POST OFFICE

tele communications

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SPRING 1960

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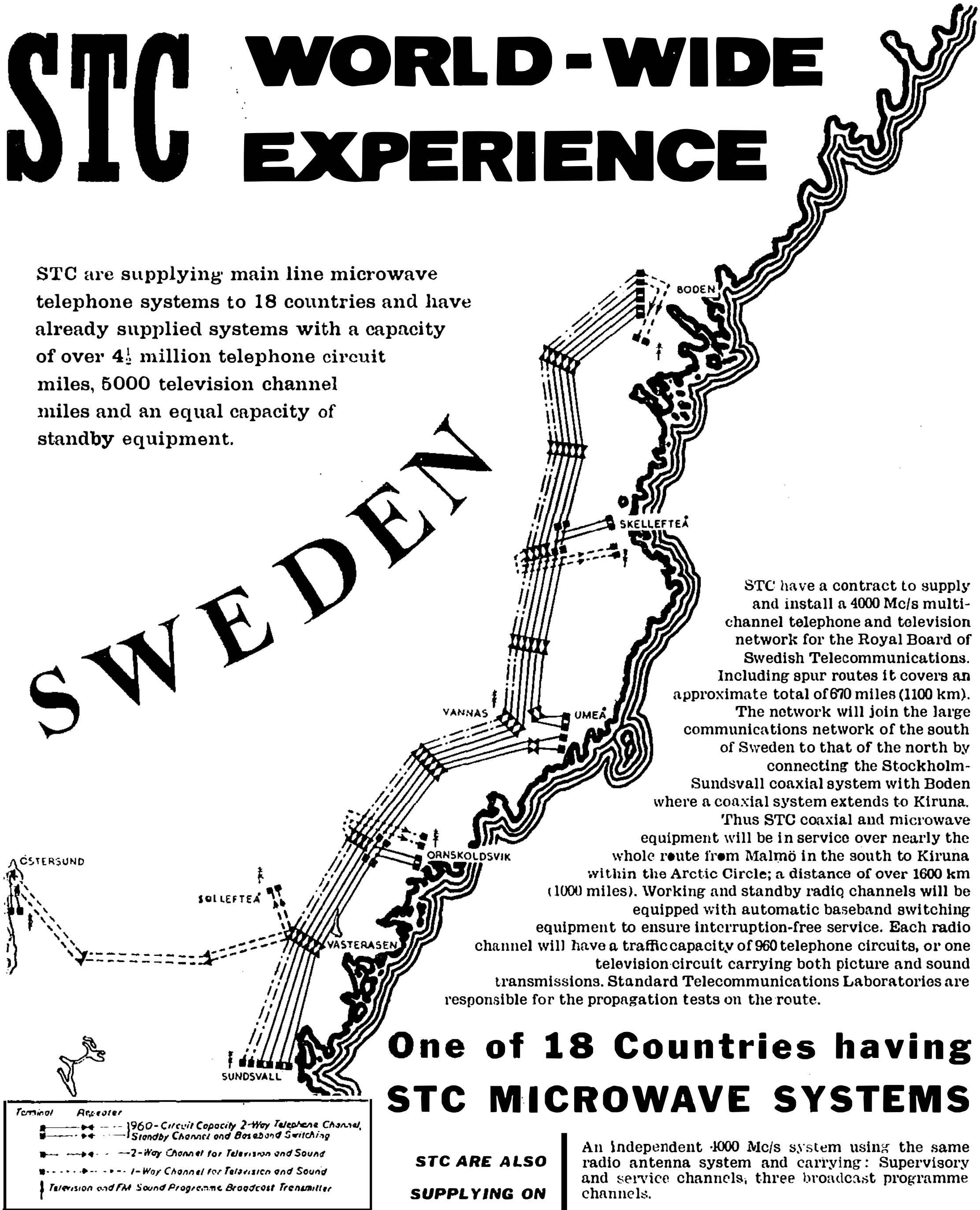
STC are supplying main line microwave telephone systems to 18 countries and have already supplied systems with a capacity of over 4½ million telephone circuit miles, 5000 television channel miles and an equal capacity of standby equipment.



STC have a contract to supply and install a 4000 Mc/s multi-channel telephone and television network for the Royal Board of Swedish Telecommunications. Including spur routes it covers an approximate total of 670 miles (1100 km). The network will join the large communications network of the south of Sweden to that of the north by connecting the Stockholm-Sundsvall coaxial system with Boden where a coaxial system extends to Kiruna. Thus STC coaxial and microwave equipment will be in service over nearly the whole route from Malmö in the south to Kiruna within the Arctic Circle; a distance of over 1600 km (1000 miles). Working and standby radio channels will be equipped with automatic baseband switching equipment to ensure interruption-free service. Each radio channel will have a traffic capacity of 960 telephone circuits, or one television circuit carrying both picture and sound transmissions. Standard Telecommunications Laboratories are responsible for the propagation tests on the route.

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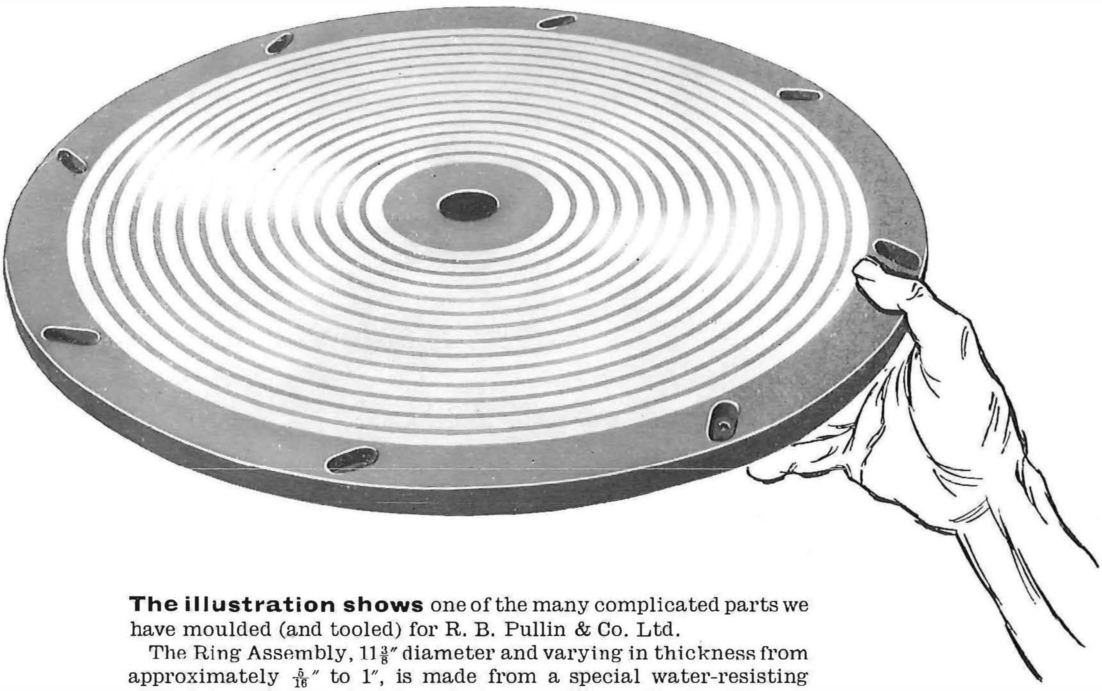

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Post Office Telecommunications Journal

Published by the Post Office of the United Kingdom to promote and extend knowledge of the operation and management of telecommunications

Contents

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Commonwealth Leads Again

JUST 60 YEARS AFTER THE GOVERNMENTS OF THE United Kingdom, Australia, Canada and New Zealand were planning a trans-Pacific telegraph cable (ultimately laid in 1902) to complete what was in those Imperial days known as the "all-red route", representatives of the same countries met in Sydney last autumn to plan a trans-Pacific telephone cable. They recommended that a cable should be laid as soon as is practicable. All the four Governments have now accepted the report.

Thus the four countries have taken another major step towards the "Round-the-Commonwealth" telephone cable chain which the Commonwealth Telecommunications Conference in London accepted in principle eighteen months ago. The first link in the chain, the Anglo-Canadian transatlantic telephone cable, commonly known as CANTAT, to be laid in 1961, will be linked with the Pacific cable through Canadian landlines.

Like the Western end of TAT1 the Pacific cable will be a single, both-way line equipped with British-type rigid repeaters, and, like CANTAT, will be of the lightweight type. Both the repeaters and the lightweight cable are the outcome of a combined effort by the Post Office research laboratories and British manufacturers. It will be equipped with modern British equipment designed to produce the maximum number of speech channels.

The new cable will be a substantial contribution to the expansion of world communications. The British Commonwealth once again—as a century ago in laying world telegraph cables—is in the forefront of the advance.

Plans to Spend £240-250 Million on Telephones

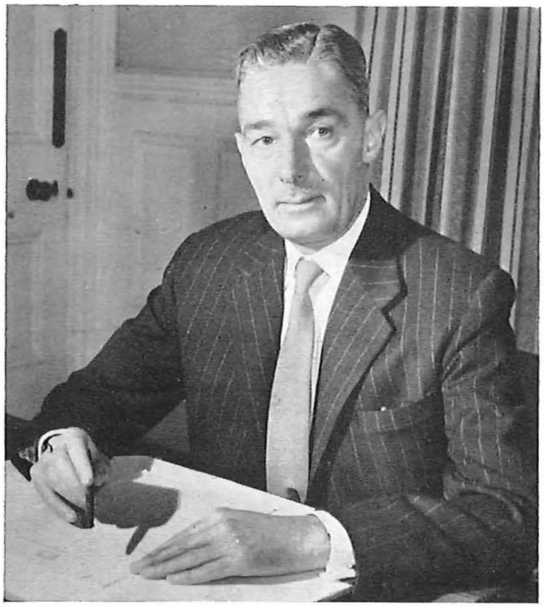
ON NOVEMBER 13 THE POSTMASTER GENERAL opened the Second Reading debate on a new Post Office and Telegraph (Money) Bill providing for borrowing £120 million for capital expenditure covering a period of about 2½ years from January, 1960. The Bill received the Royal Assent on December 17.

Following are some of the main points, principally concerning telecommunications, from the Postmaster General's speech:—

The Postmaster General pointed out that the fact that the present Bill asks for £120 million, compared with £75 million provided in the Act which came into force on April 1, 1958, does not mean "that there is to be a rapid acceleration in Post Office development. The annual level of expenditure covered by the 1958 Act and by this Bill is very much the same. It is largely because the two Measures cover different spans of time. We started to use the £75 million authorised by the 1958 Act in April of that year and it will be exhausted by January, 1960. Under the Bill, we are asking for a sum which should satisfy our needs throughout 1960 and 1961 and until about the middle of 1962. For obvious reasons, I cannot be precise about the date.

"I expect the total amount of capital expenditure during the period to be about £270 million all told, as defined in our Post Office accounts. Of this, about £150 million will be met out of depreciation provisions, leaving about £120 million to be borrowed through the Bill. Naturally, the money asked for in the Bill reflects the amount which the Government are likely to give us during the next two or three years as our share of capital investment in the public sector.

"Shortly before the previous Bill was introduced in 1957 the Post Office, along with other bodies in the public sector—electricity, housing, and so on—had to face a fairly severe cut in its capital investment as its contribution to meeting the economic difficulties at that time. Since then, the reduction has been progressively restored, and the investment which has now been approved for the next two years is almost back to the level of the financial year 1956–57. The capital investment figures, in terms of the redefinition of what constitutes capital investment, are £91.5 million for 1959–60 and £92.9 million for 1960–61. A provisional planning figure of £92 million has been agreed for 1961–62.



"Of all our services, it is the telephone that needs the greatest capital expenditure. Between £240 million and £250 million will go on telephone development. About £20 million will be spent on the postal service and about £7 million on the telegraph service.

"If I had more capital—I wish I had—we could develop this (telephone) system even more rapidly than we are at present doing. But, on the whole, I do not think that we have done too badly during the last two years, since the last money Bill was brought in. For example, we have connected nearly 750,000 new telephones, and we are now putting in more than 1,000 a day. During the last two years, we have cut down the number waiting for new exchanges or more cables from 110,000 to 50,000. I hope that this progress will continue; but, of course, a great deal will depend on the rate of demand as it develops.

"Today, this demand for the telephone, of course, is much higher than it has been for many years. I should like very much to go beyond simply holding the position. I should dearly like to be in a position where very few applicants had to await the building of an exchange, the laying of a new cable, or the taking of a shared line. This is something of the greatest importance. It is a source of irritation. It causes, probably, more criticism of the Post Office than any other single factor. I shall certainly do all that lies within my power to tackle it.

"A quite significant part of the capital expenditure on telephones will go on mechanization —about £25 million. This involves completing the mechanization of local exchanges. At present 5,000 out of the 6,000 exchanges are automatic, and we plan to complete the conversion by 1970. I do not wish to weary the House with all the technicalities or details of our mechanization programme, but, at the end of the day, subscribers thoughout the country will be able to dial not only their own local calls, but also their own trunk calls.

"By March, 1961 I expect to give the same facilities to subscribers connected to about 90 other exchanges throughout the country. Conversion to this system, known as STD, will then gather momentum and, by 1965, about 60 per cent. of all long distance calls will be dialled by the caller. By 1970, as I said—it may be sooner; I hope that it can be—STD should be available to about 90 per cent. of all the telephones then in use throughout the land.

"I am glad to say that since 1957 the number of calls has increased substantially. The number of trunk calls is growing at the rate of about 10 per cent. per annum. I am most anxious that the telephone should be used more often, particularly for local calls and for trunk calls during the cheap period. For this reason, we must constantly ask whether we have our concession rates right and whether we have our cheap period rates right. This is, I think, very important and it is something which I shall continually be doing."

Coming to the telegraph service, the Postmaster General said that, consequent on the Sinclair Report (*Journal*, Winter 1958) "we are now studying with the trade unions how we can best run the service with a view to keeping the loss within bounds.

"We have also adopted a proposal of the Sinclair Committee that a wider range of greetings telegrams should be considered. We have introduced four new designs of greetings telegrams, and these seem to be fairly popular with the public.

"The telex service—that is, the system by which subscribers can exchange printed messages—is flourishing. I have seen it at work in Liverpool and it is an excellent service. At present, we have more than 5,000 customers. Not only can they communicate with one another, but also with subscribers in nearly 40 other countries. Telex is expanding rapidly and by 1970 we expect to have about 20,000 subscribers. In 1961, we hope to be able to introduce subscriber dialling facilities to the Continent of Europe.

"About £33 million of our capital expenditure during the period covered by the Bill refers to the provision of new buildings and the improvement of existing buildings. Since the war, we have been restricted very much, and we still have substantial arrears to overtake. Over the years postal buildings have had to take a second place to telephone buildings, but I am glad to tell the House that we expect to start 50 major Post Office buildings in this financial year, 59 next year, and 70 in 1961-62.

"What about the cost of these new buildings? Two years ago, my predecessor announced the setting up of a joint development group, consisting partly of Post Office representatives and partly of representatives from the Ministry of Works, to go into the possibilities of making economies in Post Office building, without sacrifice of efficiency. I take some personal pride in this, because I had a hand in it when I was a very junior Minister, about five years ago, at the Ministry of Works.

"As hon. Members know, the first transatlantic telephone cable was provided in partnership between the Post Office, the Canadian Overseas Telecommunication Corporation, and the American Telephone and Telegraph Company. It was opened for service in 1956, and the volume of traffic is now more than three times what it was before the cable was available. Technical developments have enabled the conversation capacity of the cable system to be increased, and by the use of these new equipments—some designed in the Post Office research laboratories and some in America—we expect that, by next year, the conversation capacity will be two-and-a-half times more than it was.

"The Americans, in partnership with France and Germany, finished a transatlantic telephone cable between America and France this summer. That breaks no new ground in technical design. Indeed, much of the cable was manufactured in this country, and most of it was laid by the Post Office Cable Ship *Monarch*. She completed the work after the unfortunate loss by fire of the Submarine Cables Ltd. ship *Ocean Layer*.

"In association with Cable and Wireless Ltd. we are taking a big part in the further and rapid development of international communications. In 1961, a submarine telephone cable is to be laid between Canada and the United Kingdom. This will be of larger capacity than the present transatlantic cable. It will be single cable of new design carrying traffic in both directions. Two-way repeaters, which will be used throughout, are the result of Post Office development. This cable will be the first part of a wider plan for a Commonwealth round-the-world telephone cable system linking the Commonwealth countries.

"Representatives of the Post Office and of Cable and Wireless have only recently taken part in a conference in Australia, where plans were drawn up for the construction of a cable between Australia and Canada via New Zealand. These plans will now be considered* by the Commonwealth governments concerned. This link will be four times as long as the transatlantic link. No part of the scheme is included in today's Bill, and the United Kingdom's share will be financed by Cable and Wireless. A contract has recently been placed with Fairfield's, on the Clyde, for a new Post Office cable ship of 4,000 tons. This ship is being designed primarily for maintenance of the ever-growing numbers of submarine telephone cables in the North Atlantic. It will replace the Cable Ship *Alert* which is due to come out of service quite soon."

In her reply to the debate, the Assistant Postmaster General spoke on mechanization and staff.

"Mechanization brings me to the human problems of staff redundancies and the changing of jobs. The conversion of a telephone exchange from manual to automatic working may mean a change in the place of work for many telephone operators. In the Post Office this and similar problems are being squarely and fairly faced by management and trade unions working together. This is the only way in which we can solve problems of this sort."

*See "Commonwealth Leads Again", page 51

THE SYDNEY CONFERENCE

Seated (left to right): Mr. T. A. HOUSLEY, General Manager, Australian Overseas Telecommunications Commission; Mr. (now Sir) ROBERT HARVEY, C.B., Deputy Director General; Hon. C. W. DAVIDSON, O.B.E., M.P., Postmaster General, Australia; Mr. D. F. BOWIE, President, Canadian Overseas Telecommunication Corporation; Mr. D. DONALDSON, Deputy Director General, New Zealand Post Office. Standing (left to right): Mr. S. F. KELLOCK, Chairman, and Mr. E. C. HARCOURT, Overseas Telecommunications Commission; Sir BEN BARNETT, K.B.E., C.B., M.C., Chairman, Commonwealth Telecommunications Board.

Follow-up on the Ray Report

F. I. Ray, C.B., C.B.E.

On December 15, twelve months after presenting his Report (published as Telephone Service and the Customer), *on the visit to the Bell Telephone System in the United States, on which he led a Post Office group, Mr. Ray, who is Director of the Inland Telecommunications Department, gave the following informal talk "Follow-up on the Ray Report" in Post Office Headquarters. We published the Report in our Summer issue last year.*

IT WAS A YEAR AGO THAT MISS HAMPTON, MISS Whitelaw, Mr. Hill, Mr. Harper and I returned from America full of new ideas for improving the telephone service. Tonight I want to do some stock taking to find out what has been achieved, and a little crystal gazing into the future to see what remains to be done.

But first of all I must recall what most impressed us about the American telephone service. It was the emphasis given in both the formation and execution of policy to the paramount idea of pleasing the customer. Every problem is considered in the light of the customer's probable reactions, and if necessary, these are determined, either by survey or by experiment. Time after time in our discussions we found that arguments which seemed to us to be soundly based on equity and logic were not accepted merely because "the customers would not like it". This attitude sprang from the teachings of that most remarkable man Theodore Vail, the General Manager and later President of the American Telephone and Telegraph Company. It was said of Vail that he made the A.T. & T. "the most service conscious organization of private enterprise in the country", and we were left in no doubt that that spirit still prevails.

