co. increased.

Metal Industries Group, which includes Avo, Lancashire Dynamo Electronic Products, and Taylor Electrical Instruments among its subsidiaries, reports a group trading profit of £2,451,993 for the year to March 31st. Sales by the subsidiaries marketing electrical and electronic control equipment totalled over £10M showing a trading profit before tax of £1.5M.

Telefusion Ltd.—Group net profit for the year to April 25th last is £584,845 as compared with £443,950 the previous year. Net profit after taxation is £370,087 (£292,257).

Ultra Electric (Holdings) Ltd. have announced a group loss of £344,782 for the year to March 31st last. Since this loss was incurred entirely by Ultra Electronics Ltd., in which company Ultra Electric (Holdings) has a 60% interest, the net loss attributable to the holding company after tax recovery amounts to £125,376. It is stated that a balance of approximately £300,000 is due to be received during the course of the current year resulting from the sale of Ultra Electric's radio and television interest to the Thorn Group.

"Local area carrier" is the name given by Standard Telephones & Cables Ltd. to a new experimental system of carrier telephony designed to increase substantially the number of telephone circuits carried by existing and new cables between telephone exchanges. It uses techniques similar to those on long distance cables and tests in the London area are being made by the designers, S.T.C., to evaluate whether it is cheaper to lay new voice-frequency cables or to install the carrier multiplexing equipment.

Raytheon marine radar is to be marketed in the U.K. by the Cossor Group, which has plans to begin manufacture "as soon as the volume justifies." It is also announced that the complete range of Raytheon marine products is "under study for sale and ultimate manufacture by the Cossor Group for Europe."

Ad. Auriema Inc., New York, has formed a U.K. subsidiary company, Ad. Auriema Ltd. with offices at Empire House, 414 Chiswick High Road, London, W.4 (Tel.: Chiswick 2204). Among the 40 U.S. manufacturers Ad. Auriema Ltd. will represent in the U.K. are Aerovox Corp. (capacitors), Knight Electronics (test instruments and radio kits), and National Radio Co. (communication receivers).

Tellux Ltd. have moved from their Brunel Road, London, W.3, offices to new factory premises at Avenue Works, Galleons Corner, Colchester Road, Romford, Essex (Tel.: Ingrebourne 43971). Several new radiograms and record reproducers are being introduced on to the market under the trade name Verdi. The company is continuing to market Sony radio receivers and tape recorders, Telefunken valves and semiconductors, Isophon speakers and Sennheiser microphones.

Cossor Concentration.—All operations and headquarters of Cossor Instruments Ltd., now at Highbury, of Cossor Communications Co. Ltd. now at Stanmore, Middx., and of Cossor Communications (Air) Ltd., of Bagshot, Surrey, are to be transferred by the end of November to Cossor's premises at Harlow, Essex.

Jiskoot Autocontrol Ltd., suppliers of instrumentation equipment, including control units, counters, binary dividers, etc., have moved from Conduit Street, London, W.1, to 85 Goods Station Road, Tunbridge Wells, Kent (Tel.: Tunbridge Wells 22291).

New Regentone Showroom.—The London showroom of the Regentone-R.G.D. group has been transferred from Davies Street to Knighton House, Mortimer Street, London, W.1 (Tel.: Museum 2561).

Storno-Southern Ltd. announce the opening of London offices and showrooms at Newby House, Chase Road, Southgate, N.14, and that the sales department has been transferred from Camberley to this new address.

Cawkwell Research & Electronics Ltd., advise a change of address for their laboratories and offices to Western Avenue, Acton, London, W.3 (Tel.: Acorn 6751).

Ace Radio Acquired by K.-B.—Kolster-Brandes Ltd., a subsidiary of S.T.C., announce the acquisition of Ace Radio Ltd., Tower Works, Tower Road, London, N.W.10. Ace Radio, a family business founded in 1937, has specialized in radiogram manufacture. V. Taylor, who has been personally responsible for the design of Ace models, is retained as director and general manager. The company's recently opened factory in Rhyl will continue to manufacture Ace products.

Marconi Marine Name Change.—The Marconi International Marine Communication Co. Ltd. is to drop the word "communication" from its registered trading name. Reason given is that activities are no longer confined to maritime communications but now embrace radar and other electronic aids to navigation.

Moir Consultancy.—James Moir, who left Goodmans Industries a year ago to set up in private practice as a consultant in the electro-acoustic field with an office at 28 Victoria Street, Westminster, has now moved his office and laboratory to 16 Wayside, Chipperfield, Herts. (Tel.: Kings Langley 2955).

Clairtone-Braun U.K. Distribution.—Argelane Ltd., 251 Brompton Road, London, S.W.3, have undertaken the distribution in the U.K. of the range of radio and stereo gramophone equipment manufactured by Clairtone Sound Corporation of Canada and Braun Electric of West Germany.

Sound Coverage Ltd., a company formed recently with objects of carrying on the business of consultants, designers, manufacturers of and dealers in sound reproducing and recording equipment, is now trading from premises at 42 Hallowell Road, Northwood, Middx. Directors are Anthony E. Walker, a former project engineer with Pamphonic Reproducers, Nigel H. Bassett and Francis L. O'Flynn.

Chilton company reorganization has resulted in the name of the parent company being changed from Chilton Aircraft (Holdings) Ltd. to Chilton Electric Ltd. Two new companies—Chilton Engineering Co. Ltd. and Chilton Electronics Co. Ltd.—have been registered, while Chilton Electric Products Ltd. continues as a manufacturing company within the group.

OVERSEAS TRADE

A new communication link now being supplied by Standard Telephones & Cables to Austria is the 4000 Mc/s radio system which will be brought into service later this year to carry multi-circuit telephony and television between Klagenfurt and Sonnwendstein, near Vienna. An S.T.C. 6 Mc/s cable system incorporating vestigial sideband equipment is to link Vienna television studios with the local transmitter at Kahlenburg.

Radio Bandeirantes S.A. of Brazil has signed a contract with the Marconi Company for the provision of the major items of equipment for a new television station in Sao Paulo. The transmitting equipment to be supplied includes two 5kW vision transmitters to operate in parallel, one 5kW sound transmitter (to give a vision-to-sound ratio of 2:1), paralleling equipment, programme input and ancillary equipment, and a quantity of test-gear and spares. The station will operate in Band III, channel 13, to F.C.C. 525-line standards.

The "Mobil Endurance," a 50,700 tons d.w. tanker built for the Mobil Shipping Co. Ltd. at Eriksburg Mekaniska Verkstads A/B, Gothenburg, Sweden, has been fitted with radio equipment by Associated Electrical Industries Ltd. The "Mobil Endurance," which has now completed her acceptance trials, is the third of five vessels to be built for Mobil at Gothenburg. All five ships will finally be fitted with A.E.I. marine apparatus.

NATIONAL RADIO SHOW REVIEW

NEW TECHNICAL TRENDS ANALYSED

TELEVISION

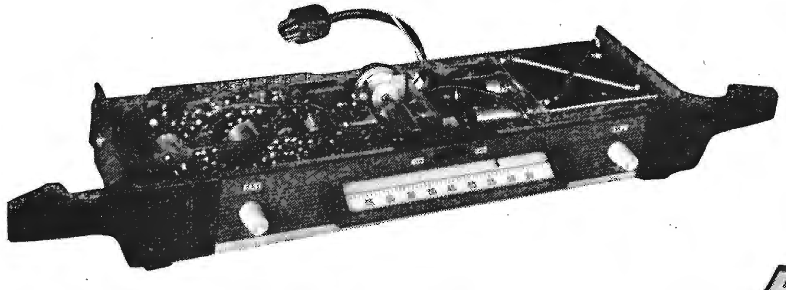
THE recent presentation of the Pilkington report has ensured that attention this year is focused on the several aspects of television that have previously been subjects for surmise. The most immediate problem that engineers and dealers must face is the eventual replacement of the existing standard of transmission with the 625-line, f.m.-sound system in use in Europe. Two main solutions to the problem are currently used, and these were expounded in detail in our 1961 (October) issue. To recapitulate, the chief points of difference between the two standards are as follows. Apart from the new line structure, frequency-modulated sound is used, video modulation is negative going (positive going sync. pulses), channel bandwidth is increased and the new transmissions will initially be in the u.h.f. range of frequencies only.

Many parts of the receiver are affected by these changes, and it says much for the ingenuity of circuit designers that equipment designed to operate on both standards is subject to so little increase in cost. However, advertising being what it is, many potential purchasers are probably feeling completely baffled by the welter of descriptions applied to the process. Terms such as " dual-standard," " switchable " and " convertible " abound, and it is probably worth while using a little space to define our terms.

Several firms (for instance, the Pye group, the Thorn group, Kolster-Brandes, Defiant) showed receivers that, at the touch of a switch, are capable of receiving both 405- and 625-line programmes and *Wireless World* proposes to name these receivers " dual-standard." The switch is a multi-pole slider type switching between i.f. response-shaping circuits, sound detectors, video detector loads, line time-base functions and line oscillator frequencies. Flywheel sync. is switched in for 625, if not used on 405, as any impulsive interference would affect the positive sync. pulses. The u.h.f. tuner, usually a 4 line lecher-tuned device, can be either supplied with the set or very easily added (for a few guineas) when the transmissions begin.

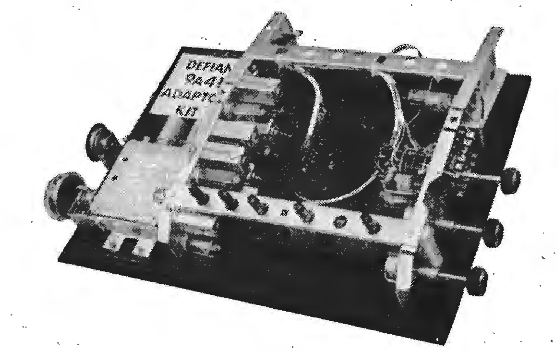
On the other hand, the opinion is also tenable that it is preferable to make provision for the modification of 405-line receivers when required. In this way, it is said, cheaper equipment is provided when it is possible that, during the life of the set, modification will not be necessary. If 625-line reception is required, complete adaptors can be plugged in, and the 405-line i.f. circuits either replaced by a combined 405/625 panel, or augmented by a 625 i.f. unit. In either case, the adapted equipment is completely dual-standard. These receivers we propose to call " adaptable."

An examination of the functions which are switched in a typical dual-standard receiver may prove instructive. On operating the system switch, the output of either the v.h.f. or u.h.f. tuner is connected, via response-shaping filters, to the i.f. input (sometimes the mixer grid to obtain a little gain). The h.t. to the tuners can be switched, or, in the case of G.E.C. receivers, which were shown to the trade outside the Show, a pulse from the line output transformer is used to " kill " the v.h.f. tuner. The video diode detector is reversed or its load is transferred to cope with the opposite modulation sense. As the d.c. component is retained as far as the anode of the video amplifier, the amplifier must have its bias resistor switched, any sound traps in the cathode being also changed by this switch. White-spot limiters are rendered inactive on 625, as, apart from the changed modulation polarity, experience on the Continent has shown that noise in the u.h.f. band is not nearly such a problem as it is at v.h.f. A.m. sound on 405 is fed into the first sound i.f. in the normal way straight from the tuner, amplified and detected; on 625 the sound and vision are amplified together as far as the



405/625 adapter for Murphy Astra Mark II receiver

405/625 adaptor for Defiant 9A41.



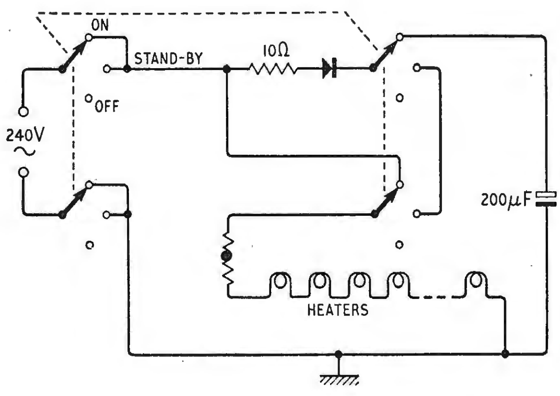
vision detector, at which point they beat together to form a 6Mc/s sound i.f. Further amplification precedes the discriminator. The remaining switching is concerned with the line time-base: multivibrator grid timing components are switched and a flywheel sync. circuit switched in if not used on 405, or varied for the new frequency. Switched series resistors or windings keep e.h.t. constant if time-base stabilization is not used, and linearity-correction capacitors are changed. In all, up to 20 functions require variation.

Individually, receivers vary little, but several interesting points were noted.

On the Pye and G.E.C. group receivers, the sound discriminator takes the form of a locked-oscillator. An EH90 heptode is used, with a tuned circuit in the third grid. Together with the input tuned-circuit this forms an electron-coupled oscillator, the third grid being in quadrature. Variation of the input frequency varies the anode current and voltage, the frequency discrimination thereby being obtained.

Even with the introduction of 625 lines, one still comes across efforts being made to reduce lininess, and K.-B. "fill up the gaps" by slightly defocusing the spot. A negative 500V d.c. is obtained from a rectified pulse derived from the line output transformer and applied to the focus electrode. (A positive voltage would cause too much defocusing on highlights.)

Representative of the adaptable receivers were ranges shown by Defiant and Murphy. The Defiant sets are adapted by means of a plug-in frame which fits on the rear of the set, with spring-contact plugs and a 9-pin valve holder to establish connections. The adapted equipment has two complete i.f. strips and the u.h.f. tuner is rather more elaborate in that it has a stage of amplification at i.f. The adaptor contains a flywheel sync. unit which is operative on both standards. Murphy also employ separate i.f. strips, and do not attempt to disguise their unit, but rather make a feature of the plinth in which it is housed.



Mullard's stand-by circuit for rapid "warm-up."

In Bush receivers the old i.f. strip is replaced with a switched type, the existing receiver already containing a systems switch and wiring for time-base and associated changes.

In the G.E.C., Sobell and McMichael sets, the same number of i.f. stages is used for the new switchable i.f. strip as in the old 405 arrangement by the simple method of changing the valve types to the EF183 frame grid pentode. The i.f. response is potentially 6Mc/s on 405, but sound and adjacent-sound traps shape it to 3Mc/s. On switching to 625, the traps are inactive and the full 6Mc/s bandwidth is obtained.

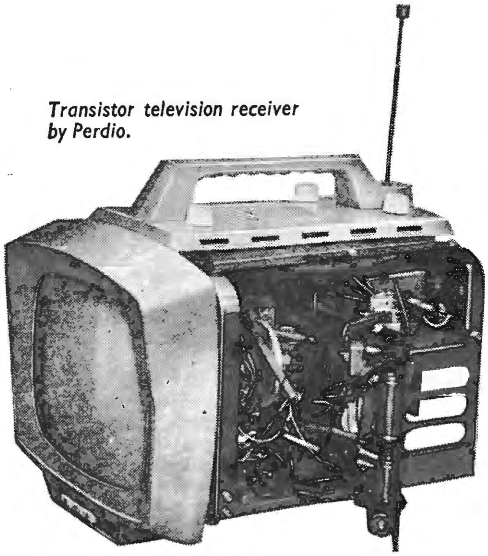
Because of the possibility of 625-line programmes being "piped" at v.h.f., the Thorn group have made provision for their receivers to work on 625 lines in Band III. A disc is mounted on the v.h.f. tuner shaft, the disc having thirteen positions in which a peg can be fitted. A micro-switch, operated by the peg, routes the signal to the v.h.f. or u.h.f. circuits.

Mean-level a.g.c. seems to be returning to favour with most firms, possibly because of the difficulties of arranging gated type on two different standards.

In order that Mum and Dad shall be able to devote the whole of their combined awareness to television and run no risk of being called to the cot-side until Baby is actually having convulsions, K.-B. have made provision for the connection of a "baby sitter" to their VV range of receivers. This takes the form of a microphone and transistor amplifier, which is fed with collector voltage by the parent receiver via droppers, and which drives the grid of the a.f. voltage amplifier. The slightest squawk is then able to override the television signal.

The enraging minute or two when one can hear the sound of six-shooters and not be able to see the gun battle is greatly reduced by the Mullard stand-by circuit, which requires nothing but the provision of a 3-position on-off switch. In the stand-by position, the heater chain is connected to the output of the silicon h.t. rectifier, whose surge resistor is then used to drop the heater power by half. On switching the set to "ON," the vision warm-up time required is only a few seconds longer than sound and nails remain unbitten.

The only transistor television receiver on show was a developed version of the Perdio set shown last year. This is a mains/battery portable receiver with an 8-in 90° tube (Mullard AW21-11). It is available to work on 405, 525 or 625 lines and a transistor u.h.f. tuner is under development. Flywheel sync. is employed, *Transistor television receiver by Perdio.*



with blocking oscillators in both time-bases. The line output stage provides 10.5kV e.h.t. from 90V h.t. Mean-level a.g.c. is used to forward bias the "front end" and an AF118 provides 70V of video drive for the tube.

The requirements which are consequent on the choice of 39.5Mc/s as the 625 vision i.f. are worth mentioning, as they are rather more stringent than has been the case. The main problems to be encountered are image interference, oscillator radiation and colour subcarrier/sound carrier beating on monochrome receivers which use intercarrier sound. The oscillator frequency is chosen to be higher than the signal frequency, and the resulting image frequency will be signal frequency +79Mc/s. Many of the groups of transmitters to be used for u.h.f. transmissions have a frequency difference between highest and lowest channels of 80Mc/s, or 10 channel widths. The response of the tuner should therefore be well down to a frequency 79Mc/s higher than the wanted signal to avoid "n + 10th" channel interference, and the figure recommended by the British Radio Equipment Manufacturers' Association is 53dB or greater. The i.f. response must be −10dB at a frequency of 1Mc/s lower than the wanted vision carrier to avoid "n−10th" channel interference.

Oscillator radiation is a problem, as the frequency of the "n + 4th" channel sound carrier (n + 32 + 6Mc/s) is only 1.5Mc/s below the oscillator frequency of channel "n." It is necessary to prevent viewers mistuning their receivers by more than about 1.4Mc/s and automatic frequency control is desirable. This confers the additional advantage that, as drift is avoided, the West European i.f. of 38.9Mc/s can be used, the image rejection requirement of 53dB being thereby reduced to 29dB.

To obtain compatibility with colour transmissions, it is necessary to take account of the fact that the colour subcarrier (4.43Mc/s is assumed) will beat with the intercarrier vision/sound spacing of 6Mc/s to produce a 1.57Mc/s interference pattern. A reduction of receiver response at sound carrier frequency of about 36dB will therefore be required.

Colour receivers were shown by fourteen firms and were mainly of the type intended for monitor work, although the Thorn receivers are more "domesticated" in that they employ a.c./d.c. techniques. Most receivers used LC oscillators for sub carrier regeneration, the exceptions being Bush and G.E.C., whose phase-locking systems employ crystal ringing circuits and a crystal oscillator respectively. The modified N.T.S.C. system is used exclusively, and as SECAM is yet to be evaluated, the final choice of system seems rather remote. Hue and saturation controls are somewhat oddly placed at the front on most receivers, and this may have something to do with the fact that perfectly normal people appeared to be apoplectically puce at one end of the Avenue and *mal de mer* green at the other, with most shades in between. 21-in, 70° tubes are used at the moment, but a 90° tube is expected to make an appearance quite soon, and Thorn Electrical have recently announced that the zebra beam-indexing tube with a single gun is under development, but that production is still a considerable way off. Programmes on 625 lines were transmitted by line to Earls Court from the Television Centre, and performance was, therefore, a little unrealistic. Bush, with their crystal regeneration circuit, were, however, only too willing to demonstrate the lack of effect on colour rendering of a simulated 50 miles more between transmitter and receiver.

U.H.F. AERIALS

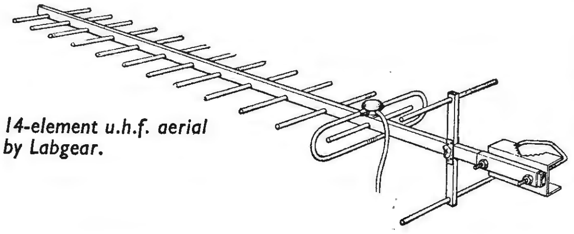
AS there was only one manufacturer (Labgear) of u.h.f. television aerials at the Earls Court Radio Show, visitors were unable to make any comparison with regard to design or price. However, it has been established that u.h.f. aerials will, in general, cost more than v.h.f. aerials and will also be more expensive to install. U.h.f. aerials are of comparatively small dimensions; a half-wave dipole for the top channel (68) in Band V is only about 7-in long and one for the bottom channel (21) in Band IV about 13-in. Most viewers whose aerials are virtually within line-of-sight of the transmitting aerial will find a u.h.f. aerial of 8 to 10 elements suitable. (This gives a gain of 8 to 10dB and a front-to-back ratio of 20 to 30dB.) Less favourably situated viewers will require aerials with up to 20 elements and a gain of 14dB.

To recap, the B.B.C., with the co-operation of the G.P.O., I.T.A., and industry and trade, have now commenced a new series of field trials in order to obtain more information about propagation in the u.h.f. bands and the problems of reception. Transmissions on channel 44 from the B.B.C.'s Crystal Palace station began on September 1st and have a nominal range of 30 miles. Early next year simultaneous transmissions will be made on channel 34 and at a later stage the frequencies will be changed to two of the channels allocated to London in the Stockholm Plan (23, 26, 30 and 33). In most cases the channels used at a particular station will be either all in Band IV (470 to 582Mc/s, channels 21 to 34) or all in Band V (614 to 854Mc/s, channels 39 to 68). As there is a spacing of ten channels, i.e., 80Mc/s, between the lowest and highest channels at these stations, it is consequently important to ascertain that the receiving aerial covers at least this frequency range.

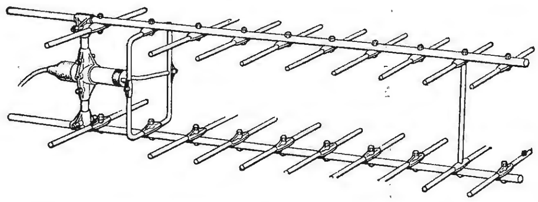
To sum up, because of the sharp directivity of the multi-element aerials used on u.h.f., considerable care is required in siting and orienting them in the right direction, and they must be fixed rigidly in position so that reception does not vary in rough weather. Aerials with good front-to-back ratio should always be used to avoid interference from other stations sharing the same channel, as well as to reject reflections from hills or buildings behind the receiving point. The mounting arrangements for an aerial should permit the ready adjustment of orientation and of the position of the active part of the aerial, so as to allow a displacement over a range of at least 2-ft in all directions. All viewers, no matter how close they live to a u.h.f. transmitter, must expect to need an outside aerial unless they are in particularly favourable situations.

Labgear have introduced four u.h.f. aerials, available to the trade only, designed to enable dealers to demonstrate 625-line u.h.f. television to the public. In addition specially designed J-Beam u.h.f. aerials for communal televison systems were shown by Teleng.

To assist installation engineers in the siting of u.h.f. aerials, Labgear have also introduced their E.5108 signal



14-element u.h.f. aerial by Labgear.



J-Beam special quality u.h.f. aerial shown by Teleng.

strength meter. A standard u.h.f. tuner is used, the input characteristics thereby being similar to those of a television receiver, and the meter is directly calibrated over the range 10μV to 10mV. An audio output is provided so that headphones can be used to identify the transmission. The unit is mains powered, and tunes over the range 470-850Mc/s.

SOUND RECEIVERS AND REPRODUCERS

Transistor Equipment.—In the field of "sound" the greatest developments have occurred among transistor receivers. The simultaneous running of two contrary trends—towards miniature or, alternatively, much larger table models—is now clearly discernible. Combined portables and car radios are also becoming increasingly popular. On the circuit side "peak performance control" and complementary symmetry are being increasingly adopted.

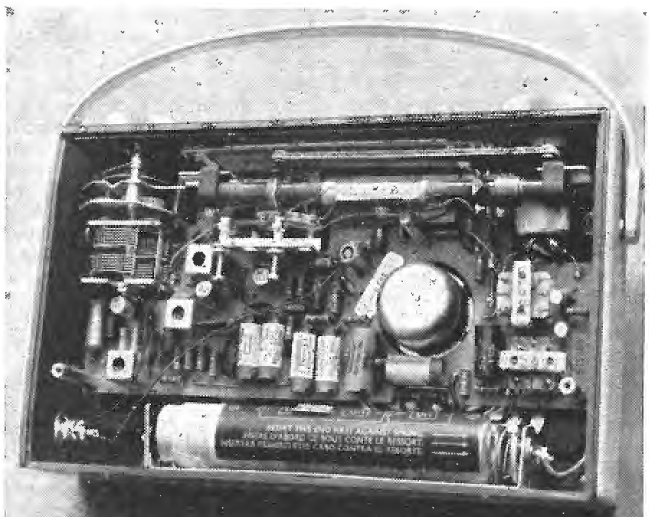
The use of complementary symmetry (an n-p-n and a p-n-p transistor) in the audio output stage gives several advantages: the elimination of transformers in both the driver (since the input is single-ended) and output stages results in a better l.f. response and lower distortion, and the quiescent current drain is halved since the transistors are in series rather than in parallel. The bias can be stabilized by connecting a thermistor across the bias resistor between the two transistor bases.

Stabilization of the base of ordinary push-pull output transistors is being increasingly adopted and was given considerable emphasis this year as "peak performance control." The method now usually adopted is simply to replace the bottom limb of the normal base bias potential divider by a transistor connected as a diode (emitter open circuited). Changes in the impedance of this transistor then stabilize the output stage quiescent current against changes both in the ambient temperature and in battery voltage. Since the output stage current determines the cross-over distortion, such stabilization reduces the distortion produced on a cold day or by a run-down battery—the latter effect can give a 20% increase in useful battery life.

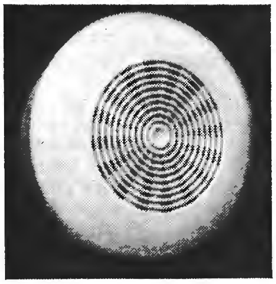
A combined portable/car radio which, on plugging into its compartment in the car, is automatically connected to the car aerial and battery as well as to a larger loudspeaker, was introduced last year by Ever Ready, and this year by several other manufacturers. In addition the Pye and Ekco combined receivers can have a larger (3-watt single-ended) audio amplifier in the car. This is not done in the Philips receiver, but the available output power is increased to 1½ watts both because of the higher battery voltage (12 as against 9) and, since battery economy is no longer important, because the output stage bias can be changed to give a higher power. Another interesting feature of this receiver is that the normal a.g.c. damping diode across the first i.f. also clips out any "bottoming" oscillations (to which some high-frequency transistors are prone) which may occur on switching on. All these receivers use a separate set of r.f. coils in the car to eliminate interference picked up by the ferrite rod aerial on which the normal set of r.f. coils is mounted. A similar arrangement is provided in the new Perdio "Town and Country" receiver for use in a car.

