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THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

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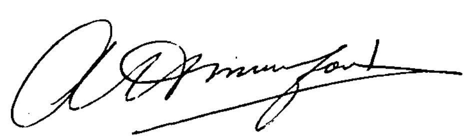
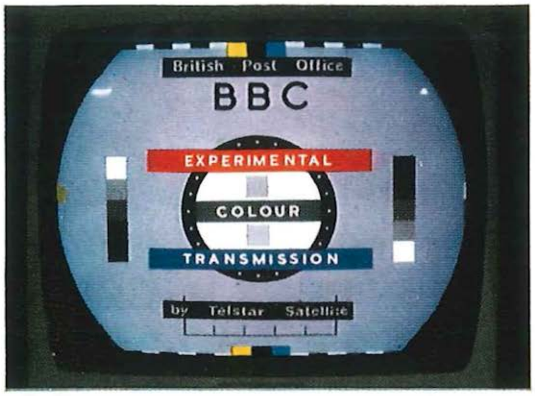
Satellite Communications

With the launching of the TELSTAR satellite by the United States National Aeronautics and Space Administration on 10 July 1962, and the success of the first tests and demonstrations using the satellite—described elsewhere in this Journal—an important step forward has been taken in the development of satellite communications. In this work the Post Office satellite communication ground station at Goonhilly has made its own valuable contribution.

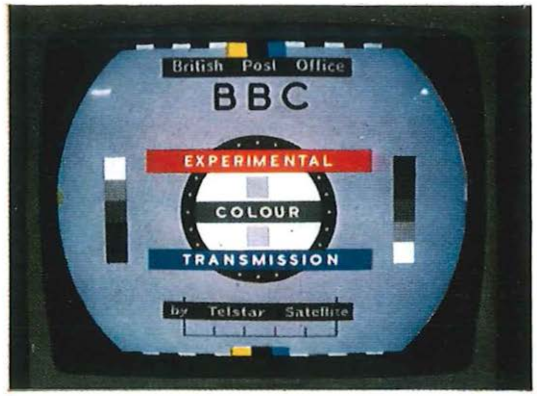
I feel sure that all readers of this Journal will join me in congratulating all concerned in this project, both here and abroad, and in particular those engineers of the British Post Office—and there are many in the team—who have been involved in the development and construction of the Goonhilly station in so short a time, and the Consultants and Contractors responsible for the design and construction of the aerial, the British Telecommunications Industry and the Services Electronics Research Laboratory.



President of The Institution of Post Office Electrical Engineers



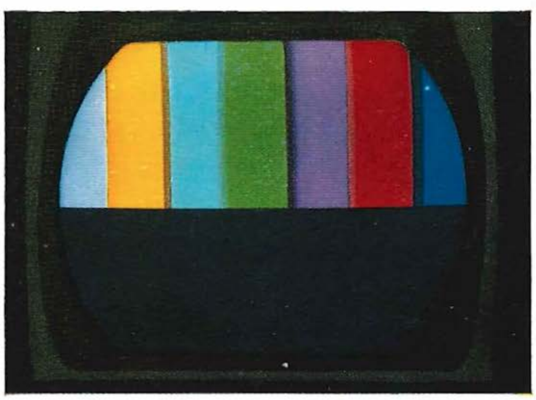
(*a*) Test card as transmitted from Goonhilly to TELSTAR



(*b*) Test card as received back at Goonhilly from TELSTAR

(*c*) Picture as transmitted from Goonhilly to TELSTAR

(*d*) Picture as received back at Goonhilly from TELSTAR



(*e*) Test card received at Goonhilly from Andover, U.S.A., via TELSTAR

(*f*) Picture received at Goonhilly from Andover, U.S.A., via TELSTAR

COLOUR TELEVISION TRANSMISSION VIA TELSTAR

Preliminary Results of the Project TELSTAR Communication Satellite Demonstrations and Tests: 10–27 July, 1962

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The successful transmission of television pictures across the Atlantic via a satellite in July this year received wide publicity, but television represents only one of several types of transmission for which Project TELSTAR was designed. This article describes a number of demonstrations and tests of television, multi-channel telephony and phototelegraphy which were carried out within the first fortnight of TELSTAR being launched, and gives a general impression of the results achieved with particular reference to the Post Office Satellite Communication Ground Station at Goonhilly Downs.

INTRODUCTION

THE Project TELSTAR communication satellite, which was designed and built by the Bell Telephone Laboratories, U.S.A., was successfully launched by the U.S. National Aeronautics and Space Administration (N.A.S.A.) from Cape Canaveral at 8.35 G.M.T. on Tuesday, 10 July 1962. This event marked the beginning of a development in world-wide communications that may well be of considerable political, economic and cultural as well as technical significance.

In the first fortnight of the operation of the satellite a number of demonstrations and tests of television, multi-channel telephony and phototelegraphy transmission were carried out. It is the aim of this article to give a general impression of the preliminary results achieved, with particular reference to the Post Office satellite communication ground station at Goonhilly Downs, Cornwall.[1, 2, 3]

Clearly, many more tests and measurements will be required before a detailed, statistical statement of the performance of the satellite system can be made; nevertheless, the preliminary results achieved are already of considerable interest and value.

Although these first results relate to the TELSTAR satellite, it is to be noted that other communication satellites, including the RELAY satellite designed and constructed by the Radio Corporation of America, are to be launched by N.A.S.A. later in the year, and will provide additional information and data.

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THE CO-OPERATING GROUND STATIONS

In this first phase of the Project TELSTAR tests the co-operating ground stations were as follows:

(*a*) The American Telephone & Telegraph Co./Bell Telephone Laboratories station at Andover, Maine.

(*b*) The British Post Office station at Goonhilly Downs, Cornwall.

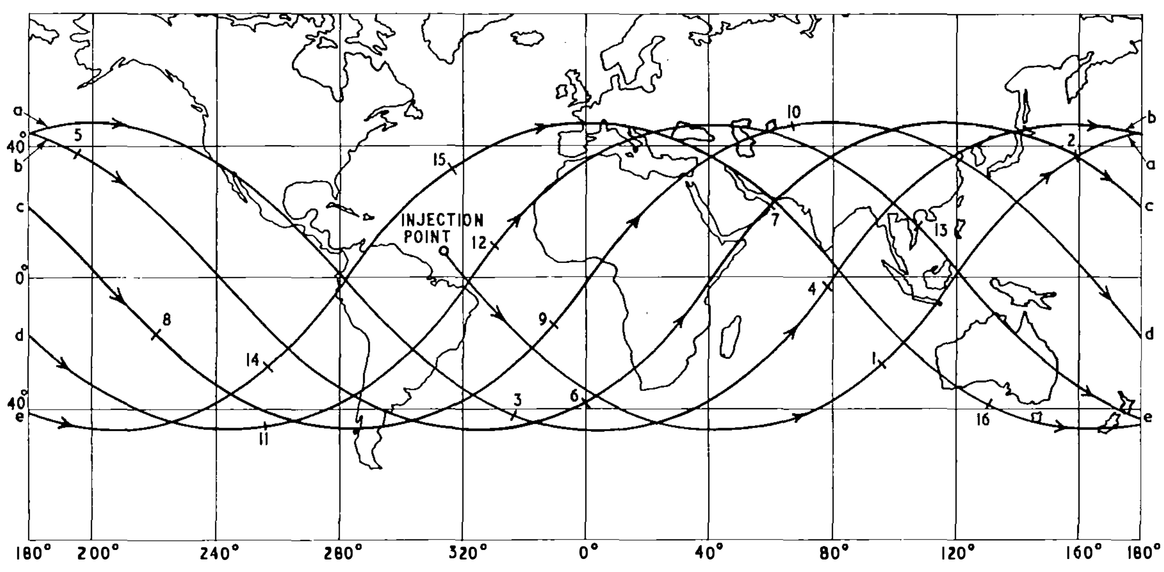
(*c*) The French station at Pleumeur Bodou, Brittany,

The American and French ground stations are of essentially similar designs, using steerable horn aerials some 175 ft long operating inside 210 ft diameter radomes.[4]

The British Post Office ground station, on the other hand, uses an 85 ft diameter steerable parabolic-dish aerial weighing some 870 tons that can be steered with the desired accuracy in winds up to 65 m.p.h. or more, without a radome.[5]

THE TELSTAR SATELLITE AND ITS ORBIT

The TELSTAR satellite, which weighs some 174 lb and is 34·5 in. in diameter, contains a single wide-band transponder suitable for the reception of wide-deviation frequency-modulated signals in a 50 Mc/s band centred on 6,390 Mc/s, and for amplifying and transmitting



Numbered marks on plot indicate hours elapsed after injection

FIG. 1—PLOT OF TELSTAR ORBIT (FIRST SIX PASSES)

them at a power of about 2 watts in a similar band centred on 4,170 Mc/s. These signals use right-circular and left-circular polarization, respectively. In addition, the satellite provides for the reception and transmission of v.h.f. command and telemetry signals, including the transmission of satellite environmental and condition data, and for the transmission of a low-power microwave beacon signal on 4,080 Mc/s for tracking purposes.

The TELSTAR orbit is elliptical and is remarkably close to the design objective: the actual orbital parameters are as follows:

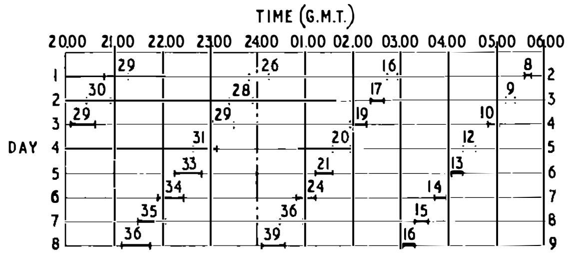
Perigee: 954 km (590 statute miles).

Apogee: 5,638 km (3,500 statute miles).

Inclination of plane of orbit relative to Equator: 44·8 degrees.

Period: 157·8 minutes.

A plot of the TELSTAR orbit, i.e. the location of the satellite projected on the Earth's surface, is shown in Fig. 1. It can be seen that each pass traces out a different path on the Earth's surface, due to the rotation of the Earth. The periods of mutual visibility between Andover and Goonhilly thus vary from pass to pass, and from day to day; typical examples are shown in Fig. 2.



x indicates the periods of mutual visibility and their durations in minutes

FIG. 2—TYPICAL VARIATION OF MUTUAL VISIBILITY BETWEEN ANDOVER AND GOONHILLY FOR TELSTAR SATELLITE

It is to be noted that Fig. 2 includes all the passes of mutual visibility occurring within each 24 hours. The periods of mutual visibility extend up to 30 or 40 minutes and occur in groups of three or four in each 24 hours. The start of mutual visibility is determined by the satellite appearing over the horizon at Goonhilly and the finish by its disappearance below the horizon at Andover.

Not all of a period of mutual visibility can in practice be used for tests or demonstrations. The usable time is less than the period of mutual visibility due to transmission-loss variations at elevation of less than about 2° and by the time required to turn off the satellite transmitter while still above the horizon from Andover.

ACQUISITION OF THE SATELLITE

In preparing for "acquisition" of the satellite the Goonhilly aerial is pointed in the direction of the point on the horizon at which the satellite will appear, using predicted orbital data supplied by the Goddard Space Flight Center, U.S.A. As described elsewhere,[1, 2, 3] the aerial is then steered automatically from 1-second data recorded on punched-paper tape, small corrections being applied manually. A very small circular scan of the aerial feed is provided to enable the direction of the beacon signal relative to that of the aerial to be determined.

It is of particular interest to note that at Goonhilly the satellite is generally "acquired", i.e. a signal is first received, with the aerial beam less than about 0·5° above the horizontal. The satellite is then almost 1° below the horizon, its apparently positive elevation being due to tropospheric refraction.

The accuracy of the predicted orbital data, and the steering of the Goonhilly aerial, has been such that the beam-direction corrections applied have been generally less than five minutes (angle) of elevation and ten minutes (angle) of azimuth, excluding minor calibration errors.

Fig. 3 shows the variation of received signal level with angle of elevation and time on a typical pass. It indicates:

(*a*) acquisition with the aerial beam close to the horizontal,

(*b*) variations of received signal in the first 2° of elevation (believed to be due to tropospheric propagation effects), and

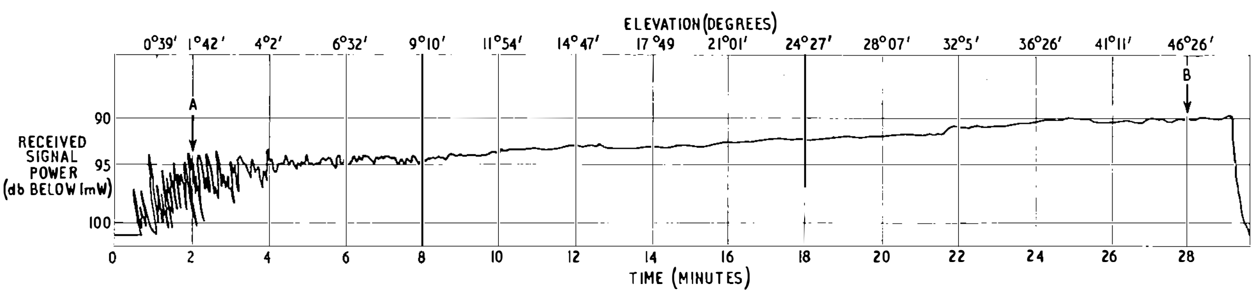
(*c*) a steadily increasing level of signal as the satellite range decreases from 7,000 to 3,000 miles.

Apart from the fluctuations in the first two degrees or so of elevation, the propagation of the microwave signals has been remarkably consistent and free from fading or multi-path effects.

DEMONSTRATIONS AND TESTS (10–27 JULY)

During the period 10–27 July, a number of demonstrations and tests were carried out involving the transmission of television signals (both video and accompanying sound, and including colour as well as monochrome signals), 12-channel both-way telephony, simulated 600-channel telephony, and phototelegraphy.

These demonstrations and tests, which illustrate clearly the potentialities of satellite systems for worldwide communications, are summarized below in chronological order.



At elevation A the satellite was 10,000 km from Goonhilly
At elevation B the satellite was 4,370 km from Goonhilly

FIG. 3—VARIATION OF RECEIVED SIGNAL LEVEL WITH ANGLE OF ELEVATION AND TIME DURING A TYPICAL PASS

10–11 *July: First Attempt at Television Reception*

A difficulty was encountered on the first usable passes (6 and 7) on the night of 10 July, due to a reversal of the direction of rotation of the wave polarization of the Goonhilly aerial relative to that of the TELSTAR satellite. This arose from an ambiguity in the accepted definition of the sense of rotation of circularly polarized radio waves, a difficulty which has been encountered recently in the U.S.A. as well as in the United Kingdom. The effect was to introduce a serious weakening of the strength of the signals received at Goonhilly and only a noisy picture was received on the sixth and seventh passes.

11–12 *July:* (*i*) *First Satisfactory Television Pictures Received at Goonhilly*
(*ii*) *First Live Transmission of Television by Satellite*

During the day of 11 July the sense of polarization of the Goonhilly aerial was reversed and in the evening, on pass 15, excellent pictures were received at Goonhilly from Andover. Fig. 4, the "Indian Head" test-card, is typical of reception at Goonhilly of signals from Andover at that time. During the 16th pass a live television transmission (the first live intercontinental television transmission by an active satellite) was made from Goonhilly to Andover. This transmission comprised still captions and test cards, followed by live pictures from British Broadcasting Corporation (B.B.C.) cameras, showing scenes in the control room at Goonhilly, with a commentary from Mr. Raymond Baxter of the B.B.C. and a talk by Capt. C. F. Booth, Deputy Engineer-in-Chief of the British Post Office. The pictures and accompanying sound received at Andover were reported to be of excellent quality and were broadcast as received throughout the U.S.A.; 15 minutes later they formed the basis of a recorded documentary program which was also broadcast by networks in the U.S.A.

FIG. 5—MAP OF THE U.K. TRANSMITTED FROM GOONHILLY VIA TELSTAR AND RECEIVED BACK AT GOONHILLY, 11 JULY 1962

Fig. 5 shows a map of the United Kingdom transmitted from Goonhilly via TELSTAR and received back at Goonhilly; Fig. 6 shows a scene from the live broadcast from Goonhilly, as recorded on video tape in the U.S.A.

12–13 *July: First Two-Way Transatlantic Telephony by Satellite*

During the 24th pass on 12 July the first two-way transatlantic telephony tests were made between engineers of the British Post Office at Goonhilly and the American Telephone and Telegraph Co./Bell Telephone Laboratories engineers at Andover. These tests, which used 12 telephone channels in each direction, showed that good-quality, stable telephone circuits with low noise levels had been achieved.

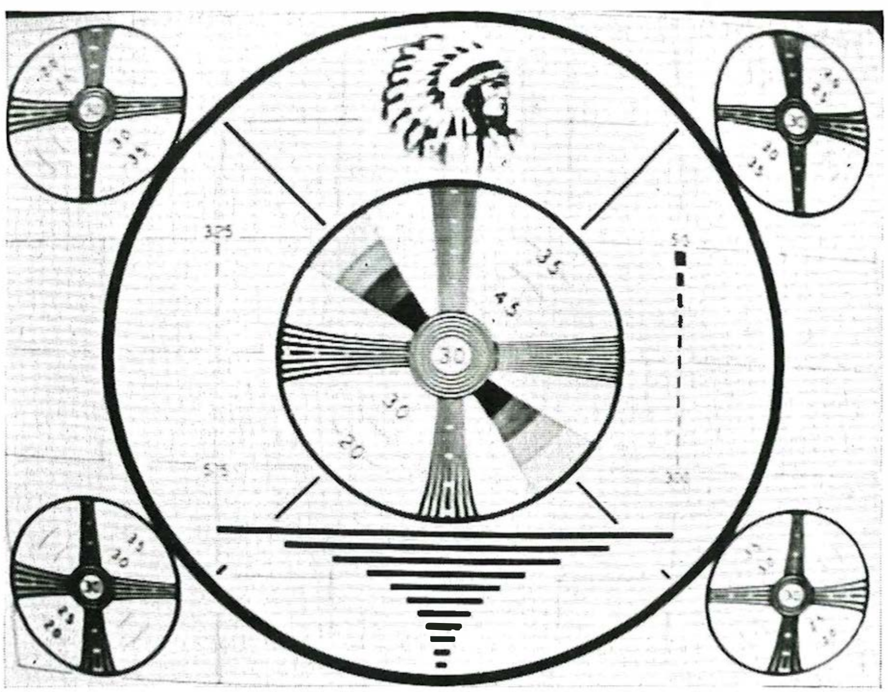


FIG. 4—"INDIAN HEAD" TEST CARD RECEIVED AT GOONHILLY FROM ANDOVER, VIA TELSTAR, 11 JULY 1962

14–15 *July:* (*i*) *Two-way Transatlantic Telephony Demonstrations*
(*ii*) *First Phototelegraphy Transmission by Satellite*

During the 34th pass on the night of 14–15 July a demonstration telephone call was carried out successfully between Sir Ronald German, Director General of the Post Office, at his home in London, and Mr. McNeely, President of the American Telephone and Telegraph Co., in New York. Simultaneously with this and other conversations in the 12-channel group, one pair of channels was used successfully to transmit phototelegraphy (facsimile) pictures between London and New York.

Fig. 7 shows the first phototelegraph picture to be transmitted by satellite, as recorded in London. It shows the TELSTAR satellite being mounted on the Thor-Delta launch vehicle, just prior to the satellite launching.

FIG. 6—SCENE FROM THE LIVE BROADCAST FROM GOONHILLY AS RECORDED ON VIDEO TAPE IN THE U.S.A., 11 JULY 1962

15–16 *July: First Tests of 600-Channel Transmission by Satellite*

Tests were carried out on the 43rd pass on 15 July to assess the ability of a communication satellite to transmit large numbers of telephone conversations. The tests were carried out on a one-way basis using "white" noise to stimulate 600 simultaneous 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 to the accepted standards of performance of first-grade international circuits, should be possible by satellite. (It is to be noted that the TELSTAR satellite incorporates only one wide-band transponder; the simultaneous two-way transmission of as many as 600 telephone circuits will require a satellite with two transponders or their equivalent.)

16–17 *July: First Transmission of Colour Television Signals by Satellite*

During the 60th and 61st passes on the night of 16–17 July the first transmissions of colour television signals by a satellite were made from Goonhilly, with the co-operation of the Research and Designs Departments of the B.B.C. who provided a colour-slide scanner and picture-monitor equipment. The signals, which were on 525-line, 60 frames/second National Television System Committee (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. Andover reported: "colour, good; picture quality, excellent." The success of these tests is a striking demonstration of the excellent transmission quality of the satellite link; in particular it was noted that there was no perceptible deterioration of colour quality due to Doppler frequency shifts.

Similar colour television transmission tests were also carried out on the 88th pass on the night of 19–20 July; these included transmissions from Andover to Goonhilly. Pictures transmitted from, and received back at, Goonhilly on this occasion are shown in the colour plate (facing page 147) together with pictures transmitted from Andover and received at Goonhilly. It will be appreciated that there are necessarily certain limitations with the presentation in colour-print form of the results achieved, due to the several processes involved and the different source of origination of colour plates (*e*) and (*f*) from that of colour plates (*a*), (*b*), (*c*) and (*d*). Nevertheless, it will be evident that the satellite link has a negligible effect on the transmission of colour television signals.

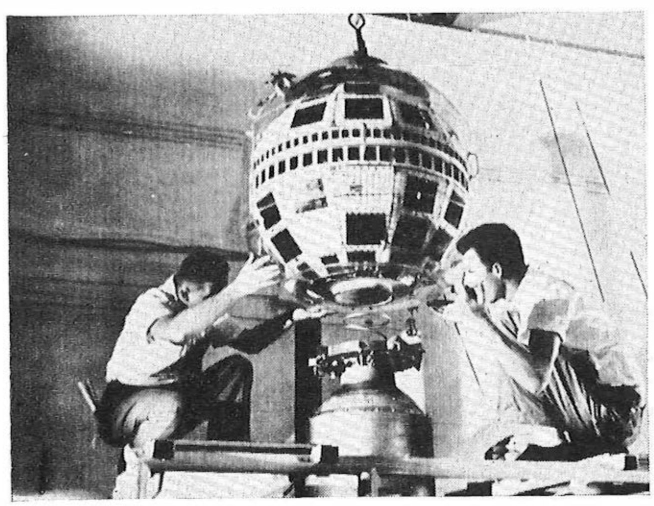


FIG. 7—FIRST PHOTO-TELEGRAPH PICTURE TO BE TRANSMITTED BY SATELLITE, NEW YORK TO LONDON, 14 JULY 1962

19 *July: Transatlantic Press Telephone Calls via TELSTAR*

On the initiative of the British Post Office, arrangements were made on 19 July, using pass 87, for the British Press to make telephone calls from Fleet Building, London, to the American Press in New York. Twenty-four calls were made with favourable comments as to the clarity of the reception and the absence of noise on the circuits.

23 *July: Transmission of European Broadcasting Union Television Program to the U.S.A.*

The European Broadcasting Union television program was transmitted from Goonhilly to Andover on the 125th pass on 23 July. The 18-minute program, which comprised scenes transmitted by the Eurovision link from many European countries, was 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.

26 *July: United States Information Agency's "People-to-People" Telephony Demonstration*

During the 151st pass on 26 July the TELSTAR satellite link between Goonhilly and Andover was used to provide seven two-way speech circuits for the United States Information Agency's "People-to-People" program involving telephone conversations between notable persons in some twenty selected pairs of cities in the United States and Europe. The satellite circuits were reported by the London International Exchange supervisor as "excellent."

Objective Tests

In the brief period under review it has not been possible to do more than commence the planned extensive series of objective tests. However, some interesting measurements have already been made in addition to the 600-channel noise-loading test already described. They include measurements of the gain/frequency response and group-delay/frequency response from baseband input to baseband output, psophometric noise, system noise-temperature/time characteristic, intermodulation, loading capacity and time domain (sine-squared pulse and bar) characteristics. These and other tests will be repeated frequently over a considerable period so that the overall performance of the satellite link can be determined on a statistical basis.

CONCLUSION

The results obtained from the TELSTAR demonstrations and tests to date have confirmed the expectation that active communication satellites could provide high-quality stable circuits both for television and multi-channel telephony. The very good results obtained with the transmission of colour television signals—a stringent test of any transmission system—and in the tests involving 600 simulated telephone circuits, are particularly noteworthy. However, much remains to be done to collect the detailed information and data on which the design of future systems for commercial operation must be based; in this the Goonhilly station will undoubtedly play a useful role.

The performance of the Goonhilly station, after the correction of the initial difference of polarization, has been excellent in every respect. The TELSTAR satellite has been "acquired" by the aerial, often within 1° of the local horizon, and tracked with great accuracy throughout the periods of mutual visibility. The complex electronic equipment, almost all of which is of new design, has worked well.

ACKNOWLEDGEMENTS

The authors would like to thank their colleagues, not only in the Space Communication Systems and Research Branches, but also many other Branches of the Engineering Department who were concerned, and in particular the staff of the South West Region, for their substantial contributions to the success of what has been a truly co-operative effort.

Their thanks are also due to the staff of the American Telephone & Telegraph Co. and the Bell Telephone Laboratories at the Andover ground station for their help in the demonstrations and tests; it is a pleasure to put on record the very friendly spirit of co-operation that exists between the Andover and Goonhilly stations.

On behalf of the British Post Office they would also like to pay tribute to the excellent co-operation received from the British electronics industry and the consulting engineers and contractors responsible for the design and construction of the large steerable aerial, and also to the staff of the British Broadcasting Corporation and the Independent Television Authority for their valuable contributions to the television demonstrations and tests.

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[3] Bray, W. J., and Taylor, F. J. D. The Post Office Satellite System Ground Station at Goonhilly Downs. *British Communications and Electronics*, Vol. 9, No. 8, p. 574, Aug. 1962.

[4] The Andover Ground Station for Project TELSTAR. *British Communications and Electronics*, Vol. 9, No. 8, p. 580, Aug. 1962.

[5] Husband, H. C. The 85 ft Steerable Dish Aerial at Goonhilly Downs. *British Communications and Electronics*, Vol. 9, No. 8, p. 584, Aug. 1962.

Book Review

"Power System Engineering." F. de la C. Chard, M.Sc., M.I.E.E. Cleaver-Hume Press Ltd. xi+288 pp. 154 ill. 50s.

This book deals with the methods of calculation needed for the design and study of systems of electricity supply. As the foreword indicates, not only are megawatts having to be transmitted over longer distances but more megawatts are having to be transmitted over moderate distances. Consequently power transmission engineers need the modern techniques of analysis of power supply systems described in the book.

Problems are stated by equations in matrix form and familiarity with the matrix and tensor concepts is necessary to study this work. To assist the reader, however, Appendix 1 states the fundamentals of matrix algebra which enables the simultaneous equations used to be expressed in a compact form.

Chapter 1 deals with the fundamentals of phasor algebra applied to electrical quantities and the quadrant diagram, and gives the values of component impedances and admittances for some typical circuits. The second chapter explains the principles of network solution, describes the various network laws and theorems employed, and works out in detail a typical network as an example of the methods used. Chapter 3 considers the various types of synchronous machine, their stability, maximum outputs and behaviour under short-circuit and parallel operation. The transmission line theory and operation are discussed in Chapter 4, and transformers, switchgear and protective gear in Chapter 5. The causes and effects of short-circuits, the resultant unbalance in the supply system and some examples of the effects of faults on a synchronous generator driven by a synchronous motor are described in Chapter 6 together with some useful information on network analysers. The last two chapters treat quite adequately the factors affecting the stability of a supply system and the various problems associated with the transmission of several hundreds of megawatts at extra-high tension.

The book is well written and printed, and is illustrated quite clearly and adequately, but its interest will be limited to the field of electrical engineers employed in the design of electricity supply systems.

R.S.P

Large Steerable Microwave Aerials for Communication with Artificial Earth Satellites

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U.D.C. 621.396.676:621.396.934

A review is given of the types, required characteristics, and the design and operation of large steerable microwave aerials. The many problems associated with the development and construction of these aerials are discussed, and indications of some solutions are also included.

INTRODUCTION

THE requirements for a large ground-borne steerable microwave aerial for communication with artificial earth satellites may be defined briefly as:

(*a*) high gain,
(*b*) narrow, but not too narrow, beamwidth,
(*c*) high efficiency,
(*d*) low noise-temperature,
(*e*) high figure of merit—which may be expressed, at any one frequency, as the ratio of aerial gain to the aerial noise-temperature,
(*f*) ability to steer over the whole hemisphere above the horizontal plane,
(*g*) ability to steer automatically either to a predetermined program or under the control of a beacon signal emitted by a satellite,
(*h*) suitability for simultaneous transmission and reception of signals,
(*i*) ability to withstand climatic conditions, and
(*j*) acceptable cost.

For aerials which are to be used experimentally there are two additional requirements: suitability for use over a wide range of frequencies, and flexibility of the aerial-feed arrangements to cater for changes of frequency and signal polarization. Aerials used for operational telecommunications systems will have as a further requirement the ability to remain operational under all but the most exceptional weather conditions.

The necessity for high gain is self-evident and narrow beamwidth is then unavoidable. When transmitting, the largest possible proportion of the signal energy should go in the right direction, the limit being set only by considerations of the ability to steer the beam. For reception the maximum of signal energy must be collected. Both of these conditions lead to the use of aerials with large apertures.

The requirement for high efficiency follows from considerations of gain and beamwidth but it is dictated mainly by the necessity to achieve low aerial noise-temperatures. If an aerial has an efficiency of, say, 70 per cent then some of the 30 per cent of ineffective energy transmitted or received will lie in lobes outside the main beam. It is not too significant if these minor lobes are at angles close to the main beam but if, as shown in Fig. 1, they are to the sides and back then the aerial noise-temperature will be degraded by noise received from the ground at a temperature approximating to 290°K. Also, there will be an increased likelihood of mutual interference with any ground services sharing the same frequency.

†Post Office Research Station.

The figure of merit must be high. It forms a useful means of comparison between receiving aerials for,

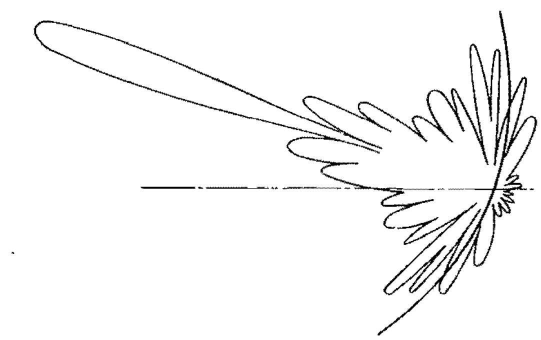


FIG. 1—SIDE LOBES RECEIVING NOISE POWER FROM THE WARM EARTH

clearly, a small and cheap receiving aerial will be as good as a large and more expensive one if the ratio of aerial gain to noise-temperature is the same, since, other things being equal, both are capable of giving the same received signal-to-noise ratio. However, it must be borne in mind that the use of an aerial of smaller gain requires increased transmitter power if it is to be used for communication to, rather than only reception from, a satellite.

As a satellite may appear, from a given ground location, anywhere in the hemisphere above the horizontal plane, ability to steer the aerial beam throughout the whole of that hemisphere is necessary. The rapidity of steering required will be determined by the maximum angular velocity, relative to the ground station, of the satellites to be followed and it is the low-orbit satellite that sets the limit. Control of the beam steering may be by means of predicted data, i.e. information in terms of forecasted co-ordinates and time, or by the reception of a beacon signal from the satellite, or by both. In addition, manual control will also be required.

Ability to withstand climatic conditions is an obvious requirement involving the effects of temperature, rain, wind, snow, ice and, in some parts of the world, seismic effects. Experimental aerials may be usable only under normal climatic conditions and turned to a stowed attitude of minimum stress when abnormal conditions obtain, but fully operational aerials will have to be designed to remain in service under all but the most extreme weather conditions. Radomes may be used to protect aerial structures from the elements, but it must be remembered that these, too, have to withstand the weather and cause some degradation of performance of the aerial.

Large aerials required for experimental rather than operational purposes need considerable flexibility in respect of their frequency range and aerial-feed structure. For example, aerials intended for exploring the range of frequencies most likely to be of interest for civil communications satellite systems need to be suitable for, say, the 1–10 Gc/s range, to be capable of being equipped with aerial feeds to operate at frequencies within that span, and to cater for both linear and circular polarizations.

TYPES OF AERIAL

The various forms of aerial structure that are available may be considered, somewhat arbitrarily, as falling into five categories:

(*i*) Multi-dimensional arrays of individually steerable or sensibly isotropic elements.

(*ii*) Simple parabolic-reflector aerials in which the ratio of focal-length to the diameter can be fixed within a wide range of possible values.

(*iii*) Offset-feed or horn aerials using part of a paraboloid of revolution as the reflector.

(*iv*) Multiple-reflector structures similar in principle to the Cassegrain or Gregorian optical arrangements.

(*v*) Spherical reflector arrangements in which only a relatively small part is illuminated at any one time.

Multi-Dimensional Array Aerials

The two-dimensional array of sensibly isotropic elements without mutual coupling may be considered as a field of aerials which may be given directive properties provided that they are interconnected in such a way that signals from, or to, the required direction add in phase with, ideally, mutual cancellation of signals from other directions. However, at present, the two-dimensional array does not look too promising in the applications with which this article is concerned. The numbers of aerials, amplifiers, phase shifters and interconnexions necessary are too great.

Parabolic-Reflector Aerials

Without doubt, present requirements are such that more favourable aerial structures are those presented by the large reflector types. Aerials based on the use of a parabolic reflector depend for their operation on the fact that a spherical wave emitted by a feed situated at the focus produces a plane transmitted wave. Conversely, a plane wave arriving parallel with the axis of the reflecting surface will result in a spherical wave converging on the focus.

Ideally, all of the energy from a feed would be incident upon the reflector and transmitted in the required direction. Practically, however, this is impossible and it is necessary so to design the variation of illumination over the reflector that the maximum figure of merit is obtained. For example, whereas the illumination taper of an aerial for a microwave line-of-sight system will be designed for maximum gain and edge illumination will be some 10 db below that at the centre of the dish, the illumination of a communications satellite system aerial may have an edge taper of some 12–16 db with a reduction of perhaps a decibel of gain but a figure of merit increased by some 4 db.

The very presence of a feed at the focus, and, where necessary, a structure to support it there, means that part of the aperture is obscured and there are scattering elements in front of the dish. Edge spill-over and scattering result in the propagation of energy in directions other than the wanted one, with consequent minor lobes in the radiation pattern of the aerial. Considerations of reciprocity lead to recognition of the fact that the minor lobes—some of which will "see" the ground under all attitudes of the aerial—will result in the pick-up of thermal noise and, hence, deterioration of the received signal-to-noise ratio. Much has been done to improve the efficiency of this type of aerial by careful attention to the design of feeds and to the configuration of the supporting structure.

Most of the large steerable microwave aerials used up to the present have been of the parabolic-reflector type. The classic example is the Jodrell Bank radio-telescope with a reflector diameter of 250 ft. The Jodrell Bank reflector is still the largest in the world but even larger ones are under construction. Aerials of some 60 ft and 85 ft diameter are now relatively common.

Clearly, there is a limit to the size of aerial aperture, which is fixed by considerations of both mechanical stability and cost. Again, for a given focal length the effectiveness of an increment of reflector surface becomes progressively less and less as the aperture is increased, as shown by Fig. 2. The reflecting surface is

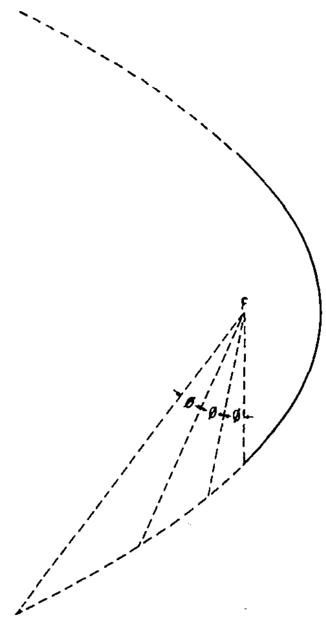


FIG. 2—DIAGRAM SHOWING DECREASE IN EFFECTIVENESS OF INCREMENT OF REFLECTOR SURFACE WITH INCREASE IN APERTURE

most effective when the ratio of focal length to aperture diameter, f/d, is large. However, under these circumstances spill-over is great unless considerable illumination taper is used, with consequent reduction of effective aperture area. Consideration is, therefore, being given to aerials of much lower focal-length-to-aperture ratio in spite of the fact that, for a given aperture, a larger overall structure is involved. f/d ratios as low as 0·1 are being considered, with the object of achieving aerials of maximum figure of merit. The aerial constructed at Goonhilly Downs for communications satellite experiments[1,2] has the focus in the aperture plane, i.e. the f/d ratio is 0·25.

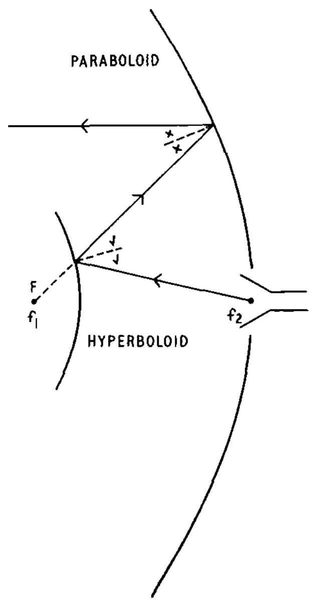
Horn Aerials

Without doubt, the reflector-type aerial with the highest figure of merit achieved so far is the horn unit as produced by the Bell Telephone Laboratories. This is made up of part of a paraboloid of revolution with the feed at the focus, metallic shields being provided to isolate the aerial from radiation to and from unwanted directions. The first steerable unit constructed was an aerial with a 20 ft square aperture. This aerial has a gain of 43 db at 2,390 Mc/s, and at that frequency, with the aerial pointing at the zenith, and a maser amplifier, it gives a receiver noise-temperature as low as 21°K. Aerials of this type, having an aperture of 3,600 ft^2, have been constructed at the Bell Telephone Laboratories' Rumford site in Maine, U.S.A., and at Pleumeur Bodou in France. The height is 94 ft and the overall length 177 ft.

The great advantages of the horn-type aerial are its high figure of merit and the ready accessibility of the focal point. Its disadvantage is that, to achieve a good performance, the horn taper must be modest, resulting in a structure that, for a given aperture, is both long and expensive.

Multi-Reflector Aerials

An attractive variation now under consideration in several laboratories and in limited practical application is to use the microwave analogue of the Cassegrain telescope. As will be seen from Fig. 3, an auxiliary reflector is used to transfer the focus to the apex or even to behind the main reflector. This has the great merit of placing the feed at a readily accessible point. However, there is necessarily some loss of aperture and there are two reflecting surfaces to produce undesirable spill-over effects. Nevertheless, such aerials have recently been constructed and their performance is most promising.



F—Focus of paraboloid
f_1—Focus of hyperboloid
f_2—Focus of combination

FIG. 3—CASSEGRAIN AERIAL

MECHANICAL TOLERANCES

All of the aerial structures considered above depend for their operation on the in-phase addition of signals. It follows that as wavelengths get smaller so do the tolerances on path length. This can be typified by consideration of the mechanical accuracy and stability of the focal point and reflecting surface of a conventional front-fed parabolic aerial. In order to achieve high gain and efficiency it is required, typically, that over 99 per cent of the surface of the reflector the r.m.s. deviation from the true parabolic contour shall not exceed one sixteenth of a wavelength. It will be apparent that the distance between the focus and all points on the reflector must conform to this limit. Thus, if an aerial is to be satisfactory up to 10 Gc/s then, as a sixteenth of the shortest wavelength amounts to just under 2 mm, an r.m.s. tolerance of 2 mm must be achieved.

In a large steerable aerial this high degree of accuracy presents numerous problems, for the dish and feed supporting structures have to be extremely stiff to maintain the required tolerance under all attitudes of the dish, ranging from the aperture-plane vertical to horizontal. Again, temperature differences, as between sunlit and shaded elements of the structure, and ice and snow loading can each give rise to distortions which must be controlled. Wind, too, can cause distortion and element vibration, as well as making necessary powerful driving means to ensure negligible movement of the beam axis.

It is of interest that for aerials with 250–600 ft diameter apertures now under design, consideration is being given to the use of adjustable reflector surfaces. The reflector will be made up of a number of individually movable surfaces positioned by cams and controlled automatically by optical or radio measurements.

Various types of reflector surface are used. Open mesh has been employed in some cases for this produces a light structure and reduces wind loading; however, it imposes radio-frequency and mechanical-distortion limitations. Alternatives now more commonly employed are:

(*a*) small interlocking flat plates,
(*b*) pre-formed curved plates, and
(*c*) stretch-formed laminates similar to those used in the aircraft industry.

RADOMES

Considerations of aerial stability have led to an examination of the possibility of using radomes to shield the aerial from the worst onslaughts of climatic conditions, though radomes do not reduce the stiffness requirement for the aerial imposed by limitations of the static and dynamic distortions resulting from aerial attitude and acceleration.

A radome supported by rigid reflecting members would be unacceptable as it would reduce drastically the figure of merit. It has, therefore, been proposed to construct self-supporting radomes using a series of interlocking multi-sided flat sheets. The 3,600 ft^2 aperture horn aerials mentioned earlier are protected by skin radomes 161 ft high and of 210 ft diameter; the radomes are maintained by air pressure ranging from 0·02 to 0·2 lb/in^2 depending upon the wind velocity. The internal air is stirred to maintain an even temperature, and in winter is heated to prevent the accumulation of ice and snow on the outer surface of the radomes.

Certainly, radomes can be used to protect an aerial structure and to make it lighter and cheaper. On the other hand, the radome itself is expensive and degrades the performance of the aerial; it may be expected to raise the effective aerial noise-temperature by some 20°K or more. There will have to be an economic appraisal of protected and unprotected aerials, due account being taken of ground-station climatic conditions and of the degradation of electrical performance which may have to be offset by greater satellite-transmitter power.

AERIAL FEEDS

Aerial feeds present a complex problem, particularly if there is to be simultaneous transmission and reception with a level difference of, for example, 160 db.

Clearly, the design of aerial feed is dependent upon frequency, band-width, polarization and power-handling requirements. As a result, there are many different types ranging from the simple flared-horn to complex structures designed for the simultaneous transmission of high-power and the reception on a different frequency of a minute signal received from a remote satellite.

It is a significant design point that any waveguide or coaxial cable between an aerial feed and the associated transmitter or receiving amplifier should be as short and have as low loss as possible. For obvious reasons it is undesirable to have many tenths of a decibel of loss in transmission lines, particularly if transmitters of several kilowatts are involved. It is perhaps less obvious why loss before the receiving amplifier is to be avoided; the reason is two-fold. In the first place, the signal is attenuated, and in the second, if the attenuating element is at normal temperature, noise is introduced at a rate which, at low attenuations, amounts to some 7°K for each tenth of a decibel. To attain a specified signal-to-noise ratio would require increasing the satellite transmitter power by an amount equal to the transmission-line attenuation plus an additional amount required to over-ride the added noise.

AERIAL MOUNTING

Up to the present time there have been two broad classes of reflector mount used for large steerable aerials. In one class the reflector is carried on two axes crossing at right angles to one another; rotation of the reflector about these axes permits the aerial beam to be pointed in any direction. The axes may be set in a variety of ways relative to the axis of the earth and this type of mount is then known variously as equatorial, polar, HA-DEC (or hour angle/declination) or, simply, X-Y.

The other class also involves two axes at right angles, but in this case one is vertical and the other is horizontal. Rotation about the vertical axis provides for variation of azimuth and about the horizontal axis gives change of elevation. This is the so-called azimuth-elevation or Az-El arrangement.

Two-axis mounts suffer the limitation that there must be a small cone of bearing through which the beam cannot traverse at the required angular velocity. This can be overcome by providing three axes and, for any satellite pass, selecting for use whichever pair of axes will permit full tracking of the satellite.

The reflector mounts for large steerable aerials present severe problems in mechanical and civil engineering, for great stability and accuracy of drive is necessary to achieve the beam-pointing accuracies that are required; aerials for communications-satellite experiments have, typically, a beam width of only a few minutes of arc so that axis-pointing accuracy to, say, 5 minutes of arc is necessary.

Considerable accommodation for apparatus is often required at the feed point, particularly if maser amplifiers and their associated refrigeration equipment are used. In this respect the front-fed dish-reflector aerial is highly inconvenient, though in some structures a small apparatus room has been provided at the focus. With a view to eliminating the requirement for an apparatus room at the focus of a front-fed dish, a room, or rooms, are sometimes provided immediately behind the reflector and, in extreme cases, mounted on gymbals so that humans as well as apparatus can be accommodated when the aerial is in operation. The penalty is, however, an increase of feeder losses and aerial noise-temperature.

Apparatus rooms are often provided at ground-level; sometimes within the supports of the structure. Frequently, these ground-level apparatus rooms are integral with, and rotate with, the aerial. A considerable advantage of the horn-type structure on an azimuth-elevation mount is that the focal point lies in one horizontal plane whatever the attitude of the aerial; it follows that apparatus may be placed in a cabin at the throat of the horn, and transmission losses and noise between feed and apparatus are almost eliminated.

The necessary radio-frequency transmission lines within an aerial structure will usually be of coaxial or waveguide type, depending upon the frequencies used, the losses that can be tolerated, and the power to be handled; the design of such lines can offer many problems. Waveguide runs may require the insertion of low-noise rotary joints and the angular movement of coaxial cables consequent upon changes of aerial direction can sometimes be accommodated by providing bights.

Connexions between a rotatable aerial and apparatus in static ground-level apparatus rooms can also present problems. They are overcome in most instances by ensuring that such connexions have to carry d.c., low-frequency a.c., or intermediate-frequency rather than radio-frequency currents. Slip rings have been used extensively but it is more common to restrict the rotary movement of the aerial to, say, one and a half turns and to make the connexions as multi-turn helices or provide bights tolerant to the small amounts of twisting involved.

STEERING

Invariably, to turn reflectors in azimuth and elevation a separate actuating mechanism has to be provided for each axis. The powers involved are large, and depend upon the size and weight of the movable elements, the velocities and accelerations required, the maximum wind velocity in which the aerial is to remain operational and, in the case of aerials using an azimuth-elevation mount, the size of the zenithal cone through which the horn cannot traverse at operational velocities. Typically, an aerial having a reflector of 85 ft diameter may require motors totalling some 200 h.p. Frequently, there will be several actuating mechanisms in parallel; for example, if there are several vertical members mounted on a horizontal circular track then motors may be provided for each member.

A not inconsiderable mechanical problem is that of obtaining smooth motion at very low velocity, which is very necessary when the satellite to be tracked is moving at a low angular velocity relative to the observing point and when the beam width is very small. Great care has to be taken to reduce the backlash to a minimum.

The most commonly used actuating means are hydraulic and electric motors. When the latter are employed it is common practice to use a Ward-Leonard type of control. A point which requires particular attention when electric drive is used is the suppression of radiation and mains surges; the wanted incoming electrical signals received by the aerial are so small that they can tolerate only minute interference.

To direct large steerable microwave aerials towards a satellite to which a signal is to be sent, or from which one is to be received, requires basic positional information which may be derived from a knowledge of the orbital elements or from a signal emitted by the target.

Orbital data may be derived from optical sighting, radar contact or measurements made on a transmission from the satellite. Often a combination of these techniques is used. Once the orbital elements are derived the local bearing/time characteristics can be determined, but these must be brought continually up to date for all orbits are subject to perturbations.

The observed characteristics of the orbit may be used to produce a steering tape, e.g. magnetic or punched-paper tape, which is used to give a position-and-time input in discrete steps. Interpolation of the discrete-step data is necessary so that velocity components can be generated to limit hunting and overshoot. Accuracy of position is achieved by deriving error signals which are fed back to the steering control-equipment input; typically, these error signals will be obtained from a comparison between the input data and the positions of the shafts determining the actual aerial-steering angles. Many ingenious mechanical, optical and electro-mechanical devices have been produced for determining shaft position, and it is possible to determine this quantity to a few seconds of arc.

Tracking networks can give positional accuracy to 0·1° some few hours after the launching. But even this high accuracy is insufficient when using large-aperture aerials at the high frequencies, which result in beam widths of only a few minutes of arc. Furthermore, there are refraction and tropospheric effects which, at the lower elevations, cause the true and radio directions of the satellite to differ slightly. It is, therefore, desirable that the radio direction to the satellite should be determined by the angle of arrival of an emission originated by it, the beacon signal being either that bearing the intelligence or one having a frequency very close to it. By a variety of techniques it is possible to derive an error signal in terms of the difference between the aerial-pointing angles and those of the incoming beacon signal and so generate a correction.

Thus, there are two processes for steering an aerial on to an active satellite. In the first, the aerial is steered primarily on the basis of predicted data, a correction signal being generated by a measure of the error between the aerial-pointing angle and the angle of arrival of a beacon signal. In the second, a wide-angle search-beam scans a pre-determined portion of the sky, awaiting the arrival of the beacon; once the beacon is received the direction can be determined and the large aerial steered appropriately.

Methods currently in use or under investigation for the automatic tracking of a beacon signal fall into three categories:

(*a*) Split-beam techniques.

(*b*) Conical or raster scanning.

(*c*) Generation of direction-dependent electromagnetic modes.

The split-beam technique has long been used in the radar field. Briefly, two slightly offset feeds result in the production of two beams, equality between them indicating the direction of the incoming echo or beacon signal. By adding and subtracting signals, correction information is derived for aerial steering. For the satellite application, steering data are required for elevation as well as azimuth control so orthogonal pairs of offset feeds are required.

Conical or raster scanning involves deflecting the aerial beam through a predetermined small excursion while measuring the magnitude or phase of the beacon signal. The beam swinging may be effected, for example, by having a rotating, shaped, dielectric prism in front of the feed, though this is limited to low-power applications. An alternative is to actually move the feed mechanically. It must be stressed that the degree of beam swinging that can be achieved by these techniques is very small; larger excursions will result in beam broadening, loss of gain, and a severe increase of aerial noise-temperature. The Cassegrain configuration offers an interesting alternative form of beam swinging, for mechanical movement of the auxiliary reflector can be used to produce conical, spiral or raster scans as required.

Mode-sensing techniques rest upon recognition of the fact that, with certain structures and for certain incoming-wave configurations, arrival angles other than the optimum will result in the production in the feed or its vicinity of particular electromagnetic-wave configurations which can be used to provide steering corrections.

AERIAL SITING

The siting of aerials is determined by two considerations: the received signal is minute and the aerial noise-temperature must be very low.

As the received signal is very small, the aerial must be sited in an area remote from possible sources of interference. In general, this means selecting a location well away from industrial areas and from transmitters which might give rise to interference. Sometimes, hills can be used as screens and some large aerials have been placed within shallow natural bowls.

Considerations of aerial noise-temperature lead to the selection of a site with a clear all-round view to an horizon having, at worst, only very small positive angles of elevation. Obviously there is a conflict here between the use of surrounding hills as natural interference screens and the effect that their presence has on aerial noise-temperature.

AERIAL-PERFORMANCE MEASUREMENTS

Testing large steerable aerials for performance is no easy task. But it is necessary to undertake such tests to determine how far the structures depart from the design goal and what appropriate corrections, if any, must be applied when steering them.

The first tests are of mechanical accuracy, and ideally this requires to be done with the structure in a large variety of attitudes and under a representative series of climatic conditions. The techniques are mainly optical or mechanical, and are akin to surveying.

Electrical tests are complicated by the fact that, in general, the far-field pattern will be generated only at a distance in excess of several miles. To measure the field at low elevations involves the use of masts, transmitters, and receivers some miles away from the aerial under test. The aerial beam can be tracked slowly in the horizontal plane and the radiation pattern examined by determining the magnitude of either a transmitted or received signal. But this test gives the characteristic in only one plane and with the aerial directed near to the horizontal; the pattern will be subject to error resulting from ground reflections and, in still air, tropospheric bending.

A technique for testing at a limited number of elevations above the horizontal is to scan the beam through the emission from some of the more prominent radio-stars, the positions of which are known with sufficient accuracy. It is of interest that the sun is not a useful source in this context in view of its wide angle ($\frac{1}{2}°$) relative to the width of the aerial beams considered here.

Without doubt, the most comprehensive test of beam characteristics is that involving the flying of transmitters in aircraft. Typically, an aerial is steered to a predetermined direction and locked. A high-flying aircraft in the far-field range carries a transmitter, and the magnitude of the received field is recorded as it flies on various bearings relative to the aerial beam. By this means a three-dimensional pattern may be built up. The technique does, however, demand an accurate knowledge of the position/time characteristic of the aircraft. One means of obtaining this is to carry out the test on a cloudless night, equip the aircraft with a flashing light of known time/duration characteristic, and photograph the aircraft track with a telescope steered in sideral time to give a bearing reference in terms of a fixed-star background.

CONCLUSION

It must be remembered that the design and operation of large steerable microwave aerials is a new art; one that is only a very few years old. Doubtless, there will be many changes in the next decade and it is interesting to speculate.

It would be desirable to get away from large structures that have to be moved mechanically; the objective should be a fixed rigid aerial that is steered electrically, but which is still capable of high gain and resolution, and is of a very low noise-temperature.

This is a challenging field and one which clearly involves continued extensive study by not only the radio engineer but also by his colleagues in the fields of power, civil and mechanical engineering.

ACKNOWLEDGEMENT

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Book Reviews

"High-Frequency Magnetic Materials." W. J. Polydoroff. John Wiley & Sons, Ltd. x + 220 pp. 117 ill. 72s.

The outlook of this book is ten years out of date. By now, metallic powder cores, though by no means extinct, have been displaced for most purposes by ferrites, mainly because of the ease of winding and adjustment of an inductor constructed on a ferrite pot-core. Yet this book devotes 17 pages to ferrites for inductor cores and 38 pages to powder cores. (There are also 23 pages on ferrites for microwave use, but they do not affect this comparison.) The rest of the book is at first sight equally relevant to powder cores and to ferrites, but, in fact, it has a strong bias towards the concepts appropriate to powder cores. There is other evidence that most of it was written some years ago—most of the references arc to prc-1950 publications, while the chapter on ferrites has a list of 21 "other pertinent references" of which the latest is dated 1956.

Nevertheless, this book is of interest. It is the work of a man who knows his subject, though his outlook is that of a latter-day Edison, reaching a useful result but giving reasons which appear to other people as inadequate or wrong. There are passages which suggest an excellent and by no means easy exercise: to ask "Does this way of looking at it teach us anything new? Can it be reconciled with the usual one? And if not, how would I explain my point of view to Mr. Polydoroff?"

In spite of his generally empirical and descriptive approach, the author quotes a number of formulae which would probably suffice for the design of an inductor for a particular application. But for this purpose there are other, better, books. The main interest of this one is that, between the lines, it is a technical autobiography of a man who provokes disagreement yet whose long experience entitles his opinions to a hearing.

A. C. L.

"National Certificate Mathematics." Vol. II (Second Year Course). P. Abbot, B.A., and H. Marshall, B.A. Completely revised by W. E. Fisher, O.B.E., D.Sc., A.M.I.Mech.E. The English Universities Press, Ltd. xii + 412pp. 133 ill. 9s. 6d.

This book was first published, together with the companion Volumes I and III, in 1938, and since then has given invaluable service to countless students, including many who were taking courses other than that leading to the Ordinary National Certificate. Very few changes have been found necessary in the text, but the number of examples included for practice has been increased considerably by extractions from modern examination papers.

A feature of this book is the careful treatment given to those parts of the syllabus which invariably appear difficult to students, but which have an important bearing on their subsequent studies. For example, two whole chapters, amounting to some 30 pages, have been devoted to more advanced work on logarithms, and the chapter introducing students to the differential calculus is also most comprehensive. There is a notable weakness in the treatment of the Binomial Theorem, however, which fails to emphasize sufficiently the importance of the expansion of $(1+x)^n$.

The presentation of the material is extemely clear and concise, and is ideally suited for a student who wishes to supplement his technical-class instruction by private study. The various sections of each chapter are amply supported by worked examples, and there are over 600 questions, generally of examination standard, which the keen student can use for practice.

Since this book was revised, the pattern of the Ordinary National Certificate course has changed, following the publication of the Government White Paper on "Better Opportunities in Technical Education." Consequently, the S1, S2 and S3 years no longer exist as such, and are being replaced by a general course leading to the O1 and O2 years of the O.N.C. Although Volume II of this series of mathematical text books was written to cover the old S2 syllabus, students will find that it is also quite adequate for the new O1 requirements in this subject.

G.H.K.

Recording and Control of Information-Service Announcements

G. L. SMITH, A.M.I.E.E., and G. HUGGINS†

U.D.C. 621.395.625.3:621.395.91

Recorded announcements of information, such as weather forecasts, are available to telephone users by dialling the appropriate codes or final-selector directory numbers. The number of services provided makes it economic to have a common pool of recording machines at the larger centres. The arrangements for recording the announcements, the methods of giving access to them from exchange switching equipment and the way in which they are distributed are described.

INTRODUCTION

THE speaking-clock service[1], introduced before the war, was the first recorded-information service to be provided in this country. In 1955 a weather information service[2] was provided, followed by the cricket test score, Automobile Association (A.A.) state of roads[3], and tri-lingual Teletourist services; the equipment used for these services is the subject of the present article.