We were also greatly impressed by the organization of the Bell System. Although ten times the size of ours, it showed no signs of being muscle-bound or unwieldy. Full devolution of authority is combined with effective control from the centre. The secret of the organization lay, or so it seemed to us, in the fact that the operating companies had not only full authority to act, but also were fully responsible for their actions, and in the policy of staffing the American Telephone and Telegraph Company (the headquarters of the Bell System) entirely by men and women who had done well in the operating companies. No doubt the competition is fierce and only the best are chosen, for there was no doubt about the high ability and knowledge of all the A.T. & T. people we met.

In our Report, *Telephone Service and the Customer*, we drew particular attention to the spirit and organization of the Bell System and we attributed the success of the system to:—

(a) clearly defined basic objectives,

(b) the way the system sets out to please the customer,

(c) the personal character of the service, and

(d) the emphasis on the personal responsibility and initiative of the staff.

This analysis largely determined both the public presentation of our Report and its implementation. Presentation required a simple slogan and our reference to the personal character of the service became "the friendly telephone", and the emphasis on the personal responsibility of the staff became "setting the telephonists free".

Such over-simplification was understandable and probably unavoidable in the circumstances. But the friendly telephone campaign laid too great an emphasis on the friendly telephonist and detracted attention from our main object, which was to reorientate the whole policy and way of thinking of the Post Office in telephone matters.

Survey of Public Opinion

It was unfortunate, too, that the friendly telephone campaign preceded, not succeeded, the survey of customer satisfaction. This survey took some time to organize and the postal questionnaire did not go out until the end of May. It would have been quite impossible to defer the publication of the Report until the survey had been completed, and therefore the result of the survey will be a measure of opinion after the campaign had been launched. The full summary of the survey is not yet to hand, but it is already apparent that it is a necessary instrument for measuring our success or failure in satisfying our customers. If taken regularly year by year, it will reveal the trend of opinion. I am sure all will appreciate the importance of knowing what the customer thinks, instead, as in the past, of merely knowing what we think he thinks.

Exchange Supervision and Operator Training

An important part of the initial campaign was the experiment in exchange supervision and operator training. I visited Peterloo exchange recently to see for myself how the experiment was proceeding there. I was much struck both by the evident enthusiasm and by the progress which had been made. The idea is that each assistant supervisor should have her own team and should be responsible for training them, both initial training and refresher training. Assistant supervisors in America told us that 50 per cent. of their time was spent on training. Obviously this leaves less time for direct supervision at the switchboard. But if operators are properly trained and given more personal responsibility, the need for direct supervision will be correspondingly reduced. This is the theory, but it seemed to me that during the interim stage—that is, until all or most of the telephonists had been trained by the new method—the withdrawal of section supervisors to train new entrants left the remaining supervisors, including the supervisor in charge, quite a lot to do. If section supervisors are to train the new entrants to their teams, there will be fewer of them employed on the direct supervision of telephonists. Ultimately, when all telephonists have been trained in this way, there should, if the basic theory is right, be less need for direct supervision, but in the meantime the remaining section supervisors, and even the supervisor in charge, are kept pretty busy on direct supervision when new entrants are being trained. I was told that, at first, assistant supervisors were rather alarmed at the prospect of training new recruits, but are quite happy with the work now they have gained self-confidence. The experiment has been so successful that it is to be extended to about 20 more exchanges, and if satisfactory, these will probably be adopted as standard. I am quite sure that it will produce better operators more quickly and also I hope it will give supervisors more satisfaction in their work.

Another change affecting switchrooms is in service observations, where we are trying out a method of recording irregularities by emphasizing successes rather than failures and by summarizing the percentage of calls well handled.

Credit Cards

Operators will also be concerned with the new credit card system (which will be introduced on March 1). Here the object is to make it easier to telephone and thus increase the calling rate.

One of the criticisms made about our telephone service by colleagues in other administrations is that we rent telephones not telephone service. The truth of this comment is shown by the average number of calls made each year per head of the population; for instance, 490 in Sweden and 78 in the United Kingdom. Because of this our policy is to encourage the use of the telephone by credit cards, freefone service, and so on. We are particularly anxious to encourage off-peak traffic because it does not require more capital investment.

Fault Reports

Turning now from the switchroom to the test room, it has been agreed in principle to try two experiments, one using the American system of fault repair clerks, and the other the full ENG service. Two joint steering groups have been set up to control these experiments, but it may be some time yet before trials can begin, and even longer before conclusions can be reached. But whatever the result, the experiments will focus attention on the need for giving a better speed of answer to fault complaints and this in turn must lead to regular and systematic service observations at test desks, similar to those made at switchboards. Indeed, something of this sort will have to be done to measure the success or failure of the two experiments. There is much to be said for the American principle that, at all points of telephone contact with customers, service observation measurements should be made. Another development from these experiments should be the fuller realization of the need for prompt attention as well as prompt answer to faults. The one should go with the other.

Business Office Representatives

Then there is the Telephone Manager's Office. We have put forward plans for introducing business office representatives and these are being considered by the staff associations. There may not be quite the same need for business office representatives here as in America, because of the agency service given at Post Office counters. Nevertheless, I would like to see customers dealt with more as individuals, especially on such a personal matter as the non-payment of an account. The principle is that the more we mechanize, the more careful we must be to provide individual and personal attention for those cases which fall outside the normal line of the machine, even where the trouble is due to the subscriber and not to the department.

I would like the business office representatives to be empowered with the full Telephone Manager's powers of waiver in order that more disputed accounts can be settled out of hand without the delay of seeking higher authority, traffic enquiry or engineering test. This would leave more time to deal with the occasional case of the customer who disputes a succession of accounts. Fortunately, these cases are rare, but when they do occur, they should be given the fullest examination and every effort should be made to discover the real cause of the dispute.

Merchandising and Tariffs

Considerable progress is being made with merchandising. We have a new Principal post in the Inland Telecommunications Department and are building up an organization for the work, although it will not be the combined ITD-Engineering Department organization which I should have preferred. The development of subscribers' apparatus is a lengthy business and must be streamlined as much as possible. Even so, it will be a matter of years before the start of the new project and the full availability of supplies. The Merchandising Duty has a master list of some three dozen projects, including such important innovations as key switching telephones, bedside telephones and loud speaking telephones.

Tariffs

The Report suggests that all our policies and procedures should be examined in the light of the Bell practice. It gives examples, but this list was not, and was not intended to be, exhaustive. In particular, no reference was made in it to tariffs, although in Appendix C it showed how the principle of pleasing the customer can be applied in this field.

Dial Service Administration

Another matter which needs attention, and one which was included in our list, is the Dial Service Administration. This poses the problem of responsibility for service in a fully automatic system.

This question is allied with another posed by the Report. What can be done to improve the flexibility of the organization? Must it remain in separate hierarchies, each protected by a demarcation line? Or can we imitate the American practice where we were told a man is selected for a post solely on his ability and knowledge?

Tone of Service

Finally, I come to perhaps what is the most important of all, the Tone of Service. This has been discussed at the Telecommunications Panel of the Joint Productivity Council, and a paper written largely by Miss Whitelaw has been prepared for circulation to Joint Productivity Committees. Already, quite a number of suggestions have been received with the comment that they have been inspired by the Friendly Telephone campaign. If the spirit of the Report can be joined to the machinery of JPC, more rapid progress can be made. But above all else, Headquarters must give that guidance which is its responsibility and indeed the justification for its existence.

My main objective, in helping to frame the Telephone Creed (and here I would pause to express regret for my weakness in dropping its title from the White Paper) was to ensure that this guidance would continue, growing ever stronger, until it can be said we are the most service conscious organization in the country and that truly "we aim not only to serve but to please".

Why the Electronic Exchange?

Brigadier Sir Lionel H. Harris,
K.B.E., T.D., M.Sc., F.C.G.I., M.I.E.E.

Engineer-in-Chief, 1954-1959

The Postmaster General demonstrated the all-electronic exchange at Dollis Hill last November. Brig. Sir Lionel H. Harris, then Engineer-in-Chief, presiding, discussed the reasons for this new exchange.

THE WAR ACCELERATED THE DEVELOPMENT OF "Electronics" and the post war period has seen the application of these techniques in many fields. The ingredients are always much the same; magnetic storage, pulse techniques, cold cathode tubes, and printed circuitry, miniaturization and semiconductor devices.

Automatic computers, data processing machines and a host of industrial aids have already emerged from the laboratories. Even before the war it was foreseen that telephone switching could be done without the use of moving mechanisms—at a price. Now the technical realization is much nearer and economic manufacture appears possible.

It may be asked why should we bother about electronic switching when electromagnetic systems throughout the world are giving satisfactory service.

I think the answer is that telecommunications engineers feel that the present mechanical systems have reached the stages of near perfection within their own limitations which prohibits any further major advancement and that although a difficult development and transition period must be faced, electronic methods are necessary if progress is to be unfettered and our sights raised to a new level of objectives otherwise unattainable.

It is probable too that we are influenced by general trends towards higher frequencies and quicker operation; towards microseconds rather than milliseconds and the realization that stability and accuracy are not sacrificed in so doing.

Even so, this higher level of objectives is not very easily defined—we should certainly save space by using electronic equipment and, in due course, reduce maintenance costs but, in the long run, I believe the ultimate advantage will be in the greater flexibility between the transmission system connecting our exchanges and the switching equipment; that is, dispersal of the latter and intermixture with the former. This would be in keeping with other tendencies which are leading to high frequency cables in the local networks; for example, for closed circuit television, for data transmission and, perhaps, even for economy.

It is not an easy task. The switching equipment is bound to have most of the complexities of computers and data processing equipment but in addition it must carry speech and tones, ring bells and operate meters and have other facilities all without noise and crosstalk. It must also provide a 24-hour-a-day 7-day-a-week service at a price fixed at a low figure by the requirements of a public telephone service.

The arrangements we have made with our five switching contractors for joint research and development have worked well. Apart from avoiding duplication, men of adequate calibre are in short supply. Moreover the essential requirements of the Post Office for our large exchanges are a single proven system with all the advantages of standardization in regard to maintenance, spare parts, engineering, training, drawings, and so on, which mean so much for plant which must have a life of upwards of 25 years to be economic.

We are, then, in an experimental phase but at the same time electronic equipment is already penetrating into the Post Office telephone service in several ways. Successful director equipments have long been working at Richmond and more recently at Lee Green. GRACE, which provides the electronic control of Subscriber Trunk Dialling at Bristol, has also been successful, and a notable example of the co-operation which continues to prove so valuable.

An Experimental Electronic Telephone Exchange

S. W. Broadhurst

IN 1956 THE POST OFFICE AND THE FIVE PRINCIPAL manufacturers of telephone equipment in this country set up the Joint Electronic Research Committee (J.E.R.C.) to co-operate on the joint research and development of electronic telecommunications exchange switching systems. The manufacturers are the Automatic Telephone & Electric Company Ltd., Ericsson Telephones Ltd., The General Electric Company, Siemens-Edison-Swan Ltd. and Standard Telephones and Cables Ltd. Since 1956 the six parties have pooled their research and development efforts with the object of producing an experimental electronic exchange for field trial at Highgate Wood in the London network.

Potentially, the use of electronic devices for telephone exchange switching offers advantages in space saving, lowering of maintenance costs because of the absence of mechanical moving parts, and economies in apparatus due to the high speeds of operation. Time in electronic systems is reckoned in microseconds as opposed to milliseconds in mechanical systems and this leads to new concepts, particularly in the design of the control equipment; it also offers potential service advantages in respect of rapid connexions on long distance calls.

Of the several possible technical solutions to the problem the "Switched Highways" time-division-multiplex system was chosen for the first experiment.

Apparatus

The equipment uses valves, diodes and transistors in large numbers and many of the basic "bricks" from which the system is built are similar to those used in electronic computers. The essential bricks are "gates" and "stores". The gate is the electronic equivalent of a relay and its contact; when operated it closes a path between two terminals. Such gates can be made to operate and release in less than a microsecond.

For storage purposes magnetostrictive delay lines (described below) and a magnetic drum are employed.

Permanent information relating to the subscribers' lines—for example, their type, class of service and meter records—is stored on a magnetic drum, each line being allocated a small section of the drum surface for this purpose. The magnetic drum is similar in appearance to that described in the Winter 1958 *Journal.* Delay line stores are used for the storage of information which is required only temporarily—for example, for digits dialled by the callers or to retain the memory of the paths over which a particular connexion has been established.

The delay line consist of a thin wire of magnetic material threaded through two coils, one at each

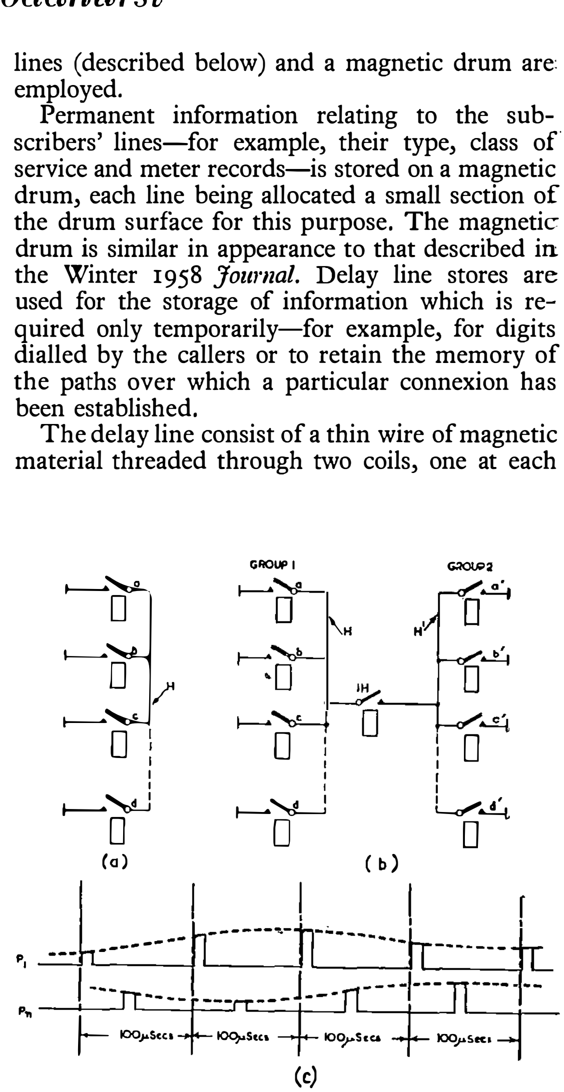


Fig. 1 (a), (b), (c): Principle of time-division-multiplex

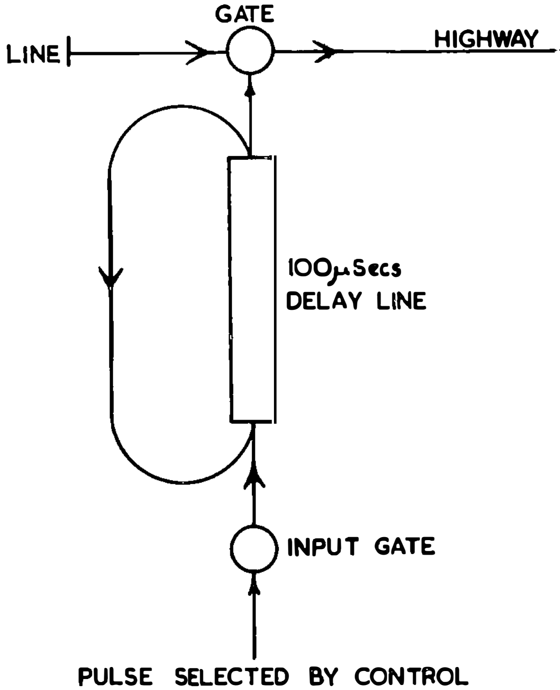


Fig. 2: Principle of delay line store

end. If a current pulse is applied to one of these coils a slight deformation takes place of the wire within the coil and a mechanical wave is transmitted along the wire, the time taken for the wave to reach the distant end depending on the nature and length of the wire—about 5 microseconds per inch for the wire used on the model. This wave is detected by the second coil, and the resulting electrical signal is amplified and re-applied to the input coil.

Thus, a number of pulses suitably displaced in time may be injected into and allowed to circulate indefinitely in the wire storage system. The delay line thus acts as a "memory" device since once in the system each pulse will be found re-entering the wire at an exact multiple of the time it was originally injected. Any pulse can be erased from the system by inhibiting its re-entry at any of these times. The delay lines used in the experiment are either 100 and 900 microseconds long, the 100 microsecond lines being commonly used in the connexion path memories and the longer lines for the storage of other information relating to the calls.

The transmission system uses the principle of Time-Division-Multiplex that is, no call has the exclusive use of any path through the exchange but, instead, each path is shared by a number of calls each of which is allocated the use of the path for a brief fixed period in a time cycle. Fig. 1 (a) illustrates the principle. A number of subscribers, four of which are shown, are connected via relay contacts to a common wire or highway H. (The relays shown are individual to the lines). To connect *a* to *c*, relays *a* and *c* must be operated at the same time, and clearly no other independent conversation is possible while this condition obtains. If, however, the relays *a* and *c* are operated and released at regularly repeated intervals which allow time for another pair of relays to operate when *a* and *c* are released, samples of two conversations will appear alternately on the highway. Each listener will hear fragments of the conversation of his correspondent but there will be no connexion between the two calls.

Further, if the relay sequence operates fast enough subscribers will not notice the discontinuities in the speech. If more than one group of lines is fitted the same principles could be applied but in considering calls between groups such as calls from *a* to c^1 (Fig. 1 (b)) care must be taken to ensure that the time period allocated for the call is not already in use in either of the groups: that is, that relay *IH* (the inter-highway connecting gate) closes only during the times allocated to the inter-group calls. On the other hand there is nothing to prevent any call which terminates within its own group from using a time period identical to one already in use on a call in another group, always providing the groups are not interconnected at that instant.

By using ultra high speed relays (electronic gates) 100 conversations can be carried on each highway. Each call is then allocated one of 100 one microsecond periods or pulse channels in a repeating cycle 100 microseconds long.

Fig. 1 (c) shows two conversations, one allotted pulse channel P_1 the other channel P_n. Both calls are carried on the same wire. At time P_1 the gates appropriate to the first call open to switch a pulse on to the highway. The amplitude of the pulse is modulated by the level of the wave form of the speech at the instant of sampling, as shown by the dotted line, which indicates the envelope of the wave form. The second conversation is sampled similarly at time P_n. Each conversation is therefore sampled for a period of one microsecond at intervals of 100 microseconds; that is, 10,000 times a second. The original wave form is reconstituted in the receiving portion of the line circuits, but in any case the discontinuities would be too short to be noticed by the callers.

The switching of the gates is controlled by delay line stores. Fig. 2 indicates the principle. A selected pulse appropriate to the channel to be used is applied to the input gate of the delay line and is detected at the output 100 microseconds later at which time it momentarily closes the gate joining the line to the highway. The pulse re-enters the delay line and reappears at the output 100 microseconds later, the process continuing despite the removal of the original pulse from the input gate. Hence once a connexion has been established in this manner the delay line will retain a "memory" of the pulse channel used on the connexion and continue to control the gate until such time as the circulating path is broken to release the call.