The first mains-operated transistor receivers were introduced by Pye and Ekco. The latter's model can also be operated from batteries. Since the current in the class-B push-pull output stage varies with the audio level, a stabilized mains supply is necessary. This is obtained by connecting the *negative* side of the rectifier to the collector of a transistor whose base is fed from a fixed potential relative to *positive*. The base bias and consequently the impedance of the stabilizing transistor then vary with the output voltage drawn from its emitter in such a way as to oppose any changes in this voltage. The fixed base potential is derived from a potentiometer and rectifier across an auxiliary secondary winding on the mains transformer; the constant loading on this winding ensures a nearly constant base potential. By varying the potentiometer setting the output voltage can be adjusted over a wide range of possible values. Two Pye mains-only transistor receivers were shown. One of these—the V.H.F. 2DT—covers the v.h.f./f.m. as well as long, medium and short bands. With its three-watt (single-ended) output, 7-in × 5-in loudspeaker and relatively large size (24-in by 6¼-in by 6⅝-in) this receiver completes the tendency of transistor receivers to be made more and more like valve table receivers. The same chassis was also used by Pye (with the addition of an extra output stage and two pickup pre-amplifiers) in the prototype of a full-size completely transistorized stereogram.

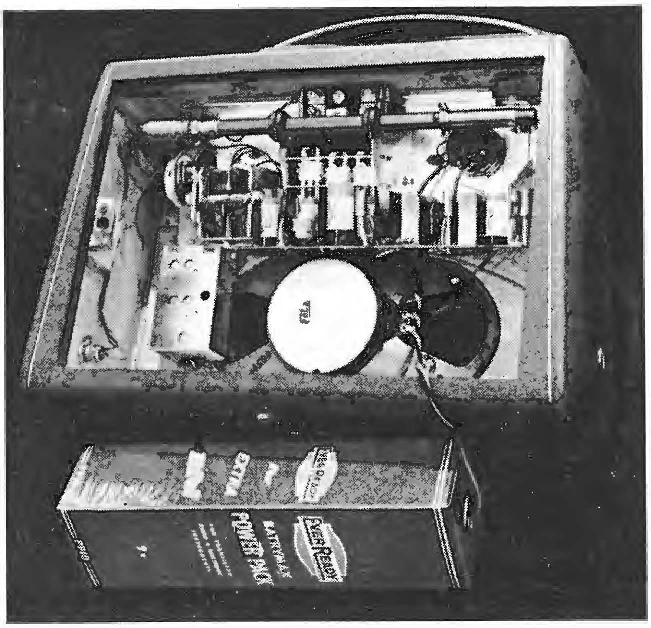
We have in the past noted the provision of a.g.c. by means of an overload damping diode placed across the first i.f. transformer. In order to render such a.g.c. more effective Philips (in their 313T a.m. receiver)



Murphy B583 a.m. transistor receiver.



E.M.I. "Minispeaker" extension speaker for small transistor receivers.



Roberts RT8 transistor receiver showing (at bottom left) screened i.f. amplifier.

and Bush (in their SRG106 a.m./f.m. stereogram) have this year connected the diode at an earlier stage—across a tap on the aerial coil (and fed from the emitter of the first i.f.). The Bush model is also unusual both in employing a separate a.m. oscillator so that a.g.c. can be applied to the mixer, and in the provision of amplified a.g.c. to the f.m. r.f. amplifier: good a.g.c. is particularly important for this receiver because it is not portable. This Bush stereogram is in fact a hybrid model employing transistors up to the detector and valves beyond.

A new variety of class-AB operation—the π mode—is utilized in a ten-watt push-pull high-quality transistor audio amplifier shown to manufacturers by Mullard. Advantages of the π mode of class-AB operation are the absence of crossover distortion, very low distortion at normal output levels, a constant supply current drain independent of the drive (simple C-R filtering of the supply becomes adequate) and avoidance of damage to the transistors if the output terminals are short circuited. In this mode of operation the load is placed in the emitter circuit and the emitter stabilizing resistance (decoupled by a suitable capacitor) increased to define accurately the direct current drawn. Up to 40% of full output the transistors operate in class A (hence the low distortion at low output levels); as the drive is further increased the transistors operate in class AB under gradually changing conditions until class B is just reached at full output. This last condition is ensured by making $I_q = V_c/\pi R_l$ where I_q is the quiescent current, V_c the collector voltage and R_l the load resistance seen by each collector.

Thermal feedback to increase thermal stability is a novel feature of a direct-coupled single-ended three-watt audio amplifier for car radios shown to manufacturers by Mullard. When the driver and output transistors are directly coupled, increases with temperature in the driver collector current tend to oppose similar increases in the output collector current. It is, however, difficult to balance exactly the magnitudes of these compensating effects to provide thermal stability, quite apart from allowing for spreads in individual transistor characteristics. In the Mullard design thermal feedback is introduced by mounting the driver transistor on the heat sink of the output transistor: this maintains the driver above ambient temperature by an amount depending on the dissipation in this output transistor. The feedback via the output transistor current, its dissipation, the driver temperature and driver current, compensates both for temperature changes and transistor spreads. Thermal stability up to 55°C is thus obtained.

In transformerless single-ended push-pull stages only half the total battery voltage appears across each transistor. With the normal battery potential (9V) current limitations in the output transistors can then prevent the attainment of the higher powers ($\approx$1W) which are being increasingly provided. A simple way out of this difficulty is, of course, to increase the battery potential, and two 9V batteries are used for this purpose in a number of new receivers.

Loudspeakers with ceramic magnets are being increasingly used in all types of large equipment; they are, however, seldom employed in small transistor receivers, since their increased stray field can saturate the ferrite aerial if this is too close. One exception we noted, however, was in the H.M.V. 2104 a.m. receiver.

Although miniaturization is obviously facilitated by using an inverted-cone loudspeaker, we noted only one example of this, in the Ferguson 3108 " Mighty Midget " receiver.

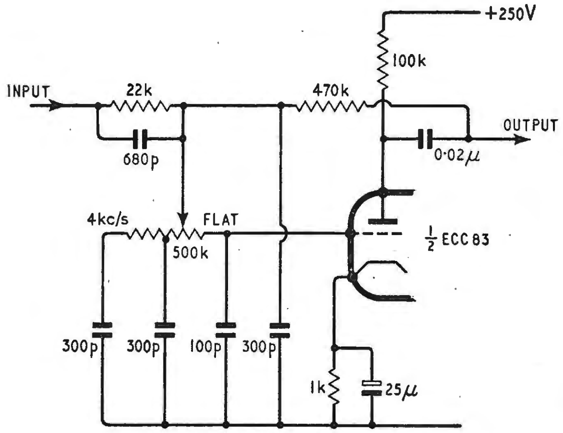
In the Murphy B583 a.m. receiver an extra audio stage in the form of an emitter follower is employed after the detector. The high input impedance of this stage reduces the loading on the detector, and this increases the detection efficiency and decreases the distortion.

Transistor rather than diode detectors can provide audio gain (as well as amplified a.g.c.) and thus allow a reduction in the number of i.f. stages required. Such an arrangement was noted in the Alba 99, Defiant A56 and A57 and Philips 313T a.m. receivers.

The use of long ferrite aerial rods and higher gain r.f. transistors can result in spurious pickup and feedback problems in transistor receivers. Such problems have been avoided in the Roberts RT8 by screening the i.f. amplifier section (see metal box on left in photograph) and mounting it separately from the oscillator section.

An additional " counterpoise " short wave aerial socket for a length of wire to provide capacitive coupling to earth is an unusual feature of the Philips 200T and Stella 416T portable a.m. receivers.

An unusual facility in small transistor receivers—bandspreading—was noted in several British Radio Corporation export models. Continuous coverage from 4 to 9Mc/s is also provided: this does not overlap any of the



Heathkit variable steep-cut filter circuit.

bandspreads (13, 16, 19 and 25 metres). The consequent need for an extra oscillator coil is, however, avoided by using second harmonic mixing on bandspread.

A 400-μA meter in the collector circuit of the second i.f. transistor provides a combined tuning and battery level indicator in the Dynatron Nomad de-luxe (the off-tune "standing" collector current indicates the battery level).

A miniature clock-controlled transistor receiver was introduced by Ferguson. An oscillatory alarm is also provided in the following way. The driver collector load resistor, besides of course being connected to the negative supply, is also connected via an additional 18kΩ resistor between the push-pull output transistors. This resistor normally merely shunts the loudspeaker voice coil: in the alarm switch position, however, the driver collector load is disconnected from the negative supply: the 18kΩ resistor then provides positive feedback which causes the audio amplifier to oscillate.

For use with miniature transistor receivers a 3⅜-in diameter extension loudspeaker—the Minispeaker—has been introduced by E.M.I.

A four-transistor microphone amplifier for use with their record players—for example as a baby alarm—has been introduced by Portogram.

A v.h.f. radiotelephone for mounting under the dashboard of a car which was shown by Pye Telecommunications—the Cambridge—features a fully transistorized receiver.

One of the problems in making small batteries for transistor receivers is maintaining contact between individual cells. Normally in lieu of soldering this is done by strapping or tying them together with materials such as paper tape. However, this can lead to a high internal resistance or, as the cells swell during discharge, the strapping material may even break and so completely destroy contact between the cells. To avoid these difficulties, Vidor have inserted the cells in metal cases with turnover ends to eliminate straps in a new range of (patented) batteries. In addition, such metal-clad batteries are much more robust and dimensionally stable both with time and between individual samples.

Valve Equipment—Artificial reverberation by means of a spring delay system has in the past been provided in radiograms by H.M.V. and Ferguson: this year it is also used by Philips in their 714A table radio. Although in general this receiver uses valves, the actual reverberation amplifier contains a transistor.

Another unusual feature both in this receiver and the Philips 612A is the provision of two separate audio channels for use with stereo input signals.

An unusual feature of the Heathkit Model AFM-1 a.m./f.m. tuner kit is the use of a push-pull full-wave detector for a.m. This produces less distortion than the normal half-wave detector for two reasons: first, it symmetrically loads the last i.f. transformer, and secondly, it doubles the ripple frequency, thus allowing smaller filter capacitors to be used and consequently improving the a.c./d.c. load ratio.

The Heathkit Model S-99 stereo amplifier kit features a relatively simple continuously-variable steep-cut (12-14dB/octave) filter. In this feedback-operated circuit (see diagram) the potentiometer controls the filter cut-off frequency: the 300pF capacitor connected to its centre tap provides a more linear scale, and the 680pF capacitor shunting the 22kΩ fixed resistor compensates for a 2dB loss at 20kc/s in the "flat" position of the potentiometer. The d.c. return path for the valve grid is provided elsewhere in the circuit.

Two unusual features of a stereo pre-amplifier introduced by Clarke and Smith—the 656—are the provision of TV pickup suppression chokes on the input, and that the record and tape characteristics are obtained by feedback round three stages rather than only one.

The new Clarke and Smith 657 stereo amplifier is characterized by employing only 10dB overall feedback. This eliminates the need for high-frequency audio phase-shift stabilizing networks and so increases the h.f. power-handling capacity.

Two unusual features of the E.M.I. Elite 2 record reproducer are that the (85V) valve heaters are fed from a tapping on the motor winding rather than from a separate transformer, and that the output stage, although single-ended and not push-pull, is operated "ultra-linearly".

A microphone or guitar amplifying stage with independent volume control (for mixing) is an unusual feature of the Fidelity "Duet Ampligram" record reproducer.

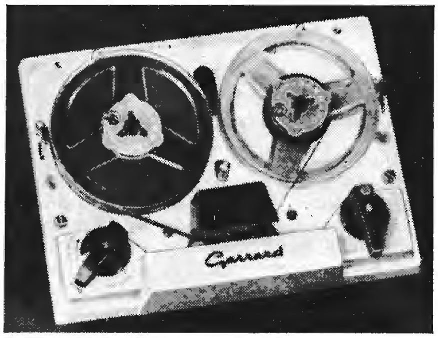
An overall height of only 3½-in characterizes a new range of radiogram chassis introduced by Lee Products.

A pickup raising and lowering device is a feature of a new record changer used by Philips in their record reproducers and radiograms.

TAPE RECORDERS

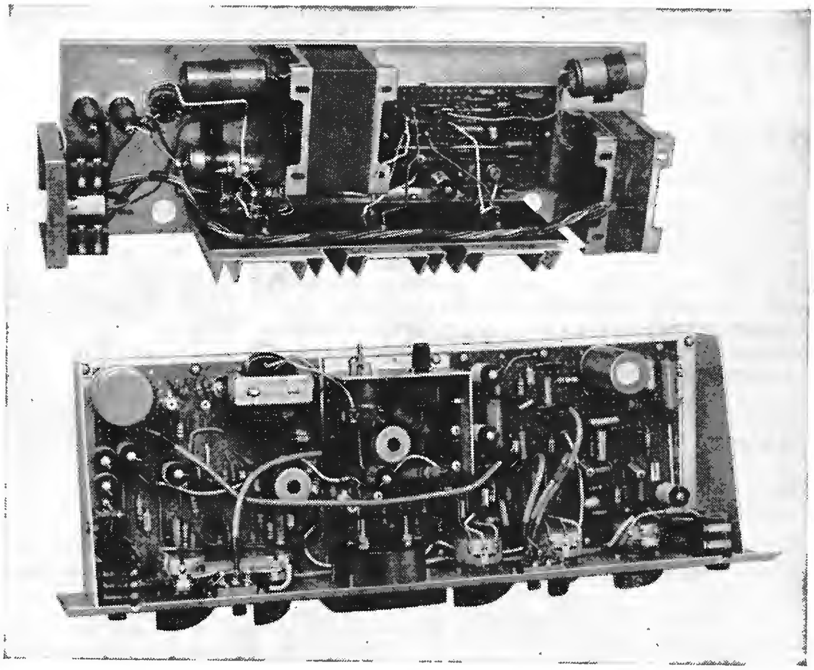
INCREASING provision in four-track recorders for stereo playback and for transfer of signals from one track to another (with simultaneous mixing) provided the only clearly discernible new general trends.

Transistorized mains recorders were introduced by two companies—Clarke and Smith, and Philips. Features of the four-track Philips EL3534 are the provision of an extra (fourth) speed (15/16 in/sec) and facilities both for stereo recording and playback (a stereo cardioid moving-coil microphone is provided). A meter rather than a magic-eye level indicator is used: with transistors this avoids the necessity for deriving a special h.t. supply solely for the magic eye. Signals can be transferred (with simultaneous mixing) from one track to another.

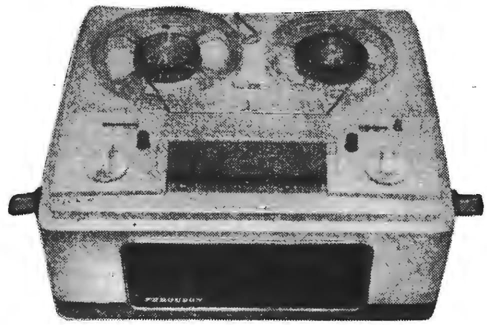


Garrard battery tape deck.

Right: Clarke and Smith transistor mains tape recorder circuits.



Below: Dynatron TRP2 recorder.



Ferguson 3202 tape recorder.

The Clarke and Smith two-track TR634 uses the Ferrograph deck. Low- and high-impedance microphone inputs are provided (alternatively) by a single transistor acting as an ordinary amplifier or an emitter follower: plugging in automatically connects the collector and emitter capacitors appropriately for coupling or decoupling. The replay head is fed from a long-tailed pair (with separate emitter resistors) but via a 1 : 1 transformer rather than a capacitor to avoid possible leakage currents causing head magnetization and consequent noisy recordings. A suitably non-linear recording level meter scale is obtained by overloading the meter input transistor.

A new tape transport mechanism has been developed by Ferguson for their 3200 and 3202 recorders. Two interesting features of this are the provision of an inching facility and a push-button reset counter. A fast automatic end-of-tape stop is provided by making the tape foil operate the stop solenoid directly (by discharging a high capacity through it) rather than via a relay. The capacity charge resistor then acts also as the solenoid hold-on resistor. A mechanical interlock delay between the record button and play key reduces head magnetization by ensuring that the oscillator is switched off before the record/replay head is switched between record and replay circuit connections. Instead of current-feeding the record/replay head with bias from the oscillator via a relatively small capacitor (which forms a potential divider with the head impedance) this head is fed from a tertiary winding on the oscillator coil via a larger capacitor. This capacitor can then be tuned with the head self-inductance to provide some treble lift on record. A special feature of the four-track 3202 is the possibility of simultaneously playing both tracks.

A new two-speed battery deck introduced by Garrard can use separate spools up to 4-in in diameter or the same company's tape magazine. Fast wind in both directions is provided.

Features of a semi-professional two-speed two-track mono recorder introduced by Dynatron—the TRP2—are the provision of separate record and replay heads and amplifiers, a push-pull oscillator, meter level indicator and low- as well as high-impedance microphone inputs. The bias can be continuously varied for superimposition. An "echo" switch mixes the playback outputs from the two heads (separation $\approx 1\frac{1}{2}$-in).

For providing stereo playback facilities on their four-track recorders Tape Recorders (Electronics) have introduced their Sound Stereo "Addon" unit. This is a selfpowered replay amplifier and loudspeaker which is fed directly from the tape head.

ELECTRONIC ORGANS

AN unusual feature of the Bird " Flamingo " and " Cygnet " electronic organs is that " voicing " is carried out by active selective amplifiers rather than passive filters. These and other Bird organs can provide artificial reverberation by means of the Bird spring delay system. Lateral vibrations of the spring are used and it is damped at its centre to reduce self-resonance. Two subsidiary springs of different lengths provide different echo delays to give a closer approximation to smooth reverberation. By simultaneously using the reverberation and vibrato controls in these organs, beating may be produced to give a " chorus " (multi-instrument) effect.

VALVES AND CATHODE RAY TUBES

THE new Mullard PL500 television line output pentode incorporates a novel form of anode structure. This consists of a plane surface at right angles to which are mounted a number of thin strip partitions. These partitions tend to trap any secondary electrons emitted from the anode before they can reach the screen grid so considerably reducing the current to this grid. The consequent improvement to the I_a/I_{g2} ratio allows the 50% or so greater power needed for 625-line time-bases to be readily obtained.

A novel method of screen material deposition for colour tubes was described on Mullard's setmaker stand. This is occasioned by the use of zinc-cadmium sulphides in the new tubes in an effort to obtain shorter persistence and higher efficiency. The disadvantage of the new materials is the fact that they are not affected to the same extent by the ultra-violet radiation which is used to " develop " the spot pattern on the screen. Green and blue phosphors can still be hardened by this method (irradiation through the shadow-mask from the gun end), but the red-fluorescent material requires a new method, chiefly because the surface rapidly develops a u.v.-absorbent layer on the surface during irradiation, and adherence to the glass is not obtained. The red material is therefore applied behind the green and blue phosphors and irradiated from the front of the tube, being masked by the green and blue dots, which are coated with u.v.-absorbent dyes. The red phosphor does not harden in these areas and is removed by development. All areas which are neither green nor blue are now red, no spaces being left, and an additional advantage is that the aluminium backing is not able to cause trouble with ambient light reflections.

I.T.A.'s SMALLEST STATION

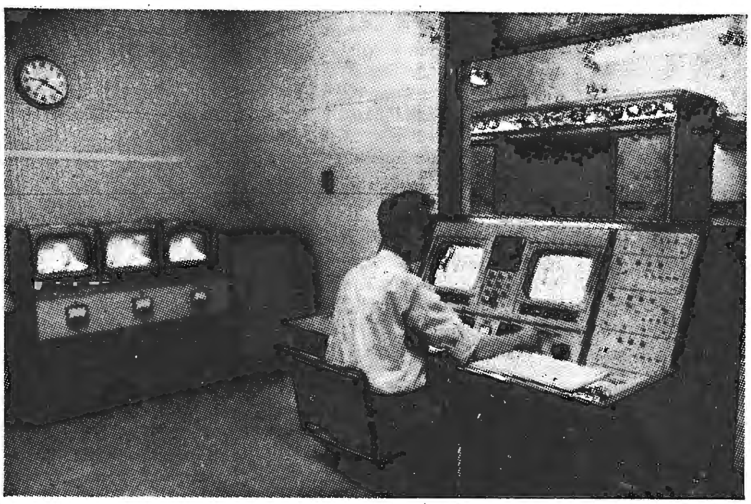
TRANSMISSIONS began on September 1st from the I.T.A.'s station at Fremont Point, Jersey, Channel Islands, which has the smallest coverage of any " independent " station built by the Authority. The population of the five islands served (Jersey, Guernsey, Sark, Herm and Jethou) numbers some 100,000. Alderney, the most northerly island, is outside the primary service area but, because of its geographical position, is ideally situated to act as the link with the mainland for the reception of I.T.A. network programmes. A G.P.O. link established on Alderney, equipped with two parabolic reflectors, picks up the transmissions from the I.T.A. station at Stockland Hill, Devon (Channel 9), which are relayed by a microwave link to the Fremont station. The Alderney relay station is also equipped to receive and relay the Caradon Hill, Cornwall, transmissions (Channel 12). At Fremont the best of the three pictures received is selected manually and passed on by coaxial cable to the St. Helier headquarters of Channel Television Ltd. (the programme contractors) where, with the addition of locally produced items, it is fed back to Fremont for broadcasting on Channel 9 (not 3, as stated in error last month).

The Fremont station is equipped with two 500-watt vision and two 125-watt sound transmitters which are operated in parallel. A comprehensive feeder-switching system makes possible two methods of parellel operation and a number of standby conditions with the transmitters and aerial feeders. The 445-ft aerial tower came from Lichfield, where it was recently replaced by a 1,000-ft mast. The E.M.I. directional aerial—limiting radiation to the French coast—has a gain of 10, giving a maximum e.r.p. of 10kW.

It is understood there are some 2,000 dual-standard (405/819 lines) set-in use along the coast of the Havre peninsula, where viewers get a reasonable signal from the B.B.C. station on the island. The I.T.A. station will, in fact, radiate a daily French news bulletin (intended primarily for the French-speaking section of the island's population) and include some French manufacturers among its advertisers.

Incidentally, as there is no Excise Duty in the Channel Islands, the combined television-sound licence costs £3 instead of £4, as on the mainland.

The technical facilities at the St. Helier studios of Channel Television, which is not linked financially with any programme organization on the mainland, was designed by A.B.C. Television, who acted as consultants.



Control room, with (left) the monitors for the three incoming signals from the I.T.A. network. The transmitters and associated control equipment were manufactured by Pye T.V.T. Ltd.

Some Thoughts on

THE PILKINGTON REPORT

By P. P. ECKERSLEY

Although the social aspects of broadcasting are not the prime concern of this journal, it is a fact that programmes and technical matters are to a considerable extent interdependent.

This is why, if justification were needed, we again open our pages to the first Chief Engineer of the B.B.C. who is well qualified to understand the technical side, and who, as those who have read his book "The Power Behind the Microphone" already know, has a lively and penetrating mind of his own when speaking of the social implications.

Ed.

AN anonymous wit is said to have commented that "giving the job to Pilkington was better than leaving it to chance." Anyone knowing the rules but unable to see through a transparent aphorism and taking the phrase literally would be sure that in an exercise of this kind, nothing is left to chance.

Committees appointed by Government to advise it about this and that are seldom expert; if they were, so thinks authority, bias might influence recommendation. It is as if an Absence of Plumbers (c.f. a Pride of Lions) was appointed as judges at a cattle show, the aim being that by taking expert evidence the best cow should win. The Pilkington Committee, composed of people who, at the outset of deliberation, knew no more about broadcasting than the intelligent listener-viewer, was not by constitution an expert committee and so, conscientiously, it took a lot of evidence. It is my contention that this evidence was selective rather than objective, that it was used more to support a foregone conclusion than to dig down to the roots of the problem.

The Establishment

Whenever a new idea, invention, political doctrine or mystical interpretation of life's purpose invades the communal conscious it is certain that a power group will attempt to use it for its own ends. The Sermon on the Mount resulted in a Pomp of Popes, murder, torture and war; it also inspired the foundations and, over some two thousand years, the beliefs and practices of western civilization.

The invention of wireless telephony was responsible for broadcasting; the subsequent control of it fell into the hands of power-groups; in the U.S.A. the tycoons, in Great Britain the Establishment.

We are governed not only by Cabinet, Parliament and the Lords, Spiritual and Temporal, but by an interlocking complex of men and women who possess authority in one form or another. Thus the Establishment is composed, for example of Sir Peter, Sir George, Sir John, of the clubs, the hairy intellectuals of the pubs, the mistery of the Civil Service, the respectably blue-suited dominants of "Labour," and the female, "more deadly than the male," by the Owls of Learning, each firmly perched on a branch of it, acute legal brains, press Barons, the top brass of the Services: the list is endless and no doubt my readers could add to it.

The Pilkington Report smacks strongly of the Establishment; it is well meaning, well phrased and well intentioned, well documented, but inevitably more conformist than imaginative. It appreciates that there is a lot to be said on both sides but does not succeed in saying much of real value on either. Anyway it is the image of a Committee and has all the characteristics of committee deliberation.

It has been said that a camel is a horse designed by a committee—unfair to camels. They surely are functionally apt for purpose? Coventry Cathedral is the outcome of committee compromise; it embodies fine things but it lacks conceptual grandeur; in contrast St. Paul's—"*si monumentum requiris circumspice*"—look around you and see a monument to one man's genius. The Pilkington Report is not the outcome of one man's genius, it represents the character and outlook of the Establishment, its report is a painstaking and worthy effort but, so it seems to me, it avoids the real issue.

This foregoing, possibly laboured, generalization forces me to come nearer to the point and to define what I mean by "the real issue." In so doing it may be as tedious as it is essential to repeat for the *n*th time in nearly forty years that, in my belief, the "real issue" is technical; more precisely that once broadcasting is freed from the limitations of means, it will the more readily discover its true ends. In other words the ideological issues, which produce such frenzy in the attitudes of those who discuss them, would seem more or less trivial if broadcasting, like the press, were allowed to publish as and how those who control it desired.

In my submission a preamble to the Report should have stressed the fact that the B.B.C. was established as a monopoly only because of the limitations of telecommunication technology (in passing it might well be said that the ill-wind of channel shortage blew the admirable B.B.C. into its pride of place), but with the expansion of the means to distribute programmes and because democracy abhors dictatorship, be it ever so benevolent, it was later thought to be right to set up an alternative service. This, it should have been said, was ideologically sound even though imperfect in some of its practices.

These statements should, in logical sequence, have prompted the Committee to conceive its task as recommending how to provide more alternative sources and programmes rather than, as it did, seeking restrictive controls in the name of respectability.

Admittedly the Committee had to deal with the realities of the situation as it exists today, but a more positive character would have dignified the Report if, as problem after problem was revealed, a rider would have shown that if there were more channels the artificialities imposed by shortage would be abolished. I propose, from this point onward, to do just what I think the Report should have done, namely to consider the more onerous problems which exist today and see how they might be alleviated by the provision of a multi-channel system of programme distribution.

Freedom to Choose or to Refuse

First then this vital question of choice. The Report states that a wide range of choice is an essential prerequisite of democratic broadcasting, "anything less . . . is a deprivation." I quote again from a résumé which states that the Committee "examines the view that the broadcaster must choose whether 'to give the public what it wants' or 'what he thinks is good for the public.' It rejects these alternatives as gross over-simplifications of a complex and continuing problem, as statements which present unreal extremes as though they were the only choices." Hear! Hear! I add that the public cannot know what it wants until it is given a large range of contrasting examples to choose between. In spite of the Committee's agreeable introductory generalities it appears, reading on, that if the range of choice were made too wide then a tiresome public might choose to listen to programmes of a type which the Committee would not approve.

The Committee's justification for this attitude, which tends to condemn the popular, is surely that which leans towards the policy of giving the public what the broadcaster thinks "is good for the public." The Establishment often blunders into thinking that it can raise public taste by creating a vacuum above it; surely a better, if a more vulgar way, is to get underneath and push. This is the easier as there are more ways in, more channels, some of which could carry the type of programme material that does get down to the position in which public taste can be lifted.