Speaking-clock announcements, once recorded, thereafter remain unchanged. Special equipment is provided for this important service, and to ensure continuity, duplicate installations at London and Liverpool distribute the announcements nationally over ring circuits.

For the other information services it is necessary to change the announcements at frequent intervals, and equipment of a more conventional type is appropriate. For the first weather service, three tape recorders were used: one for reproducing current announcements, a second for recording a new announcement, and a third as a standby machine. Multiplication of machines on this basis as additional services were provided would have been very wasteful, and, except at small centres, the present information services are supplied from a pool of machines, any one of which can be used for any service. By remote control, a machine is selected, the recording made and the machine connected to provide the appropriate service.

The recordings, with the one exception of the Teletourist services for which the announcements are recorded by B.B.C. staff, are made by Post Office operators. The recorded information is amplified and is available to the public from main or local distribution centres by dialling the appropriate codes or final-selector directory numbers.

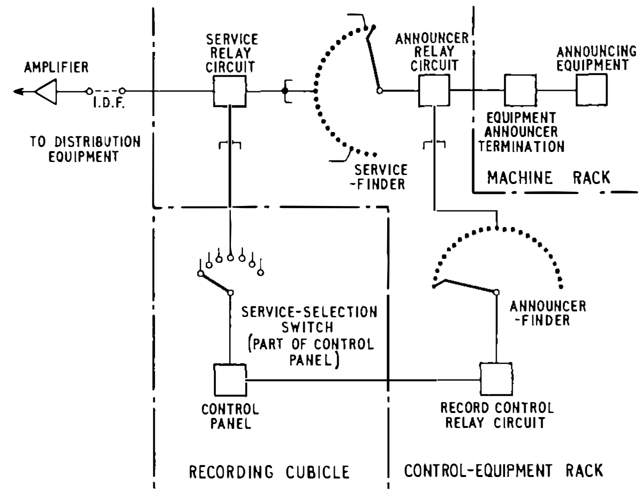
RECORDING CENTRES

When an announcement distribution centre is selected, preference is given to a group switching centre (G.S.C.) having a manual switchboard in the same building, so that operating staff are always available to make recordings. Where such a choice is not possible, the recording and control equipment is installed in the nearest exchange having operating staff, and the recordings are extended over junction cables to amplifiers at the G.S.C. for distribution.

Control Equipment

Large Centres. The basic functions of the control equipment are: to provide access to a machine; to enable the previous recording to be erased and a new message recorded and played back for check; to cause the cycle to be repeated until a satisfactory announcement has been recorded; and, finally, to connect the new announcement to the distribution equipment in place of the existing announcement.

Fig. 1 is a block schematic diagram of the equipment



A complete installation caters for 20 information services, 24 announcing equipments and three recording control panels

FIG. 1—BLOCK SCHEMATIC DIAGRAM OF CONTROL EQUIPMENT

used to control up to 20 information services using a pool of 24 machines; three recording control panels, each in a separate recording cubicle, are provided for a fully-equipped centre. Fig. 2 shows the face layout of a control panel.

A lamp display is provided on the control panel to indicate which machines are available for use, and the lamps opposite the numbers of all free machines glow when the appropriate key is depressed. When a free machine has been identified, a 24-position machine-selection switch is turned to the appropriate machine number and a connect key operated. This causes the announcer-finder to switch the control circuit through to the selected machine and to switch on the machine ready for the normal processes of erasure, recording and playback.

When the new recording has been checked by the operator, a 20-position service-selection switch is turned to the required service and the service monitored; at the end of the announcement, or at some convenient point, a change-over key is operated causing the service-finder of the selected machine-circuit to move to the selected service and disconnect the machine already supplying the announcement. On release of the change-over key the machine with the new recording is switched into service and the disconnected machine is returned to the pool of spare machines.

Only one control panel at a time can use the change-over circuit, and a supervisory lamp signal glows on the other two control panels while one panel is effecting a change-over. The limited availability presents no difficulty since the change-over time is less than 3 seconds. The control equipment also enables the operator to

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FIG. 2—CONTROL PANEL FOR USE AT LARGE CENTRES

ascertain which machine is connected to a particular service at any time, to monitor machines in service and to extend play-back of an announcement to a remote office before connexion to the distribution equipment.

Fig. 3 shows the basic transmission path used in

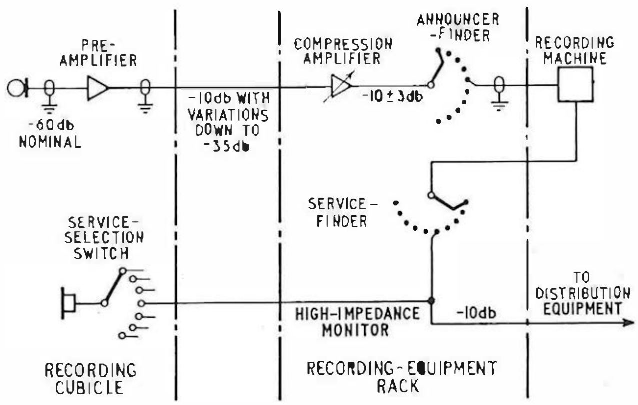


FIG. 3—TRANSMISSION PATH

recording and distribution. Acceptable announcement reproduction with adequate volume when different operators dictate the announcement is ensured by using a good-quality moving-coil microphone and a compression amplifier that maintains the nominal output level within ± 3 db. The microphone output is − 60 dbm* nominal and is amplified by a low-noise 50 db-gain transistor-type pre-amplifier whose output is connected direct to the input of the compression amplifier by screened-pair cable. Owing to the high gain of the compression amplifier with no input signal, induced electrical noise or crosstalk from relays or other similar devices could cause background noise and distort announcements recorded at a low level. The effects of switching-transients and crosstalk are reduced by connecting the pre-amplifier at a point near to the microphone in the recording cubicle, so increasing the signal level in the screened pair to the input of the compression amplifier.

With a noise level of −70 dbm at the input, the compression amplifier can be adjusted to cater for speech input-level variations between − 10 db and − 35 db while maintaining an output level within ± 3 db of nominal, with acceptable quality and a satisfactory signal-to-noise ratio. In practice, the range of level variation with a trained operator speaking is much less, and an optimum adjustment for the compression amplifier at each centre is determined from test recordings made by the operators concerned, this adjustment then remaining unchanged.

A nominal level of − 10 dbm is maintained throughout the rest of the transmission path, which consists of electromechanical components to switch the announcement to a recording machine or connect the output of a machine to the input of the distribution amplifier. Normal speech transmission levels through this section of the transmission path allow standard techniques to be used for cabling and wiring the equipment. The provision of a high-grade transmission path between the microphone and compression amplifier and a normal-grade path through the major part of the equipment gives announcements of an acceptable quality with adequate signal-to-noise ratios.

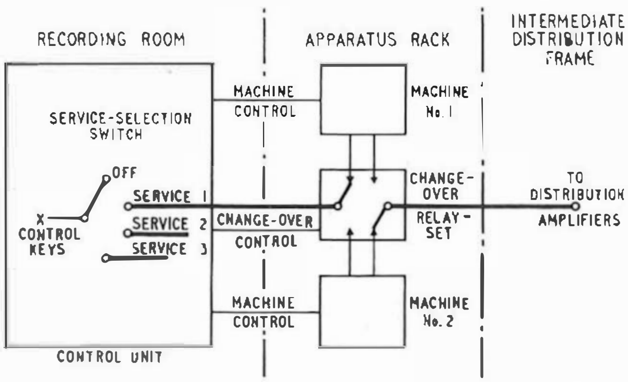
Small Centres. The small recording centre caters for a maximum of three services operated from a single control panel (Fig. 4). The control equipment is simple, since there are two machines permanently associated with each

FIG. 4—CONTROL PANEL FOR SMALL CENTRES

* dbm—decibels relative to 1 milliwatt.

service, one providing service while the other lies idle awaiting a revised recording. Six machines are required, therefore, for three services. If a single machine were used for each service, allocated from a common pool of machines, it is doubtful whether a centre could operate three services satisfactorily with less than a total of five machines, and more complicated and costly control equipment would be necessary.

Fig. 5 shows, in simplified form, the arrangement used. The output of the machine selected to supply the



The machines and change-over relay-sets for services 2 and 3 are connected similarly to those for service 1

FIG. 5—SIMPLIFIED BLOCK SCHEMATIC DIAGRAM OF EQUIPMENT AT SMALL CENTRE

announcement is connected, by control of the change-over relay, via the intermediate distribution frame to the distribution amplifier, and each service has a change-over key on the control panel connected so that while one machine is in service the other is available for connexion to the recording circuit. Connexion of the common recording circuit to the spare machine of a service is controlled by moving a rotary switch to the appropriate service position; the same operating procedure for recording as with the equipment for larger centres is then followed.

ANNOUNCING MACHINES

The machines used are either modified commercial dictating machines or machines specially developed for information services, such as those designed at the Post Office Research Station[4].

Both types of machine give recorded announcements having a duration from 10 seconds to 4 minutes and include a memory device, either mechanical or electrical, to store information relating to the end of the announcement. The arrangement is such that continuous repetition of playback is given with a gap not exceeding 12 seconds between the end of one announcement and the beginning of another.

The machines use a plastic material impregnated with iron oxide as the medium for announcement recording. This material, taking the form of a drum-mounted tire or flat disk on a turntable, revolves beneath a recording and replaying head, and during both recording and playback an identical spiral track is traced across it.

With the electrical memory device a tone is recorded magnetically to mark the end of the message, and on playback this tone is detected electronically and operates a return mechanism. Machines with the mechanical device have a retractable arm positioned, at the end of the recording, by an electromagnet so that when the end of message is reached on playback the tip of the arm operates a microswitch and thence a return mechanism.

The nominal frequency response given is 200–3,400 c/s with input and output levels of − 10 dbm.

DISTRIBUTION AMPLIFIERS

The announcements received at a distribution centre may come from recording machines in the same building, from a remote building or over line links from other centres. Under these conditions the received level of announcement may vary between − 20 dbm and + 10 dbm, and the 2-stage distribution amplifier has been designed to cater for this range of levels. As a terminating amplifier its input impedance is 600 ohms; when tapped across a circuit distributing national services, such as cricket-test score, its input impedance is 5,000 ohms, giving a tapping loss of less than 0·5 db on a 600-ohm circuit.

The number of simultaneous connexions to the output of the amplifier can vary between 1 and, say, 200 at any time. To ensure that under these conditions there is no appreciable change in output level, the amplifier is connected via transformers to provide a low-impedance output at the distribution point.

A speech-level alarm circuit is included that can be adjusted to operate to a 12 db decrease in speech level which is continued for 30 seconds but not to a maintained decrease of 10 db. Under alarm conditions incoming calls are not switched but are connected to busy tone.

The amplifiers (Fig. 6) are rack mounted and connected

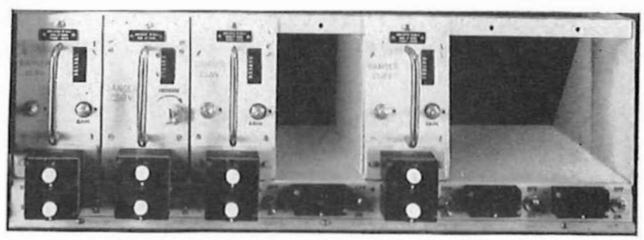


FIG. 6—DISTRIBUTION AMPLIFIERS

to the shelf wiring via multi-contact links to enable a faulty unit to be quickly replaced, a necessary feature since few services justify the cost of automatic change-over. If the importance of a service warrants standby arrangements, however, two amplifiers are provided together with a change-over relay-set which includes alarm facilities.

ACCESS TO ANNOUNCEMENTS

The arrangements made for access to the announcements from the exchange switching equipment depend upon the traffic that a service attracts from the public. Services with an average volume of traffic or a large volume outside the busy hour are connected to the banks of information-service final selectors; calls to a particular service are then switched to the common outlet allocated to the service, as the information-service final selector does not busy the outlet to which it switches.

Services with very high calling rates or heavy traffic peaks that might affect normal traffic are obtained via group-selector levels and special relay-sets similar to those used for the speaking-clock service.

An outline of the trunking arrangements covering these two conditions in a typical non-director area G.S.C. is shown in Fig. 7. The test-match-score service shown connected to level-1 group-selector outlets via outlet relay-sets is an example of a nationally distributed high-calling-rate service with automatic standby announcement facilities. The national speaking-clock service is provided with standby facilities, but, having a more average calling rate, is connected to the bank outlets of information-service final selectors. Other less important services, such as local weather and A.A. road services, are connected via simple control relay-sets to the outlets of the special final selectors.

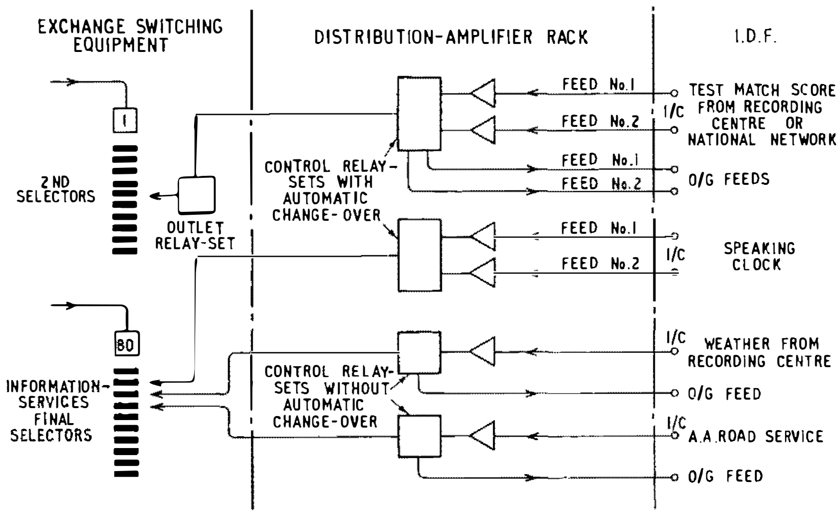


FIG. 7—TYPICAL TRUNKING ARRANGEMENTS

The arrangements in Fig. 7 show that, for some services, feeds from the G.S.C. are provided to other centres for local-distribution purposes. By giving local access in this manner, much of the information-service traffic originating within any group is diverted from the G.S.C., thus avoiding congestion of its junction routes and switching equipment. The equipment required at the local distribution centre is similar to that shown in Fig. 7.

CONCLUSION

The two standard recording-control equipments now available for information services are of adequate flexibility and capacity to meet any likely future demands for services that are recorded and controlled by the Post Office.

The Teletourist services differ in that they are B.B.C. recordings made by announcements transmitted from the B.B.C. offices over a junction to the Post Office recording centre, a separate recording machine being allocated for this purpose. The recorded disk has then to be transferred manually to one of the pool machines. Development is now in hand to enable such recordings from an outside source to be made via the normal recording-control panel, which will be attended by a Post Office operator who will check the recorded announcement and connect it to the public service.

The control circuits of both equipments have been designed to work into a variety of remotely-controlled recording machines so that advantage may be taken in the future of the competitive market in recording equipment.

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"Basic Electricity." A. Marcus. George Allen & Unwin, Ltd. xv + 493 pp. 326 ill. 35s.

This book, first published in America in 1958, has been specially written for beginners with no previous knowledge of physics or mathematics other than ordinary arithmetic. It is divided into six sections. The first, and introductory, section deals with the question, "What is electricity?" The second section deals with direct-current phenomena. Alternating current is discussed in the third section. The fourth section deals with generators of electricity—mechanical, chemical, etc., including some of the new and experimental types of generator such as the solar and atomic cells.

Practical applications of electricity are discussed in Section 5, a separate chapter being given to each type of application, based upon the various effects of the electric current, such as the thermal, luminous, chemical, and magnetic effects. D.C. and a.c. types of electric motor are dealt with in a chapter of their own. Electronics form the subject of Section 6. The valve and transistor are explained and their practical applications are discussed.

The book is well illustrated with explanatory drawings and photographs. A set of questions is provided at the end of each chapter.

"Open-Wire Carrier Telephone Transmission." C. F. Boyce, M.Sc., A.M.I.E.E., M.(S.A.)I.E.E. Macdonald & Evans, Ltd. xx+307 pp. 82 ill. 63s.

The use of carrier circuits on open-wire routes has played a significant part in the development of long-distance communications networks in sparsely populated countries with cities hundreds of miles apart, such as Australia, South Africa, South America, Canada, the Western States of America, and Asia. Today, although microwave, carrier-on-cable and coaxial cable systems, and v.h.f. radio circuits compete strongly with open-wire carrier systems, there is no doubt that the extensive existing open-wire networks throughout the world will still form the backbone of the communications systems of many countries for a long time to come.

This book presents the many considerations which go to the planning, establishment and maintenance of a network based on the use of such open-wire carrier systems. The author, Assistant Chief Engineer of the South African Post Office, is particularly qualified to write on this subject as he has played a prominent part in the development of the open-wire carrier network of the Republic of South Africa, which, with its nearly one and a half million circuit-miles, today ranks in size among the first three in the world.

Photographing Subscribers' Meters

L. A. MISSEN and H. BLAKEY†

U.D.C. 778:621.395.663.2

For those exchange areas where punched-card equipment is used for the preparation of subscribers' accounts, photographing the subscribers' meters enables the meter readings to be presented to the accounting equipment in a simple and economic manner. The photographic and negative-viewing equipment used in a field trial of such a process is described and the results are discussed.

INTRODUCTION

THE photographing of subscribers' meters as a step towards preparing telephone accounts may seem outmoded when compared with the advantages of fully-mechanized systems. However, the systems of complete mechanization that have been considered[1] are costly and may only be applicable to the larger exchanges. Moreover, the capital invested in existing equipment cannot be disregarded, and the use of photography offers a means of obtaining a normal economic life from subscribers' meter equipment in existing exchanges while at the same time offering some improvement in the efficiency of reading the meters and transcribing the results.

Early in 1959, photographic equipment of Swiss manufacture was purchased and subjected to field trial in the Edinburgh Telephone Area. As a result of this trial the photographing of subscribers' meters is being introduced in those exchange areas in which punched-card accounting equipment is employed or is to be provided. A description of the equipment used in the field trial is given in the following paragraphs and the results of the trial are also described.

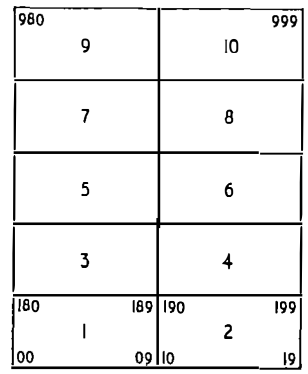
From some earlier experiments in photographing meter readings on 35 mm film[2] it was known that readable negatives could readily be produced, and no difficulty was expected with the trial equipment although the method of illuminating the meters when photographing was by the use of electronic flash, whereas in the earlier experiments filament lamps were used. However, the presentation of meter readings in this form is not necessarily a more economic method of preparing subscribers' accounts, and, in this country, it is only when used in association with punched cards in a mechanical accounting equipment[3] that its advantages can be realized to simplify and speed up telephone accounting.

The equipment to be described has been designed for use with punched-card equipment, and it is in the presentation of the meter readings to the punched-card operator that the novelty of the equipment lies; this function is performed by a special film viewer and scanner known as the Autoscope. A length of exposed film is inserted in the Autoscope and, after initial adjustment, each meter reading is displayed in turn on a recessed illuminated screen, in synchronism with the punched card to which it relates, and in correct numerical sequence.

LAYOUT OF SUBSCRIBERS' METERS

Before describing the photographic and negative-viewing equipment, a brief explanation of the layout of subscribers' meters on a rack will enable the design features to be better appreciated.

The standard method of mounting 100-type meters is in rows of 20, and 1,000 meters are mounted on a complete rack (Fig. 1). The lowest-numbered meter is that at the left-hand side of the first row at the bottom of the rack. Numbering is along a row from left to right; therefore, if the first meter is numbered 00, the meter at the end of the row is numbered 19, meter No. 20 is at the left-hand side on the row above, and so on until the top of the rack is reached. The next meter in numerical order is then at the left-hand side of the bottom row on the rack to the right of the first rack.



Groups of 100 meters are numbered in the order in which they are photographed

FIG. 1—NUMBERING OF SUBSCRIBERS' METERS ON A RACK OF 1,000

It is necessary to display the meter readings one at a time in the correct sequence, and this is done by the Autoscope. Although the subscribers' numbers on the meters are also photographed, these are only used at the commencement of a series of readings and to check that synchronism between meters and punched cards is maintained. It is essential for the Autoscope to be completely restored to its normal position before scanning commences, otherwise it might start at some intermediate point in the sequence of operations and synchronism would be lost.

Each negative embraces a block of 100 meters, and, because of the meter layout, this will consist of meters 00 to 09, 20 to 29, and so on (Fig. 1). The next negative is of meters 10 to 19, 30 to 39, etc., which are in the adjoining block of 100. To ensure a scan in numerical sequence, it is therefore necessary to arrange for the Autoscope to commence its scan at the first row of meters and continue across the two negatives. This is allowed for in the design by causing the Autoscope carriage to take 10 normal steps, then a longer step in order to cover the gap between the two negatives, followed by a further 10 normal steps.

The Autoscope thus displays the readings of meters 00 to 19 in the first row and then steps automatically to the first meter in the second row and so on until an entire block of 200 meters has been scanned (Fig. 2). It then positions itself to display the first meter on the third negative.

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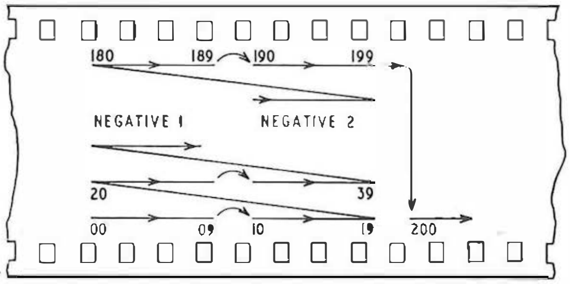


FIG. 2—AUTOSCOPE SCANNING SEQUENCE SHOWING LONGER STEP BETWEEN NEGATIVES

Although 35 mm film is used, the actual negative is less than 24 mm square, and in this space the image of 100 meters is recorded. Considerable accuracy in the stepping mechanism of the Autoscope is required, since the four digits (five in later types) of the meter reading are 1·3 mm long on the negative, and the spacing between readings is approximately 0·67 mm. The magnification of the negative by the Autoscope is 33 times, resulting in an image of the meter approximately twice the actual size.

PHOTOGRAPHIC APPARATUS

The photographic equipment comprises a portable assembly consisting of a sheet-metal hood designed to fit over a block of 100 meters, an electronic-flash unit and a camera. Associated with the flash unit is a mains-operated power unit. Hoods of different shapes and sizes are also available for use at those U.A.X.s where the meters are not arranged in blocks of 100.

The flash tube is enclosed in a rectangular housing secured to the hood by two knurled nuts. The camera is located and secured to this housing by spring clips and pegs.

The flash-tube housing is provided with two light-polarizing filters to reduce specular reflection of the light to a minimum. The first of these filters is in front of the flash tube and the other is in front of the camera lens. The light from the flash tube, passing through the filter, is polarized. Some of this light will be reflected as diffused unpolarized light and it is this light that produces the image of the meters. The reflected polarized beam from the meters is prevented from reaching the film by the second filter (rotated through 90° relative to the first filter) in front of the camera lens, and specular reflection is thereby largely eliminated. Reference to the practical effects of reflection from the meters will be made later when discussing the results of the field trial.

The power unit for the electronic-flash supplies a regulated output of 150 watt-seconds to the 500-volt flashtube. An interval of 6–10 seconds is required between each discharge to allow the electrolytic capacitors to recharge. A neon lamp on the flash unit glows to indicate that recharging is complete.

The hood, with camera associated, is applied to the meters to be photographed, as shown in Fig. 3. The edge of the hood is located at the lowest row of meters in the block to be photographed and is moved forward until stops at each corner rest against the meters. Small metal lugs in the lower and upper horizontal portions of the hood engage in the gap between the fifth and sixth meters in the first and tenth rows, respectively, to position the camera correctly relative to the meters.

There is considerable advantage in using the design of hood depicted. The camera is accurately located relative to the block of meters, and the lens may be focused and set to give optimum results; the distance of the light source to the meters remains constant and extraneous light is excluded.

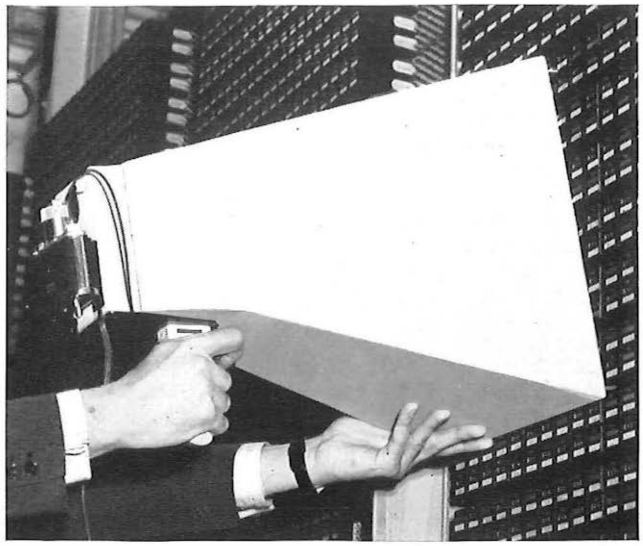


FIG. 3—CAMERA, FLASH UNIT AND HOOD IN USE

A pistol-grip type of handle fitted to the flash unit carries a trigger that operates the camera shutter via a wire release. The camera shutter in turn closes the circuit for the flash discharge.

The camera is fitted with a $f3{\cdot}5$ lens housed in an adjustable focusing mount, but the focus is adjusted and set by the manufacturers. It is possible to vary the lens aperture and, since the exposure time is fixed, this is used to obtain properly-exposed negatives. As high definition is required it is good practice to use the smallest aperture that will give adequate exposure, and an aperture between $f5{\cdot}6$ and $f11$ is recommended by the manufacturers. Maximum contrasts in the negative are secured by using a documentary-type film and extended development time.

Although the shutter speed is nominally 1/60 second, the exposure time is determined by the duration of the flash, which is of the order of 1/1,000 second. The setting used ensures that the shutter is fully open when the flash occurs.

The winding-on of the film and resetting of the shutter, after each exposure, is performed automatically each time the shutter-release is operated. The motive power is provided by a coiled-spring motor, which, when fully wound, is operative for a complete series of 55 exposures. Later models will have a lever on the camera to wind the film and reset the shutter after each exposure, and the negatives will be spaced as on a standard 35 mm film.

The depth of the camera hood is something of a compromise. When taking photographs the operator stands behind the hood, and, therefore, to ensure reasonable accessibility in the limited space in front of the meters, it is desirable that the depth of the hood should be a minimum. On the other hand, if the camera is too close to the meters, the window edges of the meter covers on the outermost meters tend to cut off the first and last digits of the meter readings on the right-hand and left-hand sides and, similarly, the tops and bottoms of the digits of the lower and upper rows of meters.

With the equipment used for the field trial the distance of the camera lens from the meters is less than 20 in. and a wide-angle lens is therefore required to embrace 100 meters.

The image of the meters on the negative represents a reduction of 14·5 : 1.

AUTOSCOPE

The Autoscope, or film viewer and scanner, may be considered in three parts: an optical system, the film transport, and the electromechanical control that determines the order in which the meter photographs are presented to the punched-card operator.

The optical system, shown schematically in Fig. 4, comprises a 30-watt lamp accurately centred and aligned

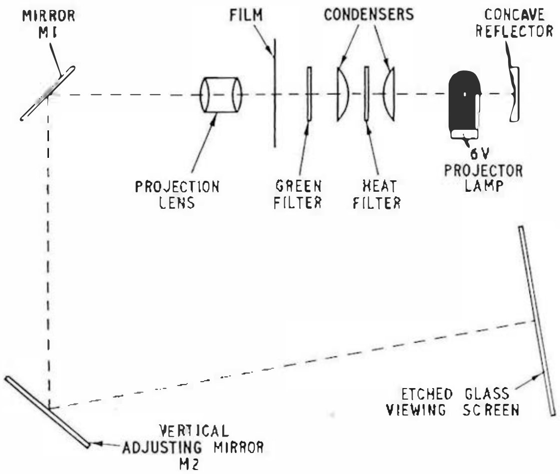


FIG. 4—OPTICAL SYSTEM OF AUTOSCOPE

with a rear concave reflector and a pair of condenser lenses, a projector lens, and an etched-glass screen to receive the image. To keep the light path, and hence the Autoscope, reasonably compact, reflectors are introduced at points M1 and M2. A green-coloured filter is supplied to ensure comfortable viewing conditions.

Only a small area of the film under examination is illuminated, and the 30-watt lamp therefore produces a very bright image. This, together with the recessed screen, makes it possible to use the viewer under normal office-lighting conditions, and the low wattage obviates the need for a cooling fan. Heat filters are provided to prevent local overheating of the film and projector lens. The film passes over two sprockets and is gripped by spring-loaded glass plates to hold it flat and in position, so that when the image has been correctly focused it remains so throughout the length of the film.

Control of the Autoscope

As will be seen from the illustration of the trial-model Autoscope (Fig. 5), there are six press-button keys to the left of the ground-glass viewing screen. On later models, which will cater for meters that are of various sizes and are differently mounted, it is expected that four system-selection keys will also be fitted.

Control of the optical system is by (*a*) adjustment of a milled disk (A) protruding through the top of the Autoscope container to focus the lens, and (*b*) turning the upper of the two knobs (B) at the left-hand side to adjust the vertical-shift mirror.

A knob (C) at the side of the Autoscope centres the

A—Focus control. B—Vertical-shift control.
C—Horizontal-shift control. D—FORWARD key.
E—REVERSE key. F—DIGIT key.
G—TEN key. H—DISCONNECT-DRIVE key.
J—DISCONNECT-EXTERNAL-PULSE key. K—ON/OFF switch.

FIG. 5—AUTOSCOPE

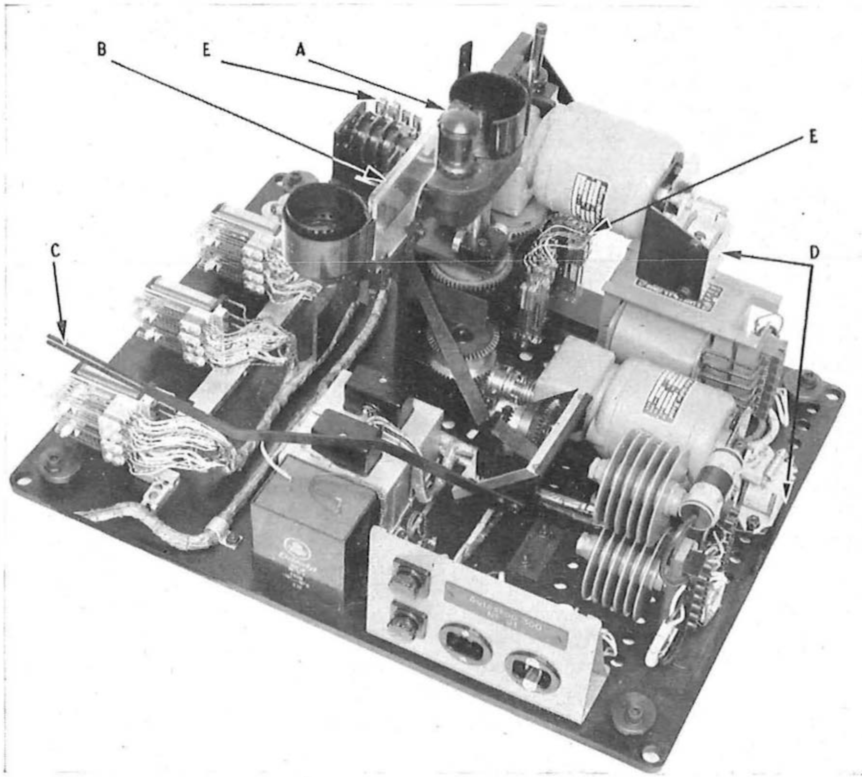
image on the screen by overcoming the pressure of a friction clutch to move the film to the left or right as required. Normally, these adjustments to be made to centre the meter reading on the viewing screen are required only at the commencement of a length of film.

After the ON/OFF switch (K) has been operated to the ON position, the film platform is brought to the starting position by operating one of the block-changing keys.

Assuming the Autoscope to be displaying a meter other than the first in a particular block, a short depression of the FORWARD key (D) would cause the Autoscope to select the starting point of the next block of meters, and a short depression of the REVERSE key (E) would result in a return to the starting point of the block in which it is already stationed. If either of the keys is held operated, the film runs continuously until the key is released; the action then continues automatically until the film is in position to display the first meter of the block being shown when the key is released.

The DIGIT key (F) provides a method of control alternative to that of a control impulse from a punched-card machine. It steps the film to display one meter image at a time. Operation of the TEN key (G) causes the film platform to be lowered successively until, when the topmost scanning position is reached, the next operation causes the platform to return to its starting position. The use of these keys facilitates selection of any meter the reading of which is to be re-checked. Of the remaining two controls, the DISCONNECT-DRIVE key (H) operates the clutch magnet to disconnect the horizontal drive and the circuit for the horizontal-travel relay, whilst the DISCONNECT-EXTERNAL-PULSE key (J) disconnects any pulses from the punched-card machine. The display seen on the screen in Fig. 5 is of a negative taken under practical conditions. The meter reading is uppermost and the subscriber's number is underneath.

Fig. 6 shows the Autoscope, with the cover removed, viewed from the right-hand side and towards the rear of the machine. Parts of the linkage mechanism to the



A—Film sprocket. B—Glass pressure-plates.
C—Vertical-shift-control lever. D—Motor brakes.
E—Control spring-sets and cams.

FIG. 6—INTERIOR OF AUTOSCOPE

controls and also parts of the optical system are incorporated in the cover and cannot, therefore, be seen in this photograph.

When a start signal has been applied to the Autoscope, automatic action is maintained by a group of relays, seen on the left-hand side of the photograph, that control the stopping, the forward and reverse movement.

The motor brakes (D), which are normally on, are applied through a serrated disk secured to the motor shaft. Operation of one of the stepping relays releases the brake on the horizontal-drive or vertical-drive motor, and the appropriate motor is then free to rotate. The direction of movement is determined by change-over contacts between the supply and the delta-connected motor.

The 35 mm film used for meter photography is of the standard type perforated along each edge, and these perforations engage with the film sprocket (A). Accurate spacing of the photographs of blocks of meters and accurate location subsequently by the horizontal transport mechanism are thereby achieved. Vertical accuracy is ensured by the provision of a robust lead-screw that gives vertical motion to the film carrier.

The order in which the meter images are presented on the etched screen is predetermined by a sequence or "program" built into the Autoscope in the form of control springs (E) operated by cams secured to an extension of the motor-armature shaft. As each image is displayed, the springs operate simultaneously to disconnect the supply to the appropriate motor and apply the mechanical brake.

The display can be controlled by a foot switch, a press-button or by a pulse from a punched-card unit.

RESULTS OF FIELD TRIAL

Inevitably, meter windows become dusty in the course of time, and the meter readings tend to become less distinct, but the margin for obtaining good negatives is such that it is worthwhile removing the dust before photographing is commenced.

Reflection of the light source from the meter covers is invariably due to a crease or indent in the plastic material of the window. Such defects can be detected by shining a light on the meters and viewing them from various positions and angles. The remedy is to change the window, making sure that the replacement is flat and not stressed when inserted into the meter cover.

Unfortunately, the requirements when photographing the meter reading (white figures against a black background) and the subscriber's number (black figures against a white background) are conflicting, and development of the negatives has to be accurately controlled. Considerable variations occurred in the printing of subscribers' number labels, and better conditions for photographing can be obtained by using numbers with bold black lettering. At new exchanges, particular attention will be directed to securing these characteristics. The situation could be much improved by providing subscribers' label numbers with white figures on a black background.

One other change was found to be necessary: the meter-cover securing nut has a large knurled rim that tends to obscure the meter-number wheels of the bottom row of a group of 100 meters, and the shadow it casts causes the negative to be under-exposed at these points. Reversal of the nuts on this row of each group of 100 meters so that the knurled rims are adjacent to the meter covers overcomes this difficulty.

Apart from the minor difficulties described above, the equipment has functioned satisfactorily in the Edinburgh Telephone Area since June 1959, and subscribers' accounts have been prepared from negatives from that date to the present time. The Autoscope is popular with the accounting staff and, owing to the improved legibility of the readings, much less re-checking is required.

ACKNOWLEDGEMENT

Permission to publish information concerning the photographic equipment and the Autoscope has been given by Messrs. Alos, A.G., Zurich, and is gratefully acknowledged.

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Telephone Equipment Connexions

K. W. HIX, A.M.I.E.E.

U.D.C. 621.315.68:621.395.7

The efficiency of a telephone exchange depends mainly upon the reliability of the electrical connexions between conductor wires and switching equipment. This article describes the many types of electrical connexion now in use or being developed for telephone equipment and discusses the factors which must be considered in the design of an electrical connexion for a particular purpose.

INTRODUCTION

THE number of connexions between conductor wires and switching equipment in a telephone exchange of average size can amount to several million and for the correct functioning of the exchange every one of these needs to be of low and constant resistance. Various methods of connexion are employed which can be considered in two broad divisions:

(*i*) Permanent connexions, such as those employed on the connexion strips fitted on frames and racks. It is the usual practice to solder this type of connexion but solderless wire-wrapped terminations are also used.

(*ii*) Separable connexions, e.g. shelf plugs and jacks, which are required for maintenance and test purposes.

Methods of making both of these types of connexion and factors which influence the choice of materials used are described in this article. The action of wipers on selector bank contacts and of relay contacts has not been considered as the problems arising differ in many essentials from those encountered with the above forms of connexion.

METHODS OF PERMANENT CONNEXION

Any connexion should be capable of being changed although a large majority of those in an exchange normally remain unaltered for periods of up to 40 years. Such connexions are referred to as permanent connexions and may be made by any of the following methods.

Soldering

It has been standard practice to employ soldering techniques for the connexion of wires and a high standard of reliability is afforded by this type of connexion. The success of a soldering operation is dependent upon the correct preparation of the surfaces to be connected, the control of the soldering-iron temperatures, the use of suitable solders and fluxes, and a measure of experience and care on the part of the operative. Neglect of these factors can lead to ultimate failure of the connexion, not necessarily to the point at which a disconnexion occurs but frequently to the point at which a varying resistance is introduced into the circuit. The degree of care in supervision and inspection given to the making of soldered joints for submarine repeaters virtually eliminates faults of this type. It is quite uneconomic to exercise the same degree of care in making the vast quantities of joints required for telephone exchange equipment and it is generally accepted that a continuing failure rate on soldered joints is inevitable. Typical failure rates of the order of 1 in 4,000 per year have been quoted. The evidence from the periodic vibration testing of transmission equipment[1] is that failures can occur in a random manner throughout the life of the equipment.

One measure that has been instrumental in reducing failures of joints on telephone equipment has been the adoption of a barrier layer of nickel on brass tags which prevents the long-term migration of zinc to the surface.[2] Another factor is the improved quality of the p.v.c. insulating material which enables adequate heat to be applied for making a good connexion with reduced risk of damage to the p.v.c. Nevertheless faulty joints will continue as long as hand-soldering methods are used, and a considerable effort is being devoted to the mechanization of the soldering operations.

Automatic dip soldering has been used by the telephone manufacturers for the soldering of wires on motor uniselector and 2-motion selector banks with successful results. The principal application of this technique has, however, been to printed boards used on electronic equipment. The success of these operations is largely dependent upon the cleanliness of the materials employed, and it is sometimes a matter of difficulty with the inevitable heat from soldering baths in factory conditions to ensure that some corrosion does not occur prior to the soldering operation.

Solderless Wire Wrapping

Solderless wire-wrapped joints are normally considered as permanent connexions and their application to telephone exchange equipment has been described in a previous article.[3] The development of combined stripping and wrapping tools mentioned in that article has proceeded further and successful results have been obtained with a tool which makes an annular cut in the insulation at the commencement of wrapping and pushes the tube of insulation from the end of the wire in the process of making the connexion. Fig. 1 shows this tool at the completion of a wrapping operation.

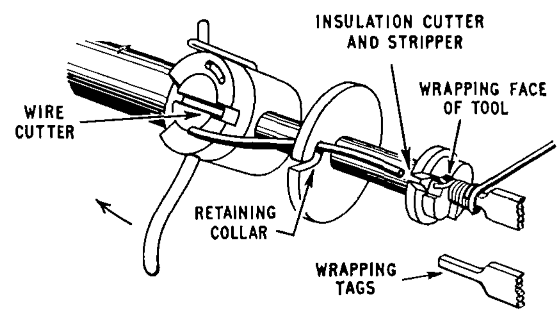


FIG. 1—STRIPPING AND WRAPPING TOOL AT COMPLETION OF WRAP

The reliability of wrapped connexions is generally accepted and the method is finding increasing application on electronic equipment both for direct wire terminations and as a means of interconnecting electronic equipment packages. The formation of a bound connexion is shown in Fig. 2 and a double-wrapped strapped connexion is shown in Fig. 3. With specially-designed unwrapping tools this form of termination permits equipment to be changed without using a soldering iron and is cheaper than connexion by plug and socket.

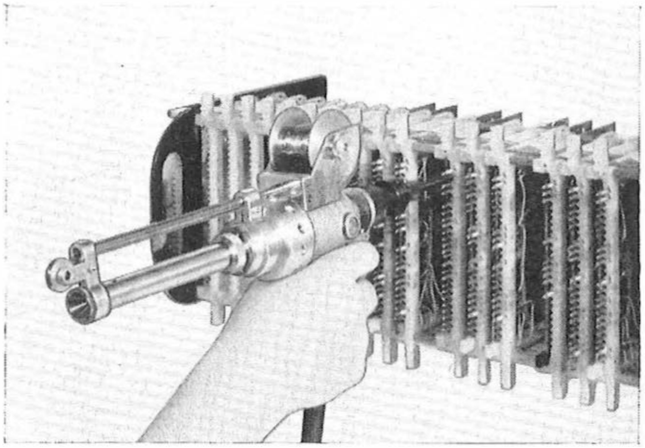


FIG. 2—METHOD OF CONNECTING PRINTED BOARDS BY BOUND WRAPPED JOINTS

Crimping

A crimped connexion is a controlled pressure joint in which a specially-shaped terminal is forced into contact with the conductor in such a manner that subsequent relaxation is improbable. Both terminals and conductors are strained beyond their elastic limits in the process and it is important to ensure that the design of terminal and the material used are suitable. Connexions of this type have been used on telephone equipment for connecting lugs to power cables as well as for the connexion of terminals to instrument cords. This type of wire connexion, when associated with screw terminals with or without locking washers, permits conexions to be separated at will. Other forms of crimped terminals are available using taper pin and socket designs which are suitable for high-pressure permanent connexions; the use of this type of terminal enables factory-made cable forms to be shipped for site installation complete with readily connectable terminals. Fig. 4 shows the cross-section of a typical crimped connexion made on a 7-strand conductor. Crimps of this type can be made by a hand tool or by a high-speed automatic machine. Whilst crimping is a very suitable method of terminating stranded conductors it is also practicable for single conductors of 25 S.W.G. ($6\frac{1}{2}$ lb/mile) or larger gauges, and it is claimed that, despite the relative expense of the terminals required, the overall cost of a crimped installation can be less than that for soldering whilst reliability is also improved.

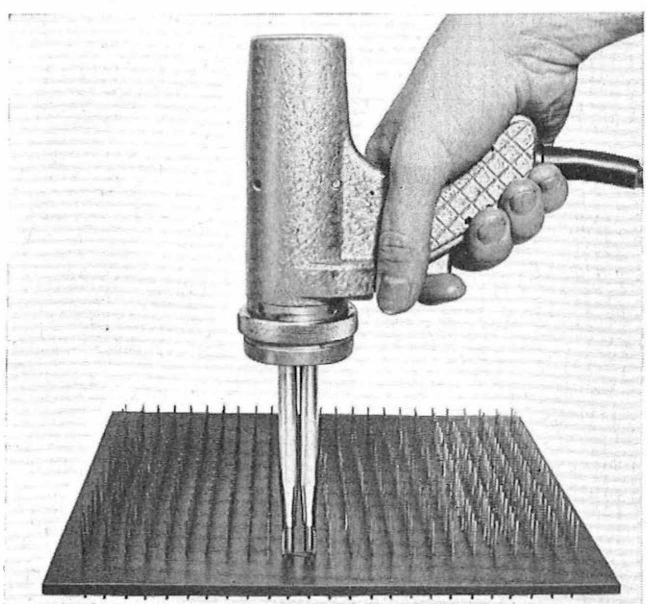


FIG. 3—DOUBLE-HEADED WRAPPING GUN IN ACTION

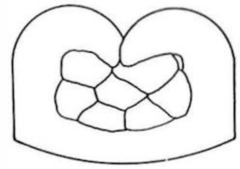


FIG. 4—CROSS SECTION OF A CRIMPED CONNEXION ON STRANDED WIRE

Other Possible Methods

Methods not yet used in telephone exchange practice but which could have future application include welding and chemical methods. Welded joints are in many ways ideal connexions, being proof against failures from vibration, corrosion and heat, but have so far been considered too costly and cumbersome for use on telephone equipment. Spot welding and later methods of ultrasonic and friction welding developed in recent years are of potential interest, but cold-welding techniques as used in the construction of transistors introduce a degree of distortion which is unlikely to be acceptable in exchange construction. Developments have also been taking place in the use of electrically-conductive adhesives; for the connexion of fine wires, and in association with micro-miniature equipment, this method appears attractive. One of the materials in use employs a silver conductive material contained in Araldite but the need for stoving of the completed joint, together with the relatively high cost of materials, are disadvantages.

SEPARABLE CONNECTORS

For convenience in the manufacture, installation and maintenance of telephone exchange equipment it has been the practice to use plug-in equipment. Plugs and sockets are also widely employed for test purposes. The production of reliable plugs and sockets is therefore a matter of importance and the multi-point connectors used on telecommunications equipment need to be made to close physical limits with much attention given to the electrical properties of the materials used. The design of separable connectors involves a compromise between the high pressure and abrasive contact action needed for the rupture and subsquent exclusion of corrosion films, and the conflicting requirement of easy insertion and withdrawal of the plug. For a multi-point connector in circuits with low voltages and currents, base metals and alloys are usually unsatisfactory; for reliable contact operation noble-metal contact surfaces are required.

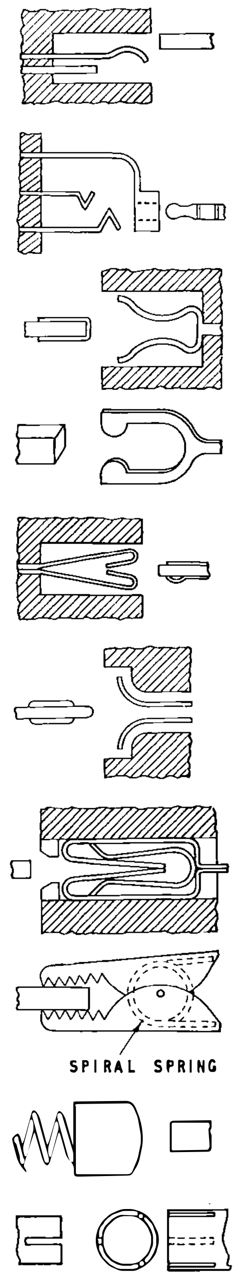
PHYSICAL DESIGN OF SEPARABLE CONNECTORS

Many designs of separable connector using a wide variety of types and shapes of contact spring have been produced, but the contact pressure is usually provided by one of three methods—spring action, screw action or wedge action.

Spring Action

The simplest and most widely-used types of connector use some form of spring action for applying the contact pressure. The well-known crocodile clip connectors use springs which are not required to carry current and contact members which need not be resilient. Most of the spring connectors used in telephone exchanges, however, consist of a simple contact spring of carefully chosen temper, the natural deflexion force of which is used to exert the contact pressure. Springs of this type can lose tension from heat and fatigue as well as from accidental distortion, and it is desirable to incorporate safeguards, e.g. limit stops for the springs and restricted entry angle for the plugs, in the design to reduce this danger.

The shaping of the housing for the springs is frequently used to limit the spring movement, and close control of the physical tolerances of springs and mouldings is particularly necessary in multi-point connectors to ensure that adequate contact force is present at all contact points. If the fixings of the plug and the jack enable the plug to centralize its position relative to the jack, a cumulative build-up of tolerances leading to low contact pressures at one end is avoided. The latest design of shelf connector used in telephone exchanges incorporates this



(*a*) Spoon-ended single spring. Movement limited by stiff limit-spring.

(*b*) Shaped springs of switchboard plug and jack. Angle of entry limited by bush of jacks.

(*c*) Cup spring—plain or partially split, giving some floating action. Double-contact action with distortion limited by moulding. Used with printed boards.

(*d*) Shape of spring gives high force concentration. Double-contact action. Suitable for printed boards.

(*e*) Test Jack No. 21 MK.4. Movement of springs limited by moulding. Dimple on plug member gives latching action.

(*f*) Single-contact or double-contact design. Movement limited by moulding. Rib on plug to concentrate force.

(*g*) Auxiliary steel spring used to concentrate force.

(*h*) Crocodile clip. Force is concentrated by the teeth.

(*i*) Butt contact.

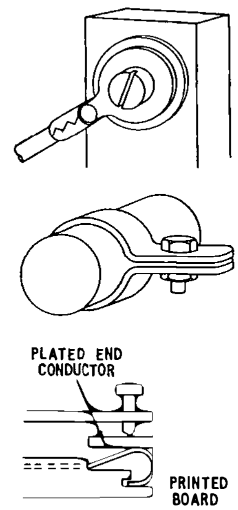
(*j*) Chuck-type socket. Split plug or socket used.

FIG. 5—CONNECTORS EMPLOYING SPRING ACTION

floating action on the plug.[4] Contact springs require to be carefully set to predetermined angles prior to assembly, and these settings, combined in some jacks with the shaping of the springs, enable the contact force to be concentrated in a small area of the plug surface. Favoured methods of spring shaping include spooning of the ends of the springs and the formation of dimples or ribs on the spring surface. Fig. 5 shows a number of designs of spring-action connectors, illustrating the different methods of shaping the springs and limiting their action. It will be seen that both single-spring and double-spring designs are in use, and, whilst double springs occupy more space and are more expensive, their use can be justified if the connexion is likely to be exposed to dust and dirt in the open-circuit condition. For a connector which is usually closed, e.g. a shelf jack, it is preferable to concentrate the available force at a single contact point, as in the standard shelf jack.

Screw Action

Individual screws for the connexion of wires and wire terminations of various types have been extensively used and are the standard for removable items such as fuses, switchboard cords and some items of subscribers' equipment. In external pillar and cabinet assemblies screws are used to give a form of crimped connexion. Screw action can result in high point pressures; damage to wires can occur through over-tightening and damage to screw threads can result in low-pressure connexions. The use of some form of locking washer is frequently justified. The mechanical advantage of screw action enables high spring pressures to be applied in multi-point connexions such as the printed board connector (Fig. 6).



(*a*) Soldered-crimped connexion to terminal. Locking washer is used.

(*b*) Screw-clamp fixing to a terminal post.

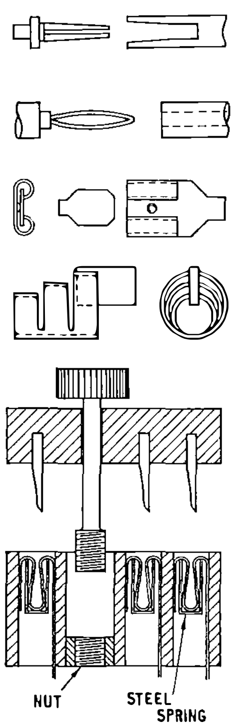
(*c*) Printed-board connector. Movement limited by shape of moulding.

FIG. 6—CONNECTORS EMPLOYING SCREW ACTION

To secure the best results with screw-action connectors it is desirable that relatively soft materials capable of yielding under pressure should be used. The absence of any wiping action suggests that plating of the contact surfaces would be beneficial but the high pressures frequently applied can rupture plating at the contact points.

Wedge Action

Where a high degree of reliability is required and a considerable force is available, contact-spring designs using a wedge action may be used. The inevitable distortion resulting from this type of action precludes its use where frequent insertion and withdrawal of the plug member is required. The high contact forces involved wipe the contact areas clear of corrosive material and the plating of the contact areas is rarely justified, although some cheap form of plating such as tin may be used to reduce the contact resistance. One of the earliest successful applications of the wedge action was the historic Post Office resistance box which used untreated brass for the contacts. A design which uses screw force to apply the wedging action on a multi-point plug is used on the subscriber trunk dialling register translators.[5] Examples of wedge-action connectors are illustrated in Fig. 7.



(*a*) Taper pin and socket. Close control of manufacturing tolerances required. Crimped connexions usually used.

(*b*) Banana plug. Used as test-equipment connector.

(*c*) Three-point connector with dimpled base, curled-edge springs and flat-tab connector.

(*d*) Triple-ring connector.

(*e*) Sectional view of multi-point connector used on S.T.D. register-translator equipment. Screw locks plug into position.

FIG. 7—CONNECTORS EMPLOYING WEDGE ACTION

Clamping devices to retain the plug in position are not provided normally but where the plug experiences vibrations in service some form of screw, spring-action retaining device or latch may be necessary.

Whilst the choice of the contact material and spring design is obviously important, the success of multi-point connectors can be affected by the design of the insulating moulding and the physical construction of the spring mountings. The operating conditions in telephone exchanges do not usually call for the use of high-grade insulating materials, and phenolic mouldings and synthetic resin-bonded paper have been successfully used. The better physical and electrical properties of materials such as nylon, polystyrene and the alkyds may justify their use for special purposes but it has been found that a nylon-filled phenolic moulding is generally a satisfactory material for the construction of connectors.

CONTACT PERFORMANCE AT LOW VOLTAGES AND CURRENTS

The currents and voltages used in telephone switching and signalling are such that satisfactory connexions can often be established over indifferently connected joints. As the available potential difference in circuits is reduced the interference which can result from the presence of fine particles and surface films on contact surfaces increases. The effects of this interference can produce noise from random resistance variations, circuit faults due to progressive increase in contact resistance, intermittent disconnexions and, ultimately, complete disconnexions. The minimum voltages and currents at which these phenomena appear may vary, but as a guide it is considered that special action to mitigate these effects is necessary if the open-circuit potential between any two points falls below 6 volts.[6]

In the atmospheric conditions obtaining in the majority of exchanges severe contact corrosion is rare but contact troubles can occur on apparently clean contacts due to the presence of thin surface films. The potentials available in normal telephone speech and d.c. signal circuits are usually sufficient to disrupt these films but when the available circuit potential is below 5 volts at any point disconnexion can occur. Contacts in low-level a.c. paths are referred to as dry contacts and it has been standard practice to superimpose d.c. potentials, which pass a wetting current to break down these films, with the object of maintaining the contact in a state of conductivity. Wetting currents of the order of 2 mA at an applied potential of 50 volts are usual on telephone equipment in this country, but h.f. currents have been used abroad for the same purpose. It is not always practicable or economic to superimpose such wetting currents; a noble metal such as gold or platinum is then used for the contacts since these materials do not form resistive surface films.

Contact Corrosion

Contamination of contact surfaces can be produced by adsorption, chemical corrosion or tarnishing, as well as by the adherence of oil, grease and dirt particles. Surface films in normal atmospheres usually consist of oxides of the contact material in use but in industrial localities sulphates and carbonates may appear. These films may be present at the time the equipment is installed or corrosion products may build up slowly during the life of the equipment, taking advantage of any physical relaxation of the contact members. It is thus desirable to keep the contact forces as high as possible with the twofold objective of rupturing any surface film on engagement and guarding against long-term attack.

It is normal practice to compare available contact forces by the measurement of spring tensions but it should be realized that such comparisons can be misleading due to variations in the physical forms of the springs and the size of contact areas. When two contacts engage, the first connexion is normally established at minute points on the surfaces and the actual pressure in pounds or grammes per square inch is momentarily of high value. As the contacts are brought closer together by the increasing force these initial contact areas spread as the contact asperities tend to flatten. Soft corrosion products are pushed away from the contact points and may be retained in the cavities between the contact regions and have, initially, no deleterious effect. A resistive nucleus is, however, in existence which can build up with subsequent corrosion to a point at which the contacting surfaces are forced apart and the corrosion product insulates the contact points. The sequence of operations is illustrated in Fig. 8.

To safeguard contacts it may be necessary to employ materials which do not become corroded or, alternatively,

(a) Limited contact established at points A, B and C.

(b) Initial pressure penetrates corrosion film and metal–metal contact established.

(c) Corrosion build-up forces contacts apart.

(d) Corrosion spreads over exposed contact surface.

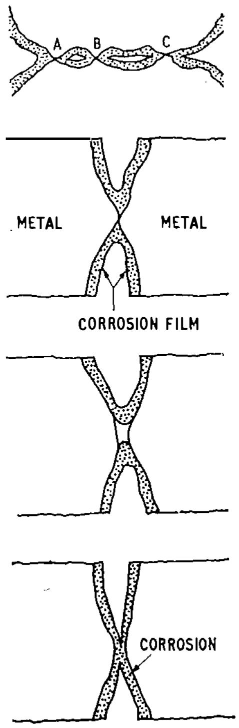


FIG. 8—THE GROWTH OF CONTACT CORROSION

to protect them by excluding any contaminating influence. Attempts to seal contacts by physical means against air-borne interference are expensive and have not always been successful. Some improvement may be introduced by the use of dust-proof covers but for maximum security it is usually preferable to apply a protective coating of non-corrosive material to the contact surface.