The circuits are arranged so that as long as the subscriber's line is looped a train of pulses will flow out on to the highway at the time indicated by the delay line. During dialling these pulse trains will be interrupted but the connexion will remain held, both the set-up and release of connexions being controlled by common apparatus.

The block schematic diagram of a two group system is shown in Fig. 3. The traffic carrying capacity of each group is about 60 erlangs so that the number of lines (subscribers' plus junctions) in a group may vary considerably. At Highgate Wood it will be 800.

The exchange divides into two parts, the switching network and the controls. The switching network contains the highways and their interconnecting gates, with similar gates by which any highway can be connected to the register. In contrast to step by step systems the network does not include means of selection, the paths to be used for any call being selected by the common control. The high speeds of electronic apparatus enable one selector to serve even for the largest exchanges; they also enable calls to be set up on a "one at a time" basis because at any instant only one call, either incoming or outgoing, can be in process of being connected.

When a call is originated the selector chooses a pulse channel to connect the caller with the register, the appropriate gates being operated as previously described with reference to Fig. 2. If a number of calls arrive simultaneously they are connected by the control in a particular sequence, the time of connexion of each call to the register being so short that there is no apparent delay. The final

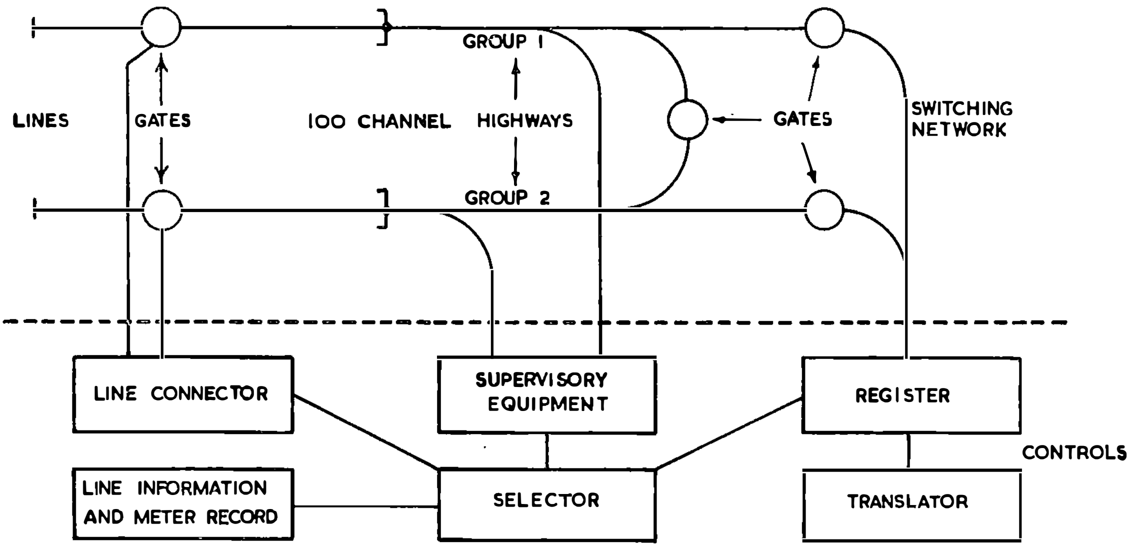


Fig. 3: Diagram of experimental electronic exchange

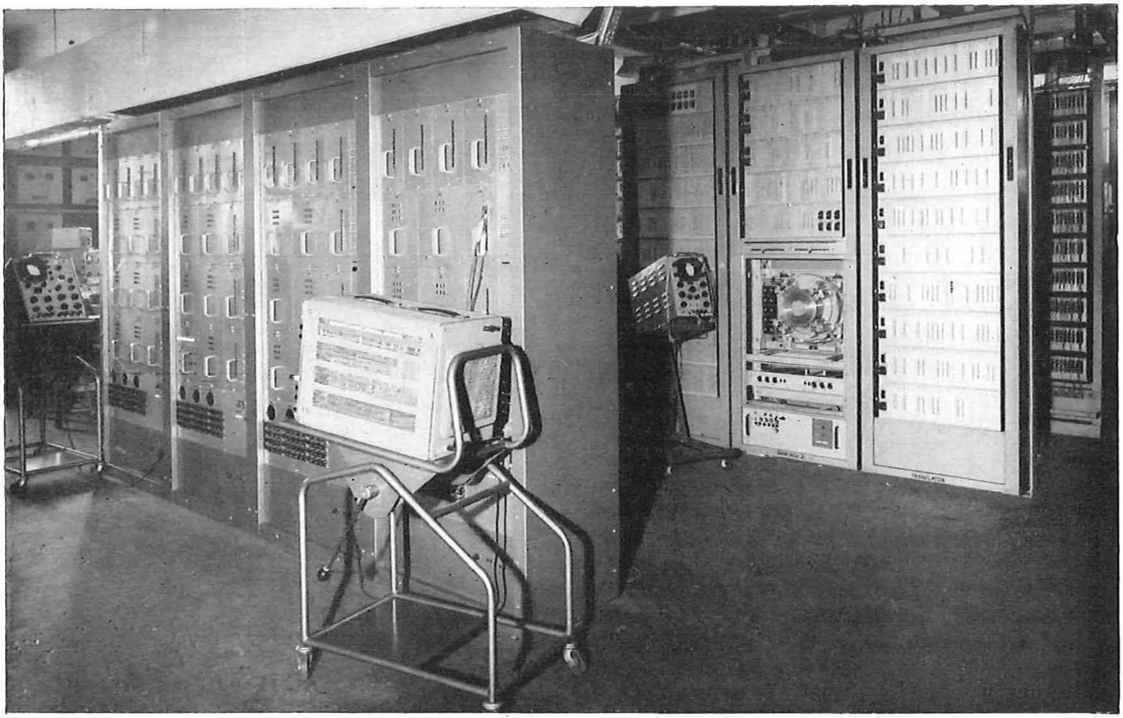


Fig. 4: General view of equipment racks

connexions to the called lines are set up in a similar manner, only one call being dealt with at one time.

The equipment provides all the normal facilities of a director exchange and allows for developments such as Subscriber Trunk Dialling. Register and supervisory equipments give standard facilities but are arranged on a common basis, the application of time sharing principles enabling one set of storage equipments to deal with a large number of connexions. Up to 100 registers can be made common in this manner and the common supervisory apparatus can monitor and control all the calls in the exchange.

The system provides full flexibility. Any type of line can be given any position in the exchange. P.B.X. lines and junctions can be selected sequentially even when not wired to adjacent equipment positions.

A view of a section of the model is shown in Fig. 4.

Conclusion

Highgate Wood will not be opened for public service until the equipment has been subject to the most stringent tests. Although every care will be taken to minimize the risk of breakdown some risk must always remain when an experiment of this magnitude is undertaken. Hence the present electro-mechanical installation will be arranged to serve as an emergency reserve for the electronic exchange. One effect of this decision is that the electronic system has to use the existing subscribers' apparatus, including the standard dial and bell set. Since electronic switches cannot readily handle the high power necessary to ring the bells each line circuit is equipped with a relay for this purpose. Indeed, in respect of connexions to the outside world the electronic system is in the same position as the earliest automatic exchanges and conversion equipment has to be fitted on all external circuits to ensure compatibility between the new system and the old.

The design and development of the system has meant considerable effort from each of the parties to the J.E.R.C. Agreement. Although detailed design work and manufacture has been apportioned between the parties the close co-operation between them has ensured the development of a fully integrated system.

Other People's Jobs

Senior Communications Officer, Home Office

J. E. Young, O.B.E., E.R.D.

ONE OCCASIONALLY READS INTRIGUING ANnouncements in the Post Office Circular that the Home Office require the services of some person or persons unknown to perform duties which are specified as concerning "Regional Headquarters telephone and teleprinter installations, administrative and operational layout of accommodation, provision and operating methods, despatch rider and messenger services, Civil Defence Corps Authorities' operational procedure and methods, training, message room staffing, air raid warning schemes, field telephone, wireless and visual signalling systems".

Some three years ago I succumbed to the temptation to try my luck, attracted perhaps by thoughts that lighting bonfires on the tops of various "telegraph hills" might make a welcome change from the intricacies of "package" deals, Subscriber Trunk Dialling and other complications looming on the Post Office horizon.

In spite of the vast amount of ground covered by the duties specified, I have found that most of these matters *are* pretty constantly in front of a Senior Communications Officer, although so far I have yet to be confronted with a mountain top, a bonfire and box of matches (or tinder box). There is perhaps still time . . .

The Home Office has an amazingly wide range of activities although the man in the street—and possibly most Post Office officials—would normally associate its activities only with police, youthful delinquents, prisons and the public hangman. But the Home Office is deeply involved also in such divergent matters as dangerous drugs, explosives, immigration control and firemen. It was almost a shock to find that it has a large interest in telecommunications, owning much expensive gear and many hundreds of wireless sets, and has a real thirst for scientific knowledge and experience of all manner of strange devices. Home Office people seem prepared to try anything once although, like Post Office people they have to get their money from the Treasury; even mildly adventurous inspiration has therefore—in common prudence—to be critically pondered in its earlier stages.

The business of law and order makes vast demands on telecommunications. Police forces cannot operate without their networks of Post Office rented private telephone and teleprinter circuits. The wireless equipped police car has now become so common that a motorist automatically slows down on seeing in the driving mirror a black car sporting a VHF aerial. The intricacies of frequency allocation in a tightly packed small country with vast numbers of television viewers apparently waiting for the opportunity to complain of interference, are only too well known and appreciated by the Post Office.

This is where the Senior Communications Officer enters the scene. With the utter dependence of the police, fire, local authorities and all the paraphernalia of daily government, administration and such on firmly established communications, there is always the nagging background worry about how we would fare without such communications.

The point had to be faced on a widespread but comparatively small scale during the Second World War, when the Post Office were often hard put to maintain essential communications.

After the war, in 1945, we hoped that this problem would not have to be faced again, and the Civil Defence Forces, and much of their more or less permanent communications, were allowed to die a slow and peaceful death. Unfortunately it became slowly and painfully obvious that the old axiom about keeping your powder dry could not be forgotten. It thus seemed not unreasonable to halt the decline of the Home Office's Civil Defence organization, and at least to keep the damp away.

Unlike the Post Office, with its increasing decentralization, most of the Home Office lives in a historic and somewhat uncomfortable building in traditional Whitehall, with the remainder in more modern accommodation comparatively near at hand.

In Whitehall there is a Communications Branch, broadly divided between wireless and line communications, which interests itself chiefly in the detail of ordinary peacetime Police and Fire communications and the broad principles of other communications matters. The Branch has a Director of Communications, a Chief Communications Officer, two Senior Wireless Engineers, two Senior Communications Officers, two Communications Officers, and supporting staff.

One of the Home Office's many duties, however, is to provide local authorities throughout the country with encouragement, advice and material for keeping Civil Defence problems under investigation, and training volunteers. Whitehall is a long way from the West and East Ridings of Yorkshire, for example, and some representation

Members of Leeds Civil Defence Division practising field cable laying

(Courtesy, The Yorkshire Post)

Mobile signal office, City of London Civil Defence Corps
(Courtesy, Central Office of Information)

on ground nearer the local government authorities is highly desirable. So Regional Directors of Civil Defence were appointed about five years ago as decentralized outposts of the Home Office Civil Defence Department, to whom local authorities could turn for direction and guidance. There are 11 regions and each contains one Senior Communications Officer, who thus becomes the direct local contact between the Home Office and the local authorities, for training Civil Defence communications personnel, and integrating all Home Office communications interests.

During the war, much experience was gained in operating air raid warning systems, and these systems, which immediately after the war were allowed to go into decline, have been brought back to operational efficiency by the local authorities under the general guidance and control of Regional Communications Officers. Raid damage and reporting and control procedures had to be sharply re-assessed, however, as the atomic bomb completely altered the conception of Civil Defence generally. Many readers will no doubt recollect attending a study at the Civil Defence Staff College in 1954 to assess the magnitude of the communications problems thrown up by "the bomb".

No sooner had we got over one unpleasant fact-facing and down to the job of deciding what to do about it than we were faced with a problem of inestimably greater magnitude! The megaton range of nuclear weapons—in popular parlance the H bomb—became, about four years ago, the basis of Civil Defence planning, and this is what we are at present attempting to assess and prepare for.

Nobody would pretend that things were easy in the latter part of the Second World War and some very strenuous efforts were required of the Post Office to maintain essential telephone services in the face of the high explosive bombs of the day, when the Civil Defence services proved their worth on innumerable occasions. The services were not only instrumental in saving tens of thousands of lives but they also succeeded in maintaining control of territory which was damaged or on fire, and often without food, shelter, or communications. This was achieved only by very close co-operation between the Post Office and the Home Office, and careful planning and laying out of control and communications centres before the event. As most telecommunications engineers will well appreciate, much can be done to restore damaged communications surprisingly quickly—providing we know beforehand what the problem is likely to be, but any attempt at *ad hoc* restoration of a communication chain through badly-placed control centres, with the plant to be restored buried under mountains of flaming or water soaked rubble, is an entirely different proposition.

The scale of attack we must contemplate as possible today makes it quite obvious that a primary task of Civil Defence is to assure the survival of some form of law and order. Hence, local authorities must know now what their aims are, and are actively training volunteers in putting out square miles of fires, rescuing countless thousands of casualties, and caring for millions of homeless.

It is not to be expected that in such circumstances the Post Office could provide communications as and when required, and this is why the Regional Communications Officer must spend much of his effort in planning—with the Post Office and local authorities—how best to lay out control and communications channels to be ready when they are wanted—if unfortunately they ever are. He must also integrate into such systems the static and mobile wireless, owned by the Home Office but lent to and in the custody of local authorities, and

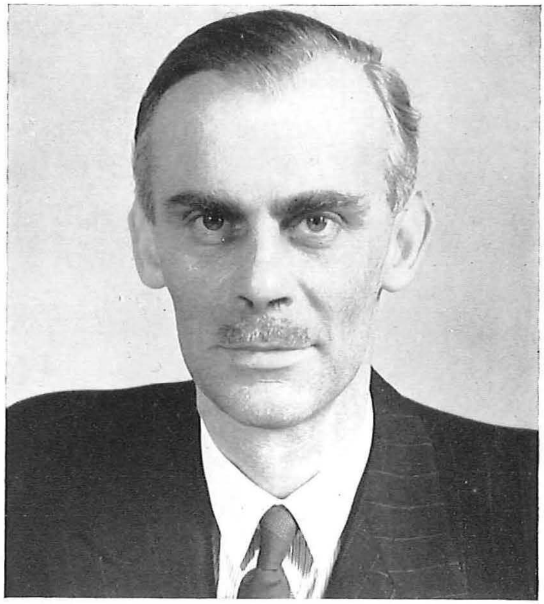
Walkie-talkie operators of Leeds Civil Defence Division *(Courtesy, The Yorkshire Post)* the field telephones and field cable (which the Civil Defence volunteers struggle so manfully to erect high enough to clear a double-decker bus).

For training, he must arrange exercises, and supervise their efficient carrying out, and look for any lessons to be learned from imaginative studies which will give pointers to the lines on which future thinking—and training—must run. This involves spending much time "on the ground" with wireless sets, field cable teams, control vehicles and so on assessing their potentialities and capabilities. If he can also lend a hand in erecting a 30-foot mast on a windy hilltop, or start a recalcitrant petrol-electric generator, or prevent death from slow strangulation by a piece of field cable, his presence is usually doubly welcome. It is all good fun—but deadly serious, and always tempered by the thought that we devoutly trust the efficiency we strive for and the lessons we painfully learn will never be put to the test of actual use.

The job thus offers ample scope for trying pretty well every technique the communications world has to offer, and forming opinions about its value in the ultimate disaster. Many readers have no doubt had much experience of "exercises" with volunteer forces, who get much of their training by this means. The pre-war Territorial Association and Supplementary Reserve camps produced situations in which both directing staff and volunteers learned many lessons that produced highly competent and efficient forces by the time they were required. The Senior Communications Officer is perhaps in somewhat the same position with Civil Defence Section training and must have a pretty flexible outlook, as the points of training and procedure on which he may be expected to pronounce—or even lend a hand at instant notice—cover everything in any way ambiguous in the instructions.

The thought has recently struck me—prompted by mountaineering in the Civil Defence Landrover in VHF wireless exercises—that perhaps I have lighted a bonfire on top of a hill after all. The same transmission medium is used, the frequency is very different but the range is about the same. You only need more elaborate equipment to do it these days than they did in the days of Napoleon (or William the Conqueror or Julius Caesar). Perhaps times don't really change. Perhaps someone will be doing it in future years with even more elaborate equipment—or, appalling thought, with still slightly radioactive brushwood and tinder box.

Sir Robert Harvey, K.B.E., C.B.



The Editorial Board of the *Journal* offer their heartiest congratulations to one of their former chairmen (1949–1953), Mr. Robert James Paterson Harvey, on being honoured with a K.B.E. in the New Year List. Mr. Harvey has been a Deputy Director General of the Post Office since 1955; previously he was Director of Inland Telecommunications for five years, and later of Radio Services. He led the United Kingdom delegation at the Sydney conference last autumn.

Other Honours

Mr. W. K. Mackenzie, Deputy Director, Midland Region, who leads the Post Office side on the joint Research and Development Group with the Ministry of Works which designed the new Altrincham Telephone Exchange, received the O.B.E.

The M.B.E. was conferred on Mr. R. W. Chandler, Chief Telecommunications Superintendent in the Inland Telecommunications Department, now External Telecommunications Executive.

Eight B.E.M.s were awarded to other telecommunications staff.

Closed Circuit Television for Stock Exchange Dealings

W. E. Ready

TEN MILLION TELEVISION RECEIVING LICENCES have been issued in the United Kingdom. Television, in most homes, has become a necessary part of the domestic scene.

But there are many activities outside the world of entertainment to which television is making its contribution. These activities range from the remote observation of processes in situations dangerous to human beings, to the viewing of documents; from traffic control to observation by medical students of techniques in operating theatres. The potential uses of television cover a wide field and they are growing in number rapidly as new ideas from the world of business and industry create more opportunities for exploiting the medium.

When television signals are transmitted direct from point-to-point on a private circuit the system is known as a closed circuit as distinct from the broadcast circuits which carry signals for public transmission and which are provided for the broadcasting authorities. Reproduction of still pictures at distances over a closed circuit has, of course, been possible for some considerable time by facsimile transmission but with the equipment at present in common use this method is too slow for some modern needs.

A closed circuit television facility comprises cameras, camera control units, a linking circuit, picture reproducing apparatus or monitors and any auxiliary items, such as switching equipment,

Fig. 1: Relative sizes of standard 0.375″ coaxial cable and 0.163″ coaxial cable

which may be required for the particular application. A customer interested in closed circuit television will usually, in the first instance, seek advice from one or more electronic equipment manufacturers specializing in the supply of camera and monitoring equipment. If an external connecting link is required he will also consult the Post Office.