The criticisms and comments which the Report has provoked in letters and articles often deny an analogy between press and broadcasting. This is strange; both media are forms of publication, i.e. links between the public and people with something to say; some idea to proselytise, some event to report upon. To my mind the analogy, though imperfect, can nevertheless point the conclusion, that diversity of publication is essential to a democracy. The press is reasonably diverse and, in one sense of the phrase, gives the public what the public wants, namely diversity, and hence freedom to choose. It is unlikely, for instance, that readers of the Sunday-serious papers will be tempted to subscribe to the Sunday-salacious; there is readership for both. But each class of readership is satisfied. Those who think that it is regrettable that the Sunday-salacious is available to the vulgar are the do-gooders, those who deplore mass appeal and also fail to see that, consistent with liberty, the only way to get rid of what has sometimes been described as the gutter-press is to get rid of the gutter.

But, if free expression means anything, it means the right of anyone to start a newspaper or a periodical and to seek readership. The character of the publication, provided it does not offend against the laws of decency, is neither here nor there, it is "better to go wrong in freedom than to go right in chains." We criticise the dictatorships for their denial of free speech, but when it comes to broadcasting seek to regulate and confine it.

In giving lip service to the principle of freedom of choice ("anything less is a denial") the Committee recommends that the new channel that is to become available shall be filled by B.B.C. programmes. I am consistent in my admiration for the B.B.C. but I cannot see how the Corporation can provide programmes which are in contrast to the programmes it provides. Obviously a training with Mr. Bradshaw will see to it that the items can be at any given time of a contrasted form but this has little to do with true diversity.

Style means "the performance of an act without waste," it is "the contribution that expertism makes to culture." There are many writers with as many different styles and these contrasting styles represent diversity in literature. You are you, I am me, and nothing alters us in relation to our essential characters. We may take a brief and argue a case in which we do not believe in, just for the fun of it, but our style will be recognizably different. In sum the B.B.C. can competently plan a programme series and avoid overlapping: what it cannot do is to exhibit true contrasts, contrasts, that is, of style.

The Free Press and Restricted Broadcasting

Returning to what I hope is a fair analogy, namely that of the press, would it be good policy to shut down the *Daily Mirror*, or more analogously limit its supply of newsprint so that *The Times* would have a wider circulation? *The Times*, the house organ of the Establishment, satisfies a certain section of public readership; according to a vulgar advertisement Top People read it. The *Daily Mirror*, gamin in its attitudes as it may be (bad manners, good matter), is a vital paper and because its presentation satisfies the tastes of a majority it has a profound influence upon opinion, as much, I should say, as *The Times*. This fact justifies the meaning of the phrase "the free press of democracy"—would that we had the free broadcasting of democracy as well.

It is particularly relevant to remark a leader in the *Observer* which, commenting on Pilkington, said that if, in lamentable circumstances, all other newspapers save the *Daily Express* and the *Daily Mirror* had to shut down then it would be the bounden duty of Government to institute an inquiry. Exactly! And as a corollary, if there were an abundance of broadcasting organizations as there still is an abundance of newspapers there would be no need for enquiry, no need for these decennial committees employing the uses of literacy to argue the need for restriction.

So if we conceive the means for consummating a broadcasting service to be as generous as those given to the press, then, unless we want to oversee and control the press (which some uplifters do) we realise that this question of choice which concerned the Pilkington Report so acutely is illusory; it raises itself only because of the channel shortage and the outlook of the smug characters who despise the tastes of a majority. Quoting Alan Day in a percipient article in the *Observer* about the Report, he says it "sets out the admirable principle of a wide freedom of choice and then fails to apply it on many crucial issues, but instead slides into a priggish distaste for an incomprehension of popular culture."

More Channels More Diversity

There is such a thing as a popular culture and in many instances the B.B.C. recognizes it, but in a particular style; there are other ways of satisfying it and diversity of choice would demonstrate them. There are those who argue that, desirable as it may be to have diversity, there simply is not enough material to fill the many channels which a revolution in technical method would provide. This is tenable only if we visualize that, with a large range of choice, all programmes could have the same characteristics; more Quizzes, more Compacts, more Z-cars, more Westerns. This is not my concept; more channels should provide a greater satisfaction for minorities; more educational broadcasts, more local programmes, and so forth. By this means the service would be refreshed from a multitude of sources rather than present the monolithic and (alas!) stereotype character that channel shortage has forced upon us.

Maurice Wiggin, television critic of the *Sunday Times*, sometimes refers in his articles to "the Electronic Theatre." The need to fill an evening viewing with all sorts, because of only one or at most two channels to carry the programmes, makes the term less evocative than it might be could we truly imitate the theatre on the home screen. We go to the theatre and see a play from beginning to end, too often a television serial with dramatic development is spun out over many weeks. There are other things to do beside look at television or listen to sound programmes and sometimes one is forced to miss an episode; to leave the theatre in mid-scene as it were. This is tiresome.

Given an abundance of channels, one of them could carry the play from end to end; there could well be intervals as in the theatre. The well-chosen term "the Electronic Theatre" could then apply with full justification.

Finally, on this question of choice, I quote the ending of Felix Aylmer's letter to *The Times* thus, "Control and censorship must always remain a matter of public policy but, with this proviso, we hold that government of the people, for the people, by other people (whether they like it or not) should perish from the earth."

There is a phrase which runs about everywhere which talks about "lowering of standards"; commercial broadcasting is said to have lowered B.B.C. standards. If this be true it is a serious criticism of the B.B.C. Asked what effect the alternative programmes had made upon the B.B.C., an executive said that it put the Corporation in much the same situation as that of a wife whose husband had taken a mistress. The analogy is striking because it points the conclusion that, in the circumstances, a shrewd woman would be a better wife not a worse mistress. The B.B.C., apart from Philistine sneers and apart from an institutional grandeur which impresses the inferior, is warmly and generously admired by the great majority; it has a style, a character, and it is by upholding this, by developing its unique qualities to the full, that it will continue in its pride of place. The worst thing it can do is to compete for meretricious applause. The spectacle of a gentleman aping the clown is shaming.

The shamateurs of culture, living elegantly in the Ivory Towers of Establishmentville, seek to prove that popular entertainment corrupts; and among the arguments which are used in an attempt to prove the contention is that violence shown on the screen provokes violence in the streets. To my way of thinking, this is another example of looking at the surface of things and failing to dig down in search of root causes.

There are many causes for the increase of crime, chief among them is the fact that, in search of money for more hire purchase, mothers of young children go out to work in factories and offices, thus failing to provide that disciplined love which creates confidence in the young and so no need for revolt. Robbed of kindly control, the children get into mischief which, in the long run, becomes criminal. There is, moreover, the excess of money in adolescent pockets, and of equal importance the lack of religious faith. This deprivation results in a weakening of the deterrent fear of Eternity's reprisals. In a phrase, the adolescent criminal is created first and foremost by home environment, physical and ideological.

It may well be that violence seen on the television screens and acting on the susceptible does tip them into the stream of crime, but I am sure that children who are brought up in security and are given stability by discipline and love are not in the least affected by, for instance, the outright violence of Westerns. Bang! bang! the bad man is dead. How right! Just like taking an opponent's Queen in chess.

Once more insisting on the liberation of broadcasting by more abundant means I would expect to see some dilution of its bad effects upon weak characters if there were more specialized programmes which sought to capture less anti-social interests. The young fall for jazz, motors and motor cycles, swimming, sailing, athletics and so forth; hobby programmes concerned with such subjects would emphasize the healthy and dilute the bad. I accept the contention that television can corrupt, but suggest that home environment has weakened resistance to its worse influences. A more expansive broadcasting service, offering diversity, would, as it were, dilute the bad effects of the few programmes which at present corrupt. Why deny a healthy majority the Western and detective story, because of a few weaklings?, and as for the weaklings, give them distractions. These advantages would spring from diversity. The price of liberty is high, but it is worth paying.

Restriction Favouring Respectability

Between the lines of the Report one sees that the Committee was inclined to seek evidence which it found agreeable and reject what it considered did not support its foregone conclusions. One can imagine the welcoming smiles that greeted a B.B.C. executive, the look-away embarrassment when a proponent for commercial broadcasting sat his inquisition. This attitude was markedly demonstrated in relation to Pay Television. I gather that from the Report that, in the Committee's opinion, Pay Television would not pay because listeners would not be so foolish as to pay for it. In these circumstances it would seem unnecessary to recommend its prohibition. But there appears to be a fear in the Committee's mind that some might find the system agreeable and so this would, for such, "upset the balance of programmes."

This is a familiar phrase. When I was associated with the development of what the Post Office once called Wireless Exchanges, i.e., means of picking up a programme from the air and transmitting it through wires at audio frequency to householders, it was forbidden to substitute foreign programmes for those officially broadcast from the monopoly stations of the B.B.C. This was ruled for fear of "upsetting the balance" of the official programmes. Anyone with a radio receiver could spend his time unbalancing the equilibrium of Savoy Hill or Broadcasting House but the relay companies? No! Here is the dead hand of control, the denial of majority choice. For it is certain that in those days, listeners preferred the giddy offerings of Luxembourg or Radio Normandie to the sober Sunday soporifics so beautifully balanced on the knife edge of boredom.

The idea of using the wire, with its abundance of channels, is gently frowned upon. According to the Committee's recommendations, the relay companies are forbidden to retransmit the sound of television programmes. My own choice when TV offers me music is to dim the screen; I thereby avoid the irritation of a fidgety camera taking me, one moment under the harpist's foot, the next to the empurpled swelling of a trumpeter's cheek, the items divided by the beaming unction of the conductor. I want to listen not to see, but if I were a relay subscriber then television music, undiluted by the unquiet eye, is denied me. Why?

Expansion Favouring Freedom

From an early age until now I have suffered the infection of ideas. All at their first appearance have been rejected by authority, some rightly, others wrongly. Backed by the authority of the B.B.C. and benefiting from the inspired leadership of Lord Reith, some of these ideas have been put into practice and are now accepted as having been useful contributions to broadcasting technology. Inspiring my proposals, either when working for the B.B.C. or outside it, has been the consistent belief that the sociological value of broadcasting will be the greater as its scope is wider. To repeat what I think to be the operative phrase, broadcasting needs to be "refreshed from many sources," or, risking the pompous, it should be "the rostrum of democracy, the patron of the arts."

In these circumstances I am bound to be disappointed about the Pilkington Report. The Committee appears to accept the limitations of broadcasting technology as inevitable, meaning that the onerous problem which these limitations impose will remain with us always. Having accepted what are, in effect, limited terms of reference, policies are recommended which are as narrow as the assumptions on which they are based. Even then the recommendations are further restricted by the assumption that existing problems can only be solved by further restrictions. Starting with fine phrases about the necessity of giving the audience a wide range of choice "anything else would be denial" the Committee proceeds to suggest more controls, more restrictions. Pay Television—out! Wire broadcasting—coldwater. Relay companies no television sound. The new channel, local broadcasting, sound broadcasting, all are to be controlled by the B.B.C. (which is to compete with itself so as to undermine its own character). The profits of the commercial companies are to be diverted to the Treasury (poverty will result in asceticism?).

Maybe, gentle reader, this is unfair to Pilkington, maybe you could wish for a more constructive criticism than I have promulgated, maybe you are right; here goes.

Broadcasting requires two supports, channels and money and the more channels the more money. It is all very fine to preach, in general terms, the need for diversity but coming down to practical terms how is it proposed to find the means to provide it?

Today two sources of revenue exist, the license fee and the advertising revenue. It would be wrong to increase the license fee to an extent which would pay for an expanded service; would it be fair and practicable to divert what some believe are the excessive profits derived from advertising to set up a communication network, radio or wire, which would be more provident than that in use today? I think this would be a better scheme than the dull one which directs profits to the Treasury, but there is a better one still.

I recently wrote a letter* to the Committee which suggested in a very generalized way, that more channels would become available either by the use of centimetric waves or by the use of the wire: Consider the latter and characterise it, as Dr. R. C. G. Williams has done, as the Electronic Grid. By this is meant a web of wires and radio links meeting at exchanges; the wires terminating in houses. Suppose that the Post Office set up this grid and used it for all forms of communication which benefit the business or the dwelling house. "All forms" embraces telephone, teleprinter, television and sound broadcasting. Surely this electronic grid could reach everywhere; and represent substantial economies?

In this connection the Post Office understandably complains of the high capital cost of installing the normal householder's telephone, complains that, having installed it, the householder fails to use it, complains that the householder complains about the charges he has to pay for not using it!

But these complaints would surely be unjustified if the electronic grid provided all forms of communications and so made installation and amortization charges for the domestic and business telephone the less, while the Post Office would derive a satisfactory revenue not only because the grid consummated the telephone service but also because it would be rented to the broadcaster for television and sound programme distribution.

Conclusion

Given such technical facilities we should rid ourselves of these tiresome restrictions which arise only because of the failure of technology to provide diversity of means. Given such abundances we could realise the potentials of broadcasting to the full; not by chance but by design, not by Pilkington but by imagination.

---

* *Wireless World*, December 1961, p. 606.

Stereo Broadcast Decoders

CIRCUITS FOR USE WITH THE F.C.C. SYSTEM

By G. D. BROWNE*

To enable stereo radiogramophones to utilize v.h.f./f.m. stereo transmissions, suitable decoding circuits are necessary. In the U.S.A., the F.C.C. have approved the Zenith/General Electric system for stereo broadcasting, and regular transmissions are established. In Europe, Working Party S of the European Broadcasting Union have proposed that the same system be adopted. However, "storecasting" has been excluded and a pre-emphasis of 50μs is specified.

The spectral response of a transmitted multiplex signal complying with F.C.C. rules is shown in Fig. 1. It will be noted that the sum signal, that is (A + B), appears in the audio frequency range and thus provides compatability. All the other information is only for use in stereophonic receivers.

A normal f.m. receiver, up to and including the discriminator, may be used. Certain rather critical aspects of design and performance are discussed below.

Multiplex Output at Discriminator:—The multiplex waveforms observed at the discriminator output prior to de-emphasis form a very valuable guide to receiver performance and suitability for stereo applications. Thus advantage should be taken of any suitable pure-tone broadcast tests to evaluate receivers. The following conditions are particularly useful.

(*i*) *Full Carrier Modulation with A = B:*—In the absence of the 19kc/s synchronizing signal, the display on an oscilloscope is normally indistinguishable from that obtained under monophonic conditions. Introduction of the 19kc/s pilot carrier information will cause a "thickening" of the trace. If the audio tone happens to be a sub-multiple of 19kc/s, the synchronizing signal will appear as a steady undulation superimposed on the tone.

(*ii*) *Full Carrier Modulation with A Only:*—In this case, there will be an audio component due to A together with sidebands of A, and the resulting waveform is as in Fig. 2 which shows, in addition, the pilot carrier. A similar display would, of course, be observed using B only.

(*iii*) *Full Carrier Modulation with* A = –*B:*—The audio component should be zero. (This may be checked by a listening test.) All information is now in the sidebands and is pictorially represented in Fig. 3. The addition of the pilot sub-carrier will have the same general effect as before.

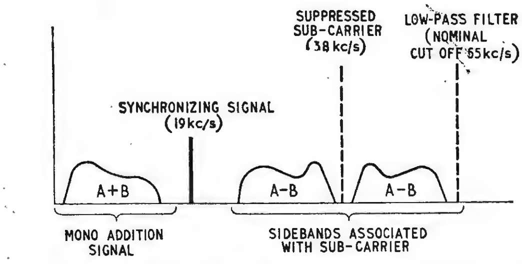


Fig. 1. Multiplex transmitted spectrum complying with F.C.C. rules.

Some Performance Criteria:—Certain features of design or performance, which may be just acceptable for monophony, can render a receiver unsuitable for stereophony. Observation of the multiplex waveform, particularly with full modulation due to A only, generally yields a very good indication of the nature of the trouble. Experience gained by examining a number of receivers of British, Continental and American origin points to certain general classes of inadequate performance which can be classified as follows:

(*i*) *Odd-harmonic Distortion:*—Odd-harmonic distortion is characterized by a flattening or dimpling of the peaks of the observed waveform. It almost certainly results from the lack of sufficient band-

*Mullard Research Laboratories

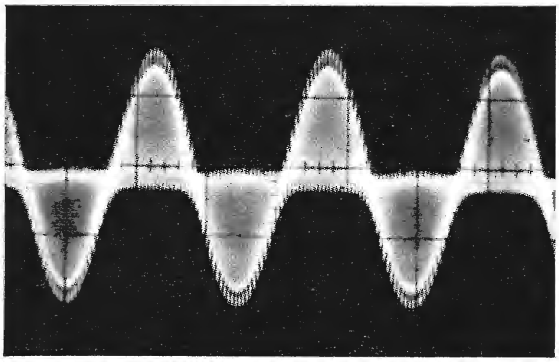


Fig. 2. Multiplex waveform for A only.

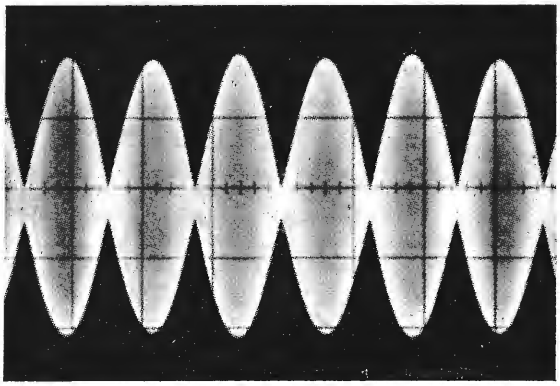


Fig. 3. Multiplex waveform for A = —B.

width in the i.f. chain or from a non-linear discriminator. It must be remembered that, with a stereo transmission, much more energy is contained in the remoter sidebands than is the case with mono.

In almost all cases, this defect also produces the effect described under (iii) below. In a subsequent decoder, synchronization would be impaired or be impossible at maximum deviation since the synchronizing signal would be amplitude-modulated by programme information. This may give rise to cross talk (poor separation) and distortion.

(ii) Even-harmonic Distortion:—Even-harmonic distortion is evident as a lack of vertical symmetry. With the recommended A-only condition, the display should be "skew symmetrical". Lack of such symmetry indicates non-linearity—probably of the discriminator, but also possibly of the i.f. circuit (asymmetrical response). I.F. feedback, insufficient to cause obvious instability or give rise to serious distortion on a mono signal, can be responsible. Here again, the effect under (iii) below is also often present. The 19kc/s synchronizing carrier will be amplitude-modulated by programme information, with results as in (i) above.

(iii) Poor Frequency or Phase Characteristic:—With full-modulation A-only conditions, the oscilloscope display should be as in Fig. 2; that is, with a straight line as the horizontal axis. A "wavy" axis can be attributed to incorrect frequency or phase response of either the i.f. chain or the discriminator or both. If the axis is substantially a sine wave in phase with upper and lower envelope peaks, the high-frequency response is below the low-frequency response. This may be caused by insufficient i.f. bandwidth or a relatively peaky overall characteristic. Alternatively, the r.f. bypass capacitor in the discriminator may be too large. If, on the other hand, the axis is out of phase, the low-frequency response is below the high-frequency response. This condition is unusual but is generally caused by grossly overcoupled i.f. transformers (intentional overcoupling or the result of spurious feedback).

Incorrect phase response in simple cases is characterized by the axis becoming saw-tooth or triangular in form. This is unusual in a receiver, but may be produced by some types of modulator.

Generally speaking, frequency response and phase response are interrelated so that, in a practical case, the axis may assume varying degrees of "waviness". Poor overall response in either or both of the above respects would cause crosstalk and possible difficulty with effective synchronization. Correct i.f. transformer design and stable operation are essential, together with good discriminator action.

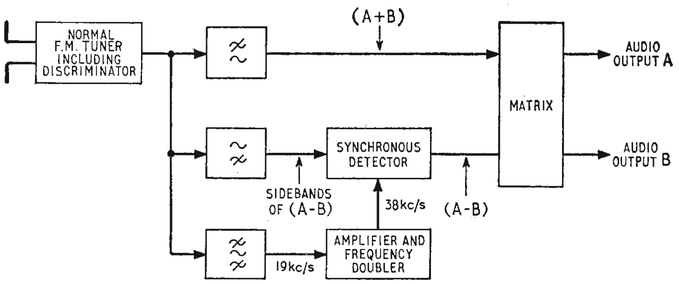


Fig. 4. Block schematic diagram of basic decoder (adaptor).

Finally, a check should be made to see that a.m. suppression is effective not only with low frequencies but also over the full width of the band concerned; that is, up to modulation frequencies as high as 53kc/s and at full deviation.

Testing and assessing decoders not provided with the correct input is fruitless and can be very misleading. However, compensation for certain shortcomings of the receiver performance may, in some circumstances, be made in the decoder design.

Basic Decoding Arrangements:—The block schematic diagram of Fig. 4 illustrates the process of decoding. The basic functions are largely self-explanatory.

In a practical embodiment, certain design features have to be dealt with. The main items are as follows:

(i) The 19kc/s selection circuit must have an adequate Q-factor to reject unwanted information, but must clearly not be too critically dependent on temperature changes and other variations which would cause undesired phase changes.

(ii) The low-pass and high-pass filters are almost certain to have different phase (time-delay) characteristics. It is generally necessary, therefore, to provide a suitable compensating network.

(iii) The amplitude and phase of the locally-generated 38kc/s signal require careful consideration. The phase is particularly important for good cross-talk performance and the amplitude must be adequate for complete demodulation without being so large that means, other than a normal de-emphasis network, are required for subsequent removal.

(iv) In order to allow for correct matrixing, some control over the amplitude of (A+B) or, if more convenient, of the recovered (A−B) must be provided.

Simple Decoder Circuit:—It is possible to avoid certain of the difficulties outlined above, particularly regarding the low-pass and high-pass filters, by the simple expedient of omitting the features. This involves little or no danger, particularly in the absence of subsidiary communications such as "store-casting". Thus, where the complete flexibility of a highly sophisticated circuit is not required, a simple decoder suitable for receivers in the inexpensive and medium-price range can be constructed. Fig. 5 shows a basic circuit of this kind.

The 19kc/s pilot carrier is extracted by means of the tuned circuit designated "19kc/s", and amplified by the pentode section of an ECF80. Since distortion is not particularly important, the pentode can be run under starvation conditions, yielding a gain of nearly 100 times. This amplified signal is then fed to the triode section of the ECF80 working as a frequency doubler with a 38kc/s tuned primary transformer in its anode circuit. The complete multiplex information is applied to the centre tap of the tightly-coupled secondary. Demodulation of the (A−B) sidebands and matrixing with the (A+B) signal occur automatically in the diode circuits After normal de-emphasis, which also attenuates unwanted products* of the process, A and B appear at the respective output terminals.

*These include not only 38kc/s and its harmonics but also the sidebands and their harmonics.

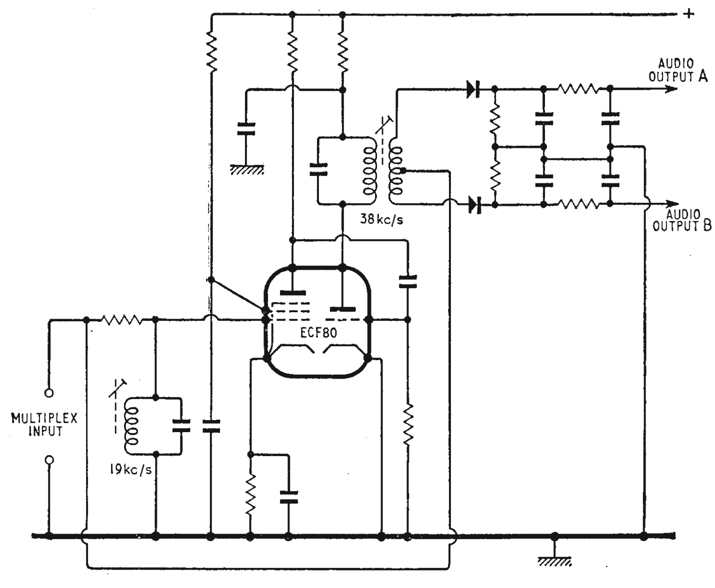


Fig. 5. Basic decoder circuit.

Such a simple arrangement has several disadvantages, the chief of which are:

(i) It gives an effective signal level loss of some 3 to 4 times due to converter action.

(ii) If both tuned circuits are peaked, the phase of the 38kc/s supply differs by 90° from requirements. (This can be simply corrected by detuning the 19kc/s circuit by 45°, but this is by no means elegant.)

(iii) Although the input impedance is moderately high, the decoder must be fed from a source of relatively-low impedance, not greater than, say, 10kΩ. Thus it may be operated directly from a typical ratio detector. The source impedance is limited by the feedback of the residual 19kc/s signal from the diode circuit. Furthermore the source resistance forms part of the diode load circuit.

(iv) In most practical cases the level of the multiplex signal will probably be too low to allow effective demodulation by the diodes without distortion.

Some of these disadvantages may be overcome by slight re-arrangement of the circuit, as discussed in the following section. An advantage of this simple decoder circuit is that its output impedance is relatively low and the capacitance to earth of screened connections to subsequent audio amplifiers may form part of the de-emphasis network.

Practical Decoding Circuit :— A development of the basic circuit is shown in Fig. 6. It is intended to operate directly from a typical discriminator providing an r.m.s. output signal of between 0.5 and 1.5V.

To provide a high input impedance and an overall gain of about unity, the complete multiplex signal is first amplified by a triode provided with negative current feedback. Care must be taken in this stage to avoid distortion which would give rise to intermodulation products.

The entire output is connected by way of a phase correcting and buffer network to a 19kc/s tuned circuit. The pilot sub-carrier is developed across this tuned circuit and applied to the grid of the triode frequency doubler. The output at 38kc/s appears across the tuned primary of the transformer in the anode circuit. The necessary fraction of the amplified multiplex signal is fed to one end of the secondary of the 38kc/s transformer, as before.

Both tuned circuits may initially be peaked for maximum output and a final slight adjustment made on either for minimum crosstalk. This minimum will be about −20dB measured over a complete f.m. radio link. Details of experimental coils are given in Appendix 2.

Provision of reverse compatibility:—This is not inherent in this simple circuit; that is, it cannot

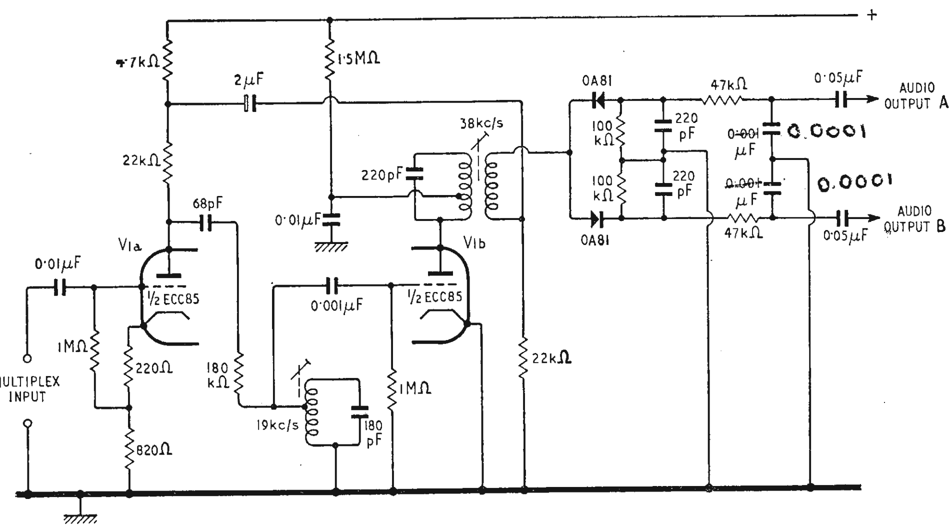


Fig. 6. Practical decoding circuit corresponding to Fig. 5.