CONTACT MATERIALS

It is fortunate that a number of materials with adequate resilience for use as contact springs can also be used for making electrical connexions. Nickel silver, phosphor bronze, beryllium copper and brass have been used for contact materials in telephone equipment. The basic contact resistance of nickel silver is of a higher order than most other good conducting materials, but with the normally-used voltages and currents this is of little importance, and the resistance to corrosion of this alloy has resulted in its wide use on telephone equipment. All the above-mentioned base-metal alloys require contact forces of the order of 1,000 grammes for satisfactory contacting under unwetted conditions, but with suitable wetting 100 grammes is adequate.[4,6]

To improve the contact performance of natural spring materials, riveted contacts, rolled inserts and chemical or electro-deposited coatings of other materials have been used. Riveted contacts such as are used on relay springs are mechanically unsuitable for plug and socket applications, although designs of connectors have been produced in which the pressure to connect the contacts is applied after the insertion of the plug member. Rolled inserts are used to provide higher-grade material at the contact points whilst retaining the physical advantages of the natural spring material. Thin coatings of noble metals produced by chemical replacement processes or electro-deposition are used on most commercial forms of plug and socket for electronic panels, and the choice and control of the application of these coatings is of considerable importance.

Silver

Silver is an extremely useful contact material which has been used in the form of domed contacts for many years on electrical equipment. It is susceptible to attack from atmospheric sulphur, however, and the chemical products formed are relatively soft but adherent. Such corrosion films can be penetrated if spring forces of the order of 300 grammes are available although, being only loosely adherent, the films can frequently be removed from the contact points by a wiping action of the contacts at lower pressures.

A film of silver has been electro-deposited on items such as plugs and jacks, but under certain conditions breakdown of the insulating medium separating adjacent contact springs has occurred and extreme care must be exercised in using silver in such applications. The electrochemical action leading to this failure (usually referred to as silver migration[7]) arises from the application of a steady d.c. potential to thc contacts and the presence of moisture. The action results in the formation of silver salts on the surface of the insulating material and a reduction of insulation resistance permitting the passage of leakage current which progressively increases to the point at which the leakage path becomes carbonized (tracking) and complete insulation breakdown occurs. In some conditions the action is accelerated to such an extent that the breakdown over a surface of phenolic insulation $\frac{1}{32}$ in. thick can occur within 12 months. By increasing the length of leakage path and choosing insulating materials which do not absorb moisture, e.g. polystyrene, the danger of migration is virtually eliminated, but such action can place severe limitations on the design of plugs and jacks.

If a rolled insert of silver is used in a sheet of material such as phosphor bronze, springs can be produced with a metallic barrier to the migration of silver. This method of bi-metallic construction[4] has been used for the contact springs of shelf plugs and jacks and, while these have given satisfactory service, the material is not widely used in industry and supply difficulties can occur. Furthermore, it is possible for impurities to be rolled into the surface of the silver during manufacture unless stringent precautions are taken.

Tin

One of the cheapest protective coatings suitable for application, alone or in combination with such metals as lead and nickel, is tin. It has a low basic contact resistance and may be applied by hot dipping or electro-deposition. Investigations into the possibility of using tin to improve the conductivity of contact-spring materials as an alternative to the use of silver have shown that provided adequate contact pressures are available and atmospheric conditions are not too corrosive its use can be successful. The long-term possibility of diffusion of base materials through the tin, and the possibility of crystalline whisker growths[8] appearing as a potential source of insulation breakdown, may make the material undesirable for general adoption.

Palladium

Palladium has not been used extensively in this country as a contact material, and for operation where high contact temperatures can be attained, as in breaking large currents, it is less suitable than platinum. For tarnish-free operation at low currents it is completely satisfactory and is of importance in that it is much cheaper than gold or platinum. Difficulties have been reported in the past in obtaining satisfactory adhesion by plating methods and as the material is not used in the jewellery trade little experience has been obtained of its large-scale application. Recent developments have shown that the material can be applied satisfactorily by both electro-deposition and by chemical replacement methods, and it is now finding increasing application, e.g. on various printed board connectors for electronic equipment as well as for low-voltage applications on standard shelf plugs and jacks. Contact forces of the order of 100 grammes are recommended[6] but this is rarely found to be a limitation.

Gold

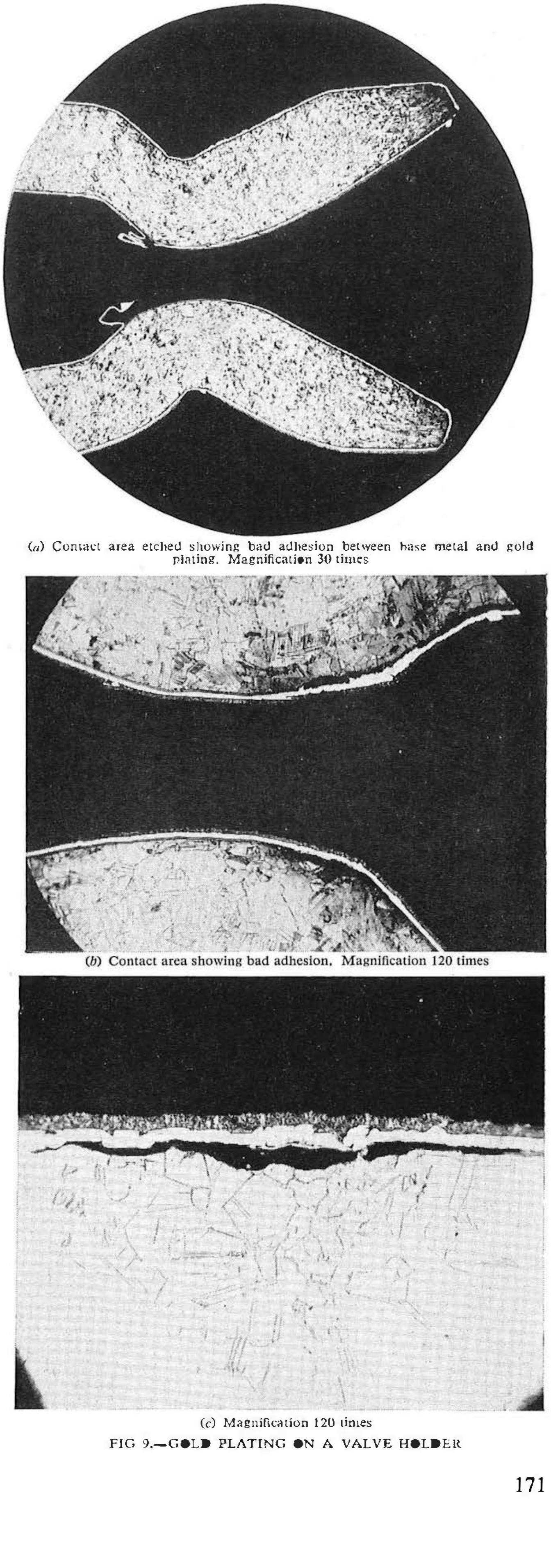
Gold as a surface material has been used in various forms for contact purposes, and being resistant to all forms of tarnishing is the first choice when the highest standard of contact reliability is required. In its pure form it is relatively soft and, considering wear, is unsuitable for use when frequent operations at high physical pressures are necessary; furthermore, the softness of the material can make a multi-point plug difficult to withdraw as a result of an action referred to as "galling." As a contact force of 30–50 grammes is adequate for gold contacts it is preferable to design plugs and sockets specifically with a view to their use with gold plating rather than to adopt designs which give higher contact pressures. Pure gold is rarely used at the present time as a number of plating solutions are available which use additives such as silver and nickel to increase the hardness and durability.

Thin coatings of gold—sometimes referred to as flashes—can be applied by chemical replacement methods, but the thicker deposits, required to give a non-porous coverage, necessitate electro-deposition. The cost of the material can sometimes justify the expense of selective plating methods, but it is usual to design the contact springs to be as small as possible to reduce the wasted surface coverage. A minimum deposit of 0·0002 in. has been considered essential to ensure complete coverage with no risk of pinholes or porous areas, but it may be possible to obtain satisfactory results with thinner films by careful control of the plating of well-prepared contact surfaces. For deposits less than 0·0001 in. thick there is a real danger of corrosion of the base material occurring and spreading over the surface of the gold. The difficulty in obtaining reliable coverage of an irregular surface is illustrated in Fig. 9, which is an enlarged view of the contact area of a valve holder; corrosion can readily occur through the gaps in the gold deposit.

Platinum and Rhodium

Platinum, one of the most expensive of the noble metals, has been used extensively for many years for relay contacts, and where long life under high-temperature conditions is required it is unchallenged, but for low-voltage operation it has no advantage over such materials as gold and palladium. Furthermore, it is not an easy material to electroplate and consequently its use as a contact material for connectors is rarely justified.

Rhodium is another expensive material which has been used for contact purposes in the electroplated form. It is an exceptionally hard material and this is an advantage



(*a*) Contact area etched showing bad adhesion between base metal and gold plating. Magnification 30 times

(*b*) Contact area showing bad adhesion. Magnification 120 times

(*c*) Magnification 120 times

FIG 9.—GOLD PLATING ON A VALVE HOLDER

when used on switches with a rubbing action; in other uses it is a disadvantage because, when compared with a softer material, the effects of dust can be more serious in giving rise to open circuits. The electro-deposits of rhodium can often be highly stressed and result in surface crazing which can give rise to resistive contacts.

Alloys of Noble Metals

In an endeavour to improve the performance of contacts and at the same time economize in the use of the more expensive materials, many combinations of materials have been tried both in the solid contact and electroplated forms. An alloy of platinum, gold and silver has been used for relay contacts on pre-3,000-type relays and, in addition to alloy contacts of this type, contacts using a noble-metal surface on a stud of a cheaper material such as copper have been advocated. Most of the contact alloys marketed use silver to a greater or lesser extent in combination with one or more of the metals copper, cadmium, nickel, palladium, platinum or gold. Some of these alloys, such as those of silver with nickel and silver with copper, increase the resistance to mechanical wear and the current-handling capacity, but the alloyed combinations of silver with palladium, platinum and gold are intended primarily to be tarnish resistant.

Whilst the advantage of alloyed contacts is usually thought to be economic, claims have been made that better performance in particular conditions can also be obtained by the choice of the correct combination of materials.

CONCLUSIONS

The permanent wiring connexions on telephone equipment are usually soldered and a high degree of reliability is obtainable, while the use of automatic methods should reduce faults occasioned by operator fatigue. Solderless wrapped connexions are now being increasingly exploited, particularly for new equipment designs, whilst crimped, welded and chemical joints may offer advantages in certain circumstances.

The most usual form of connector for electro-mechanical equipment is the plug and jack employing base-metal alloy contact surfaces with spring action, although screw and wedge actions have found application.

The determining factors in the efficiency of plug and jack connectors are the contact material and the contact pressure, which must be chosen to suit the circuit voltage and current whilst meeting the physical requirements of ready separation and freedom from undue wear.

The order of current and voltage used on electronic equipment necessitates the use of noble metals on contact surfaces, and, with the correct choice of materials and appropriate physical design, connectors designed for this purpose can have a high order of reliability.

ACKNOWLEDGEMENT

This article has drawn freely on a variety of published information appearing in specialized publications, laboratory and research reports. Some of the views contained in the article were expressed at the 1961 Institution of Electrical Engineers Convention on Components and Materials used in Electronic Engineering and appear in the report of that Convention. Permission of Automatic Telephone and Electric Co., Ltd., and Ferranti, Ltd., to reproduce Fig. 2 and of Standard Telephones and Cables, Ltd., to reproduce Fig. 8 is acknowledged.

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Book Review

"Information Theory." Papers read at the Fourth London Symposium on Information Theory held at the Royal Institution, London, 1960. Edited by C. Cherry. Butterworth & Co. (Publishers), Ltd. xl + 476 pp. 95s.

The Fourth London Symposium on Information Theory was held at the Royal Institution, 29 August–2 September 1960, having been organized by Professor Cherry. This volume contains the full texts of the 36 papers presented, together with their discussions. The papers were chosen, out of a very much larger number offered, to represent good examples of new developments in several different fields where information theory is being applied.

The first two groups of papers, seven dealing with coding theory and three on telecommunication systems, are largely theoretical. The heading Telecommunication Systems is represented by papers on "Congestion in Telephone Exchanges," "Communication in Digital Systems" and "Optimum Receivers for Randomly-Varying Channels." In the next three sections a great deal of experimental work in the human and biological fields is discussed which should interest those concerned with human reactions to information, such as customer dialling and information services. Three papers deal with character recognition and four with learning. The final section is again theoretical, including classification theory and semantics. Speech and hearing, covered rather generously in previous symposia, were purposely omitted from the fourth.

A book of this type does not provide popular reading and each succeeding symposium on this subject inevitably becomes more specialized than the last. Nevertheless, it is evident from the names appearing in the discussion that considerable communication of ideas was taking place.

This volume, like its two predecessors from the same publisher (the first symposium was published only privately), clearly provides essential reference material for many researchers in a wide variety of fields. Most, however, will prefer their libraries to make the actual purchase. The production is excellent and includes, for full measure, eight pages of cartoons from *The New-Yorker*.

D. L. R.

Time-Shared Code Translators for Letter-Sorting Equipment

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U.D.C. 621.394.14: 681.187

In the automatic letter-sorting equipment that has been on field trial since June 1960, code translators are necessary to enable each envelope to be marked with routing codes appropriate to the address. Other translators are required to convert the codes subsequently read from the envelopes into instructions to the sorting machines. The general principles of the operation of these translators are described.

INTRODUCTION

An experiment in automatic letter-sorting has been in operation at Luton since June 1960. In this experiment letters are stacked and placed in a coding desk that presents them, one at a time, to an operator. The operator, using a typewriter form of keyboard, types a code consisting of a number of characters which he selects, according to a simple rule, from the address on the envelope. A translator receives these keyboard characters, translates them into a 12-bit binary code and returns this code to the coding desk. At the coding desk the envelope is marked by a phosphorescent material with a pattern corresponding to the code. The envelope is then passed through automatic sorting equipment, which may be remote from the coding equipment, with the routing being controlled by the code marks. Fig. 1 is a schematic diagram showing the equipment and the two translators required to serve it.

The ultimate aim of this method is that each envelope should be read by an operator only once in its passage through the postal system.

Previous articles[1,2,3] in this journal have given a broad survey of the project as well as a more detailed description of the mail-handling equipment, of the means for printing code marks on envelopes and for reading these marks at a later stage. The present article deals with the translators used in the automatic letter-sorting experiment at Luton and its related projects.

Two translators are in use at Luton, working in the system shown in Fig. 1. The first receives alpha-numeric

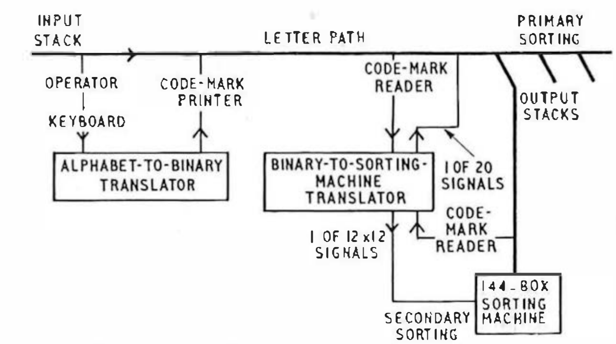


FIG. 1—USE OF TRANSLATORS IN AUTOMATIC LETTER-SORTING

codes* typed on a keyboard and translates them into 12-bit binary codes for marking the envelopes; the second receives these binary codes when they are read from envelopes and translates them into sorting-machine instructions. A third translator, similar to the second, was required to carry out this binary-code to sorting-machine-code translation at a distant forwarding office in order to demonstrate remote automatic sorting; the London Inland Section sorting office at Mount Pleasant was chosen for this purpose.

A fourth translator is used at Norwich, where all addresses have been given a public code. This public code consists of a group of six characters, such as NOR 12A, in which the first three characters define the town and the second group of three characters define the street or small part of the town that is indivisible as regards a postman's walk. The equipment at Norwich translates directly from alpha-numeric codes received from the operator's keyboard into sorting-machine instructions because there is no code marking and fully-automatic sorting is not being performed at Norwich. The object of the experiment at Norwich is to assess the reaction of the public to the use of such codes and to find some of the operational difficulties that are likely to occur. It is necessary to carry out this part of the experiment because the full advantage of automatic letter-sorting will only be achieved if these public codes can be employed in conjunction with the code marking of envelopes.

USE OF RECTANGULAR-HYSTERESIS-LOOP CORES

Three types of magnetic core are used in the translator: one for the input code, a smaller one for the output code and a third type of core, the smallest size, for input storage. All of these cores are made of a magnetic material that has a rectangular B/H, or hysteresis, loop.[4] Fig. 2 shows the three types of core on graph paper having 0·1 in. squares.

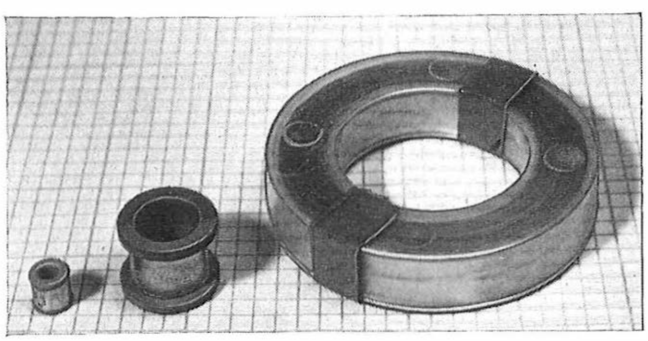


FIG. 2—THREE TYPES OF MAGNETIC CORES USED IN TRANSLATOR

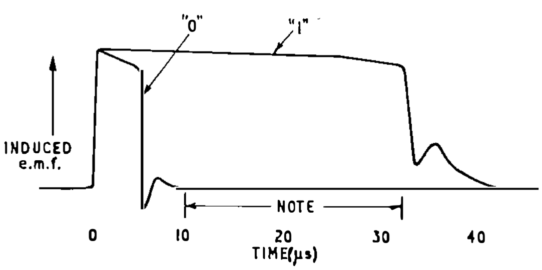
The rectangular-hysteresis-loop characteristic can be used in many ways. In the translator the following uses are made of it:

(*a*) *Translator Input Stores.* The smallest size of core is used for memory elements in the input stores. All cores in these stores are normally in the reset condition; those required to store signals are switched by a strong magnetic field to the set condition. When the information held in this store is required for use, all cores in the store are switched to the reset condition; the only cores that will

† Post Office Research Station.
* Alpha-numeric codes—codes made up of both alphabetical and numerical characters.

experience a large change of flux and induce a "1" signal in an output wire will be those which had previously been switched to the set condition. The stored information is thus available at the output for a few microseconds. This form of reading information is said to be destructive because the output signals are obtained only by switching all cores in the store to the same condition, with the result that the store no longer contains the information. Erasure of the information stored in the input stores after it has been transferred to the translator is required and the destructive nature of the reading is not therefore a disadvantage.

(*b*) *Translation-Field Input-Code Stores.* The main, or input-code, cores in the translation field are the largest size used. Each core has a driving circuit that has the property of providing, for currents less than 150 mA, a constant-voltage source having an impedance of less than 1 ohm and, for a current of 150 mA, a constant-current source having an impedance of more than 10,000 ohms. When driven by this circuit a core will switch at a rate limited by the voltage of the switching circuit until the current limit of 150 mA is reached in the switching circuit. This means that, when switching, the core will induce a constant voltage in a winding, but when the current limit is reached no further change of current can occur and there is therefore no further switching of the core. The circuit switches the core to the set state; if the core is already in that state then only a small flux change can occur and the induced signal, a "0" signal, will have only a short duration of less than 8 μs. If the core is in the reset state, however, a large flux change will occur that will result in a "1" signal having a duration greater than 28 μs. Fig. 3 shows voltage waveforms of these two signals superimposed one upon the other. These cores



Note: Period during which ratio of amplitude of "1" signal to amplitude of "0" signal is high.

FIG. 3—TYPICAL WAVEFORM OBTAINED FROM INPUT-CODE CORE

can thus be used to induce signals into wires that thread them. These signals have a duration of at least 20 μs during which the ratio of their amplitudes exceeds 100:1. This can be used to "gate" a signal passing through the translation field and thus obtain the required translation.

(*c*) *Translation-Field Output Cores.* Three advantages are obtained from the use of rectangular-hysteresis-loop material for the output cores. The first of these comes from the use of material having a characteristic such that a magnetizing field of $\frac{1}{2}H_{max}$ is not able to produce any appreciable change in the flux in a core whereas a field of H_{max} will fully switch the core. By first applying a field of $\frac{1}{2}H_{max}$ to all cores during a translation it is necessary for the translation signal to supply only $\frac{1}{2}H_{max}$ in order to switch a core. This is known as a coincident-current switching technique. The use of this technique allows the diameter of the core aperture to be doubled for a given amplitude of translation signal.

The second advantage obtained from the rectangular hysteresis loop of the output cores is simply one of storage. This enables the core to be set without a load connected to a secondary winding, thus requiring a smaller switching field. The third advantage is also connected with this storage facility, in that when the signal is required from the output cores a powerful reset signal from one pulse generator can be applied to all cores. This will cause the output signals of those cores which had previously been set to have a voltage amplitude about 10 times greater than that which occurs when the cores are set by the translation signals. The cores are thus used as a form of magnetic amplifier.

GENERAL DESCRIPTION

The translators employ electronic techniques, and consequently can operate very quickly. It is therefore possible for the translators to work, apparently simultaneously, for many operators. The number of operators, or translation channels, to be served by one translator was originally set at 20. Whilst no translator is equipped with more than 10 channels at present, the design is capable of extension to many more than 20 channels should this be required.

The translator is shared amongst the translation channels on a time-division basis; each channel in turn is allotted a certain length of time for a translation. When every channel has received its allotted share of time, the cycle is repeated. In the Luton equipment the allotter allows 2 ms for a translation to each of 24 channels, only two of which are at present used; each channel is thus offered a translation at intervals of 48 ms.

Fig. 4 shows, diagrammatically, the main items of such an equipment. They are:

(*a*) A translation field capable of providing all the translations required.

(*b*) Input and output stores that hold the signals until the receiving end is prepared to receive them.

(*c*) An allotter that divides the translation time equally amongst all the channels.

It can be seen that all input stores are able to send signals to the translation field for translation, and the resultant output is sent to all output stores. An input store will, however, send signals to the translation field only under the control of the allotter. This ensures that only one translation is being performed at a time. When an input store sends signals to the translation field it also sends a priming signal to its associated output store, which will then receive and store the translated signal. Without the priming signal from the input store, outputs from the translation field are ignored, thus ensuring that

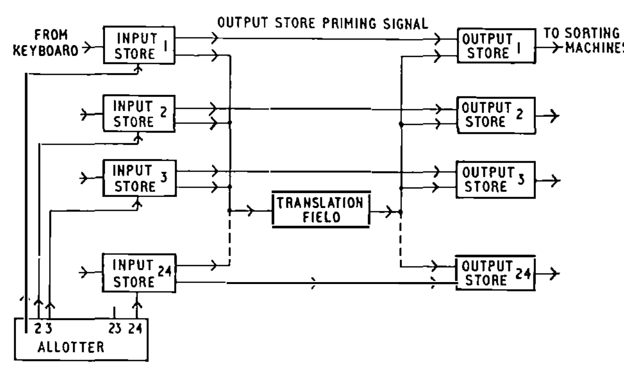
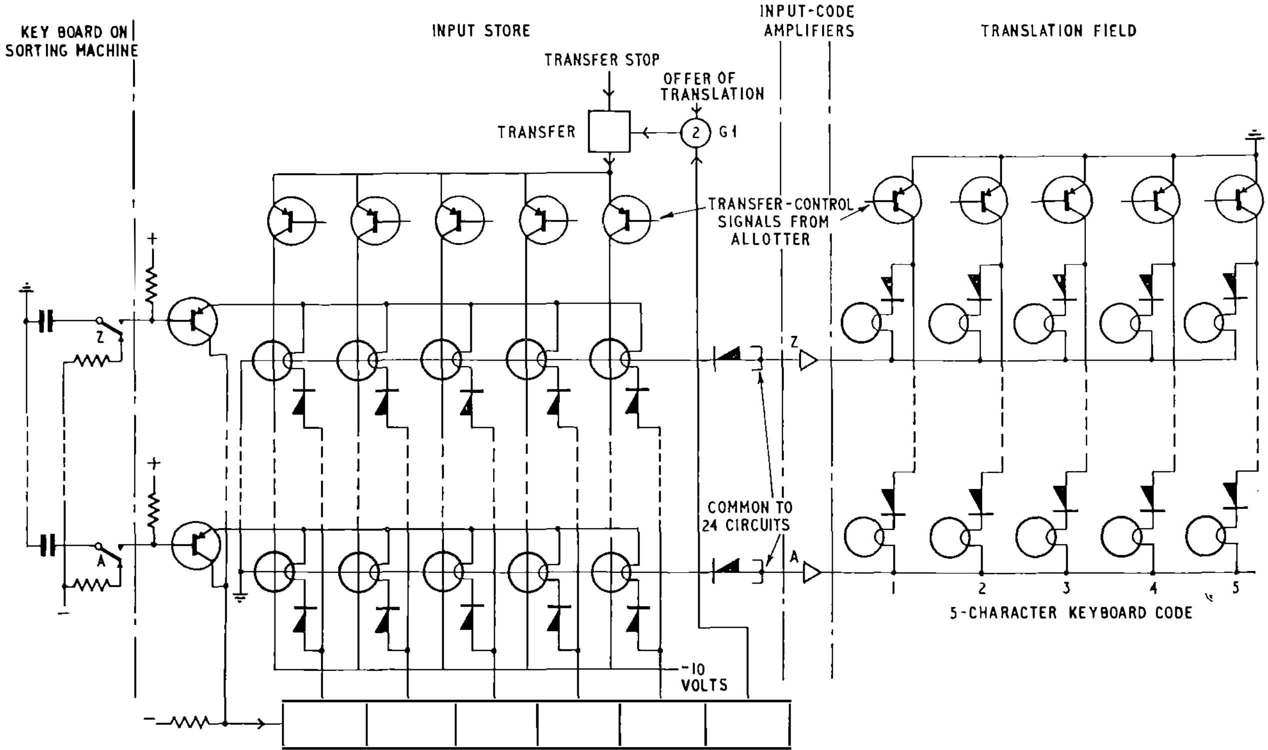


FIG. 4—SIMPLIFIED DIAGRAM OF TIME-SHARING ARRANGEMENT



Note: For clarity, only the letters A-Z are considered.

FIG. 5—INPUT STORAGE AND STORE TRANSFER

unwanted translations are not registered in any output store.

It is not intended to give here a detailed description of all four translators, but a general description will be followed by a more complete description of each part; circuit diagrams will only be shown if they have a special interest. Where examples are given they will normally be for the Luton translator, but it will be obvious that they may be modified to suit the requirements of any similar translator.

Input Store

The keyboard has a normal 4-row typewriter layout with 44 keys (in addition to the 26 letters and 10 numerals, keys are used for special abbreviated codes). Each of these keys operates a microswitch. When operated, each of these switches discharges a capacitor, and the resulting current is amplified by one of the 44 amplifying transistors at the input to the input store (Fig. 5). The discharge of the capacitor is completed in less than 4 ms and, after this period, the input store is prepared to receive the next character. This means that a second key may be operated before the first is released, and if, as is normal, key operations are spaced by much more than 4 ms, it is not necessary to have any keyboard lock. The input store is fitted with a 6-stage counter to guide the keyed characters to the appropriate column, each of which contains 44 magnetic-storage cores.

When the counter reaches the sixth position a signal is sent to a 2-input "and" gate, G1, to indicate that a complete code has been received and that a translation is required. The second input to gate G1 is the signal from the allotter offering this particular channel a translation. When these two signals coincide an output signal from gate G1 initiates the transfer of signals from the input store into the translator. The stored code is transferred sequentially, under the control of the allotter.

Translation Field

An earlier article in this Journal[4] described a translator that has been in use at Southampton since March 1958. The method of obtaining a translation is similar in these new translators, but there are important changes, most notably in the range of output signals that are offered (only 144 at Southampton while 2^{12} or 4,096 are now available at Luton).

Fig. 6 shows the arrangement of the translation field for one of the Luton translators. On the left of the diagram

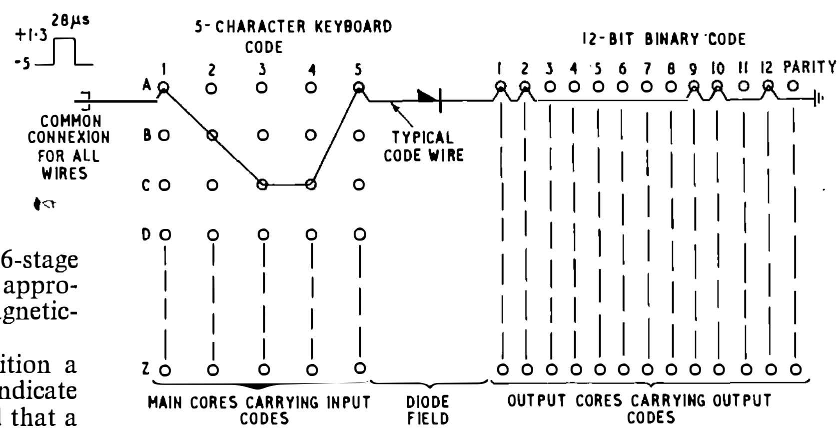


FIG. 6—ARRANGEMENT OF TRANSLATION FIELD

are the main cores that carry the input code and, on the right, the smaller cores that receive the output code. One code wire is shown threading the cores; each code to be translated requires a code wire and 3,000–3,500 wires are commonly required in a translation field. On the left the wire is connected to a common connexion normally at a potential of — 5 volts relative to earth; in the centre is a diode (one diode is provided for each wire) and at the right all wires are connected to earth.

Several thousand code wires are inserted in each translator and, to make this task as easy as possible, all surfaces over which a code wire must be drawn are covered with p.t.f.e.,* a material offering a low coefficient of friction. The whole wiring field is painted white to make the code wires (36 S.W.G. enamelled wire) more easily visible. The enamel on the wire is of a type that does not require stripping prior to soldering. In spite of these and other efforts to make the task easy, it was still found that about 1 per cent of the code wires had an error in the code, and careful checking was required after the wiring was completed.

Initially all cores in the translation field are in the reset condition. When a code is to be taken from an input store for translation the main cores that represent that code are switched to the set condition. The actual translation is then carried out by switching all main cores to the set state simultaneously. At the same time the negative bias of — 5 volts that is applied to all code wires, and that prevents the diodes from conducting, is changed to + 1·3 volts for 28 μs. Each main core, in switching to the set state, induces signals of about 1 volt in each wire passing through it. This signal persists for longer than 28 μs in all cores except those which had previously been set by the input code. The signal induced by these cores persists for less than 8 μs. The code wire that threads main cores, all of which were previously set, will then have a period of 20 μs when no voltage is induced in it. The + 1·3-volt pulse at the common connexion is then able to cause a current to flow in this wire. All other wires will have at least one full signal of 28 μs induced in them and this is sufficient to prevent conduction.

The current that will flow in the wanted code wire is restricted to 100 mA by the code-wire diodes, which, because of the large numbers necessary, are required to be cheap. This current, flowing in a single-turn winding for only 20 μs, would be sufficient to influence only a very small core. By employing a coincident-current technique for setting this output core it is possible to double its diameter, thus increasing by four times the area available for threading code wires.

The output cores were required to pass a selection test that required them to be fully set by a signal of 0·18 ampere-turns persisting for 20 μs but to be unaffected by a signal of 0·09 ampere-turns of the same duration. This test simulates the conditions that occur in the translator. During a translation, a signal of 0·09 ampere-turns is applied for 20 μs to all cores: this must not affect any cores. At the same time, however, the 100 mA current is flowing in the wanted code-wire that passes once through output cores representing the required output code. These cores therefore receive a switching signal of 0·19 ampere-turns and will be fully switched, thus storing the required output code.

A powerful reset signal is then applied to all output cores. Only those cores that have been previously switched to the set condition, and are thus storing the output code, will show a change of flux sufficient to operate the output circuits. The output will be the translation required and must be passed to the appropriate store.

Output Stores

The signal from the output cores is of little more than 1-volt amplitude and exists for only a few microseconds. This signal is used to operate monostable pulse generators that have an output signal of 100 volts amplitude and 300 μs duration and are capable of firing the cold-cathode triodes used in the output store.

The output signal from the translation field is sent to all output stores but it must pass the 2-input "and" gates at the input to every output store. The second input to all these gates is from an output-store priming circuit. By arranging that the output store is primed by its associated input store as a code is passed for translation (Fig. 4) it is possible to ensure that the output store receives only the required translation.

Cold-cathode triodes are used in the output store where they provide both a visual output and the high signal-level required by the cold-cathode triodes at the input of the sorting equipment. The visual output is a very valuable feature in a large electromechanical system.

Allotter

An allotter is used to send signals to each input store in turn (Fig. 4). An input store can have a translation only when one of these signals is received. By suitably spacing these signals it is possible to ensure that the translation field is serving only one input store at a time.

In addition to sharing the translation time equally among all stores the allotter is required to control the transfer of the stored codes from the translator input stores. The code is transferred serially, character by character, in order to use one set of 44 keyboard-code amplifiers six times for a 6-character code instead of having to use the 6 × 44 amplifiers that would be required if parallel transfer were used. Fig. 7 shows the six store-transfer-control signals that are generated by the allotter every 2 ms immediately after each offer of a translation is given to the input stores. Fig. 8 shows how these signals are generated; an 8,000 p.p.s. square-wave generator is used as a master oscillator to drive frequency-dividing stages and shift registers. Each of these shift registers is, in effect, one row of storage points, and when one common driving signal is applied to the whole shift register it is able to transfer all the stored signals along by one stage; successive drive signals are thus able to move the information along the row.

By feeding the shift register with stored signals via frequency-dividing stages it is possible to ensure that the whole register never contains more than one signal. By taking an output from each storage point a distributor or allotter is formed that gives an output from each storage point in turn as the one stored signal is moved along the shift register. Fig. 8 shows how successive stages of frequency division are used to obtain a series of six store-transfer signals that are repeated after each of 24 channels are offered a translation. This form of shift register was chosen in preference to the more common ring-counter arrangement as the system used is self-starting and, after the first cycle of 48 ms, cannot contain more than one signal.

The allotter is also required to control some other minor operations, the most important of these functions

* p.t.f.e.—polytetrafluorethylene.

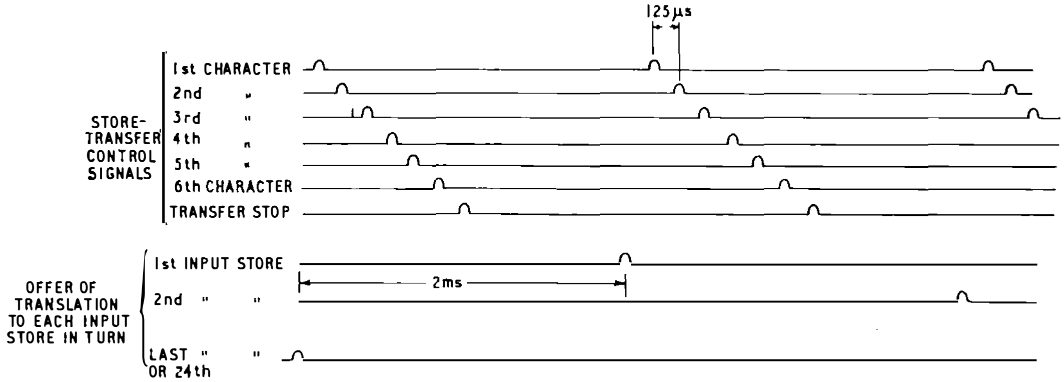


FIG. 7—STORE-TRANSFER-CONTROL SIGNALS GENERATED BY ALLOTTER

being the control of a tester that employs a third shift register, this time providing six sequential outputs to six switches. Each of these switches may be set to one of 44 positions. In this way the tester can simulate a keyboard giving out any code composed of up to six characters. These signals are repeated at about 10 times per second, thus enabling the operation of any part of the translator to be observed on an oscilloscope.

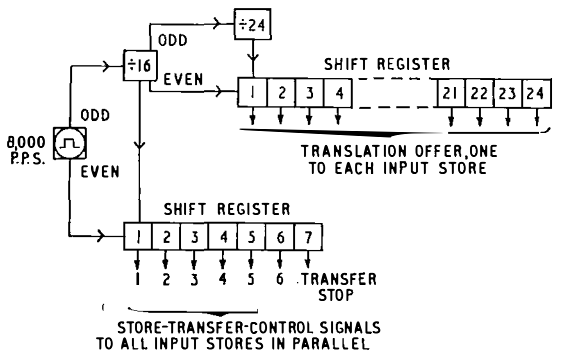


FIG. 8—GENERATION OF STORE-TRANSFER-CONTROL SIGNALS

Shift Register Employing Magnetic Cores and Transistors

Fig. 9 shows a shift register used in the allotters and testers of these translators. It is required to give a pulse of about 10 μs duration at each output in turn as a signal is shifted along it.

The core used is the smallest shown in Fig. 2; the flux change that occurs when this core is switched from one saturated condition to the other was calculated from the known value of B_{max} for the B/H loop (8,000 gauss for this material) and for the known value of cross-sectional area of the core of about 0·001 cm^2. This gives a total flux change of about 150 lines, i.e. 1·5 microvolt-seconds per turn (see Appendix). In the shift register shown in Fig. 9 the cores have 5-turn windings. If a core, previously in the set condition, is switched to the reset condition, a signal of 7·5 microvolt-seconds is induced in each 5-turn winding of that core. The polarity of this signal ("spot" end of winding positive) is such as to cause the base–emitter of the transistor to which it is connected to conduct. The winding that causes this conduction is connected to the base of the transistor and to the 0·5-volt line.

When conducting, the base of the transistor will present a low-impedance circuit having a p.d. of about 0·25 volts. This results in the amplitude of the signal from the core being clamped at about 0·75 volts. Any attempt by the drive circuit to switch the core at a greater rate and produce a greater e.m.f. than this will result in a higher current passing in the base winding and this will cause a reduction in the magnetic force available to switch the core, because the reset current in the drive circuit is of constant amplitude. With the switching e.m.f. limited to 0·75 volts and the available voltage-time pulse area of 7·5 microvolt-seconds then the duration of the pulse will be fixed at 10 μs.

With the base circuit conducting for 10 μs the collector circuit must also conduct for this time. The transistor conducts fully and the current is limited by the collector resistor and the supply voltage. This current is fixed at 100 mA in the circuit shown; the resulting switching force of 0·5 ampere-turns is sufficient to switch the next core in the shift register to the set condition. This action induces a negative signal at the "spot" ends of the other windings and the positive signal induced at the base of the next transistor will not cause conduction.

In this way a drive signal on one of the two drive circuits has caused a set condition to move from one core

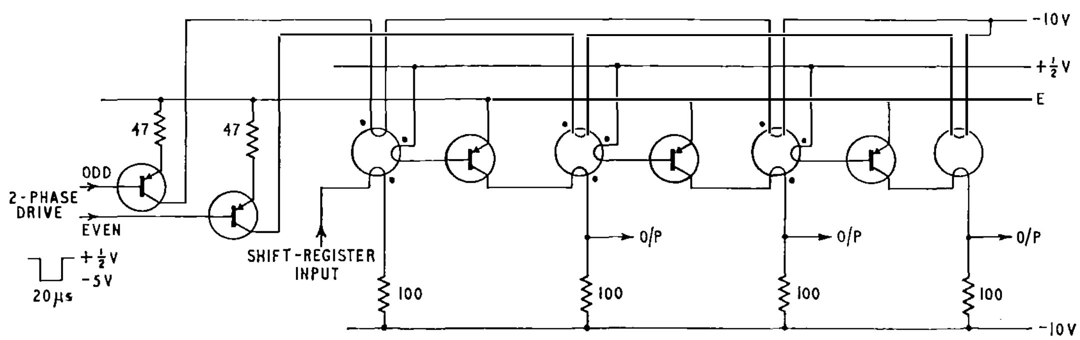
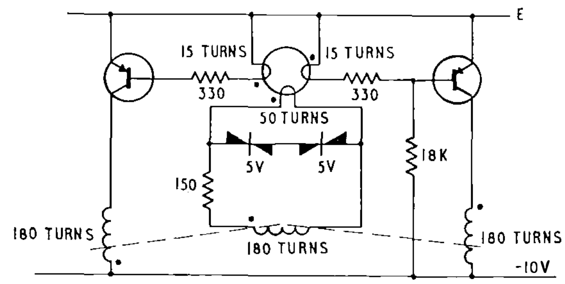


FIG. 9—MAGNETIC-CORE SHIFT REGISTER

to the next one in the sequence. Two phases of drive are necessary with this type of shift register so that signals can be moved from, say, the odd-numbered cores into the even-numbered cores, which are all in the reset condition and undisturbed by drive signals. This type of shift register is known as a two-core-per-bit type because two cores are required for each signal or binary digit (bit) that it is required to handle.

Square-Wave Oscillator of Constant Frequency

Fig. 10 shows a circuit which also employs the constant voltage-time area characteristic possessed by a winding on a magnetic core having a rectangular hysteresis loop. The master oscillator which controls the allotter in these translators is of this design.



— — — — denotes coupled coils.

FIG. 10—STABLE OSCILLATOR EMPLOYING MAGNETIC FEEDBACK

The circuit was required to provide a square wave having a reasonably constant frequency of 4 kc/s unaffected by changes of load, supply voltages and temperature. The circuit is a magnetically-coupled multivibrator; the non-saturating transformer in the collector circuit is switched first with the "spot" end of a winding positive with 10 volts across a 180-turn winding and, in the next half-cycle, with the "spot" end of a winding negative, again with 10 volts across a 180-turn winding. In order to maintain this oscillation a signal is fed back from a third 180-turn winding of this non-saturating transformer. The signal fed back is magnetically coupled into the base circuit of each transistor by means of a magnetic core having a rectangular hysteresis loop. This core will permit a signal having a voltage-time area of about 750 microvolt-seconds to appear across its 50-turn winding; after this pulse-signal area has occurred the feedback transformer will be saturated and the conditions will reverse to allow a further half-cycle to occur, again governed by the 750 microvolt-seconds limitation of the feedback transformer, but this time with the pulse of opposite polarity.

In order to fix the time for one half-cycle of oscillation it is only necessary to limit the voltage amplitude of this 750 microvolt-seconds signal. This is done with two Zener diodes connected face-to-face; when one of the diodes is conducting in the forward direction with a p.d. of about 1 volt across it, the other will be operating as a voltage limiter. In this instance 5 volts has been chosen as the limiting voltage giving a total voltage-limiting level of 6 volts. With the limit of 750 microvolt-seconds on the pulse area this fixes the time for which one half-cycle of feedback can occur at 125 μs. The frequency of operation is thus fixed at 4 kc/s by the characteristics of the Zener diodes and magnetic core in the feedback path. Large variations in load, temperature and supply voltage can occur without appreciably affecting the frequency of operation.

The 330-ohm resistors in the base circuits are provided to ensure constant-current drive for the transistors. With 6 volts across the 50-turn winding an e.m.f. of nearly 2 volts will be induced in the base circuit. With a base-emitter p.d. of about 0·25 volts, the remaining e.m.f. of about 1·7 volts will appear across the 330-ohm resistor. This will fix the base current at about 5 mA. The 18,000-ohm resistor in one base circuit ensures that the circuit is self-starting.

The inductance of the non-saturating transformer was found from formula (2) given in the Appendix.

Miscellaneous Circuits

Fig. 11 shows some of the methods used in the output stores of the translators to connect low-voltage low-impedance transistor circuits to high-voltage high-impedance cold-cathode valve circuits.

Fig. 11 (*a*) shows how a signal of small amplitude and duration may be used to cause a cold-cathode triode to strike. A blocking oscillator[4] is used to switch on a high-voltage transistor; the signal from this transistor is capable of causing the triode to strike.

Fig. 11 (*b*) shows a fairly simple way of controlling a transistor from a cold-cathode triode. The transistor, normally non-conducting, will conduct during an inspection pulse only if the triode is not conducting.

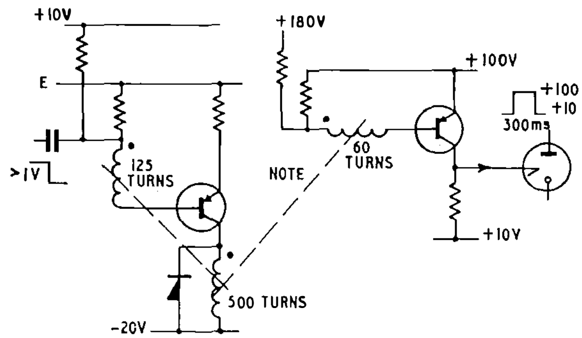
Fig 11 (*c*) shows a method that may be used to extinguish cold-cathode triodes. The transistor is normally fully conducting, but a positive-going signal is able to switch the transistor off. The voltage at the collector will fall to +100 volts, at which value it will be clamped by the diode. Any triode that had been conducting will have had a cathode potential of about 100 volts, with its cathode capacitor charged to this value. When the anode potential is reduced to +100 volts no potential exists across a previously conducting triode and it will be extinguished.

Fig. 11 (*d*) shows a more novel way of extinguishing cold-cathode valves. This method is used in the Mount Pleasant translator and is not known to have been used before. The method involves the generation of the + 180 volts h.t. supply from the — 10-volts supply by means of a convertor. This convertor is a 5 kc/s square-wave oscillator operating in the same way as the stable oscillator already described, but it does not employ Zener diodes in the feedback path, as frequency stability is not important. The non-saturating transformer of the oscillator has an output winding of a large number of turns. The signal from this output winding is rectified to provide the h.t. By switching off this oscillator at a low-voltage point it is possible to switch off the h.t. supply.

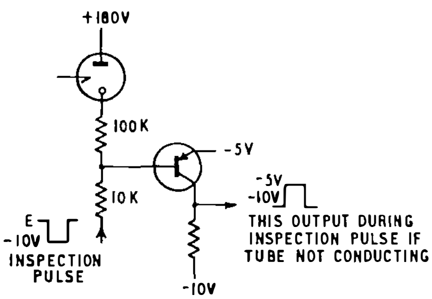
THE MOUNT PLEASANT TRANSLATOR

The translator made for Mount Pleasant sorting office is more simple than the other three translators. The simplifications are mainly due to there being no sharing requirements and to the smaller range of codes to be translated. Experience gained from running the other three translators and the increased time available for development made it possible to incorporate some improvements and new ideas.

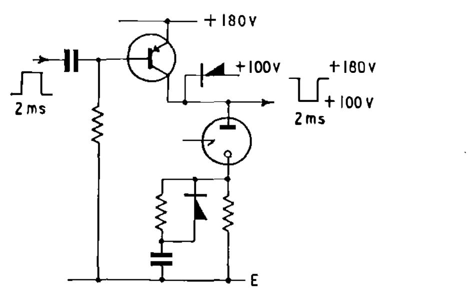
The most important change was an increase in the switching rate of the main cores. This results in an increase from about 0·9 volts to about 1·2 volts in the e.m.f. induced in a code wire passing through a core. This change reduces the effect of the code-wire resistance and unwanted induced e.m.f.s.



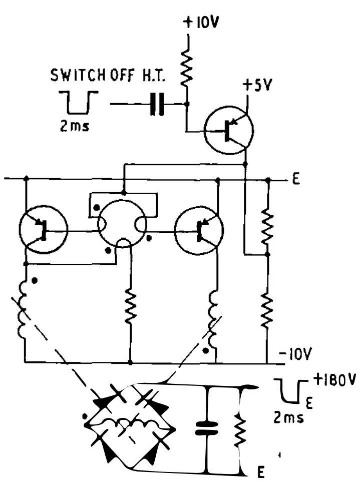
(a) Connexion of Transistors to Cold-Cathode Tubes



(b) Connexion of Cold-Cathode Tubes to Transistors



(c) Circuit for Extinguishing Cold-Cathode Tube by Switching a Series Transistor in the H.T. Line



(d) Circuit for Extinguishing all Cold-Cathode Tubes by Switching the H.T. Generator

— — — — denotes coupled coils.

FIG. 11—MISCELLANEOUS CIRCUITS EMPLOYING TRANSISTORS IN CONJUNCTION WITH COLD-CATHODE TUBES

Another change was in the power-supply arrangements; instead of fitting a low-impedance mains-input power unit for each of the d.c. voltage supplies of —5 volts, —10 volts, — 20 volts and — 30 volts, only one power-supply unit is fitted (see Fig. 12). The unit supplies about — 50 volts d.c. from a relatively high impedance; this supply is taken to simple series-transistor stabilizers each using a Zener diode to give a reference potential. The serious drawback which series-transistor stabilizers have of being destroyed by even a brief overload at the output is avoided in this design by the use of a series resistor in the collector of each stabilizing transistor. This resistance will "bottom" the transistor (i.e. it will be current-saturated) and thus limit the current and transistor dissipation at a chosen level. If the supply should be required to pass currents momentarily greater than this limiting value then a capacitor shunting this limiting resistor would allow this.

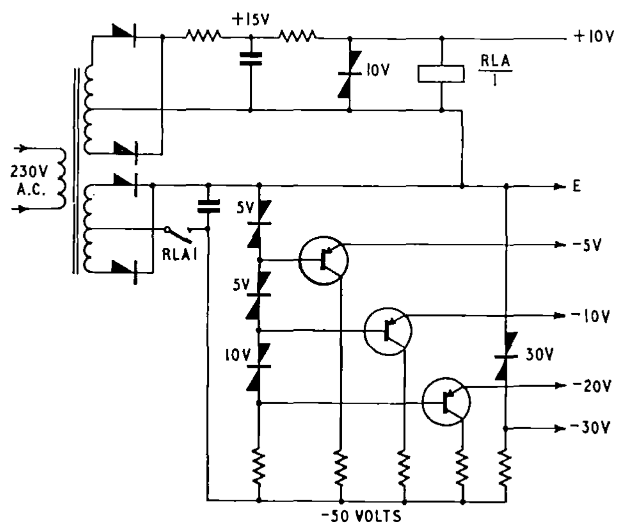


FIG. 12—POWER-SUPPLY UNIT USED FOR MOUNT PLEASANT TRANSLATOR

CONCLUSIONS

The mechanization of the handling of mail is essentially a mechanical problem. This problem is very difficult to solve satisfactorily, and the use of electronic techniques such as those just described are necessary to make such mechanization possible. In order that mechanization should be not only possible but also economically acceptable it is necessary to take advantage of the inherently-high operating speed of electronic equipment by sharing a common item, such as a translator, among a large number of mechanical equipments. This sharing may even be extended by the use of line links from one central point to several subsidiary sorting offices. Because one fault in the common equipment could stop the whole sorting system, it is essential that such equipment should be very reliable.

For a large system, the degree of reliability required of common electronic equipment might well be attained by the use of two parallel equipments with a fault indication if the output signals were not identical. The use of two complete equipments would also simplify maintenance and the requirements for change of routing instructions.

The translators discussed above were put into service immediately the production faults had been cleared. Inevitably, some less-obvious faults still existed; when these had been eliminated the translators proved extremely reliable. The approximate total numbers of components used in the four translators are as follows:

2,400 transistors (mostly CV 7006)

19,000 diodes (mostly CV 7048)

6,500 resistors

5,000 magnetic cores of metal tape having a rectangular B/H loop

300 transformers (mostly pulse transformers on ferrite pot cores)

1,600 capacitors

500 cold-cathode valves (mostly type XC 18 triodes)

About 50 per cent of these components are in the Norwich translator, which is permantly energized and had run for about 13,000 hours by June 1962. Forty-five per cent of the components are in the Luton translators, which are now energized 24 hours per day for 5 days per week. These translators had run for about 8,000 hours by June 1962. The remaining 5 per cent of the components are in the Mount Pleasant translator which ran for about 3 hours per day, 5 days per week for 6 months. This had been energized for about 500 hours at the end of 1961 and is used only intermittently at present.

Apart from the initial period when production faults were being cleared, the only component failures that have occurred are one wire-wound resistor that became open-circuit, two silicon diodes and about 40 cold-cathode triodes, most of which were changed as a result of routine checks that showed that their characteristics had moved beyond an acceptable limit.

The high degree of reliability of the translators has been achieved by the use of design methods that make the circuit operation almost independent of the characteristics of active elements. The majority of the circuits are, for a very wide range of transistor characteristics, dependent only upon resistor and inductor values for their operation. With cold-cathode valves this method of operation is not so readily achieved and this fact is illustrated by the relatively large proportion of cold-cathode triodes (about 8 per cent) which have required replacement.

ACKNOWLEDGEMENT

The authors wish to acknowledge contributions which Mr. E. D. Chapman made to the mechanical design of the translators.

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APPENDIX

Design of Magnetic Circuits

When designing any of the magnetic circuits described, only the three following formulae are employed:

$$H = \frac{4\pi NI}{10l}, \text{ or } H' = \frac{NI}{l'} \text{ in m.k.s. units} \quad (1)$$

$$v = L\frac{di}{dt} \quad (2)$$

$$v = N\frac{d\phi}{dt} \quad (3)$$

from which it can be shown that

$$vt = N\phi \times 10^{-8}, \text{ or } vt = N\phi' \text{ in m.k.s. units} \quad (4)$$

where v = potential in volts
i = current in amperes
t = time in seconds
H = coercive force in oersteds
H' = coercive force in ampere-turns/metre
l = magnetic-path length in centimetres
l' = magnetic-path length in metres
N = number of turns
ϕ = change in magnetic flux linking windings (in lines)
ϕ' = change in magnetic flux linking windings (in webers)
L = inductance in henrys

Formula (1) is used to determine the ampere-turns required to produce saturation in the rectangular-hysteresis-loop circuits. The value of H is found from the hysteresis loop for the material and l is the length of the magnetic path of the toroid.

Formula (2) is used to ascertain the value of inductance required by the non-saturating transformer. Because of the air gaps in these cores the inductance can be assumed to be linear for increasing current, so that the formula becomes $L = v.t_p/i_{pk}$, where t_p is pulse duration in seconds and i_{pk} is peak magnetizing current in amperes. This formula was used in the design of the square-wave master oscillator described controlling the allotter. When using this formula v and t_p will usually be defined by the circuit and i_{pk} can be chosen to be a reasonable value (50 or 100 mA is often chosen in the translators described). It is necessary to check that a transformer designed using this formula is not saturated as a result of employing too small a magnetic core. This may be checked from formula (1) knowing the saturation value of H from the B/H characteristic of the core or from equation (4) knowing the saturation value of B from the B/H characteristic.

Equation (4) shows that the voltage-time area of a pulse of induced voltage, i.e. the area under the voltage-time curve, is proportional to the number of turns of the winding and to the flux change that links the winding. In magnetic materials having rectangular hysteresis loops the flux change in a core will be the same whenever the core is switched fully from one saturated condition to the other. This means that the voltage-time area of a pulse from a winding on a core of this material can be made to have a fixed value. If a circuit is designed to fix the voltage level of this pulse then the time also is fixed. This very useful feature is used in the design of the shift register and the square-wave oscillator of these translators.

Book Received

"Electronics as a Career." H. F. Trewman. B. T. Batsford, Ltd. 136 pp. 16 ill. 12s. 6d.

This is one of the Batsford Career Books. These illustrated books form a series, "which aim to provide the young person with interesting and accurate descriptions of a number of worthwhile careers. How, for instance, does he, or she, enter the profession or trade? What qualifications are required? What happens in the training period? Above all, what are the opportunities for the ambitious?"

Professor Trewman, the author of "Electronics as a Career", has held numerous important positions in the world of electronics and has been for many years particularly concerned with the education and training of prospective engineers and technicians. It is not surprising, therefore, to find that this book fully covers all the aims of the Career Books. After a brief introduction describing in general terms the career requirements and possibilities available both at professional and technical levels in the field of electronics, details are given of the following sections of the industry: radio and television, telecommunications, commerce and industry, medicine and surgery, instrumentation, the Civil Service, the Armed Forces, and teaching. The final chapter of the book describes the various Degrees, Diplomas and other qualifications appropriate to a career in electronics, together with methods of entry, courses of study, etc.

Selective Voice-Frequency Signalling for Motorway Emergency Telephone Systems

E. H. SEYMOUR, A.M.I.E.E., and G. TURNER†

U.D.C. 621.395.385.4:621.395.9:625.711.3

The d.c. signalling system provided for the emergency telephone service on the M1 motorway is subject to inductive interference from adjacent e.h.t. power lines. Because of this, a voice-frequency signalling system has been developed and will be used for all future motorway emergency telephone services. The principles and the features of the system are described.

INTRODUCTION

THE experimental emergency telephone system[1] provided for the first motorway, M1, used d.c. signalling because this was the simplest and cheapest method of meeting the Ministry of Transport requirements.

Unfortunately, along various sections of its length the motorway is parallel with e.h.t. power lines, and the resulting induced voltages in the telephone cables are severe enough, on occasion, to cause false calling signals. Additional interference is expected, from about 1963 onwards, after completion of the 25 kV a.c. electrification of the Euston–Crewe railway line.