The requirements of the linking vision circuits are generally similar to those of the circuits forming the broadcast vision network although the closed circuits may have to transmit signals of bandwidths of the order of 3 Mc/s or 5 Mc/s, depending on whether pictures of 405- or 625-line standards are to be reproduced. As most closed circuit television links are short and neither terminate in Post Office premises nor interconnect with the main long distance telephone network, the Post Office commitment is limited wherever possible to providing the necessary cables without equipment. The performance obtained from the complete installation, from camera to picture display, then becomes the responsibility of the camera equipment contractor. However, if the customer prefers or if the length of the link is such that intermediate amplification is necessary, the Post Office provides all the equipment for the cable amplification and equalization and accepts responsibility for the performance of this section.

The network of closed circuit television links recently completed in the vicinity of the London Stock Exchange provides a good example of the type of service in which the Post Office contribution consists only of unequipped coaxial cables. In small nearby offices, known as boxes, firms dealing on the Stock Exchange maintain records of current prices which are continuously amended as up to the minute information is brought in from the Exchange by messengers. Information from these records is passed by telephone to the firms' main offices, usually situated within half a mile of the Stock Exchange. Prices are likely to change from minute to minute and at times this arrangement proves too slow. Two firms of stockbrokers therefore decided to make price changes instantly available by using closed circuit television systems to connect their boxes, both of which are situated in Capel Court, to their main offices and also to the offices of several of their clients.

It was expected from the outset that there would be further demands for this service in the Stock Exchange area but before any new cable network could be provided, the consequences of prematurely exhausting the already very limited duct capacity in this area had to be considered. Providing additional duct on a large scale in the

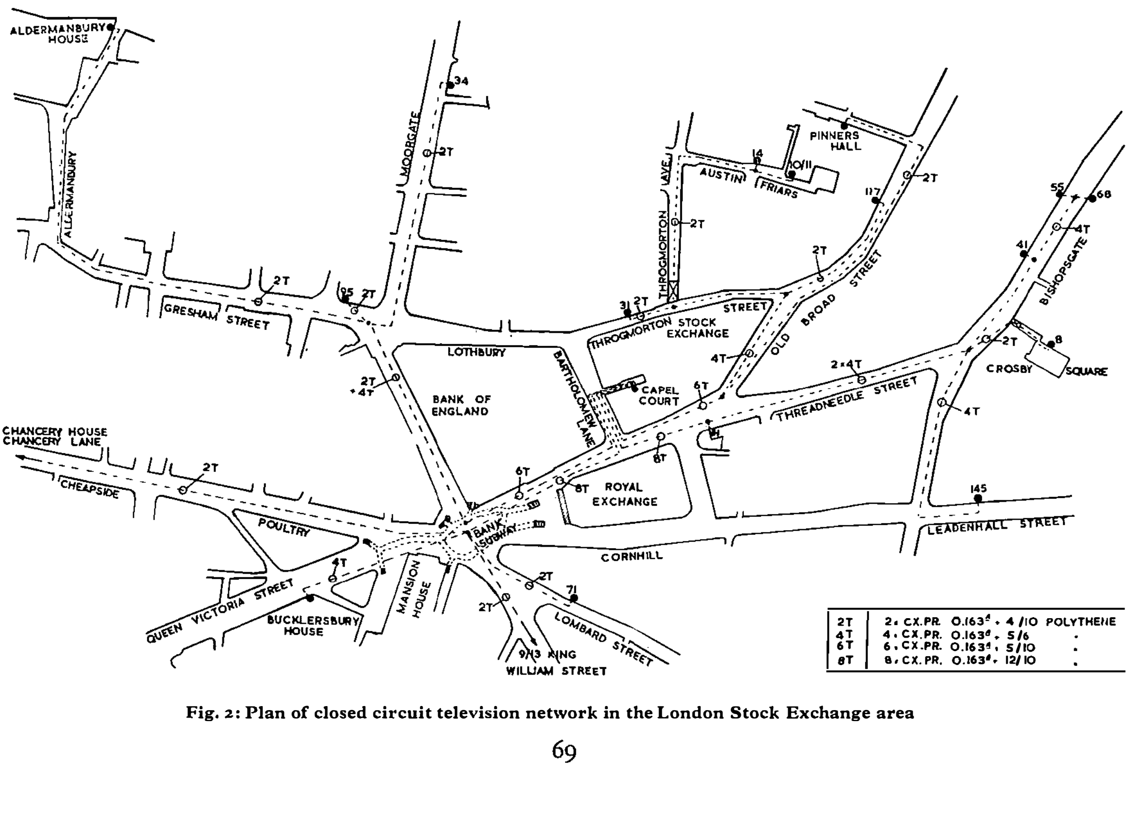


Fig. 2: Plan of closed circuit television network in the London Stock Exchange area

congested City thoroughfares would have been difficult, expensive and time consuming. The solution to the problem of providing the new network without absorbing too great a proportion of the existing duct capacity was found in a new type of coaxial cable containing tubes of small diameter which have been developed to carry blocks of about 100 telephone circuits.

The coaxial core of this cable has an outer conductor diameter of 0.163″ and a dielectric of expanded polythene. Two lappings of steel tapes over the outer conductor add strength to the construction and provide magnetic screening. Plastic tapes, coloured to give a means of identification, are wrapped over the steel tapes to insulate the coaxial cores. A complete cable is made up of two, four or more of these coaxial cores and includes, in the interstices, polythene insulated telephone type pairs which can be used for control and supervisory purposes. The outer sheath is plastic. The use of expanded polythene dielectric makes the core mechanically robust, an advantage where cables of rather small overall diameter have to be installed in ducts and jointing chambers.

Fig. 1 shows the relative size of standard 0.375″ coaxial cable and the 0.163″ coaxial cable. Each cable contains four coaxial tubes. At first, joints were made in the 0.163″ coaxial cable using methods similar to those employed for the standard 0.375″ cables but on later installations an improved jointing technique evolved by the Post Office will be used. The attenuation coefficient of the 0.163″ cable is approximately 2.5 times greater than that of the 0.375″ cable.

Fig. 2 shows the complete cable network provided and indicates the cable size at various points in the network. With the exception of short links of lead-in duct at Capel Court and several of the terminal points, existing duct was used throughout.

The first circuit was arranged by the equipment contractor to operate in Television Band I at approximately 50 Mc/s using ordinary domestic receivers capable of working with a link loss of some 50 decibels. These receivers can be made cheaply and are readily available.

An advantage of this method is that equalization of the cable response is unnecessary because of the very low ratio of highest to lowest transmitted frequency. The route distance, however, is limited at this frequency to five-eighths of a mile by the loss of the cable which is nearly 70 decibels a mile.

Later circuits were provided by unbalanced video techniques in which the signal output from the camera (0–3 Mc/s) is transmitted directly over the link without any change of frequency. At 3 Mc/s the loss of the 0.136″ diameter cable is approximately 17 decibels a mile and with suitable equipment zero loss circuits are possible for intermediate amplification over distances up to about 3 miles. The Post Office, having had considerable experience of these techniques, gives technical advice on this problem to the equipment contractors.

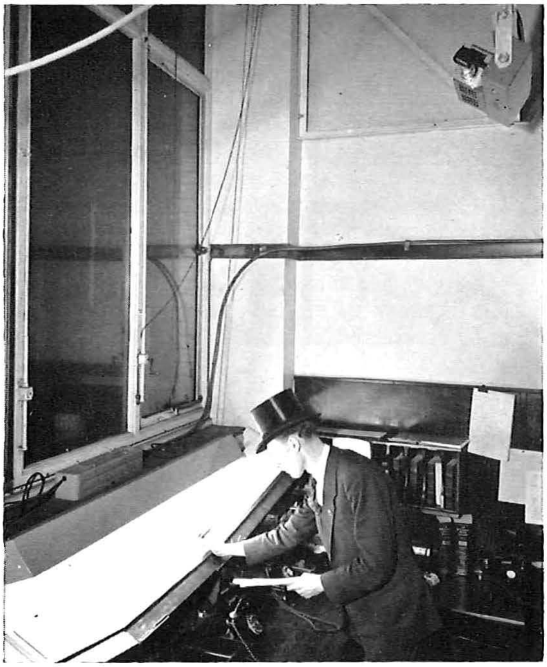


Fig. 3: Installation provided by Pye Ltd. The camera can be seen in the top right hand corner with the prism mounted in front of the lens

The first system installed was equipped by Pye Limited. In the box at Capel Court the prices of selected stocks and shares are entered on a board measuring 5 feet by 5 inches. By means of a motor driven prism, mounted in front of the camera lens, the camera is arranged to scan the entire board from left to right every minute and a quarter. At each receiving point arrangements have been made to feed several monitors.

The second system was equipped by Decca Radar Ltd. using equipment known as Deccafax. With this equipment the information is written on a transparency placed on a screen which is

Fig. 4 : Deccafax equipment at Capel Court

Fig. 5 : Office end of a closed television circuit

continually scanned by a flying spot scanner. Three scanners each supplying different groups of prices were provided. The information of all three scanners was required simultaneously at the broker's main office but the needs of the other recipients were met by selection at will of the information from any one of these scanners. Both systems were to 405-line standards.

Closed circuit television links have been provided for customers with a wide range of business interests, and the number of enquiries for this type of service is increasing. The first television link in this country to carry a signal of 625-line standards has been equipped by the Post Office and provided in Manchester for a business user. The scope of the use of television in the business and industrial worlds seems immense. There is little doubt that over the whole country the demands on the Post Office for closed circuit television links will continue to increase.

Acknowledgments

The writer wishes to express his thanks for permission to use photographs as follows: to Standard Telephones & Cables Ltd. for Fig. 1; to Pye Ltd. for Fig. 3 and to Decca Radar Ltd. for Figs. 4 and 5. He also acknowledges with gratitude the assistance given by colleagues in the Main Lines Planning and Provision Branch of the Engineering Department.

Telecommunications Statistics

	Quarter ended 30 September, 1959	*Quarter ended 30 June, 1959*	*Quarter ended 30 September 1958*
Telegraph Service			
Inland telegrams (excluding Press and Railway)...	3,651,000	3,194,000	3,749,000
Oversea telegrams:			
Originating U.K. messages	1,679,725	1,198,124	1,177,589
Terminating U.K. messages	1,616,692	1,208,828	1,653,871
Transit messages	1,397,408	1,352,719	1,434,774
Greetings telegrams	902,000	740,000	888,000
Telephone Service			
Inland			
Gross demand	109,860	111,551	94,737
Connexions supplied	100,010	100,668	83,157
Outstanding applications	137,683	140,757	157,375
Total working connexions	4,680,680	4,643,206	4,537,000
Shared service connexions	1,131,768	1,135,847	1,141,383
Total inland trunk calls	97,149,000	93,106,000†	87,815,000
Cheap rate trunk calls...	23,691,000	21,203,000	22,400,000
Oversea			
European: Outward	699,815	682,037	620,884
Inward	697,700	642,650	596,013
Transit	not available	not available	1,469
Extra-European: Outward	61,863	62,190	54,168
Inward	68,280	66,725	59,103
Transit	19,366	17,142	14,336
Telex Service			
Inland			
Total working lines	5,438	5,226	4,595
Calls from manual exchanges	698,000	704,000	*
Calls from automatic exchanges	220,000	217,000	*
Metered units from automatic exchanges ...	945,000	937,000	*
Oversea			
Originating (U.K. and Irish Republic) ...	568,352	554,174	470,565
Terminating (U.K. and Irish Republic) ...	550,091	529,598	456,805
Transit	7,291	6,135	5,392

* No comparable figures † Amended figure

Post Office Report and Commercial Accounts 1958-59

"LAST YEAR", SAID THE *Post Office Report and Commercial Accounts, 1958–59*, "it was reported that 1957–58 had been a year of steady progress in the mechanization of many Post Office services . . . the keynote of 1958–59 was Personal Service within an expanding framework of mechanization". "Personal Service" in the telephone field was expressed mainly in the "Friendly Telephone" policy promulgated just within the financial year—on March 11 1959.

Financial Analysis

Results

	1957–58 £m	1958–59 £m
General Account		
Income	389.2	417.0
Expenditure	386.6	408.3
Surplus (+)	+ 2.6	+ 8.7
General Reserve at March 31	− 0.5	+ 8.2
Postal Account		
Income	190.0	202.4
Expenditure	190.5	199.4
Surplus (+) Deficit(−)	− 0.5	+ 3.0
Telegraph Account		
Income	18.6	19.8
Expenditure	20.8	22.3
Deficit (−)	− 2.2	− 2.5
Telephone Account		
Income	180.6	194.8
Expenditure	175.3	186.6
Surplus (+)	+ 5.3	+ 8.2

The Report emphasizes that progress in mechanization gained momentum during the year. In telecommunications the increased momentum led to the start of Subscriber Trunk Dialling, in Bristol, on December 5 1958 and the opening of the first two automatic telex exchanges in London and Leeds, serving about a quarter of the system, in August 1958. Automatic exchanges enabled the introduction of "Twopenny Telex", which was described in the Summer 1959 *Journal.*

Among other developments during the year the Report records further progress through the Joint Electronic Research Committee towards the all-electronic telephone exchange; reductions of up to 20 per cent. in the amount of equipment needed in automatic telephone exchanges by closer adjustment of the mechanical equipment to traffic requirements; improved automatic exchange maintenance techniques which reduced the maintenance effort by 7 per cent. despite an increase of about 4 per cent. in the amount of equipment; progress on the installation between London, Oxford and Birmingham of the first coaxial cable system with repeater-spacing reduced to three miles and a capacity in each tube for more than 2,400 telephone channels; development of a new type of coaxial cable containing transistors instead of valves; two new types of submarine cable terminal equipment providing increased traffic capacity, one developed by Post Office engineers and the other in America; increasing the capacity of oversea wireless telegraph and telex circuits by modern channelling techniques; and the use of error correcting devices to make radio teleprinter working more reliable and to permit the use of teleprinters on routes hitherto operated by morse.

The Report also shows that, of the £92 million capital expenditure by the Post Office, £74.9 million was applied to telephone plant as follows (previous year's figures are given for comparison):

	1957–58 £m	1958–59 £m
Trunk and Junction circuits	15.8	14.4
Local lines	21.4	20.5
Subscribers' circuits	18.7	19.0
Exchange equipment	19.6	20.2
Oversea and miscellaneous	1.1	0.8
	76.9	74.9

(*Continued on page 76*)

TELEPHONE SERVICE *(from Commercial Accounts, 1958-59)*

	1957–58 '000	1958–59 '000
NUMBER OF EXCHANGE CONNEXIONS AT END OF YEAR		
On automatic exchanges	3,483	3,594
On manual exchanges	1,017	1,012
Total	4,500	4,606
ANALYSIS OF EXCHANGE CONNEXIONS UNDER RENTAL CATEGORIES, &C.		
Business Rate—exclusive service	1,642	1,668
shared service	144	135
Residence Rate—exclusive service	1,575	1,663
shared service	1,009	1,006
Post Office Service	58	61
Call Office	72	73
Total	4,500	4,606
NUMBER OF STATIONS AT END OF YEAR		
Exchange Service	7,300	7,468
Private Circuits (telephone and telegraph)	61	64
Total	7,361	7,532
NUMBER OF APPLICATIONS FOR EXCHANGE CONNEXIONS DURING THE YEAR	345	390
NUMBER OF APPLICATIONS FOR EXCHANGE CONNEXIONS OUTSTANDING AT END OF YEAR	171	145
TRAFFIC—NUMBER OF CALLS		
Inland:		
Trunk	327,000	340,000
Local	3,671,000	3,700,000
Overseas:		
European cable services:		
Outward	2,221	2,451
Inward	2,174	2,349
Transit	46	53
Radiotelephone and Extra-European cable services:		
Outward	201	227
Inward	214	247
Transit	204	237
Short range radiotelephone calls with ships:		
Outward	11	12
Inward	86	93
Total	5,157	5,669

	1957–58	1958–59
NUMBER OF LOCAL EXCHANGES AT END OF YEAR		
Automatic	4,897	4,982
Manual	1,099	1,027
Total	5,996	6,009
NUMBER OF AUTO-MANUAL AND SEPARATE TRUNK EXCHANGES AT END OF YEAR	278	298

Mechanization and Buildings Department

THE MECHANIZATION AND BUILDINGS DEPARTMENT has existed as a separate department of Post Office Headquarters for about three years. It is responsible for developing postal and office mechanization, for organization and methods (including Work Study), for providing new and keeping up existing buildings, and for administrative questions relating to motor transport. The Department advises the Ministers on these questions, formulates policy, conducts research and development, and issues instructions for guidance of Regions.

Under the Director of Mechanization and Buildings there are three Branches, each in charge of an Assistant Secretary: Postal Mechanization, Central Organization and Methods, and Sites and Buildings.

A fourth division, the Post Office section of the Joint Post Office-Ministry of Works Research and Development Group, is the charge of a Deputy Regional Director.

The main function of the Postal Mechanization Branch (PMB) is to promote mechanization of the postal services with due regard to economy and the interests of both the Post Office and the staff. This requires that the Branch shall work in very close co-operation with the two branches of the Engineering Department which are mainly responsible for designing, constructing and installing postal machinery—Dollis Hill and Power Branch—and with the Postal Services Department.

Other subjects in which PMB are concerned are development studies, and the design and lay-out of sorting offices for the larger postal buildings. One section is responsible for coordinating matters affecting motor transport, including legislation and road traffic accident prevention.

The Central Organization and Methods Branch (COMB) is generally responsible for clerical efficiency throughout the Post Office. It has direct responsibility for providing and efficiently using office machines, and for promoting their use. The Branch has recently completed a systematic review of clerical organization and methods in Post Office departments. For the future, most of the resources of the Branch are likely to be devoted to office mechanization, and in particular the application of automatic data processing. In addition COMB has latterly been investigating some relatively new

Left to right: Mr. C. R. SMITH, Assistant Secretary, COMB; Mr. S. SCOTT, Assistant Secretary, PMB; Brigadier K. S. HOLMES, C.B.E., Director; Mr. S. HORROX, Assistant Secretary, SBB; Mr. W. K. MACKENZIE, O.B.E., Deputy Regional Director, R & DG.

Work Study techniques and will be increasingly engaged in future in promoting their application in the Post Office.

The Sites and Buildings Branch (SBB) is concerned with matters affecting provision and maintenance of land and buildings for the Post Office. It shapes Post Office policy relating to the purchase and leasing of sites, as determined by the many Acts of Parliament governing the acquisition and development of land. It controls an annual buildings programme of some £11 million and is responsible for setting standards for all types of Post Office accommodation, in collaboration with the operational interests. The Branch works closely with Ministry of Works, who design and erect buildings to Post Office requirements, and with the Joint Post Office-Ministry of Works Research and Development Group on Post Office Buildings.

The Research and Development Group (R & DG) was established about two years ago and is charged to investigate and develop new methods for reducing the cost and improving the design of all types of Post Office buildings. It has already designed the 10,000-line automatic telephone building for Altrincham, as recorded in the Autumn 1959 *Journal*, and a Head Post Office for Hitchin, at a cost of about half that of comparable buildings built since the war. The R & DG includes administrative, postal, finance and engineering staff from the Post Office with architects, quantity surveyors and structural engineers from the Ministry of Works—all working alongside.

The aim underlying all the activities of MBD is to promote efficiency, reduce costs, and at the same time to improve working conditions for the staff.