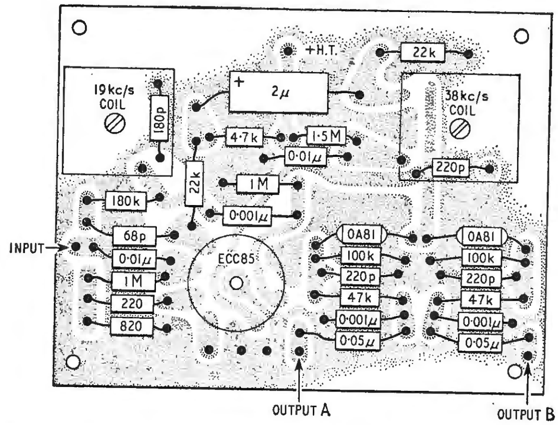


Fig. 7. Suggested layout of the circuit in Fig. 6 using a printed board.

handle a mono signal. This lack can however be overcome in two ways. In the first method, a d.c. potential may be applied to the diodes by means of a switch, thereby disabling them during mono reception. This method, while preserving the best possible mono signal-to-noise ratio, raises the effective gain under these conditions by about 10dB. However, gain equalization may be achieved by suitable switching.

In the second method, either the 19kc/s circuit or the 38kc/s circuit may be self-oscillatory. The 19kc/s circuit can readily be made self-oscillating by, for example, tapping the cathode of the doubler triode into the 19kc/s tuned circuit. Oscillation at 38kc/s may be achieved by connecting a suitable capacitor (perhaps in series with a resistor) between the secondary of the 38kc/s transformer and the grid of the doubler. Under stereo conditions, synchronizing provides a locked oscillator, while for mono reception the diodes merely act as free-running supersonic choppers. Such an arrangement gives no significant change of level when the programme changes from stereo to mono or vice versa, but under mono conditions the signal-to-noise ratio suffers a deterioration of just over 20dB.

Practical Lay-out:—The circuit of Fig. 6 can be constructed quite simply on a small printed board and a suitable arrangement is shown in Fig. 7. The basic pot-cores only of the Vinkor assemblies have been used and omission of the metal containers reduces capacitance to earth of the windings. Since the self-capacitance of the coils themselves will depend to an extent on the actual windings, the final tuning capacitors are best determined by experiment.

An h.t. supply of between 170V and 250V is required and the current drain is approximately 6mA.

Alternative Valves:—In place of a double triode, a triode-pentode such as the ECF80 may be used in the circuit of Fig. 6. The main advantage resulting from the use of a pentode is that it enables an electron-coupled oscillator-doubler circuit to be used. The cathode, control grid and screen grid operate as a 19kc/s locked oscillator, the 38kc/s signal being extracted from the anode.

Decoder using Switching Valves:—There are always certain difficulties which arise in detection (synchronous or otherwise) when the recovered audio frequency is not far removed from the carrier frequency. One major problem, centred around time constants, largely disappears if, particularly for purposes under discussion, use is made of switching valves rather than simple diodes. A circuit showing such an application is given in Fig. 8.

The separation of the 19kc/s pilot carrier and production of the locally generated 38kc/s supply may be effected by two triodes, as shown and previously discussed. Antiphase switching waveforms are applied, via phase-correcting networks, to the respective second control grids in a pair of heptodes so as to give a substantially square-wave anode

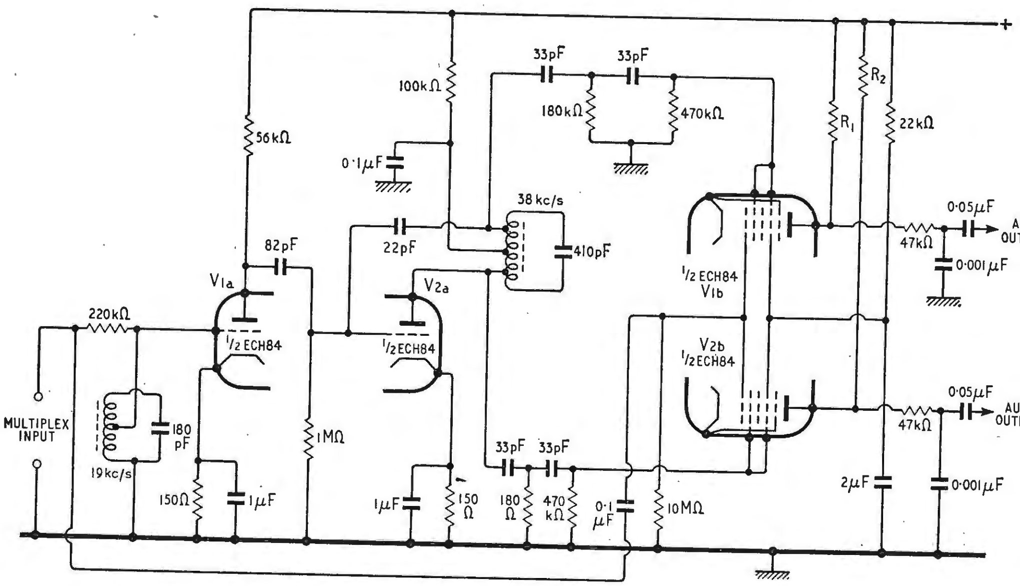


Fig. 8. Decoder using switching valves.

current. The complete multiplex signal is fed to commoned first control grids. The required bias is produced partly by the cathode current in the common-cathode resistor and partly by grid current. Normal synchronous detection now occurs, and the A and B outputs appear at the respective anodes where the usual de-emphasis networks complete the arrangement. Interchannel crosstalk is about −24dB including the complete radio link. A suitable valve complement for this circuit is a pair of ECH84, and the component values for these types are given in Fig. 8.

Since such a decoder is capable of giving quite a considerable gain if required, the values of the heptode anode load resistors R1 and R2 have not been given. As a guide, it may be stated that a load value of 4.7kΩ gives an overall gain of about 10dB.

Two general points may be noted:

(i) Although the heptodes are largely grid-current biased, they share cathodes with the triodes and therefore have a safe minimum bias in the absence of a signal.

(ii) Reverse compatibility is inherent whether the 38kc/s supply is self-oscillatory or not. If it is self-oscillating, the switching potential is always present, so that the gain, and hence the audio output, is substantially independent of whether the programme is mono or stereo. However, as in the case of the diode circuit, the mono signal-to-noise ratio suffers deterioration. If it is not self-oscillating, the second control grids revert to earth potential, and the heptodes act as normal class-A audio amplifiers giving an increase in gain of some 6 to 10dB over switched conditions. As in the previous examples, any desired compromise may be reached by suitable switching.

Alternative Switching Valves:—If desired, the two triodes associated with the pair of ECH84 may be replaced by ECC81, ECC85 or ECF80. The two heptodes can then become a pair of EH90. Alterations to some of the circuit values may be necessary, but no basic changes are involved.

Another possibility is the choice of a double triode in the role of switching valves. In this case, it would be convenient to apply the switching waveform, from a low-impedance source, in opposite phases to the two cathodes, and feed the multiplex signal simultaneously to the two control grids.

APPENDIX 1: Notes on Discriminators

Ratio Detectors.—The output impedance of a conventional ratio detector for mono purposes is relatively low (approximately a quarter of the total diode load) and its audio-frequency response prior to de-emphasis substantially level over the normal audio range. To ensure adequate output bandwidth for stereophonic purposes, de-emphasis is not, of course, used at this stage. A good frequency response must be maintained up to at least 40kc/s. Generally speaking, the total diode load should not materially exceed 20kΩ and the total i.f. bypass capacitance, including stray capacitance, screened connections and so on, should not be greater than, say, 300pF.

Phase Discriminators (for example, Foster-Seeley).—Most phase discriminators have a relatively high output impedance (about one-half the total diode load) but their sensitivity is generally greater than that of a ratio detector. Designs for stereo applications based on the Foster-Seeley arrangement do not include de-emphasis at this point. They should generally have each diode load not greater than about 47kΩ (or a total of not exceeding 100kΩ). The total i.f. bypass capacitance should certainly not exceed about 100pF and a smaller value should, if possible, be used. Due regard must be paid to this point if the decoder is not near this type of discriminator, particularly if they are joined by a screened connection as, for example, in an "add on" adaptor unit.

APPENDIX 2: Experimental Coil Details

For convenience of construction and adjustment, Mullard Vinkor pot cores, type LA2505, were used in the experimental receivers.

19kc/s Coil (Figs. 6 *and* 8)*:* 1525 turns of 45 s.w.g. enamelled-copper wire, tapped at 380 turns from the earthy end; tuning capacitance, 180pF±2%.

38kc/s Transformer (Fig. 6)*:* Primary: 680 turns of 45 s.w.g. enamelled-copper wire, tapped at 250 turns from the anode end; tuning capacitance, 220pF±2%: Secondary: 125 turns of 36 s.w.g. enamelled-copper wire.

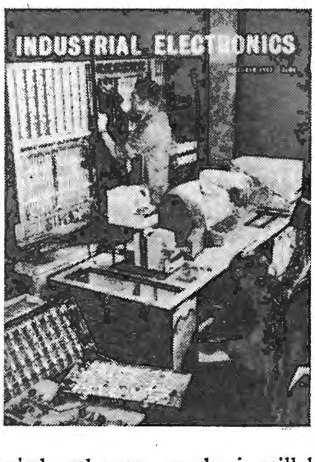
38kc/s Auto Transformer (Fig. 8)*:* 520 turns of 40 s.w.g. enamelled-copper wire, tapped at 185, 260 and 335 turns; tuning capacitance, 410pF±2%.

APPENDIX 3: Additional Separation (Anti-cross-talk) Circuits

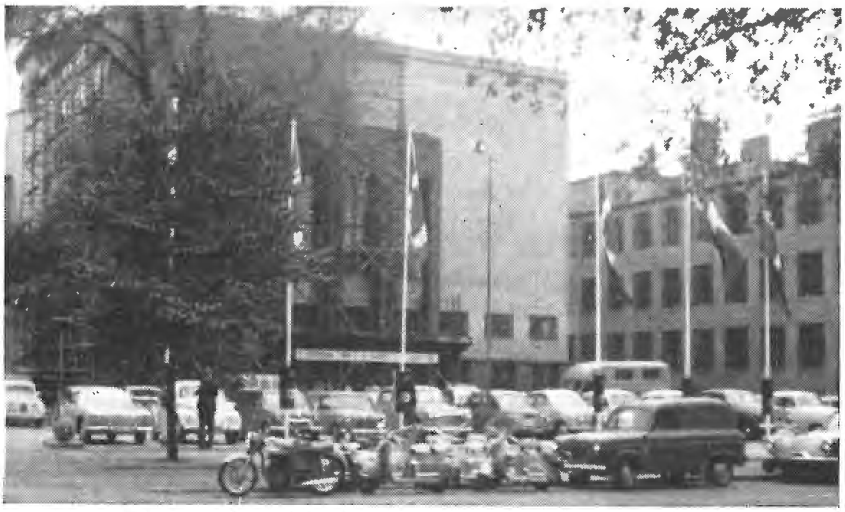
Where crosstalk between two channels is reciprocal, linear and such that the unwanted signal in one channel is in phase with the wanted signal in the other channel, a relatively simple audio circuit modification can offer an improvement of as much as 12 to 20dB without much difficulty. The arrangement, which is equally suitable for stereo broadcasting or stereo tape or disc reproduction, does not appear to be widely known. The cathode circuits of two audio amplifying valves, one for each channel, are wholly or partly unbypassed but are connected to each other by a variable resistance. Simple circuit analysis will show that it is thus possible to use "cross-injection" which, when the variable resistance is adjusted, reduces crosstalk to any required value within circuit limits. If desired, the value of the variable resistance together with that of a simple fixed resistor, may be such as to include both "separation" and "blend" facilities.

"Industrial Electronics"

THIS is the new title of our sister journal *Electronic Technology* and with the change of title comes an alteration in editorial content. While maintaining the same editorial standards that have existed throughout the life of the journal—39 years—its coverage will be



greatly extended and more emphasis will be placed on practice and less on theory. The first issue of the re-styled and renamed journal, dated October, will be available on the 9th of the month.



POINTS FROM PAPERS READ IN COPENHAGEN

21st—28th AUGUST 1962

Fourth International Congress on Acoustics

THE field covered by acoustics today is wide and topics discussed at the Congress ranged from the effects of the hundreds of *megawatts* of acoustic power radiated from the launching pads of the latest space rockets to the minute quanta of vibrational energy (phonons) involved in the transfer of energy between ultrasonic waves and electrons in the interstices of crystals. Between these extremes there was, among the 350 papers read and discussed in nine concurrent sessions, something for everybody including those interested in high-quality sound reproduction (possibly even "hi fi fans"!)

Mega-acoustics

According to present estimates, future space vehicle rocket engines, such as NOVA, will produce 500 MW of acoustic energy at lift-off, and to ensure that intolerable or even hazardous noise levels do not reach residential communities, the choice of launching sites is now under active review. According to F. M. Wiener (Bolt, Beranek and Newman, Inc.) sound pressure amplitudes equivalent to $\frac{1}{10}$ atmospheric pressure (160dB) are generated in the field near the launching pad. Reduction of noise by the injection of water streams (to increase density and so reduce the velocity of the exhaust gases) has been suggested but is hardly feasible since the flow requirement at launch would be of the order of half a million gallons per minute. Launching over a static water tank would also be ineffective and there seems no alternative to the wedge shaped deflector system which splits and diverts the stream in opposite directions. Measurements made by J. M. Cole, *et al.* (Aerospace Medical Research Labs. U.S. Air Force) on static tests and the launch of SATURN (10^6 lb thrust) indicate noise levels of the order of 130dB at a distance of one mile during the first half minute.

This energy is capable of causing structural damage not only in the rocket but also in ground installations. J. K. Hilliard *et al.* (L T V Research Centre, U.S.A.) showed photographs of fatigue failure produced in test panels after five minutes exposures at 170dB. The sound source was a battery of electro-pneumatic modulated air stream generators, horn-coupled to a progressive-wave tube of 5ft × 6in cross-section.

Macro-acoustics

Sound is propagated in water to distances of the order of thousands of miles and is now playing an important role in oceanography. L. B. Brekhovskikh and I. E. Mikhaltzev (Acoustics Institute, Academy of Sciences, U.S.S.R.) described investigations of the surface acoustic channel above the upper isothermal layer by means of calibrated TNT charges, and of the use of the wideband characteristics of the pulse to determine (by the deformation of the echo) the nature of the ocean floor.

Underwater signalling at a distance of 60 miles in the middle of a storm was reported by J. L. Stewart and W. B. Allen (U.S. Navy Electronics Lab.) who showed that pseudo-random (PR) signals of large time-bandwidth product in conjunction with a cross-correlation technique can give more information about the perturbation of underwater propagation than impulsive or single-frequency signals.

Returning to dry land, and exchanging our scale of miles for feet we next consider—

Room Acoustics

This was the title given to the section dealing with sound in enclosed spaces and it included many papers covering sound transmission through partitions and many other aspects of what is generally termed architectural acoustics. But it was in the qualities of listening rooms, studios and concert halls that most readers of this journal would have been most interested.

Dr. Ing. R. Boutros-Attia (Alexandria University) described an important method of assessing instantaneously and subjectively the acoustics of a room by means of ultrasonic waves in a model. A recording of a speech or music in an echo-free room is made on tape at a normal (low) speed. This is replayed *n*-times faster (*n* being the scale of the model) and reproduced by an ultrasonic "loudspeaker." Microphones in an artificial head inside the model pick up the reverberant sound which is then recorded at high speed and played back at the original low speed in separate headphones. With normal longitudinal tape recording a time lapse between the original sound and the playback from the model is inevitable because of the change of tape speed, but it is proposed to overcome this by using a wide tape running at constant speed in conjunction with three heads rotating at different speeds (modified television tape recorder). The first pair of heads records and monitors the original "dry" sound, the second set revolves at say 10 times the speed of the first, and the third at the original (low) speed. This will pose some difficult mechanical problems because the first and third heads must be given a longitudinal motion equal to 0.9 tape speed if all the traverses of the tape are to be made at the same angle. The longitudinal head motion will be saw-toothed since the heads must return to their original position for the start of each track with correct synchronism.

The quality of diffusion, or the distribution in direction of the received sound, is important in listening rooms and concert halls. G. A. Goldberg (Academy of Sciences, Moscow) described a method of displaying the reflections from a spark source by means of 90° crossed microphones connected to the x and y plates of an oscilloscope. By differentiating the microphone outputs, directional ambiguity was removed and "rose patterns" photographed at various time intervals after the spark showed the build-up of diffusion from the first reflections onwards.

Many papers dealt with the design of recently contructed large concert halls. In continental Europe the seating capacity is usually 1,000-2,000, but in the U.K. and in America the tendency is to larger halls seating 3,000 or more. L. L. Beranek (Bolt, Beranek and Newman Inc.) gave an invited paper on criteria for the design of concert halls and opera houses, based on detailed acoustical analysis of 54 halls in 16 countries and a subjective judgment of these halls by 22 renowned conductors and 23 professional music critics. The results explode the idea that judgment is personal and a matter of individual taste, for he found full agreement between musicians and technicians in their grading of these halls.

Noise. The mounting level of noise in civilized communities is causing our legislature some concern, and they in turn are pressing scientists for criteria by which subjective nuisance can be assessed from objective measurement. As D. W. Robinson (N.P.L.) put it, "We are being asked to say 'yes' or 'no' on matters on which the scientist himself has doubts." Nevertheless, some good progress had been made in correlating the readings of a sound level meter, with the so-called "A" weighting scale to stimulate the characteristics of the ear, with subjective judgment. In Dr. Robinson's view consistency of subjects' response meant measurement, but in relying on this statistical approach for international agreement, care was necessary in translating instructions; emotive adjectives like "loud," "annoying," "disturbing" could be changed in meaning. Much work still remained to be done on time-dependent factors, such as occurred in drop forging or pile driving. Some work on impact noise reported by G. J. Thiessen and K. Subbarao (Nat. Research Council, Ottawa) leads to the conclusion that tolerance of impact noise is increased if the reverberation time of, say, an office is reduced by means of absorbing material. One interesting by-product of work in noise assessment was that judgments indoors of street noise tended to be harsher than out-of-doors; it seemed that walls were subjectively transparent and that one tended to project oneself outside.

Psychological and Physiological Acoustics

Some properties of the brain which play an important role in the perception of sound were discussed by Prof. E. C. Cherry (Imperial College) who held that the function of two ears was primarily to separate sound images rather than to give directional properties. Although complete fusion takes place between these images and we hear "one world," the mind is able to concentrate on one speaker in the babel of sound at a cocktail party. This is to some extent dependent on our linguistic heritage and the fact that there is an associated (even if suppressed) motor activity in the mouth when listening to speech. He demonstrated that separation of two superimposed voices is easy when the words spoken are coherent but that this facility fails when both speeches are composed of random clichés.

In Dr. Cherry's view binaural fusion is a central correlation process carried out in two stages; first autocorrelation at each ear to establish the envelopes of high-frequency components of the sound in time, and then cross-correlation between these envelopes. Experiment had shown that the fusion process was operative up to time differences of 6 to 7 milliseconds between signals applied separately to each ear. The points of the nervous system where these processes are carried out are not yet known with any certainty, but Dr. Cherry put forward the hypothesis that the properties of the cochlea could provide the mechanism of autocorrelation by the interaction of compressional waves in the fluid with transverse waves in the basilar membrane.

The response of the ear to transients of short duration (5 μsec) has been investigated by D. L. Pimonow (Centre Nat. D'Etudes des Telecomm.). Separate sources of pulses at 1 second intervals were applied together to an amplifier and Ionophone loudspeaker having a pass band of 100 kc/s. The pulse trains were staggered so that an observer heard clicks at 0.5 sec intervals. A variable low-pass filter (10 kc/s upwards) was then introduced into one chain, and subjects were asked to restore any inequality by adjustment of the gain of the pre-amplifier in the filtered channel. One boy of 15 years could detect a cut-off frequency of 45 kc/s and other observers, irrespective of age, made adjustments at 20 kc/s or higher (more than twice the cut-off frequency of the ear in all cases). These results may influence the design of high-fidelity equipment and of hearing aids, since the intelligibility of speech is closely associated with the transients of consonants.

Electro-acoustics

Prof. E. Meyer (Göttingen University), in an invited paper, took as his theme the prospects which are opened by a closer examination of possible analogies between acoustical and electromagnetic fields and oscillators. He chose three examples:

(1) An acoustical travelling wave amplifier in which sound is passed, together with a steady air stream (equivalent to an electron beam), through a tube with a periodic wall structure. Amplification of the input sound had been proved experimentally.

(2) Broadband reflection-free surfaces with wedge structure in which phase relationships in waves travelling parallel with and adjacent to the surface had been investigated by observing the motion of particles suspended in the acoustic medium.

(3) Acoustic and electromagnetic absorption by reverberation methods. The reverberation room at the Göttingen Physikalisches Institut had been lined with copper and when empty had been found to have an e.m. "Q" of 2,000,000 at 10kc/s.

Loudspeakers and Headphones. The successful reproduction of stereophonic sound depends on clearly defined arrival times of the components from the two loudspeakers, and to this end F. H. Brittain (G.E.C.) described a modified version of the "Periphonic" push-pull system in which the middle and upper frequency units are arranged vertically above the low-frequency push-pull pair. Particular attention has been given to equality of polar response at all frequencies above 500c/s.

High-quality electrostatic headphones which do not require any polarizing voltage have been developed by G. M. Sessler and J. E. West (Bell Telephone Labs.). A laminar (4-layer) Mylar diaphragm (total thickness 0.001in) carries a central (metallized) electrode and is polarized (with 3500V at 120°C for 15 minutes) to form an "electret" (the electrical equivalent of a permanent magnet). The diaphragm is mounted between parallel perforated metal plates to which the push-pull signal is applied. Tests on an artificial ear show a frequency response ±3dB between 30 and 11,000c/s and harmonic distortion less than 0.9% at a sound pressure level of 100dB.

Pickups. Prof. F. V. Hunt gave a paper on the rational design of the stereo disc pickups in which he divided the available groove-wall reaction force (which balances the bearing weight) between requirements of stylus acceleration, low-frequency tracking and tone-arm acceleration. He showed that the allowable value of stylus mass is set by the acceleration due to the second harmonic components of tracing distortion, and that in stereo recording these components are additive in the vertical plane, whether the fundamental groove modulation is lateral or vertical. The non-linear character of the stylus-groove contact means that resonance at this point can contribute to in-band noise through intermodulation. This noise can be suppressed if the first resonant mode is located at or above the translation loss cut-off frequency but this requires an effective stylus mass/bearing weight ratio of 0.14 mgm/gm and this is nearly an order of magnitude lower than is available in present-day pickups. An extended discussion of these points has been submitted for publication in a forthcoming issue of the *Journal of the Audio Engineering Society*.

The high-polymer plastics used in pickups and other transducers to control their mechanical performance may exhibit sharp transitions in rigidity and internal energy loss with temperature, particularly below freezing. P. Lord and E. R. Pithey (Royal College of Advanced Technology, Manchester) described a torsional vibration method of determining these parameters rapidly at audio frequencies and gave some results which indicate that the damping may be controlled by cross-link density between polymer chains without adversely affecting the modulus of rigidity.

Micro-acoustics

As this account started with mega-acoustics it seems logical to finish at the opposite end of the scale.

In our report of the 3rd Congress at Stuttgart in 1959 we recorded the fact that acoustic exploration of solids and liquids at high ultrasonic frequencies was not only shedding new light on crystal and molecular structure but was proving a useful practical tool in chemical analysis by revealing the relaxation times of transitions of atoms in complex molecules.

At Copenhagen E. H. Jacobsen (General Electric Co., Schenectady) described research which is now going on at frequencies up to 10 kMc/s. The ends of a quartz or ruby rod terminate in annular cavity resonators which act as transducers by the interaction of the electric component of the field with the end faces of the rod. The velocity of the stress wave through the quartz is observed from standing-wave peaks in the receiving oscilloscope, due account being taken of the acoustic waveguide mode and of flexural modes in the end faces. The quartz crystal must also be cut in a direction favourable to propagation of the wave. The whole unit is cooled to 12°K or less to eliminate disturbances from thermal "phonons".

Experiment has support the hypothesis of a quantum-mechanical basis for vibration and "sound," the phonon being defined as the elementary quantum of elastic energy associated with change of state of elementary particles in atoms. It has been found, for instance, that paramagnetic atoms react strongly under microwave ultrasonic excitation, which provides energy for electron spin reversal at critical frequencies. The ferrite $Fe^{++} \cdot MgO$ shows this effect well and exhibits marked anomalous dispersion effects near the resonance frequencies. There is a close analogy here with light quanta (photons) in an electromagnetic field. Stimulated emission of phonons from inverted states has been achieved in ruby in the X-band using plump frequencies in the K-band.

Ultrasonic travelling wave amplification in n-type semiconductor crystals was described by D. L. White (Bell Telephone Labs.). When an ultrasonic wave traverses the crystal in a preferred direction it is accompanied by an alternating electromagnetic field and current; the current produces heating and the ultrasonic wave is attenuated. If, however, a direct current with an electron drift velocity exceed-the velocity of sound flows through the crystal, the ultrasonic wave grows in amplitude. The gain can be very high (e.g. 0.35dB per wavelength). In practice a d.c. pulse is applied to prevent spontaneous oscillation and overheating (at 1000 V) and a gain of 57dB has been observed in a 1.2cm bar of cadminium selenide (Cd Se) using shear waves at 45Mc/s. Applications envisaged (up to 1 kMc/s where continuous operation without overheating is feasible) include low-loss wide-band ultrasonic delay lines and possibly amplification of electrical signals as well as the primary uses as a generator, amplifier and detector of ultrasonic energy. It is particularly useful as a detector, since the d.c. is also amplified.

The organization of the Congress by Prof. Fritz Ingerslev, Chairman of the Acoustical Society of Scandinavia and of the Acoustical Society of Denmark, and his colleagues ran like clockwork—literally. Just before the end of the twenty-minute period allowed for the reading of each paper the sound of a metronome faded unobtrusively in and out of the loudspeaker system in each lecture room as a gentle reminder that time was running short. At the end of the period music gradually swelled and finally drowned the words of the lecturer. On the last day Prof. Ingerslev fell victim, whether by design or accident will never be known, to his own device, which appropriately terminated both his closing speech and the congress.

The next (5th) International Congress on Acoustics will be held in Belgium (Liège) under the chairmanship of Prof. J. Frenkiel.

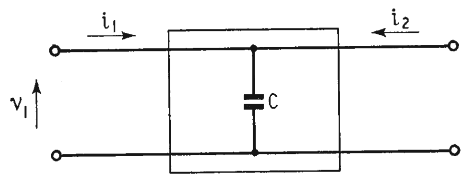
LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

The Reciprocity Theorem

MR. THOMAS RODDAM in his article "Ban the Reciprocity Theorem," p. 409, September issue, has described network analysis as a "simple logical closed system." I trust he will forgive me for failing to see the logic by which he concludes that "at any instant the total power supplied (to a black box containing no resistors) must be zero, since once power is supplied it turns into heat and cannot be turned back . . ."