It is now evident that this pattern of long lengths of parallelism with one or both of such sources of inductive interference is likely to be a recurring feature on many of the new motorways planned for this country. In order to obtain immunity from signalling interference and to allow the insertion of isolating transformers in the external cables to limit induced voltages from e.h.t. systems to the required safety level, it was decided to develop a voice-frequency (v.f.) signalling system and to use it for all new motorways.

The basic requirements remain the same as those for the M1 emergency telephone system, but for convenience the salient points are briefly restated here. To economize in line-plant, a maximum of 10 roadside telephones are connected as a party line on each pair of wires, but the significant features that affect the signalling system are: (*a*) individual identification of each calling telephone is required at the controlling police stations, and (*b*) callers should not have to perform any signalling operation other than lifting the telephone handset.

OUTLINE OF SIGNALLING SYSTEM

A total of five signalling frequencies, 1,500, 1,740, 1,980, 2,220 and 2,460 c/s, is used, the 10 different signals required for identification purposes being obtained by using the five frequencies in a two-out-of-five code. The use of coded signalling gives some degree of immunity from signal imitation, but additional immunity is obtained by the use of a noise guard circuit tuned to 1,020 c/s in the control-station equipment. The lowest frequency used is kept as high as practicable to increase the inherent immunity from the inductive effects of railway electrification.[2] These effects include the radiation of a wide range of harmonic frequencies in addition to the fundamental at 50 c/s. Conversely, the highest frequency used is made as low as practicable to avoid approaching the cut-off frequency of existing older types of loaded cable that may have to be utilized to provide the cable spur connexions from some motorways to the controlling police stations.

Two v.f. oscillators are provided at each roadside telephone, and the lifting of the handset causes a 2-frequency signal to be sent automatically to line for approximately 1 second. At the control station one pair of a set of five selective amplifier-detectors responds to the signal and causes a group calling lamp and the appropriate identification lamp to light on the operator's switchboard panel.

Transistors are used in the electronic apparatus, both at the control stations and at the roadside cabinets.

CONTROL-STATION EQUIPMENT

It is necessary to receive two signalling frequencies in order to give the requisite calling signal to light a calling-telephone identification lamp and a group lamp. However, because motorway telephones provide an emergency service, a group calling-signal should be ensured even if, as the result of a fault, only one signalling frequency is received and identification of the calling telephone is prevented. The arrangement adopted is shown schematically in Fig. 1. The incoming signal is applied to the main channel and normally causes an identification lamp and a group lamp to light on the switchboard, in which case the by-pass channel remains inoperative. If under fault conditions the main channel does not respond fully, the single-frequency signal is diverted through the by-pass channel to give a calling signal on a group basis. As the latter sequence is indicative of a fault, arrangements are made to light an alarm lamp to draw attention to the fault.

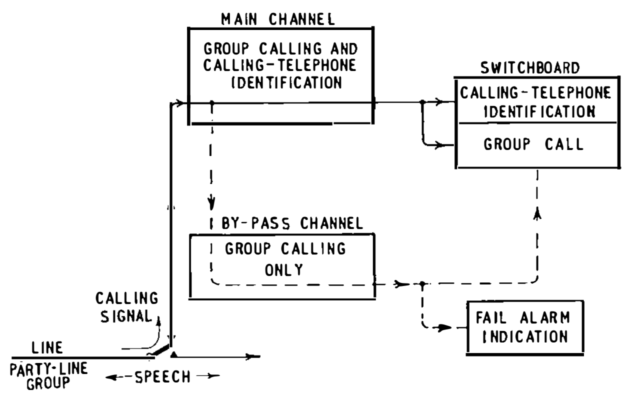


FIG. 1—BASIC SIGNALLING ARRANGEMENT

Main Channel

A simplified circuit diagram is shown in Fig. 2, which also includes a schematic representation of 10 roadside telephones connected to the group.

The lifting of the telephone handset at, for example, roadside telephone No. 4, causes two frequencies, P

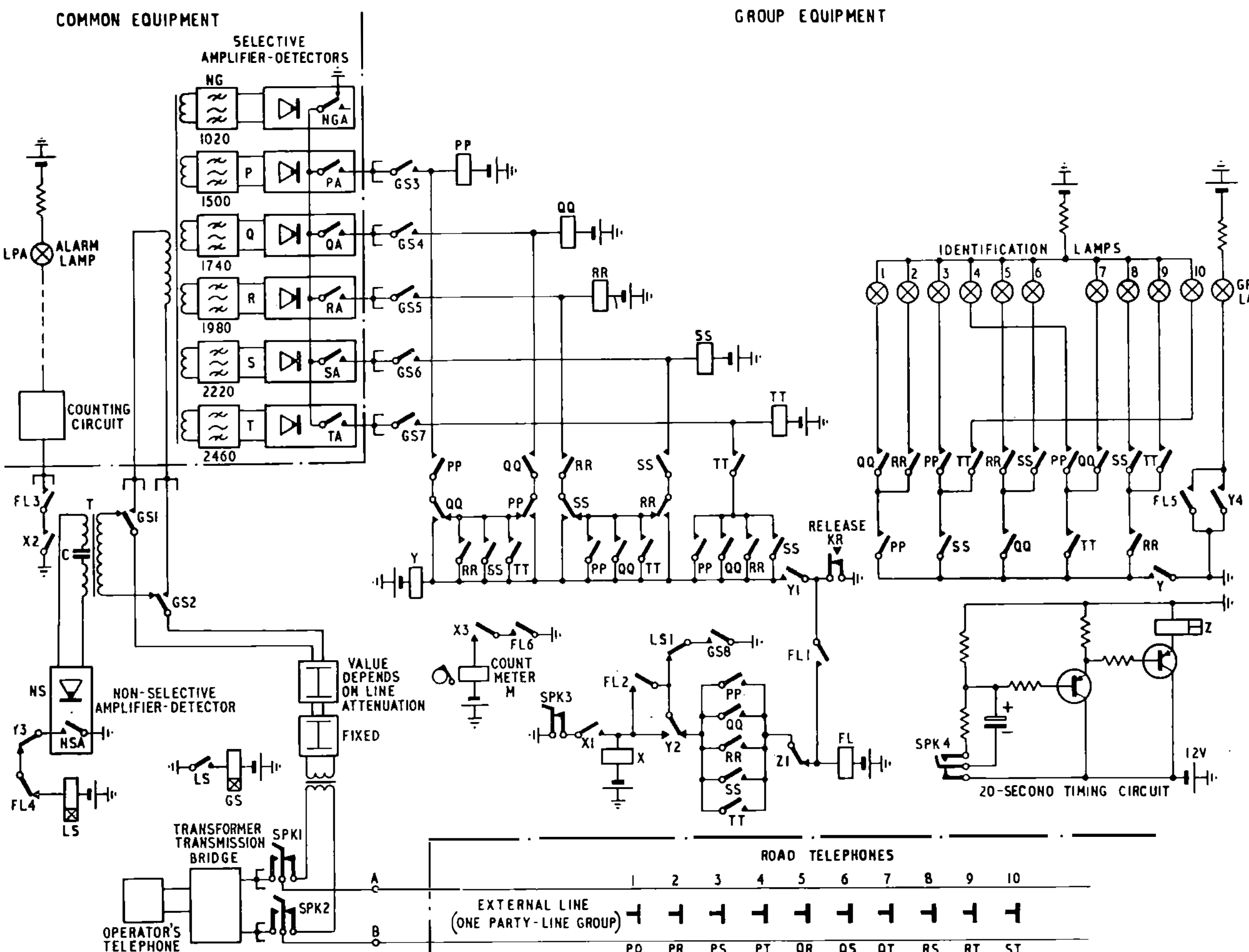
†Subscribers' Apparatus and Miscellaneous Services Branch, E.-in-C.'s Office.

and T at 1,500 and 2,460 c/s, respectively, to be sent to line for approximately 1 second in a manner described later. The incoming signal is first applied to the non-selective amplifier-detector NS, which responds, and contact NSA closes to operate relay LS, which in turn operates relay GS. Contacts GS1 and GS2 switch the line to the inputs of the five selective amplifier-detectors, P, Q, R, S and T, and to the noise-guard amplifier NG, and contacts GS3–GS7 connect the outputs of the selective amplifier-detectors to the switching relays PP, QQ, RR, SS and TT. Only the amplifier-detectors P and T respond to this particular 2-frequency signal, and contacts PA and TA operate relays PP and TT. When both of these relays operate, a path is provided to operate relay Y, and relays PP, TT and Y then lock to contact Y1. The relevant PP and TT contacts light the appropriate identification lamp (in this example No. 4), and contact Y4 lights the group lamp.

At the operation of contacts GS1 and GS2, the incoming signal is removed from the non-selective amplifier-detector, so that NSA releases and, in turn, relays LS and GS release. Because of the slow-release lags, relay LS releases before relay GS and, at contact LS1, operates relay X via operated contacts GS8 and Y2; relay X locks to its contact X1. Contacts X2 and X3 perform no function in the main channel operation. Contact Y3 disconnects relay LS, so that neither relay LS nor relay GS can re-operate, and the signalling equipment is locked off the line.

In response to the calling signal a police officer operates the speak key. This puts the line through to his telephone at contacts SPK1 and SPK2 and breaks the locking circuit to relay X at contact SPK3, the earth at contact GS8 having already been removed by the release of relay GS. The group lamp and the identification lamp remain alight for the duration of the call. At the end of conversation the speak key is restored to normal, and the press-button release-key, KR, is also depressed momentarily to release relays Y, PP and TT. The identification and group lamps go out and all apparatus is restored to normal.

If the caller does not replace his handset for a period after the operator has restored the speak key, the line becomes reconnected to the signalling apparatus, and any noise picked up by the telephone transmitter, due either to speaking, whistling, etc., on the part of the caller, or to mechanical vibration when the handset is replaced, is likely to actuate the v.f. receivers and cause a false calling signal. To prevent this, a noise-guard receiver, NG, tuned to 1,020 c/s is used. The type of



Signalling frequencies: P=1,500 c/s, Q=1,740 c/s, R=1,980 c/s, S=2,220 c/s, T=2,460 c/s.

FIG. 2—CIRCUIT OF CONTROL-STATION EQUIPMENT

noise mentioned has a sufficient component at 1,020 c/s to operate receiver NG, and contact NGA removes the common earth from the Y, PP, QQ, RR, SS, and TT relays so that they cannot operate. Conversely, the tuned noise-guard receiver remains inoperative to a genuine signal.

By-pass Channel

If a fault results in only a single-frequency signal being received, only one of the relays PP, QQ, RR, SS, and TT will operate, and in this event an operating path is not established for relay Y so that an identification lamp cannot light. Relays LS and GS, however, operate and release in the normal manner, and, at the release of contact LS1, relay FL operates via contacts GS8 (not yet released), Y2 (not operated), and one of the PP, QQ, RR, SS, and TT contacts. Relay FL locks via contact FL1, and contact FL5 lights the group calling lamp. Contact FL4 prevents any further operation of relays LS and GS. In these circumstances, therefore, a calling signal is given on a group basis, even though identification cannot be given.

At the end of a call, and after the operator has restored the speak key, relay FL in the by-pass channel, which is responsive to a single-frequency signal, is inevitably more vulnerable than the main channel to false operation from noises picked up by the telephone transmitter, and to overcome this a delay circuit is used. At the release of the speak key, contact SPK4 causes relay Z to operate and hold for approximately 20 seconds. The operation of the timing circuit is the same in principle as that used at the roadside cabinets, which is described later. The result is that contact Z1 disconnects relay FL for about 20 seconds after the restoration of the speak key, and this should allow ample time for the caller to replace his handset, or at least to cease speaking into the transmitter. This temporary suppression of the group-call facility, however, does not prevent another genuine calling signal from being established via the main channel.

Fault Indication

An operation of the by-pass channel indicates that a fault exists (or has existed), and relay contacts X2 and FL3 give the necessary fault indication on an alarm lamp, LPA. Because of the fast switching time on receipt of a calling signal (about 250 ms), it is possible for a fault to be transient in nature and hence not to be repeated subsequently. To avoid calling out a maintenance officer unnecessarily for such a fault, the alarm lamp is not operated directly by contacts X2 and FL3 but via a counting circuit, which can be arranged to light the alarm lamp after any pre-determined number of operations from 1–11. The number of operations allowed may vary in different control stations depending on the number of party-line groups connected, and the alarm may be set to operate within the range quoted above to suit local conditions.

When maintenance attention is given, the alarm-counting circuit is re-set to zero, and to keep a record of the total number of faults the number of operations of the counting circuit is also recorded permanently, for each group, on meter M, which is operated via contacts X3 and FL6.

Common Equipment

To economize in equipment costs and accommodation space the receive filters and amplifiers are common to the whole station equipment, irrespective of the number of party-line groups. The connexion of the common equipment to the various group equipments is made at the appropriate times by the switching contacts GS1 to GS7. The use of common switching equipment is possible because of the comparatively low calling rate, coupled with the fact that the occupancy time of the v.f. receivers is less than 500 ms per call.

Two secondary-cell batteries are provided, one of 12 volts for the transistor equipment, and one of 50 volts for the relay equipment, both being trickle-charged from the mains. Direct working from mains power-units is not permissible because the emergency nature of the system requires a safeguard against mains failure.

EQUIPMENT IN ROADSIDE CABINETS

In addition to the telephone, each cabinet is provided with two v.f. oscillators and a timing and switching unit. The arrangement is illustrated in Fig. 3 in which, for simplicity, the telephone and only one oscillator are shown, in schematic form. The oscillator requires a 20-volt supply, but has three battery terminals, A, B and S, the 20-volt supply being connected permanently across terminals A and B. With only the 20-volt supply connected the oscillator is quiescent; it is rendered active by the additional application of a potential of 2·5 volts between terminals A and S. In the idle condition of the circuit, the transistor VT is in the cut-off state, the base and emitter having substantially the same potential.

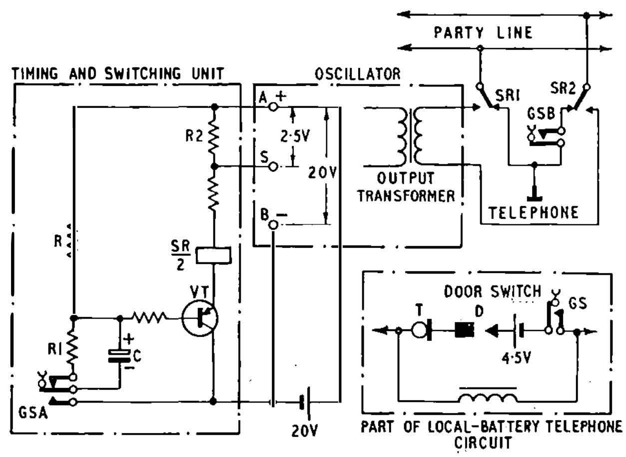


FIG. 3—CIRCUIT OF ROADSIDE-CABINET EQUIPMENT

When a call is made the lifting of the handset operates the gravity springsets GSA and GSB. The operation of springset GSA causes the capacitor C to start to charge in series with resistor R, and initially the base of transistor VT becomes negative relative to its emitter so that emitter–collector current flows and operates relay SR. Contacts SR1 and SR2 disconnect the telephone from the line and connect instead the output terminals of the oscillator. The value of resistor R2 is such that a p.d. of 2·5 volts is produced across the resistor when emitter–collector current flows in transistor VT, and this p.d. applied between terminals A and S of the oscillator causes it to oscillate and the signal passes to line.

When capacitor C becomes fully charged, the base and emitter of transistor VT again acquire substantially the same potential, and transistor VT cuts off. Relay SR releases, reconnecting the telephone to line in readiness for speech, and the removal of the p.d. across resistor

R2 renders the oscillator inoperative. At the end of the call, replacement of the handset restores springset GSA to normal, capacitor C discharges very rapidly through resistor R1, and the circuit is then ready for further calls.

The timing of the circuit is determined basically by the time constant *CR*. However, since the transistor emitter current rises sharply to its determined working value and then falls gradually to (almost) zero, the period for which relay SR remains operated also depends on its release current. In the circuit used, this period is approximately 1 second, which allows ample time for the operation of the control-station receiving equipment.

Because of the exposed positions of the roadside cabinets, relay SR is a special type totally enclosed in a gas-tight case from which air has been evacuated and replaced by an inert gas. This feature, together with the use of special contact materials, should ensure fault-free service from the relay.

If a caller omits to replace the handset for any reason at the end of a call, the telephone transmitter would normally remain energized, and any noise picked up by it, for example due to the vibration of passing traffic, might cause a false calling signal or prevent the reception of a genuine calling signal from another telephone on the party line. To safeguard against this, a micro-switch is fitted to the cabinet door, and its contacts, D, make when the door is opened and break when the door is closed. When the telephone is not in use the cabinet door is self-closing under the action of a spring, and the telephone transmitter is automatically disconnected from its local battery, thus precluding the possibility of a live transmitter giving false signals. This feature also prevents the local battery from being discharged under such conditions.

The telephone itself, to which the motoring public has access, is a wall-mounted 700-type local-battery instrument; it is fitted in its own compartment at the top of the cabinet. The signalling apparatus and other auxiliary apparatus such as test tablets are fitted in a separate compartment below that of the telephone. This compartment is provided with a lockable door and can be opened only by Post Office staff.

Three primary-cell batteries are provided: one of 4·5 volts for the local-battery telephone, one of 22·5 volts for the oscillators and timing unit, and a third also of 22·5 volts, to provide wetting current for the various switching contacts. Because of the importance of having batteries in good working order, they will be changed systematically at intervals appreciably less than their normal working lives.

SIGNALLING LEVELS AND LIMITS

The two signalling frequencies are sent to line at each roadside cabinet at a combined level of −3 dbm,* the individual signal levels being about −5 or −6 dbm. A higher level would be permissible from line transmission considerations alone, and would have been preferable in order to give greater inherent immunity from signal imitation, but in this system the upper limit is set by the fact that party-line working is employed. When one caller is engaged in conversation on one of the 10 party-line telephones it is always possible that another person might make a call from one of the other nine telephones, in which event his signal to line would be heard by the first caller and the switchboard operator. Tests indicated that a combined level of −3 dbm was the highest desirable in such circumstances to avoid causing aural discomfort to the parties already on the line.

To meet transmission requirements the attenuation of the external lines must not exceed 13 db, and, as there is no point in exceeding this figure for signalling purposes, the signalling system is also designed to operate over lines having the same maximum attenuation. The signalling design parameters however, would permit working over lines having an attenuation of some 23 db, and this gives a working safety margin of about 10 db to take account of component tolerances, voltage variations, and aging of the equipment while in use. The maximum line attenuation must not be exceeded at frequencies up to 2,560 c/s and not merely at a nominal frequency of 800 c/s.

The signalling paths at the control station include attenuation pads having values depending on the line attenuation (Fig. 2). This enables the attenuation of the signalling path of each external line to be adjusted to the maximum of 13 db, and this assists in rejecting spurious signals. It also serves to limit the range of level of the (genuine) signal input to the receivers to only 5 db, irrespective of the party line to which the receivers are switched.

IMMUNITY FROM INDUCTIVE INTERFERENCE

The two main sources of inductive interference are e.h.t. grid power lines and railway high-voltage a.c. electrification, both having a fundamental frequency of 50 c/s. It was decided as a matter of policy that the Post Office would not ask the British Transport Commission to suppress interference at source on railways adjacent to motorways because of the high cost of such suppression.

The control-station common v.f. equipment, which is preceded by band-pass filters, is immune to false operation from these sources of interference, but the non-selective amplifier used on each party-line group to detect the calling signal and then switch the line to the common equipment has insufficient inherent immunity. Additional attenuation at low frequencies is introduced in this signalling path by the transformer-capacitor combination, T and C, and, with the circuit used, a minimum transverse voltage of 30 volts at 50 c/s is required at the line terminals A and B (Fig. 2) to cause false operation of the non-selective amplifier.

Thirty volts is a very much greater voltage than that likely to be induced by an unsuppressed 50 c/s railway-electrification system. The amplitudes of the higher harmonic interfering frequencies[2] decrease at a greater rate than that at which the attenuation of the transformer-capacitor combination falls, so that at least the same degree of immunity is preserved at these higher frequencies.

Where induction from e.h.t. sources occurs, the induced longitudinal voltages have to be limited for reasons of safety to a maximum of 650 volts.[3] On routes where the induction is severe enough this will be done by inserting isolating transformers in the external cables at appropriate intervals. The resulting transverse voltages will then be considerably less than 30 volts, so that if these safety precautions are observed the signalling system will also be immune to interference.

At the control stations, under both signalling and speaking conditions, all lines are terminated on earth-free transformers to secure maximum balance and, hence, maximum transverse-to-longitudinal voltage attenuation.

* dbm—decibels relative to a milliwatt in 600 ohms.

CONCLUSION

The system described provides an emergency telephone service for motorways which meets the operational requirements of the Ministry of Transport and the police authorities. It uses v.f. signalling to avoid the effects of interference from e.h.t. grid power lines and railway electrification and also to allow the insertion of isolating transformers in the external cables where induced voltages from e.h.t. power lines would otherwise exceed the permissible safety limit. Although changes to circuit details may be made subsequently in the light of experience, no major change is envisaged at present, and the system sets the pattern for telephone communications for all new motorways to be built in this country.

ACKNOWLEDGEMENT

Appreciation is expressed to the Radio and Electronics Division of the General Electric Co., Ltd., for their co-operation in supplying suitable oscillators, receivers and filters, which assisted greatly in designing the system.

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Fault Recorder No. 1B

U.D.C. 621.395.004.64: 53.087.4

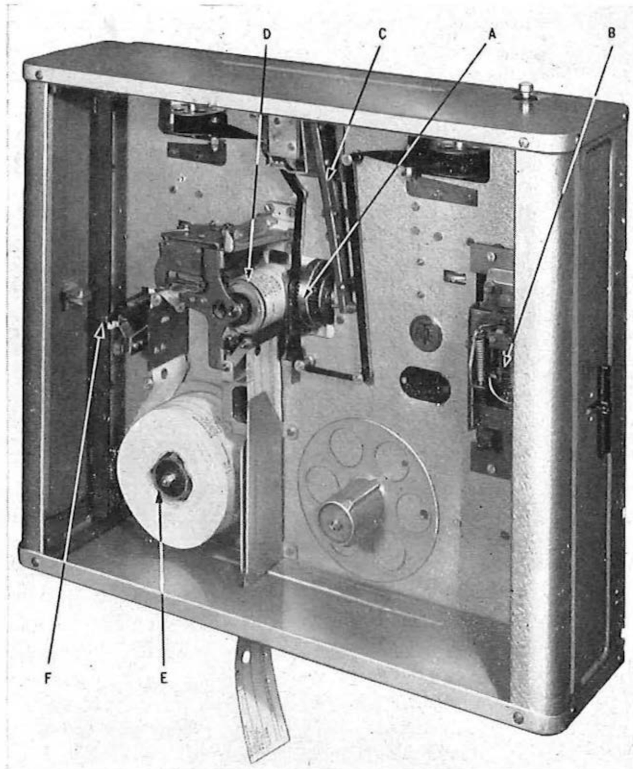
MODERN routiners for exchange equipment incorporate facilities for the connexion of a docket-printing machine to record automatically the details of faults found during routine testing. By this means routiners can be run at times which cause least interference with traffic, e.g. during the night, when maintenance staff may not be on duty. The Fault Recorder No. 1* was introduced experimentally for this purpose some years ago and following its successful performance a slightly modified version (No. 1A) has been installed at a number of exchanges.

The recorders supplied up to the present time comprise a number of separate units—mechanisms on their mounting plates, a relay mounting, paper container, etc.,—assembled together in an outer case which in turn fits into a rack-mounted cradle. Connexion between the recorder and the cradle is made via two 32-point shelf plugs and jacks. This form of construction proved somewhat expensive, and in consequence a complete physical redesign has been effected.

The component parts of the new recorder, Fault Recorder No. 1B (Fig. 1), are now assembled on a single plate provided with a transparent front cover and metal rear cover, each fixed by quick-release catches. The recorder has the same basic mechanism, i.e. uniselectors and teleprinter parts, as the earlier machine and there has been no departure from the original operating principles, but the plug-and-jack connexions have been replaced by permanent wiring to connexion strips.

Letters A to Z, figures 1 to 9, 0 and symbols – and / are available on the typehead (A), and the selection of a character is achieved by connecting a marking earth potential to the bank contacts of a 50-outlet uniselector (B). The uniselector hunts to find this earth and thus sets the typehead in the desired printing position. To transmit the rotation of the ratchet and wiper assembly of the uniselector to the typehead a pair of 1 in. gear wheels and a flexible rubber coupling are used. The purpose of the latter is to protect the driving ratchet from the inertia effects of the typehead.

The hammer (C), which is massive to give good printing



A—Typehead. B—Uniselector. C—Hammer. D—Platen.
E—Roll carrier. F—Spring-set.

FIG. 1—FAULT-RECORDER NO. 1B

quality, is magnetically operated, a rocker-type interrupter breaking the electrical circuit late in the stroke of the hammer. Adjustment of the interrupter, therefore, rather than the restoring springs, controls the energy with which the hammer strikes the characters of the typehead. A delay of approximately 100 ms is introduced in the printing-hammer operating circuit to allow the typehead to come to rest before printing occurs.

The paper is carried on a cork-faced platen (D) on

*URBEN, T. F. A. The Fault Recorder Docket Printing Machine. *P.O.E.E.J.*, Vol. 45, p. 115, Oct. 1952.

which printing takes place and which is driven by the mechanism of a Post Office Type 2 uniselector. Pressure is maintained against the drive platen by a rubber-covered roller and a flat spring. The self-reversing-type ribbon mechanism is basically that of a teleprinter, with a uniselector magnet and pawl utilized to provide the drive.

A completed docket, which is 2 in. wide, is shown in Fig. 2, and it can be seen that printing takes place within

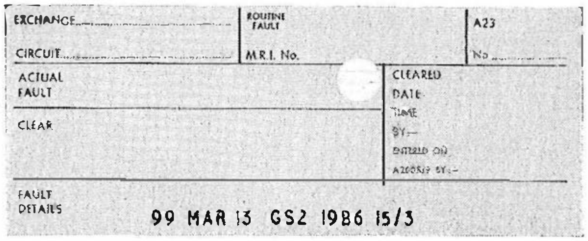


FIG. 2—FAULT DOCKET

the ½ in. space at the bottom of the paper. Dockets are supplied in rolls of 1,000, wound on sturdy cardboard centre spools. The roll carrier (E) is free to rotate under the pull of the paper dockets. A similar carrier to the right of the main spool is used to carry a spare roll of dockets. The spring-set (F) positions the dockets so that when printing commences the first character is about 1 in. from the perforations on the left-hand end of the docket.

The information printed on the docket is as follows:

(*a*) The docket serial-number.
(*b*) The date.
(*c*) The class of routiner in use.
(*d*) The location of the faulty equipment.
(*e*) A coded indication of the fault.

When printing is complete the platen uniselector continues to drive until the next docket is correctly positioned, i.e. until the spring-set referred to above is operated by the "end of docket" lever detecting the ⅜ in. hole in the docket preceding the one in the printing position.

All existing fault recorders, including the Fault Recorder No. 1B, are rack mounted and are associated with routiners of relatively recent design, but a trolley-mounted version of the recorder described above is to be introduced for use with routiners of earlier design. Connexion will be by flexible cords, and to avoid the necessity for extensive routiner modifications the information to be recorded on the docket will be restricted to the class of routiner and the location of the faulty equipment.

H.B.

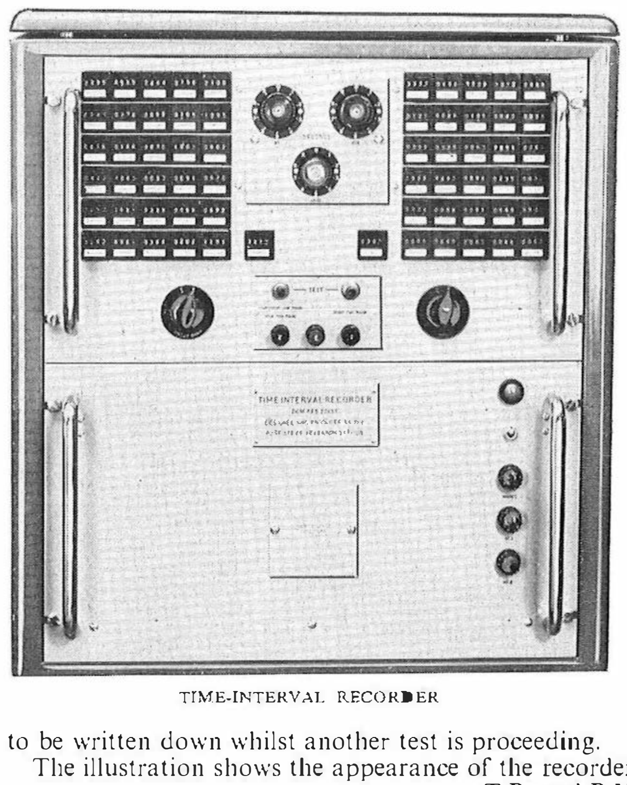
A Time-Interval Recorder

U.D.C. 531.761 (083.58

THE Medical Research Council is carrying out work, on behalf of the British Post Office, that has as its aim the evaluation of the various psychological problems involved in encoding postal addresses and in the use and design of keyboards suitable for letter-sorting machines. For this work it is necessary to be able to measure the time required to perform certain operations or groups of operations. It is also very desirable that the measuring apparatus should record these times in the form of a histogram, thus giving the distribution of the reaction times measured over a given test period.

A time-interval recorder has been specially designed for this purpose and has been used on letter-sorting-machine problems by the Applied Psychology Research Unit of the Medical Research Council. It measures time-interval increments of 0·1 second between 0 and 2·0 seconds, increments of 0·5 second between 2·0 and 5·0 seconds and increments of 1·0 second between 5·0 and 9·0 seconds. Each time interval measured is then recorded, according to its duration, on one of 30 Post Office subscribers'-type meters. The results of a test involving many such measurements are obtained by reading all the meters.

The apparatus can be used either to measure and record time intervals between successive signals connected to the same input terminal, or to measure and record time intervals between a start signal connected to one input terminal and a stop signal connected to another input terminal. A duplicate set of recording meters is provided in order to allow one group of meter readings to be written down whilst another test is proceeding.



TIME-INTERVAL RECORDER

The illustration shows the appearance of the recorder.

T.P. and P.H.

Long-Distance Private Telephone Circuits for Commercial Renters

A. A. TUCKER, Graduate, Brit. I.R.E.†

U.D.C. 621.395.2: 621.395.741

The various types of private circuit, their design features and the methods of signalling adopted for them, are described. The way in which the Post Office assists renters to utilize large networks efficiently is also described.

INTRODUCTION

THE growth of the country's economic life is accompanied by an increasing need for long-distance communication. Many commercial concerns rely heavily upon the telephone for the conduct of business; usually the public telephone service is adequate, but if there is a high calling-rate between certain premises, or additional facilities are required, the private circuit may be a valuable adjunct.

To help satisfy the need for private circuits, a percentage of line plant is made available for them. In addition, public circuits that are not fully utilized are offered on a part-time, off-peak-hour, basis. The following paragraphs deal with the design, provision and use of such circuits (over 25 miles in radial length) for commercial renters.

The types of long-distance private circuit provided by the Post Office are: Tariff S, Tariff F, inter-switchboard extensions, out-of-area exchange lines, and omnibus circuits.

The provision of these private circuits involves the combined efforts of Engineering and Sales Divisions in the Telephone Areas concerned, and of the Engineering and Inland Telecommunications Departments at Headquarters, so that local-line and main-line plant can be allocated, the circuit designed and the practicability of any special features determined.

TARIFF S PRIVATE CIRCUITS

Tariff S covers the provision of a circuit that is basically intended for the transmission of speech, but, when specifically requested by the renter and if suitable plant is available, circuits are also designed for transmitting information in other ways, e.g. for telemetering, facsimile or data transmission, remote control, v.f. telegraphy, and level-indication.

The rental for the over-25-mile Tariff S circuit includes the provision of telephone instruments or private-branch-exchange (P.B.X.) termination at both ends; but if Tariff S circuits are required for purposes other than the transmission of speech the renter usually provides the terminal apparatus. This must be of a type approved by the Post Office for association with its lines, the Telephone Manager concerned being responsible for seeing that the necessary conditions are complied with. If separate access is required to the "go" and "return" paths of a 4-wire circuit, an additional rental is charged for the local ends.

Tariff S circuits are the most numerous of the private circuits; there are about 1,200 over 25 miles in length, compared with about 400 Tariff F circuits, 100 out-of-area exchange lines, and 50 inter-switchboard extensions.

Characteristics, typical of Tariff S circuits intended for the transmission of speech, are given in the table, but it must be stressed that it is not always possible to achieve similar characteristics in every respect for all such circuits. If the circuit is not intended for the transmission of speech, special attention is given to the characteristics that the renter and the Post Office consider should be of a particular standard for the function required.

Characteristics of Tariff S Circuits

Impedance	600 ohms
Frequency band	300–2,800 c/s
Equalization	+1 db to −3 db over the band with reference to the 800 c/s level.
Loss at 800 c/s	(*a*) 3 db if the circuit is 4-wire throughout.
	(*b*) Between 3 db and 13 db if a 4-wire circuit is terminated as a 2-wire circuit.
	(*c*) Between 0 db and 15 db if the circuit is 2-wire throughout.
Variation of loss at 800 c/s	Not greater than 2 db.
Transmission time	Up to 8 ms per 100 route miles.
Noise	−50 dbm in any 100 c/s band-width.

To help meet the characteristics shown in the table, Tariff S circuits may be routed 4-wire between the terminal exchanges, but from these exchanges to the renter's premises the circuit is normally 2-wire. However, to meet intercommunication requirements of private circuits in tandem, 4-wire local ends may be provided without additional costs to the renter. If intercommunication is required over circuits in tandem, the loss over a maximum of three links in tandem must not exceed 21 db.

TARIFF F PRIVATE CIRCUITS

The Tariff F service offers the part-time use of public circuits during hours when they would not otherwise be fully occupied. Customers for this class of circuit find it economically attractive if their business transactions can be concentrated into specific hours of the day.

Basically, a Tariff F circuit comprises up to three public circuits switched so that they interconnect permanent circuits between the renter's premises and the local exchanges serving them.

No more than three public circuits are connected in tandem because maintenance difficulties increase as switching points are added. If amplified circuits are

†Main Lines Planning and Provision Branch, E.-in-C.'s Office.

used, the transmission loss of each one could vary by 2 db from its nominal value giving a possible total variation of 6 db for three circuits connected in tandem. Also, from the point of view of reliability, it is undesirable to have more than one switching point in any one town, and for this reason, if the traffic terminal for the public circuit and the exchange serving the renter's premises are in different buildings, a spare cable pair is used between them.

If a part-time circuit cannot be provided without using more than three public circuits in tandem, the remaining distance is covered by the use of spare plant charged at Tariff S rates. The term "spare plant" in this context refers to cable pairs that can be used without prejudice to foreseeable public requirements, and the only other circumstances when spare plant can be used for a part-time circuit are when the completion of the circuit would otherwise be temporarily held up, or if it is necessary to utilize additional signalling apparatus at other stations.

Tariff F circuit transmission limits are the same as those for Tariff S circuits. The public circuits in use for the Tariff F service are normally switched at the 2-wire terminations, but, if transmission limits cannot be met by 2-wire switching, 4-wire switching may exceptionally be resorted to at one or more points. The most that can be gained by 4-wire switching between two public circuits is 3 db, and usually there is more to be gained by switching to a 4-wire local end.

INTER-SWITCHBOARD EXTENSIONS

Normally, renters are not allowed to use Tariff S or Tariff F circuits for extending incoming exchange calls or for originating exchange calls; prohibition equipment is usually fitted to prevent the connexion of such circuits to exchange lines. If exchange facilities are requested, then an inter-switchboard extension may be offered, on the understanding that it can be withdrawn should the circuit performance give rise to complaint. These circuits allow incoming exchange calls to be extended to a distant switchboard, but, to avoid two inter-switchboard extensions being connected by a public circuit, with consequent high transmission loss, the origination of exchange calls over inter-switchboard extensions is not permitted.

An inter-switchboard extension is basically a Tariff S circuit without an exchange-access prohibition device and with more stringent transmission and signalling limits. The extension adds a transmission loss to the standard public-network connexion; the nominal maximum permissible loss for an inter-switchboard extension has, therefore, been set at 6 db, renter-to-renter, at 1,600 c/s for 2-wire circuits and at 3 db for 4-wire circuits, with a minimum band-width of 300–2,500 c/s. However, discretion may be exercised in accepting an increased nominal overall maximum loss by taking into account such factors as the position of the renter's premises in relation to the national network, but it has to be borne in mind that the relaxation of standards for a particular subscriber may lead to complaints in other parts of the country.

OUT-OF-AREA EXCHANGE LINES

Out-of-area exchange lines are full-time circuits that terminate at renter's premises at one end and at a public exchange at the other, the renter's premises being outside the boundary of the exchange area concerned. Such circuits enable a renter to benefit directly from the service of an exchange outside his own area.

Stringent limits must be applied to the overall loss and bandwidth. The maximum loss tolerated will depend upon the type of exchange at which the circuit terminates, while the bandwidth must comply with the same requirements as an inter-switchboard extension. At a zone centre a 10 db out-of-area exchange line would be permissible; at a group centre, 7 db; and at a minor exchange, 3 db. If the circuit terminates on an automatic exchange, the maximum line length is normally restricted to about 100 miles of 20 lb/mile conductor loaded with 88 mH at 1·136-mile intervals, and Signalling System D.C. No. 2* is used.

OMNIBUS SERVICE

A Tariff S or Tariff F private circuit is sometimes required to connect more than two stations. If the stations are grouped close together, simple teeing of the 2-wire local ends is sufficient, but if the stations are spaced far apart a form of 4-wire teeing is required. The 4-wire bridge omnibus system is the method employed to give a good standard of communication between renters in such circumstances. Fig. 1 shows how

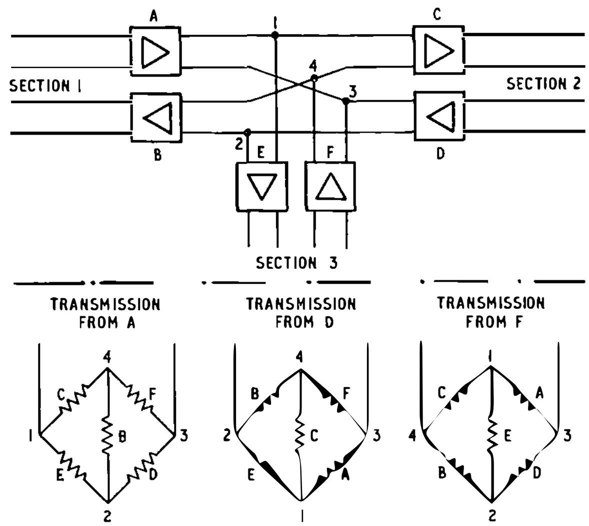


FIG. 1—FOUR-WIRE BRIDGE OMNIBUS CIRCUITS

the inputs at the junction of three sections are jointed to form a Wheatstone bridge, each section being amplified at the junction. Speech from any one section will pass to the other sections for amplification and continued transmission, but the return path of the sending section will be in a null position on the bridge and echo currents will not be passed back to the transmitting terminal.

Four-wire omnibus panels are available that contain the necessary equipment for setting the levels, correcting the impedances, and testing the circuit. One panel is required for each spur line connected.

Because of multiple circulating paths for echo currents, the maximum transmission loss between the 2-wire sides of any two terminating units cannot be predetermined. A design figure of 15 db can be assumed, but in practice this may be improved upon.

The number of stations on any omnibus circuit is not

*Welch, S., and Horsfield, B. R. The Single-Commutation Direct Current Signalling and Impulsing System. *P.O.E.E.J.*, Vol. 44, p. 18, Apr. 1951.

allowed to exceed 10, and the maximum loss permitted between any two stations is 30 db.

Lining-up the main circuit is carried out in the usual manner, with the spur amplifiers replaced by 600-ohm dummy loads to prevent echo currents originating from the spur lines, and spur lines can be lined-up concurrently with the main circuit. Equalizers must not be fitted at points where they may cause over-equalization in some sections, although correct for other sections. Sections of the circuits that may be equalized are:

(*a*) the main cable between spur stations,

(*b*) sections between spur stations and main-circuit terminals, and

(*c*) sections between spur stations and the terminals on the spur lines.

The stability of an omnibus circuit is liable to differ in different sections of the circuit; therefore, when lining-up is complete, all terminals are checked for stability by listening on the 4-wire portion of the circuit with all terminal units disconnected on the 2-wire side.

Omnibus circuits can be provided on a Tariff F basis, but additional limitations are imposed. Because of the complexity of apparatus and switching, 2-wire teeing only is allowed. Switching points must not exceed five in number.

SIGNALLING OVER PRIVATE CIRCUITS

Signalling methods employed on private circuits are decided primarily by the following considerations.

Type of Cable

A quad-worked† audio cable will permit the use of d.c. or a.c. signalling, but d.c. signalling is not favoured if the phantoms are available for circuits.

Signalling over group-worked‡ cable is restricted to a.c. methods, to avoid complex repeater station wiring.

Low-frequency (i.e. 17–50 c/s) signalling over trunk and junction cables is avoided as far as possible because of disturbance to other circuits.

Circuits routed on carrier or coaxial cable use a.c. signalling at frequencies within the pass band of the channel translating equipment.

Class of Circuit

Tariff S and Tariff F circuits do not require any particular form of signalling apart from that dictated by other considerations. However, an endeavour is normally made to provide automatic signalling. Automatic signalling, as distinct from generator signalling, gives supervisory signals from either end without any special action on the operator's part. This is normally only practicable if a d.c. path is available.

Two methods of automatic signalling are available for over-25-mile circuits: one-wire-earth signalling, and balanced-battery signalling. One-wire-earth signalling is restricted to circuits having a loop resistance of about 4,000 ohms or less. The insertion of a plug by an operator to take the circuit into use automatically applies an earth potential to one conductor of the circuit. The distant end uses the other conductor in a similar manner. This system is being superseded in some instances by balanced-battery signalling, in which calling is effected by the application of a negative potential or "battery" to both conductors of the circuit. The answering signal is given by negative battery applied in opposition to the calling battery. With this method of signalling the resistance limit for the circuit is extended to about 12,000 ohms, depending on the types of switchboard on which the circuit terminates.

If the line plant available does not permit the use of automatic signalling, a non-automatic form of balanced-battery signalling is used. Negative battery applied to both conductors of the circuit is the calling signal and the only signalling condition available. If the circuit is routed over a cable that requires a.c. signalling, signalling converters are fitted at each end of the section. These convert the balanced-battery signal to a 500 c/s tone interrupted 20 times a second for transmission over the cable and, at the other end, reconvert the 500/20 c/s signal to a balanced-battery signal. This in no way affects the operating procedure for the private circuit.

With Tariff F circuits there is another signalling restriction imposed by the type of public circuit used: if one of the public circuits uses a.c. signalling the private circuit must also use a.c. signalling over that particular public circuit, even though audio cable suitable for d.c. signalling is used for the public circuit. D.C. signalling would restrict the availability of alternative public circuits in the event of breakdown or rearrangement.

Inter-switchboard extensions are only routed over audio-type quad-worked cable, the type of signalling being limited to the automatic forms to avoid exchange equipment being held on an incoming call pending attention by the P.B.X. operator.

Out-of-area exchange lines connected to manual exchanges employ a form of signalling using 17 c/s-to-balanced-battery converters known as Units, Signalling, No. 7 (U.S. 7). To call the exchange the subscriber applies a loop to the local U.S. 7 by lifting the telephone handset or inserting a plug into an exchange-line jack. This loop causes the U.S. 7 to apply balanced battery to line; this in turn causes the distant U.S. 7 to apply a loop to cause the subscriber's calling lamp to glow at the exchange. When the subscriber clears, the calling loop is removed automatically and a clear signal is given. In the other direction, the exchange applies 17 c/s ringing current to the first U.S. 7 and the distant U.S. 7 connects 17 c/s ringing current to the subscriber's line. On answering, a loop is again applied to give a supervisory signal to the exchange.

If an out-of-area exchange line is connected to an automatic exchange, Signalling System D.C. No. 2 is employed, as previously mentioned. This system permits direct access to a distant automatic exchange from a subscriber in another automatic exchange area. The following facilities are available:

(*i*) Bothway working.

(*ii*) Seizure from the selector multiple on calls incoming to the subscriber.

(*iii*) Conversion of double-current signals on the line during dialling to loop-disconnect signals to operate the automatic equipment.

(*iv*) Transmission of the called subscriber's answer or clear signals on calls incoming to the subscriber.

(*v*) Seizure of the subscriber's line circuit when the subscriber makes an outgoing call.

(*vi*) Transmission of supervisory tones.

†Quad-worked cable—A cable is described as quad worked if the "go" and "return" pairs of each 4-wire circuit form a quad.

‡Group-worked cable—To reduce near-end crosstalk, the pairs in a cable can be divided into groups, the pairs within a group being used to transmit in one direction only.

Omnibus circuits are usually arranged so that a call from any one station rings all other stations, the signalling paths being merely commoned. Occasionally, selective ringing is called for, and a suitable signalling system is then designed to meet the individual requirements of such circuits.

Terminal Apparatus

Usually, a private circuit terminates on an extension indicator of a P.M.B.X. or on the manual position of a P.A.B.X.; the d.c. signalling methods previously described may then be employed. Exceptions to this are dealt with below:

Extension indicator not available. The circuit is terminated on an exchange-line position if one is available. This necessitates 17 c/s signalling in both directions.

Telephone at both ends. A local-battery telephone with a hand generator can be fitted at each end and signalling is 17 c/s in both directions, but to avoid sending 17 c/s over trunk or junction cables a U.S. 7 is fitted at each terminal exchange. These converters can be modified to give a battery feed to the instrument and to accept one-wire-earth calling. By this means the local battery and hand generator can be dispensed with.

Switchboard at one end and a telephone at the other end. If a d.c.-signalling path is available and the switchboard is a standard type of P.B.X., an automatic form of balanced-battery signalling can be used. A U.S. 7 is used at the telephone exchange to which the telephone end of the circuit is connected. The U.S. 7 is modified to provide a battery feed to the telephone and to operate to the telephone loop. On calls originated from the telephone, balanced battery is applied to line as a calling signal and as a supervisory signal to indicate that the telephone handset is off its rest.

To call the telephone from the switchboard, negative potential is applied to line to cause the distant U.S. 7 to apply ringing current to the telephone.

By fitting a suitably-modified U.S. 7 at the switchboard end, it is possible to work to other types of switchboard in a similar manner.

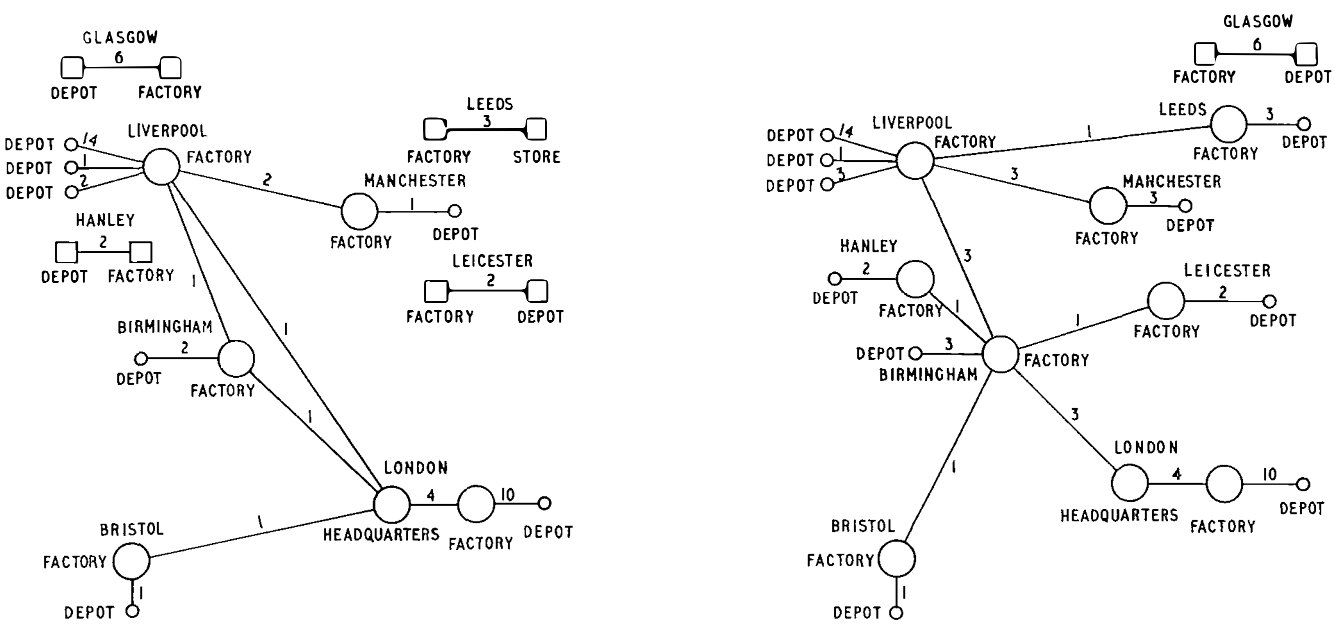
Telephone or switchboard at one end and house exchange system at other end. A call-button at the non-multiple position of the house exchange system causes a reversal of battery potential to operate a U.S. 7 at the local exchange. This extends balanced battery to line as the calling signal. When the telephone handset is lifted, balanced battery is applied to the line from a U.S. 7 at that end and causes the line to be switched through for speech. This same balanced-battery application is used as a calling signal when a call is made from the telephone.

A house exchange system at both ends. The private circuit uses a spare exchange-line position, and an additional relay-set is fitted at each house exchange to give automatic balanced-battery signalling.

SPECIAL FACILITIES

The foregoing signalling methods are all standard, but it often happens that the subscriber wants a special facility. Such requests are acceded to if they are practicable and it is considered advisable to do so. Any additional apparatus required to meet this type of request necessitates increased rental.

Most of these requirements are too individual to warrant description here, but the night-service facility will be mentioned. This facility enables the private circuit to be connected directly to a nominated extension at times when the switchboard is unattended. The method used depends on the type of switchboard and the method of signalling on the private circuit.



(a) Network Before Investigation

(b) Network After Investigation

Station with access to network

Station without access to network

The numerals indicate the number of circuits on each route.

FIG. 2—TYPICAL LARGE PRIVATE NETWORK

LARGE NETWORKS

Some of the bigger companies have gradually built up, over the years, extensive networks linking various headquarters and numerous smaller offices widely scattered over the country.

It has been found that large networks can become unwieldy and inefficient, with the result that the Post Office receives complaints of unsatisfactory service. Investigation may reveal that, as the circuits have been added piecemeal, the network as a whole has become cumbersome and individual circuits are at times used in a manner never intended. When this state of affairs exists the Post Office offers an advisory service free of charge and provides the company with a report outlining an integrated-network plan designed to give the subscriber a good and economical service.

During an investigation all aspects of the company's telecommunication networks are studied. Specially-printed telephone-call tickets and teleprinter-message record sheets are used to compile a record over several days, at all offices. In addition to the collection and analysis of information, main establishments are visited to obtain opinions of local managers.

In addition to planning the network, the investigating team advise on the principles to be observed for efficient use of the system. To ensure that calls will be connected in a way that conforms to the design of the network, procedural instructions are provided for each switchboard. Attention may be drawn to the number of private calls recorded, which, if high, may justify the installation of coin-box exchange lines in some offices. To reduce delay on circuits a limit of, say, 6 minutes may be recommended for all calls, and if delay still occurs the renter may be advised that the overflow should be connected via an exchange line.

A typical network, before and after investigation, is shown in Fig. 2. If 3-link calls were envisaged in the revised network, the loss over each of the long-distance circuits should not exceed **7** db and circumstances might justify reducing this loss on the principal intercommunication link. In the example shown, the total annual cost, including calls over the public network, was £13,550 before the network was investigated. After investigation, the cost was £13,000.

FUTURE DEVELOPMENTS

The future of the private circuit is largely dependent on the development of telecommunications in general.

Subscriber trunk dialling, with its facility for the rapid connexion of calls, and charging arrangements that relate directly to the conversation time, will no doubt have some effect on the demand for private circuits. Nevertheless, the private circuit is likely to remain attractive if it can be used fully and efficiently.

At present some requests for inter-switchboard extensions, out-of-area exchange lines, and dialling facilities over private circuits cannot be met because the necessary signalling conditions cannot be provided, but developments are in hand that will remedy this.

Book Reviews

"Cybernetics." Second Edition. Norbert Wiener. John Wiley & Sons, Ltd. xvi + 212 pp. 11 ill. 52s.

The second edition of a book, which may well become a classic, is naturally of great interest. The title is derived from the Greek meaning "steersman," and is intended to cover all kinds of control problems. What we are now offered is the original 1947 text with some minor revisions and two supplementary chapters.

The author and his associates at the Massachusetts Institute of Technology became involved during World War II in the problem of target prediction from radar data. They were led to theories of information and of control systems with feed-back which parallel those of Shannon and others whose works are more familiar to communication engineers. Their main interest lies, however, in other directions, notably in animals as machines. The book describes some astonishing similarities between commercial communication and control systems and those existing in animals between the brain and organs for the control of movement. Animal performance exceeds that of machines in, for example, recognizing a tree as a tree from whatever angle it is viewed. Can machines be improved to rival animals in learning, self-reproduction and original thinking? Can our knowledge of machines explain some of the workings of animal brains and bodies? These are some of the topics discussed in a book which recalls the work of Turing in this country and makes one wonder what his contribution might have been but for his untimely end.

Although mathematical arguments are an important part of the book, much of the text is philosophical, speculative, and most interesting reading. For this reason the book can be recommended to a wide range of readers to whom this line of approach is attractive.

T. H. F.

"Electromagnetic Waveguides and Cavities." Dr. Georg Gonbau. Pergamon Press, Ltd. xvii + 657 pp. 225 ill. £5.

This book was planned, according to the foreword, in 1944 but 17 years have elapsed before it has been presented to the English-speaking world; consequently much of the information contained in the book is available elsewhere. Thus Chapter 1, which comprises the first 87 pages, gives the theory of waveguides which has been repeatedly published in textbooks. Likewise the section on filter theory contributes little which is new to this subject. The treatment of cavities, which includes perturbation theory and a study of coupling methods is, however, most exhaustive and may well justify purchase of the book. Other aspects of waveguide transmission such as equivalent circuits and matching techniques are dealt with ably. The book is limited to theoretical studies and no practical or measurement problems are considered.

It is unfortunate that, when translated from German, the original equations which contain Gothic letters have been retained. Thus, on page 8 for example, reference is made in the text to E, H, J, etc., but the following table contains Gothic letters. This will obviously hamper rapid assimilation of the subject matter, especially if the book is used only occasionally for reference purposes. A more serious handicap to the reader, accentuated by the use of the Gothic letters, is the poor printing as typified by pages 103 and 108. Many of the figures are practically useless, for example those on pages 333, 433 and 499.

There is no doubt that the usefulness of the book is severely marred by the defects mentioned above and careful consideration is suggested before it is purchased in its present form.

C. F. D.

Narrower-Frequency-Band Channels for V.H.F. Land Mobile-Radio Services

L. T. ARMAN and E. J. M. PECK†

U.D.C. 621.396.931

Prior to 1957 the bandwidth of mobile-radio service channels was 50 kc/s in the low band (71·5-88 Mc/s) and 100 kc/s in the high band (165–174 Mc/s). The growth of mobile-radio services has made it necessary to reduce the bandwidth occupied by channels, firstly, to 50 kc/s for the high band as well as the low band, and more recently it has been agreed to adopt 25 kc/s as the bandwidth for channels in both bands, and this decision is now being implemented.

INTRODUCTION

PRIVATE land mobile-radio services enable an operator to establish telephone communication between his headquarters and any number of suitably equipped vehicles anywhere within the service range of a base station. In the United Kingdom such services are used by fuel and power authorities, municipal authorities, ambulance, fire and police services, by the G.P.O. itself and by a multitude of other users under the general heading of commercial and industrial services, the last including taxi services. A typical usage of a mobile-radio service is shown in Fig. 1 and 2. The former is an

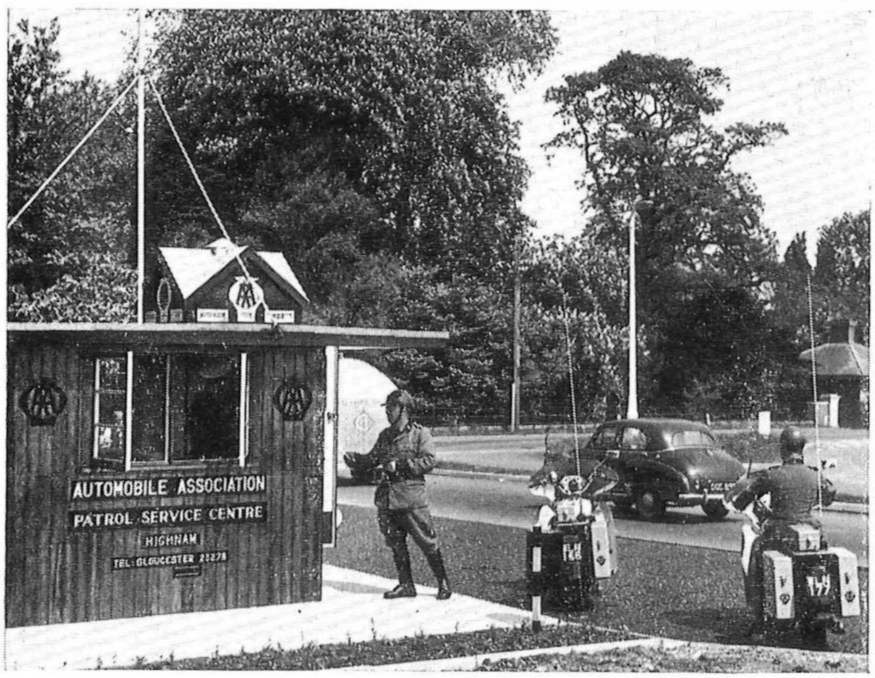


FIG. 1—TYPICAL MOBILE-RADIO-SERVICE BASE STATION

Automobile Association (A.A.) patrol-service station which is also used as a base station for the mobile-radio service; only a portion of the aerial mast is visible. In Fig. 2 an A.A. scout is talking to a base station; his radio equipment is mounted on the top of the motorcycle carrier, by the side of the aerial.