Report and Commercial Accounts

(*concluded from page 73*)

Expenditure on exchange equipment included:

(i) continued mechanization of operator-controlled trunk traffic to enable operators to dial direct to the wanted number;

(ii) provision of Subscriber Trunk Dialling equipment to extend the system introduced at Bristol Central Exchange in December 1958;

(iii) extension of exchanges to cater for growth —181 large, and many small exchanges were extended;

(iv) replacement of 71 manual by automatic exchanges;

(v) replacement of 29 large automatic exchanges and numerous small ones for various reasons; some were obsolescent and others could not be extended sufficiently to meet the growth in demand.

The capacity of the telephone system to accommodate new exchange connexions was increased by 262,000.

Telegraph staff fell during the year from 6,762 to 6,634 while there was an increase from 50,290 to 51,650 in telephone staff. Engineering staff was reduced from 87,975 to 87,070.

Telephone Preface Re-Styled

THE PREFACES TO TELEPHONE DIRECTORIES ARE being redesigned. The first new-style preface is in the Stoke-on-Trent directory which was issued in December. This design is still experimental; experience—and possibly adaptation to local circumstances—may lead to further changes. The London Directory, for example—on which the designers are now working—presents a special problem.

Following Call Charges on page 2, page 3 shows how to make a call and has space for subscribers to note new and changed numbers.

Page 4 lists Facilities and Services, faced by an Area map on page 5, on which a heavy black broken line demarcates the Area from the surrounding areas. Following the map, a list of the correct postal addresses fills a couple of pages in the Stoke-on-Trent preface.

The new style was designed for the Post Office by London Typographical Designers, using Eric Gill's Monotype Perpetua Bold type, designed on the basis of ancient Roman inscriptions, for headings, and, for text, Monotype Times New Roman, designed for *The Times* in 1932. Times New Roman is probably the best, most easily read text type for use on the inexpensive, rather absorbent paper used for telephone directories.

Section 111 — 1001

TELEPHONE DIRECTORY

STOKE-ON-TRENT AREA

DECEMBER 1959

TELEPHONE MANAGER: H. TODKILL, M.I.E.E, STAFFORD STREET, HANLEY, STOKE-ON-TRENT, STAFFS
TELEPHONE: STOKE-ON-TRENT 92 TELEX: 36527

ADVISORY COMMITTEES: *Where there is a local Advisory Committee for Post Office Services you are invited to bring before it any general matters relating to Postal, Telephone and Telegraph Services.* (Secretaries: Mr I. P. Peak, Leek Trades Council, 15 Westwood Grove, LEEK, Staffs; Mr D. Turner, British Pottery Manufacturers' Federation, Federation House, Station Road, STOKE-ON-TRENT (Stoke-on-Trent 48631); Miss E. Shaw, Craft House, 37 High Street, NEWCASTLE, Staffs (Newcastle, Staffs 67381); Mr N. A. Stokes, Secretary, W. G. Bagnall Limited, Castle Engine Works, STAFFORD (Stafford 321).

CONTENTS

EMERGENCY SERVICES

FIRE POLICE AMBULANCE

Coastguard, Lifeboat and Rescue Stations

Dial 999

(where appropriate)

OR CALL THE OPERATOR

Tell the operator the service you want give your Exchange and Number

Wait until the Emergency Authority answers give them the address where help is needed and other necessary information

PLEASE DO NOT CALL THE EMERGENCY SERVICE FOR NON-URGENT CALLS, as vital calls may be delayed, but use the Authorities' numbers shown in this directory

1002 — Section 111

CALL CHARGES

Local Calls 3d

Trunk Calls

	CHARGE FOR 3 MINUTES	
	Full Rate	*Cheap Rate*
	s d	s d
Up to 35 miles	1 0	1 0
35 to 50 miles	1 9	1 3
50 to 75 miles	2 3	1 6
75 to 125 miles	3 0	2 0
Over 125 miles	3 6	2 6

NOTE: The cheap rates may be suspended on certain days at Christmas and the New Year.

TIMING: Trunk calls are charged for a minimum period of three minutes from the time the call is connected: beyond three minutes, calls from subscribers' lines are charged at one-third the rate shown on the left for each extra minute.

Coin Boxes

LOCAL CALLS 4d.

TRUNK CALLS 3d. additional to the charges shown on the left.

CHEAP RATE PERIODS FOR INLAND CALLS

WEEKDAYS: 6 pm to 6 am the next morning SUNDAYS: 2 pm to 6 am Monday morning

Subscriber Trunk Dialling Tariff

Subscribers on those exchanges with the new trunk dialling (STD) facilities have different call charges as follows:

	TIME FOR 2d	
	Full Rate	*Cheap Rate*
LOCAL CALLS	3 minutes	6 minutes
DIALLED TRUNK CALLS		
Up to 35 miles	30 seconds	45 seconds
35 to 50 miles	20 seconds	30 seconds
Over 50 miles	12 seconds	18 seconds

Coin Boxes: The charge is 3d for each of the periods quoted.

Note: For trunk calls via the operator the charges are as shown at the top of the page.

Overseas Calls

	CHARGE FOR 3 MINUTES	
	s	d
EUROPE	*from* 6	0
Paris	6	0
Amsterdam, Brussels	7	0
Frankfurt, Geneva	10	0
Rome, Warsaw	18	6
USA AND CANADA		
Full rate	£3 0	0
Cheap rate	£2 5	0
OTHER COUNTRIES	£3 to 3 15	0

Each extra minute is charged for at one-third of the rate for three minutes.

Two pages showing the new look and (below) *the old*

(Section 111) — 1003

STOKE-ON-TRENT AREA

(Including NORTH STAFFORDSHIRE)

JANUARY, 1959

TELEPHONE MANAGER:
Lt.-Col. W. C. Huff, T.D., M.I.E.E., Stafford Street, Hanley, STOKE-ON-TRENT, Staffs.
(Stoke-on-Trent 92†). (Telex 36527, Telman, Stoke).
† If the telephone used has a coin box dial 0.

Enquiries, Faults and Service Difficulties

Enquiries and reports of faults and service difficulties, concerning the Telegraph and Telephone Services should be passed to the appropriate service points, as indicated in the following pages and Dialling Code cards where these are issued. Persistent or recurring difficulties and enquiries concerning telephone accounts, the provision or alteration of telephone installations, etc., should be referred to the Telephone Manager's office; please state your telephone number when writing. Enquiries concerning Postal, Savings Bank, Money Order, etc., services should be referred to your Post Office.

Advisory Committees for Post Office Services

The public are invited to bring before the appropriate Committee Secretaries: Mr. I. P. Peake, Leek Trades Council, 15, Westwood Grove, LEEK Staffs; Mr. D. Turner, British Pottery Manufacturers' Federation, Federation House, Station Road, STOKE-ON-TRENT (Stoke-on-Trent 48631); Miss E. Shaw, Craft House, 37, High Street, NEWCASTLE, Staffs (Newcastle, Staffs 67381); Mr. N. A. Stokes, Secretary, W. G. Bagnall, Ltd., Castle Engine Works, STAFFORD (Stafford 321)], matters relating to the Telephone Service in its wider aspects. Questions affecting individual installations such as faults, etc., should not, however, be referred to the Committee but to the appropriate service point as stated above.

How to use the Telephone

IF YOU HAVE A TELEPHONE WITH A DIAL refer to the dialling instructions in the following pages or to your list of Dialling Codes. The progress of a call is indicated by the following four tones (except for some of the smaller exchanges).

TONE	INDICATES
Continuous purring (dialling tone)	You may start to dial.
A double beat repeated regularly (ringing tone)	The number is being rung.
A single beat repeated regularly (engaged tone)	The number, or connecting apparatus, is engaged.
A continuous note (unobtainable tone)	The number is unobtainable.

The charge for a call is registered when the subscriber you are calling answers. Should you obtain wrong numbers, report this to the operator.

IF YOU HAVE A SHARED SERVICE TELEPHONE WITH A DIAL, lift the receiver and press down the "CALL EXCHANGE" button, where fitted. Release the button when you hear dialling tone (or after three seconds on the smaller exchanges) and dial the number you require.

If, on lifting the receiver, you hear conversation, your partner is using the line. Replace your receiver and release the button. Try the call again in a few minutes.

If you hear a series of rapid clicks it indicates that your partner is dialling. As lifting your receiver will have interfered with his dialling, wait on the line until he has finished dialling and explain what has happened, then replace your receiver so that he may dial again.

To call the other subscriber on your line, dial 0 (or 01) and when the operator answers, say "Party" and quote your partner's exchange and number, followed by your own exchange and number. When asked by the operator, replace your receiver so that she may ring your partner. Give him enough time to answer the telephone before you lift your receiver again to complete the connection.

IF YOU HAVE A TELEPHONE WITHOUT A DIAL lift the receiver and when the operator answers ask for the exchange and number or service you require. The progress of your call will be indicated by verbal announcements from the operator, or by one of the above tones.

IF YOU HAVE A SHARED SERVICE TELEPHONE WITHOUT A DIAL lift the receiver. When the operator answers, ask for the exchange and number or service you require and quote your own exchange and number.

If, on lifting the receiver you hear conversation, your partner is using the line. Replace receiver. Try the call again in a few minutes.

To call the other subscriber on your line, lift the receiver and when the operator answers, say "Party" and quote your partner's exchange and number, followed by your own exchange and number. When asked by the operator, replace your receiver so that she may ring your partner. Give him enough time to answer the telephone before you lift your receiver again to complete the connection.

When answering incoming calls do not lift the receiver while the telephone bell is actually ringing or your partner's bell may ring also.

THE RECEIVER SHOULD BE REPLACED FIRMLY ON ITS REST WHEN THE TELEPHONE IS NOT IN USE, otherwise you and other subscribers may lose calls.

Before dialling—WAIT for dialling tone.

1004 — (Section 111)

How to Make a Call

If your telephone **HAS A DIAL**	To call a subscriber on your own exchange, dial the number you require. **For all other calls refer to the instruction card or separate list of dialling codes.** If neither is available, dial 0 (or 01) and ask for the exchange and number, or service you require.	
If your telephone has **NO DIAL**	**Local Calls** .. .. / **Trunk Calls**	ask for the exchange and number you require. If you have a shared service line quote your own exchange and number.
	Directory Enquiries ..	ask for "Directory Enquiries".
	Enquiries (other than Directory) / **Faults** .. .. / **Service Difficulties** ..	ask for "Supervisor".
	Telegrams (Inland, Overseas and Radio) / **Telegram Enquiries** ..	ask for the service you require.

Call Charges and Services

Local Calls

A charge of 3*d.* is made for a call from a subscriber's line (without a coin-box) to another line on any exchange within the local call area; when the call is made from a call office or coin-box telephone the charge is 4*d.* Lists showing the exchanges to which calls can be made for 3*d.* have been sent to subscribers: additional copies may be obtained from the Telephone Manager.

Trunk Calls

For the calculation of call charges, exchanges are grouped and a central point in each group is used for the measurement of chargeable distances in calculating trunk call charges.

Distances between groups	Minimum charge for calls connected within the period	
	Monday to Saturday 6 a.m. to 6 p.m. Sunday 6 a.m.-2 p.m.	*6 p.m. each day (2 p.m. Sunday) to 6 a.m. next day
	s. d.	*s. d.*
Up to 35 miles ..	1 0	1 0
Over 35 and up to 50 miles ..	1 9	1 3
Over 50 and up to 75 miles ..	2 3	1 6
Over 75 and up to 125 miles ..	3 0	2 0
Over 125 miles ..	3 6	2 6

* These reduced charges are suspended on certain days at Christmas and New Year; if in doubt ask the operator.

When a trunk call is made from a call office or a coin-box telephone an additional charge of 3*d.* is payable by the caller. These rates apply to calls made within Great Britain, Northern Ireland and the Isle of Man, and to the Channel Islands.

Timing and Charging

The minimum chargeable period for an ordinary trunk call is three minutes, commencing from the time when the number wanted has been connected. All calls are timed in periods of one minute after the first (minimum) three minutes and are charged pro rata. Guidance as to the passage of time during a trunk call is normally given by an automatic signal consisting of a series of "pips" of sound, the first "pip" occurring approximately 12 seconds before the expiry of each 3-minute period; on certain types of calls the signal may not be available. Calls are charged for the full period for which the trunk connection to the distant telephone is held at the disposal of the caller, whether or not the "pips" are heard. The Postmaster General reserves the right to restrict the duration of any call. The actual duration and cost of a particular call will be notified on its completion for an additional fee of 3*d.* for each inland call. The request should be made to the operator to "Advise duration and charge" preferably when booking the call.

Answer the telephone with your name or number.

Automatic Error-Correction for Long Distance Radio Telegraphy

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

THE OUTLOOK OF INDUSTRY AND COMMERCE today may be summarized by saying that automation is a common objective.

Communications must pursue the same objective. The automatic telephone was probably the first step towards automation in telecommunications. In telegraphy, among such developments as automatic switching and routing and automatic reporting, we have automatic correction of errors during transmission over that largely unpredictable medium, high frequency radio. Automatic error correction on radio links is valuable in several ways; it ensures reliable automatic circuit selection by correct reception of routing signals, provides telex and private wire teleprinter service with the accuracy needed by a business office, and does this with an increase in the effective traffic capacity of the telegraph circuit.

During the past 30 years machine printing by the teleprinter has superseded virtually all other forms of printing telegraphy in the internal services of all major countries. The teleprinter is used in Europe for international telegraph communication by voice frequency telegraph circuits carried in telephone cables.

During the Second World War various methods of radio-teleprinter working were devised and the recent expansion of telex and telegraph leased services has further encouraged the development of high performance radio-teleprinter systems. The increasing use of teleprinters in the Commonwealth and elsewhere has produced a need for a radio transmission system designed specifically for teleprinter working and has led to the adoption of Automatic Error-Correcting (ARQ) systems for public telegram traffic, international telex (customer to customer switched service) and leased private wires.

Telegraph Systems Used

Radio signals in the 3 to 30 Mc/s band (high frequency) are affected by fading, multipath propagation, noise, and interference from adjacent radio emissions. Naturally, the objective of the radiotelegraph receiver is to mitigate these effects but they cannot be eliminated.

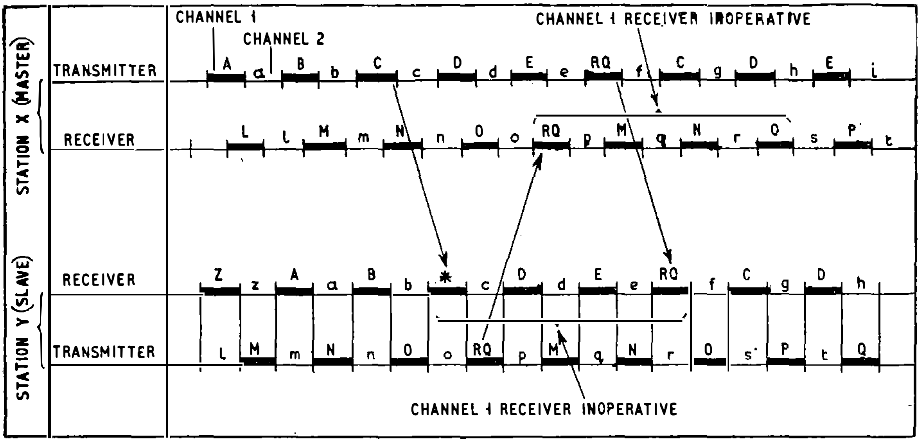
A radio transmission may employ a carrier which is amplitude-, frequency- or phase-modulated. Originally, most radiotelegraph transmissions were of the amplitude-modulated type, the modulating signal keying the transmitter so that the carrier frequency was either transmitted ("On") or suppressed ("Off"). This method is still used but it suffers from the disadvantage that during the off period of the carrier there is no signal to operate the automatic gain control (a.g.c.) of the receiver. The most common methods of operating telegraph circuits over main high frequency radio links are now:

(*a*) frequency-shift keying (including multiple frequency-shift keying),
(*b*) "on-off" keying, and
(*c*) an independent sideband (i.s.b.) modulated by multi-frequency tones.

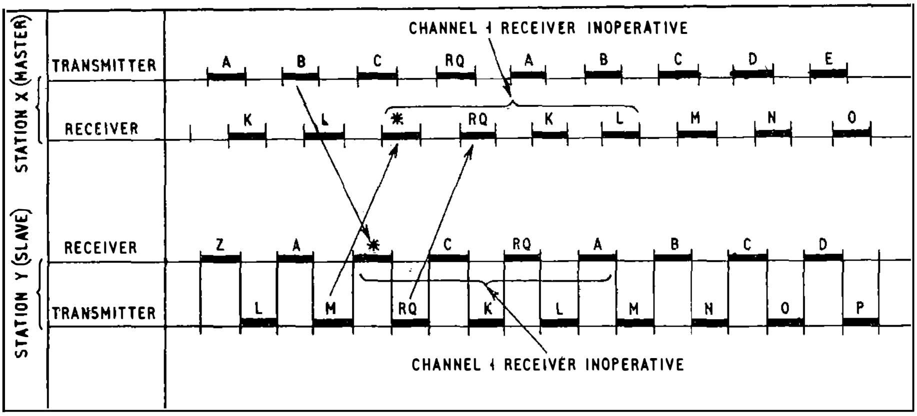
Phase modulation is seldom used.

Frequency-division telegraph transmission on an i.s.b. channel is attractive because of its economic use of radio bandwidth and equipment.

Time-division working implies that each of a number of telegraph channels is given in rapid



(*a*) *Simple Mutilation in One Direction of Transmission*



(*b*) *Simultaneous Mutilation in Both Directions of Transmission*

The Master station controls the telegraph speed of the whole system. The Slave station must remain in a locked relationship with the Master station both when receiving and transmitting.

Fig. 1 (a) and (b) Timing of 4-character repetition cycle

succession exclusive use of a common transmission path which may be provided by any one of the three methods above. Synchronized transmitting and receiving "distributors" allocate each channel to the common transmission path for a fixed period. This will remind older telegraphists of the Baudot system.

Special methods of input involving storage are used to present the 5-unit start-stop signals to the system at the correct instants. This is called "synchronous working" but it does not use special synchronizing signal elements as in ordinary start-stop teleprinter working, as it derives synchronism from transitions of the code elements.

Synchronous working gives two major advantages; it provides for examining elements on an accurately-controlled time-base which gives practically double the distortion margin compared with start-stop working, and it obviates loss of synchronism of the receiving teleprinter which would result from the loss of a "start" or a "stop" element. Loss of synchronism could result in a sequence of incorrect characters being printed before the teleprinter gets back into the stop condition correctly and is ready to print properly synchronized characters. The use of high accuracy oscillators for controlling each terminal of a time division system ensures that synchronism is not lost during a complete fade-out of the radio link for periods up to 15 minutes.