Consider a simple example such as that in the accompanying figure:



In this particular case the voltages v: and v; at a given instant are equal (to v, say) having a value dependent on the past history of the black box. If we assume further that $v=0$ at time $t=0$, and that subsequently

$i_1 + i_2 = i$ (constant),

the voltage at a subsequent time $t=t_1$ is $v=it_1/C$ and the power is then

$v(i_1 + i_2) = vi = i^2\, t_1/C$

which is not zero unless $i = 0$ (since $t_1 \neq 0$ by assumption). Furthermore the power is not turned into heat but into the energy of an electrostatic field, which is recoverable.

Mr. Roddam can still independently *postulate* as an element of the logical system one which will obey the equation

$v_1\, i_1 + v_2\, i_2 = 0.$

He could also doubtless prove that such an element would contain no resistors, for good measure. He finds an example in the ideal transformer. He may equally well postulate an element which obeys the equation for all values of i_1 and i_2, and find the logical consequences of this behaviour: I think that this is what he has done, although "this is to be true for all values . . ." sounds more like an assertion than a postulate. Having done this the rest follows.

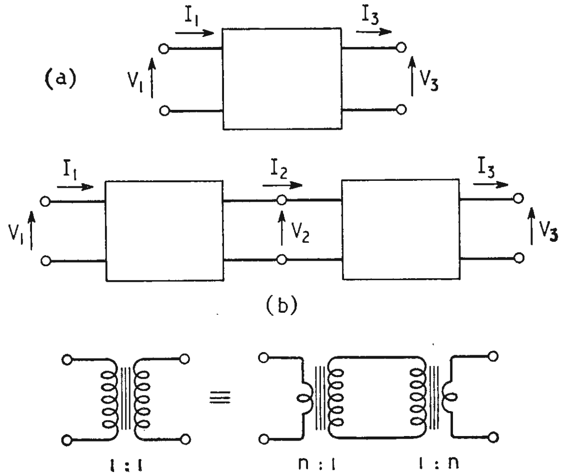
I take it that the Reciprocity Theorem became established during a time when nobody happened to have thought of this device, the gyrator, which presumably cannot be represented as a common branch between meshes. Or can it? I cannot help a sneaking feeling that there might be a sixth element, whose discovery might perhaps invalidate the proof that the five were all-sufficient.

Manchester. R. S. TAUNTON.

The author replies:

If Mr. Taunton will examine my text he will see that I say that "a network . . . made up of meshes . . . inductance, capacitance, resistance, . . . mutual inductance . . . a simple logical closed system." He is quite correct, however, in saying that the total energy supplied to a reactive network need not be zero. I must confess that I had overlooked the fact that it was as long ago as September 1957 that I discussed the gyrator more fully and I was seeking to keep compact the discussion I knew I had given in an earlier article. The right approach is to say that we have energy dissipators (R), energy storers (L and C) and, should we say, energy level converters. Then we say that this last class is defined by the transformer equation, $v_1\, i_1 + v_2\, i_2 = 0$, which leads on to the gyrator.

This is Tellegen's approach and Mr. Taunton will find the formal treatment he wants in *Philips Res. Reports*



3, 81 (April 1948) or *Philips Tech. Rev.* 18, 120 (1956). Note the date and note also that before this Firestone and others had discussed anti-reciprocity (the references are given in the *P.T.R.* (loc. cit.)).

There is a way of arriving at the gyrator equations which has a certain formal and historical interest. Suppose that the box in the accompanying diagram (a) contains an ideal 1 : 1 transformer. If the signal in is S_1 and the signal out is S_2 we can say that $S_2 = T(S_1)$ where T is the operation carried out on S_1 by the box. Let us split this box into two identical boxes so that $S_2 = T'. T'(S_1)$, where T′ is the operator describing the box function. Subject to the rules of the game

$$T' = \sqrt{T}$$

We know that we can introduce square roots into operator problems: for example $p^{\frac{1}{2}} H(t) = 1/\sqrt{\pi t}$, when H(t) is the Heaviside unit function and p^{-1} is the function of definite integration. Now if we proceed, we have

$V_1 = V_3$ and $I_1 = I_3$. We can take

$V_1 = V_2 = V_3$ and $I_1 = I_2 = I_3$

giving us two ideal 1 : 1 transformers.

We could take $V_1 = nV_2 \qquad V_2 = \frac{1}{n}V_3$

$$I_1 = \frac{1}{n}I_2 \qquad I_2 = nI_3$$

which means only that we write

$S_3 = T'.(T')^{-1}(S_1)$

where T′ now describes a 1 : n or n : 1 transformer (in turns ratio, n : 1).

However, suppose we write

$$V_1 = mI_2 \qquad V_2 = mI_3$$

and

$$I_1 = \frac{1}{m}V_2 \qquad I_2 = \frac{1}{m}V_3$$

We shall get overall $V_1 = V_3$ and $I_1 = I_3$. The operation described by the equations $V_1 = mI_2$, $I_1 = \frac{1}{m}V_2$ is something which none of our previously known elements can produce, but it is a passive operation.

To some minds this process resembles the sequence: $1 : \sqrt{1} = \pm 1.\ \sqrt{+1} = \pm 1;\ \sqrt{-1} = i$. We know that once we introduce $\sqrt{-1}$ the system is closed. We cannot produce operations which need a new kind of number. In the same way the gyrator closes our set of passive linear network elements. To produce an extension of the range we need only abandon the superposition theorem and we have a set of non-linear elements: if we retain linearity we are content.

I know by bitter experience that one can come to believe that any passive network must be reciprocal and that, as a result, one can refuse to accept some of the results which follow from the use of gyrators without a great deal of banging of soft heads against hard walls. Fortunately we now have a number of schemes which include active networks as well in their classification. One such is that discussed by Kawakami (*I.R.E. Transactions on Circuit Theory*, CT-5 No. 2 June 1958 pp. 115-121).

THOMAS RODDAM

Retrieval of Technical Information

I READ the article by A. E. Cawkell in the August issue on information retrieval with interest. Regarding requirements for an ideal system—completeness of references held, exact access however a question is formulated by the searcher and complete retrieval—I would add the all-important aspect of practicability of filing references into the system.

It is this which consumes the man-hours, an expense dominant in any managerial consideration of information work. The hours of time saved for enquiries is, alas, very much a hidden profit unless a spectacular result occurs such as providing details of work or experiments previously done duplicating intended projects (as quoted).

Whatever system is used, the more cross references there are filed in, the more expensive it is and often, also the more costly, complicated and liable to error.

I have been operating a large universal decimal classification index and experimenting with a " concept co-ordination " or " Peek-a-boo " system.

The main policy of the latter is to rely on etymology and syntax as indicators. It appears absurd when we have a simple four-letter word to describe an item exactly, that it should have to be translated into a number using an index and then this number later converted to a report number or journal reference.

A glossary of synonyms and homonyms is needed for the " Peek-a-boo " system but this possibility of confusion exists with all systems, being inherent in language, except for special fields of chemical nomenclature.

Minimum mechanization and maximum flexibility lead to immediacy of operation. For usual information work the computeritis from which the U.S.A. is suffering would not pay for itself and, although a tribute to electronic technology that it is so far in advance, until more is known about human memory and language only military urgency appears to justify fully automatic retrieval.

Salwick, Lancs. RUPERT L. TAMS.
Information Officer
for Head of Reactor Fuel Element Laboratories,
United Kingdom Atomic Energy Authority.

U.K. Citizens' Radio Service?

OVER the past few years I have come across quite a number of business people and private individuals who are aware of the advantages which a mobile radio system could bring them in the way of improved efficiency and convenience. In all cases their requirements have been for two to four units with a range of five miles or so, and upon enquiry the cost of the available commercial equipment, together with installation, has proved more than they could afford. The private individuals do not fall within the terms of eligibility for a licence and so are in any case excluded. Even the cost of the licence and equipment for the G.P.O. Public Radiotelephone scheme is much more than many can afford.

It seems to me that there might well be a case for the establishment in the United Kingdom of a Citizens' Radio Service similar to that which has existed for some years in the United States of America and has been recently introduced in Canada. In such a service the technical standard of the equipment is considerably lower than that of the equipment presently available, and this is, of course, reflected in its lower cost. A licence to operate in the Citizens' Service would be issued upon request in the same way as a Broadcast Receiving Licence. In the two countries mentioned above the frequency band allocated is 26.96-27.28Mc/s, although in my view a more useful band here would be 70.2-70.4Mc/s, since transmitter harmonics would fall outside the broadcasting Bands I, II and III.

It would be interesting to hear the views of any potential licensees for a Citizens' Service and from those who might manufacture the necessary equipment.

Sunbury-on-Thames. G. E. STOREY.

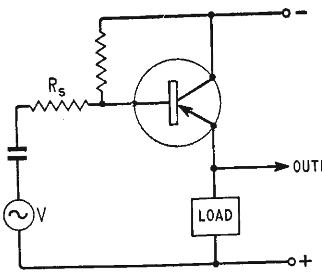
The Indusistor

I WAS interested to read a letter by M. Draganescu in the June issue concerning the " Indusistor "—and inductive transistor.

The transistor used as an emitter follower behaves in some ways like a generator with an inductive impedance when the signal is applied through a series resistance.

In the following circuit, with $R_s = 0$ and the load purely resistive, the frequency response (V′/V versus *f*) is substantially flat up to high video frequencies (even using an OC71 transistor).

When R_s is finite, the response exhibits a typical RC-type (or perhaps I should say LR-type) cut-off, the

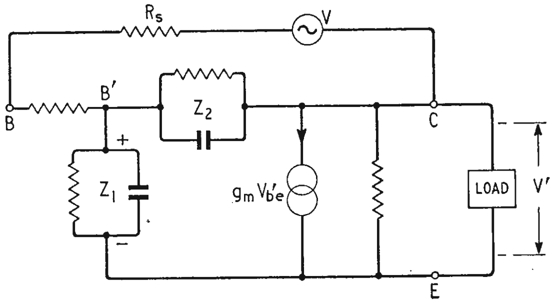


product of R_s and cut-off frequency being roughly constant for any one transistor. This is attributable to an input impedance which falls off with rise in frequency.

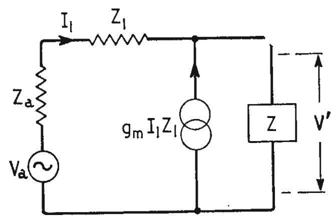
When the load resistance is shunted by a capacitor, the cut-off frequency is naturally reduced, but at the same time the response curve exhibits a rise just below cut-off. The effect occurs whatever the value of R_s, but is most marked when R_s lies between about 300 ohms and 3 kilohms. For example, using an OC45 transistor, a 5 dB rise occurs at a frequency of 1.2Mc/s when $R_s = 1k\Omega$ and the load consists of 1.2kΩ in parallel with 700pF.

As might be expected, the response of the circuit under these conditions to a voltage pulse shows marked ringing the ring being identical on leading and trailing edges providing the input pulse is of sufficiently small amplitude.

This effect is an interesting result of the h.f. equivalent circuit of the transistor. Using the hybrid-π equivalence, the whole circuit is as follows:—



This may be reduced to:—



where $Z_a = Z_2$ in parallel with $(R_s + r_{bb'})$, $V_a = Z_2V/(Z_2 + R_s + r_{bb'})$ and Z = load in parallel with r_{ce}.

Analysis shows that the ratio of (V'/V_a) when Z consists of a pure resistance R to (V′/VA) when Z consists of the resistance R shunted by a capacitor C is:

$$1 + \frac{jt}{1 + \left[\dfrac{kR}{Z_a + Z_1}\right]}$$

where $t = \omega CR$ and $k = (1 + g_m Z_1)$.

Were the term in the square bracket real, the modulus of the whole expression would necessarily be greater than unity, implying that the output voltage would necessarily fall when the load is shunted by a capacitor. (This is exactly what happens in a cathode follower, the corresponding expression for which is $1 + \frac{jt}{1 + [g_m R]}$).

But k, Z_a and Z_1 are all complex, and it may be shown by substituting typical values that the modulus is less than unity in the region of cut-off, implying that the output voltage is increased by shunting the load with a capacitor.

Bedford. G. HOFFMAN DE VISME.

Complementary Multivibrator

WE can confirm the findings of J. C. Rudge in his article on complementary multivibrators in the August issue, and wish to add the following information.

Using an OC42/OC140 transistor pair, a longer space period can be obtained for given values of C and R_T if the latter is returned to the negative line as in Fig. 4 of the article. Such a circuit will be astable if, instead of the TK 71 C, an n-p-n germanium alloy transistor is used, in which $\Delta I_c/\Delta V_b$ is large enough to initiate switching while the base is still negative with respect to the emitter. The OC140 in fact begins to conduct with the base at −100 to −200mV. The "space" time is longer because, during the "space" period, a maximum of 6 volts appears across R_T instead of 12 volts as in Rudge's circuit, so that the condenser charges more slowly. The leakages of the two transistors set a limit to the maximum useful value of R_T; if this is increased beyond about 2MΩ, no further increase of space period is produced.

The circuit can be made monostable if the transistor which initiates the switch-on is held non-conducting by keeping its emitter some 300mV positive with respect to the negative line. This can conveniently be done by connecting a silicon diode in its emitter lead and passing current through it in a forward direction through a resistor connected to the positive line.

The use of germanium transistors instead of silicon makes the cost of the circuit lower, and the reduction of the value of C required may make it more compact.

London, S.E.18. J. T. CAMPBELL, T. HAMMOND, R. J. SIMPSON,
U.K. Atomic Energy Authority, Research Group, Woolwich Outstation.

Rectifier Instruments

THE use of voltmeters and ammeters employing rectifier-operated permanent magnet moving coil elements has become extremely widespread due, largely, to their sensitivity and robust construction and in consequence the serious errors that can occur in their indications under certain conditions are sometimes completely overlooked.

These instruments are calibrated on the assumption that they will be used on a true sine wave supply, their readings being proportional to the mean value of such a sine wave. If the waveform departs appreciably from the true sine form the mean value will be something quite different and errors of up to 50% are possible.

The following example recently came to my notice. The circuit comprised a half-wave silicon rectifier followed by an 8μF smoothing condenser. This was feeding an inductance of approximately 40 henries with an ohmic resistance of approximately 2,500.

The current taken by this circuit when measured by a rectifier instrument was approximately 70mA and when measured on a precision moving iron instrument the reading was approximately 120mA.

It appears from these readings that the nature of the circuit in which the measurements are being made should be seriously borne in mind when taking readings using instruments of the rectifier-operated moving coil type.

Oldham, Lancs. J. BAGGS.

OCTOBER MEETINGS

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

LONDON

3rd. Brit.I.R.E.—"Storm warning and wind finding radar" by G. G. Roberts at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

4th. Television Society.—"New developments in SECAM" by G. B. Townsend at 7.0 at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.

11th. I.E.E.—Presidential inaugural address by C. T. Melling at 5.30 at Savoy Place, W.C.2.

11th. Radar & Electronics Assoc.—"Survey of aerials for radar and allied applications" by Dr. K. Milne at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

11th. Society of Relay Engineers.—"The design of aerials for long-distance television reception at v.h.f." by D. J. Whythe at 2.30 at B.I. Callender's Cables, 21 Bloomsbury Street, W.C.1.

17th. I.E.E.—Electronics Division chairman's inaugural address by J. A. Ratcliffe at 5.30 at Savoy Place, W.C.2.

17th. Brit.I.R.E.—Discussion on "Standard logical elements" at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

22nd. I.E.E.—"The theory and practical value of ternary systems" by Dr. F. G. Heath at 5.30 at Savoy Place, W.C.2.

23rd. I.E.E.—"Radioactivity and process control" by Dr. Denis Taylor, Science and General Division chairman, at 5.30 at Savoy Place, W.C.2.

24th. Brit.I.R.E.—"Plasma physics" by Dr. A. Von Engel at 7.15 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

24th. British Kinematograph Society.—"Pay television systems" by G. E. Partington at 7.30 at the Central Office of Information, Hercules Road, Westminster Bridge Road, S.E.1.

24th-26th. I.E.E.—"Symposium on electronic equipment reliability" at Savoy Place, W.C.2.

29th. I.E.E.—Discussion on "Digital data reduction" opened by Dr. S. Rosenbaum at 6.0 at Savoy Place, W.C.2.

30th. I.E.E.—"Fundamental problems in engineering education" by Professor M. W. Humphrey Davies at 5.30 at Savoy Place, W.C.2.

31st. Brit.I.R.E.—"Noise control" by Professor E. J. Richards at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

BIRMINGHAM

11th. Brit.I.R.E.—"The measurement of traffic noise" by D. W. Robinson at 6.15 at the University Electrical Engineering Dept.

BRISTOL

9th. Television Society.—"Shapes and sounds" by C. Simpson at 7.30 at Royal Hotel, College Green.

10th. Brit.I.R.E.—"Digital servo-mechanisms" by G. B. Kent at 7.0 at the School of Management Studies, Unity Street.

CARDIFF

3rd. Brit.I.R.E.—"Silicon controlled rectifiers," at 6.30 at the Welsh College of Advanced Technology.

CHELTENHAM

23rd. Society of Instrument Technology.—"Ultrasonic flowmeters" by R. E. Fischbacher at 7.30 at Belle Vue Hotel.

EDINBURGH

10th. Brit.I.R.E.—"Videotape—television tape recording" by Aubrey Harris at 7.0 at the Department of Natural Philosophy, The University, Drummond Street.

FARNBOROUGH

25th. Brit.I.R.E.—"V.H.F. communication receivers and transmitters using transistors" by D. C. Carey at 7.0 at Farnborough Technical College.

GLASGOW

11th. Brit.I.R.E.—"Videotape—television tape recording" by Aubrey Harris at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

LEICESTER

24th. Brit.I.R.E.—"Silicon controlled rectifier applications" by J. H. Tuley at 6.45 at The University, University Road.

LIVERPOOL

17th. Brit.I.R.E.—"Stereophony" by Professor Colin Cherry at 7.30 at the Walker Art Gallery.

MIDDLESBROUGH

11th. Society of Instrument Technology.—"Transistors applied to modern instrumentation" by J. E. Fielden at 7.0 at Cleveland Scientific & Technical Institution, Corporation Road.

NEWCASTLE-UPON-TYNE

10th. Brit.I.R.E.—"Long-range v.h.f. air/ground communications" by E. H. Bruce-Clayton and D. B. Clemow at 6.0 at the Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road.

PLYMOUTH

4th. I.E.E.—Address by Dr. D. Dempster, chairman of the South-Western Sub Centre, at 3.0 at the College of Technology.

RUGBY

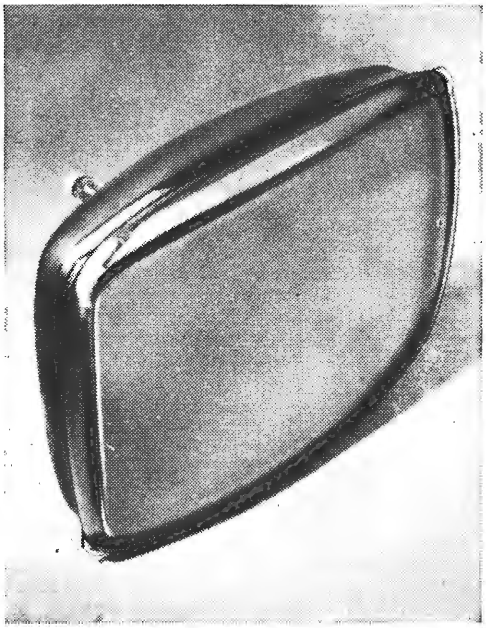
9th I.E.E.—Address by T. P. Qualye, chairman of the Rugby Sub Centre, at 6.30 at the Rugby College of Engineering and Technology.

WOLVERHAMPTON

3rd. Brit.I.R.E.—"High-fidelity loudspeakers—the state of the art" by J. Moir at 7.15 at the College of Technology.

MAZDA

ALL GLASS twin panel tubes



110° 19" and 23" twin panel

SHORT TELEVISION TUBES

CME1906/A47-13W
CME2306/A59-13W

These new tubes differ from previous 19in. and 23in. tubes of the Mazda range in that each has a moulded safety panel of tinted glass bonded directly to the front face of the tube. In neck length and electrical characteristics these tubes are identical to CME1903 and CME2303 respectively, having 110° deflection angle and using magnetic deflection and electrostatic focus.

General details

Twin Panel	Tinted Grey Glass
Rectangular Face	110° Deflection Angle
Aluminised Screen	Silver Activated Phosphor
Electrostatic Focus	Magnetic Deflection
Short Neck	Straight Gun—non ion trap

External Conductive Coating
Heater for use in Series Chain
Heater Current I_h 0.3 A
Heater Voltage V_h 6.3 V

Design Centre Ratings

		CME1906	CME2306	
Maximum Second and Fourth Anode Voltage	$V_{a2,a4(max)}$	17	17	kV
Minimum Second and Fourth Anode Voltage	$V_{a2,a4(min)}$	13	13	kV
Maximum Third Anode Voltage	$V_{a3(max)}$	+1 to −0.5	+1 to −0.5	kV
Maximum First Anode Voltage	$V_{a1(max)}$	550	550	V
Maximum Heater to Cathode Voltage-Heater Negative (d.c.)	$V_{h-k(max)}$	200	200	V

Inter-Electrode Capacitances

Cathode to All*	c_{k-all}	3.5	3.5	pF
Grid to All*	c_{g-all}	8.5	8.5	pF
Final Anode to External Conductive Coating (approx.)	$c_{a2,a4-M}$	1250	2000	pF

*Including AEI B8H Holder VH68/81 (8 pin)

Typical Operation

Grid Modulation (Voltages referred to cathode)

Second and Fourth Anode Voltage	$V_{a2,a4}$	16	16 to 17	kV
First Anode Voltage	V_{a1}	400	400	V
Beam Current		350	350	μA
Third Anode Voltage for Focus (Mean)	$V_{a3(av)}$	200	200	V
Average Peak to Peak Modulating Voltage		35.5	35.5	V
Grid Bias for Cut-off of Raster	V_g	−40 to −77	−40 to −77	V

Maximum Dimensions

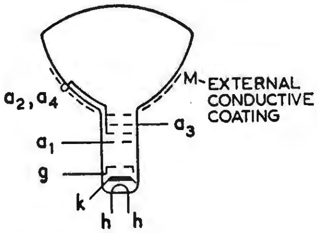
Overall Length	317	374	mm
Face Diagonal	491†	614‡	mm
Face Width	441	544	mm
Face Height	361	443	mm
Neck Diameter	29.4	29.4	mm

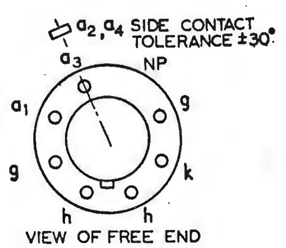
†The maximum dimension over the complete panel is 507 mm
‡The maximum dimension over the complete panel is 631 mm

Tube Weight

Nett (Approx.)	22.5	37.5	lbs.

Side Contact: CT8 (Cavity) **Base:** B8H





MAZDA *VALVE COMMERCIAL DIVISION* 155 Charing Cross Road, London WC2 Telephone GERrard 9797

EDISWAN *EXPORT DIVISION* Thorn House, London, WC2 Telex: London 21521 (Thorn Ldn)

THORN-AEI RADIO VALVES & TUBES LTD

FUNDAMENTALS OF FEEDBACK DESIGN

10.—POSITIVE FEEDBACK AND NEGATIVE RESISTANCE

By G. EDWIN

WE have already seen that the effect of positive feedback, indeed of any feedback, is to modify the terminal impedances and that these are multiplied or divided, by a factor $(1 - \mu\beta)$, according to the method of connection. Positive feedback is commonly used only when extreme values of impedance or admittance are required, and then it is clearly necessary that $(1 - \mu\beta)$ should be a small quantity, though for stability it must be positive. It is not very difficult to see that the overall gain of a system with this sort of feedback will have a frequency response which is very far from flat, since very small changes in μ will produce a very large effect on $\mu/(1 - \mu\beta)$ when $\mu\beta \approx 1$. This is only common sense, for the system is near to oscillation and will show a fairly sharply peaked gain-frequency response. It is often assumed that the impedance characteristic is uniformly low or high, for it is either zero impedance or a virtual open-circuit which we require. A moment's reflection will show that the impedance, too, must have all the defects of any quantity which depends on the small difference of two nearly equal numbers, 1 and $\mu\beta$. This fact is often hidden by the practice of checking impedance at only a single frequency. The easiest way of seeing this is from a diagram, shown as Fig. 56. The vector $\mu\beta$ lies along the axis OAR at the middle of the working frequency range, where the low and high frequency roll-off have no effect or are in balance. The length RA is then $(1 - \mu\beta)$ and is about 0.1. Examination of a typical response shows, however, that the phase angle of μ shifts away from its zero (or 180° according to the way you look at the valve phase reversals) value long before there is any detectable change in μ. The result is that the vector OP is typical of the conditions over most of the band, while OA represents only a limited region near the middle. It will make the mathematics especially easy to take $|\mu\beta| = 1$, and we then see that $|1-\mu\beta| = |\mu\beta|$ as soon as we have 45° phase shift. The angle will not be much different if $\mu\beta = 0.9$, as we can see from the figure.

The figure also shows how rapidly the amplitude

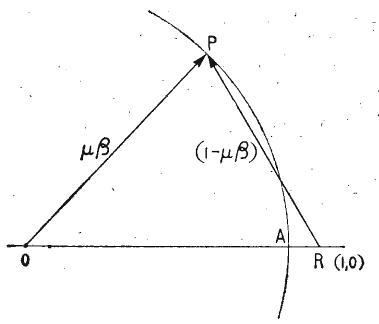


Fig. 56. Simple Nyquist diagram for working region of system based on positive feedback.

response will change with only small changes in phase. Systems which depend on positive feedback for their characteristics must therefore be designed to have a Nyquist diagram of the form shown in Fig. 57 for their important region. This can be seen to demand a gentle rise of the amplitude characteristic away from the band centre, and a phase angle which does not exceed a few degrees over the whole of the working band. This latter requirement leads to rather careful design of the response shape outside the working band. It will be found that a circuit peaking sharply upwards outside the band must be used to compensate for the phase shift in the band: typical circuits are those shown with $k = 2$ and $k = \sqrt{2}$ in the charts in Bode (*Network Analysis and Feedback Design*, p. 445 *et seq*, Macmillan). A

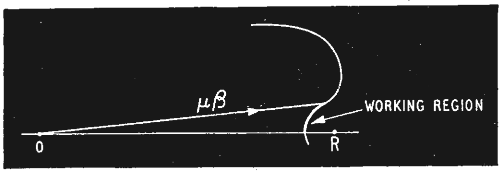


Fig. 57. Desirable Nyquist diagram for working region of system based on positive feedback.

circuit with a k of about 1.5 will compensate a normal roll-off ($k = 0$) up to about 0.25 times the cut-off frequency, according to chart 1. This is quoted as an indication of the ratio of useful bandwidth to the bandwidth of the amplifier alone.

In a way this is not a surprising result. When negative feedback is used we get, roughly speaking, an extra octave of flat gain for every 10dB of feedback: we are talking here of a $(1-\mu\beta)$ of around 0.1 so that we should not be surprised to find that we have lost a couple of octaves at each end of the band. It always hurts, however, when we are told that we cannot get something for nothing.