All the afore-mentioned services are classed as private because they are not allowed direct connexion to the public telephone network. Would-be users must first obtain a licence and specific frequency assignments from the G.P.O., except the fire and police services for which the Home Office is allocated groups of channels and makes its own specific assignments within these groups.

Frequency Bands and Assignments

The frequency bands 71·5–72·8 Mc/s, 76·95–78 Mc/s, 85–86·7 Mc/s and 86·95–88 Mc/s, often referred to collectively as the "low band", together with 170·85–175·05 Mc/s and 180·85–183·95 Mc/s, similarly referred to as the "high band", were originally allocated to land mobile-radio services in the United Kingdom. These bands were split into smaller sections to provide for the requirements of various categories of service, and divided into channels for assignment to specific users. In 1955 the high band was amended to 165·05–173·05 Mc/s to clear frequencies above 174 Mc/s for television in accordance with the "Atlantic City"* recommendations, existing mobile-radio services on frequencies above 173 Mc/s being given some years grace in which to change to new assignments. It should be appreciated that in general these services operate on a two-frequency basis, i.e. one frequency for the base-station transmitter and another for the mobile-station transmitter, these two frequencies being separated by several Mc/s. For example, the bands 71·5–72·8 Mc/s and 85–86·3 Mc/s are complementary, the former embracing the transmitting frequencies assigned to mobile stations and the latter those for the corresponding base stations; the frequency separation between a base-station assignment and the corresponding mobile-station assignment in these particular bands has a constant value of 13·5 Mc/s.

It might be thought that single-frequency working, in which a base station and its associated mobile units all operate on the same frequency, would be a more efficient way of using the available spectrum. However, single-frequency working has a serious drawback in that the base-station receiver, which must be sensitive enough to receive very low-level signals from the mobile units, must in consequence be protected from high-level interference by base-station transmitters operating on neighbouring channels, and this implies a wide geographical separation between base stations with closely-spaced assignments. In practice, mobile-radio services tend to

†Inland Radio Planning and Provision Branch, E.-in-C.'s Office.

*International Telecommunications and Radio Conference, Atlantic City, 1947.

FIG. 2—MOBILE RADIO STATION

be concentrated in relatively small areas, e.g. London or South Lancashire, and two-frequency working proves to be the more efficient method. Nevertheless a few single-frequency services are permitted in exceptional cases, mainly for very localized networks and with lower powers than normal services, and these are accommodated in the band 86·3–86·7 Mc/s.

The "channel width" is defined by the frequency separation between transmitter carrier frequencies adjacent in the frequency spectrum; each carrier frequency is in the centre of its channel. With ideal equipment which neither transmits nor receives energy outside the limits of the channel in use, the only restriction on the assignment of frequencies would be that imposed by co-channel interference, namely, that the same channel must not be allotted to base stations separated geographically by less than a certain distance, typically about 40 miles. However, equipment falls short of the ideal by an amount determined not only by the present state of technical development but also by cost, and consequently attention must be paid to the possibility of interference from strong signals in other channels.

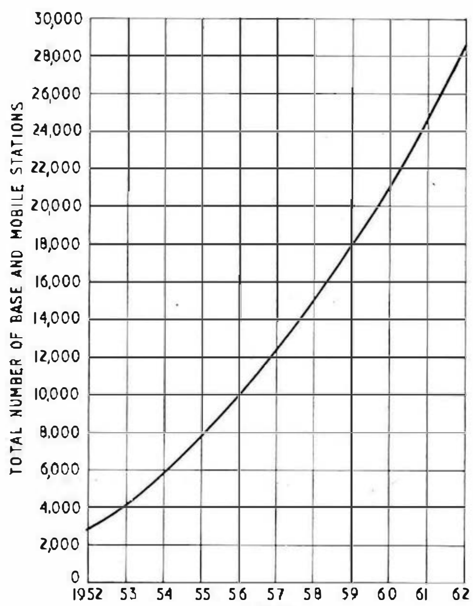
In order that the planning of frequency assignments may be soundly based, it is necessary to know the minimum performance of the transmitting and receiving equipment, and accordingly it is a condition of the licence that the equipment to be used must have been type tested by the G.P.O. against the appropriate specification. Such specifications are agreed between the G.P.O., the manufacturers and other interested parties, and are published by H.M. Stationery Office. The main points covered by the specifications are, on the transmitting side, the power, frequency accuracy and the limitation of out-of-band radiation ; and on the receiving side, the sensitivity, selectivity and the susceptibility of the receiver to intermodulation, cross-modulation and desensitization.

Frequency (or phase) modulation or amplitude modulation of the transmitted carrier is permitted but some 70 per cent of the systems in operation employ amplitude modulation. The maximum effective radiated power allowed is 25 watts, though mobile transmitters seldom exceed 15 watts because of the need to limit the drain on the car battery ; the carrier frequency must lie within ± 1·5 kc/s or ± 3·0 kc/s of the assigned value for base and mobile station equipment, respectively.

Interference from a transmitter working on a channel other than the wanted channel will clearly depend upon a number of factors such as transmitted interfering power, aerial height, frequency spacing, receiver selectivity and wanted-signal strength. Considering the case of a fixed station transmitter of 25 watts e.r.p. and aerial height 60 ft, used in conjunction with a mobile receiver meeting the current performance specification, the mobile receiver may be subject to interference if it is used within the following ranges of another base station: 500 yards for adjacent channel interference ; 300 yards for desensitization ; 600 yards for cross-modulation, though this effect will not arise with an f.m. system ; and 1,000 yards for intermodulation between two unwanted signals if the products generated happen to fall within the receiver wanted-signal pass-band. These factors must all be taken into account when planning frequency assignments.

DEVELOPMENT OF NARROWER-FREQUENCY-BAND CHANNELS

The growth of mobile-radio services between the years 1952 and 1962 is shown in Fig. 3.



The graph shows the total number of base and mobile stations, the ratio of mobile to base stations being about 10 : 1.

FIG. 3—GROWTH OF MOBILE-RADIO SERVICES BETWEEN 1952 AND 1962

The amount of frequency spectrum available for private mobile-radio services is limited and the demand continually increases. If the available channels are shared to the maximum extent possible, the only way of meeting the increasing demand is to use narrower channels and this has been the trend during the development of the services. When the first channelling plans were made the channel width in the band 71·5–88 Mc/s was 50 kc/s, and that in the band 165–184 Mc/s was 100 kc/s. Subsequently the Mobile-Radio Committee was appointed by the Postmaster General to advise on mobile-radio-service matters, and in July 1956 issued a report[1] recommending a reduction of channel width in the high band from 100 kc/s to 50 kc/s, and consideration of the use of 25 kc/s in both the low and the high bands. The former recommendation was to be implemented for new services from 1 January 1957 and for all services from 1 January 1962.

With regard to the use of 25 kc/s channels it was felt that trials of such systems should first be carried out by the G.P.O. with the co-operation of manufacturers, and target specifications for the equipment to be used for trails were agreed between these parties. Accordingly a system representative of services operating in an urban area on three contiguous two-frequency channels in the band 71·5–88 Mc/s was set up. During the second half of 1957 tests were carried out on this system by the G.P.O., in co-operation with the manufacturers, to determine the extent of mutual interference between adjacent channels. The results of these trials showed that the target specifications were realistic and that the degree of interference was considerably less than that which could be experienced with the then current specification for wider-band equipment. These conclusions were submitted to the Mobile-Radio Committee which then recommended[2] that 25 kc/s channels be adopted in the 71·5–88 Mc/s band from 1 June 1959 for new services, and five years grace be allowed for the change-over of existing services. This recommendation was adopted and user-equipment specifications were agreed with the radio industry, the latter closely following the target specifications used for the trials. Subsequently similar tests were made with 25 kc/s channels in the high band, the results being the subject of a further Mobile-Radio Committee Report in August 1960,[3] in which it was recommended that this channel width be adopted in the high band for new services from 1 January 1961 with a complete change to this standard by 1 January 1966. This recommendation also was accepted and is now being implemented, specifications for equipment again being agreed with the industry.

The present position, therefore, is that all new v.h.f. mobile-radio services must use equipment suitable for 25 kc/s channels ; existing services are being converted, but it will be some time before the change is completed. In the interim the additional channels resulting from 25 kc/s spacing, i.e. those between the present 50 kc/s channels, will not be generally available because of interference due to the overlap with the existing 50 kc/s channels, although the need for additional channels is great in some congested areas.

One difficulty encountered in this method of increasing the number of channels available is that, although receivers have been made more selective so that interference might be expected to be less, the probability of interference from intermodulation products is increased because of the greater number of transmissions possible. Furthermore, intermodulation products can be generated at a transmitting station site having two or more transmitters, and in this form can cause interference over a much wider area than if the products are generated in the receiver. The careful planning of frequency assignments to base-stations and attention to the engineering of the stations is of the greatest importance.

FUTURE DEVELOPMENT

There appears to be no scope for any further reduction of the channel width with a frequency-modulation system. There have been proposals for interleaved channels giving effectively 12·5 kc/s spacing but with overlapping sidebands. This arrangement is however, not very profitable since the protection required against an interfering signal 12·5 kc/s from the wanted carrier is not much less than that required for a co-channel signal and a large geographical spacing must be maintained between frequency-modulated stations operating with 12·5 kc/s spacing.

With amplitude modulation, 12·5 kc/s would be adequate to accommodate the essential sidebands but the performance of the equipment would need to be improved in respect of transmitter out-of-band radiation, frequency stability and receiver selectivity, and this is not yet practicable. Still further economy of bandwidth could, theoretically, be obtained by single-sideband operation but no suitable equipment for this purpose has so far been developed and the complexity and cost of such equipment would undoubtedly be a deterrent to its use for some considerable time to come.

Some further frequency-spectrum space in the u.h.f. band between 450 and 470 Mc/s is allocated to private mobile-radio services in the United Kingdom but as yet there is practically no development of services in this band. This is probably due to the fact that the equipment is more costly and its range of operation is shorter. However, when the v.h.f. bands have been fully exploited using 25 kc/s channels, it will be necessary to turn to these higher frequencies to meet any further demands.

ACKNOWLEDGEMENT

The photographs in Fig. 1 and 2 were supplied by the Automobile Association, to whom acknowledgement is made.

References

[1]Second Report of the Mobile-Radio Committee (H.M. Stationery Office, July 1956).

[2]Third Report of the Mobile-Radio Committee (H.M. Stationery Office, March 1959).

[3]Fourth Report of the Mobile-Radio Committee (H.M. Stationery Office, August 1960).

Book Received

"*The Engineer* Buyers Guide," 1962 Edition. Published by *The Engineer*, London. 1,008 pp. 10s.

This book provides a valuable and up-to-date list of 1,940 suppliers of a wide variety of engineering and industrial products and services. It contains over 35,750 entries arranged under approximately 2,780 classified headings with 1,650 cross-references to help the user to find what he wants. In addition, the book gives much useful information about the engineering industry in general, such as forthcoming exhibitions, details of Associations, Institutions and Societies, trade names, national undertakings, etc.

An Electronic Telegraph Serial-Numbering Transmitter

H. MARSH†

U.D.C. 621.389:621.394.618

Mechanical telegraph serial-numbering transmitters have been in use on tape-relay systems for some years. They are relatively costly to maintain and operate, and the electronic numbering transmitter was designed to reduce these costs and to give more reliable service.

INTRODUCTION

A LARGE amount of telegraphic traffic consists of messages to which no immediate reply is required. To use 2-way communication as provided on the telephone and telex networks is wasteful, particularly on long-distance circuits, if this type of traffic is considerable. Such circuits can, however, be used more economically if both directions of transmission are used separately. This gives the desired economy, but suffers from the inherent disadvantage that no answer-back is received and there is no proof that any message has reached its destination. To overcome this difficulty and to enable mutilated messages to be re-transmitted, the messages are numbered and the sequence of the received messages checked at the distant station. The electronic serial-numbering transmitter has been designed to prefix each message automatically with a preamble of up to 46 characters, including four serial-numbering digits. The preamble would normally include the code of the station to which the message is addressed, four numbering digits, the start-of-message code and functional characters such as letter shift, line feed and carriage return.

The numbering transmitter is normally used with a clutch-controlled automatic message-transmitter and an associated control relay-set. The message transmitter is loaded with tape and the start key operated. The preamble, serial number and message are then transmitted without further action. The first character of the preamble, usually a letter-shift character, starts the distant machine; this is followed by a delay of about one second to enable that machine to reach working speed. The remainder of the preamble, including the serial number, follows. At the conclusion of the preamble a "serial-number-sent" signal is forwarded to the control relay-set. The message transmitter then starts and transmits in the normal way and the numbering transmitter is released. The numbering transmitter advances the serial number by one, ready for the next message. If several message transmitters work sequentially on one circuit, the 1-second delay is omitted on the second and subsequent messages of each batch. The serial number can be suppressed on service messages by the operation of a key on the message-transmitter position. The numbering transmitter is provided with four push-button keys; one key restores the number sequence to 0001, and the other three keys are used to set the transmitter to any required number.

The transmitter is designed for mounting on a pre-51 type rack and occupies about 14 in. of rack space; a pulse generator and rectifier are required to feed a group of numbering transmitters.

CIRCUIT OPERATION

The numbering transmitter consists of a cold-cathode-tube ring counter, four uniselectors and associated control relays. One uniselector acts as a code distributor and the other three uniselectors act as a number register. The ring counter operates on a pulse-plus-bias basis and is controlled by pulses applied continuously at 20 ms intervals from the pulse generator. When the numbering transmitter is seized, one of the ring-counter tubes is caused to strike, succeeding pulses cause the tubes in the ring counter to strike one after another, and as each tube strikes the preceding tube is extinguished. Five of the tubes in the ring counter are each connected to a separate wiper of the code-distributor uniselector, CD, and to the control grid of a pentode valve, as shown in simplified form in Fig. 1. As each tube strikes, the pentode either

† Telegraph Branch, E.-in-C.'s Office.

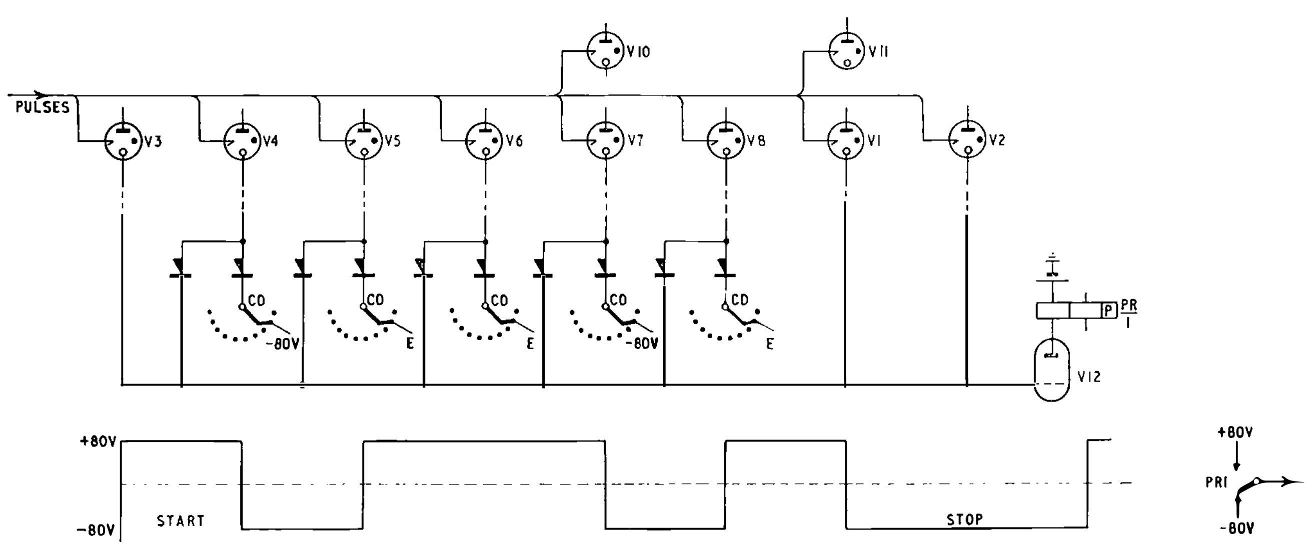


FIG. 1—SIMPLIFIED CIRCUIT TO SHOW GENERATION OF TELEGRAPH SIGNALS

conducts or does not conduct depending on the combination of potentials applied to the grid circuit by the conducting tube and the associated uniselector wiper. The pentode valve controls a polarized relay that connects positive or negative signals to the line.

Fig. 1 also shows the arrangement of the circuit for transmitting the character "D". The tubes V1 to V8 are the ring-counter tubes; V10 and V11 strike in conjunction with V7 and V1, respectively, and control the operation of the code-distributor uniselector (CD). The third tube, V3, provides the start element of each character, and V1 and V2 provide the stop element. Tubes V4 to V8 are connected to the wipers of uniselector CD and to the grid of the pentode valve V12. The banks of uniselector CD are connected to earth or to − 80-volt potential. As each of the tubes V4 to V8 strikes, the cathode potential of that tube changes, and this change, acting with the potential on the associated wiper of uniselector CD, affects the control grid of valve V12, causing the valve to conduct or not to conduct. Relay PR is controlled by V12 and the relay contact PR1 transmits double-current signals. After each character has been transmitted, uniselector CD steps to the next contact, the tubes in the ring counter strike in sequence and a further character is transmitted.

The 1-second delay necessary after the transmission of the first character, to enable the distant machine to reach working speed, has been arranged by the use of a further tube, V9, as described later.

Ring-Counter Circuit

The elements of the ring-counter circuit and the start circuit for the ring counter are shown in Fig. 2. Tube

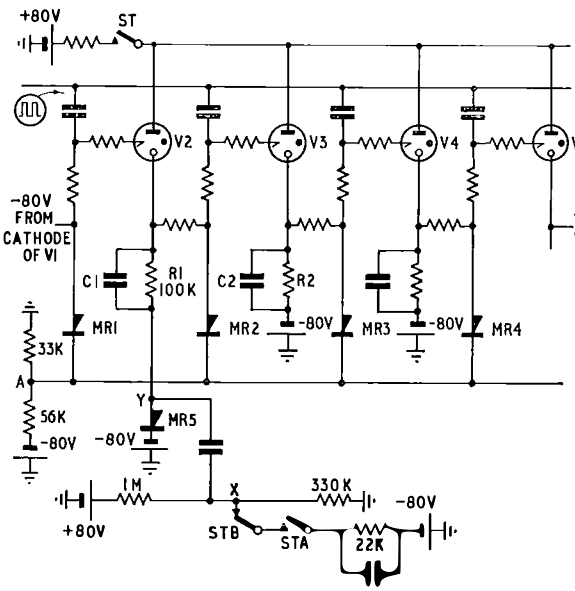


FIG. 2—ELEMENTS OF RING-COUNTER CIRCUIT

V2 is caused to strike to start the ring counter. When V2 strikes, a circuit is prepared for V3 to strike when the next pulse is received. Tube V3, on striking, extinguishes tube V2 and prepares a circuit to cause V4 to strike when the next pulse occurs.

The striker electrode of each tube is at a potential of − 80 volts, derived from the cathode circuit of the preceding tube. Positive input pulses of 50-volt amplitude and 200 μs pulse-width are applied to the striker electrodes of each tube at intervals of 20 ms. Each pulse raises the potential of the strikers by 50 volts to − 30 volts, but as each cathode is at −80 volts, the pulse is insufficient to cause any tube to strike. When the transmitter is seized, the start relay is operated and a contact of that relay applies a positive potential of 80 volts to the anode circuit of each tube. Another contact of the start relay operates the relief relay, STA, which in turn operates relay STB. A contact of relay STA causes the potential at point X to fall rapidly from +20 volts to about −80 volts, momentarily reducing the potential at Y by about 100 volts. Thus a negative pulse of about 100 volts is applied to point Y, reducing the potential at that point to about −180 volts. With point Y at a potential of −180 volts, the potentials of the striker and anode with respect to the cathode of V2 are +100 volts and +260 volts respectively, and tube V2 strikes. The ring-counter start circuit for tube V2 is disconnected when relay STB operates.

When V2 conducts, the cathode potential rises to about −10 volts and the rectifier MR2 is forward-biased. The potential on the striker of V3 is increased from −80 volts, but is held to a potential of about −30 volts by the potential divider at A. When the next pulse is received, the striker potential is increased to about +23 volts and tube V3 strikes.

A characteristic of the cold-cathode tube is that, when conducting, the voltage across the tube is roughly constant and is independent of the current flowing through the tube. This voltage, the maintaining voltage, is about 75 volts for the type of tube used in this equipment. Thus, when tube V3 strikes, the voltage across the tube is about 75 volts, and as the capacitor C2 in the cathode circuit momentarily short-circuits the resistor R2, the anode potential of V3 falls to about earth potential. As the anodes of all tubes share a common supply, the anode potential of V2 also falls to the same potential, but its cathode potential is held at about −10 volts by the charge on capacitor C1 in the cathode circuit. The anode-cathode potential of V2 thus falls to about 10 volts and, as this is insufficient to keep the tube conducting, tube V2 is extinguished. The time taken for capacitor C1 to discharge through resistor R1 allows the tube V2 time to de-ionize before the full cathode potential is again applied to it. Tube V2 is thus prevented from re-striking to the pulse used to strike V3. The tubes V4, V5, V6, V7, V8 and V1 strike similarly, one after another, to the pulses received.

The rectifiers MR2, MR3, MR4, etc., connect the striker of each tube to the potential divider at A to guard against fluctuations in the −80-volt supply.

Signal Delay to Enable Distant Machine to Start

When the first cycle of the counting circuit has been completed and the first character, usually a letter-shift, has been transmitted, the ring counter is stopped for about 1 second and a −80-volt potential is connected to line. The letter-shift character starts the motor of the distant machine, and the delay allows the motor to reach working speed before any more characters are transmitted. This prevents the mutilation of characters received while the speed of the distant machine is increasing.

Fig. 3 shows the circuit element giving the 1-second delay. As V1 strikes during the first cycle of the ring counter, the cathode potential at L is about −10 volts. Rectifier MR1 is forward-biased and the potential at P rises to about −27 volts, which is positive with respect

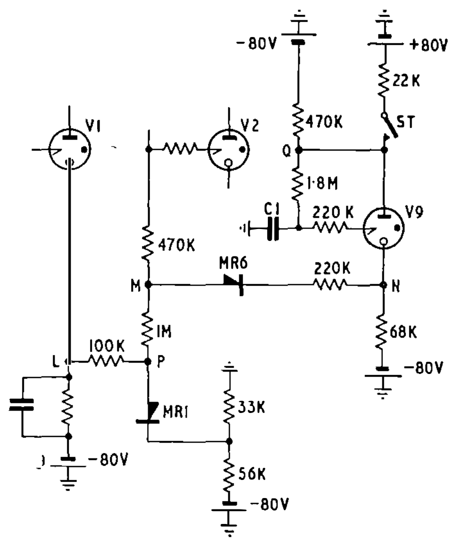


FIG. 3—DELAY CIRCUIT TO ALLOW DISTANT MACHINE TO REACH WORKING SPEED

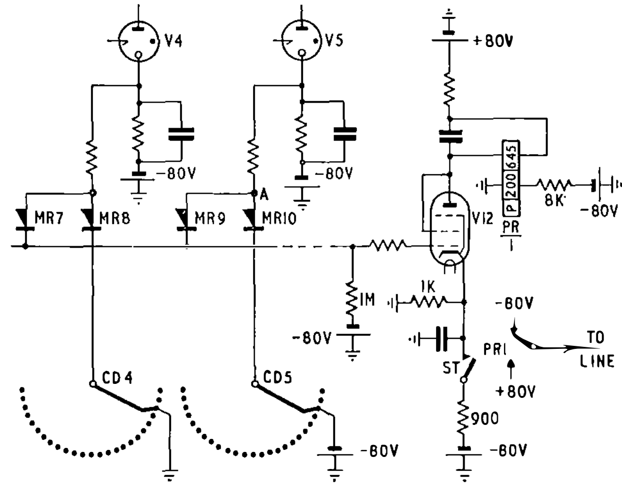


FIG. 4—OUTPUT CIRCUIT

to the −80-volt potential on the cathode of V9. Rectifier MR6 is, therefore, forward-biased and, in this condition, the potential at M is about −68 volts due to the high resistance (1 megohm) between points M and P. The striker circuit of V2 is thus at a potential of −68 volts, and this is sufficient to prevent V2 from striking when the next pulse is received. The counting circuit stops with V1 conducting.

The operation of the start relay, in addition to starting the counting circuit, also applies a positive potential to the anode of V9 and increases the voltage at Q from −80 volts to about +80 volts. The voltage on the striker circuit of V9 increases slowly from −80 volts as the capacitor C1 charges, and after about 1½ seconds the tube strikes. With V9 conducting, the potential at point N reaches −10 volts and the rectifier MR6 is back-biased. With tubes V1 and V9 conducting, the potential on the striker of tube V2 rises to about −27 volts and this tube strikes when the next pulse is received from the pulse generator. The counting cycle then begins again. Tube V9 remains conducting for the rest of the time that the transmitter is in use, and the counting circuit continues until the preamble has been transmitted.

Output Circuit

The output of the message transmitter consists of double-current signals from a polarized relay. This relay is controlled by a pentode valve that conducts, or does not conduct, according to the potential applied to the grid of the valve. Fig. 4 shows the output circuit and the connexions between the grid of the output valve, the ring counter and the code-distributor uniselector.

With the transmitter at rest, the cathode of V12 is at earth potential and the control grid at −80 volts. The valve does not conduct under these conditions, and the armature of the output relay PR is held in the "stop" position by a current flowing in the 200-ohm winding. The contact of relay PR connects a stop potential of −80 volts to line.

When the transmitter is started the cathode potential of V12 is lowered to its correct working value of −42 volts. This voltage is derived from the potential divider formed by the 1,000-ohm and the 900-ohm resistors in the cathode circuit. If the wiper of CD4, for instance, is standing on a contact connected to earth, this earth potential connected to the grid circuit of V12 has no effect on the output, due to the high backward resistance of MR8. When tube V4 strikes, its cathode potential rises to about −10 volts. This is positive with respect to the −80-volt potential on the grid circuit of V12 and rectifier MR7 is biased in the forward (low-resistance) direction, raising the potential on the grid circuit to −10 volts. As the cathode of V12 is at −42 volts, the valve conducts for the 20 ms that V4 conducts, and a current of 4 mA flows in the 645-ohm winding of relay PR. The relay armature moves and connects a "start" potential of +80 volts to the line. The rectifier MR9 is biased in the reverse direction, so that the rise in potential on the grid circuit is not reduced by the connexion to V5.

The next incoming pulse causes tube V5 to strike, and as the associated wiper of uniselector CD is standing on a contact connected to −80 volts, the potential at A cannot rise above −80 volts because of the low resistance of MR10, which is forward-biased. The grid circuit of V12 remains at −80 volts and the valve does not conduct; the armature of relay PR returns to the stop position under the control of the bias winding, and a negative potential is connected to the line for the 20 ms that V5 is conducting. Thus, the polarity of the transmitted element depends on the connexions to the banks of uniselector CD and, by suitable strapping, any character can be transmitted.

During the stop element of each character, the uniselector CD steps to the next contact. The uniselector magnet is controlled by the tubes V10 and V11. These tubes strike at the same time as tubes V7 and V1, respectively. When tube V10 conducts, the magnet is energized and when tube V11 strikes, the magnet is de-energized and the uniselector steps during the 40 ms stop signal.

Transmission of Serial-Number Codes

Four consecutive contacts on arcs 4–8 of uniselector CD are used for the transmission of the serial numbers, which range from 0001 to 1999. Fig. 5 shows the method of transmitting the codes of the numbers and the stepping circuit of the numbering uniselectors. The codes for the hundreds, tens and units digits are transmitted from the contacts of the banks of uniselector CD connected to the wipers of the hundreds (H), tens (T), and units (U)

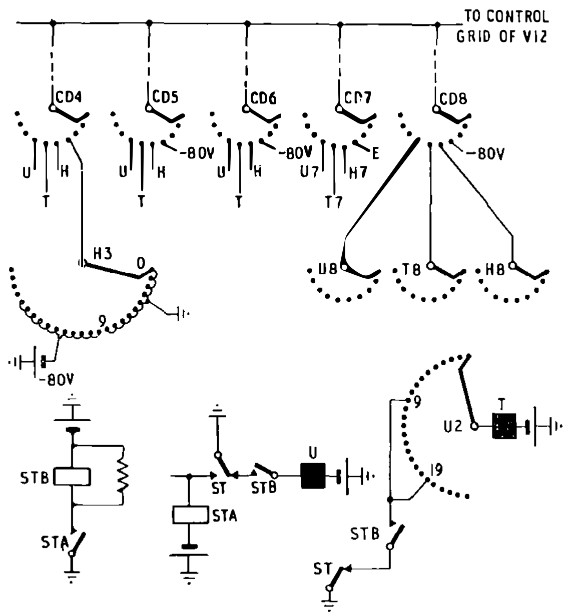


FIG. 5—NUMBERING CIRCUIT

uniselectors. The banks of uniselectors H, T and U are connected to earth or −80-volt potential according to the code of the appropriate digit. The code for the thousands digit, which might be 0 or 1, is transmitted from the first of the numbering contacts on the banks of the uniselector CD. As the codes for the digits 0 and 1 differ only in the first element, the elements 2–5 of the thousands digit are transmitted using connexions of earth or −80-volt potential direct to the banks of the code-distributor uniselector. The first element is transmitted using the third bank of uniselector H.

At the conclusion of the preamble a signal is forwarded to the control relay-set, which releases the numbering transmitter. The releasing of the start relay and relays STA and STB causes the drive magnets of the appropriate numbering uniselectors to be energized. These uniselectors step to the next serial number, and the uniselector CD drives to the home position.

If more than 25 characters are required in the preamble, it is necessary for uniselector CD to rotate twice. During the second rotation, different potentials may have to be applied to the contacts of the banks 4–8, as characters on the second rotation may have different codes from characters on the first rotation. The different codes are applied by the operation of a switching relay that operates at the end of the first rotation. The contacts of arcs 4–8 carrying the serial numbers are not used during the second rotation; the counting circuit is stopped when the uniselector reaches these contacts and a self-drive circuit is completed so that the uniselector will pass over the four contacts concerned without transmission taking place.

CONCLUSION

The transmitter has proved very reliable in use and is more convenient than mechanical numbering transmitters, as no punched tape is used for the numbering preamble. The power consumption is small, and maintenance and operating costs are low. The equipment can be easily modified to give single-current output or an output with a different baud-speed.

The equipment has been used extensively in conventional torn-tape-relay networks and on push-button tape-relay networks. It has also been employed in a modified form as a telegraph-message generator; by suitable programming and control the transmitter can select and send any one of a number of pre-determined messages. In this form it has been used on alarm-reporting equipment for the transatlantic cables.

Book Received

"Fundamental Formulas of Physics." 2 Volumes. Edited by D. H. Menzel. Dover Publications, Inc., New York, and Constable & Co., Ltd., London. Volume I: xx + 364 pp. Volume II: xxi + 377 pp. 32s. the set.

This two-volume, paper-backed book is an unabridged and revised version of the work first published in one volume in 1955. It is a comprehensive work ranging from simple operations to highly sophisticated ones, all presented with terms carefully defined and formulas given completely. In addition to listing the formulas, mathematics is integrated into the text so that many chapters are brief summaries or even short textbooks of the field represented. The scope of the book can be judged from the following chapter titles:

Vol. 1: Basic Mathematical Formulas, Statistics, Nomograms, Physical Constants, Classical Mechanics, Special Theory of Relativity, The General Theory of Relativity, Hydrodynamics and Aerodynamics, Boundary Value Problems in Mathematical Physics, Heat and Thermodynamics, Statistical Mechanics, Kinetic Theory of Gases, Viscosity, Thermal Conduction and Diffusion, Electromagnetic Theory, Electronics, Sound and Acoustics.

Vol. 2: Geometrical Optics, Physical Optics, Electron Optics, Molecular Spectra, Atomic Spectra, Quantum Mechanics, Nuclear Theory, Cosmic Rays and High-Energy Phenomena, Particle Accelerators, Solid State, Theory of Magnetism, Physical Chemistry, Basic Formulas of Astrophysics, Celestial Mechanics, Meteorology, Biophysics.

"Plastics Mould Design." Vol. I: Compression and Transfer Moulds. R. H. Bebb, A.M.I.Mech.E. Iliffe Books, Ltd. 124 pp. 83 ill. 27s. 6d.

This is the first volume of a book on mould design; the second volume deals with the design of injection moulds. Originally published by the Plastics Institute as one of a series of monographs exclusively for the use of their own members, this work by R. H. Bebb has now been extensively revised for the present edition which is being made available to a wider readership.

It is a practical book on the design and manufacture of moulds for compression and transfer mouldings, and contains numerous worked examples of typical design calculations with a series of exercises for further study. The chapters on design procedure are followed by one on the hobbing of moulds and one on ferrous metals for mould making. A prominent feature of the final chapter is an eight-page comprehensive table of proprietary materials, their analysis, application in tooling, manufacturing method, heat treatment, manufacturers, and brand or specification.

Although this series of monographs has been designed for those taking the professional examinations of The Plastics Institute, it will also prove invaluable to all those interested in the technology of plastics.

The Post Office Engineering Department's Computer

G. D. ALLERY, B.Sc.(Eng.), A.M.I.E.E.†

U.D.C. 681.142

The types of engineering work for which a computer can be used are considered, and their influence on the choice of a suitable machine for the Post Office Engineering Department is discussed. The computer installation at the Post Office Research Station, its operation and utilization are described.

INTRODUCTION

THE Post Office Engineering Department has, for about the last ten years, been concerned with many aspects of computing. The similarity of circuit techniques, particularly with those used in telephony for signal storage and for switching, has produced articles in this Journal that bear on the solution of problems in the strictly computational field.

As early as 1939, the modifications in design of a Hollerith tabulator were described;[1] these gave special comparison facilities to enable lists for the distribution of Engineering Instructions to be prepared automatically.

In 1955 a series of articles[2] dealt with the Mosaic computer designed and constructed at the Post Office Research Station for the Ministry of Supply.

In more recent years the Engineering Department has been concerned with the selection of a computer to assist the Post Office Supplies Department in provisioning procedure, and with the installation and maintenance of the National-Elliott 405 computers forming the London Electronic Agency for Pay and Statistics (LEAPS).[3]

Up to the time that the LEAPS computers were installed, computing facilities in the Post Office Engineering Department had been provided by hiring time on computers owned by their manufacturers. Such machines are run on a service basis, and a charge of £20–£250 per hour is made for their use. This charge does not include the preparation, writing and punching on tape of the program; these are the responsibility of the user. For the intermittent user such facilities are most valuable, but a point is reached with increasing use when, both for economy and convenience, access to a machine owned by the user would be better. This is particularly true if time spent in travelling and operating as well as delays in booking periods on the machine are considered.

In 1959 the Engineering Department was using commercial machines for 2 hours a week but the cost and inconvenience restricted the use to a few people concerned with mathematical and telephone-traffic problems, mainly in the Post Office Research Station. The use of spare time available on the LEAPS computer was therefore considered. This machine is still being used by the Engineering Department, but, due to heavy commitments for payroll work, its availability for engineering computation is very restricted. Furthermore, with the length of training and practice required for programming, the use of this machine for small and non-repetitive jobs is not worth while. In the meantime, a review was started of possible work for an Engineering Department computer.

Types of Work for a Computer in the Engineering Department

Consideration was given first to the amount of computational work in the Engineering Department carried out manually, or by desk calculators, to aid engineering design. This work proved to be very large in quantity and widespread, although the bulk of it was located in the Post Office Research Station. Much of it was tedious and time consuming, even with the aid of mechanical calculators, and was clearly a brake on analytical solutions or the analysis of experimental data. Apart from this basic load, there were a large number of problems, much too big for desk calculators, that did not justify the staff effort, even if it were available, involved in programming them for commercially-available service computers. Over and above this, there was the possibility of computer applications that would involve processing large quantities of scientific and technical data, and problems requiring simulation of either mathematical or physical engineering design within a machine.

Broadly, computing work in the Engineering Department can be grouped into three categories:

(*i*) calculation as an aid to design and development,
(*ii*) engineering and scientific data-processing, and
(*iii*) simulation of engineering problems.

Calculation as an aid to design and development may involve any problem that is expressible as the solution of a mathematical formula for a specific range of values. An example of this might be the calculation of the response of a filter network over a range of frequencies at specified intervals. Such a problem would require the input and output of a small quantity of data, but would need a reasonably-fast arithmetic unit. If the expression to be computed was more complicated, additional fast-access internal storage, usually a magnetic-core store, would be required for holding the longer program and the intermediate results.

A problem in the engineering and scientific data-processing category is recognized by the need of the program to operate on, and possibly to provide an output, of a large quantity of data or results. In either event the data have to be stored in a way that gives the program a reasonable rate of access to them. This is usually provided by means of magnetic tape or, possibly, by a magnetic disk; the output may be printed by a high-speed printer. An example of such a problem is maintaining a record of the utilization of cable pairs in trunk cables, to facilitate the routing of circuits and the preparation of circuit-provision advices.

In simulation work, magnetic tape is required for the storage of reference data or programs, and a large random-access medium-speed store is needed for the simulation of the problem itself. A recognized application of this procedure is to determine the effect of random telephone traffic on various model trunking systems simulated in the computer.

Another requirement applicable to each of the three categories is ease of programming. This is particularly true of (*i*) in which the drudgery of programming the work may be no better than the tedium of mechanical or manual calculation. For (*ii*) and (*iii*), ease of programming is also very important, but it may be masked by the more difficult logical organization of the problem

†Organization (Complements) Branch, E.-in-C.'s Office.

itself. The difficulties mentioned earlier with the LEAPS computer illustrate these points.

One other consideration that bears on ease of programming is whether a computer installation should be run on the "closed-shop" or "open-shop" basis. Most clerical data-processing installations are run on the closed-shop principle, whereas engineering and scientific computers are usually operated using the open-shop method. For clerical computing, overall planning, programming and running of the problem on the machine are carried out by a special "closed" group of people. This is done to concentrate expertise in one place, and it is necessary because

(*a*) work overflows the existing group boundaries and no individual member of the staff knows all the requirements,

(*b*) programs should be as efficient as possible, since, due to repetitive use of the computer, time is at a premium in such applications, and

(*c*) the minute logical detail of programming does not come naturally to people having a clerical or business background.

Engineering calculation and simulation, however, form a part of a particular design project and are controlled and indeed defined by the engineer in charge of the project, and only he can lay down the terms of the program. Generally, high efficiency in program writing is not required as repetitive running and time factors are not so critical as for clerical jobs. The logical detailed thinking required in programming comes more easily to the engineer (in fact, apart from programming, this is necessary for the solution of the problem anyway) although the tedium of writing down the actual instructions tends to be a psychological barrier. Because of these conditions, engineering problems are dealt with on the open-shop principle, and each individual who has a problem writes the program and tests it himself.

Engineering data-processing falls between the two extremes and has characteristics of both, but on the whole the work may best be treated on the open-shop basis. This is particularly true where the data being processed are part of a planning or design project.

From the foregoing it is clear that the justification for the open shop from the user's point of view stands or falls by the answer to the question: "Is it easier for the user to program this computer or for him to explain his problem to an expert programmer?"

As explained in a previous article,[4] programming is made easier by the use of autocodes, and their use is generally a further requirement for a computer used for engineering and scientific work. In addition, simulation work often requires the examination of the bit structure of the computer word. This is usually difficult in autocode languages, and thus easy machine-code programming is a further requirement for such work.

Choice of a Computer

Of the three categories of work described, engineering data-processing and simulation require a large amount of problem-preparation and programming effort, and, although the returns are great, such work is hardly suitable for the inexperienced user. Also, a large and expensive machine is required at the outset. On the other hand, in engineering calculation to aid design, a large range of problems from the simple to the complex existed and were spread over many branches of the Engineering Department. Furthermore, the specification of many of these problems was straightforward and already known; some of them were already being solved manually or on desk calculators, and it would be only necessary to write fairly straightforward programs. It was therefore considered that the quickest way of spreading widely a knowledge of and familiarity with computing methods would be by concentrating initially on engineering design calculation.

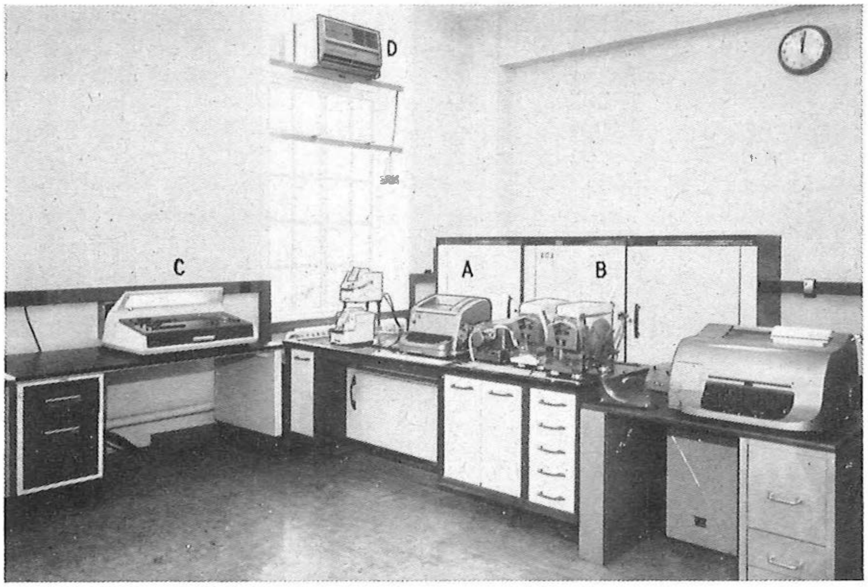
The requirements for this type of application demanded a machine in the small-computer class. Also, if the installation was extendable by the later provision of an additional magnetic-core store or magnetic tapes this would be an advantage, as some embryo simulation or small amounts of engineering data-processing could then be carried out. A further advantage of such an approach is that during the early stages, when due to lack of programming skill the machine may not be used efficiently, the amount of capital committed is small and can be increased as the need and efficiency justify. A final requirement was that of reliability—an important factor in deciding on a particular machine. Experience of earlier computers had established the fact that once confidence in the reliability of a machine was suspect (even though the reliability was considerably greater than that of a human) a general disinclination to put work on it resulted, and trust in the machine was difficult to restore.

The foregoing factors led to the consideration of a number of commercially-designed computers, and the final choice was the National-Elliott 803B machine. Due to the concentration there of the right type of work it was decided to install the machine at the Post Office Research Station, Dollis Hill.

The National-Elliott 803B Computer is a small general-purpose machine that has been supplied for scientific calculations, small-scale data processing and as the central unit for the control of factory processes. Each of these types of application require different ancillary equipment, but all are dependent on the central control unit, or logic cabinet. Connected to this and under its control are the various ancillaries, often referred to as peripheral equipments, whose purpose is almost entirely concerned with establishing a means of communication between the central control and the outside world. Input and output of data is normally achieved by means of punched-paper tape or, sometimes, by punched cards, but for process-control applications data may be fed in directly electrically, to special registers. Process-control applications require special peripheral devices depending upon the system controlled, such as transducers for reading temperature, pressure, and similar parameters that can be converted to digital form so as to be suitable for input to the computer and to be scanned in sequence on a time-division basis. A keyboard is provided for manual control of the machine, and the output can also be printed directly by a teleprinter. For data-processing applications, up to four 35 mm magnetic-film units can be connected; these provide storage of data in a serial form that is considerably more compact than punched-paper tape and, also, access to it is more rapid. A 1,000-ft reel of film will hold 10 million binary digits and transfer them at a peak rate of 29,000 digits/second.

POST OFFICE RESEARCH STATION INSTALLATION

The equipment installed for the Engineering Department computer is typical of that for scientific and engineering calculations. It consists of the central control unit, paper-tape station, control keyboard and power-supply equipment. The layout of the computer room is shown in Fig. 1.



A—Power cabinet B—Logic cabinet C—Keyboard D—Air-conditioning unit
FIG. 1—GENERAL VIEW OF COMPUTER INSTALLATION

Central Control Unit

The central control unit is housed in one logic cabinet measuring 5 ft 6 in. long × 4 ft 8 in. high × 1 ft 4 in. deep. The cabinet can accommodate 71 plug-in circuit boards, each approximately 18 in. × 10 in. (see Fig. 2).

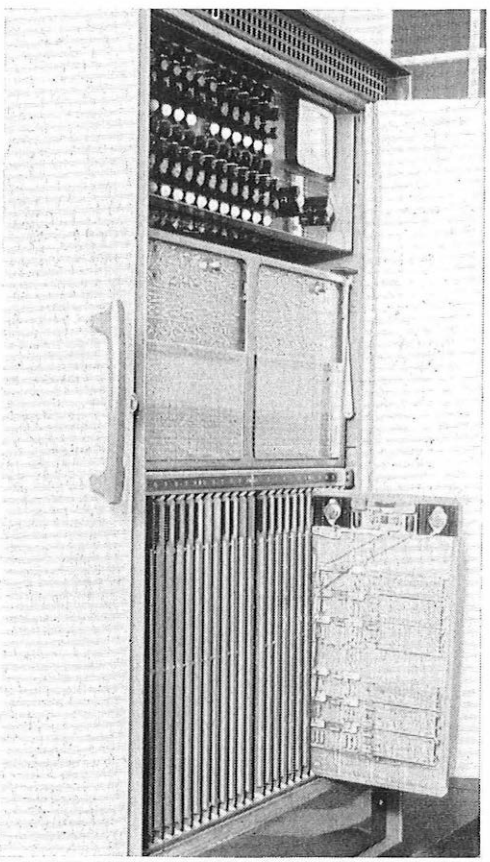


FIG. 2—LOGIC CABINET WITH A LOGIC BOARD WITHDRAWN

The number of boards fitted will depend upon the computer configuration, but in the Engineering Department computer there are 47 boards, including four nickel delay-line boards. These boards carry the logic circuits and control registers of the machine. The core store consists of 4,096 words, but is capable of extension to 8,192 words each of 40 bits, i.e. 39 information bits and one error-detection bit. It is made up of 40 planes (or layers) each containing 64 × 64 cores, and 4,096 words of core storage are contained in a space of about a 1 ft cube. A meter panel and access points for voltage-margin testing[5] are also provided, and can be seen at the top right-hand corner of Fig. 2.

The machine uses solid-state components throughout, and in the logic cabinet of the Engineering Department computer there are about 2,000 transistors. The heat dissipated in the cabinet is about 600 watts and this is removed by air drawn in at the bottom by fans, blown over the logic boards and expelled through a grill at the top (see Fig. 2).

Paper-Tape Station

The paper-tape station is illustrated in Fig. 3, and has two input and three output channels. The two tape-reader inputs are shown on the left, one above the other,

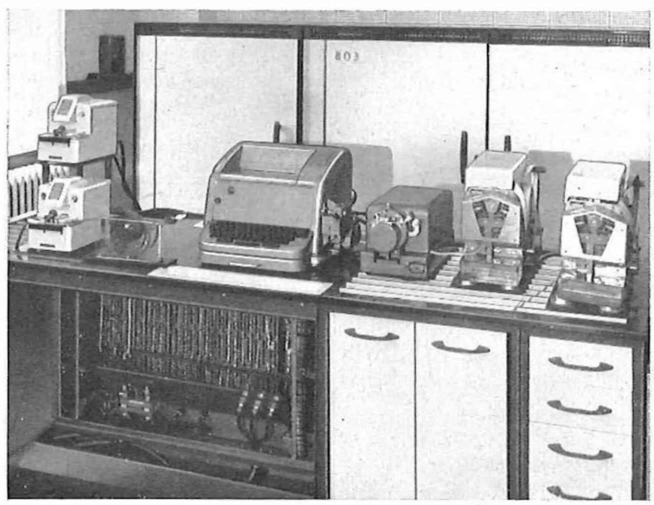


FIG. 3—PAPER-TAPE STATION

and those supplied for the Engineering Department computer are capable of reading photo-electrically, at 500 characters/second, a 5-track tape. On the right are two tape punches, each capable of punching at a maximum rate of 100 characters/second. The third output channel is a directly-connected teleprinter (shown in the centre) that prints 75 characters/second. The auto-transmitter is not connected to the computer, and simply allows printing of the punched tape on a remote teleprinter, shown on the right in Fig. 1.

The control circuits for the peripheral devices are contained on 20 plug-in boards similar in size to those in the logic cabinet and are located in the paper-tape station.

Control Keyboard

The control keyboard, shown on the left in Fig. 1, stands on a separate table. Controls on the keyboard give various facilities, including switching the power on and off the computer. Instructions can be inserted manually into the machine by using 39 push buttons on the keyboard that set each binary digit to 0 or 1 and simulate the instruction required; this instruction is then placed into the computer under the control of another key.

Power Supplies

Power is derived from a single-phase a.c. mains supply that is taken to a battery-charger rack (not illustrated in Fig. 1) accommodating switchgear and full-wave bridge rectifiers. A.C. and d.c. voltage stabilization is provided. The battery charger gives a sensibly constant output voltage of about 28 volts from no-load up to 65 amp. The charger functions as a single-phase rectifier on light loads, but changes to 2-phase working as the load increases. The output from the battery charger is taken to the power cabinet (Fig. 1) that houses the floated battery, circuit-protection equipment and d.c. stabilizers,

The battery that supplies the main d.c. output is used primarily as a means of eliminating electrical noise, particularly high-frequency spikes that may be mains-borne or fed back from the computer circuits. It consists of 20 cells with electrodes of cadium hydroxide and nickel hydroxide supported in sintered nickel; the electrolyte is potassium-hydroxide solution. The battery is normally trickle-charged at about 200 mA, but can supply peak loads of 200 amp for several seconds. Normally, no gas is given off by the cells, but to cover fault conditions a pressure-release valve operating at 4 lb/in^2 is fitted.

Accommodation

The computer installation occupies a floor area of about 500 ft^2 divided into two rooms; one contains the tape-preparation and editing equipment and the other the computer. Some allowance for growth of the installation has been made in the computer room. Both rooms have been fitted with acoustic tiles to reduce the effects of noise from the tape-punching and teleprinter equipment.

Air Conditioning

Two air-conditioning units have been fitted in the computer room; each has been mounted in the frame of a window (see Fig. 1). These two units are capable of cooling at the rate of approximately 30,000 B.t.u./hour or heating at 16,000 B.t.u./hour. The maximum total heat dissipated by the computer is about 12,000 B.t.u./hour. With this arrangement it is estimated that it will be possible to maintain the computer room temperature at 70 ± 3°F throughout most of the year, and that it will not exceed 70 ± 10°F for external temperature limits of 30°F and 90°F. The fresh-air ventilation rate is at 125 ft^3/min.

DESCRIPTION OF LOGICAL OPERATION OF NATIONAL-ELLIOTT 803B COMPUTER

An earlier article[6] has referred to the elementary logical design of a computer. Here it is proposed only to give a brief outline description of the logical operation of the National-Elliott 803B machine and to give a short description of the basic logical circuit elements.

The machine is timed from a master crystal oscillator having a frequency of 166·5 kc/s, and the basic digit period is thus 6 μs. As will be indicated later, it is necessary to produce two "clock" supplies 3 μs out of phase with each other; these are referred to as the alpha and beta phases.

The 39 information bits in each word of the ferrite-core store can hold either data in the form of a number or two computer instructions. Each instruction of 19 bits (one bit of each word is used for special control) consists of 6 bits for the function and 13 bits for the address. The function and address parts together constitute an instruction. The function part defines the operation to be performed and the address part indicates the location of a number (or another instruction) in the store on which the operation is to be performed.

The National-Elliott 803B is a serial machine with single-address instructions. This means that the machine will obey one instruction at a time; the next instruction is normally that stored in the next location in the store. The procedure for obeying each instruction can be considered as occurring in two beats.*

A simple example of adding two numbers stored in two separate locations in the store by means of two instructions, and holding the final result in the arithmetic unit will give an illustration of the sequence of the beats and the logical operation of the machine. Reference is made to the block schematic diagram, Fig. 4.

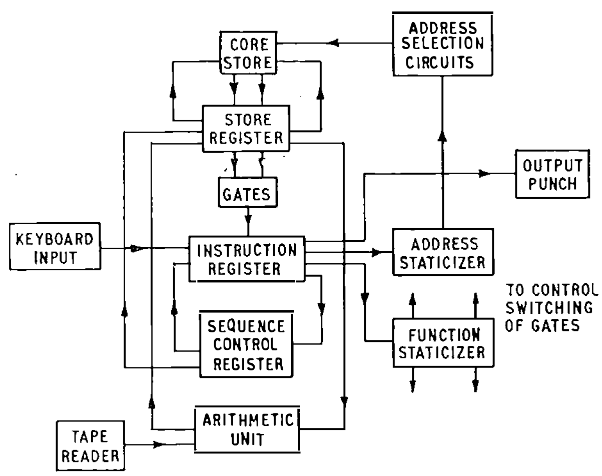


FIG. 4—BLOCK SCHEMATIC DIAGRAM OF COMPUTER

The instructions of the program are assumed to be in the store, and the address of the pair of instructions has been set on the keyboard and put into the instruction and sequence-control registers. The operation then continues as follows:

*Beat-one of the possible states of the control system of a computer, e.g. in a 2-beat machine one beat might be devoted to setting up the correct circuit to perform a function which is carried out during the second beat.

(a) First Instruction

First Beat

(i) The sequence-control register has a capacity of 14 bits, 13 nominating the address of the store location of the pair of instructions to be dealt with and the 14th bit indicating whether the instruction in the first half or second half of the word in that location is to be obeyed. The pair of instructions is thus taken from the store into the store register and the first half containing the first instruction from the store register into the instruction register.

(ii) The binary digits of the function part of the instruction are then staticized.‡

(iii) As the action of reading out from the store destroys the information in that location, the contents of the store register are written back to replace it.

(iv) The address digits of the instruction are then staticized.

Second Beat

(i) The address-selection circuits are then set, and the first number is read from the store and transferred to the store register.

(ii) The function, staticized in the first beat, is performed by transferring the contents of the store register (first and second half) into the arithmetic unit.

(iii) One is added to the 14th bit position of the sequence-control register.

(iv) The store register contents are then written back into the store.

(v) The contents of the sequence-control register are then transferred to the instruction register and the 13 bits indicating the address of the instruction pair are staticized.

(b) Second Instruction

The procedure in dealing with the second instruction is similar to that already described, except that the second half of the instruction word is dealt with. As before, during the second beat the appropriate function (in this instance adding the second number to that already in the arithmetic unit) is carried out. Each of these instructions takes 576 μs to complete. The total time to read from the store and to write back again into it is 20 μs.

A maximum of 64 different functions is available, including automatic input from the keyboard and tape reader and automatic output to the tape punch. One point of interest is that the output to the punch is controlled by an instruction that has a fictitious address. The least significant five bits of this address specify the character to be punched. This is detected in the instruction register and it is for this reason that the punch is connected to the instruction register and not to the arithmetic unit.

The arithmetic unit consists of five nickel delay-line registers, the maximum length corresponding to a delay of 0·27 ms. Two other registers, the sequence-control register and the B register (not shown in Fig. 4), are nickel delay lines. The store and instruction registers are made up from the basic magnetic-core logical circuit elements described below.

‡Staticized—converted from a time sequence of states representing digits into corresponding space distribution of simultaneous states.

Logical Circuit Elements

Two basic types of logical circuit elements are used throughout the machine: one is used in the logic cabinet and is of the core-transistor form; the other is used in the paper-tape station and is of the transistor-resistor type.