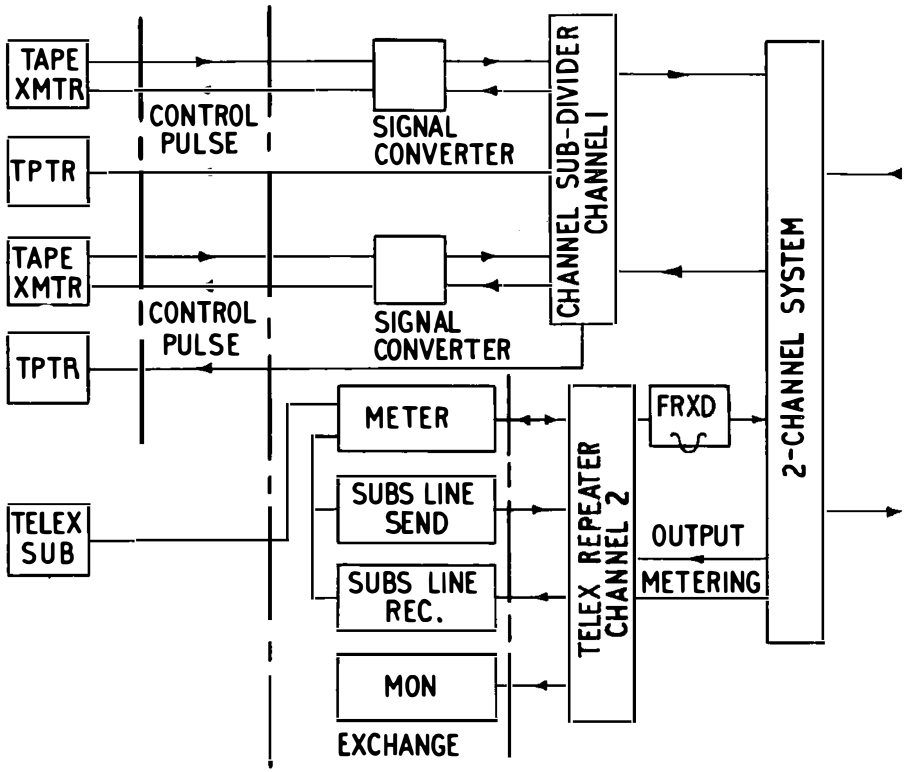


Fig 2: Ancillary equipment

The 5-unit code, owing to its lack of "redundancy" (that is, unused combinations) will produce a combination used by another character if any signal element is mutilated.

Although five is the minimum number of elements needed to transmit each character of the 5-unit alphabet, a sixth element may be needed to transmit the additional supervisory signals of "call" and "clear" for telex working or some other special facility.

Much thought has been given to the use of a signalling code which will ensure detection, and possibly correction, of mutilations. An obvious way is to send the five intelligence elements twice and compare the received results. If the results are identical the character can be assumed to be correctly received. This method has the disadvantage that, for each character transmitted, the number of signalling elements is doubled, so the traffic capacity of a telegraph system is halved.

Other codes have been devised which use extra elements to check the "intelligence" elements and even to correct some mutilations, but this again increases the number of elements used and so decreases the traffic capacity of the link. The value of an error-*correcting* code must therefore be assessed in terms of circuit capacity, because the code must be used all the time, even when the radio link performance is good. By comparison, the code used with an error-*detecting* system contains fewer extra elements than an error-*correcting* code and so, during good radio conditions, will clear more traffic; when used with an automatic repetition device the traffic clearance rate will be reduced only as errors occur on the radio link.

However, such systems require the simultaneous serviceability of both directions of transmission of the radio circuit. On balance it is considered that the use of an error-detecting code with automatic repetition to provide correction offers the best commercial solution, though the consequent use of seven signal elements means increasing the bandwidth required for transmission compared with the unprotected 5-unit signal.

An economical error-detecting code can be formed by adding two elements to the five intelligence elements of each character and several inventors produced codes with various methods of error-check. However, J. B. Moore, of the Radio Corporation of America, invented a code in which each character included three mark and four space elements, this being the common characteristic checkable for transmission error. Common radio mutilations consist of simple changes of mark elements into space elements or *vice versa*, and as these obviously upset the mark/space ratio of the code they are detectable as errors. However other types of mutilation, fortunately far less common, do not alter the 3:4 ratio and are therefore undetectable as errors.

Using seven elements for each character there are 35 combinations of mark and space elements which give a 3:4 ratio. This allows the necessary 32 combinations for the 5-unit characters and three special combinations. Dr. Van Duuren of the Netherlands Administration adopted the code invented by J. B. Moore and designed an automatic error-correcting system based on the detection of a mutilation and the retransmission of the faulty character until it is correctly received.

International committees for telegraphy and radio have recommended the adoption of this 7-unit code and certain other features of the Van Duuren system. Incidentally, the terms "mark" and "space" are being replaced in international terminology by designations "Z" and "A".

Principles of the Van Duuren System

Both two and four-circuit systems are in use but for convenience I shall describe a two-circuit system. (A circuit is a bothway telegraphic path, comprising a "go" channel and a "return"

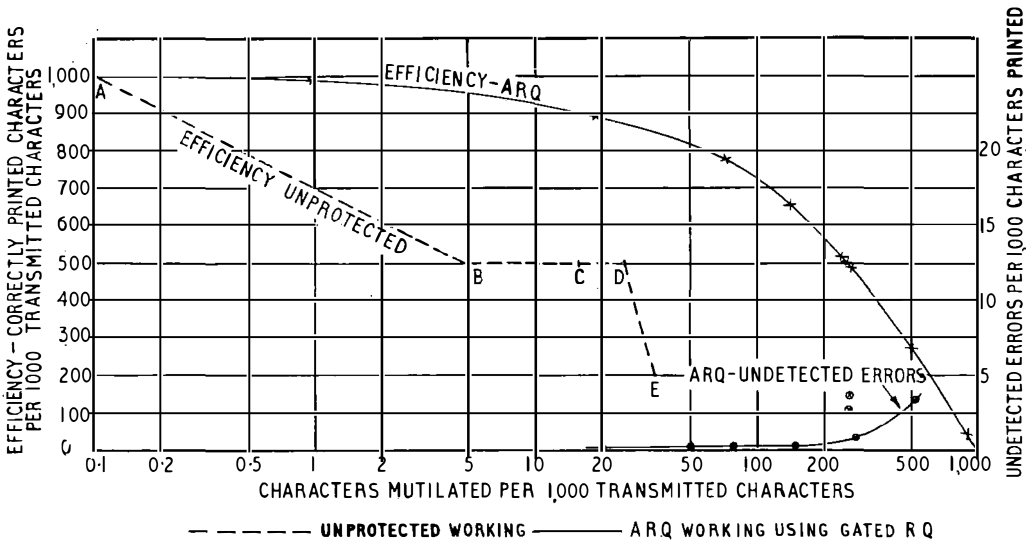


Fig. 3: Radio telegraph test results with and without ARQ operation

A–B Transmission of traffic once—termed ZSO working.

B–C Transmission of traffic twice—termed ZST working.

C–D Poor transmission, may be ZST or unusable—termed ZSU.

D–E ZSU.

The points B, C, D, are approximate values, determined by the receiving operator and the nature of the messages.

Where there is some redundancy of words a worse mutilation rate can be corrected by the operator than could be corrected for ordinary messages or messages in code.

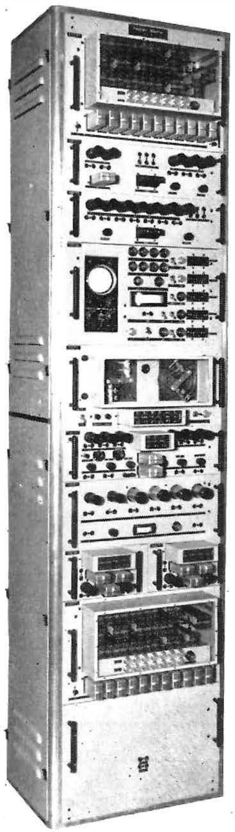


Fig. 4: Electro-mechanical 2 circuit TOR
(Courtesy, Hasler A.G., Bern)

channel). The automatic repetition cycle operates on a circuit basis so that repetition can take place on either circuit independently.

Each character received from the start-stop transmitting apparatus or machine is converted from the 5-unit code to a selected 3:4 ratio 7-unit combination. It is transmitted over the radio link and recorded in a store which holds it pending any demand for repetition. If no repetition is demanded the stored character is destroyed. The number of characters required to be stored depends on the loop propagation time of the radio circuit, but three caters for the majority of cases and is the internationally agreed "preferred" size of store. At the receiving terminal each combination of the incoming radio signal is examined for the 3:4 mark-to-space ratio. If correct, the combination is translated by means of a decoder into the 5-unit code and sent as a start-stop character to the receiving teleprinter. Meanwhile, traffic is passing similarly in the opposite direction on the return channel; this is shown in Fig. 1 (*a*).

Correction of a Single Mutilated Character

Now assume that the character "C" transmitted from station X to station Y is mutilated. If the 3:4 ratio is affected the examination at the receiving station will detect the error, stop printing for a period of four characters, and initiate the transmission of an RQ signal (request for repetition) over the return channel. This RQ signal is a special 7-unit combination included in the 35 combinations provided by the 3:4 code. The RQ signal is injected into the return channel as soon as the timing permits and suspends traffic on the return channel, but as this traffic is prevented from being transmitted no characters are lost. In practice each character is "called" into the channel sender, and by interrupting the pulse which calls in the character the RQ signal can be injected in lieu; this is followed by a repetition from the cyclic store of the preceding three characters to have been transmitted. The purpose of this will be seen later.

The arrival of the RQ signal at the originating station X suspends normal transmission of traffic to Y, but causes the transmission of an RQ signal followed by the last three characters previously sent from X, which are still recorded in the store in their correct sequence. Since the incorrect reception of "C" at station Y stopped transmission to the local teleprinter for four character periods, the transmission from X of the RQ signal and of the three characters from store causes a second reception of "C" immediately after the teleprinter is again ready for reception. Because, in effect, four characters are lost from each channel, and the effect of a three-character store is to repeat transmission of a mutilated character four character-periods later, no extra characters are printed and no characters are lost during the RQ cycle, though circuit time is lost. This applies for any propagation time up to the limit set by the number of characters of the store, by special timing arrangements on the equipments.

To ensure that the radio conditions have improved before printing is resumed, the RQ signal is checked not only for 3:4 ratio but also for the correct sequence of marks and spaces. This feature is called "Gated RQ" and in practice it results in an appreciable reduction in the occurrence of undetected errors. The repetition of "C" is again tested for 3:4 ratio before it is printed; if it is found incorrect, a further repetition is initiated.

I have said that when the receiving station Y detects a mutilation, the RQ signal is injected into the return channel to the sending station X followed by the three characters just transmitted. This in turn causes the sending station X to transmit an RQ to the receiving station Y. If the return RQ signal is mutilated the detection of it as a mutilation at the receiver will cause a request for repetition. If the RQ signal is correctly received it causes no action in respect of the return channel from the receiving station and printing is resumed at the end of the 4-character cycle. It can be proved that, by using this 4-character repetition cycle in each direction of transmission, the system is immune from breakdown by mutilations to any character during a repetition cycle, and it provides for the correction of mutilations in both directions of transmission as shown in Fig. 1 (*b*).

With certain ARQ equipments as an alternative to error-correction, errors can be indicated by printing an "error" symbol on the receiving teleprinters in place of the mutilated character. This facility may be useful at times when a return channel is not available.

The Van Duuren system has certain disadvantages which add to the complication of the arrangements. A disadvantage is that a mutilation requires a loss of four character periods in the traffic being carried in each direction of transmission in order to correct the error by repetition. Secondly a traffic store is necessary so that the multiplex equipment can take up by "pulsing" characters as required for transmission. These pulses will be suspended while repetitions are occurring. Two methods are in use at the present time on error-correcting circuits.

One method is signalling directly into the ARQ system from a pulsed tape transmitter, which may be at a customer's office.

The alternative method is storing incoming telex traffic in punched tape form ready for subsequent transmission from a pulsed tape transmitter adjacent to the ARQ equipment. This requires a special machine known as a Reperforating Retransmitter or FRXD. These arrangements are shown in Fig. 2 which also shows the arrangements when sub-divided channels are used. Sub-dividing provides a renter with transmission at either 200 or 100 characters a minute in place of the normal 400 characters a minute, with saving in cost.

In an ARQ system using the second method the amount of tape stored in the machine will increase

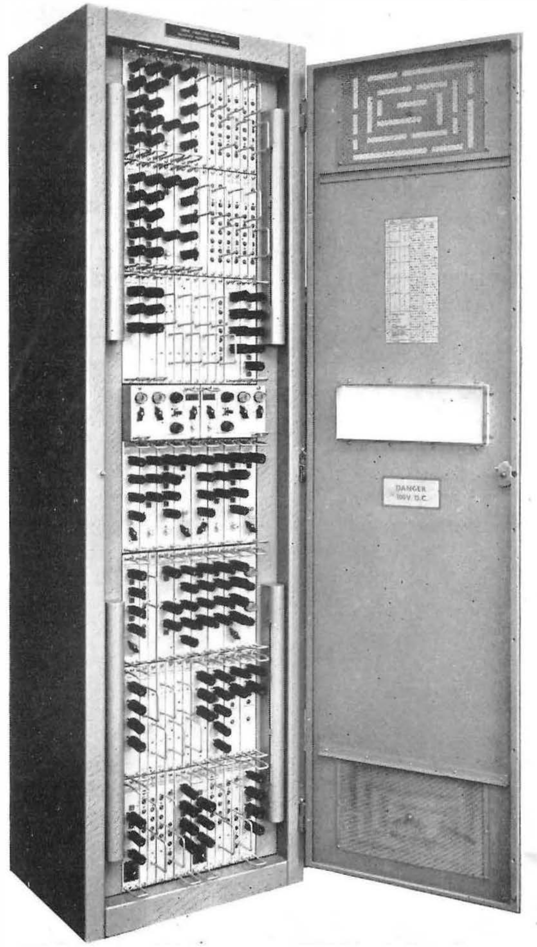


Fig. 5: Type HU 20 automatic error detection and correction equipment
(Courtesy, Marconi's Wireless Telegraph Co. Ltd.)

during radio disturbances, but will decrease during good transmission conditions.

The first method is attractive in that the sender is aware of any delay occurring in clearance of traffic, but a pulsing circuit must be provided in addition to the signalling circuit to the renter's premises.

This description shows that an error-correcting system inevitably produces complications and is in itself a complicated equipment. To decide whether the complications are worth while, the problems of the customer and the improvements the system offers must be considered.

While it might appear that when a printed error is received on a teleprinter the receiving operator should detect it, a little consideration will show that this is not always possible, for a mutilation may change a letter and still give a readable word, or the message may be in code form or figures. Of course, when an operator sees a mutilation, a request for repetition (RQ) of part of the message can be sent manually, but such repetitions are laborious and expensive in circuit time. Undetected errors may be very serious.

When the circuit error rate is between two and five errors in every thousand characters printed, a circuit is barely commercial, because of lost circuit time and waste of operators' time. This, of course, allows that most but not all of the errors are detected by the receiving operator; obvious errors, thanks to the fact that errors in individual letters often raise no doubt about the word intended, are corrected without reference back to the transmitting end. However, certain errors must be referred back, or arrangements made for transmitting each message twice and for correcting by comparison of the received messages; this is termed "slips-twice" working, which reduces the circuit capacity to one-half and leaves the work of correction to the receiving operator. The corrections so made may be obvious to the recipient of the message, causing suspicion and lack of confidence in the message and the service.

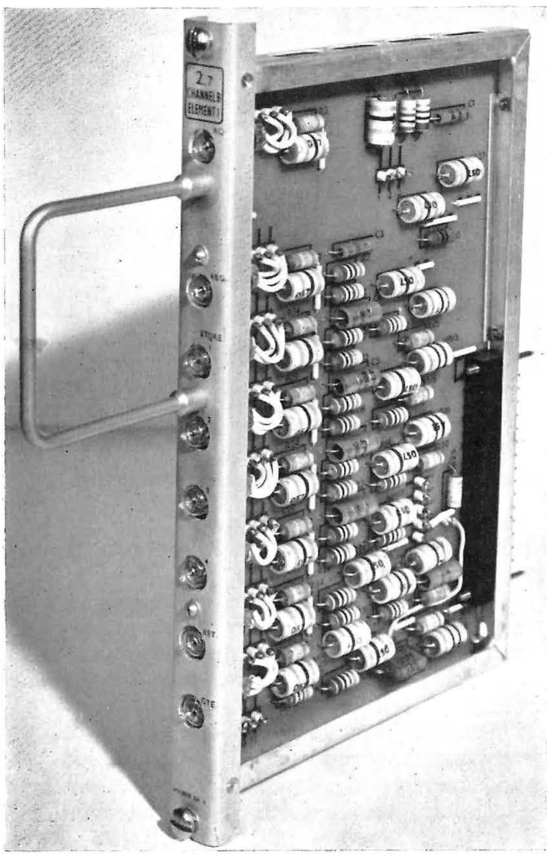


Fig. 6: Typical printed-board unit of type HU 20 equipment
(Courtesy, Marconi's Wireless Telegraph Co. Ltd.)

The use of automatic error-correction ensures that only the minimum repetition is demanded and maintains the channel for traffic use except when mutilations are actually occurring.

The introduction of ARQ operation enables a circuit error rate of 2-5 errors in a thousand characters to be improved to better than 1 in 100,000 and the curve in Fig. 3 shows the high traffic-clearing capacity of the telegraph channel even under the conditions of increasing error rates that may arise in typical radio conditions.

The mutilation rate on a long-distance radio-telegraph circuit varies widely during each day from good reception to complete fade-out, and necessitates the change to a lower radio frequency for use during the night. The proportion of good reception time depends on many factors. Obviously the value of ARQ on any circuit depends on the mutilation rates encountered during a 24-hour period, and on the long-term effect of sunspot activity on radio propagation. The improvement in mutilation rate afforded by the use of the 3:4 code can be assessed mathematically.

However, use of the RQ cycle with gated RQ gives a further improvement, because when this refinement is used the probability of an undetected error following immediately after an RQ cycle is the product of the very high protection afforded by the check of the RQ signal and the protection afforded by the 3:4 ratio check. This can be calculated for controlled conditions, but calculation would be difficult for radio conditions where the signal level varies continuously and at random. Under such conditions the receipt of a genuine RQ signal may be followed by a fade, when the effectiveness of the check of the RQ cycle is that of the 3:4 test alone. Under radio conditions the use of gated RQ can give a reduction in the undetected error rate of 5 to 1 compared with ungated RQ.

In Fig. 3 typical test values of undetected errors have been plotted against the character mutilation rate existing on the radio circuit. For example, with a circuit mutilation rate of 100 in 1,000 the undetected errors were about 0.4 per 1,000 characters printed, an improvement of more than 200:1. Fig. 3 shows that at this error rate of 100 in 1,000 the efficiency of the ARQ circuit is about 74 per cent. at a time when the unprotected circuit is not commercial.

These results are for instances of errors in one direction only, and the efficiency of the return channel would be correspondingly reduced. It has been claimed that the improvements shown in the table below are achieved by ARQ working. The greater improvement at lower signal mutilation rates is because of the increasing probability of only single element errors, which are always detected.

The net value of ARQ must be assessed for a particular link from consideration of the increase in traffic capacity, integrated over the 24-hour period, bearing in mind the periods during which radio transmission is poor, the saving in operators' time resulting from automatic correction and from providing "clean" copy suitable for the customer, and the facility of working automatic and switched services in a reliable manner.

The international recommendation that the error rate for telex services should not exceed 10 errors in 100,000 characters can be achieved by using ARQ, except in the worst transmission conditions.

Use of the Van Duuren ARQ system

At present (November, 1959) the services operated from Electra House, London, on an ARQ basis include Berne, Bombay, Buenos Aires, Osaka, Nairobi, New York, Lagos, Pretoria, Rio de Janeiro, Singapore and Sydney. The circuits provided include 16 for public telex service, seven leased circuits (full speed), and seven circuits sub-divided into a mixture of ¼ and ½ speed circuits; of these, 13-¼ speed and 5-½ speed circuits have been leased. (Others remain spare pending demands for them).