It is of considerable interest to consider what happens when we make $\mu\beta$ greater than unity. The resulting systems have found wide application and the theory has, indeed, surprisingly wide application. Usually we are concerned with the terminal impedances and because we wish to handle power we can consider only the output terminals. We know that the impedance will be either $R(1-\mu\beta)$ or $R/(1-\mu\beta)$. We can therefore plot the shape of this as $\mu\beta$ is increased from zero (no feedback) up to a value of two, selected arbitrarily. The result is shown in Fig. 58, where it will be seen that $R(1-\mu\beta)$ falls steadily until it reaches zero at $\mu\beta=1$ and then goes on decreasing to $-R$ at $\mu\beta=2$, and so on. The other form, $R/(1-\mu\beta)$, rises as we know, and becomes infinite at $\mu\beta=1$. For $\mu\beta$ just greater than unity we find a very large negative value which falls along a rectangular hyperbola to reach $-R$ at $\mu\beta=2$, and then proceeds towards the asymptotic value of -0.

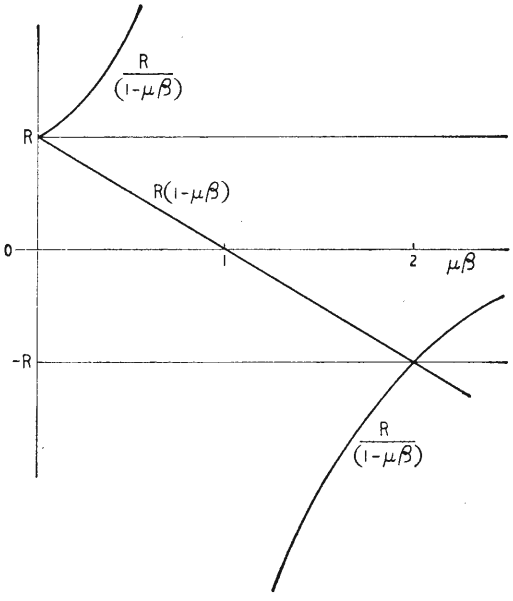


Fig. 58. Plot of two forms of amplifier terminal impedance as $\mu\beta$ is increased from zero (no feedback).

For everyday purposes we can say that at the terminals of a device of this kind with $\mu\beta > 1$ we have a negative resistance and that it will behave just as though the terminals were connected internally by something having $V/I = -R$. As a behaviour description this, although limited, is perfectly adequate. We can connect a signal V_0 in series with this device and a resistance R_0 and we shall get a current $V_0/(R_0 - R)$. On this basis we would expect the current to be in phase with the voltage if $R_0 > R$. We could, however, use a Norton Generator, and if the current fed in is I_0 we should observe a voltage of $I_0 (R_0^{-1} - R^{-1})$. The voltage would be in phase with the current if $R_0 < R$. Now when the current and voltage are in phase the generator is supplying power, but if they are in antiphase it is absorbing it, so that the negative resistance must be supplying it. The system must be oscillating.

This apparent contradiction is simply the result of simplifying the analysis and lumping together two different devices. These are normally called the short-circuit stable and open-circuit stable negative resistances. It is easy to see that the short-circuit stable one is the one which gives us stability when $1/R_0 > 1/R$ (or $R_0 < R$), while the open-circuit stable one is stable with $R_0 > R$.

In the derivation of the impedance we noted that the exact form depended on the load impedance, because μ itself depends on the load impedance. The contradiction arises because we have not taken this into account. The simplest way of seeing what happens is to consider first the effect of a short circuit. With the output short-circuited the load voltage must be zero and the load current a maximum: this current can be assumed to be produced by noise at the input. When we use voltage feedback, there is no voltage to be fed back, or, if you like, there is a short circuit across the input to the β path. Such a system cannot be unstable. Similarly, if the output of a system with current feedback is open-circuited, there just will not be any current and therefore no feedback, no instability. Most practical circuits can be examined in this light to reveal unambiguously whether they are short-circuit or open-circuit stable.

Another very useful approach is based on the rather obvious fact that the physical devices, the valves or transistors, can only give a limited output. Try to get more and at one end of the range the current would need to reverse, and at the other end the voltage. When this happens the device does not give any gain. Consider a system for which we know that the gain has a characteristic of the form shown in Fig. 59a. A valve with a g_m which does not change much with current will give this: feedback in the cathode will ensure it. At low currents the gain falls as we reach the tail. At high currents we see the effect of grid current lowering the input impedance.

Fig. 59b is a plot of V against I at the terminals of a system with positive feedback. A line of constant slope represents a resistance and even if it does not pass through the origin the slope is still equal to the resistance, for then $V = V_0 + RI$ and $dV/dI = R$. We can draw a line of slope $-R$ for the region of high constant μ. When μ starts to fall, what happens to this line? We see from Fig. 58 that if we are dealing with $R(1 - \mu\beta)$ we have zero resistance, while if we are dealing with $R/(1 - \mu\beta)$ we have infinite resistance. When μ is lower than this value of $1/\beta$ the resistance is positive. We can thus extend the $-R$ section to form either an N-shaped curve or an S-shaped curve, both of which appear on Fig. 59b. This very simple analysis leads to the expectation that we should always finish up with a form like Fig. 60, in which the characteristics approach the simple line $R = V/I$ when μ becomes zero. This does

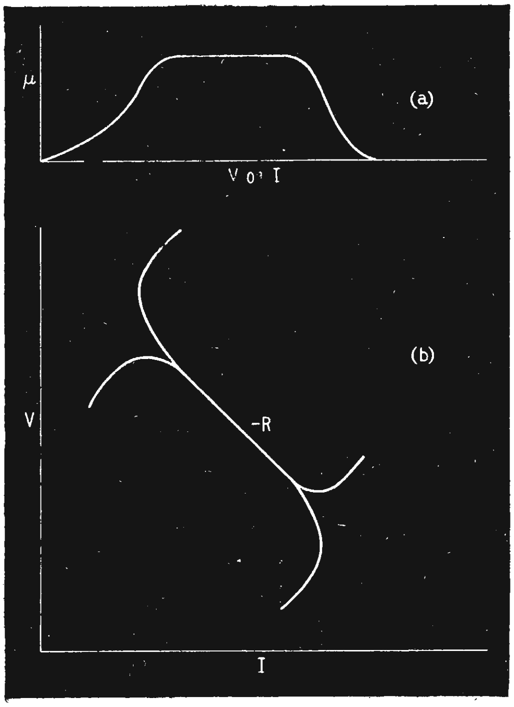


Fig. 59. (a) Typical practical gain characteristic. (b) Plot of V against I (around normal operating levels) at the terminals of a system with positive feedback.

not happen in practice because some other mechanism comes into play: the basic N or S-characteristic is, however, always there.

The network theory approach is related to the idea of inside and outside the loop which the impedance must describe in the complex plane. If we plot the actual impedance of the system viewed from its terminals we shall have the shape shown in Fig. 61. At zero and infinite frequencies there is no gain, so the loop will be closed at the origin. Now if we connect a resistance R_0 across the terminals and we think for a moment of the frequency ω_1, the loop resistance will be $R_0 - R$ and this is the distance between the point on the axis at ω_1 and a point at $-R_0$. This point $(-R_0, 0)$ is the key to stability. If the curve encircles it, the system is unstable. What, as the lunatic said to the monkey at the zoo, is inside and what is outside? As all witches know, if you go round widdershins you are not encircling the inside at all, you are encircling the outside. If the progression ω_2, ω_1, ω_3 corresponds to an increasing frequency the inside is just what you would expect: if, however, the frequency increases from ω_3 to ω_1 to ω_2, all the area containing the symbols is inside and the finite heart-shaped area is outside. In the first case the system is open-circuit stable, in the second short-circuit stable.

These two ways of treating negative resistance reflect the ways in which it can be applied. The plot of impedance in the complex plane assumes that there is only a small signal present so that the system is a linear one. Our concern is with stability, usually with a circuit connected externally which is by no means a pure resistance. No longer are we concerned with $-R$ and R_0 but with the impedance $-Z$ and an external impedance Z_0,

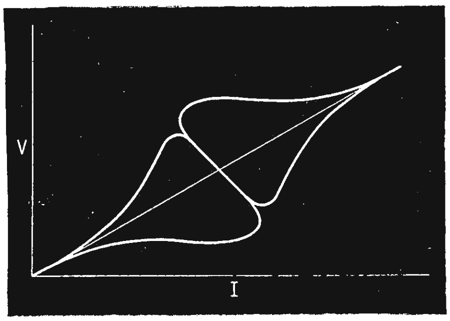


Fig. 60. Simple theoretical full plot of V against I at the terminals of a system with positive feedback.

both of which depend on frequency. We find this when we start to apply negative resistance for ordinary amplification purposes in telephone circuits.

The voltage-current diagram is used chiefly when we are interested in steady-state conditions. Here we take our N or S-diagram and apply the external resistance to it as a load line. If this load line passes through the middle of the $-R$ section, a matter of biasing, it may intersect the system characteristic at either one or three points. A comparison of slopes with the rules already laid down will show that when there is only one extersection point it is stable. It must be, of course: one is reminded that Boswell told Johnson that someone "accepted the Universe". "By God, Sir, he had better." With three intersection points,

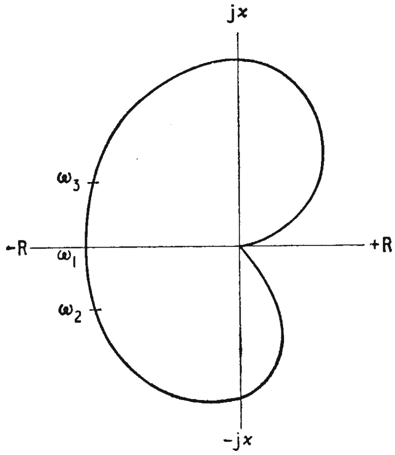


Fig. 61. Plot against frequency of terminal impedance of system with positive feedback.

however, we find that the centre one is unstable and that the circuit will only remain stable at either of the two outside points. This is the principle of operation of the whole family of multivibrators and trigger circuits, and is also the way in which that extremely simple device, the tunnel diode, operates.

We do not escape the frequency dependent part of the negative impedance system, however, even in this simple approach. The operation of the device depends on the fact that for one reason or another it will transfer from the stable position at one end to the stable position at the other. The speed at which it does this and the path it follows are determined by the reactances in the system, and those are just the factors which are described by the impedance plot in the complex plane.

MOBILE RADIO

THE demand for land mobile radio licences in the U.K., which are issued by the Post Office permitting the establishment of a radiotelephone link between a fixed station and mobile stations, has increased some six-fold during the past 9 years. As will be seen from the following table, the number of licensees has risen from 583 in 1952 to 2,349 at the end of last year, but the number of stations from about 4,000 to nearly 26,000. These figures include all industrial and professional users, taxis and public services (excluding Police and Fire).

There has been a gradual reduction in the channel spacing in both the low-band (71.5-88Mc/s) and the high band (165-173.05Mc/s) and by January this year all 100-kc/s equipment in use had to be replaced by 25-kc/s transmitter-receivers. January 1966 is the time limit set for the replacement of all 50-kc/s equipment by sets employing 25kc/s separation. The annual licence fee is £3 for each of the first two stations (base and mobile) and £2 for each additional station, but for a temporary mobile radio service of not more than 28 days the licence fee is only £1.

		Stations			
	Licensees	Base	Mobile	Hand portable	Trans-portable
1952	583	538	3,281	152	43
1956	1,202	1,389	10,638	493	126
1961	2,349	2,894	21,853	866	195

Balloon-Supported Aerials

FOR USE AT V.L.F.

By R. N. GOULD,* M.Sc., Ph.D., W. R. CARTER,* B.Sc., and A. T. RAWLES*

CONVENTIONAL v.l.f. aerial installations are large, costly and relatively inefficient. These characteristics are inherent in the fact that at v.l.f. the aerial current path is only a small fraction of a wavelength.

A method of overcoming the associated problems is suggested by using balloon-supported aerials. These would be cheap, simple and efficient and would be capable of a variety of uses, in spite of limitations imposed by adverse weather conditions.

Long-distance Communication:—Radio communication over distances of several thousands of miles is usually achieved either by the use of frequencies in the h.f. band or by frequencies in the v.l.f. band, between about 10–30 kc/s.

H.f. propagation is closely dependent on ionospheric conditions and frequent changes in operating frequency are necessary throughout the day, even for fixed-range working. The v.l.f. band is particularly well suited to long-range propagation, since not only is the attenuation rate low at long ranges, but changes in operating frequency are not required. This is because the very long wavelengths involved are too large, in general, to be affected by ionospheric disturbances. Furthermore, the unique phase stability observed at great distances enables various o'her uses to be made of v.l.f. transmissions. (Ref. 1.)

The Design of Transmitting Aerials at V.L.F.:—It is not particularly difficult to design transmitting aerials of reasonable size and acceptable efficiency for use in the h.f. band, because the current path in the aerial can be made comparable with the wavelength involved. The state of affairs at v.l.f., however, is quite different, and aerial design presents difficulties in many ways; the fundamental problem is that of designing an efficient aerial under conditions in which the current path is a minute fraction of a wavelength.

Conventional v.l.f. aerials are inevitably very large, inefficient and costly structures. The radiation resistance is extremely low, because the current path is short compared with the wavelength. Therefore, the current in the aerial must be very high if appreciable power is to be radiated. A relatively high impedance is presented to the transmitter, and consequently very large voltages are needed in order to drive appreciable current into the aerial. The Q of the aerial must be made as high as possible in order to obtain acceptable efficiencies with the low radiation resistance available. At v.l.f. this imposes undesirable bandwidth limitations on the type of intelligence which can be transmitted. Phase instability can also occur in large, sharply tuned aerials of this kind, due to the effects of high winds and the approach of large cloud masses. These effects have been observed by the G.P.O. on the transmissions from Rugby (GBR).

Since the physical height of a conventional v.l.f. aerial can never be more than a very small fraction of a wavelength, it is usual to add a large horizontal " roof " to the system in order to provide essential additional capacity. The purpose of this capacitive top (while, of course, adding to the size and complexity of the installation) is to reduce the aerial impedance to a level at which worthwhile currents can be obtained with realizable voltages. An additional advantage of a high aerial capacity is that the effective height of the aerial, on which the radiation resistance depends, is brought closer to the actual physical height.

Typical of the size of a v.l.f. installation is that at Rugby (GBR). The aerial extends over about 900 acres and is supported on 12 masts 820 feet in

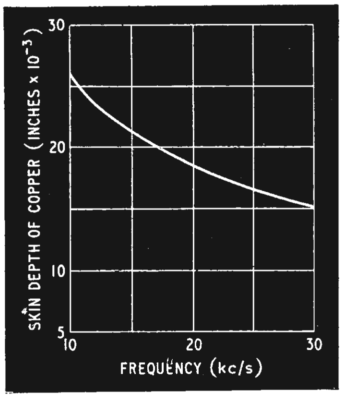


Fig. 1. Variation of effective skin depth with frequency in copper.

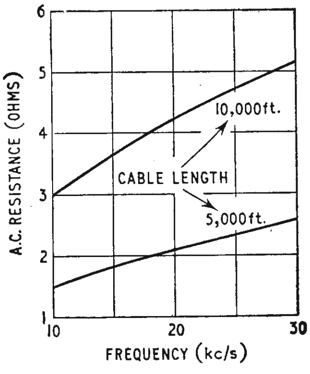


Fig. 2. Variation of a.c. resistance of prototype cable with frequency.

* Royal Naval Scientific Service.

height. Even with a structure of this size, the radiation resistance is less than one tenth of one ohm and the efficiency is about 13½% at the operating frequency of 16 kc/s.

New Approach to the Problem:—There appear to be at least two types of approach to the solution of the problems created by the use of short generating current path lengths. These are:—

(a) By increasing the electrical length of the aerial artificially, without increasing the physical length (height). This would be expected to lower the aerial impedance, but limitations on the radiation resistance would still remain. For example, the aerial could be enclosed in a substantial casing of ferrite material, and although a significant reduction in aerial input impedance should occur, the loss resistance would inevitably rise without corresponding increase in the radiation resistance.

(b) By actual increase in the physical length of the current path. A possible method of achieving this is at present under investigation. Briefly, the idea is to feed r.f. current across the neck of a peninsula of land of appropriate size, in an attempt to persuade the current to follow a preferred sea-water path several miles in length along both sides of the peninsula. So far the results of this investigation have been inconclusive, but further experiments are planned in the near future.

A more obvious method is to increase aerial heights by exciting even higher structures than those at Rugby, for example. Unfortunately, no significant increase in the height of aerial structures can be achieved along conventional lines without prohibitive cost arising from the enormous engineering difficulties. There is a novel approach to this same problem, however, which has recently been studied seriously. The proposal is to consider the use of aerials supported by balloons flying at heights of the order of 5,000–10,000 feet. Such aerials would be simple, economical, undoubtedly effective, and would be capable of a flexibility in use which is quite unobtainable with conventional installations.

The obvious drawback to this system, namely the sensitivity of the balloons to weather conditions, can be overcome to a large extent in certain important applications.

Theory of the Balloon-supported Aerial.

The Cable:—It is clear that the a.c. resistance (R_{ac}) of the balloon cable should be as low as possible. A typical steel cable in use has an external diameter of about 0.3 inch and is made up of six adjacent windings each consisting of seven wires about 0.03 inch in diameter. Such a cable haa a breaking strain of about 4¼ tons. An estimate has been made of the a.c. resistance (Ref. 2) by assuming a permeability value of 100. In this case R_{ac} is about 17 ohms per 1,000 feet at 20 kc/s.

This figure could be improved upon by using copper and not steel as the conductor. Since most of the current flowing in the copper would be confined within the skin depth of the conductor, it is convenient to envisage a cable consisting of a steel inner core (for strength) surrounded by a copper sheath which is thicker than the skin depth. The variation of skin depth in copper against frequency is shown in Fig. 1.

A specification for such a multiple cable has, in fact, been drawn up by Standard Telephones &

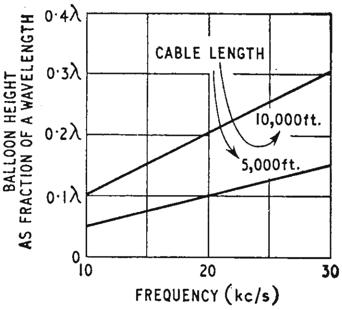


Fig. 3. Relationship of balloon height to wavelength at different frequencies.

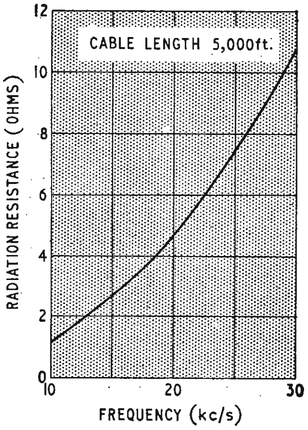


Fig. 4. Calculated radiation resistance.

Cables Ltd. It consists of a core of six layers of steel wire, the diameter of which is 0.242 inch. Surrounding the core is a seventh layer of copper which increases the core diameter to 0.334 inch. The eighth and ninth layers are of Melinex tape and high-density polythene respectively. The breaking strain would be about 3½ tons. Throughout this article, the cable just described will be called the "prototype cable." Its a.c. resistance at 20 kc/s is expected to be about 0.4 ohm per 1,000 feet. The variation of R_{ac} with frequency is shown in Fig. 2 for cable lengths (i.e. aerial heights) of 5,000 feet and 10,000 feet.

Normally a balloon is raised or lowered by means of a winch attached to a truck. The use of the balloon cable as a radiator of electromagnetic energy requires that the truck should be isolated from the ground. It would be preferable also to isolate the winch from the truck.

Radiation Resistance:—Fig. 3 shows the variation of balloon height in wavelengths with frequency in the v.l.f. band, for cable lengths of 5,000 feet and 10,000 feet. This figure is included to illustrate the possibility of a λ/4 aerial if balloon heights of the order of 10,000 feet are used. Attention will be confined here, however, to a cable 5,000 feet in length. The current distribution in this cable will not be uniform along its length. However, an approximation to uniformity can be made in terms of the current at the base of the aerial if an effective height equal to 0.54 of the physical height is used when calculating the radiation resistance. This parameter is plotted in Fig. 4 for a cable height of 5,000 feet.

Ohmic Losses in the Cable:—In the type of radiator under discussion, it would be incorrect to compute the ohmic losses in the cable as the product of the square of the current multiplied by the a.c. resistance. The mean value of the square of the non-uniformly distributed current taken over the cable length can be shown to be equal to one third of the square of the base current. Hence in terms of the base current, the ohmic losses have been computed by assuming a value of R_{ac} equal to one-third of the value for uniform current distribution.

Ohmic Losses in the Aerial Loading Inductance:—For the purpose of estimating these losses it is assumed that the loading coil has a Q of about 400. Since the capacity of a balloon-supported aerial 5,000 feet in height is of the order of 0.009 microfarads, the loss resistance in the loading coil will be less than 5 ohms over the band.

Ground Losses:—Special measures are normally taken at v.l.f. to minimize ground losses, by laying down very large earth mats. The following analysis is based on the treatment given by Brown, Lewis and Epstein (Ref. 3). It is there shown that the power loss dP in a ring of earth of width dx encircling the aerial at a radius x is given by:

$$dP = \frac{I^2\, dx}{2\pi\, S\gamma x} \quad \ldots \quad (1)$$

where I = the current at the base of the aerial
S = the skin depth in the earth
γ = the conductivity of the earth

If this equation is integrated between upper and lower limits of x_u and x_l we have:—

Total power loss in a ring of internal and external radii x_l and x_u respectively is

$$P_T = K.I^2 \log_e \frac{x_u}{x_l} \quad \ldots \quad (2)$$

where K is a constant for any given frequency.

$$\text{Now } I^2 = \frac{\text{Power radiated}}{\text{Radiation resistance}} = \frac{P_R}{R_r} \text{ say}$$

$$\text{Then equation (2) becomes } P_T = \frac{KP_R}{R_r} \cdot \log_e \frac{x_u}{x_l} \quad (3)$$

The power loss in the ground of the balloon-supported aerial can now be compared with that of a conventional v.l.f. aerial installation such as Rugby (GBR). The earth-mat system at Rugby is complex in form, but a very rough approximation to its effect can be obtained by assuming that x_l for Rugby = 700 metres. Then for the same aerial efficiency, as far as the ground losses are concerned:—

$$\frac{1}{R_r^B} \log_e \frac{x_u}{x_l^B} = \frac{1}{R_r^R} \log_e \frac{x_u}{700} \quad \ldots \quad (4)$$

where the superscripts B and R refer to the balloon aerial or to the Rugby aerial respectively.

Rearranging equation (4):—

$$\frac{x_l^B}{x_u} = \left(\frac{700}{x_u}\right) R_r^B / R_r^R \quad \ldots \quad (5)$$

In computing the ground losses x_u must be chosen sufficiently large to include all the losses occurring in the ground in the immediate neighbourhood of the aerial. Losses occurring in the ground beyond this range gradually become propagation losses. The choice of x_u is to some extent arbitrary; a value

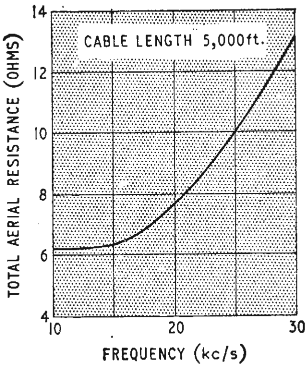


Fig. 5. Variation of total aerial resistance with frequency.

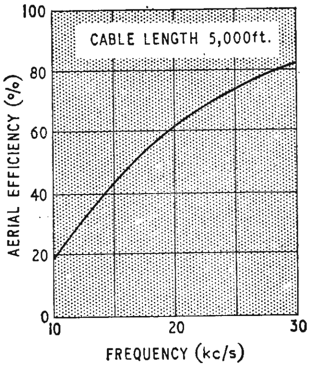


Fig. 6. Estimated efficiency using the prototype cable.

of 0.3λ or 0.4λ was taken for the cases considered in Ref. 3. In any case, a realistic value of x_u will not be less than 2 or 3 km. Remembering that the ratio of the two radiation resistances in equation (5) is of the order of at least 30 : 1, substitution of the above value for x_u yields a vanishingly small value of x_l^B. It can firmly be concluded that in the case of a balloon-supported aerial the ground losses are so minute that an earth mat is quite unnecessary. Provided that a good earth connection is made the ground losses have virtually no influence on the efficiency achieved.

Aerial Efficiency:—It is now reasonable to assume that practically all the loss resistance occurs in the cable itself and in the loading inductance. These two components of resistance, together with the radiation resistance are plotted as the total aerial resistance against frequency in Fig. 5. Since the aerial efficiency is the ratio of radiation resistance to total resistance, an estimate of the variation in efficiency can be made. This is shown in Fig. 6 for the prototype cable of length 5,000 feet, over the frequency band 10-30 kc/s.

Effective Aerial Impedance:—An aerial height of 5,000 feet represents an electrical length of from 0.05λ to 0.15λ at v.l.f., and, therefore, the aerial reactance is essentially capacitive. The balloon-supported cable has a capacity of about 0.009 microfarads, which is the value assumed in computing the effective aerial impedance, the variation of which is shown in Fig. 7.

Q-factor of Balloon Aerial:—This is shown in Fig. 8, assuming a balloon height of 5,000 feet

(Continued on page 505)

and the use of the prototype cable. At 16 kc/s the Q is about 14% less than that of Rugby. This comparison ignores, of course, the difference in efficiency between the two aerials. For the same aerial efficiency at 16 kc/s the balloon aerial would have a Q value of about 25% that of the Rugby aerial. For certain applications, for example in automatic telegraphy, where a wider bandwidth may be required, the same efficiency can be achieved with a deliberately damped balloon aerial having four times the bandwidth of the conventional system. It is worth noting that the Q-factor decreases with height, and is likely to be as low as 40 if a cable 10,000 feet in length is used. The effect of a broader characteristic response would be advantageous in improving phase stability and permitting the use of high data rates.

Preliminary Experimental Measurements

The Transmitter:—This was a 50-watt audio amplifier fed from a signal generator at the Rugby stand-by frequency of 19.6 kc/s. The transmitting site was at Cardington where high-flying balloons were made available, by the courtesy of Royal Aircraft Establishment, Farnborough, and the Commanding Officer, R.A.F., Cardington. The truck containing the cable drum and winch was isolated from earth by driving it on to an insulated base.

The Cable:—This consisted of the conventional steel tethering cable described earlier, together with a copper cable to improve the electrical conductivity. The auxiliary copper cable consisted of 7-stranded 23 s.w.g. wire suspended from the balloon in parallel with the strain cable. These two conductors were bonded mechanically and electrically at frequent intervals of length. By this expedient it is estimated that the a.c. resistance was reduced to about 10 or 11 ohms.

Parameters of the Experimental Aerial:—In this experiment 4,800 feet of cable were paid out from the winch and the capacitance to ground of this system was measured as the balloon ascended. The results obtained are plotted in Fig. 9. The Q of the loading coil was 100 at 19.6 kc/s and contributed between 9 and 10 ohms to the overall resistance. The radiation resistance was 3.2 ohms based on a mean flying height for the balloon of 4,200 feet. The current at the base of the aerial was 0.78 ampere giving rise to a radiated power of nearly 2 watts. The aerial efficiency was about 20% with a Q-factor of about 60.

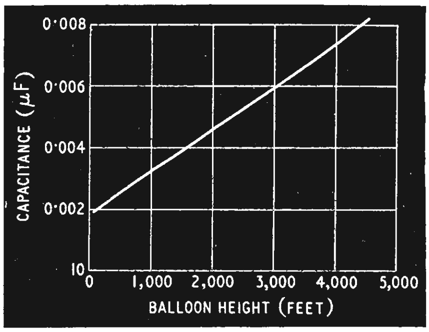


Fig. 9. Measured capacitance at various heights.