Core-Transistor Type. These logical circuit elements (Fig. 5) each consists of a 3 mm ferrite core wound with

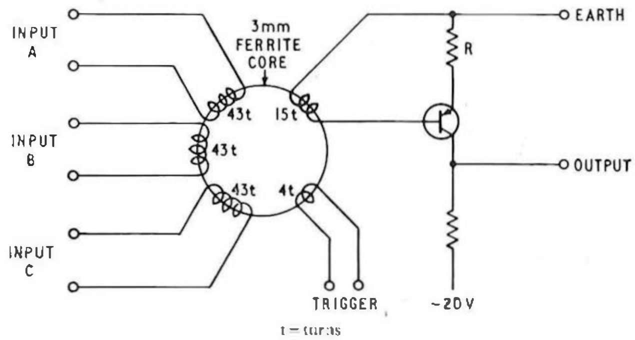


FIG. 5—BASIC CORE-TRANSISTOR LOGICAL CIRCUIT ELEMENT

a maximum of five windings, encapsulated in a plastic container, as shown in Fig. 6. The encapsulated core

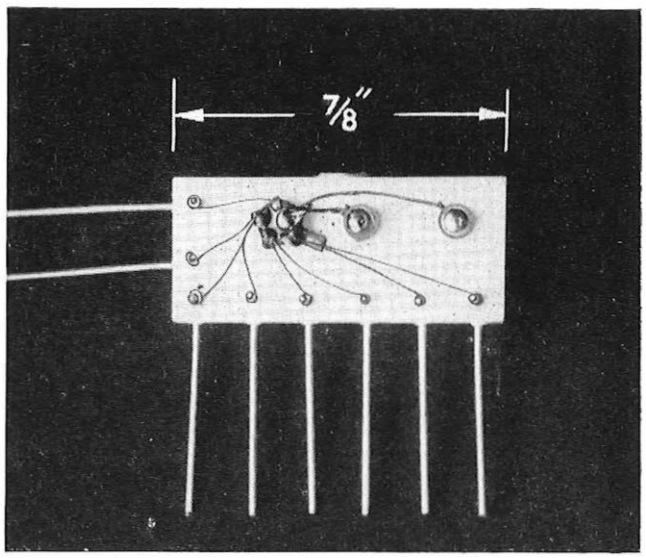


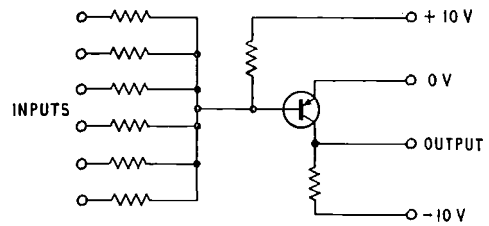
FIG. 6—LOGIC CORE BEFORE ENCAPSULATION

with its transistor and resistor occupies a space of about 2 in. × 1½ in. Up to 36 of these elements can be mounted on one logic board.

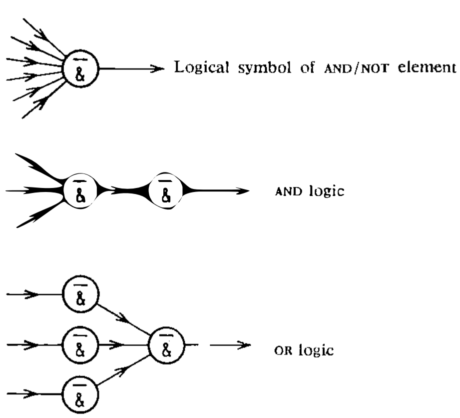
Individual pulses applied separately to the inputs A, B or C can set and store in the core a binary 1 state. A trigger pulse subsequently applied to the trigger winding will set the core back to the 0 state. In so doing, a pulse is produced in the 15-turn output winding; this drives the base of the transistor negative, switches on the collector current and produces a positive pulse in the output, representing a binary 1. Only the trigger pulse will produce an output, as the input pulse in driving the core from 0 to 1 drives the base of the transistor positive and holds the transistor cut off. There must be some delay between setting a core and interrogating it with a trigger pulse, and this has been set at half a digit period, or 3 μs. This allows the output of one core to set another following it, and for this in turn to be triggered to produce an output half a digit period later. This requires the trigger windings of alternate cores in a chain to be connected to the alpha trigger-pulse phase and the others to the beta phase. The trigger-drive pulses are generated and supplied through power transistors, one for each phase on each logic board. These may be seen at the top of the board in Fig. 2

By reversing the connexions to one of the inputs, an inhibit winding is produced. This winding will oppose a normal drive winding. The element is then changed from a 3-input inclusive OR or MIX element into a 2-input AND element as long as the inhibit winding has a 1-state signal connected to it. Various logical elements are possible by combinations of inhibit and drive windings. One core output often drives two other core inputs in series. Additional cores are driven by adding parallel transistors to the element.

Transistor-Resistor Type. These logical circuit elements (Fig. 7 (*a*)) are used in controlling the peripheral equipment on the paper-tape station. The basic element is encapsulated and measures 2 in. × 0·85 in. × 0·625 in., and a number of them may be mounted on plug-in



(*a*) Basic Logical Circuit Element in Paper-Tape Station



(*b*) Logic Using AND/NOT Element

FIG. 7—TRANSISTOR-RESISTOR LOGICAL CIRCUIT ELEMENT

logic boards. The element corresponds to a logical AND followed by a NOT. Up to six inputs are provided, and these must be either positive or negative. If an input is not connected it may be regarded as positive and ignored. With all inputs positive, the transistor is cut off and the output is down.†† If any of the inputs are negative the transistor conducts and the output is up.††

††Up, down–A pair of terms used in this context to differentiate between binary states that may occur at a point in an equipment. The terms are derived from the relative voltage or current levels that represent these states.

The output is capable of driving as many as five inputs of another element.

Fig. 7 (*b*) shows an arrangement of this basic element to form AND or OR logic.

UTILIZATION

Programming and Training

One of the requirements stated for the machine was that it should have an autocode suitable for dealing with engineering calculations as an aid to design: the Elliott autocode[4] fulfils this requirement. The National-Elliott 803B machine-code instructions, as already mentioned, consists of a function part and a single address. This code is relatively easy to use, and is useful mainly where autocode might be inefficient, as in data processing or simulation problems. However, almost all programs have been written in autocode.

About 170 engineers and scientists have attended a number of 3-day autocode training courses at the Research Station, and a number of senior engineers and scientists have attended half-day appreciation courses.

The 3-day courses include one and a half days of lectures, the remaining time being spent in writing programs and running them on the machine. At present, about 20 per cent of those attending the course have subsequently written practical programs in connexion with their work. The main advantage, however, has been that in a short time a large number have been given some indication of the potential value of computers as an engineering tool, and it may well be that this sort of instruction should be part of the basic training of all engineers concerned with development work.

Operational Organization

The computer, which was installed in March 1961, is run on the open-shop system and time on the machine is bookable in quarter-of-an-hour periods. The day-to-day administration is part of the responsibility of the mathematics group in the Research Station. Programs, although written by the user, are punched on to tape for him by a machine operator at the computer, but the testing of the program on the machine is the responsibility of the user. Nevertheless, consultants are available for advice and help in programming. When a program has been proved and subsequent routine running of it is required, this is carried out by the operating staff and the results are sent to the user.

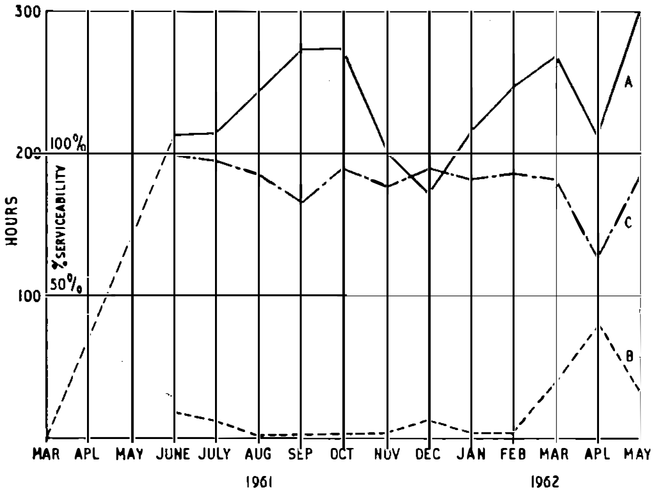
Use Made of the Computer

Twenty four engineering branches or divisions of the Engineering Department and three other departments of the Post Office have made use of the computer. As envisaged, most of the work has been calculations as an aid to design and development. Many interesting applications have been made and some of these will be described in more detail in subsequent issues of this Journal. However, the following titles of four of the programs run will indicate the range of work: busbar loading, character recognition, transistor parameters, epicyclic-drive velocity.

As yet, little has been done in processing large quantities of engineering and scientific data or in simulation work. These important applications require more powerful facilities.

Service Given by the Computer

The computer was installed and is maintained by the contractor. During the first three months the load built up very rapidly and the present average time that the machine is switched on is 60 hours a week. Fig. 8 curve



Curve A—Monthly switched-on time
Curve B—Installation-work, modification, maintenance and testing time
Curve C—Serviceability ratio

FIG. 8—UTILIZATION AND SERVICEABILITY OF MACHINE

A shows the monthly switched-on time from the computer installation until May 1962. This includes time for daily routine running of test programs, periodic engineering overhaul of the machine, and modification and installation work, which have been plotted separately as curve B. The time that should be available for computing is the difference. However, time due to faults reduces this and the percentage ratio of the actual computing time to the actual computing time plus time lost by faults, which is called the serviceability ratio, is shown by curve C. Generally, this has been above 90 per cent, but the fall to 64 per cent in April 1962 was the by-product of moving the machine to a new site and installing a new paper-tape station. It is interesting to note that this produced a very sharp decline in the demand for time, which before and after April showed a steady rise.

CONCLUSION

The Post Office Engineering Department's computer has proved to be of much benefit to its users, the majority of engineering branches or divisions having placed work on it. A large number of varied problems have been programmed, most of the work being calculation as an aid to design and development.

Programming the machine in autocode has been successful for the type of problem tackled, the main advantages being the ease of writing programs and the fact that it can be quickly taught.

Apart from the direct benefits, the machine has served as an effective means of quickly and simply introducing to a large number of engineers the possibilities of computer solutions to engineering problems.

ACKNOWLEDGEMENTS

The computing equipment was designed and installed by Elliott Brothers, Ltd. who have also assisted in the preparation of this article. The air-conditioning equipment was supplied by Stewart King Industries, Ltd.

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Book Review

"Relais Electromagnétiques." P. Chougnet. Editions Eyrolles, Paris. 260 pp. 240 ill. 47·30 N.F.

It may seem surprising that a book devoted solely to the consideration of relays should be published just now. The following questions spring to mind—"Does such a simple device as a relay justify a book to itself?", "Are there not already many specialized works on the subject?" and "Surely, it's too late, now that electromagnetic relays are being replaced by electronic devices?" In fact, these very questions are posed and answered in the preface and the introduction. Here it is stated that the present work is intended to collect all the experience gained by the author and his colleagues and to make it known to the wider society of engineers who are not concerned solely with relay design. Much of the information is original and much had hitherto been available only in languages other than French.

The book certainly fulfils its aim of covering the design and use of relays over the telecommunications field although notable omissions are high-speed relays, reed relays and remanent relays. The reader's knowledge of French need not be extensive since most of the technical terms are readily recognizable and the many useful illustrations require no interpretation.

The volume is split into four sections:

I. Construction and use, where the relay is considered as a circuit element. Detailed explanation is given of exactly what may be expected of a relay and how its intrinsic performance may be modified. One chapter is devoted to circuit logic, including an introduction to Boolean algebra.

II. Theoretical determination of magnetic, electrical and mechanical characteristics.

III. Practical behaviour, in which are discussed the influences of mechanical imperfections and environment, manufacturing methods and contact phenomena.

IV. Measurements, being a short description of methods of testing the constituent materials and the complete relay.

Each section covers the basic principles of the particular features discussed with a brief but lucid explanation of how the principles are applied. The arguments are supported by numerous graphs and diagrams, and references are made to 41 English or French publications.

Two small disadvantages are that all the relays used as examples are of French pattern and that the c.g.s. system of units is employed. However, the fundamentals are the same and the relays themselves are very similar to their British counterparts.

H.B.

Notes and Comments

Retirement of Mr. W. E. Hudson, O.B.E., Whit.Sch., B.Sc., A.C.G.I.

The 31 July 1962 marked the end of an era, at least in the Home Counties Region, by the retirement of its Chief Regional Engineer, Mr. W. E. Hudson. He was of that select group who began their careers in one of H.M. Dockyards—in his case, at Chatham in 1915. After four years in the Upper School he was awarded a Whitworth Scholarship to the City and Guilds Engineering College (London University) where he gained an honours degree.

Leaving college in 1921, he joined Siemens Bros., and was involved in the design of their No. 16 system. In 1922 he was successful in the first post-war Assistant Engineers (old style) examination, entering the Post

Office at Dollis Hill Research Station where he studied switching systems. Later, under Mr. B. O. Anson, he was engaged on the critical study of automatic and coded-call indicator (C.C.I.) circuits, leading to the standardization of a number of Post Office circuits. During this period his book "The Director System of Auto-Telephony" was published.

In 1930 he transferred to the Facilities Group of the Telephone Branch and was promoted to Executive Engineer (old style) in 1931. Promoted in 1936 to Assistant Staff Engineer in Organization Branch, he concentrated on maintenance organization until the outbreak of war when he transferred to the London Telecommunications Region. He there played a major part in the restoration of London's telegraph services after the destruction of the Central Telegraph Office. In 1942 he transferred to the Home Counties Region as Deputy Chief Regional Engineer, becoming Chief Regional Engineer in 1944.

Mr. Hudson has left his indelible imprint on many fields, not only by the application of his outstanding gifts of intellect and memory but by the human outlook he applied to all staff matters. His kindly manner endeared him to all with whom he came in contact, and his immediate colleagues and many friends wish him a long and contented retirement.

H.S.T.

A. H. C. Knox, B.Sc.(Eng.), M.I.E.E.

Mr. A. H. C. Knox, who has been appointed Chief Regional Engineer in the Home Counties Region, served an engineering apprenticeship in the Royal Dockyard at Devonport before entering the Post Office as a Probationary Inspector by Open Competition in 1927. He later gained his B.Sc.(Eng.) degree as an external student of London University.

Following his initial training in Inspection Branch and the South Eastern District, Mr. Knox spent some three years in the Equipment Section of the Engineer-in-Chief's Office. Success in the Limited Competition for Assistant Engineer (old style) led to his appointment to the South Lancashire District in 1931 where he was employed for some seven years on external planning and construction in the Section and the Superintending Engineer's Office.

In 1938 he was appointed Area Engineer in the South

West Area of the London Telecommunications Region (L.T.R.) on external work. His great knowledge and experience of this type of work proved invaluable during the 1940's when his Area was faced with heavy bomb damage affecting many vital communications, and rapid restoration was essential.

As an ex-shipyard worker he was mobilized in 1944 in R.E.M.E. and served for two years. On his return to the Post Office he resumed as a Senior Executive Engineer at L.T.R. Regional Headquarters on local-line planning duties.

Promoted to Regional Engineer in the Home Counties Region in 1948, he was in control of the Lines, Power, and Radio Groups, and also had responsibility for minor-staff recruitment, training, etc. This was a time of rapid expansion and he played a large part in this from both the line development and staff expansion points of view. Promotion to Deputy Chief Regional Engineer in 1957 led to almost complete concentration on engineering staffing matters, and as Chairman of the Regional Engineering Promotion Board he had a heavy load in dealing with the acute staffing problems which the ndustrial and residential expansion of south-east England produced. His work in this field has been distinguished by a lively and personal interest in the progress of the staff under his charge, and many, of all grades, owe much to his encouragement and practical advice.

Mr. Knox's interest in the welfare of his colleagues has always gone well beyond the bounds of his official appointments. From his early days as Inspector he has shouldered some of the burdens of staff-association work. He was for a time a member of the Council of the Society of Post Office Engineers and for 14 years was Secretary of the Association of Staff and Regional Engineers. He has had experience on Whitley Committees both as Staff and Official Side representative.

For the past seven years he has been a member of the Council of the Institution of Post Office Electrical Engineers, three of which were as representative of provincial Chief Regional and Regional Engineers and four as President of the Associate Section of the Institution. In this latter capacity he has addressed numerous meetings of the various Centres, and has played a prominent part in its growth and development.

These activities have brought Mr. Knox a host of friends throughout the country, and he is recognized not only as an engineer of ability but as a fine lecturer and debater. All who know him wish him well in his new appointment.

W.J.E.T.

Award by the Institution of Electrical Engineers

The Board of Editors has noted with pleasure that Dr. G. H. Metson, of the Post Office Research Station, has been awarded the Institution Premium by the Institution of Electrical Engineers for the following papers, supported by his contribution in a number of papers on the same subject during the past three years:

"Conductivity of Oxide Cathodes, Part 10: Spontaneous Generation of Negative Ions." I.E.E. Monograph No. 433E, May 1961 (*Proceedings I.E.E.*, Vol. 108B, p. 471, July 1961).

"Conductivity of Oxide Cathodes, Part 12: Influence of Strontium Ion Migration on Matrix Conductivity." I.E.E. Monograph No. 473E, Oct. 1961 (*Proceedings I.E.E.*, Vol. 108B, p. 672, Nov. 1961).

Model Answer Books

Books of model answers are available for some of the City and Guilds of London Institute examinations in telecommunications subjects, and details of these books are given on the last page of each issue of the Supplement to the Journal.

One of the books, Telephone Exchange Systems I, was prepared for the syllabus of the old Telecommunications Engineering Course but students will find it of considerable value when studying for the Telecommunication Technicians' Course. However, because this book no longer applies to any one year of the new syllabus it has been reduced in price from 5s. to 2s. (2s. 6d. post paid).

Institution of Post Office Electrical Engineers

Essay Competition 1962–63

To further interest in the performance of engineering duties and to encourage the expression of thought given to day-to-day departmental activities, the Council of the Institution of Post Office Electrical Engineers offers five prizes, a first prize of six guineas and four prizes of three guineas, for the five most meritorious essays submitted by members of the Post Office Engineering Department *below the rank of Inspector*. In addition to the five prizes, the Council awards five certificates of merit. Awards of prizes and certificates made by the I.P.O.E.E. are recorded on the staff dockets of the recipients.

An essay submitted for consideration of an award in the essay competition and also submitted in connexion with the Associate Section I.P.O.E.E. prizes will not be eligible to receive both awards.

In judging the merits of an essay, consideration will be given to clearness of expression, correct use of words, neatness and arrangement, and, although technical accuracy is essential, a high technical standard is not absolutely necessary to qualify for an award. The Council hopes that this assurance will encourage a larger number to enter. Marks will be awarded for originality of essays submitted.

Copies of previous prize-winning essays have been bound and placed in the Institution Central Library. Members of the Associate Section can borrow these copies from the Librarian, I.P.O.E.E., G.P.O., 2–12 Gresham Street, London, E.C.2.

Competitors may choose any subject relevant to current telephone, telegraph or radio practice. Foolscap or quarto-size paper should be used, and the essay should be between 2,000 and 5,000 words. An inch margin is to be left on each page. A certificate is required to be given by each competitor, at the end of the essay, in the following terms:

"In forwarding the foregoing essay of........ words, I certify that the work is my own unaided effort both as regards composition and drawing."

Name (in block capitals)..............................

Signature..............................

Rank ....

Departmental Address..............................

....

Date....................

The essays must reach
The Secretary,
The Institution of Post Office Electrical Engineers,
G.P.O.,
2–12 Gresham Street,
London, E.C.2.
by 31 December 1962.

The Council reserves the right to refrain from awarding the full number of prizes and certificates if in its opinion the essays submitted do not attain a sufficiently high standard.

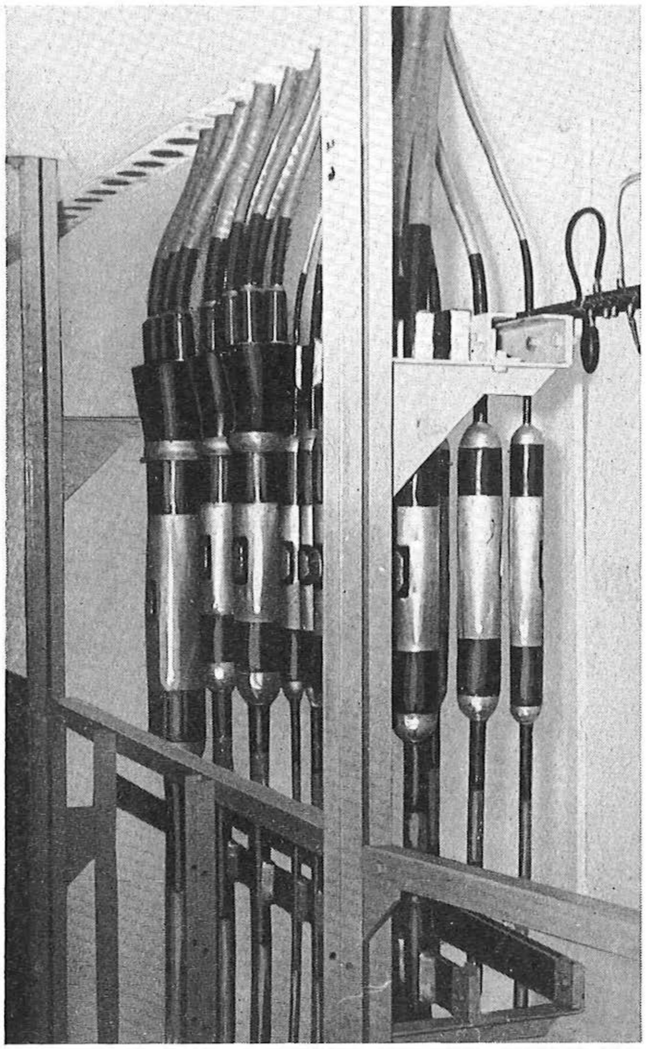
S. WELCH
General Secretary.

Regional Notes

Midland Region

THE M.D.F. AT THE NEW STAMFORD EXCHANGE

The main distribution frame (M.D.F.) at the new Stamford exchange was originally to be equipped with 200-pair verticals. At a later stage 400-pair verticals had to be fitted and this caused congestion in the cable chamber. The original cable-chamber ironwork had been provided with additional tacking-bar space at the non-growing end in order to accommodate a number of relatively small MU and CJ cables and avoid encroachment on the tacking-bar space below unused cable risers. Thus, only half the tacking-bar space required to accommodate the vertical joints was available.



THE CABLE CHAMBER AT STAMFORD EXCHANGE SHOWING THE DOUBLE TACKING BARS

The difficulty was overcome by fitting double tacking bars. The finished layout is shown in the photograph and no undue difficulty was experienced during the installation.

F.J.S.

A NEW DESIGN OF LIGHTNING PROTECTOR

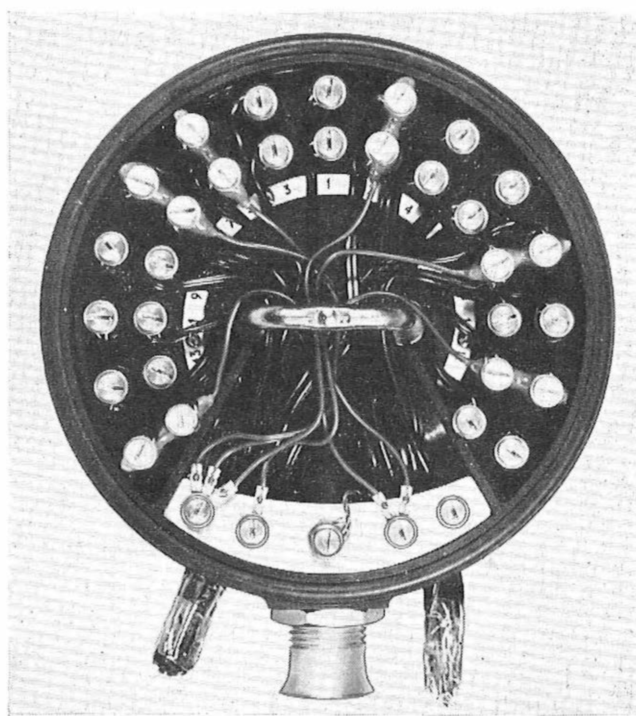
The new policy of circuit protection is to provide the new-type fuse at the main distribution frame (M.D.F.) and to fit lightning protectors at the distribution poles (D.P.) to those lines that require lightning protection, which depends on the amount of open wire in the circuits.

The Midland Region Engineering Branch has produced a lightning protector that can be fitted into the Block Terminal No 17; the protector is a twin unit, capable of protecting both lines, and is enclosed in an epoxy-resin coating.

The Midland Region protector can be immersed in water for several days and still maintain an extremely high insulation resistance; otherwise the protector has the same basic electrical properties of the Protector-Electrode 1B. In order to provide a common earthing point in the terminal block the earth terminal is removed and replaced by a nickel-plated brass earth-bar, on which the earth leads from the protectors are terminated.

A field trial was commenced in two exchange areas in 1960: one is a director exchange in Birmingham, and the other a non-director exchange in a small town with a fairly large rural element. To date, no low-insulation troubles have been experienced, and no cable damage due to lightning has occurred. More recently two other exchanges have been protected with these protectors, and it has been found most convenient to use these items where M.U. and C.J. cables require lightning protection. In total, some 1,500 protectors are in field use.

The fitting of 15 electrodes into an existing fully-used terminal block takes about 1 man-hour; this allows for re-terminating the 15 one-pair leads. Further time is normally required for changing doubtful leads, cleaning out the block, providing an earth connexion from the earth bar to the pole earth-wire, and generally tidying up the pole wiring. It has been found that where lines at a D.P. are protected, then on average five to six pairs require protection. Once the block has been provided with an earth bar it becomes a simple matter to provide protection to any new line of more than four spans connected to the block. In effect, when using these devices, a Block Terminal No. 17 fitted with an earth bar provides the same facilities as a Protector Unit, Pole-top, 15 pair. If at any time it were to be decided to protect lines of four or less spans, it would be an easy



THE MODIFIED BLOCK TERMINAL SHOWING PROTECTORS FITTED TO SIX LINES matter to go back to the block and fit additional protectors of the type described.

With the agreement of the External Plant and Protection Branch, Engineering Department, a bulk order of 20,000 electrodes is being arranged with the object of carrying out extended trials.

The photograph shows a Block Terminal No. 17 with all pairs terminated with Cable, Leading-in, 1 pr., 12½ lb/mile, Flat, and fitted with six of these protectors. Recently the shape of the earth bar has been slightly modified in order to reduce production costs.

G.A.R.M. and D.G.W.

North Western Region

SUBSIDENCE NEAR A 70-WAY TRACK

As a result of excavations for a new building, extensive subsidence occurred in York Street, Manchester. The building contractor claimed that there was danger to a four-storey building across the road and that it was urgently necessary to drive 42 ft steel piles to shore up the roadway.

The circumstances were such that the piles had to be driven very near to a 70-way multiple-duct track housed in a tunnel. The track contained 36 cables, including coaxial and carrier systems to Birmingham, London, Leeds, Derby and Sheffield, and cables used by the British Broadcasting Corporation and Independent Television Authority. The disruption to service, probably on a national scale, which would have ensued if a pile had been driven into the track necessitated as accurate a determination of the track position as possible.

It was considered too dangerous for men to expose the track before the piles were driven, and, furthermore, the depth of excavation required would have increased the risk of further subsidence. Track-locating equipment was used, therefore, on a cable in the nearest bore to the proposed piles and allowance was made for the hard-core filling alongside the duct block. The works diary for the cable tunnel, dated 1927, gave the dimensions of the tunnel excavation. This confirmed that the proposed piles would be driven very close to the track but the contractor was allowed to commence piling, extra care being taken as the first piles reached the appropriate depth. Arrangements were also made to continuously monitor those systems for which this was possible, and for piling to stop immediately if any fault developed.

The locator had indicated that the track curved towards the proposed line of the piles, and to enable the line of the track to be located more precisely a lighted electric torch was drawn through a spare bore. The torch clearly showed the curvature of the track, which was such that the torch could no longer be seen at a distance of about 35 yd. By sighting on the torch at 30 yd and extending the line of sight up to the manhole entrance it was possible to establish above ground the line of bore of the length affected. This check indicated that the operations could safely continue, and piling was completed in seven days, working 24 hours a day.

The examination of the bores in the light given by the torch also showed that no damage appeared to have been done by the original subsidence. It is thought possible that the track had acted as a concrete beam and prevented subsidence worse than that which occurred.

A.T.M.

UNUSUAL RIVER CROSSING AT LANCASTER

During planning for additional Carlisle–Lancaster and Barrow–Lancaster MU cables it was found that the traditional Skerton Bridge route over the River Lune at Lancaster was no longer practical, due to congestion. It was then decided to cross the river down-stream from the bridge by placing the cables under the bed of the river, which is tidal at this point. The position chosen for the crossing is thought to be that of a Roman ford and has easy access on both the north and south banks of the river.

It was obvious that specialized contractors would have to be employed on this rather unusual project. The work of excavation and pipe-laying was entrusted to Harbour & General Works, Ltd., London, who have depots at Morecambe and Heysham. The jointing of the pipes below the water-level formed a separate contract which was given to a specialist diving firm, Under Water Demolition & Construction, Ltd., London.

Protracted wayleave negotiations revealed that the work had to be completed before the end of March to avoid interference with the run of migratory fish.

Work began from a slipway on the southern bank of the river and the method used was as follows:

(*i*) Trial holes were made in the paved slipway to determine the most suitable line into the river. The selection of this line was critical because the slipway passes under one arch of a 100-year-old main-line railway bridge, for which no reliable information regarding the extent of its foundations was available.

(*ii*) A trench was excavated to contain two 12 in. pipes with a 12 in. separation which had to conform to a predetermined contour under the river bed.

(*iii*) The pipes, supplied in random lengths of 28–32 ft, were placed in position and jointed using Johnson couplings. The maximum permissible "set" at each coupling was 1·5°. At each joint the coupling was bypassed by a metal bonding strip, secured to studs previously welded to the pipes.

(*iv*) The 12 in. pipes were terminated on each bank of the river, above the high-water mark, in R11-type manholes.

Before the trench could be cut into the river bed from the south bank it was necessary to break through a massive concrete plinth, which formed a strut between the foundations of the railway bridge. Near the same point it was necessary to pass under a 24 in. pumping sewer, which had been laid in the river bed parallel to the concrete strut and at a depth of 4 ft. This operation took two full days to complete.

In the section of the river between low-water marks the trench was cut by means of a dragline excavator, which operated from a causeway provided by the contractor. The causeway, extending to a point near mid-stream, consisted of a combination of 450 tons of imported rubble and suitable material taken from the trench. It was subsequently recovered from the south bank and placed similarly out from the north bank. When the operations were complete all surplus material was taken away as it was a condition of the wayleave that the contour of the river bed should remain unaltered.

Before each length of pipe was lowered into position a steel hawser was passed through it and was connected to a specially-made steel end-cap. When each pipe had been accurately positioned by the diver it was jointed to its predecessor, longitudinal movement of the joint being prevented by the tension of the hawser applied by a power winch on the south bank. Final adjustment of the trench bed was made with a high-pressure water-hose operated by the diver, who also placed 25 half-hundredweight bags of concrete around each joint for protection and prevention of lateral movement. Communication between the diver and the operators lowering the pipes and concrete was maintained by telephone.

Normally the River Lune has a fresh-water underflow of 3 knots but excessive storm water can increase this flow to 7 knots. With a 3-knot underflow it was possible for the diver to work standing erect but under storm-water conditions work had to be carried out in a recumbent position.

One difficulty met with at the north-bank end of the crossing was that of access; the only way to the river at this point was under a railway bridge with only 12 ft headroom, making it necessary to dismantle and reassemble the mechanical excavators.

Throughout the whole of the operations the working day was adjusted to obtain favourable tide conditions and this enabled completion to be effected well inside the target date.

It was considered essential to provide complete separation for each cable in the steel pipe allocated for MU cables, and this was accomplished subsequently by drawing in rigid p.v.c. tubes. As an initial provision three pipes were provided; two of these were of 3 in. diameter and one of 4 in. diameter. They were supplied in 20 ft lengths and were laid out and jointed, by solvent welding, in a convenient street leading to the north bank of the river. They were drawn in with a guide rope, which passed through each p.v.c. tube and was fastened to a pushing block at the back end; there was a protective cone at the front end. The 12 in. pipes were filled with water and the p.v.c. tubes slid into place without any difficulty.

The successful completion of this work was due to the excellent co-operation between the contractors and Post Office staff in the Area, in Regional headquarters, and in the Engineering Department.

A.A.K., K.S.J., and G.F.S.

Wales and Border Counties

LIGHTNING DAMAGE AT CARNO

Unusually severe damage occurred at Carno in Montgomeryshire when a complete span of aerial cable disappeared literally in a flash.

At 9.30 p.m. on Sunday 27 May lightning struck a 15 pr., 10 lb/mile polythene-covered aerial cable. The aerial cable and the supporting steel wire disappeared completely from the span and all that was found in nearby hedges and fields were short lengths of polythene sheath and pieces of steel wire whose lengths appeared to correspond with the laps of the lashing wire. Of the copper conductors there was no trace, but the short lengths of steel were all brass plated instead of galvanized, doubtless due to zinc-copper alloying.

The adjoining spans of aerial cable were less severely damaged. Much of the underground portion of the cable on the exchange side, buried direct in the ground, had disappeared and the ground was split open along the line of the cable. In all, some 650 yd of cable were damaged.

A nearby farmhouse, served by the cable, had all its windows and some window frames blown out. The walls and ceilings were cracked. Protection at the house was given correctly by dummy fuses and electrodes, and although little was left of the lead-in, the telephone was undamaged.

Considering the magnitude of the strike very little damage was caused to telephone instruments in the vicinity, and all fuses, heat coils and electrodes at the U.A.X. were normal.

E.T.

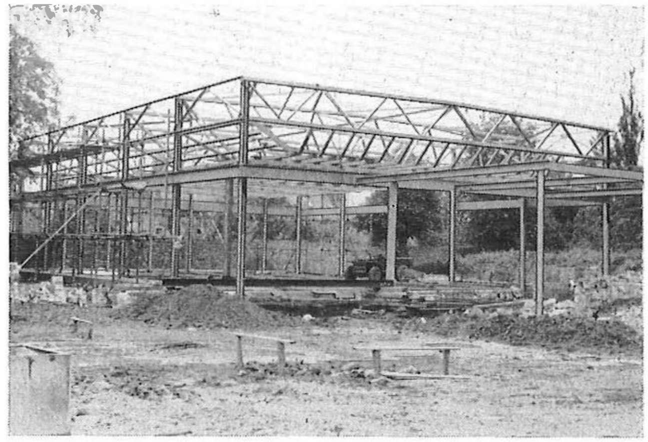
Home Counties Region

K-TYPE BUILDINGS FOR TELEPHONE EXCHANGES

Several prototypes of the recently introduced K-type buildings are being erected in the Home Counties Region.

The first of these prototypes is of the original, or Mark I, design except that the partition between the M.D.F. and apparatus room will be omitted to conform with the later versions of the design. This building is being erected at Leighton Buzzard, and is one of the K1c type with a 5-bay apparatus room. The contract was placed in March 1962 and completion is expected before the end of the year.

The photograph shows a general view taken when the building was about 25 per cent completed. All the framework of the apparatus room had been erected, and part of that for the ancillary accommodation. The special deep



CONSTRUCTION OF A K-TYPE BUILDING AT LEIGHTON BUZZARD

trusses to accommodate the cabling loft spanning the apparatus room, and the longitudinal inverted T-irons on which the loft flooring will rest, can be seen. The bottom members of the trusses and the T-irons are sloped upwards at the apparatus-room sides and at the non-growing end, to allow the ceiling of the apparatus room to be inclined upwards on three sides of the room, thus obtaining the best practicable daylight from the high-level sections of the windows. Hit-and-miss type ventilators will be provided over these windows; this controllable high-level outlet will provide means of dispelling any hot air which might collect at high level in the apparatus room under summer conditions. The heating elements for the under-floor electric heating system will be laid on the floor slab and covered by a $2\frac{1}{2}$ in. screed, which will provide the necessary mass for thermal storage and sufficient depth to protect the elements from rack fixing bolts. Polystyrene edge insulation has already been built into the structure from floor level downwards and horizontally for about 2 ft under the periphery of the slab.

Three prototype Mark II K1-type buildings are to be built at Wickford, Beaconsfield and Berkhamsted. The contracts for these have been placed and completion is expected by mid-1963. They differ from the Mark I version in that the omission of the partition originally intended between the M.D.F. and apparatus room and adjustment of the position of the power and battery-room wall so that it is in line with the columns has enabled the steel framework to be simplified, and has allowed a little more width (21 ft $7\frac{1}{2}$ in. in lieu of 19 ft $1\frac{1}{2}$ in.) to be provided in the combined engine, power and battery room.

Three Mark III K1-type buildings are also to be erected: two will be at Wantage and Pagham; the location of the third has not yet been decided. They will differ from the Mark II version in having roof trusses at 6 ft 4 in. centres in lieu of 12 ft 8 in. This permits wood-wool slabs of standard sizes to be used for the thermal insulation of the roof. A timber joist and plasterboard ceiling will also be used. These changes will result in a saving of steel and a reduction in costs.

South Western Region

SUBAQUEOUS STEEL DUCT ACROSS POOLE HARBOUR

A 6 in. subaqueous steel-duct crossing of about 100 yd long has been laid in Poole Harbour, near the opening road bridge to Hamworthy, to accommodate local cables and to cater for the renewal of a submarine cable damaged by ships' anchors. The use of a pipe was decided upon as it will be less liable to damage than armoured cables.

Underwater work was carried out by two diving teams assisted by Post Office staff. Due to the rapid silting action of the tide, the trench was excavated and the pipe laid in approximately 20 ft sections at a depth of up to 4 ft below the harbour bed. The proximity of the proposed duct to the bridge, and to Post Office and electricity submarine cables, precluded the excavation of the trench by normal dredging or blasting and an "air-lift" method was employed.

The air-lift consists of a light-gauge steel tube some 12–18 ft long and 5 in. in diameter held vertically on the harbour bed and completely submerged. Compressed air, at a rate of 200 ft^3/min, was admitted approximately 1 ft from the lower end and, in expanding up the tube, lifted the harbour-bed material out of the top end, whence it was carried away by the tide. A high-pressure water hose was used to loosen hard material.

The pipe sections were floated into position secured to empty oil drums, one at each end. Air lines were connected separately to each drum and, by a series of stop taps on shore, it was possible to provide or release air to each drum, thus facilitating the lowering and positioning of the pipes. Joints were made with suitably adapted Johnson couplings.

The main obstacles met were a series of old bridging piles, which were either cut off below trench level or completely removed.

The whole operation including land sections of duct and joint boxes took about 10 weeks to complete. The Area is indebted to the officers of External Plant and Protection Branch, Engineering Department, who designed the scheme and gave technical advice.

E.J.F., J.D.R., and R.J.M.

Northern Ireland

EXPERIMENT IN LAYING LONG LENGTHS OF POLYTHENE CABLE

An external development scheme at Dundonald provided the opportunity to introduce experimental 800-pair and 400-pair polythene cables to Northern Ireland and, at the same time, to gain further experience in the technique of drawing in long lengths. In all, 1,633 yd of 800 pr., 4 lb/mile and 1,430 yd of 400 pr., 6½ lb/mile were provided; the 800-pair cable was in three equal lengths and the 400-pair was in two lengths of 480 and 950 yd. The operation was carried out on a busy main road in a built-up area on the outskirts of Belfast. The problem of guarding and minimizing obstructions at the crossings of side roads had to be taken into account.

Representatives of External Plant and Protection Branch, Engineering Department, attended during the cabling operation, and their advice was sought, particularly with regard to alternative methods of communication between the winch operator and the men on the drum, a distance, in one instance, of nearly 800 yd. Both manual signalling, using two men at intermediate points, and radio communication by walkie-talkie were used for different sections. The radio was not entirely successful but it was thought that with suitable sets and a little practice this method would be the best. The use of an alarm bell or magneto telephone circuit between the two extremities was not practicable because of the road crossings, although in other circumstances this simple method might have been used.

The winch was first set up at a JRC12 joint box with the object of drawing in 576 yd of 800-pair cable in one direction and 534 yd in the other. In neither case, however, was it possible to set up the drum at the extremities because of acute bends in the track. It was decided to position the drums so that a reasonably straight pull was possible over the majority of the section. The remaining short length of cable was taken off the drum and drawn into the "back-end" of the duct.

Care had to be taken to minimize the effect of friction when drawing the cable through joint boxes or manholes where the two sections of duct were not in alignment. A bell-mouth was used on one side, but little could be done at the side where the cable entered the box apart from ensuring that the mouth of the duct was smoothly finished. It is understood that a modification to the cable recovery apparatus is being considered as a possible solution to this problem.

The rest of the operation, the equipment used and the precautions to be taken conformed to standard cabling procedure. The employment of a skilled operator at the winch to ensure a steady and uniform pull was particularly important.

Although 10 men were employed it was thought that with experience a 6-man gang would be sufficient: two men to be employed at the winch, two at the drum, one man watching the head of the cable as it was drawn through intermediate boxes, and the foreman in control. Nevertheless, in spite of the excessive staff used for this operation a cabling performance of 80 per cent was achieved. It was estimated that 1,410 manhours, including ineffective time, were saved on "jointed pairs" alone. It was evident that although this technique would require careful survey and layout it should lead to very considerable labour economies.

The Area staff were impressed by the lightness and durability of the cable and the ease with which it could be managed.

C.E.M.B.

Book Review

"The Amateur Radio Handbook" (3rd edition). Radio Society of Great Britain. 552 pp. Over 750 ill. 34s.

The Radio Society of Great Britain has now produced a third edition of its "Handbook" which represents a substantial improvement of the earlier editions. The book runs to over 500 large pages profusely illustrated with over 750 diagrams and photographs, the whole production being of a very high standard.

The book covers a wide range of amateur activity ranging, as it does, from a simple introductory chapter on fundamentals to full constructional details of sophisticated receivers and transmitters. The theoretical treatment in all cases is simple and down to earth, emphasis being placed more on producing working equipment than on developing a full understanding of the basic theory involved.

The general availability now of v.h.f. and u.h.f. valves and components is reflected in the greatly extended chapters on v.h.f. and u.h.f. receivers, transmitters and aerials. Again, growing congestion in the h.f. bands has raised interest in single-sideband working, which is the subject of an excellent chapter. Semiconductor devices are discussed in a new chapter containing many illustrations of practical circuit designs, although not in the detail devoted to valve operated equipment. The section on interference covers in some detail the now important problems of designing the amateur installation to avoid causing interference to television reception.

A comprehensive chapter on measurements is followed by a short one on operating technique and station layout, which could perhaps be augmented to assist the newcomer to amateur radio.

A few errors are to be expected in a work of this magnitude but none were observed that could affect the sense of the text. The reviewer, however, found rather disconcerting the sporadic appearance in Chapter I of the old terms "resistances," "condensers" and "inductances."

Although this volume is primarily intended for the amateur radio enthusiast, any professional engineer concerned with transmitters or receivers will find it of great interest.

R.A.D.

Associate Section Notes

Bristol Centre

During the month of April the Bristol Centre was re-opened with an address by Mr. C. A. L. Nicholls, of the Senior Section. The annual general meeting followed and officers were duly elected. The membership now totals 120. Interesting visits and lectures have been suggested for the summer and winter program and we hope to comment on these in future issues.

A.E.M.

Bath Centre

The New Year was opened by Mr. M. G. Smith, Staff Tutor in physics at Bristol University, who chose "Radio Astronomy" as his subject for his fourth visit to the Centre. Mr. Smith, a fluent and natural lecturer, treated the subject as a continuation from the previous lectures he has given on astronomical subjects, covering the principles and techniques of radio-frequency measurements in further exploration of the cosmos.

In contrast, the February program was made up of the "Annual Telephone Dance" and an aqua-diving expedition. The annual dance was highly successful in every respect. Pearce Cadwallader provided very popular entertainment with the traditional jazz music made by his "Stompers." The Dance Secretary (Mr. J. Moxham) and his committee deserved all the praise and congratulations received for a job well done.

The initiation of members to free diving, at the Beau Street Baths, was not all plain sailing. However, the divers were closely supervised by members of the local branch of the British Sub-Aqua Club (B.S.A.C.) and anything more serious than a few splutters was averted. The dive was arranged by Cliff Wall, Training Officer of the Bath branch of the B.S.A.C., to whom our thanks are due.

The winners of the table-top rally held in March were: first, Messrs. P. G. Martin and R. K. Wall; second, Messrs. R. Bostock and R. Hutchins; and third, Messrs. R. Metteyear and G. Embledon. The course, which was sub-divided into five sections, tested map reading and navigation against the clock. Whilst the results were being prepared, a film show on motoring subjects was given.

At the annual general meeting, held in April, the following were elected to be officers of the Centre for the following year: *Chairman*: Mr. L. W. F. Vranch; *Vice-Chairman*: Mr. A. F. Arlett; *Treasurer*: Mr. R. P. Bowers; *Librarian*: Mr. R. Darke; *Secretary*: Mr. D. G. Rossiter; *Assistant Secretary*: Mr. W. J. Rossiter; *Dance Secretary*: Mr. M. J. Moxham.

The local fire brigade were visited in May, and the officer of the watch arranged demonstrations of fire drill, rescue methods and equipment. The usual highlight of such a visit, the operation of the 100 ft turntable ladder, was eclipsed by a genuine turnout. The Brigade was away in less than 30 seconds. The callout provided a dramatic and spectacular climax to an excellent visit.

D.G.R.

Cornwall Centre

At the annual general meeting in May the following officers were elected: *President*: Mr. S. T. Stevens; *Chairman*: Mr. R. R. Sweet; *Vice-Chairman*: Mr. C. H. Gardener; *Secretary*: Mr. A. R. Brown; *Assistant Secretary*: Mr. D. L. Curin; *Treasurer*: Mr. D. L. Moore; *Committee*: Messrs. J. Stevens, G. Trelgilgas, H. H. Pearce, K. Tonkin and F. M. Roberts. The Secretary thanked the retiring Chairman, Mr. J. C. Wyatt, and Mr. R. Moore who has served on the committee and has now been promoted to Assistant Engineer.

On 7 June our members again attended the annual Mullard lecture and film show. This was followed by a half-day visit to the Bush radio and television factory at Plymouth. On 29 June we made a visit to the new Trinity House ship *Stella*, which is based at Penzance. The staff demonstrated the ship's apparatus and as the *Stella* is an all-electric ship this proved of great interest to our members.

A.R.B.

Gloucester Centre

The activities of 1961–62 started in June with a visit to the Steel Company of Wales at Margam. Visits were also made to G.E.C. (Telecommunications) Ltd., Coventry, in July, Swindon Railway Works in September, and Vauxhall Car Works, Luton, in March. All these visits were well supported and of great interest to members. Our sincere thanks are offered to our many generous hosts.

The following meetings were held during the winter session.

26 October 1961: Mr. R. J. Root of Mobilgas Oil Co., Ltd., gave a talk, "More Miles Per Gallon," illustrated by the film "Mobilgas Economy Run."

29 November 1961: Mr. C. A. May, from the Telephone Electronic Systems Development Branch, Engineering Department, gave "An Introduction to Electronic Telephone Exchanges" that was much appreciated.

18 January 1962: "The Pay-on-Answer Coin-Box" was a particularly topical talk given by Messrs. Smith and Morrissey of the Subscribers' Apparatus and Miscellaneous Services Branch and the Telephone Exchange Systems Development Branch, Engineering Department, respectively, coinciding with the introduction of pay-on-answer coin-boxes at Gloucester.

21 February 1962: Messrs. Smith and Tillett from the local firm of Daystrom presented a very effective demonstration of stereophonic sound reproduction.

22 March 1962: Messrs. Hubbard and Mack from the Telephone Exchange Standards and Maintenance Branch Circuit Laboratory, Engineering Department, gave their talk "Optical Aids to Development and Maintenance," illustrating it with many slides and films of great interest.

17 April 1962: One of our members, Mr. R. H. Stroud, projected two excellent 8 mm films that he had helped to make and produce. These were followed by the annual general meeting.

The following officers and Committee members were elected: *President*: Mr. S. D. Chapman; *Vice-President*: Mr. R. T. Hoare; *Chairman*: Mr. A. K. Franklin; *Secretary*: Mr. J. A. Wallis; *Treasurer*: Mr. G. J. Franklin; *Librarian*: Mr. N. Mountjoy; *Committee*: Messrs. P. D. Smart, R. Harvey, T. D. Jones and R. Moule. The present membership is 136.

J.A.W.

Edinburgh Centre

The first visit of the new session was to the Lyceum Theatre, Edinburgh, where a group of members learned something of stage lighting and general theatre practice.

At the end of June, a large party visited the site of the Forth Road Bridge at South Queensferry. The opportunity to see constructional work of this nature, and on this scale, occurs infrequently and full advantage was taken of the facilities made available by the A.C.D. Bridge Company. This visit received better support than any other organized in recent years.

Work on the winter program is well advanced and we expect to be able to offer visits to a brewery and a motor-vehicle factory in addition to talks on a wide range of subjects.

D.S.H.

Middlesbrough Centre

The annual general meeting of the Middlesbrough Centre was held on 3 April at the new telephone exchange. The following officers were elected: *Chairman*: Mr. D. A. Pratt; *Secretary*: Mr. N. Williams; *Treasurer*: Mr. K. Ashworth; *Librarian*: Mr. M. A. Landers; *Committee*: Messrs. B. Clare and E. E. Sparkles.

It was decided at the meeting that the magazine "Which?" be purchased and added to the library.

N.W.

Sheffield Centre

Our 1962 program opened with the Christmas social. Following a film show and supper, members and their families and friends concluded an enjoyable evening with games and dancing.

On 31 January, following up his lecture about the Jodrell Bank Telescope, Mr. C. M. Kington of Husband & Co. gave a further lecture entitled "Electrical and Electronic Aspects of Radio-Telescope Drives."

During February we visited the works of Messrs. Davy & United Engineering Co. to see the manufacture of heavy machinery.

The Regional Engineer, Mr. A. M. Hunt, took the chair at this year's joint meeting with the Senior Section. The paper, "The Effects on Telephone Cables of the A.C. Electrification of British Railways," by Mr. A. Rosen of British Insulated Callender's Cables, Ltd., was read in his absence by Mr. A. Muir. Guests at the meeting included members of British Railways and the Yorkshire Electricity Board. Following the lecture we were shown an excellent colour film on railway electrification, with a question session to round off the evening.

An interesting film show in April of various documentaries was followed in May by the annual general meeting, at which the following were elected: *Chairman;* Mr. L. G. P. Farmer; *Vice-Chairman*: Mr. F. S. Brasher; *Secretary*: Mr. D. Ashton; *Assistant Secretary*: Mr. B. A. Sargent; *Treasurer*: Mr. C. S. Shepherd; *Librarian*: Mr. G. Woodhouse; *Scribe*: Mr. J. E. Simons; *Committee*: Messrs. G. T. Ridsdale, C. B. Gray, F. Bough, R. B. Lines, J. Poulton, A. Knowles, S. Cottage and J. Tomlinson.

The summer session opened in June with social outings to Doverdale, a local beauty spot, and to Alton Towers.

J.E.S.

Bletchley Centre

The Bletchley Centre, although one of the youngest Centres in the country, having been formed in June of last year, already has a membership of approximately 90.

On 5 April a party of its members started a three-day visit to their colleagues of the Netherlands Postal and Telecommunications Services at The Hague. The party was led by the Associate-Section President, Mr. A. H. C. Knox, the Centre Chairman, Mr. W. J. Allen, and the Assistant Secretary, Mr. E. W. H. Philcox, and was accompanied by the Vice-President of the Centre, Mr. J. H. Facer, and several members of the Senior Section who came from all over the Home Counties Region.

The party set off from Harwich on a wet, windy night aboard the *Duke of York* arriving at the Hook of Holland at approximately 6.0 a.m. on Friday. They then proceeded by coach to the Park Hotel in The Hague where they were met at 9.0 a.m. by Mr. J. Kuin of the Netherlands P.T.T. Services, who was guide, interpreter and father to us all during our stay. From this time until midday on Saturday we were conducted around numerous exchanges, repeater stations, sorting offices and administration buildings in The Hague and Rotterdam. We even visited the International Trunk Exchange in Rotterdam where some of the party made calls to their homes in England.

The highlight of the visit was at Friday midday, when the Director-in-Chief of the Netherlands P.T.T., Mr. R. Diks, entertained us to lunch at his Headquarters and it was then that a commemorative scroll from the Centre was presented to him by Mr. Knox.

Another outstanding feature of the visit took place on Friday evening, when a letter of greetings from the people of Bletchley to the citizens of The Hague was presented to the Burgomaster at the Town Hall.

After entertaining some of our Dutch friends to lunch on Saturday, the rest of the day was spent independently shopping and sightseeing.

We returned to England on Sunday with a lot of happy memories and the knowledge that we had made many new friends in Holland. Before the party went home, Mr. R. V. Sanders, the Regional Liaison Officer, proposed a vote of thanks to the organizers of the trip and expressed the satisfaction of all who had participated. For the archives of the Centre we have a number of photographs, some colour film and a tape recording.

In June, a number of Netherlands P.T.T. engineers visited England. Two of them visited Bedford Telephone Area and we entertained them socially one evening. They were able to tour Bedford Area with Mr. S. L. Freeman, who was a member of our party which had visited Holland. They were also conducted round the Home Counties Region Training Centre at Bletchley, where a number of our members work.

Our winter program ended in April, with a very interesting illustrated talk by Messrs. H. E. Robinson, Ash and Baker on "The Laying of TAT-1 cable across Newfoundland." Machines used for jointing and samples of many cables were displayed. The talk was ended by Mr. Ash showing members a colour film of New Zealand, taken during a visit there.

The first annual general meeting of the Centre was held at the Swan Hotel, Fenny Stratford, in June. The officers and committee for 1962–63 are: *Chairman*: Mr. W. J. Allen; *Secretary*: Mr. A. J. Hudson; *Assistant Secretary*: Mr. E. W. H. Philcox; *Treasurer*: Mr. D. Castle; *Committee*: Messrs. R. E. Gooden, F. R. McLellan, P. B. King, J. Vickers, M. Walduck, R. H. Stanesby and C. Tooth; *Auditors*: Messrs. E. E. Whall and F. H. Daniels. The meeting was supported by the showing of the films "The 8th Tulip Rally" and "They Chose the Sea."

The 1962–63 winter program started with a talk on 3 September on "Fire Prevention in Industry" by a member of the Buckinghamshire Fire Service, and was followed, on 8 October by a lecture on "Gas Pressurization of Cables" by Messrs. R. A. M. Light and H. B. Cooper.

The remainder of the winter program for 1962–63 is as follows:

27 October: Visit to London Airport.

3 December: "The Work of the B.B.C. Sound Effects Department," by Mr. H. B. Hadden of the B.B.C. Central Program Operations Department.

21 January: "S.T.D. Development," by Mr. E. J. T. Hitchin of the Home Counties Region.

4 March: "A.C. Electrification of the Crewe to Euston Line," by Mr. E. G. Evans of the British Railways Midland Region.

22 April: "The Growth of Telecommunications in the Bedford Area," by Messrs. J. H. Facer, Coles and W. D. Brown.

June: The second annual general meeting. Date not yet fixed.

The committee wish to express its appreciation to Mr. A. F. J. Lee, the Principal of the Regional Training School, for the use of the school premises for meetings, and to Mr. J. Missen and Mr. F. Munday for the help given in the cinema. In addition we wish to place on record our pleasure at the results of the 1961–62 Institution Essay Competition in which two of our members won a Certificate of Merit, Mr. P. Morrison and Mr. D. W. J. Smith.

The support received is very encouraging to the officers and committee.

A.J.H. and E.W.H.P.

Chichester Centre

The new session opened in October with a film show by courtesy of I.C.I. In November a combined meeting with the Senior Section was held at Portsmouth Central Exchange when the engineers responsible for the design of the "Electronic Random Number Indicating Equipment" (ERNIE) demonstrated its method of working. The December meeting was devoted to members' colour slides and films. The annual general meeting was held in March and was followed by a film show from the B.P. Petroleum Co., Ltd.

It is with regret that we record the sudden death of our Treasurer, Mr. A. T. Yardley, on 27 June at an early age. He had served the section continuously for the last 26 years and rarely missed a meeting. His services will be greatly missed by all his colleagues here in Chichester.

H.S.P., and R.D.B.

Tunbridge Wells Centre

The 1961–62 session began with a visit to the Royal Greenwich Observatory at Herstmonceaux Castle. The weather was perfect and it has been suggested that we arrange more of our visits for the summer months. In September, Mr. E. C. L. Marchant, a sub-editor of the *Daily Mail,* gave a talk entitled "Meet the Press."

The first paper under the general heading of "The Earth and its Secrets" was read by Mr. L. S. Hurst. Under the sub-title of "Older than the Hills," it dealt with the story to be found in the earth's crust from its beginning up to the coming of man. A paper on "Mechanical Aids" was to have been read by Mr. R. Nevitt, but had to be cancelled at short notice; we hope to have it in our next program.

Mr. L. E. J. Price, a keen amateur yachtsman, gave a talk on "Sailing Craft," illustrated by many colour slides and items from his own boat. Mr. L. W. Barratt, Area Engineer, who gave a talk on "The Romance of Oak" two years ago, followed this up with a talk on "Hand Woodworking Tools." Among the tools were some which had been used by local craftsmen and it was interesting to compare these with the flint tools which were on show when Mr. J. Mitchell read the second of the two papers on "The Earth and its Secrets." Sub-titled "The Mark that Man has Left" it continued the story of man's development from a primitive creature to a being who could make fire and fashion flint into knives and axes.