Improvement in Error Rate Achieved by ARQ Working

Signal Mutilation Rate	Undetected Error Rate with ARQ Working	Improvement
1/10 i.e. 1 in 10	1/1,000	100/1
1/100	1/100,000	1,000/1
1/1,000	1/10,000,000	10,000/1

The 21 systems now operating from Electra House should be increased to a total of about 80 in the next five years.

Equipment in use

Most of the equipment at present in service uses electro-mechanical components: for example, Baudot-type distributors and polarized and non-polarized (telephone type) relays. Fig. 4 illustrates such an equipment of Swiss manufacture.

However, British electronic equipment is now available. A two-circuit terminal is illustrated in Fig. 5. Typical units, of the plug-in "book"-type are shown in Figs. 6 and 7. These units employ printed wiring and both cold cathode tubes and "hot" valves. Fig. 7 illustrates units extended for test purposes.

Conclusions

The Van Duuren system has proved its efficiency over the past four years by providing a reliable radio teleprinter system accurate enough for manual telex and leased circuits. With certain further safeguards fully automatic working can be provided over ARQ circuits for telex and other automatic-switching services. The significant result of ARQ working is that the improvement in the circuit performance—reliability, increased efficiency and low error rate—has increased the demand for circuits, particularly leased full character rate and part character rate services. I believe that further extension of 4-channel (in place of 2-channel) ARQ working must follow to give the most economic use of certain radio links.

It is difficult to improve on the Van Duuren principle but detailed improvements are being considered. The International Radio Consultative Committee has recorded a recent suggestion by the Post Office and Cable and Wireless Ltd. This concerns the automatic re-phasing of ARQ systems—loss of phase may occur through oscillator drift during long fade-outs, or because of a change of propagation time following a radio frequency change or the re-routing of a circuit. This device would practically eliminate day-to-day attention to the ARQ equipments, which then could truly be called "automatic" error-correcting.

Improvement can be expected in reductions in size and power consumption of the equipment. These reductions are based on the adoption of transistors, or transistors and ferrite cores, as the basic circuit elements. Transistor designs have been proved and prototypes designed by at least two manufacturers are on field trial. The unknown

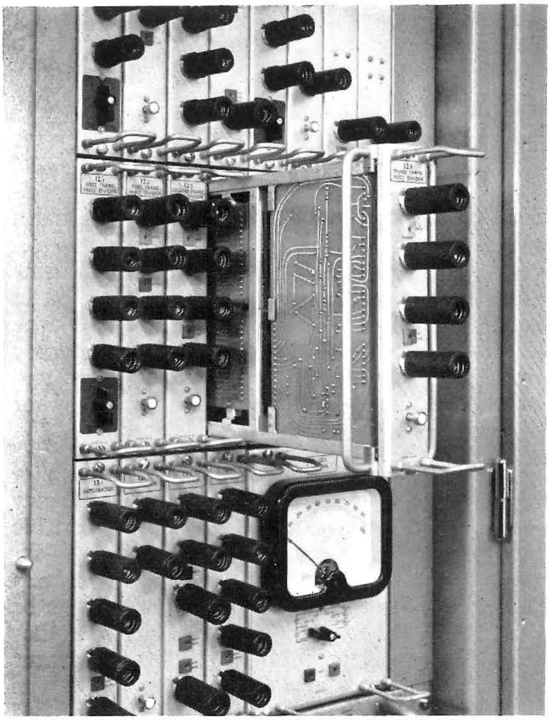


Fig. 7: The units can be readily extended to give access to both sides
(Courtesy, Marconi's Wireless Telegraph Co. Ltd.)

factor of maintenance cost for transistor equipment can be determined only by experience with working equipment. Claims by the designers suggest that maintenance attention should be less frequent but against this there may be more difficulty in locating and clearing faults. Maintenance must be tackled logically and further improvements in facilities add to the complexity of analysing a fault condition. Experience with earlier types of ARQ equipment is of great value in approaching the new types.

Trunk Mechanization at Manchester

The opening of Pioneer Trunk Non-Director exchange in November completed trunk mechanization at Manchester, the first stage of which was the opening of Guardian Trunk/Non-Director in December 1958.

All trunk and toll calls to and through Manchester, with few exceptions, are now dialled by operators via one or other of the automatic exchanges—Pioneer, Guardian or Trunk/Director.

Apart from the resultant reduction in trunk incoming positions in Manchester, the Plug-ended B and Key-sender B Positions became redundant with the opening of Pioneer and in the early hours of Sunday November 15 these suites were retired after more than 25 years' service. It is unlikely that their passing will be mourned.

By comparison with Guardian (1,500 circuits) Pioneer, with nearly 5,000 trunks and junctions, provided quite a problem in planning a method of opening which would enable switching such a number of circuits from existing networks without major disruption of service. The problem of changes to Visible Index Files at outstations had also to be borne in mind particularly at those exchanges with both Toll and Trunk routes to Manchester. The smoothness of the transfer, which took place over two consecutive nights, Friday and Saturday, paid adequate tribute to the co-operation given by outstation exchange staffs.

In addition to switching and testing the large number of circuits a considerable portion of the switchboard multiple in Telephone House, Manchester, had to be relabelled. This task, involving 10,000 labels on 470 positions, was accomplished by working continuously Friday to Sunday.

One could well have expected that after such an effort there would have been some desire for a respite by engineering and traffic staffs. A fortnight later however the job of providing a "joint trunk" multiple over the Trunk, Toll and Millgate Trunk Control suites in Telephone House was tackled.

Before Pioneer was opened, the large number of circuits in the separate Toll and Trunk multiples had prevented the introduction of a common multiple even with the high type of switchboard fitted at Manchester, but with the reduction of manual board routes following the opening it became possible to make these multiples common. From a multiple rearrangement point of view this was a much bigger task than the Pioneer change. Working over the weekend November 28–29, joint operating, traffic and engineering teams transposed more than 2,000 circuits in the multiple and changed 26,500 labels. The consequent modification of free line signals involved recovering 57,000 switchboard lamps.

This latest change prepares the way for the introduction of the "100" code, replacing "TRU" and "TOL", in Manchester.

Telephone Arrangements in Lighthouses

R. M. Watson

In our last issue Mr. Watson outlined the work of the Post Office Telecommunications Advice Service giving as an example the work done for the Rootes (Motor) Group. In the following article he tells how the Service helped to improve communication for lighthouses.

THIS EXAMPLE OF ADVISORY WORK, WHICH was undertaken at the request of the Corporation of Trinity House, may be rather a small assignment for the Headquarters Telecommunications Advice Service. Nevertheless, it does demonstrate clearly that, even when the requirements seem simple and clear, they need a good deal of care and consideration; also, that if similar facilities are required at a large number of places throughout the country, such a task is more easily and efficiently handled by a centralized team.

The Corporation of Trinity House, who have been responsible since 1854 for all lighthouses in the United Kingdom, asked the Post Office to examine the telephone arrangements in lighthouses and to advise them on the possibility of standardizing these arrangements.

Most of the shore based lighthouses at present use cordless telephone switchboards, usually with one or more exchange lines connected to them, with a number of extensions serving a number of points on the station. Experience has shown that these switchboards are not entirely satisfactory because incoming and outgoing telephone calls need to be extended and cleared down manually and there is always the inherent possibility of mis-operation when this work is a part-time job for officers who have other duties and responsibilities. The Corporation were anxious to have an arrangement by which incoming exchange calls could ring and be answered direct at any point on a lighthouse station, and for outgoing exchange calls to be made direct from any of these points.

On a typical station there are, in general, four places where a Duty Officer can be called on to answer or make a telephone call: the Watch Room, immediately below the Lamp Room at the top of the Tower; the Control Room at the base of the Tower; and the Principal Officer's House and the Fog Siren Point, which may be some distance from the lighthouse tower itself.

A further complication also arises when considering a suitable standard of facilities, as many lighthouses have a dependent sea based "daughter station" which normally communicates by a radio link with its parent lighthouse. The Corporation wanted these "sea based daughters" with their radio links incorporated in any telephone system that might be developed so that they could both receive and make exchange calls over the exchange line serving the Lighthouse Station in addition to communicating with the lighthouse.

Members of TAS visited a typical lighthouse—Dungeness—and examined the existing arrangements, discussing the problems on the spot with the lighthouse officers and with Trinity House research and development specialists. They considered many of the possible complications to be found at lighthouse stations, such as problems of power supply to the lighthouses, the fact that they were often in very remote places, usually in areas served by UAXs often using vibrator ringing supply, the difficulty of Post Office provision and maintenance, and separation of many of the points such as Fog Siren Point and officers' houses from the Lighthouse Tower.

To meet the Corporation's expressed wishes for simple standard facilities which could be used at similar lighthouses, a possible combination of standard Plan 7 and 1A extension facilities was first considered. After examination by Post Office Engineering Department ("S" Branch) experts, this combination proved impracticable for a number of technical reasons, and other standard facilities were then considered and examined, keeping in mind the ultimate aim of simplicity. Eventually a "round table" discussion between the Post Office Telecommunications Advice Service and Engineering Department and Trinity House research and development specialists, was held and this pooling of experience, knowledge and ideas

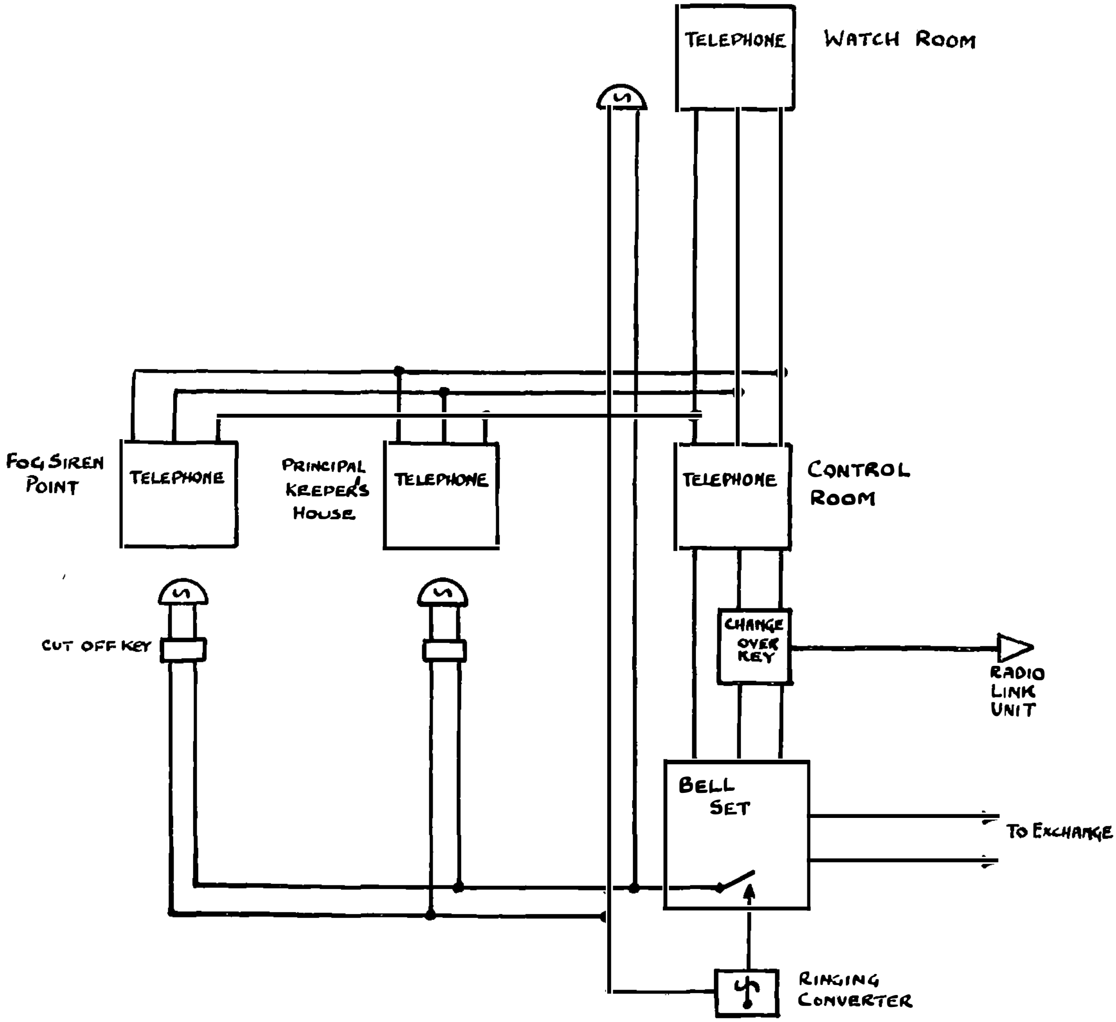


Diagram of facilities provided

produced an arrangement of telephones which everyone thought would meet the Corporation's requirements.

This proposed system was examined on the drawing board and underwent certain laboratory tests before being installed experimentally at Dungeness by the Canterbury Telephone Manager. Although Dungeness has no sea based daughter station the interconnexion arrangements of a radio link were tested at the same time.

Briefly, the facilities provided at Dungeness consisted of one exchange line terminated in the Control Room of the tower on a modified bellset. Connected in parallel to this bellset were four telephones in a Plan 1A arrangement. One telephone was associated with the bellset in the Control Room, one installed in the Service or Watch Room at the top of the tower, one in the Principal Keeper's House, and one at the Fog Siren Point. Both of the last two were external to the Lighthouse Tower. The arrangements are shown in the simple diagram.

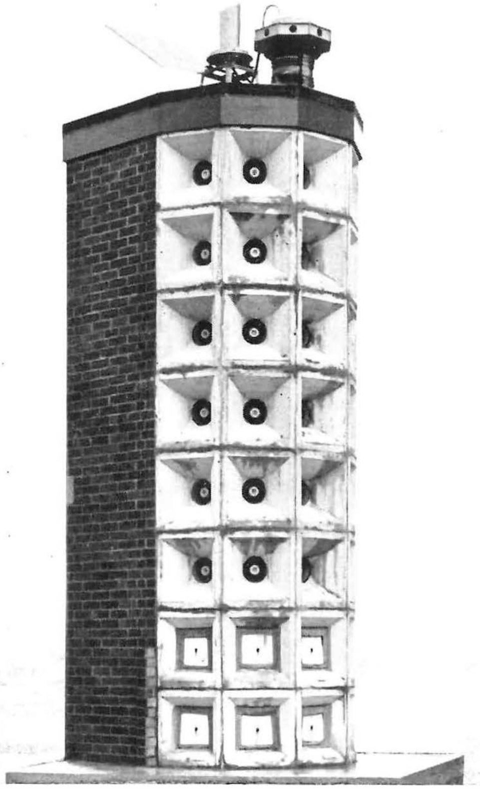
An incoming exchange call rings the bell in the modified bellset and also operates a relay in the bellset which switches in a ringing convertor operated from the local power supply. The ringing convertor, over a separate pair of wires, rings the bells associated with the telephones in the Watch Room, Principal Keeper's House and Fog Siren Point. Thus, on an incoming call, all bells are rung simultaneously at all telephones and the call can be answered at any one of these points. Associated with each of the bells rung from the locally operated ringing convertor is a cut off switch which trips the ringing convertor and so ceases ringing supply to the bells operated on this circuit.

No intercommunication is provided between any of the telephone points; Trinity House use a separate omnibus bell system of their own to warn officers when they have to answer a telephone call personally; but a call can, of course, be made from any point to the public exchange.

Associated also with the modified bellset is a special changeover switch or key to which is connected the terminal equipment of the radio link to the "sea based daughter" installation. Operating this switch permits connexion of an exchange call over the radio link to the sea based lightship and enables this distant installation to make a call over the radio link into the exchange.

The arrangement has worked extremely well at Dungeness and although one or two minor modifications may be required, involving the periodicity of the ringing supply to some of the bells, the facility seems to be the simple sort of low cost arrangement that the Corporation of Trinity House want for other lighthouses.

At a time when the Corporation are developing a fully automatic lighthouse, using a lamp no bigger than a household electric bulb but giving a light three times more powerful than the existing 212,000 candle power paraffin light; when electronic fog detectors are used and multiple electronic sound producing devices are replacing engine driven mechanical equipment as fog sirens, and when Post Office lines may be used to assist in controlling all lighthouse operations, it seems paradoxical that the telephone arrangements should move towards simplification. The new standard arrangements tested at Dungeness are really nothing more than a modified Plan 1A facility provided "off the shelf" for any business office by any Telephone Manager. But the Telecommunications Advice Service gave a great deal of thought and undertook a good deal of research before agreeing to this simple installation.



(Courtesy, British Communications and Electronics)

This bank of 32 public address loudspeakers is the new style foghorn. Such an assembly with the number of speakers doubled would be built into the structure of a new type of lighthouse. The note produced is unmistakable

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Freefone extended—"Freefone" service, provided for a Cardiff subscriber in December 1958 (*Journal*, Winter (November) 1958) is to be offered throughout the country. The service enables business subscribers to invite or allow customers to call them without payment, the charge being made to the Freefone subscriber. Special ex-directory exchange lines may be reserved, on the subscriber's request, for connecting Freefone calls.

The experimental service in Cardiff allowed only trunk calls; local calls also will be permitted now the service has been extended.

The Manufacture of Transmission Equipment

A. V. Hughes, B.Sc.(Eng.), A.M.I.E.E.

TRANSMISSION EQUIPMENT IS USED TO enable speech currents, music, television and other signals to be sent over cables and radio links, the type and amount of equipment used depending on the manner in which the signals are transmitted. It may take the form of simple audio amplifying equipment to make up for cable losses, or it may be far more complex and involve frequency translation into the megacycle range, as for coaxial cable systems.

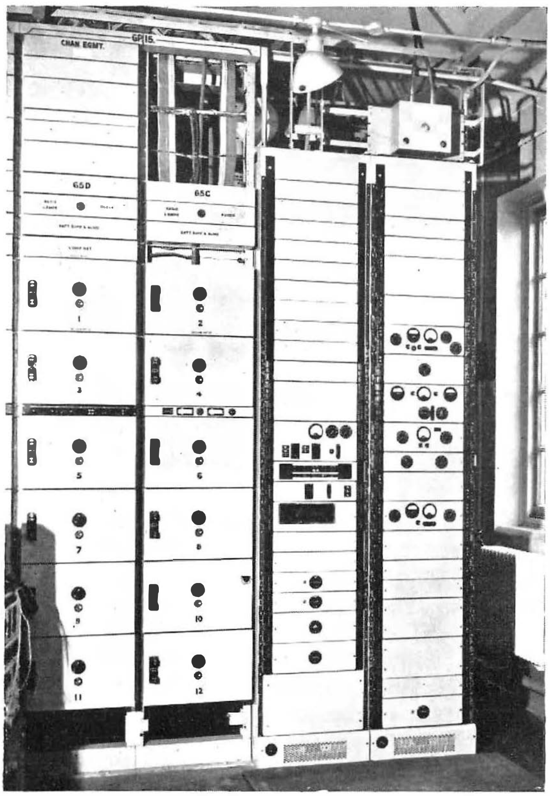

Fig. 1: OEP and 51-type equipment side by side

Normally, transmission equipment is housed in repeater stations, which may or may not be associated with telephone exchanges and the terminals of radio systems. For instance, intermediate coaxial line equipment is usually installed in small brick built huts which are to be seen at intervals along the sides of many of our roads.