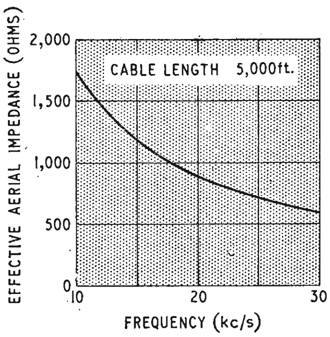


Fig. 7. Computed effective aerial impedance.

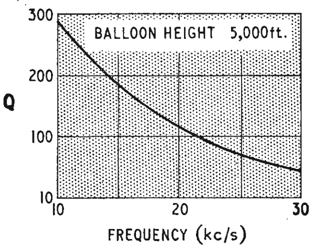


Fig. 8. Q-factor of balloon aerial.

Reception Trials:—The transmitted signal was coded to aid identification and was heard at various sites remote from the transmitter.

Its amplitude was measured at a site near Portsmouth, which is about 150 kilometres from Cardington. Assuming inverse distance propagation and the estimated aerial characteristics stated above, a field intensity of about 90 microvolts per metre would be expected. The actual measured value was just over 80 microvolts per metre, which shows a good agreement with theory. In particular it seems to be confirmed that the ground losses in the balloon-supported system are indeed negligible, as computed theoretically.

Direct Comparison With Rugby (GBR)

It is useful at this stage to draw up a comparison table between Rugby (GBR) and the proposed balloon-supported aerial with the prototype cable. In addition, the final column in the Table predicts the performance for a frequency of about 20 kc/s.

TABLE

	Rugby (GBR) 16 kc/s	Balloon 16 kc/s	Aerial 20 kc/s
Radiated Power (kW) ...	40	40	40
Capacitance (μF) ...	0.08	0.009	0.009
Radiation resistance (ohms)	0.085	3.0	4.8
Effective aerial impedance (ohms)	125	1,125	900
Q-factor	200	170	115
Efficiency (%)	13½	46	62
Aerial current (amps) ...	700	115	90
Voltage between aerial and earth	87,500	129,400	81,000
Transmitter power (kW)	300	87	65

This frequency is chosen because it represents the optimum for long-distance propagation at v.l.f.

Balloon Arrays

Although these aerial currents could, no doubt, be supported by the proposed balloon cable without overheating occurring, applications requiring large radiated powers would best be tackled using balloon arrays.

Parasitic Elements:—One possible use of the proposed balloon aerial is as a parasitic element in support of conventional transmitting aerials or driven balloon aerials. Parasitic elements would be placed in the immediate vicinity of the transmitting aerial to achieve the required directivity. By using sets of such elements various chosen directions could be catered for. In the case of a conventional transmitting aerial there is also the distinct possibility of increasing the overall efficiency. In this way a reliable continuous service would be provided by the conventional system which could be supplemented by the more efficient service using the parasitic elements when appropriate.

Driven Elements:—Large powers are normally radiated by v.l.f. from a localized position because of the expense of erecting suitable arrays. Thus an expensive aerial is required even to achieve extremely low efficiencies. For example, at a cost of about £4,000 it is possible at 16 kc/s only to achieve an aerial efficiency of about a half of one per cent with an upper limit to the radiated power of about 50 watts. Moreover, the provision of the capacitive top, essential with the short generating current path involved, is an extremely expensive undertaking if any significant current is required to be achieved. However, the balloon aerial offers a method which is easy to use without prohibitive cost. Phase feeding of the various elements would enable the beam to be swung at will; a novel departure in v.l.f. transmitting aerials.

For very large radiated power requirements and other more specific uses, the balloon array would be spread over considerable stretches of ground: for example, over the length of the British Isles. This method would have the additional advantage of providing some independence of weather conditions, in that some of the balloons would normally be able to operate even if others were grounded. Grounding of half the balloons in this way would still enable a substantial service to be given. The greater the area over which the balloon array was spread the greater the protection against weather; also more efficient use of directional properties could be made.

Conclusions:—While it is accepted that the use of balloons is dependent to some extent on weather conditions, their negligible cost relative to a conventional alternative, together with their flexibility and superior efficiency recommend their use in many applications.

Preliminary experimental results are available which have supported the predictions of expected performance and further trials are planned for the near future using a specially designed cable.

Acknowledgement: This paper is published by permission of the Admiralty.

REFERENCES

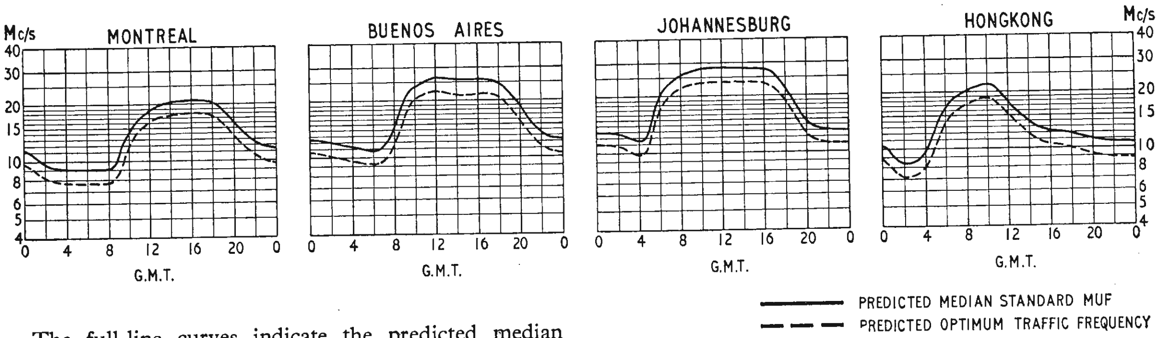
[1] "Very Low Frequency Electromagnetic Waves," by R. N. Gould and W. R. Carter *Wireless World*, Vol. 68, No. 4, April 1962 (pp. 186-190).

[2] "Radio Engineers' Handbook," by F. E. Terman (McGraw-Hill).

[3] "Ground Systems as a Factor in Antenna Efficiency," by G. H. Brown, R. F. Lewis and J. Epstein, *Proc. I.R.E.*, Vol. 25, No. 6, June 1937 (pp. 753-787).

SHORT-WAVE CONDITIONS

Prediction for October



The full-line curves indicate the predicted median standard maximum usable frequencies for the month of October.

The dashed-line curves show the optimum frequencies which are intended to allow for day-to-day variations from the monthly median.

These curves have been prepared by Cable & Wireless Ltd. from information supplied by the Radio Research Station, Slough.

Excitations and Responses

—continued again (and concluded)

By "CATHODE RAY"

THE six preceding instalments have constituted a sort of conversion course from elementary conventional circuit-response theory—impedance and all that—to a more generalized approach, in which transients enjoy equal status with steady-state responses, and circuits are put on the same footing as signal sources. Judging from British books at least, this view of things is still fairly novel, which is why I have used so much space explaining the principles. Instead of trying to recapitulate them yet again, I am venturing to take them as read, so that we can tackle some actual examples without stopping to develop the theory at every stage. These examples will still be of the simple kind we have already discussed, but they should be enough to bring out the method, which I will explain fully step by step.

There is just one point of mathematical procedure I would like to repeat before the start, for the benefit of any who are not yet used to working in exponentials. The "imaginary" exponential $e^{j\theta}$ represents a vector 1 unit long (Fig. 1) inclined at the anti-clockwise angle θ relative to the conventional zero ("3 o'clock"). If θ varies directly with time, as for example when it is ωt, the vector rotates steadily anti-clockwise. Fig. 1 shows that the familiar V cos ωt for a sinusoidal voltage of peak value V and frequency $\omega/2\pi$ can be replaced by the real part of $Ve^{j\omega t}$ (and V sin ωt by the imaginary part of $Ve^{j\omega t}$). For intermediate mathematical steps it is allowable to work directly in $e^{j\omega t}$, but we mustn't

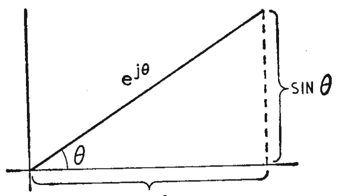


Fig. 1. A reminder of what $e^{j\theta}$ means.

forget that voltage and current are real quantities, not vectors, proportional to the *real part* of any vector quantities that may be used to represent them in diagrams or exponential mathematics. Although this complication may seem to be a point against exponentials as compared with the seemingly simpler and more straightforward cos ωt, we find that in this sort of work the latter is far from simple, and moreover is confined to sinusoidal variation whereas the exponential covers other important forms such as transients. The point I am working towards is that when using exponentials a phase shift is taken into account by adding the appropriate angle (positive or negative) under cover of j in the index; e.g., if the voltage in an inductive circuit is $\mathrm{Re}[Ve^{j\omega t}]$, the corresponding current is $\mathrm{Re}[Ie^{j(\omega t-\phi)}]$ where ϕ is the angle of lag. (In these expressions "Re" means "real part.") The actual values of the phase angles are provided by our pole-zero diagram. Finally, although ϕ is mathematically in radians, for numerical purposes where tables have to be looked up it is more convenient to work in degrees, which is what I am going to do without any further indication of that fact.

Example 1 is the RL circuit, Fig. 2. Let us pretend that it is not already excessively familiar—

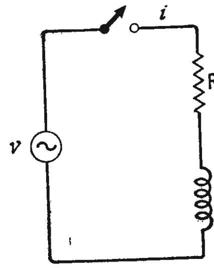


Fig. 2. Our time-honoured circuit, a numerical example of which is now to be approached afresh.

that we are, in fact, approaching it for the first time. So we have to find the locations of the poles and zeros. To do this, we write down the equation relating response to excitation. A less elementary circuit might well demand considerable prior manipulation of the Kirchhoff-law equations to do this, but here we have just a case of generalized Ohm's law:

$$i_s = \frac{v}{R + s_s L} \quad .. \quad .. \quad .. \quad (1)$$

This has the same form as "Ohm's law for a.c." and, like it, short-circuits differential equations; but note that in keeping with our more general scope we have (1) instantaneous values, indicated by the small letters i and v, (2) a subscript s to distinguish the forced response due to the source from the free one (i_c) of the circuit, and (3) s_s to denote the complex frequency of the source, instead of the $j\omega$ limited to sinusoidal excitation. (It will often turn out to be $j\omega$.) With these modifications the procedure with any circuit is the same as in conventional a.c.

Next, we rearrange (1) to get the source frequency s_s on its own:

$$i_s = \frac{v}{L(s_s + R/L)} = \frac{v}{L(s_s - s_c)} \quad .. \quad .. \quad (2)$$

Now we can look for the poles and zeros. There is no non-infinite value of s_s that makes i_s zero, so there is no zero to mark on the diagram. But there is one value that makes it infinite: $-R/L$. This is therefore the one pole, representing the circuit's own complex natural frequency, s_c. For brevity, and to bring out the "dimensions," we have been putting such natural frequencies in terms of time constants: $-1/T$, in this case. So the pole is on the negative real axis and we can draw the pole-zero diagram for the circuit. Given the actual values of R and L—or no more than their ratio—we could mark it on a numerical scale. Let us suppose these values are 2H and 400Ω. Then T is 2/400 = 0.005 sec., and 1/T is 200. So Fig. 3 specifies the circuit in detail.

This diagram could deal with any form of v that can be expressed exponentially, but to provide ourselves with an answer that can be checked by other means let us suppose it is a sinusoidal 30 volts (r.m.s.), 50 c/s. Then $V = 30\sqrt{2} = 42.5$, and $s_s = j\omega = 100\pi$. We therefore complete the diagram to show the source, Fig. 4. Note that I have now used a cross for s_s as well as for s_c, to emphasize that they can be treated as of the same kind.

Now we put into operation the rules for finding the forced and free responses; rules derived, as we have seen in previous issues, from the circuit function, eqn. (2) in our case. But v should be in exponential form, if we are to indicate the phase shift as explained:

$$i_s = \mathrm{Re}\left[\frac{Ve^{s_s t}}{L(s_s - s_c)}\right] = \mathrm{Re}\left[\frac{42.5\,e^{j\omega t}}{2(s_s - s_c)}\right] \quad .. \quad (3)$$

The magnitude of $(s_s - s_c)$ can be measured on the diagram, or calculated by Pythagoras or by trig. tables if you want it more accurately; it is 372, and its angle $+57.5°$. The rule that one divides by the magnitude of the distance between the source and circuit poles is obvious from (2) and (3) and—since this quantity is in the denominator—so is the rule that one has to reverse the sign of the angle. So we get:

$$i_s = \mathrm{Re}\left[\frac{42.5e^{j(\omega t - 57.5)}}{2 \times 372}\right] = 0.057\mathrm{Re}\,[e^{j(\omega t - 57.5)}]$$
$$= 0.057 \cos(\omega t - 57.5°) \quad .. \quad .. \quad (4)$$

This gives the relationship between t and i_s, from which we can plot a time graph of the forced part of the current, if we wish. I have not bothered to fill in the value of ω ($=2\pi \times 50 = 314$), partly not to mix radians with degrees—or make a large number by bringing ωt to degrees—but mainly because it would be a waste of time anyway, for we know the shape of a sine wave and that in our case one whole cycle takes 0.02 sec. and that the peak value is 0.057 amp., and that it lags the applied voltage by 57.5°. So we can draw its graph without further

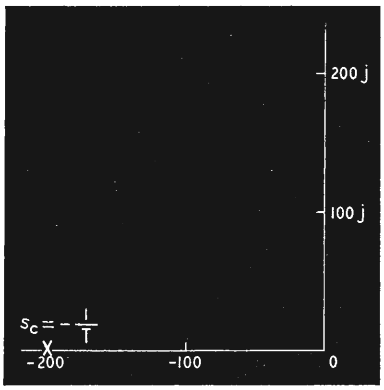


Fig. 3. Complex-plane diagram for the example of the Fig. 2 circuit, with L=2H and R=400Ω.

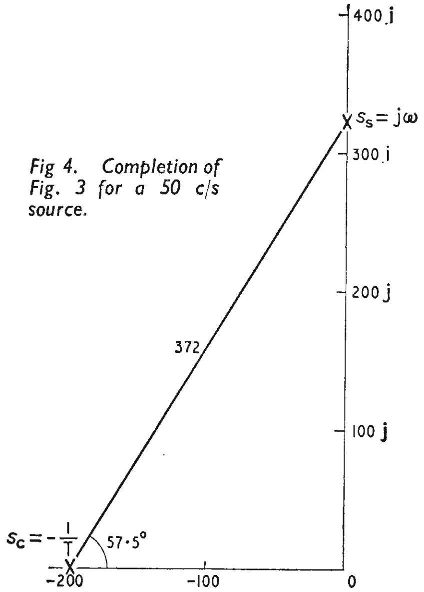


Fig 4. Completion of Fig. 3 for a 50 c/s source.

ado. But if we work to rule and go by (4), the most interesting (and easily obtained) piece of information it gives us is the value of current at the moment of switching on. This is found by putting $t = 0$, so the quantity multiplied by 0.057 is then simply $\cos -57.5° = 0.53$, and

$$i_s\,(t = 0) = 0.0306 \text{ amp.}$$

Before going on to find i_c, the free component of current, we may care to check i_s by a conventional method. The impedance of the circuit is 400 + $j\omega 2$, = 400 + j 628 ohms. Converted to polar co-ordinates, this is 744 $\angle 57.5°$. Dividing the peak voltage, 42.5, by this, we get 0.057 amp, lagging 57.5°. So the current at switch-on is 0.057 cos $-57.5°$, = 0.0306.

The obvious comment is that the first method is a very roundabout way of doing exactly the same thing. The second method, besides being familiar and therefore not needing to be explained in such detail, is admittedly a short cut, which should certainly be taken when appropriate—as it would be if one needed only the information so far sought. But it is limited in what it can do.

That is the cue for going on to find the free response, determined by the circuit's natural "frequency," s_s. The procedure is precisely the same, but the roles of the two poles in Fig. 4 are reversed. The only difficulty you might have with this arises from the fact that last month we considered an example in which both poles were on the negative real axis, so the line joining them was horizontal. This being so, we didn't bother to take account of the angle between it and the horizontal. If we had stopped to consider it—perhaps you did!—we would have realized that although at one end of the line the angle was indeed zero so that we were right to ignore it, at the other end it was 180°. Because cos 180° = −1, this introduces a minus sign. How then did we manage to get the answer right?

We got the negative sign in another way. When the two poles changed places in the denominator, $(s_s = s_c)$ became $(s_c = s_s)$, which is $-(s_s - s_c)$. In doing it

(*Continued on page* 509

the truest sound

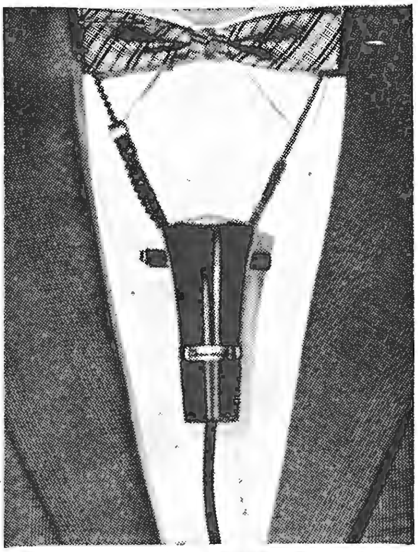
For sound reproduction as it should be—as close as possible to the original—make Shure microphones your unvarying choice. They are the finest for every purpose, years ahead of others in the technical excellence of their design and performance, the most comprehensive range obtainable anywhere.

Model 545 'Unidyne III' for public address, tape recording, communications and similar applications requiring compactness with maximum operating efficiency.

Model 420 'Commando' can be used indoors or outdoors, for all general-purpose applications. Quality performance at moderate cost.

Model 540S 'Sonodyne II' This versatile new microphone features *variable frequency response*, allowing the user to tailor the microphone to the application.

Model 55SW 'Unidyne' The most widely used microphone in the world, specified by leading sound engineers and requested by celebrities.



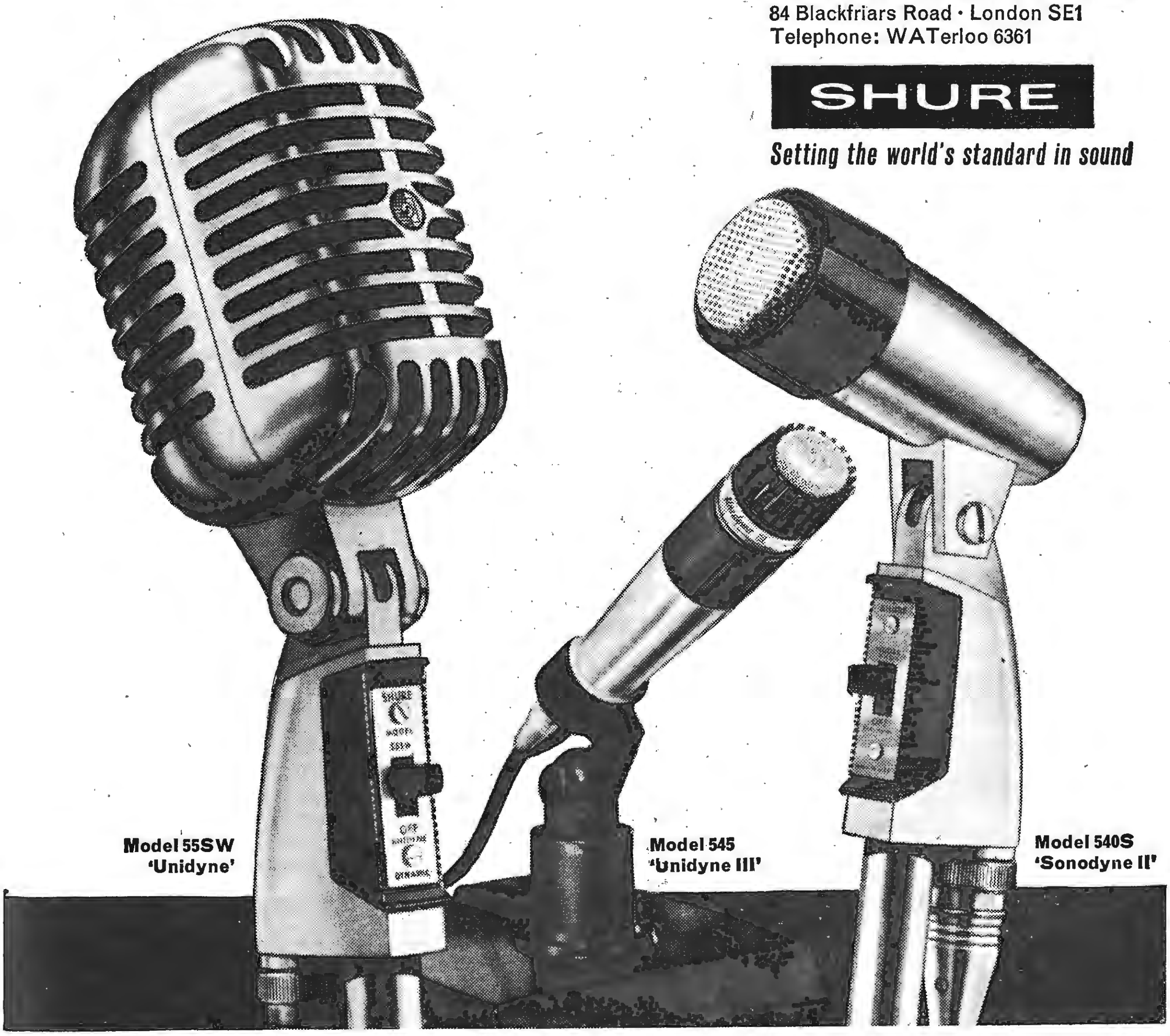
Model 420 'Commando'

The new Shure microphone catalogue is available on application to the address below

SHURE ELECTRONICS LIMITED
84 Blackfriars Road · London SE1
Telephone: WATerloo 6361

SHURE

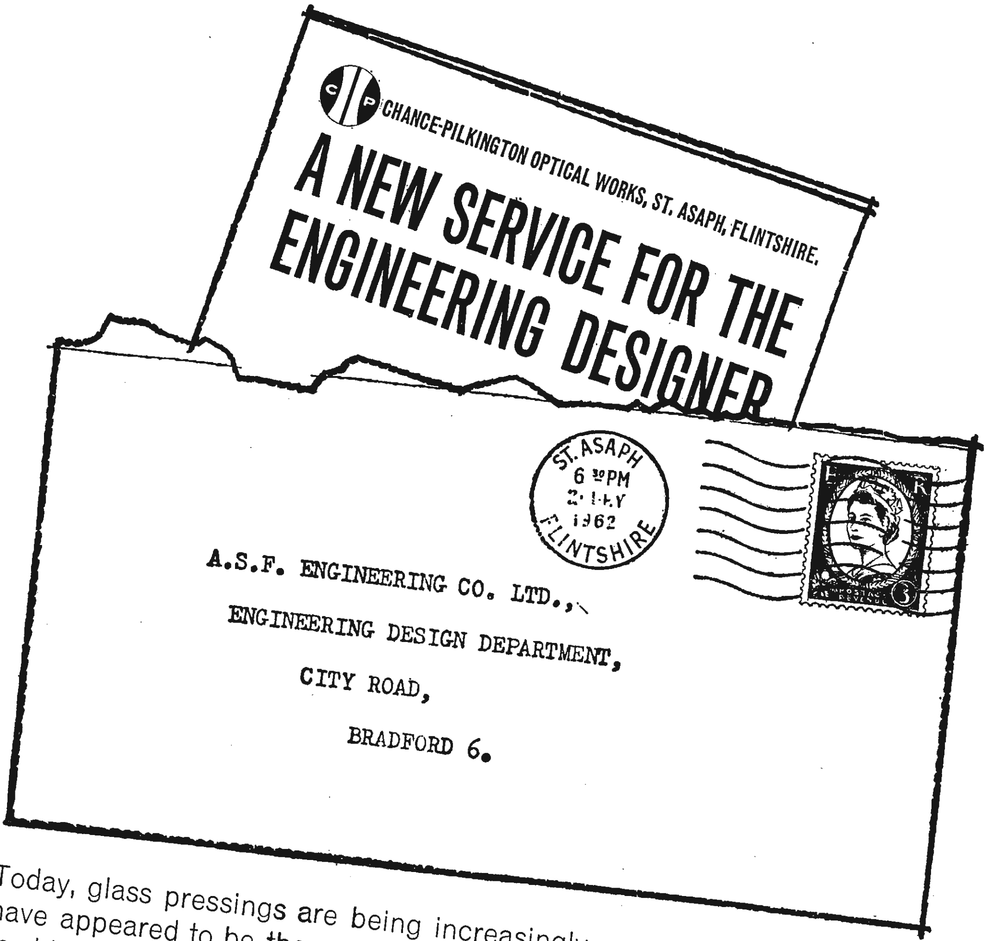
Setting the world's standard in sound



Model 55SW 'Unidyne'

Model 545 'Unidyne III'

Model 540S 'Sonodyne II'



Today, glass pressings are being increasingly specified for what might have appeared to be the most unlikely components. The reason is that the high electrical, thermal, and abrasive resistant characteristics of glass can meet exacting specifications better than most other materials, whether or not its transparency is required. Chance-Pilkington Optical Works have a world-wide reputation for the quality and precision of their glass pressings for optical and ophthalmic use. Because of this their advice has been often asked on the use of pressed glass components in engineering and industrial design. Now, **Chance-Pilkington announce the formation of a new division, set up to deal with such inquiries, and to provide a complete development and production service.** Manufacture will be by the most modern processes, linked with the stringent quality and specification control on which Chance-Pilkington's international reputation has been established.

Next time the question "What material?" crops up, telephone St. Asaph 3281 and talk to Ken Appleton, Sales Manager. Glass may well give you a better answer than you ever thought possible.

CHANCE-PILKINGTON OPTICAL WORKS, ST. ASAPH, FLINTSHIRE · One of the great Pilkington glassmaking companies

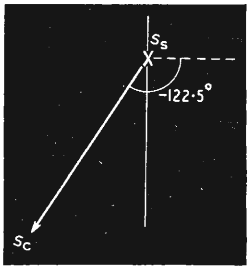


Fig. 5. Detail of Fig. 4, showing negative angle of (S_c -S_s).

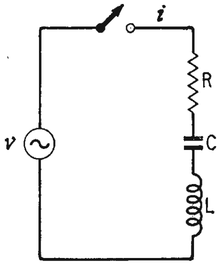


Fig. 6. The second example, in which the addition of series capacitance to Fig. 2 yields an oscillatory circuit

this way we were in fact taking account of both magnitude and direction together. That is fair enough when the line is horizontal so that direction is simply a matter of plus or minus. But in general this is not so, and I think confusion is less likely to arise if we follow the rules laid down as long ago as the May issue, interpreting $(s_c - s_s)$ and $(s_s - s_c)$ equally as the *magnitude* of the distance between s_c and s_s and taking account of angle separately. Reckoning the angle relative to 3 o'clock in every case will bring in the negative sign wherever it is appropriate.