Mr. C. Smith gave an interesting talk on "Clocks—Ancient and Modern," and showed several from his own collection.

Two other visits were made, one to the National Maritime Museum at Greenwich and the other to the A.T.V. Studios at Elstree and the Television Switching Centre.

The annual quiz contest took place at Hastings this year. Tunbridge Wells made a fine start but Hastings rallied later and finished up the victors, a trick they learned in 1066, no doubt! Mr. A. H. C. Knox, President of the Associate Section, presented an Institution Certificate to Mr. M. B. Hatch for his paper on "Cathodic Protection" and to Mr. R. W. Winn for his paper on "Electrical Design & Installation in Large Buildings." A Certificate of Merit was also presented to Mr. L. S. Hurst for an essay entitled "The Secondary Cell—A Centenarian."

It is a paradox that in spite of the high standard of many of the papers read and the variety of subjects chosen, the attendance at the meetings was disappointing. There are still many who have the wrong idea about our aims and while they are quite prepared to discuss almost any topic in the lineman's room are afraid to come to a meeting. Some of the best papers are not necessarily the most technical ones and among our members, who now number over 150, there must be much hidden talent. L.S.H.

Exeter Centre

An associate section has been re-formed in the Exeter Telephone Area, under the Presidency of Mr. S. D. Chapman, Area Engineer, and it is envisaged that with a membership of 130 we shall be able to carry out a full program of visits and lectures during the coming year.

F.R.S.

London Centre

London Centre was without a General Secretary for over a year, following the resignation of Mr. D. W. Webber after his promotion. In addition to his duties as Chairman, Mr. A. Welling acted as General Secretary until the annual general meeting in May, when Mr. A. J. Dow was elected to fill the post.

The 1961–62 session ended with a very interesting talk given by Mr. J. A. Lawrence, of the Telephone Electronic Exchange Systems Development Branch, Engineering Department. He described, with the aid of slides, the outlines on which the principles of electronic exchange systems are developing. The lecture was very well attended by members of both the Senior and Associate Section, and the many questions which followed were expertly answered by Mr. Lawrence.

Prior to the lecture, it was announced that the President of the Associate Section Mr. A. H. C. Knox, was finishing his term of office, and would be succeeded by Mr. A. J. Leckenby, M.B.E. Mr. Welling thanked Mr. Knox, on behalf of the Associate Section, for his past services, presented him with a neck square in Associate Section colours, and asked him to accept Honorary Membership.

The annual general meeting followed the May meeting. The officers of the London Centre Central Committee were re-elected as follows: *Chairman*: Mr. A. G. Welling; *Vice-Chairman*: Mr. H. A. Horwood; *Treasurer*: Mr. W. C. Peck ; *Editor, "London Centre Review"*: Mr. E. S. Glynn ; *Assistant Secretary*: Mr. W. H. Upton; *Visits Secretary*: Mr. B. C. Hatch; *Librarian*: Mr. G. S. Milne. The post of Radio Secretary has become redundant, owing to the dissolution of the radio group under the central organization. Area radio groups will, however, continue to exist under the guidance of local committees. Mr. F. C. G. Greening remains as the London Centre Liaison Officer.

The C. W. Brown Award for the 1961–62 session was awarded to Mr. R. A. Hammond of the South-West Area for his enthusiasm and loyalty to the membership in helping to keep alive the objects of the Associate Section. Congratulations to Mr. E. R. Harrington of the Cable Test Section for his entry in the Essay Competition, "Inspection of the Lightweight Submarine Telephone Cable," for which the Council of the Institution of Post Office Electrical Engineers awarded him a prize of £3 3s. and an Institution Certificate.

The lecture program for the 1962–63 session commenced on 11 September with "The Story of London Airport", by Mr. Housego, the Public Relations Officer, who gave a non-technical talk on the growth of London Airport and the development of airline services. The talk was illustrated with slides and film, and was given before an audience of members and friends in the Assembly Hall at Fleet Building.

After many years, we have at last said farewell to Waterloo Bridge House, as it has been decided to hold all future meetings at Fleet Building.

The London Centre journal received a "new look" and a name during last session, when it became the "London Centre Review". The first issue contained articles on the transatlantic cablefilm system used by the B.B.C. and the Post Office distribution network of television links in the United Kingdom. The current issue contains articles on Post Office finance, the background story of the Faraday Lecture, and other features of general interest. Our journal is circulated, free of charge, to Centre members, and is also distributed to many other interested parties, including honorary members in many parts of the country.

E.S.G.

Staff Changes

Promotions

Deputy Chief Regional Engineer to Chief Regional Engineer

Name	Region, etc.	Date
Knox, A. H. C.	H.C. Reg.	1.8.62

Area Engineer to Regional Engineer

Name	Region, etc.	Date
Glover, R. P.	S.W. Reg. to W.B.C.	9.4.62

Senior Executive Engineer to Assistant Staff Engineer

Name	Region, etc.	Date
Whyte, J. S.	E.-in-C.O.	18.5.62

Executive Engineer to Area Engineer

Name	Region, etc.	Date
Davis, S.	L.T. Reg.	19.4.62
Speechley, E.	N.E. Reg.	4.6.62

Executive Engineer to Senior Executive Engineer

Name	Region, etc.	Date
Smith, H. G.	E.-in-C.O.	26.4.62
Adams, R. H.	L.T. Reg. to E.-in-C.O.	26.4.62
Nunn, R. G. W.	L.T. Reg. to E.-in-C.O.	26.4.62
Elkins, N. A.	E.-in-C.O.	14.5.62
Sayers, C. F.	E.-in-C.O.	30.5.62
Bolton, L. J.	E.-in-C.O.	30.5.62

Executive Engineer (Limited Competition)

Name	Region, etc.	Date
Cheeseman, D. S.	E.-in-C.O.	30.4.62
Keen, D. S.	E.-in-C.O.	30.4.62
Barnes, P. R.	E.-in-C.O.	30.4.62
Button, R. W.	E.-in-C.O.	30.4.62
Cook, F. W.	E.-in-C.O. to L.T. Reg.	30.4.62
Eason, D. J.	W.B.C.	30.4.62
Gibson, M. E.	E.-in-C.O.	30.4.62
Glazbrook, J. W.	E.-in-C.O.	30.4.62
Hart, M.	E.-in-C.O.	30.4.62
Larder, D. A.	E.-in-C.O.	30.4.62
Long, M. G.	E.-in-C.O.	30.4.62
Williams, H.	W.B.C. to E.T.E.	30.4.62
Ferguson, A	Scot.	30.4.62
Askew, E. A.	E.-in-C.O.	30.4.62
Billcliff, D.	E.-in-C.O.	30.4.62
Boys, H. C.	L.T. Reg.	30.4.62
Chapman, R. K.	H.C. Reg.	30.4.62
Daines, K. N.	E.-in-C.O. to E.T.E.	30.4.62
Dobson, E. D.	E.-in-C.O.	30.4.62
Gilham, M. P.	L.T. Reg. to E.-in-C.O.	30.4.62
Long, R. C.	E.-in-C.O.	30.4.62
Burton, D. A.	E.-in-C.O.	30.4.62
Easterbrook, J. M.	E.-in-C.O. to E.T.E.	30.4.62
McLeod, A	Scot.	30.4.62
Tippler, J.	E.-inC.O.	30.4.62

Assistant Engineer to Executive Engineer

Name	Region, etc.	Date
Weedon, A. F.	E.-in-C.O.	9.4.62
Russell, P. S.	E.-in-C.O.	9.4.62
Sanders, R. V.	H.C. Reg.	16.2.62
Cripps, S. R.	H.C. Reg.	19.4.62
Ness, A.	Mid. Reg. to N.I.	14.5.62
Lee, C. F. G.	H.C. Reg. to L.T. Reg.	28.5.62
Sale, K. W.	N.W. Reg.	27.4.62
Draper, W. H.	L.T. Reg.	4.5.62
Stewart, D. H.	Scot.	11.5.62
Wilson, G. M.	Scot.	9.5.62
Gosby, J. T.	E.-in-C.O.	1.6.62

Inspector to Assistant Engineer

Name	Region, etc.	Date
Garrett, E. G. H.	H.C. Reg	2.6.61
Payne, F. J.	H.C. Reg.	4.9.61
Lawrence, W. S.	L.T. Reg.	26.3.62
Giles, R. O.	S.W. Reg.	10.4.62
Taylor, F. W.	S.W. Reg.	6.4.62
Darnley, S.C.T.	S.W. Reg.	10.4.62
Vardigans, A. G.	S.W. Reg.	3.5.62
Divall, R. H.	H.C. Reg.	12.6.62
O'Hanlon, P. J.	L.T. Reg.	22.5.62
Betton, F. W.	L.T. Reg.	31.5.62

Technical Officer to Assistant Engineer

Name	Region, etc.	Date
Woodgate, J. E.	H.C. Reg.	2.6.61
Addie, J. R.	H.C. Reg.	2.6.61
Bone, D. W.	H.C. Reg.	2.6.61
Ramsay, K. T.	N.E. Reg.	9.4.62

Technical Officer to Assistant Engineer—continued

Name	Region, etc.	Date
Nash, J. A.	H.C. Reg.	18.4.62
Armstrong, A.	N.E. Reg.	30.4.62
Clark, B. J.	Mid. Reg.	5.4.62
Clayton, E. G.	H.C. Reg.	18.4.62
Godfrey, W. H. J.	H.C. Reg.	2.4.62
Beck, N. D.	N.I.	14.3.62
Simms, W.	N.I.	14.3.62
Lawrence, W.	N.I.	14.3.62
McIlfatrick, D. A.	N.I.	14.3.62
Wolpers, R. E.	E.T.E.	2.4.62
Schofield, S.	N.W. Reg.	25.4.62
Murray, C. F.	N.W. Reg.	25.4.62
Baxter, J.	Scot.	13.3.62
Warner, J. F.	E.-in-C.O.	8.5.62
Grieg, G.	Scot.	16.4.62
Braddock, J. S.	W.B.C.	7.5.62
Williams, C. P.	H.C. Reg.	3.5.62
McQuiggin, W.	N.E. Reg.	22.5.62
Missen, R. F. J.	Mid. Reg.	14.5.62
Eungblut, A. S.	N.E. Reg.	4.5.62
Revell, G. A.	H.C. Reg.	3.5.62
Stanbury, D. J.	W.B.C.	15.5.62
Ellis, H. J. D.	Mid. Reg.	28.5.62
Gilbert, A. J.	N.W. Reg.	29.5.62
Worthington, J.	N.W. Reg.	29.5.62
Barron, G.	N.W. Reg.	29.5.62
Ridgway, H.	N.W. Reg.	1.6.62
Lancaster, E.	N.E. Reg.	19.6.62
Mirfin, T.	N.E. Reg.	1.6.62
Sams, K. P.	E.-in-C.O.	8.6.62
Donaldson, S. W. T.	Scot. to E.-in-C.O.	8.6.62
McCulloch, I. D.	L.T. Reg. to E.-in-C.O.	8.6.62
Robertson, H. V.	L.T. Reg. to E.-in-C.O.	8.6.62
Tucker, G. F.	L.T. Reg. to E.-in-C.O.	8.6.62
Portway, A. E.	N.E. Reg. to E.-in-C.O.	8.6.62
Alexander, H. J.	L.T. Reg. to E.-in-C.O.	8.6.62
Waggott, J. T.	N.E. Reg. to E.-in-C.O.	8.6.62
Langham, P. C.	L.T. Reg. to E.-in-C.O.	8.6.62
Smith, A. W.	L.T. Reg. to E.-in-C.O.	8.6.62
Pyrah, J. D.	L.T. Reg. to E.-in-C.O.	8.6.62
Bradbury, H. W.	L.T. Reg. to E.-in-C.O.	8 6.62
Bright, R. D.	L.T. Reg. to E.-in-C.O.	8.6.62
Stephenson, J.	E.-in-C.O.	8.6.62
Garard, K. J.	L.T. Reg. to E.-in-C.O.	8.6.62
Roberts, D. W.	L.T. Reg. to E.-in-C.O.	8.6.62
Briggs, B. E. R.	L.T. Reg. to E.-in-C.O.	8.6.62
Holness, J. A.	L.T. Reg. to E.-in-C.O.	8.6.62
Jones, J. R.	W.B.C. to E.-in-C.O.	8.6.62
Read, R. J.	L.T. Reg. to E.-in-C.O.	8.6.62
Trumper, D. A.	L.T. Reg. to E.-in-C.O.	8.6.62
Wallis, G. J.	E.-in-C.O.	8.6.62
Marlow, D.	E.-in-C.O.	8.6.62
Walker, A. F.	N.E. Reg. to E.-in-C.O.	8.6.62
Foulkes, M. J.	E.-in-C.O.	8.6.62
Phillpot, M. J.	E.-in-C.O.	8.6.62
Bowden, R. J.	E.T.E. to E.-in-C.O.	8.6.62
Penrose, R. J.	S.W. Reg. to E.-in-C.O.	8.6.62
Walton, L.	N.W. Reg. to E.-in-C.O.	8.6.62
Riley, J. W.	L.T. Reg. to E.-in-C.O.	8.6.62
Duckett, S. N.	L.T. Reg. to E.-in-C.O.	25.6.62
Walker, R.	N.E. Reg. to E.-in-C.O.	8.6.62
Lawson, J. S. R.	Scot. to E.-in-C.O.	8.6.62
Munday, W. F.	E.-in-C.O.	8.6.62
Cameron, J. M. M.	Scot.	21.5.62
Andrews, H. A.	Mid. Reg.	4.6.62
Smith, S. J.	Mid. Reg.	18.6.62
Silvester, W. G.	L.T. Reg.	22.5.62
Carter, A. A.	L.T. Reg.	22.5.62
Wells, J. H.	L.T. Reg.	31.5.62
Wooldridge, H. S.	L.T. Reg.	29.5.62
Webb, C. F.	L.T. Reg.	29.5.62
Ward, R. G.	L.T. Reg.	22.5.62
Andrews, P. A. F.	L.T. Reg.	22.5.62
Watts, W. J.	E.-in-C.O.	6.6.62

Technical Officer to Assistant Engineer—continued

Name	Region, etc.	Date
Milburn, H.	N.E. Reg.	19.6.62
Hart, D. G.	E.T.E.	31.5.62
Chappell, P. J.	S.W. Reg.	18.6.62
Hewitt, M. A.	L.T. Reg. to E.-in-C.O.	13.6.62
Harrison, D. J.	L.T. Reg. to E.-in-C.O.	13.6.62
Sanders, O. B.	S.W. Reg. to E.-in-C.O.	13.6.62
Cray, H. E.	L.T. Reg. to E.-in-C.O.	13.6.62
Steel, F. L.	L.T. Reg. to E.-in-C.O.	13.6.62
Parrott, F. T.	L.T. Reg. to E.-in-C.O.	13.6.62
Davies, R. G.	L.T. Reg. to E.-in-C.O.	13.6.62
Watson, F. H. J.	L.T. Reg. to E.-in-C.O.	13.6.62
Wales, P. M.	L.T. Reg. to E.-in-C.O.	13.6.62
Allen, J. G.	Mid. Reg.	21.6.62
Ashton, F. J.	Mid. Reg.	21.6.62
Elson, J. A.	Mid. Reg.	21.6.62
Lockett, R. E.	Mid. Reg.	21.6.62
English, M.	E.T.E.	7.6.62

Technical Officer to Inspector

Name	Region, etc.	Date
Hope, G. T.	H.C. Reg.	6.7.61
Brown, A. D. W.	H.C. Reg.	6.7.61
Gamblin, E. C. G.	S.W. Reg.	31.12.61
Bird, F. R. W.	L.T. Reg.	22.12.61
Phillips, P. D.	W.B.C.	16.3.62
Lane, H. J.	Mid. Reg	19.3.62
Lord, T. E.	Mid. Reg.	1.3.62
Alexander, F. E.	Mid. Reg.	1.3.62
Astley, D. J.	Mid. Reg.	19.3.62
Aston, R. H.	Mid. Reg.	1.3.62
Toombs, H. B.	H.C. Reg.	12.6.62
Baines, F. C. P.	H.C. Reg.	12.6.62
Wicks, R. V.	H.C. Reg.	12.6.62
Taylor, E. G. H.	H.C. Reg.	12.6.62
Middleton, G. A. H.	L.T. Reg.	22.5.62
Powell, A. K.	L.T. Reg.	22.5.62
Harrington, F.	H.C. Reg.	12.6.62

Technician I to Inspector

Name	Region, etc.	Date
Terry, R. A.	H.C. Reg.	2.6.61
Cutter, S. W.	H.C. Reg.	28.7.61
Powley, H. T. A.	H.C. Reg.	28.7.61
Kettlewell, K.	H.C. Reg.	28.7.61
Tomlinson, R. E.	H.C. Reg.	24.8.61
Wyllie, A. J.	H.C. Reg.	4.9.61
Patching, W. J.	H.C. Reg.	20.10.61
Maile, A. A.	H.C. Reg.	21.11.61
Dargo, P.	Scot.	20.11.61
Jordon, J. E.	Mid. Reg.	8.12.61
Gardner, K. H.	Mid. Reg.	8.12.61
Pickett, L. C.	Mid. Reg.	8.12.61
Garner, A. E.	Mid. Reg.	1.1.62
Thompson, D. H. C.	Mid. Reg.	8.12.61
Robinson, F. D.	Mid. Reg.	8.12.61
Newson, D.	Mid. Reg.	8.12.61
Woollerton, T. F. A.	Mid. Reg.	8.12.61
Savage, G. H. R.	Mid. Reg.	1.1.62
Fagg, H. F.	H.C. Reg.	13.12.61
Guest, A. H.	Mid. Reg.	1.2.62
Brolley, J. T. P.	N.I.	28.11.61
Osborne, W. J.	Scot.	29.1.62
Sellers, E. H.	Scot.	29.1.62
Brister, D. A.	Mid. Reg.	17.1.62
Purden, S. T.	W.B.C.	4.1.62
Greening, E. J.	L.T. Reg.	23.1.62
Boardman, F.	S.W. Reg.	25.1.62
Haywood, A. T. G.	S.W. Reg.	25.1.62
Iean, E.	S.W. Reg.	25.1.62
Williams, D. E.	W.B.C.	19.3.62
Turner, B. E.	N.E. Reg.	22.2.62
Hockley, R. L.	H.C. Reg.	20.2.62
Dolling, L.	H.C. Reg.	20.2.62
Ient, A. V.	H.C. Reg.	20.2.62
Judd, H.	H.C. Reg.	20.2.62
Cooke, N. B.	N.W. Reg.	26.2.62
Bambrick, W. J. S.	N.I.	12.2.62
Lamb, K. J. F.	S.W. Reg.	20.3.62
Hannan, V. J.	S.W. Reg.	7.3.62

Technician I to Inspector—continued

Name	Region, etc.	Date
Rea, A. L.	S.W. Reg.	7.3.62
Prout, K. W. R.	S.W. Reg.	7.3.62
Polley, H. C.	H.C. Reg.	2.4.62
Seed, I.	N.E. Reg.	30.4.62
Robinson, G. W.	S.W. Reg.	30.4.62
Austin, A. A.	H.C. Reg.	3.5.62
Wedge, H. E.	S.W. Reg.	21.5.62
Johnstone, W. P.	S.W. Reg.	21.5.62
Hazeldine, J. M.	N.W. Reg.	29.5.62
Gregory, F.	N.W. Reg.	29.5.62
Johnson, W.	N.W. Reg.	29.5.62
Curzon, W.	N.W. Reg.	29.5.62
Parkinson, J. C.	N.W. Reg.	29.5.62
Gore, J.	N.W. Reg.	29.5.62
Rance, W. E.	L.T. Reg.	22.5.62
McLachlan, A. H. R.	L.T. Reg.	22.5.62
Alger, J. A.	L.T. Reg.	22.5.62
Wellington, N. B.	L.T. Reg.	22.5.62
Ward, A. P.	L.T. Reg.	30.5.62
Richardson, R. C.	L.T. Reg.	30.5.62
Gordge, L. J. F.	L.T. Reg.	22.5.62
Miller, R. S. S.	H.C. Reg.	12.6.62
Collis, M. J.	L.T. Reg.	22.5.62
Foster, A. L.	L.T. Reg.	22.5.62
Bailey, E. J.	L.T. Reg.	31.5.62
Manley, E. P.	L.T. Reg.	27.6.62
Eaton, E. G.	L.T. Reg.	31.5.62
Noble, T. G.	L.T. Reg.	22.5.62
Middleton, C. W.	L.T. Reg.	22.5.62
Higgins, K. A. J.	L.T. Reg.	31.5.62
Brooke, R. H.	L.T. Reg.	31.5.62
Taylor, A. G.	L.T. Reg.	29.6.62
Stittle, D. W.	L.T. Reg.	22.5.62
Grant, F.	Mid. Reg.	25.6.62
Mort, L.	N.W. Reg.	26.6.62
Price, P. R.	N.W. Reg.	20.6.62
Read, E. J.	S.W. Reg.	4.6.62
Green, V. J.	S.W. Reg.	4.6.62
Jones, J. P.	S.W. Reg.	25.6.62
Summers, A. J.	S.W. Reg.	18.6.62
Dawson, R.	Mid. Reg.	21.6.62
Murray, W. C.	N.I.	29.5.62

Experimental Officer (Open Competition)

Name	Region, etc.	Date
Botten, B. G.	E.-in-C.O.	8.5.62

Assistant Experimental Officer to Experimental Officer

Name	Region, etc.	Date
Parker, A. E.	E.-in-C.O.	17.5.62
Wilson, S. J. (Mrs.)	E.-in-C.O.	17.5.62
Eustace, J. G. G.	E.-in-C.O.	18.5.62
Rohrer, B. R.	E.-in-C.O.	18.5.62
Murrell, D. L.	E.-in-C.O.	18.5.62

Assistant Experimental Officer (Open Competition)

Name	Region, etc.	Date
McAndrew, J.	E.-in-C.O.	2.4.62
Hetzel, D. L.	E.-in-C.O.	1.3.62
Blyth, W.	E.-in-C.O.	13.4.62
White, B. A.	E.-in-C.O.	17.5.62
Gilchrist, M. W. J.	E.-in-C.O.	16.5.62
Young, M. (Miss)	E.-in-C.O.	12.6.62
Johnson, C. B. C.	E.-in-C.O.	21.6.62

Assistant (Scientific) (Open Competition)

Name	Region, etc.	Date
Bray, K. M. (Miss)	E.-in-C.O.	19.4.62
Cunningham, P. W. H.	E.-in-C.O.	9.5.62
Kirton, V. I. (Miss)	E.-in-C.O.	5.5.62
Stone, D. J.	E.-in-C.O.	18.6.62

Assistant Regional Motor Transport Officer to Motor Transport Officer II

Name	Region, etc.	Date
Mundye, E. O.	London Reg. to E.-in-C.O.	9.4.62

Technical Assistant I to Assistant Regional Motor Transport Officer

Name	Region, etc.	Date
Fossey, G. H.	H.C. Reg. to London Reg.	20.6.62
Potts, A.	E.-in-C.O. to N.W. Reg.	20.6.62
Carruthers, W.	E.-in-C.O. to N.W. Reg.	20.6.62

Promotions—*continued*

Name	Region, etc.	Date
Leading Draughtsman to Senior Draughtsman		
Armstrong, W. J.	E.-in-C.O. to L.T. Reg.	16.4.62
Atkinson, H. W.	L.T. Reg.	16.4.62
Read, H. H.	H.C. Reg. to L.T. Reg.	16.4.62
Williams, E. V.	W.B.C. to Mid. Reg.	9.4.62
Thrift, D. H.	E.-in-C.O. to L.P. Reg.	7.5.62
Ashby, J.	H.C. Reg. to Scot.	30.4.62
Craig, G.	H.C. Reg. to L.T. Reg.	18.6.62
Harding, J. F.	E.-in-C.O. to L.P.R.	30.5.62
Draughtsman to Leading Draughtsman		
Fletcher, R. T.	H.C. Reg. to Mid. Reg.	30.4.62
Normington, A.	N.E. Reg. to Mid. Reg.	16.4.62
Rickerby, N.	E.-in-C.O.	27.4.62
Draughtsman to Leading Draughtsman—continued		
Greenslade, R. W. T.	E.-in-C.O.	6.6.62
Lindley, J. R.	H.C. Reg.	20.6.62
Executive Officer to Higher Executive Officer		
Page, W. G.	E.-in-C.O.	7.5.62
Clerical Officer to Executive Officer		
Fountain, P. W.	E.-in-C.O.	5.2.62
Froom, H. C.	E.-in-C.O.	12.2.62
Rawlins, C. G. E.	E.-in-C.O.	5.3.62
Shepherd, F. G.	E.-in-C.O.	5.3.62
Woolliscroft, C.	E.-in-C.O.	14.5.62

Retirements and Resignations

Name	Region, etc.	Date
Chief Regional Engineer		
Hudson, W. E.	H.C. Reg.	31.7.62
Area Engineer		
Allan, F. W.	N.E. Reg.	29.5.62
Executive Engineer		
Dennison, R. T. A.	E.-in-C.O.	10.3.62
Bay, H. A.	H.C. Reg.	18.3.62
Pearce, H. S.	L.T. Reg.	24.3.62
Gale, C. M. S.	L.T. Reg.	31.3.62
Garfath, A. J. A.	H.C. Reg.	18.4.62
Campbell, A. D.	E.-in-C.O.	16.5.62
Kirk, J. H.	N.W. Reg.	30.4.62
Assistant Engineer		
Burton, W.	W.B.C.	13.3.62
Dix, L. F. T.	L.T. Reg.	22.3.62
Ward, T. J.	L.T. Reg.	26.3.62
Curtis, A. V.	N.E. Reg.	16.4.62
Doherty, J. H.	N.W. Reg.	18.4.62
Cragg, H.	Mid. Reg.	19.4.62
Casey, E.S.	L.T. Reg.	20.4.62
Sharp, C. E.	L.T. Reg.	20.4.62
Taylor, T. G.	N.E. Reg.	26.4.62
Hurn, J. M.	H.C. Reg.	30.4.62
Bowler, T. R.	L.T. Reg.	30.4.62
Yates, W. E. C.	E.-in-C.O.	30.4.62
Griffiths, S. L.	L.T. Reg.	30.4.62
West, J. (*Resigned*)	Mid. Reg.	30.4.62
Wadsworth, H. A.	E.T.E.	20.3.62
Smith, J. P.	Scot.	30.4.62
Skelly, J. E.	N.E. Reg.	4.5.62
Martin, H. W. B.	L.T. Reg.	15.5.62
Wheeler, J. L.	H.C. Reg.	18.5.62
Belcher, O. G. T.	E.-in-C.O.	27.5.62
Bliss, H. T.	E.-in-C.O.	31.5.62
Griffiths, F. (*Resigned*)	E.-in-C.O.	20.5.62
Cooper, H.	Mid. Reg.	28.5.62
Pass, S.	N.E. Reg.	1.6.62
Walker, H.	N.W. Reg.	1.6.62
Shaw, E. M.	N.W. Reg.	1.6.62
Morson, A.	N.E. Reg.	1.6.62
Assistant Engineer—continued		
Williams, A. V.	W.B.C.	20.6.62
Dawson, R. (*Resigned*)	E.-in-C.O.	1.6.62
Inspector		
Stocking, W. G.	L.T. Reg.	18.3.62
Gibson, W. D.	Scot.	25.3.62
Nicholson, G.	N.E. Reg.	13.4.62
Filmer, S. H.	L.T. Reg.	30.4.62
Meningen, B. S.	L.T. Reg.	31.5.62
Puttock, A. E. V.	L.T. Reg.	8.6.62
Taylor, C. W.	H.C. Reg.	19.6.62
Williams, E.	N.W. Reg.	20.6.62
Butterworth, S.	N.W. Reg.	20.6.62
Assistant Experimental Officer		
Jeffs, E. D. (*Resigned*)	E.-in-C.O.	1.6.62
Assistant (Scientific)		
Torrance, G. I. (*Resigned*)	E.-in-C.O.	13.4.62
Dod, D. J. (*Resigned*)	E.-in-C.O.	3.5.62
Regional Motor Transport Officer		
Mills, C. F.	W.B.C.	31.6.62
Assistant Regional Motor Transport Officer		
Fraser, A. V. O.	Scot.	31.3.62
Wiles, E. J.	N.W.Reg.	31.3.62
Motor Transport Officer III		
Partington, H.	E.-in-C.O.	10.4.62
Senior Draughtsman		
Downes, F. G.	E.-in-C.O.	17.5.62
Leading Draughtsman		
Williamson, F.	E.-in-C.O.	20.4.62
Turner, C.	E.-in-C.O.	1.5.62
Whiting, H. C.	E.-in-C.O.	11.5.62
Executive Officer		
Peak, H. C. H.	E.-in-C.O.	18.4.62

Transfers

Name	Region, etc.	Date
Assistant Staff Engineer		
Brock, P. R. W.	Joint PO/MOW R. & D.G. to H.C. Reg.	2.4.62
Knight, N. V.	Singapore to Joint PO/ MOW R. & D.G.	1.5.62
Area Engineer		
Stotesbury, K. E.	L.T. Reg. to S.A.D.T.C.	1.5.62
Bidgood, D. F.	Scot. to S.W. Reg.	13.6.62
Senior Executive Engineer		
Gould-Bacon, F.C.	E.-in-C.O. to L.T. Reg.	1.5.62
Welsh, A. W.	E.-in-C.O. to Fiji	29.6.62
Executive Engineer		
Moffatt, J. J.	E.-in-C.O. to L.T.Reg.	14.5.62
Nicolls, A. C.	E.-in-C.O. to Ministry of Aviation	1.5.62
Owen, B. H.	Scot. to N.W. Reg.	1.5.62
Dudman, E. C.	L.T. Reg. to Nigeria	29.3.62

Transfers—*continued*

Name	Region, etc.	Date
Executive Engineer—continued		
Fletcher, J. L...	N.I. to Ministry of Aviation	11.12.61
Goodison, H. ..	Approved Employment to E.-in-C.O.	4.6.62
Assistant Engineer		
Rodcliffe, G. T.	L.T. Reg. to W.B.C.	12.3.62
Kirkwood, T. ..	E.-in-C.O. to Scot.	25.4.62
Graham, A. S.	E.-in-C.O. to Personnel Department	30.4.62
Griffiths, F. ..	Singapore to E.-in-C.O.	1.5.62
Tribe, H. T. ..	E.-in-C.O. to Mid. Reg.	14.5.62
Coaker, E. ..	L.T. Reg to E.-in-C.O.	14.5.62
Stretton, J. A...	E.-in-C.O. to Nigeria	6.6.62

Name	Region, etc.	Date
Assistant Engineer—continued		
Needham, F. ..	E.-in-C.O. to N.W. Reg.	12.6.62
Brown, B. F. ..	E.-in-C.O. to L.T. Reg.	14.6.62
Motor Transport Officer II		
Thomas, A. W.	E.-in-C.O. to W.B.C.	1.4.62
Assistant Regional Motor Transport Officer		
Bell, D. H.	N.E. Reg. to E.-in-C.O.	14.5.62
Williams, C. F. H.	Scot. to Mid. Reg.	10.4.62
Motor Transport Officer III		
Lord, A. C.	E.-in-C.O. to H.C. Reg.	9.4.62

Deaths

Name	Region, etc.	Date
Executive Engineer		
Glover, W. A.	L.P. Reg.	10.4.62
Westlake, C. E.	W.B.C.	15.4.62
Assistant Engineer		
Teenan, J. ..	Scot.	26.1.62
Anderson, L. ..	W.B.C.	10.3.62
Schofield, J. ..	N.W. Reg.	4.4.62
Martin, H. W.	E.T.E.	20.4.62
Harvey, F. D...	Mid. Reg.	1.5.62
Pither, R. T. ..	S.W. Reg.	9.5.62
Kent, J. D. ..	Mid. Reg.	28.5.62

Name	Region, etc.	Date
Assistant Engineer—continued		
Dixon, R. J. ..	E.-in-C.O.	24.6.62
Horne, G. H. ..	E.-in-C.O.	26.6.62
Inspector		
Walker, A. E...	L.T. Reg.	11.6.62
Senior Experimental Officer		
Yemm, H.	E.-in-C.O.	30.6.62
Leading Draughtsman		
Simmons, J. W. A.	Scot.	25.6.62

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101	4049Y	7711	453/LWA/461DA
102	4048	7712	453/LWA/450AA
102C	4049BA	7718	453/LWA/460CA
102CA	4049BB	7719 Mk 2	453/LWA/453BA
103C	4048R	7720	453/LWA/1A
103CA	4048P	7721	453/LWA/464AA
104	4049H	7723	453/LWA/464BA
105	4711C	7724	453/LWA/463AA
106	4049V	7725	453/LWA/462BA
115	4049B	7727	453/LWA/466DA
119	4049C	8001	455/LWA/432CA
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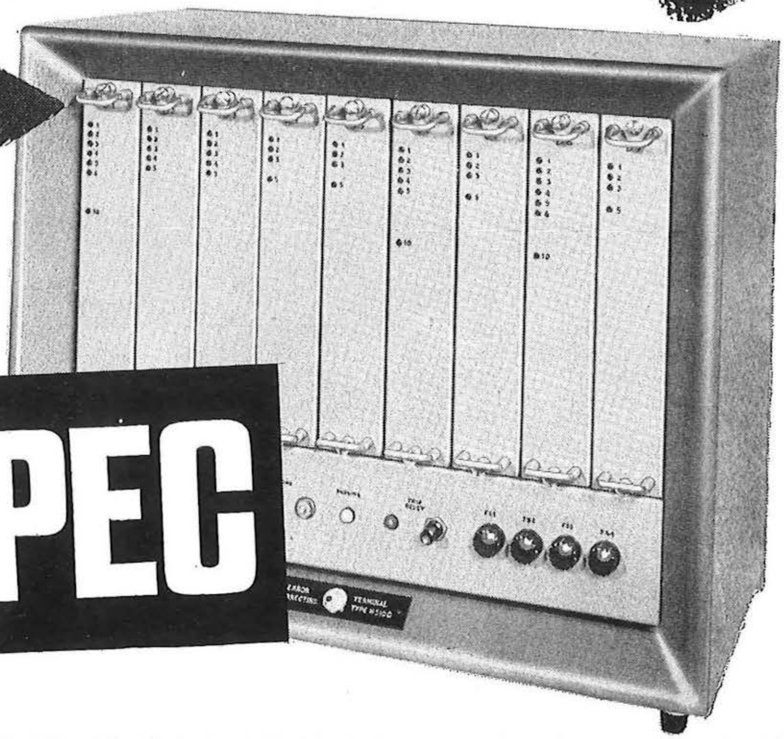

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AUTOMATIC SINGLE PATH ERROR CORRECTION

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- SIMPLE
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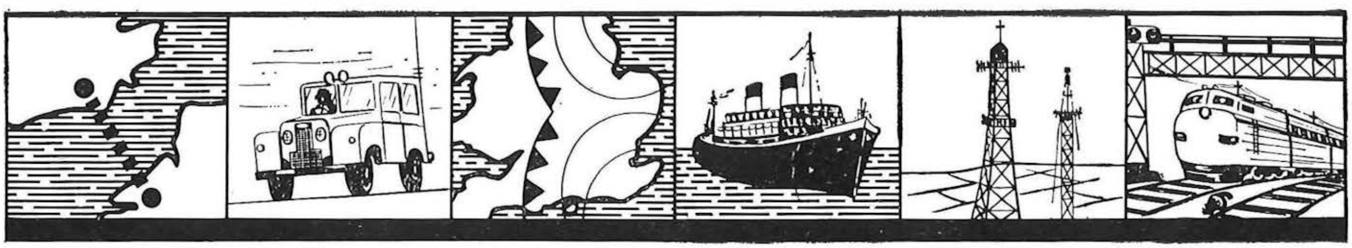
AUTOSPEC provides error proof telegraph working on services where no return path is required or on low capacity point-to-point circuits

AUTOSPEC is the first single path error corrector to include automatic correction without the need for repetition

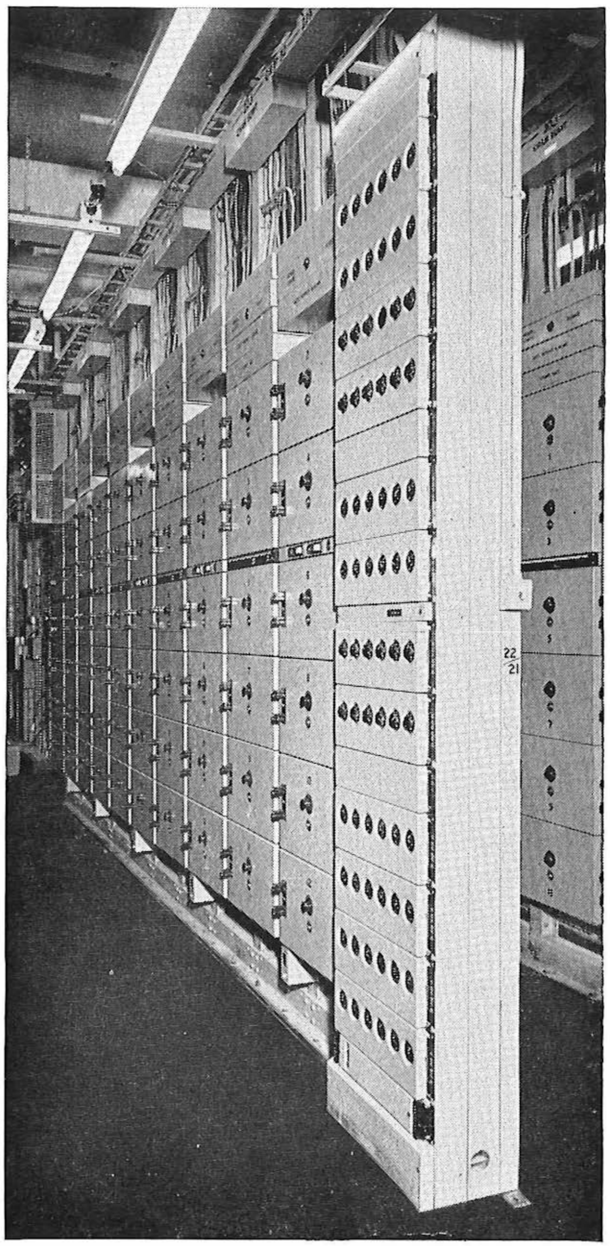
AUTOSPEC is a product of the same design team responsible for the production of the world famous AUTOPLEX



MARCONI'S WIRELESS TELEGRAPH CO. LIMITED · CHELMSFORD · ESSEX · ENGLAND

STC 56-TYPE CHANNEL EQUIPMENT

head of the line



STC transistor channel equipment has been chosen by the British General Post Office (G.P.O.) for use in main-line wide-band telephony systems. Some 13,000 channel ends have already been ordered by the G.P.O.

72 CHANNELS PER RACKSIDE

Each rackside mounts 6 groups of 12 channels designed for use with separate signalling equipment.

ECONOMY OF SPACE AND POWER

The use of transistors and modern components has reduced the size to approximately one third that of previous G.P.O standard channel equipment, and the power consumption to one eighth

STC are also supplying a quantity of transistor group translation equipment.

A single transistor-type channel rackside installed in a G.P.O. station beside a suite of older type STC equipment that provides only 6 channels on each rackside. STC have 30 years experience in the manufacture of channel equipment.

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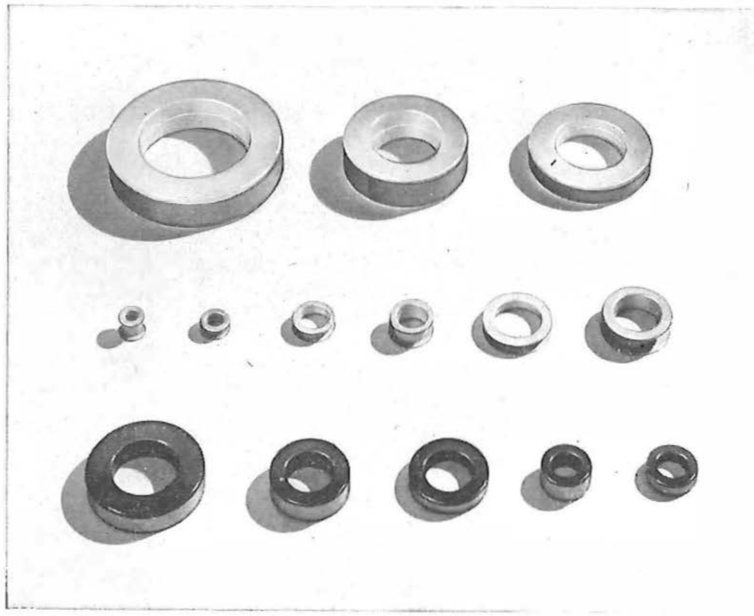

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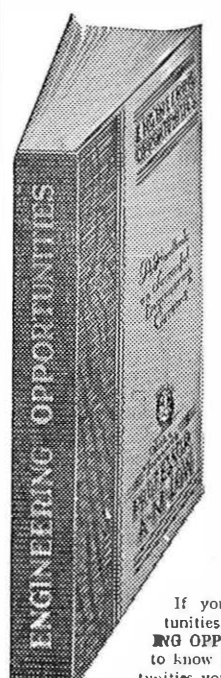

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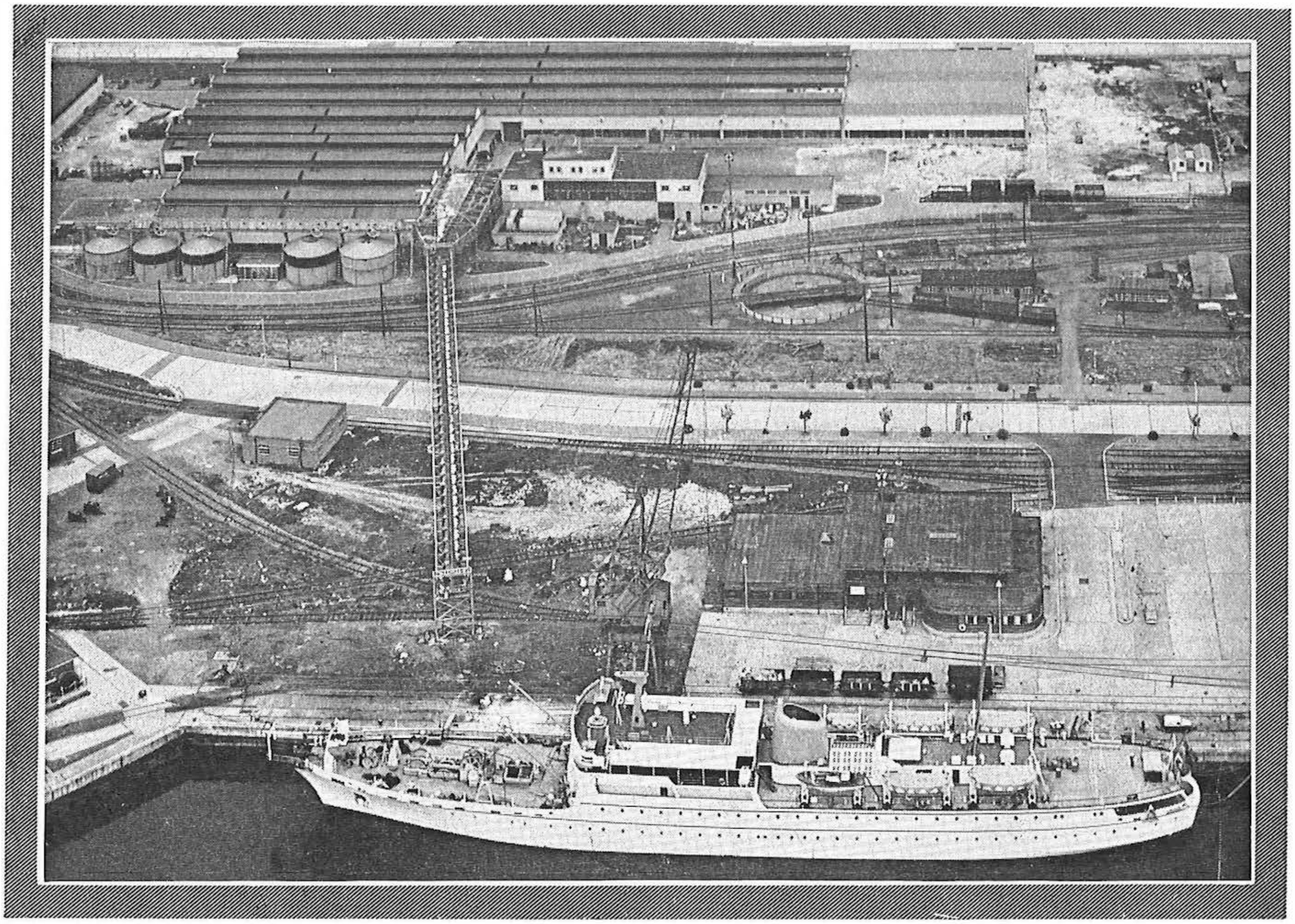

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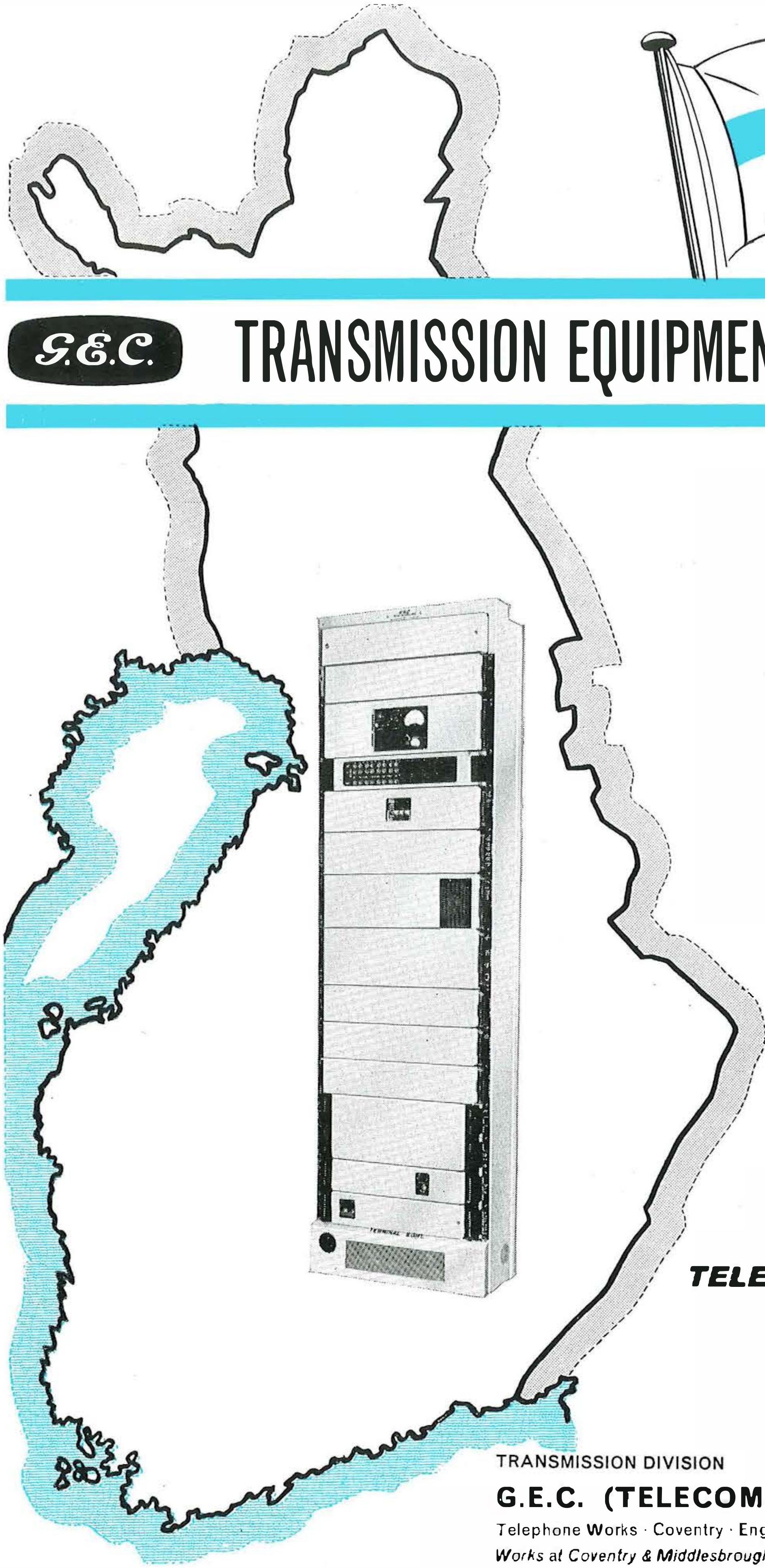

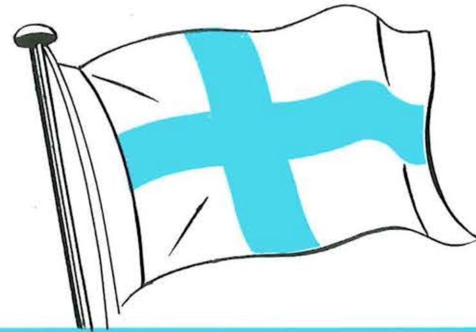

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The General Electric Co. Ltd., has been awarded a contract to supply completely transistored 3-circuit carrier telephone equipment to the Posts and Telegraphs Department, Finland, for operation over open-wire lines. Altogether the contract covers 200 terminals and 50 repeaters.

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Write for STC publications covering telecommunications cables.

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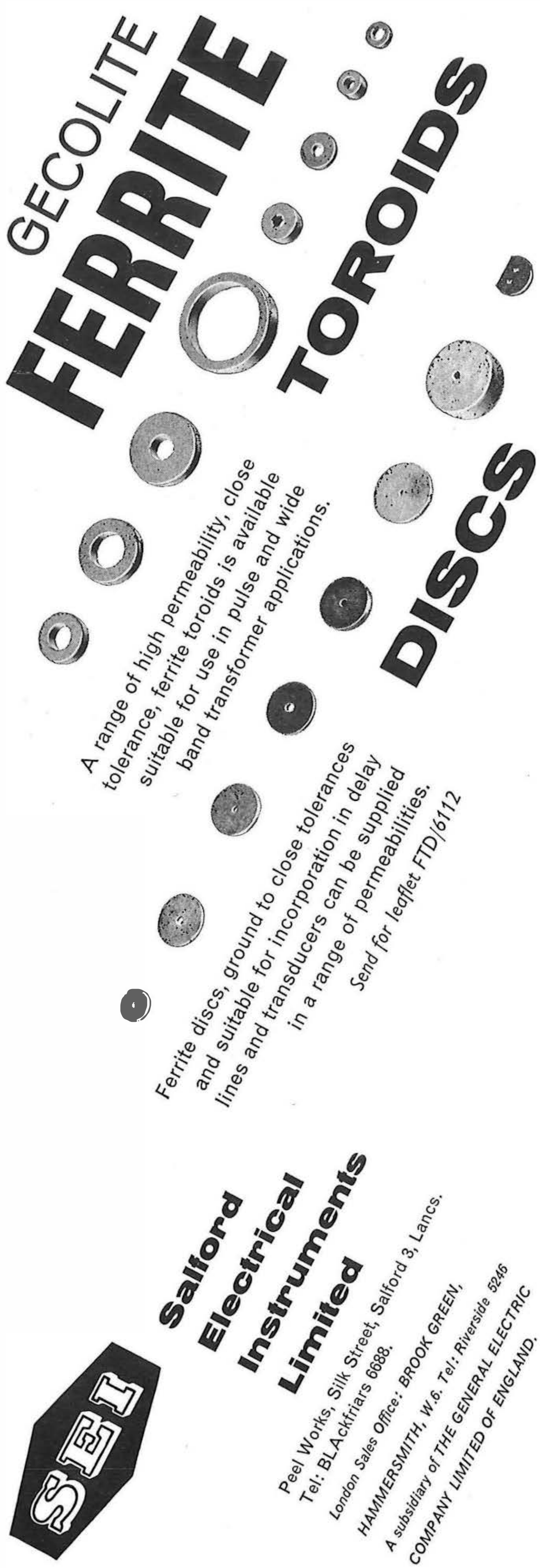

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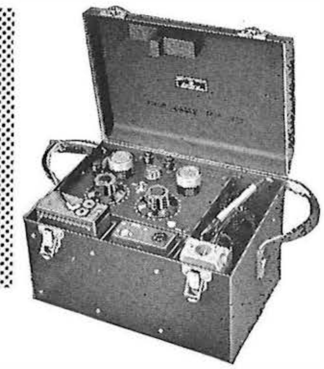
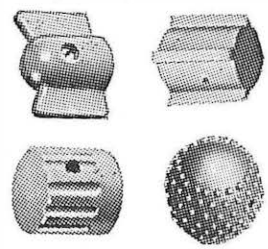


electronic equipment



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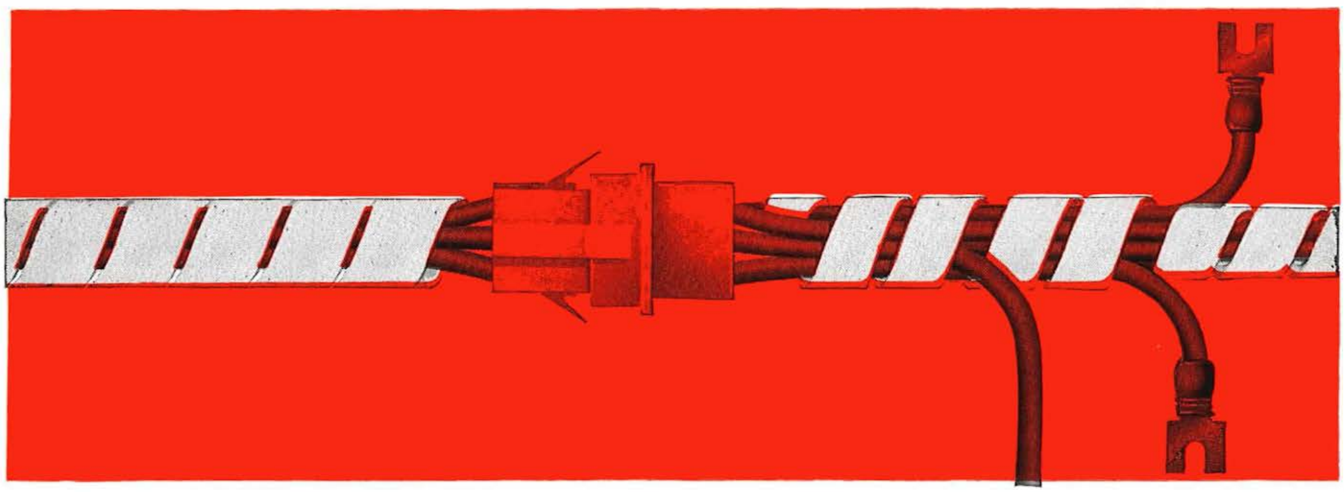

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CANADA

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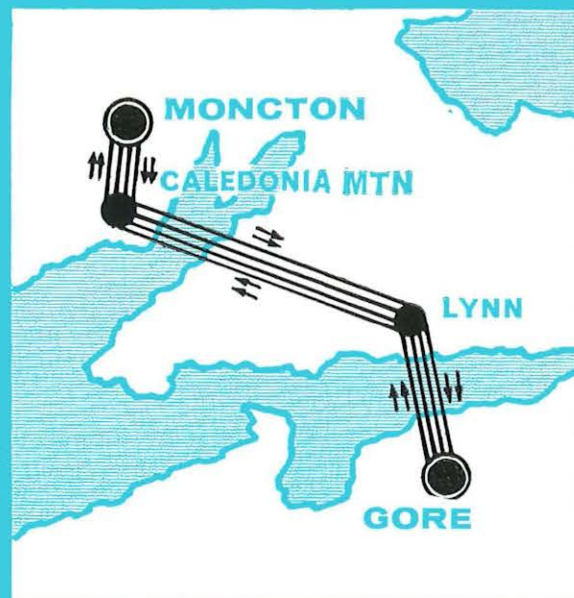
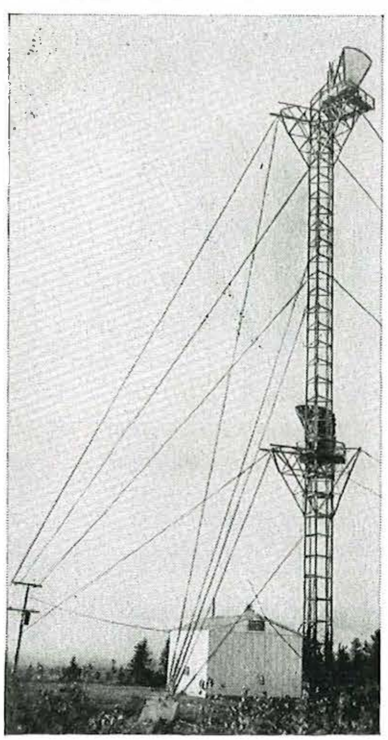


Lynn Repeater Station in Canada



The first two radio relay systems to use G.E.C.'s 6000 Mc/s equipment went into service during August. The first of these is in Canada and provides two bothway radio channels between Moncton in New Brunswick and Gore in Nova Scotia. The link is part of an extensive microwave network being developed by The New Brunswick Telephone Company and the Maritime Telegraph and Telephone Company. The radio and multiplexing equipments were manufactured by The General Electric Co. Ltd., of England and supplied and installed by Canadian General Electric Company.
The other system provides two television channels between Carlisle and Kirk O' Shotts, near Glasgow, and was manufactured and installed by

commissioned an

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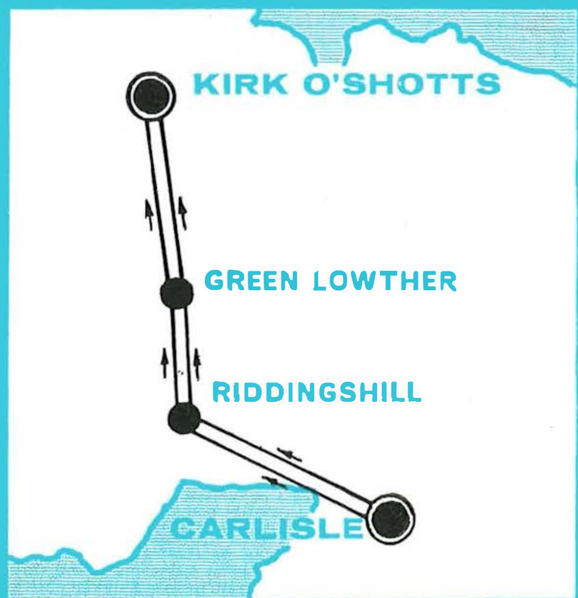
UNITED KINGDOM

D RADIO LINKS

G.E.C.