So let's get on. Exchanging s_c and s_s in (3) we have

$$i_c = \text{Re}\left[\frac{\text{V}e^{s_c t}}{\text{L}(s_c - s_s)}\right] \quad .. \quad .. \quad .. \quad (5)$$

and filling in the values, with the aid of Figs. 4 and 5:

$$i_c = \text{Re}\left[\frac{42.5e^{-200t+122.5j}}{2\times 372}\right] = 0.057\text{Re}\left[e^{-200+122.5j}\right] (6)$$

At first sight this closely resembles (4), but there is the vital difference that the variable part of the index is wholly real and negative, giving the familiar exponential die-away transient. In accordance with the law of indices the constant exponential can be separated out as the factor $e^{122.5j}$, the real part of which is cos 122.5°, = −cos 57.5°, = −0.537. Multiplied by 0.057 this is −0.0306, so we can rewrite (6) as $i_c = -0.0306e^{-200t}$. At t=0, this is −0.0306, making the total current i = 0. Fig. 2 shows that this was obviously so up to the time the switch made contact, and the inability of current to grow instantaneously in an inductor tells us that it remains so at the moment of first contact.

With the object of leaving no room (as I hopefully suppose) for unanswered doubts or questions, I have taken every step one at a time in a manner which may have been unendurably tedious to some. They at once, and the others after a little practice, will obviously find short cuts; for instance, finding both components of current together, in terms of their individual exponentials multiplied by the common factor $\text{V}/\text{L}(s_c - s_s)$. It is particularly easy to do this when there is only one source pole and one circuit pole and therefore one distance between them. Our next example will show how to extend the procedure to several distances.

Fig. 6 shows the circuit; again, not totally unfamiliar! Corresponding to eqn (3) we get, by the same general method,

$$i_s = \text{Re}\left[\frac{\text{V}}{\text{L}}\cdot\frac{s_s\, e^{s_s t}}{(s_s - s_{c1})(s_s - s_{c2})}\right] \quad .. \quad .. \quad (7)$$

As fully explained in the June issue, the two factors in the denominator result from the fact that it is a quadratic in s_s, so there are two values of it (s_{c1} and s_{c2}) that make i_s infinite, and therefore two poles in the diagram. And the s_s in the numerator means that when it is equal to zero i_s is zero, so there is a zero in the diagram at the origin.

Let us suppose that R is relatively low enough for the circuit to be oscillatory; then s_{c1} and s_{c2} are

$$-\frac{1}{2\text{T}_2} \pm j\sqrt{\frac{1}{\text{T}_1\text{T}_2} - \frac{1}{4\text{T}_2^2}}$$

as plotted in Fig. 7. T_1 is the time constant CR, and T_2 is L/R. The pole positions shown correspond to

$$\text{L} = 2\text{H}$$
$$\text{R} = 314\Omega$$
$$\text{C} = 0.81\mu\text{F}$$

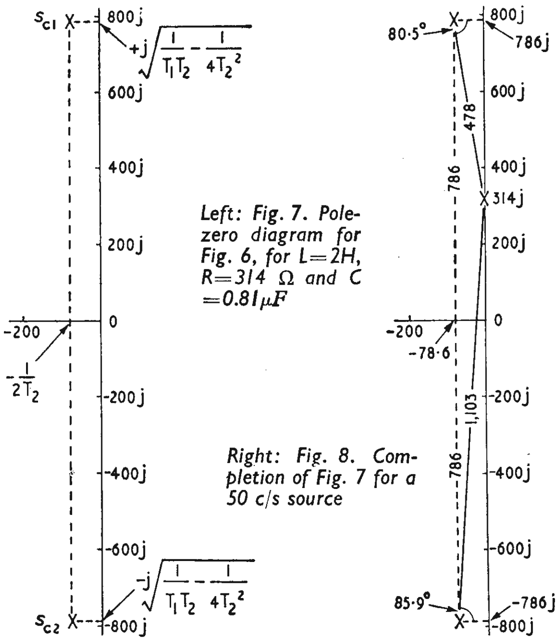
so $$\frac{1}{2\text{T}_2} = 78.6$$

and $$\sqrt{\frac{1}{\text{T}_1\text{T}_2} - \frac{1}{4\text{T}_2^2}} = 786$$

This last figure is the ω of resonance, but the ω of natural oscillation of the circuit (s_{c1}) is represented by the slightly greater distance of s_{c1} (or s_{c2}) from the origin. Q at the resonant frequency is 5, as you can easily check from the above data.

It will be rather interesting to find the response of such a circuit to a pulse produced by switching on the 50 c/s source. Its ω (=314) is 0.4 times the frequency of resonance, so should be visibly distinguishable from that of the free response.

Besides i_s, the forced response, there will be *two* free responses, corresponding to the two poles. Following the procedure of giving each of these in



Left: Fig. 7. Pole-zero diagram for Fig. 6, for L=2H, R=314 Ω and C =0.81μF

Right: Fig. 8. Completion of Fig. 7 for a 50 c/s source turn the role taken in (7) by s_s, we get the formula for the total response:

$$i = \frac{V}{L}\text{Re}\Big[\frac{s_s e^{s_s t}}{(s_s - s_{c1})(s_s - s_{c2})} + \frac{s_{c1}\, e^{s_{c1} t}}{(s_{c1} - s_s)(s_{c1} - s_{c2})} + \frac{s_{c2} e^{s_{c2} t}}{(s_{c2} - s_s)(s_{c2} - s_{c1})}\Big] \quad \ldots \ldots \quad (8)$$

Once the idea has been grasped, it is quite easy to do this, even with more complicated circuits. Filling in the values and working out the results, however, although straightforward, demands some care and concentration, as one can easily make a slip. So it is advisable to check the result by putting $t=0$ and seeing whether i comes to zero. Don't be too disconcerted if it doesn't quite, because ordinary rule and protractor measurements off a moderate-sized diagram, followed by sliderule computation, may not be quite good enough, especially in awkward cases with an error-multiplying effect. To be candid, I used the diagram, Fig. 8, just as a guide and employed trig. tables to find the actual values.

From the data given,

$$\begin{aligned} s_s &= j314 \\ s_{c1} &= -78.6 + j786 \\ &= 790 \,/\, +95.7^\circ \\ s_{c2} &= -78.6 - j786 \\ &= 790 \,/\, -95.7^\circ \end{aligned}$$

All the magnitudes are in radians per second.
From the diagram,

$$\begin{aligned} s_s - s_{c1} &= 478 \,/\, -80.5^\circ \\ s_{c1} - s_s &= 478 \,/\, +99.5^\circ \\ s_s - s_{c2} &= 1103 \,/\, +85.9^\circ \\ s_{c2} - s_s &= 1103 \,/\, -94.1^\circ \\ s_{c1} - s_{c2} &= 1572 \,/\, +90^\circ \\ s_{c2} - s_{c1} &= 1572 \,/\, -90^\circ \end{aligned}$$

So the terms inside the brackets in (8) are:

(i) $$\frac{j314e^{j(314t+80.5-85.9)}}{478 \times 1103} = \frac{j0.596e^{j(314t-5.4)}}{1000} = \frac{0.596e^{j(314t+84.6)}}{1000}$$

(ii) $$\frac{(-78.6 + j\,786)e^{(-78.6\, +\, j786)t - j(99.5+90)}}{478 \times 1572} = \frac{790e^{-(78.6-j786)t-j(189.5-95.7)}}{478 \times 1572} = \frac{1.05e^{-(78.6-j786)t-j93.8}}{1000}$$

(iii) $$\frac{(-78.6-j786)e^{(-78.6-j786)t+j(94.1+90)}}{1103 \times 1572} = \frac{790e^{-(78.6+j786)t+j(184.1-95.7)}}{1103 \times 1572} = \frac{0.456e^{-(78.6+j786)t+j88.4}}{1000}$$

Note that the j, since it denotes a phase shift of $+90°$, was eliminated in (i) by adding 90° to the index of e. And the complex factors in (ii) and (iii) were replaced by magnitudes, with their appropriate phase angles introduced into the indices. All this makes the indices rather complicated (no doubt the printer is wishing I had adopted the alternative notation "exp" followed by the index written on ground level, but it is rather late to change over now we are in sight of the end) so you will hardly wait to put $t = 0$ for checking the work. Doing this, the numerators become

$$0.596e^{j84.6} + 1.05e^{-j93.8} + 0.456e^{j88.4}$$

and taking the real parts of these we have

$$\begin{aligned} &0.596 \cos 84.6 + 1.05 \cos 93.8 + 0.456 \cos 88.4 \\ &= (0.596 \times 0.0941) + (1.05 \times -0.0663) + (0.456 \times 0.0279) \\ &= 0.0561 - 0.0696 + 0.0127 \\ &= -0.0008 \end{aligned}$$

which is near enough to zero to make one feel reasonably confident that nothing serious has gone wrong, and far enough from it to show you I haven't cooked the results or used seven-figure tables to get a degree of accuracy that is quite unwarrantad by the nature of the work.

To get the initial currents in amps we would of course multiply the above numbers by V/1000L, $=0.0212$. They are of the order of only 1mA.

Now look at the complete indices, including the

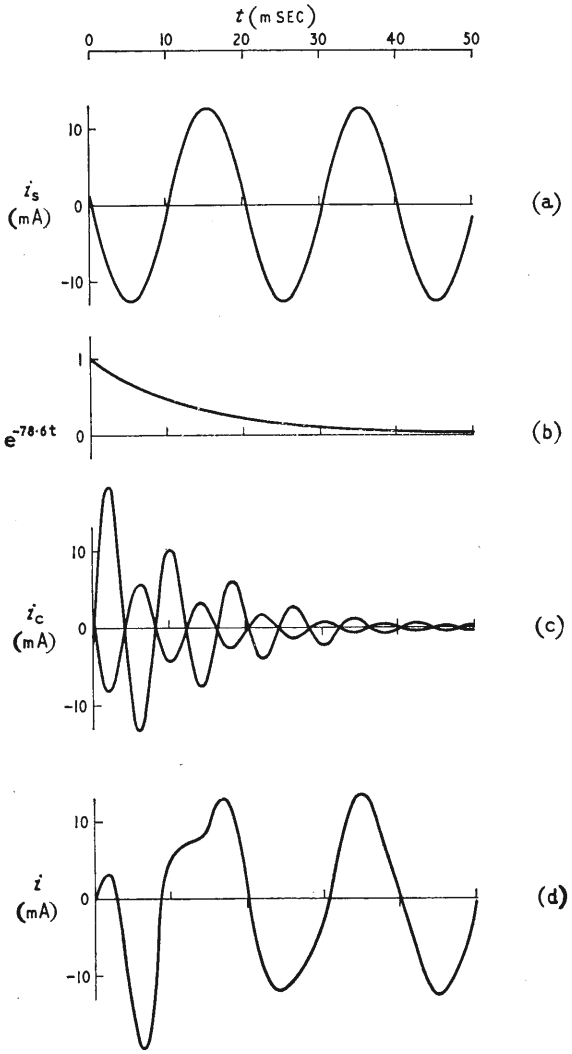


Fig. 9. (a) Forced component of current, when the source in Fig. 6 is switched on at positive maximum voltage. (b) Die-away factor of free responses. (c) Free components of current. (d) Sum of (a) and (c), being the total response from switch-on in Fig. 6.

parts multiplied by t which tell us the waveforms of the three currents from the moment the switch is closed. These parts are in radians per second, to be divided by 2π if you want them in c/s. The others, representing phase angles, are in degrees, as marked:

(i) $j(314t + 84.6°)$

(ii) $-(78.6-j786)t-j93.8°$
$= -78.6t + j(786t - 93.8°)$

(iii) $-(78.6 + j\ 786)t + j88.4°$
$= -78.6t - j(786t - 88.4°)$

The first, being all under cover of j, is a continuous sinusoidal oscillation, frequency $314/2\pi = 50$ c/s, phase angle 84.6°, leading. As the source frequency is much lower than the resonant frequency of the circuit, the impedance is predominantly capacitive, hence the leading current. As we see, the lead is not far short of 90°, and as the voltage (V cos ωt) starts at peak value, the current is near its minimum. Its peak value in *milliamps* is given by 0.596 multiplied by V/L = 12.65, so we have all the data for plotting the forced response, Fig. 9(a).

The second (when rearranged as shown) comprises one composite term like the first, denoting continuous 125 c/s oscillation with a 93.8° phase lag, plus a negative real term, denoting a die-away. As these are indices, their addition means multiplication of the two waveforms, and so the whole is a dying-away or damped oscillation.

The third has the same die-away term, but the polarity and phase and amplitude of the oscillation are all different.

Perhaps the simplest way of drawing these damped waveforms is first to sketch the die-away curve represented by $e^{-78.6t}$. Its initial amplitude is of course 1, and the only doubt that could arise is about the time scale. The time constant, which is the value of t where the amplitude is 1/e, =0.37, is clearly 1/78.6, but in what time units? The 78.6 is in imaginary radians per sec. (equal to 12.5 imaginary c/s), and as the radian is the basic mathematical unit the time constant is 1/78.6 sec., = 12.7 msec. This information enables the curve to be sketched, as at (b) in Fig. 9.

The duration of a 786 rad/sec (=125 c/s) cycle is 8 msec.; and the peak values in milliamps of the free responses, if they were not damped, would be V/L multiplied by the previously found coefficients 1.05 and 0.456; i.e., 22.3 and 9.66. Next mark the positions of positive and negative peaks and zero values on the time graph, Fig. 9(c), allowing for the calculated phase displacements, and plot the above amplitudes reduced by multiplying by the die-away curve at those points. Finally, sketch in the damped waveform through these peak and zero points.

The complete response, such as would appear on an oscilloscope connected across R, is found by adding the ordinates of all three components of current, with the result shown as Fig. 9(d).

We now see why some error in calculating the net initial current (theoretically zero) was only to be expected—at that moment the component currents are near their points of zero value and therefore of most rapid variation. A more convincing check would undoubtedly be obtained if the voltage were switched on 90° later or earlier, at its zero value.

In this example the total free response has become negligible after about two cycles of the continuous forced response. Even with this quite low-Q circuit the phase shifts are all nearly 90°, and with the higher Qs that are more usual a vast simplification of the work is allowable by neglecting the angles that are too small for comfort even in Fig. 8. One can pretty well guess the sort of total response—a combination of both source and circuit frequencies at first, with the latter dying out much more gradually than in Fig. 9(c). As the applied frequency approaches zero, the two free responses will tend to cancel one another out. But if it is raised to the point of resonance, a great increase in both free and forced amplitudes results, as can be seen by $s_s - s_{c1}$ almost vanishing. At least, there is a large *possible* free amplitude, but how much of it is actual depends on the phase at which switch contact is made.

The same procedure can be used to find the response to complex excitation; for example, damped oscillations. This is hard to do any other way. What a pity this technique was not available in the days of spark transmitters! The old-timers will remember that the aim was to apply a heavily damped excitation to a lightly damped tuning circuit, making use almost entirely of the free oscillations rather than the forced ones.

Coming back to today, we may note that double-tuned circuits (e.g., i.f. transformers) have two pairs of poles, and if the Q is very high, so that they are nearly on the vertical axis, a double humped response results, even though the pairs nearly coincide.

My limited objective has been just to introduce the technique; if you want to go really into it I recommend the following books:

Introductory Circuit Theory. By E. A. Guillemin. (Chapman & Hall, 1953).

Analysis of Electric Circuits. By E. Brenner and M. Javid. (McGraw-Hill, 1959).

On the practical side, there are "transfer function analysers," which I mentioned earlier. They consist basically of signal generators to provide the excitation, applied to equipment under test, and instruments to measure the resulting response, in A + jB and/or $M\ /\ \phi$ forms. Their powers of analysis are strictly limited. Much more interesting is the Wayne Kerr "Transfer Function Computer," which applies excitation of the desired form and measures the coefficients in numerator and denominator of the transfer function. In other words, it solves the circuit differential equations. One of the snags, when one gets to this stage by any means, is that except with simple circuits (which aren't much of a problem anyway) it is difficult to factorize the numerator and denominator, as is necessary for finding the positions of poles and zeros. A piece of auxiliary apparatus, the Wayne Kerr Root Solver, does this for one.

On that happy note I leave you.

Further Education

Borough Polytechnic, London, S.E.1. An evening course of ten lectures as an "introduction to transistor theory and applications" and a more advanced course (afternoon or evening) on "transistors and allied devices" is being given during the autumn and winter sessions. There will also be a laboratory course (afternoons) on basic transistor measurements. The college is also conducting a 20-week course on the fundamental principles of pulse techniques (evenings) and a 12-week afternoon laboratory course on pulse circuits.

Twickenham Technical College, Middx., has planned a new four-year sandwich course (6 months college, 6 months industry) in control engineering leading to the H.N.D. It also has a 22-lecture evening course on pulse circuit design and one of 20 lectures on transistor circuit design.

UNBIASED

By "FREE GRID"

Colour TV Problems

ONE of the most popular exhibits at the recent National Radio Show seemed to be the avenue of fourteen colour TV receivers shown in action. I thought the most interesting point was the different colour emphasis some of them gave to the same scene, just like the various amateur colour films which are available.

I realized, of course, that as the signals were coming from a common source, the differences in colour interpretation were arising inside each receiver. I came to the conclusion that the variations were due to the fact that the sets had been adjusted by different engineers whose eyes and other ophthalmic mechanism, had response curves widely differing from each other. If I am wrong in any conclusions, no doubt the Editor will find space to print the naked truth from any of you who are in a position to correct me.

In the case of most of us, our organs of seeing and hearing vary in differing degrees in their response to different sections of the gamut of frequencies covered by their respective spectra. It is noticeable that, apart from differences in individuals of the same sex, there is a very marked lack of agreement in the response of men, as compared with women, to different portions of both the visual and aural spectra.

We all know that women tend to turn the tone control of sound receivers, or canned concert reproducers, to "mellow." I don't know why they do this, but maybe they get tired of the sound of their own shrill voices, and prefer the mellow bellow of a male singing in his bath.

Strangely enough in the visual spectrum, the exact opposite seems to hold true, men showing a preference for the low frequency end of the spectrum, i.e., red. This would account, I suppose, for the favourable bias which men are said to show towards red-headed girls, whereas their womenfolk are apt to call them hussies, which is nowadays a derogatory term, quite contrary to its usage in the time of Chaucer when it was spelt "huswif" and was a term of great respect. Indeed, even when I served in Kitchener's army, we were all expected to carry an inanimate one in our kitbags.

Now it is well known that the eye is far more critical than the ear, and so it will be obvious that the family feuds over adjusting the colour receiver will be even greater than those over sound radio.

Forty Years On

IT is strange to think that it is forty years since the first British wireless show was held in the Horticultural Hall (October 1922) and nearly as long since the B.B.C. started regular broadcasting by giving the results of the general election. That was, of course, on Nov. 14th, 1922.

The greatest change that has come over the world of wireless in the last 40 years has been that, unlike their counterparts of today, most visitors to the exhibition of 1922 had a working knowledge of the technicalities of wireless, and that was their main interest. Few listeners cared much about the programmes. The means were indeed greater than the end.

Nearly all our sets were home-made, even though certain manufacturers offered commercially made ones. Such sets generally turned out to be a lot dearer than appeared at first sight for no receivers contained a loudspeaker; that had to be bought separately as did the batteries if the set had valves.

But it was not absolutely essential to have a valve set to work a loudspeaker, for one firm supplied an excellent microphone amplifier, and later on, sold a loudspeaker which could be coupled direct to a crystal set. I still have a specimen of one; its secret was a very compact microphone amplifier built into its base.

I wonder what the wireless sets will be like another forty years on. One thing is certain and that is I shall not be present and neither, I think, will the Editor unless, of course, very big advances have been made in geriatrics. Even without such advances, it would, I suppose, just be possible for the Editor and myself to visit the encapsuled Earls Court Exhibition of A.D. 2002 as it encircles the earth, 100 miles up. We should, of course, be transported thither in our bathchairs or, rather, bathcapsules.

Spotting the Spotter

IN certain American technical journals, advertisers are offering circuit diagrams and components for constructing receivers to warn car drivers when they are within range of a radar speed trap.

There is no point in my giving details here, as any *W.W.* reader will obviously possess sufficient technical knowledge to enable him to design and construct such a device himself if he wants to do so. Apart from that, there is always the odd chance that a copy of this journal might fall into the hands of some unscrupulous non-*W.W.* road hog who would unashamedly construct and use the device to enable him to escape his just deserts. In that case I might possibly lay myself open to a charge of inciting, or even aiding and abetting him to obstruct the police in the execution of their duty.

As I never exceed the speed limit —indeed I doubt if my old car would be capable of doing so—I could no more be held to be hindering the police by constructing and using one of these devices myself, than if I picked up Madame Estelle and her crystal ball from one of our seaside piers, and carried her in my car to help me spot the speed traps.

She herself would be fully within the law provided she avoided pretending to foretell the future like a

meteorologist, and confined herself to the present by saying, "I see strangely short electromagnetic waves in my crystal which are behaving like the corrugations of a closing concertina as we travel along."

In the old stop-watch days, of course, many motorists used to receive still shorter electromagnetic waves in their driving mirrors, reflected from a policeman's dropped handkerchief, and the law did not make such mirrors illegal.

But certain of you legal wiseacres might argue that whereas driving mirrors, and even Madame Estelle's crystal ball, had other just legitimate uses, any radar-speed-trap-spotting receiver I constructed would be incapable of fulfilling any other function. This would not be true as actually I am intending to experiment with such receiving apparatus in an endeavour to evolve an electronic speedometer based on the principle first enunciated by the Austrian scientist, Johann Doppler, in 1842.

In any case, the receiving licence issued for my car does not restrict the frequency bands which my set may cover. But naturally, I am debarred, in common with all other wireless listeners, from disclosing to others any message, other than a broadcast one, which I pick up. It would, therefore, be illegal for me to warn other motorists of the existence of a speed trap.

It might even be inadvisable for Madame Estelle to do so as certain types of magisterial bench, of which we have all heard, might decide that as her receiver was, on her own admission a crystal one, messages received thereby were protected by the non-disclosure injunction applicable to all wireless signals not intended for general reception.

Terminological Exactitude

MANY years ago when we dropped the word capacity in favour of capacitance in order to keep it in line with inductance, etc., and tidied up some other loose ends in our technical terminology, I was very sorry that we did not go the whole hog, and do the job properly.

One of the clumsiest expressions in electrical engineering is electromotive-force which we usually abbreviate to e.m.f. Surely an apt word for e.m.f. would be "pressance" from the Ciceronian word *pressus*, or "pressurance" from the less-exalted Latin word *pressura*, both of which mean pressure.

Perhaps the latter word would be better since "pressurance" would obviously show that it was merely our common word "pressure" used in a special technical sense, just as capacitance does with regard to the everyday word capacity. However, if the word "force" in e.m.f. must be preserved, we could call it "fortance."

RADIO INTERFERENCE

ANALYSIS OF "SOURCES" INVESTIGATED BY THE POST OFFICE

	No. of complaints per service				
	L.W. & M.W.	Band I	Band II	Band III	Mobile Radio
UNSATISFACTORY RECEIVING CONDITIONS					
Inefficient aerials	2,181	3,279	336	1,370	—
Faulty receivers	1,316	5,601	344	2,233	18
Maladjustment of receivers	87	606	41	196	6
"Ghosts" and "flutter"	10	601	45	520	6
I.F. breakthrough...	20	359	21	107	—
2nd channel response	13	106	13	37	2
Other spurious responses	44	158	106	74	2
Other conditions affecting reception ...	342	1,964	44	666	16
Totals	4,013	12,674	950	5,203	50
IDENTIFIED SOURCES					
Sewing machines	311	3,476	37	749	—
Hair dryers	124	1,338	16	241	1
Portable electric tools	416	1,513	30	292	1
Vacuum cleaners	353	1,686	38	253	—
Other motors, generators, convertors, etc.	706	2,853	58	492	5
Bedwarmers	101	467	6	77	1
Smoothing irons	44	96	11	21	—
Other "contact" devices	1,291	4,216	96	819	10
Vibratory devices (bells, buzzers, etc.)	98	332	10	72	—
Neon signs	161	1,314	26	295	4
Other gaseous discharge lamps ...	1,221	472	11	88	—
Filament type lamps	37	531	8	18	—
Industrial and medical r.f. apparatus ...	27	514	15	336	22
Amateur transmitters	49	309	29	67	7
Other U.K. transmitters	78	238	95	124	37
Radiation from receiver time-base circuits	659	1,316	3	253	7
Radiation from local oscillators of Band I receivers	—	622	7	2,041	35
Radiation from local oscillators of Band II receivers	—	30	2	204	1
Radiation from Band III convertors ...	1	333	—	107	—
Faulty electrical wiring of premises ...	393	397	10	71	—
Power lines, overhead	233	3,870	11	295	4
Electric railways	19	117	—	23	1
Other identified sources	806	4,889	86	1,656	36
Unidentified sources	2,059	11,504	216	2,296	94
Grand Totals ...	13,200	55,107	1,771	16,093	316

REFERENCE is made in the 1961/62 Report of the U.K. Post Office to the decrease, by comparison with the previous year, of some 13,000 in the number of complaints of interference with radio reception that had been investigated. As will be seen from the table, prepared from information obtained from the Post Office Engineering Department, the year's total was about 86,000, of which nearly 23,000 arose from "unsatisfactory conditions at the receiving site." The overall total is a reduction of some 40% on the number of complaints investigated by the Post Office in 1954, the year prior to the introduction of the regulations limiting the radiation and conduction of interference from electric motors and refrigerators.

It is, of course, still the responsibility of the user, not the manufacturer, to suppress interference from electric motors*. Some manufacturers do voluntarily fit suppressors to equipment employing small electric motors but even so, small motors still account for about 24% of identified sources of interference.

Radiation from local oscillators in television receivers tuned to a station in Band I is still by far the largest individual source of interference with Band III receivers. This is particularly bad in some areas, as for instance in the Channel Islands where the new I.T.A. station opened on September 1st. When complaints are received by the Post Office, engineers trace the offending receiver and ask the owner to approach his dealer to put it right. At the same time they notify the manufacturer.

The "unidentified sources" include those in which the interference ceased before or during the investigations and those where it was of such infrequent occurrence that it did not justify continual investigation to the exclusion of more urgent complaints.

* With refrigerators the responsibility rests upon the manufacturer or seller.

Commercial Literature

Tectonic Designers Handbook has been revised to cover further aspects of printed circuits and components design and production. Special flexible, multi-layer and cross-over circuits as well as bonding techniques for circuitry on unusual materials are described in the publication. Tectonic Industrial Printers Ltd., Cirtec Works, Oxford Road, Wokingham, Berks.

Burgess micro switches and ancillaries are described and illustrated in Concise Catalogue 62, available from Burgess Products Co. Ltd., Micro Switch Division, Dukes Way, Team Valley, Gateshead, 11. A miscellany of micro switch data and current developments is contained in the company's latest bulletin, "Micro Switchcraft by Burgess."

Siemens & Halske semiconductor devices, screened cubicles and a single-knob resistance bridge are the subjects of illustrated leaflets available from the U.K. agents, R. H. Cole (Overseas) Ltd., 26-32 Caxton Street, Westminster, London, S.W.1.

Applications of Craylene and Fablon flexible, calendered, plasticized p.v.c. sheeting in the technical, industrial and engineering fields, are described in an illustrated brochure published by Commercial Plastics (Sales) Ltd., Berkeley Square House, Berkeley Square, London, W.1.

"Nickel-containing Magnetic Materials" contains chapters on the properties and applications of high permeability nickel-iron alloys, magnetostrictive materials, alloys with low Curie points and permanent magnet alloys. The publication is obtainable from the Publicity Department, International Nickel Co. (Mond) Ltd., 20 Albert Embankment, London, S.E.1.

Synchro and resolver test equipment is described and illustrated in a series of technical bulletins available from the manufacturers, Theta Instrument Corp., 520 Victor Street, Saddle Brook, New Jersey, U.S.A. Also new is a 16-page monograph describing the application and testing of computing resolvers.