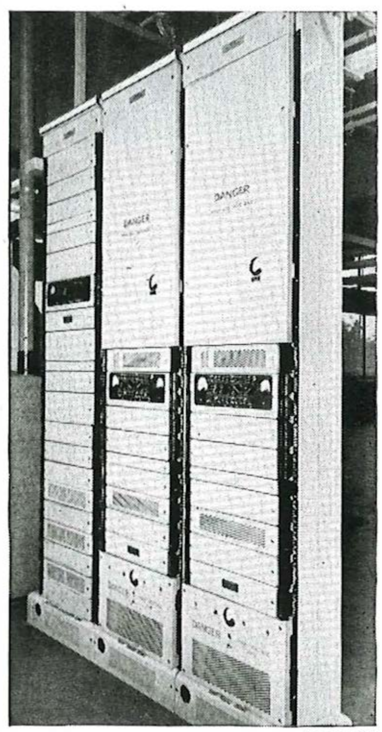


G.E.C. for the British Post Office. Both systems include two intermediate repeater stations.

The equipment in both systems is G.E.C.'s SHF broadband radio equipment which is suitable for both telephony and television applications, conveying either 960 speech circuits or a television circuit on each RF channel. Automatic changeover to a standby channel is effective in the event of failure or undue degradation of the working channels. The equipment conforms to the latest CCIR recommendations.

For further information on the radio and multiplexing equipments, please write for standard specifications, SPO 5555 and SPO 1372.

SHF Equipment at Carlisle Terminal Station



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The almost perfect screening of the television circuits within the cable, and lower transmission losses than corresponding double copper braided cable, have been achieved by producing a co-axial cable insulated with solid or low-loss foam polythene, and having an outer conductor of thin wall welded copper with either a straight or corrugated profile.

The secret behind the success of this new Pirelli General cable is the company's masterly application of continuous welding techniques.

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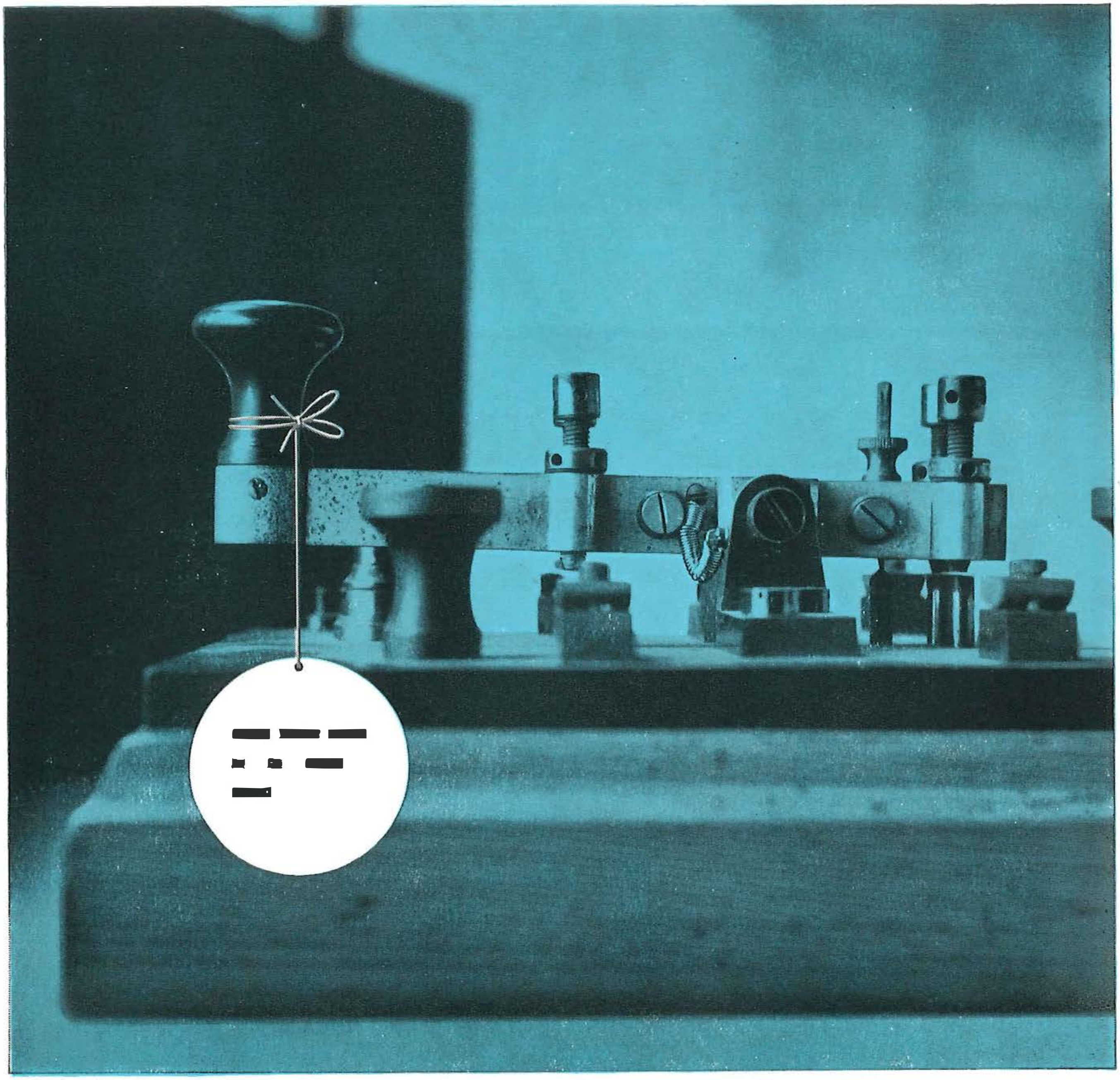


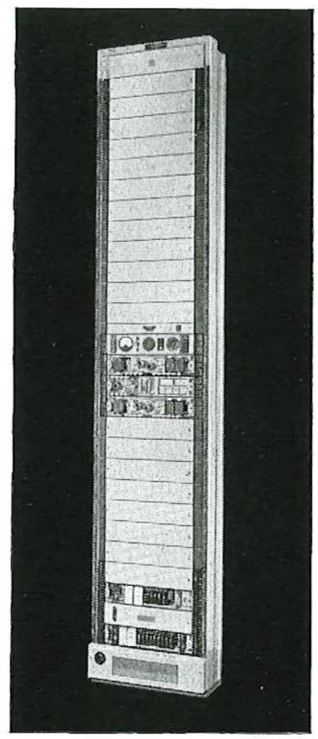
an investigation of SUBMARINE TELEPHONE-CABLE TERMINAL EQUIPMENT

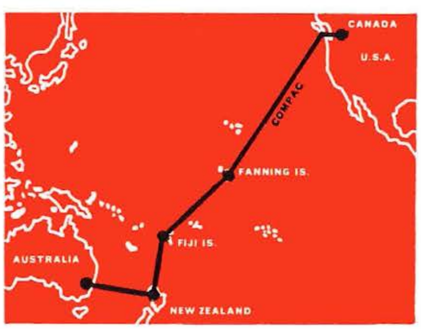
. . . would reveal that Ericsson manufacture a wide variety of audio units which are supplied to the British Post Office, and similar administrations throughout the world, for use as part of the terminal equipment for Trans-Oçeanic Submarine Telephone Cables. These units include:—

COMPANDORS—providing a means of improving the signal to noise ratio of a circuit by compressing the dynamic range of the transmitted signal which is restored at the receive terminal by expansion to its original form.

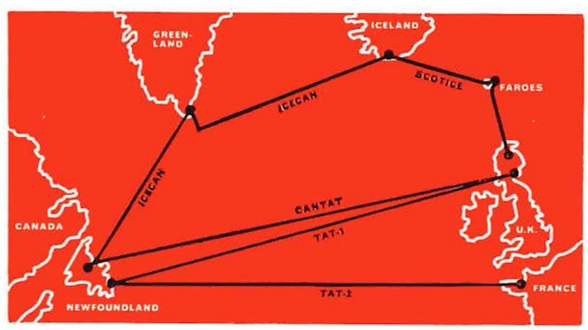
ECHO SUPPRESSORS—(illustrated right)—With the long distances involved in Trans-Oceanic cables, transmission times are such that the use of echo-suppressors is essential.

OMNIBUS SPEECH CIRCUITS—A most important facility offered by these circuits is the linking together of the Oceanic Air Traffic Controllers by a very reliable communications network—so essential with the introduction of high speed jet propelled aircraft.





TRANS-PACIFIC SUBMARINE TELEPHONE CABLES



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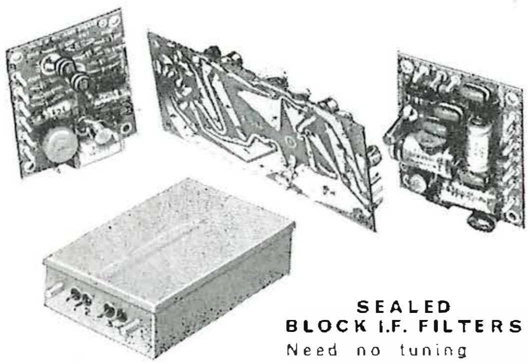

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Meets British, American, Canadian and Continental Specifications

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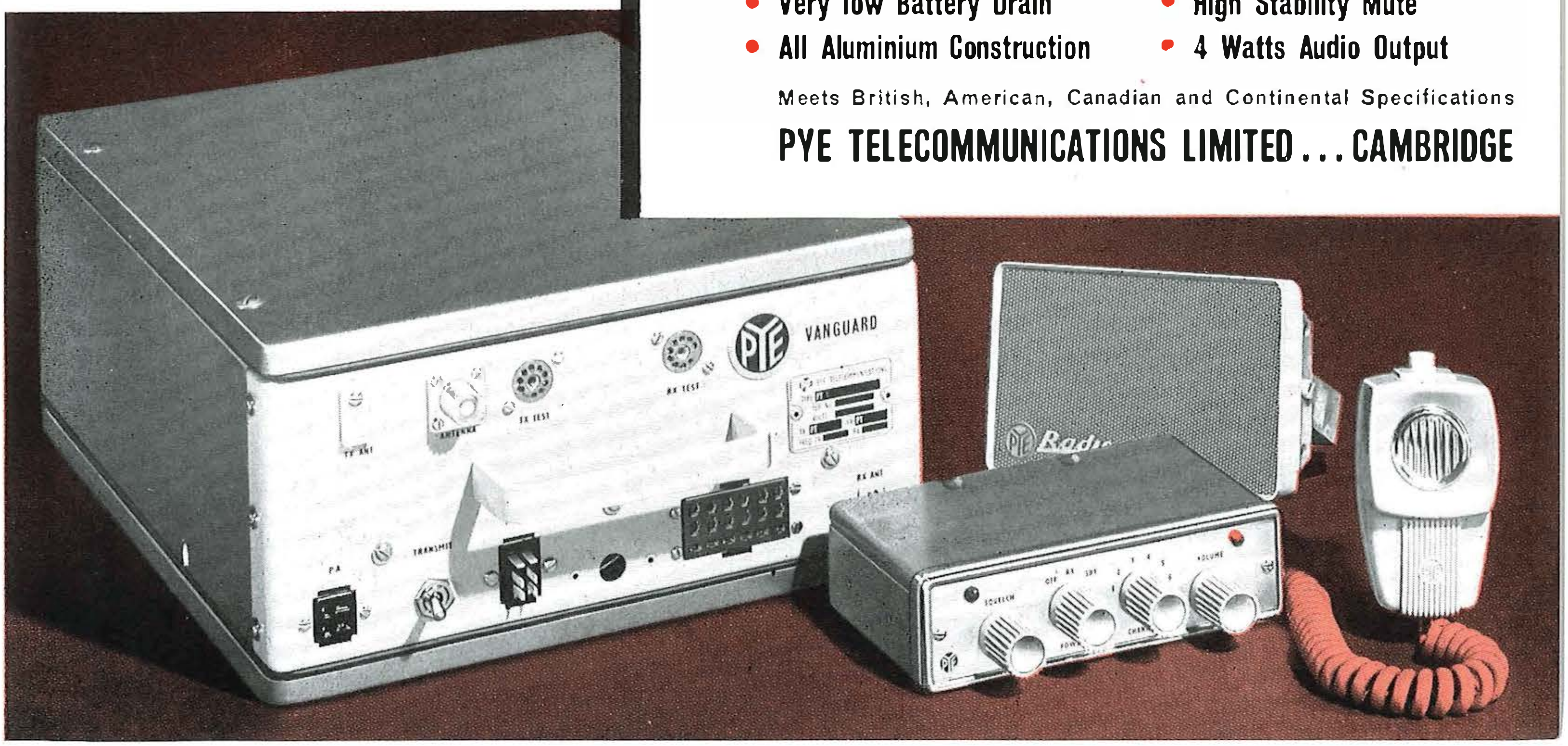
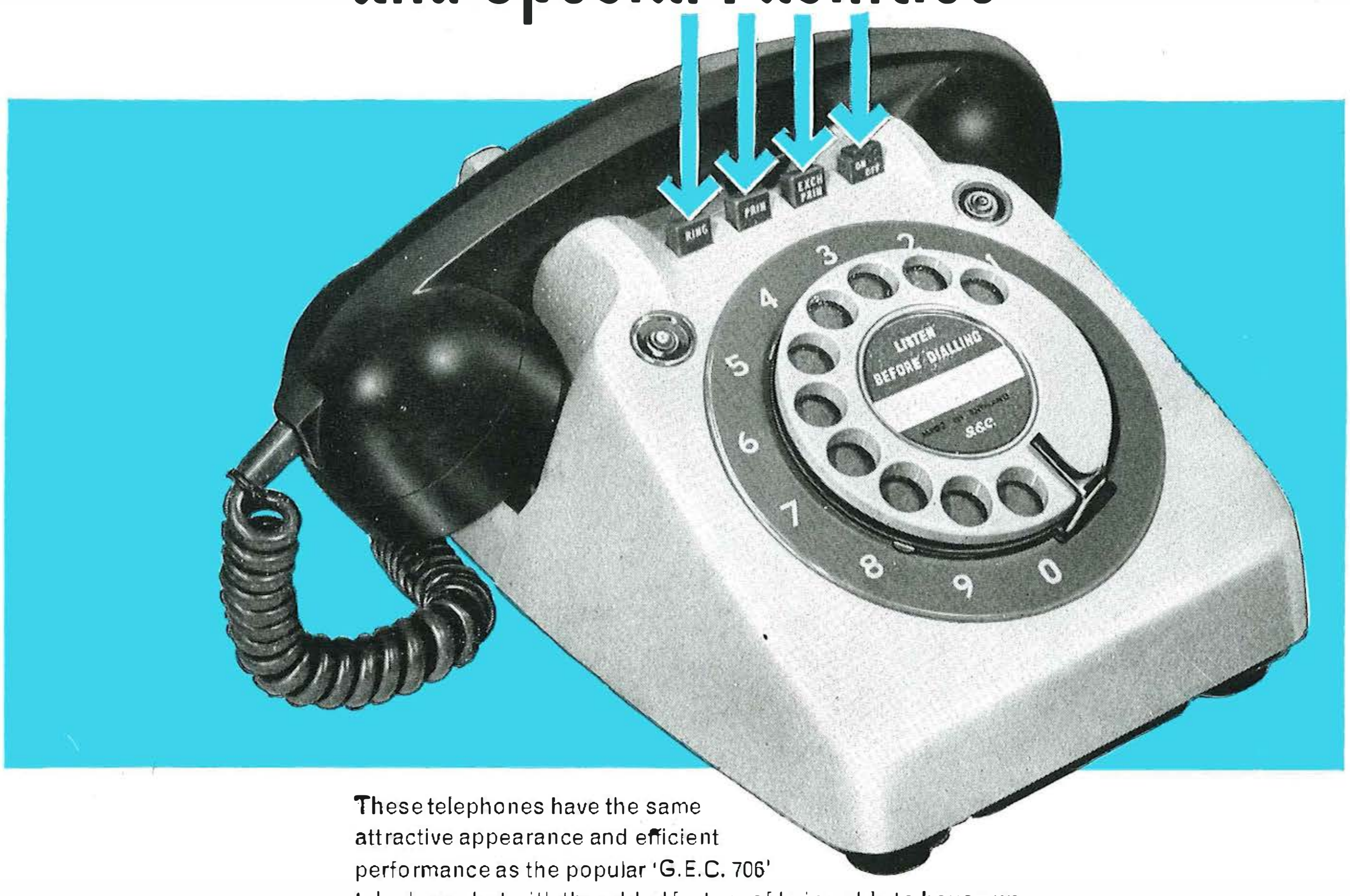


The 'G.E.C. 710' TELEPHONE

for Plan and Extension Systems and Special Facilities



These telephones have the same attractive appearance and efficient performance as the popular 'G.E.C. 706' telephone, but with the added feature of being able to house up to four pushbuttons. These fit neatly into the case in front of the handset and are invaluable when the telephone is to be used in extension systems and when the user requires special facilities, e.g. priority, recall, conference, etc. Two indication lamps are also set into the case of the instrument.

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AEI Sender-Translator equipment was recently cut into service at the Automatic Toll Exchange at Halifax, Nova Scotia. It enables the Motor Uniselector switching unit to play an even more important role in the routing of toll calls in North America by integrating Nova Scotia with the Canadian and American network.

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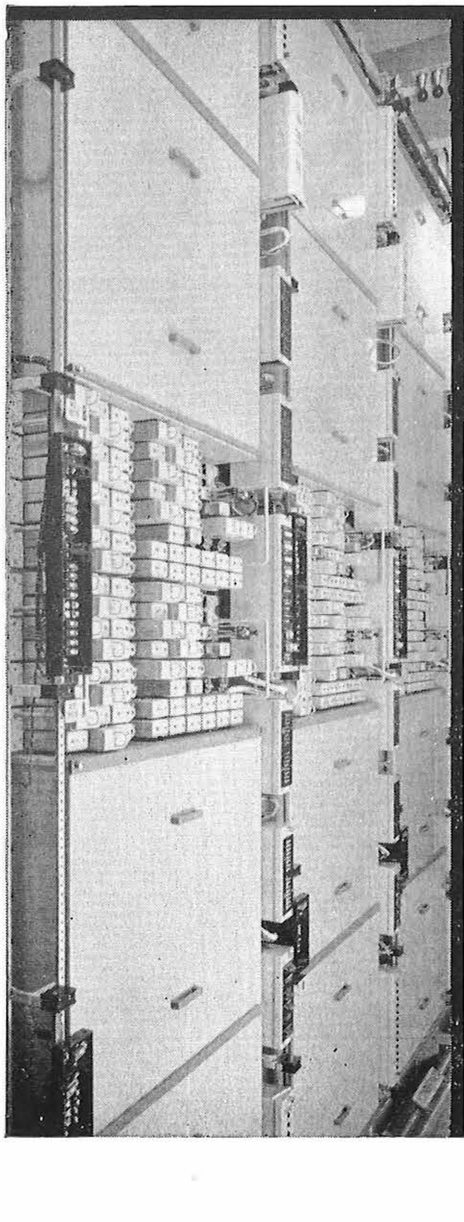
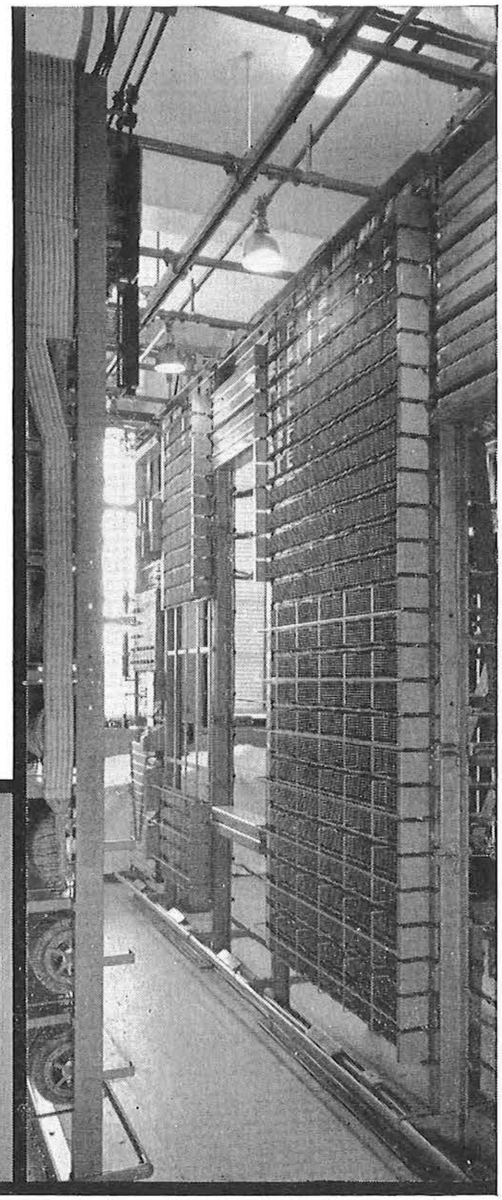
▼ Sender

Translator ▶





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Senderization

Features include:

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The continuous process of research and development which produces such equipment keeps the name of AEI in the forefront of Telecommunications.

AEI

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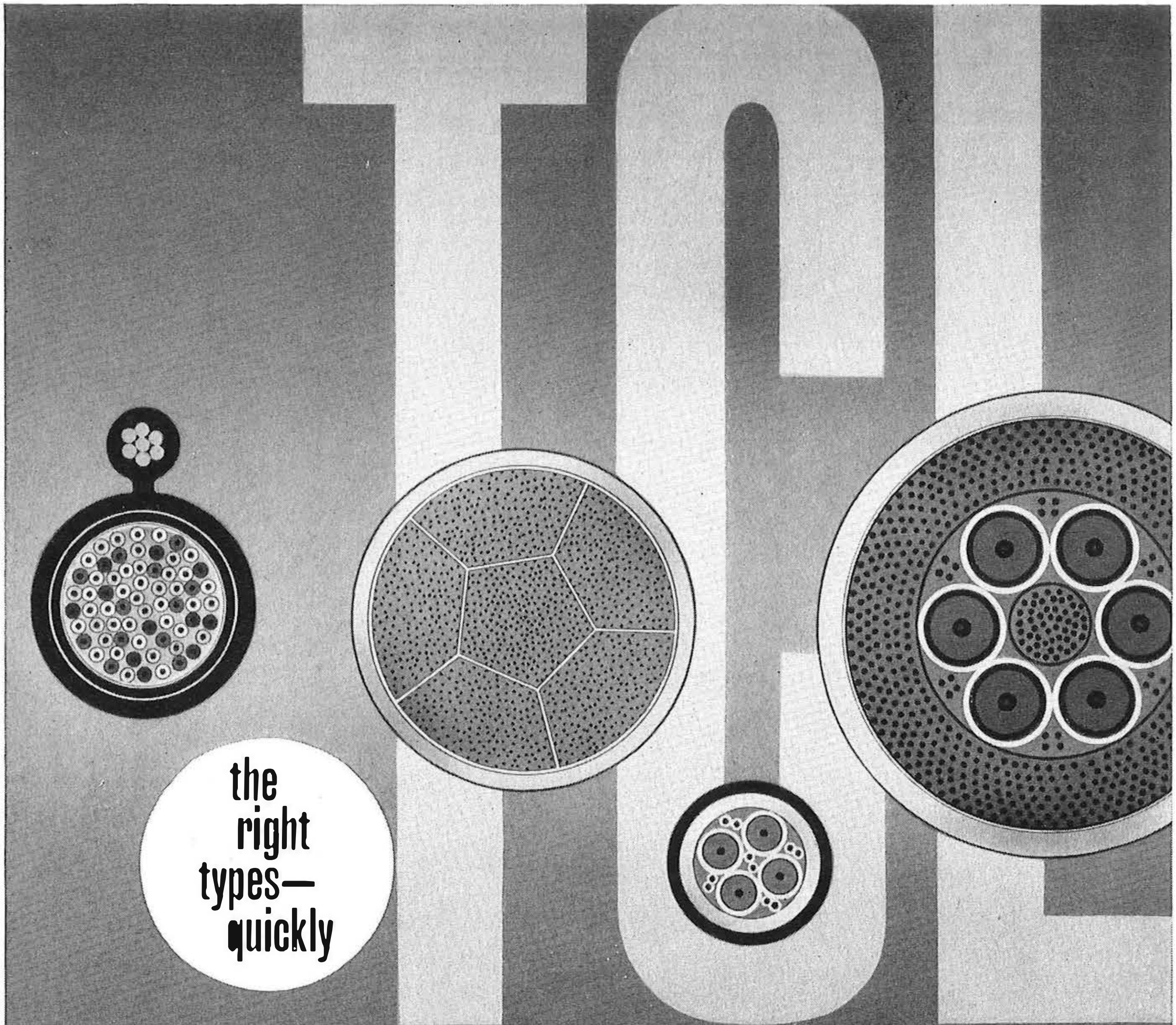

TELEPHONE CABLES LIMITED produce a wide variety of telecommunication cables for country-wide telephone and telegraph systems, sound and television broadcast networks and control systems. TCL are also able to suggest immediately the types of cable that are best suited for any application . . . and supply them quickly. If a cable has to be made for special requirements, the immense manufacturing capacity of TCL ensures early delivery. TCL can design, manufacture and install the complete cable network, and through their associated companies can provide all the most modern equipment for telecommunication projects of any size or capacity.

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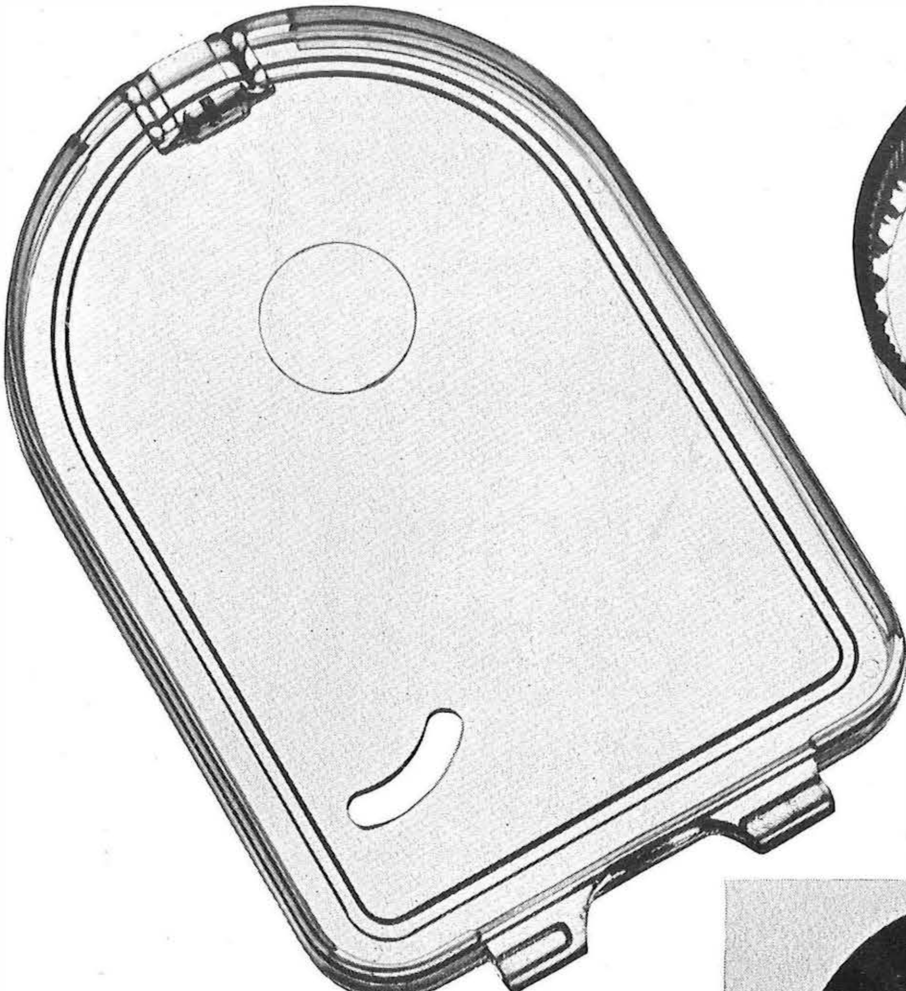
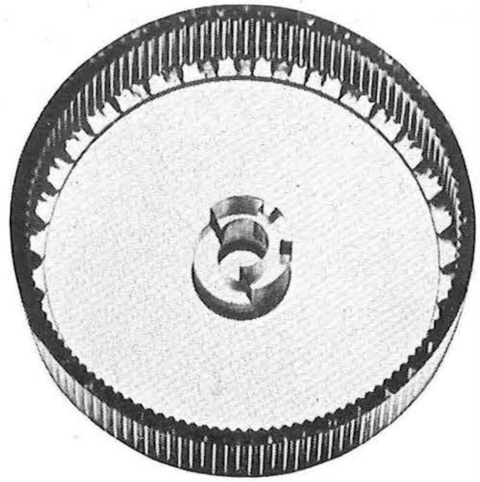
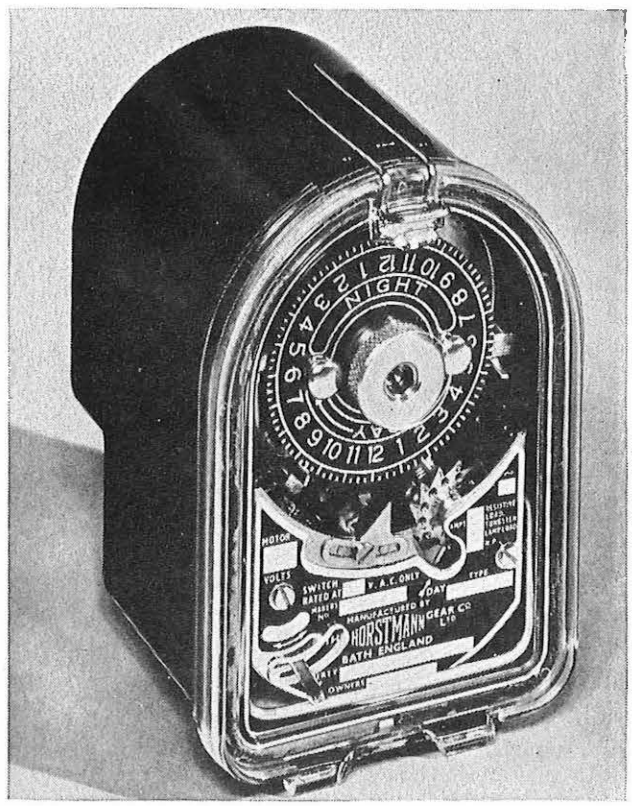




Meter cover and control knob made by Merriott Mouldings Ltd., Merriott, Somerset, from 'Diakon', for the Horstmann Time Switch.

Horstmann Type K Mark II OS Time Switch made by the Horstmann Gear Co. Ltd., Newbridge Works, Bath.



Crystal-clear 'Diakon' protects this time switch

The cover of this Horstmann time switch is moulded from 'Diakon' I.C.I. acrylic polymer. In addition to their excellent transparency, 'Diakon' mouldings have a high heat distortion temperature, and very good dimensional stability over a wide range of temperatures and relative humidities. They also have good non-tracking properties and they will not yellow with age.

Just one more use for 'Diakon'—the I.C.I. acrylic polymer which can be precision-moulded at low cost. Find out more about 'Diakon', and its uses in the electrical industry, from your nearest I.C.I. Sales Office.

'DIAKON' POLYMER

'Diakon' is the registered trade mark for the acrylic polymer manufactured by

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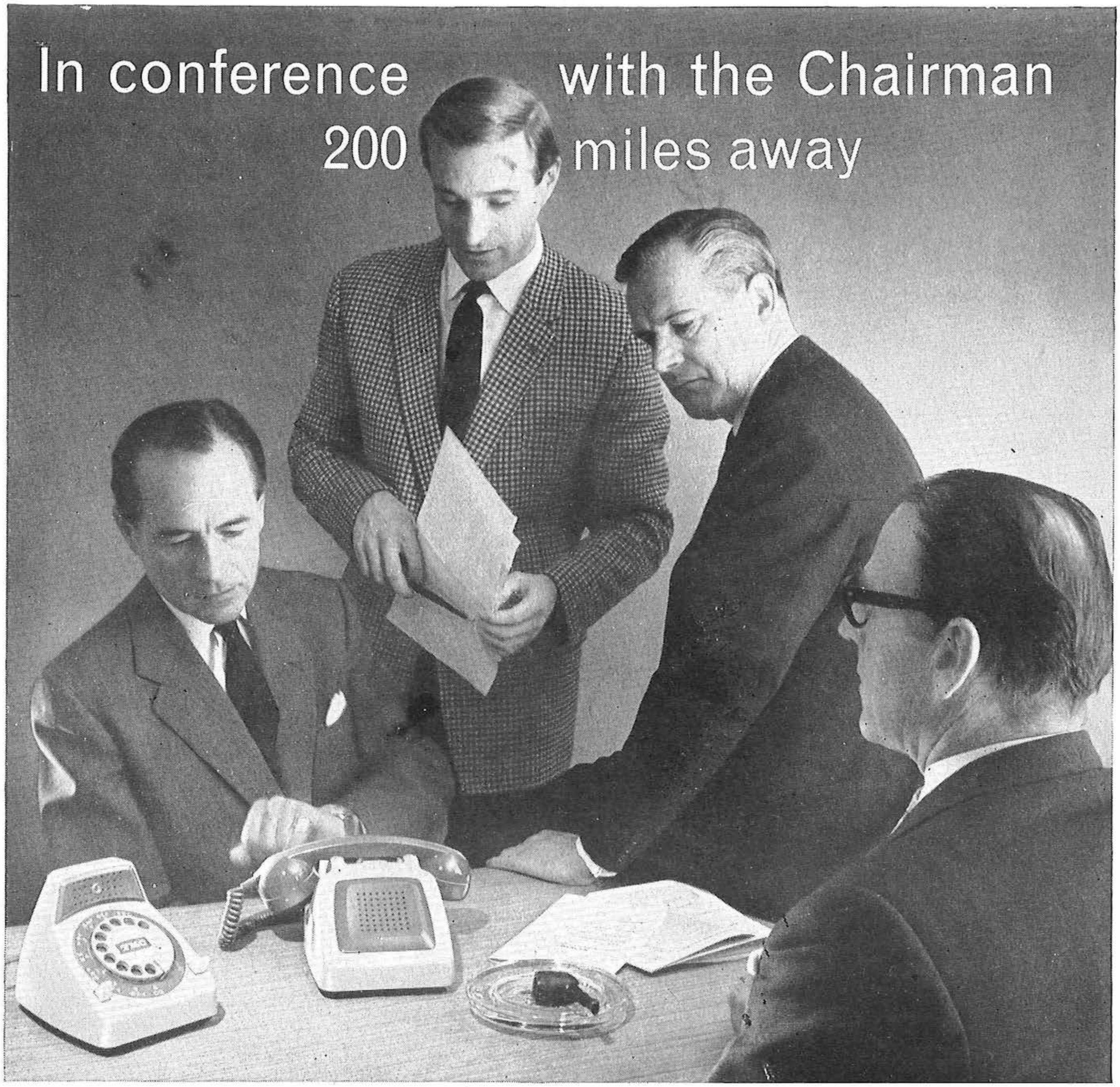

TMC LOUDSPEAKING TELEPHONE

A British Post Office design manufactured by TMC

The TMC Loudspeaking Telephone is proving to be the busy executives' best friend. He can conduct a telephone conversation with both hands free for sorting papers and jotting notes. His colleagues may listen and, indeed, take part in the discussion over the telephone. In fact, important conferences between personnel located in widely separated areas may be held just as simply and conveniently as if they were together in the conference room. When confidential matters arise the user has only to lift the handset to change to a normaltelephone conversation. Apart from the on/off switch the only other control on the TMC Loudspeaking Telephone is the three position volume control. The equipment is extremely simple to operate, and inexpensive to install and maintain. Three instruments comprise the complete installation—the Telephone Unit with built in loudspeaker; the Control Unit, which incorporates microphone, standard dial, on/off switch, volume control and indicator lamp; and the transistorised Amplifier which needs no additional power supply and may be mounted unobtrusively near the desk. Already being purchased in quantity by the British Post Office, the Type 101 is in large scale production offering prompt deliveries. The instruments are made in an attractive two-tone grey combination but other colours can be supplied for large orders. A tropicalised version will shortly become available.

United Kingdom enquiries for connection to Post Office lines should be addressed to the local Telephone Manager.

TMC

TELEPHONE MANUFACTURING COMPANY LIMITED

Telephone Equipment Division, Equipment Section,
Martell Road · West Dulwich · London S.E.21 · Telephone Gipsy Hill 2211

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By courtesy of H.M. Postmaster General.

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From AEI comes the excellent wall version of their Centenary Neophone. Elegantly styled and available in a choice of black or two-tone grey*, this outstanding telephone is made in impact-resisting injection mouldings—strong enough to withstand a long life of rugged treatment. The proved advantages of its desk-version companion, the Centenary Neophone, have all been embodied in this Wall Telephone—the revolutionary lightweight handset; printed wiring for maximum reliability; easy-to-read dial with stainless steel or plastic fingerplate.

The new AEI Wall Telephone, with automatic regulation as an optional feature, will operate on local lines of 1,000 ohms loop resistance, and is provided with a specially designed and simply attached wall bracket.

** Other colours by special contract.*

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AEI

Associated Electrical Industries Ltd

Telecommunications Division

Telephone Apparatus Department

Woolwich, London S.E.18, England

TA7/101

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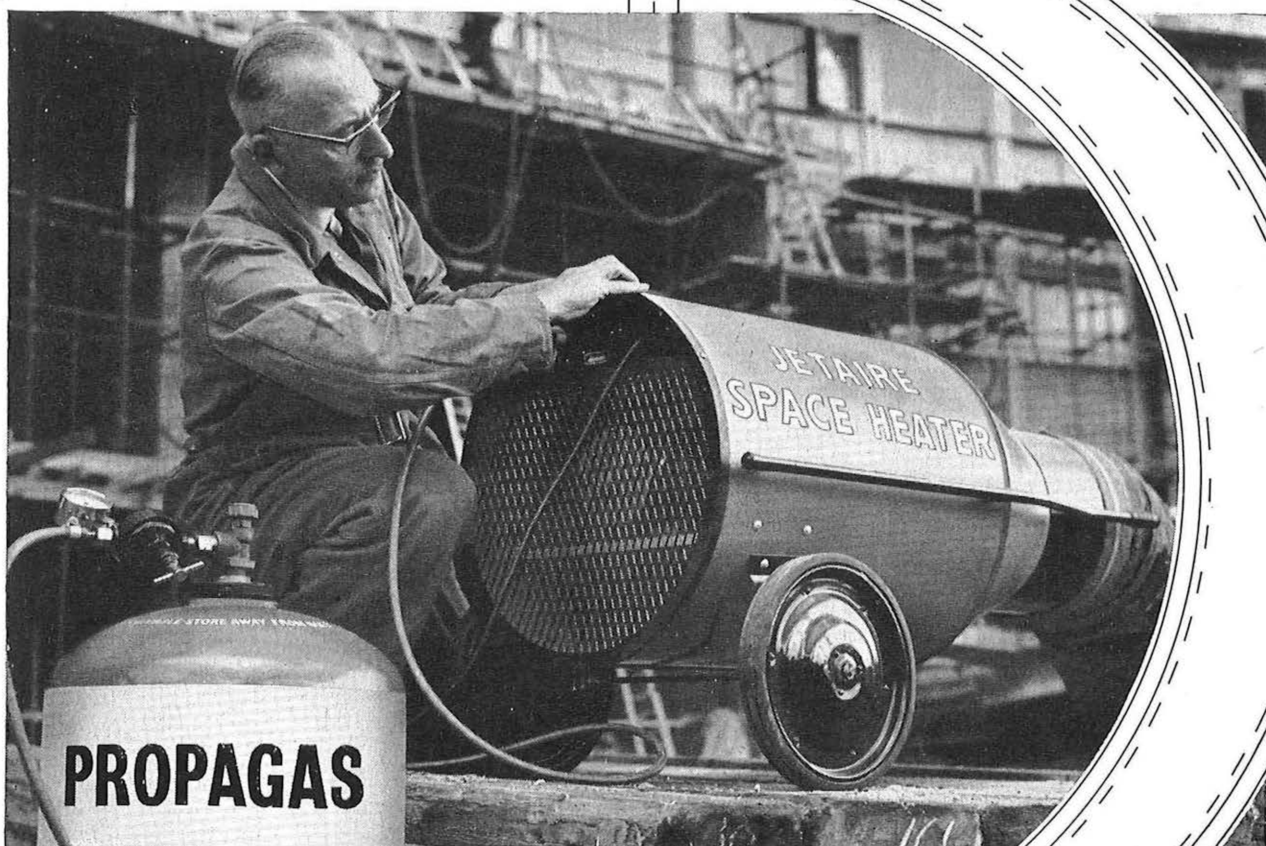

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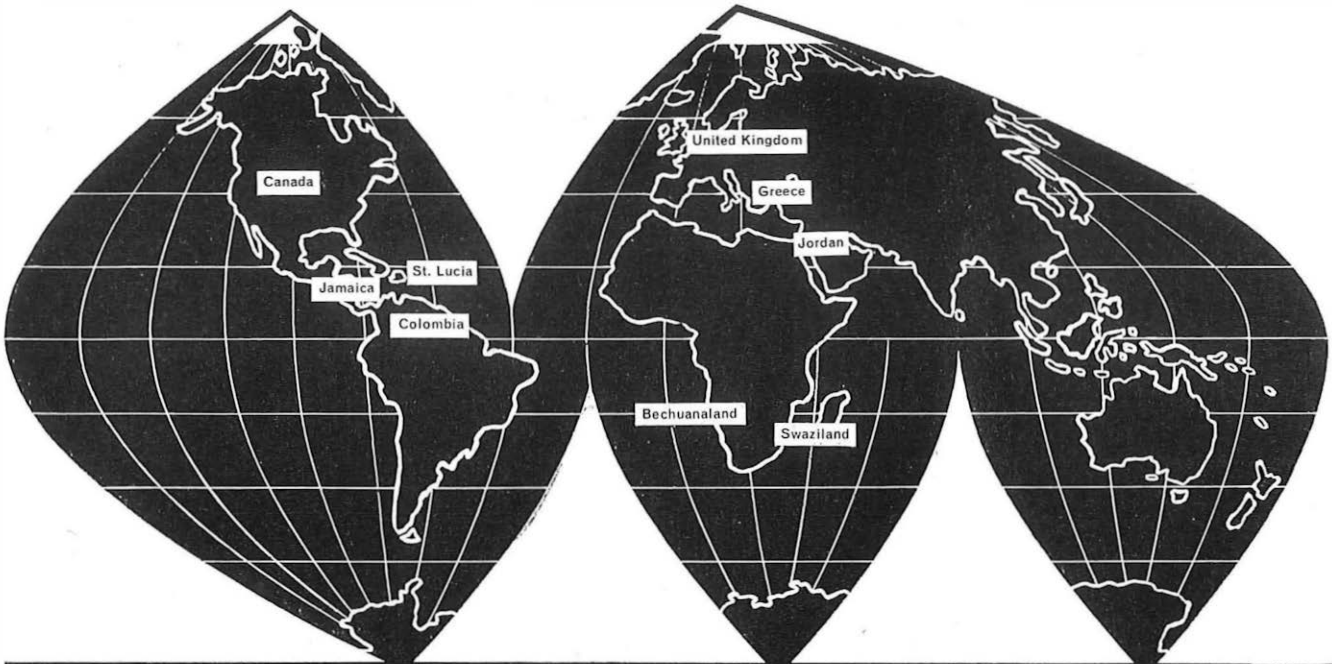

ERICSSON RURAL CARRIER EQUIPMENT

TYPE R.C. 101

- LOWER POWER CONSUMPTION
- BATTERY OR OPTIONAL MAINS OPERATION
- TRANSMITTED CARRIER FOR AUTOMATIC GAIN CONTROL AND SIGNALLING
- INTERCHANGEABLE SIGNALLING UNITS
- TRANSISTOR CIRCUITS
- COMPANDOR UNITS OPTIONAL
- AMPLE TEST POINTS
- ONE 10 CHANNEL TERMINAL ACCOMMODATED ON A WALL MOUNTING RACK 3′3″ HIGH
- SIMPLE INSTALLATION
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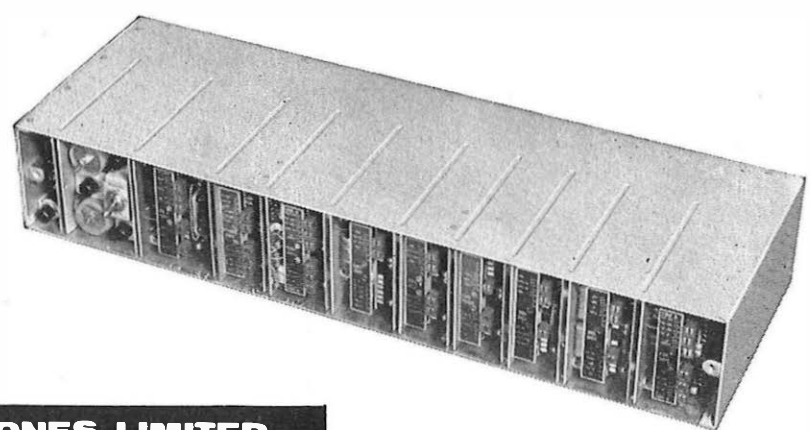
Now operating in many countries throughout the world, this equipment is designed to combine ease of maintenance with small physical size and low power consumption. It is particularly suitable for use in remote areas where the number and ability of personnel available to service carrier equipment may be limited. Faults can be cleared by substituting a spare for each plug-in unit in turn until the service is restored.

The system will provide up to ten additional speech circuits on an open wire line. The circuits are stackable and thus extra circuits may be added as demand increases. This feature, together with a wide range of pole mounted "drop-off" filter units, offers a high degree of system flexibility. Channel re-allocation is readily effected by replacement of plug-in sub-units.



Illustrated opposite is a single channel terminal (less panel cover) with mains power unit and compandor units fitted.

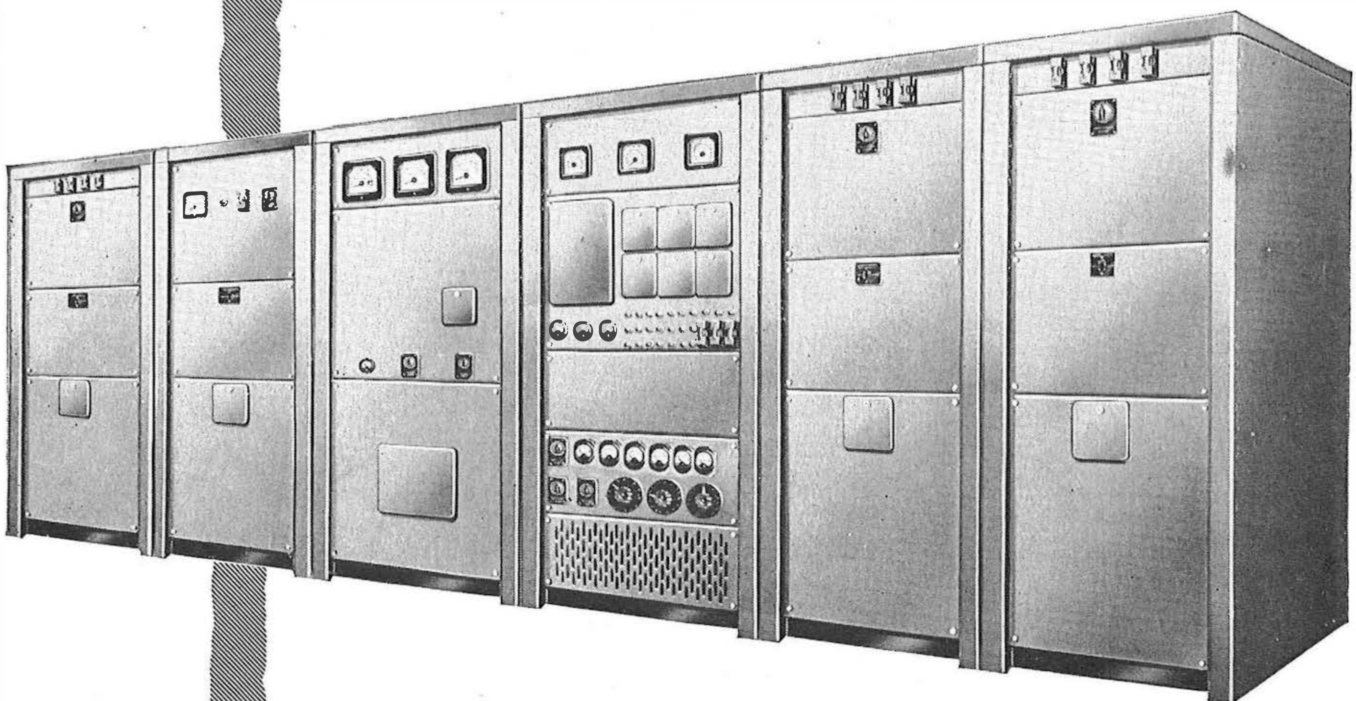
For further information please write to:-

ERICSSON TELEPHONES LIMITED
ETELCO LIMITED

Head Office: 22 Lincoln's Inn Fields, London. W.C.2. Tel. HOLborn 6936

WESTINGHOUSE

terminating and monitoring cubicles and repeater power supplies for submarine cables



The repeaters are fed with constant current from one or both ends of a link. Extremely close limits of current stability are achieved under all combinations of load and wide fluctuations of input voltage and frequency. Owing to enormous distances between terminating stations, cable power input voltages up to 15kV are quite common.

Westinghouse have supplied cable power feed equipments for Anglo-Swedish, Bermuda-Manahawkin, and Oban-Cornerbrook submerged cables. In addition to these, similar equipments are being manufactured for the Commonwealth Pacific link incorporating Sydney, Auckland, Suva, Hawaii, Vancouver and Port Alberni. Special equipments of a similar kind have also been supplied for cable laying ships "Monarch" and "Alert" and a cable power feed equipment is now under construction for the Cable and Wireless Ship No. 1305.

For further details write to Special Products, Rectifier Division, Dept. P.O. 10/62.

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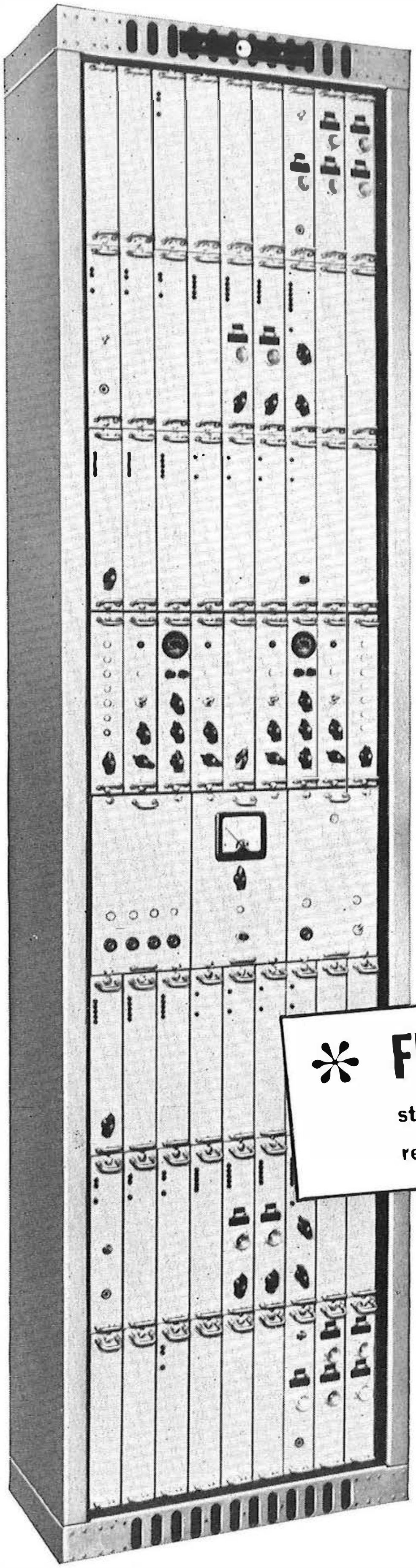

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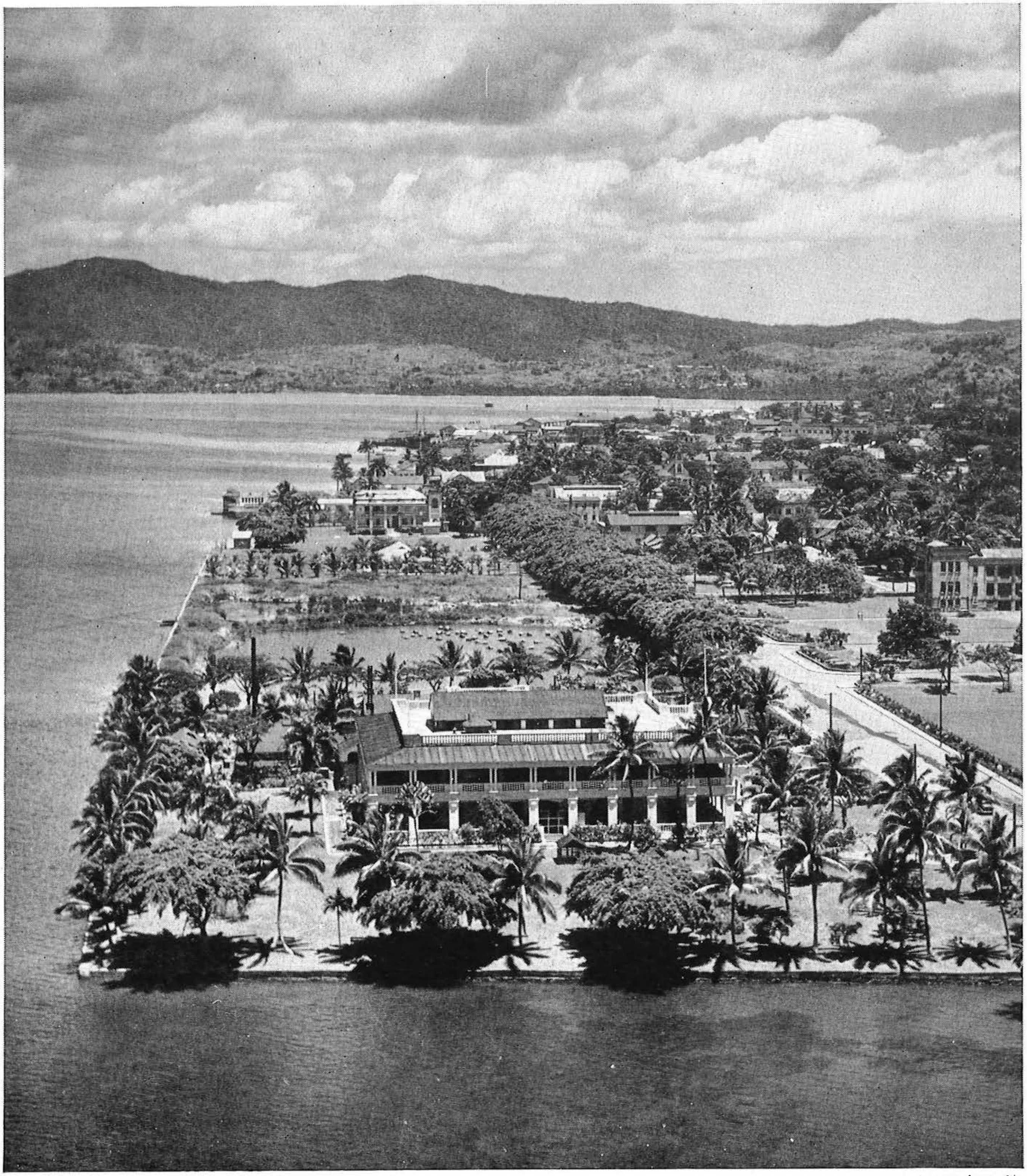

Aerial view of Suva, Fiji.