Transmission equipment can perform many functions and different types of equipment can be installed side by side. A measure of standardization as regards rack size and appearance is therefore highly desirable.

Types of Equipment Construction

Before 1951, the normal rack height in main repeater stations was 10 ft. 6 in., but nowadays this has been decreased to 9 ft. Smaller sizes of rack are made for certain applications. These sizes conform to internationally agreed standards which state that the height of a rack should not exceed 320 cms and the overall depth of a double sided rack should not exceed 45 cms.

The earlier form of construction is known as O.E.P. (Old Equipment Practice) or pre-51-type. The current standard is 51- and 56-type construction, although quantities of O.E.P. are still bought for extensions in existing repeater stations.

O.E.P. construction is very simple, but is not very suitable for modern equipment. It consists fundamentally of a steel channel framework, to which steel mounting plates are attached. These plates, covered by box type dust covers, act as chassis for the circuit components. Each assembly is permanently wired to the rack cabling via a tag block.

51-type construction is quite different. The racks are made from pressed steel sheet, and panels, complete with dust covers, are incorporated on a jack-in principle. 56-type equipment is a modification of 51-type in so far as the panels have been replaced by a number of jack-in units; this is a natural outcome of the reduction in the size of components. Both 51- and 56-types of equipment use sub-assembly units for easy manufacture and maintenance. Wherever possible, components are mounted and interconnected inside cans, which may or may not be sealed. In fact, the main unit in 56-type construction is the can, inside which the components are mounted on insulating boards with very little space left unoccupied.

Fig. 1 shows pre-51 and 51-type equipment side by side for comparison purposes. The panel sizes, also standardized, are a function of the complexity of the particular circuit, and the number of components involved.

Channel Equipment

It may be opportune here to describe briefly a particular item of transmission equipment, for example a "Channel Equipment", to indicate the general principles involved in the design and manufacture of transmission equipment as a whole.

A carrier or coaxial system is one in which a number of speech circuits can be transmitted over one pair of wires or over one coaxial tube. This is done by shifting the frequency bands by a series of modulation and demodulation processes, each speech circuit occupying a separate "space" in the frequency spectrum transmitted to line.

The basic unit of a carrier or coaxial system is the 12 channel group. This consists of equipment assembling 12 speech circuits (nominal bandwidth 0–4 kc/s; actual bandwidth 0.3–3.4 kc/s) occupying the frequency spectrum 60–108 kc/s, channel 1 using the bandwidth 108–104 kc/s, channel 2, 104–100 kc/s and so on. The equipment which performs the translation from the lower to the higher frequency range and vice versa, is commonly called a "Channel Equipment".

A complete 9 ft. rackside of channel equipment in 51-type construction caters for two 12 channel groups, whereas in 56-type construction, when transistors are used in place of valves, six groups can be accommodated on a rackside. In future it may even be possible to improve on this.

Fig. 2 shows a block schematic of part of a channel equipment and indicates the modulation and demodulation processes involved. It will be

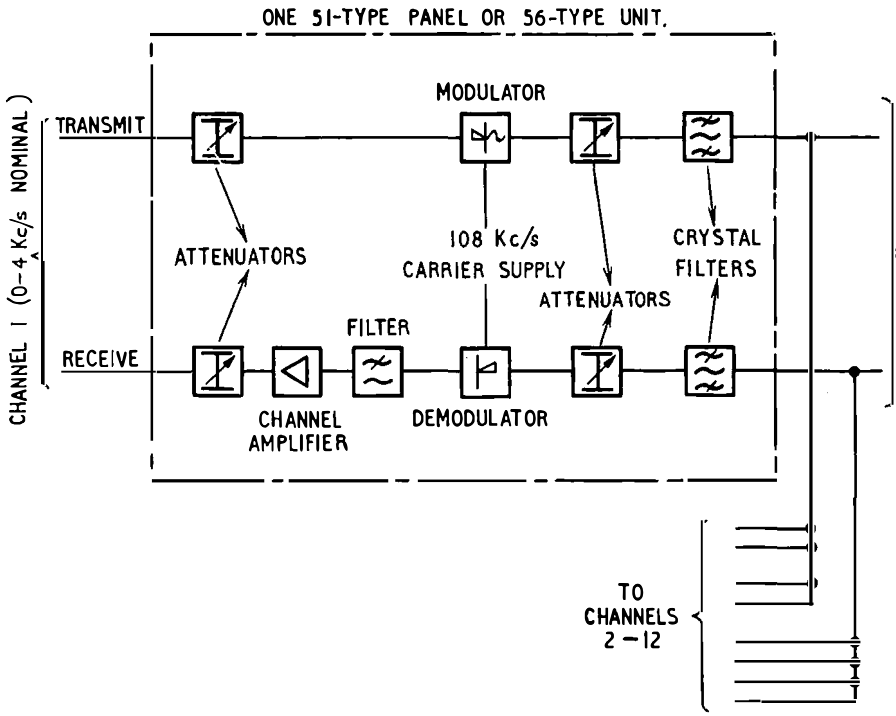

Fig. 2: Part of a channel equipment

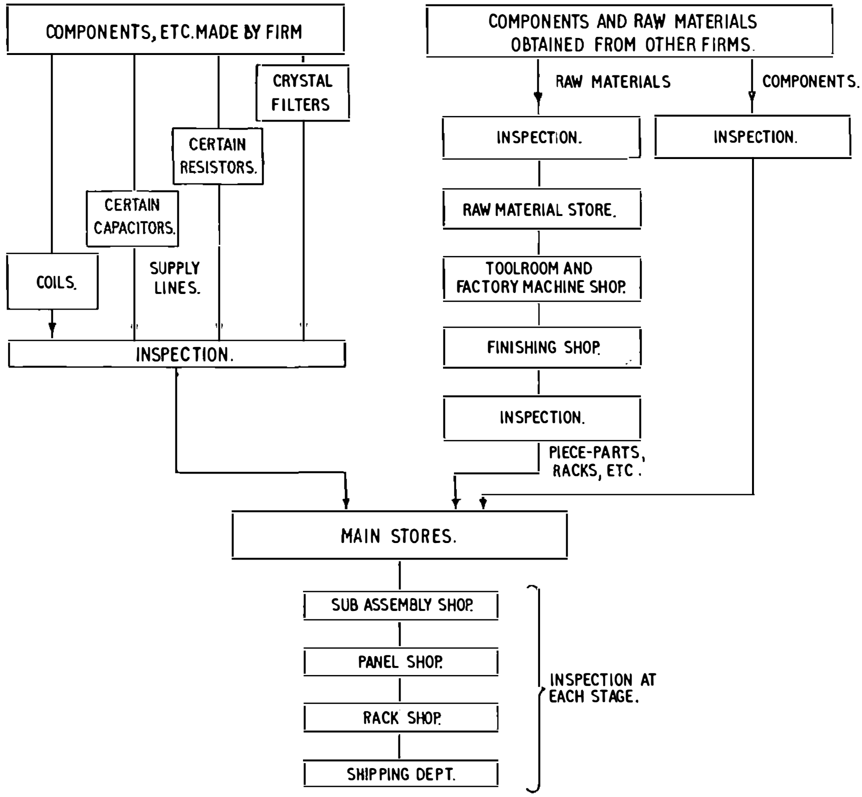

Fig. 3: Simplified arrangement of factory organization

seen that one panel of 51-type equipment, or one unit of 56-type, incorporates all that is shown within the dotted line. It must be appreciated, therefore, that before such equipment can be made, a great deal of engineering and design must take place, first in producing a "breadboard" model that conforms electrically to the specification for the equipment, and secondly arranging for the necessary component parts, sub-assemblies, attenuators, filters and other components to fit into the panel or unit, in such a way that it can be mass produced. Ample time therefore must be allowed for this work when a completion date is given for a contract.

It is also an engineer's job to specify completely factory-produced items. For example, coils or transformers should have the type of wire, the number of turns, the method of winding, the size of the bobbin or former, the type of core etc. all detailed. It is only in this way that the factory-manufactured items will be electrically similar to those used in the "breadboard" model. This is rather important if the factory-made equipment is to conform to specification limits; tolerances have a bad habit of adding up in the wrong way.

Training Assembly Staff

The majority of the normal transmission equipment is supplied to the Post Office by several large firms, all of which employ a large number of women for actually assembling and wiring the component parts. The operators must obviously be carefully trained in the special work they will have to do if the quality of the equipment is to be of a high standard. For instance, each rack of equipment contains a very large number of soldered joints, and as "dry" or imperfectly soldered joints may not show up until after the equipment has been in use for some time, it is important that any operator employed on soldering should have had adequate practice beforehand on dummy equipment. Approximately a fortnight is allowed for this, the operators during this period being shown how to solder correctly and in such a way as not to damage any component by excessive heat.

Approval of Prototype Equipment

The factory cannot start making the equipment until all stores are available and all sub-assemblies, panels and racks are fully detailed complete with assembly drawings.

If the equipment has been made previously, the work is simplified and production can usually start in the factory as soon as components are available, by using existing drawings, amended where necessary to take into account any interim improvements or modifications. However, if the equipment is entirely new, the firm will first have to arrange for a "breadboard" or laboratory experimental model to be made and only when this has been fully engineered, or in other words made up into a complete rack assembly, fully tested and drawings completed, can components be ordered and a factory order for manufacture be placed. The experimental equipment is usually made up in a model shop.

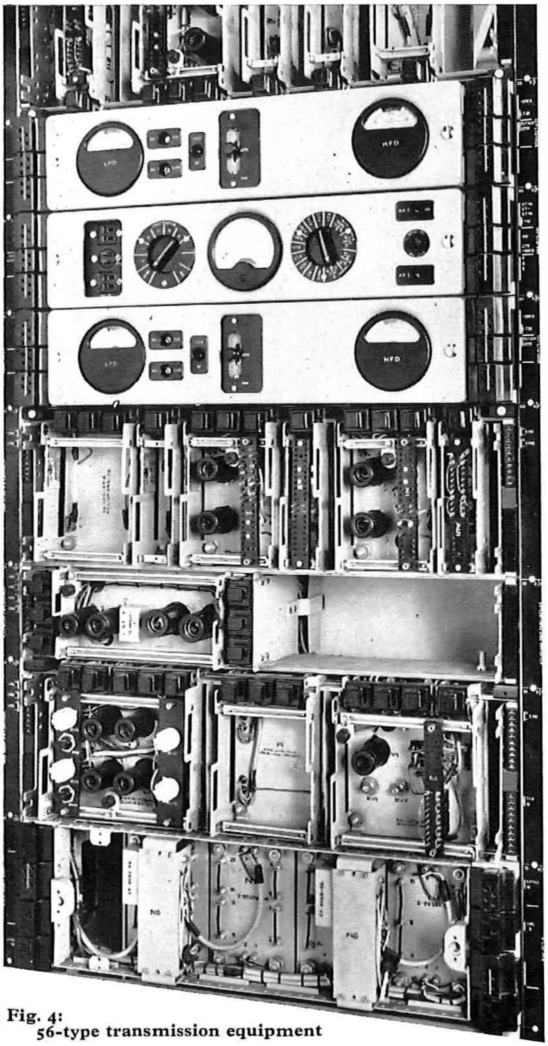

Fig. 4:
56-type transmission equipment

The first completely engineered equipment, whether made in a model shop or on an assembly line, is known as the prototype. This is thoroughly tested by both the firm and the Post Office to see that all mechanical and electrical conditions of the Post Office specification are met.

Once the Post Office has approved the prototype the remaining equipments are made to give the same standard of performance.

Factory Organization

Factory loading is extremely important, and special steps are taken to ensure, as far as possible, that the amount of equipment produced each week is about the same. In this way labour is used to best advantage. Also, to prevent unforeseen delays caused by lack of stores, a special section is set up to make sure that all component parts, whether they have to be bought from outside firms or made in the factory itself, are available at the required date.

Fig. 3 shows in block form a simplified arrangement of factory organization. The main Post Office contractors make most of the piece parts and components themselves. It may be interesting here to discuss in more detail how some of these are made.

Manufacture of Coils

The term coil covers such things as chokes, transformers and toroids.

A coil, unlike most components, can be made in many forms. In its simplest form, a coil consists of a few turns of wire, and is either self-supporting or wound around a suitable former, which may or may not have an adjustable slug for varying the inductance. On the other hand, it may incorporate a closed magnetic circuit. The magnetic path may consist of special iron laminations which, incidentally, are fitted after the coil has been wound on a bobbin, or it may be a toroidal dust core, the wire being wound concentrically around its cross section.

Whatever the type of coil, the actual winding process is most important. For instance, two coils wound to the same specification could have widely differing characteristics if different tensions were used during winding. Operators are aware of this and take special care.

Certain coils too, have to be manufactured to extremely tight tolerances, and to facilitate this, the coil is usually overwound very slightly and turns are later removed by hand.

Coil designing is a highly specialized job, as the resulting performance of a coil depends on so many factors. The coil designer must not only give the obvious requirements such as the type of wire and the number of turns, but must stipulate how these turns are to be wound on the bobbin or former. This is very important if stray capacity effects are to be effectively the same for every coil manufactured to the same specification.

Most coil winding machines are straightforward, the former or bobbin revolving on a type of lathe, and the wire wound on it in a pre-determined fashion.

Fig. 5: Toroidal coil winding machine

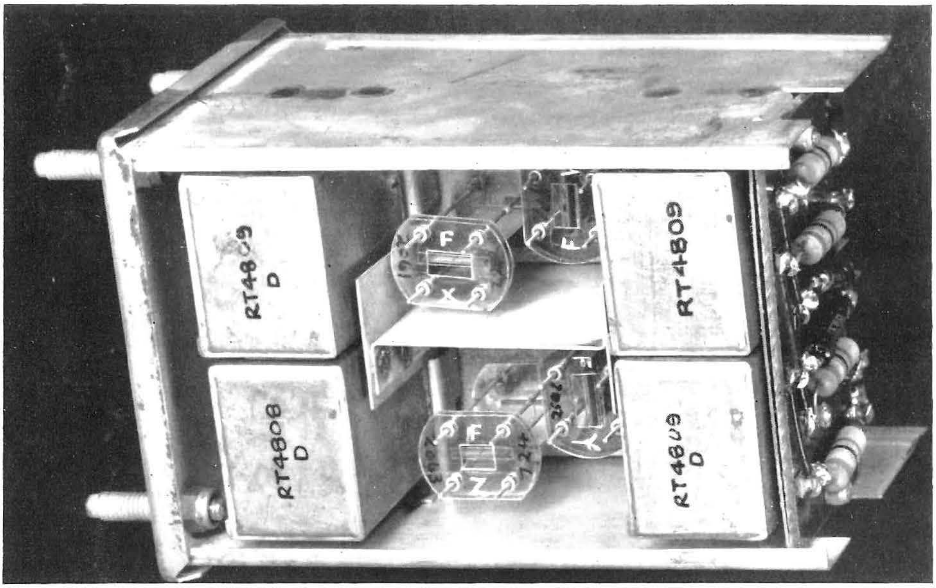

Fig. 6: Inside view of crystal filter

Making toroids, however, is a rather more subtle operation. The core or annular ring of magnetic material is kept in a horizontal position and the wire wrapped around it by a circular wire-loaded shuttle which passes through the centre of the ring. Before the shuttle is loaded with wire, it must be capable of being split to allow it to be passed through the ring.

After the coils have been wound, they may need to be impregnated with wax or some other material. They are impregnated with wax by being placed inside a special steel container, creating a vacuum inside it and then allowing hot wax to enter so as to cover completely the coils. When the vacuum is released wax is driven deeply into the windings. After the surplus wax has been drained off, the coils are taken out and allowed to cool.

Coils are not impregnated with bitumen under vacuum conditions as for wax, but are placed inside their containers or cans, and as much warm bitumen as possible poured in. After cooling, the bitumen keeps the coils absolutely rigid as well as keeping out the moisture.

Capacitors

Capacitors arc usually madc by specialized firms and are bought by transmission equipment manufacturers as and when required. However, the main contractors make a number of capacitors, such as polystyrene and paper dielectric types.

Polystyrene, for use as a dielectric, is produced in the form of a continuous strip of material, looking rather like thin celluloid. Machines are used to wind it spirally between two strips of aluminium foil, the value of the capacitance obtained depending on the thickness of the polystyrene, the number of turns and the breadth of the metal foil. During winding, the operators attach the connecting wires to each aluminium foil, one at each end of the capacitor.

The next process is to bake these capacitors in a temperature controlled oven for a predetermined period. This causes the polystyrene, which incidentally is rather wider than the metal foil, to fuse solidly at both ends, thus effectively sealing the capacitor against moisture.

Paper dielectric capacitors are made similarly except that instead of being baked in an oven, they are either impregnated with wax or sealed inside aluminium cases.

The operators work in rooms specially air conditioned, so that dust and moisture shall not contaminate the foil or dielectric.

Most resistors are bought from outside firms, but some wire-wound typcs for making up accurate attenuators are constructed in the factory. The process is quite simple. A length of resistance wire corresponding to the value of resistance required is folded in half and then wound on a suitable

Fig. 7: Operator wiring 56-type units

former, which is fixed in a type of coil winding machine. This method of winding keeps inductive effects down to a minimum.

Crystal Filters

A crystal filter is so-named because it incorporates quartz crystal units instead of coil-capacitor combinations. Quartz has piezo-electric properties and when correctly cut, can be made to resonate with very little damping loss. Because of this filters can be designed to have very sharp cut-off responses. Natural quartz is imported in the form of large irregular shaped crystals, and the crystal cutter has to find the natural axes of the mother crystals and with referencc to thcse axcs, cut out as many slabs or plates as possible of a given size. Not all the crystal can be used, as there are usually imperfections in the structure of the raw material.

The crystal is cut by diamond tipped wheels, with a suitable lubricant.

After being cut the surfaces of each plate are ground smooth to the correct thickness in special surface grinding machines before being chemically cleaned. The two large surfaces are then coated with silver by an evaporation process, a mask being used to produce similar rectangular conducting surfaces on each side of the plate. Wires are finally soldered to these silvered surfaces, special jigs being used.

The plates should now resonate at a frequency about 1 per cent. lower than required, to allow operators to adjust them accurately to the correct frequency by carcfully grinding the edges in a special machine. The resonant frequency is checked on a "frequency counter" test set.

The crystal plates, after being assembled into a unit, are wired, with other components, to form the final filter. After being tested, the filter is placed inside a metal can which is completely sealed except for two small holes in the base. These holes are left so that the container can first be tested for leaks under water, and secondly have dry air forced through it for 24 hours before being finally sealed. A final performance check is then made.

The crystal filters are assembled in a room specially air conditioned, as for capacitor manufacture.

Rack Frameworks and Piece Parts

Rack frameworks and most piece parts are made in the factory machine shop, along with any necessary jigs and tools that may be required. Rack frameworks and certain piece parts are classified as "common" or "bulk" items, and as such are made in quantity; the stock is renewed from time to time. More specialized piece parts, however, would be made only against a definite order.

As 51-type rack frameworks have a maximum height of 9 ft. large presses are required for shaping the side members out of steel sheet. Owing to the length of these side members, special jigs must be used when they are welded to the cross members to ensure that the resulting rackside framework is true to within $\frac{1}{16}$ in. in 9 ft.

From the machine shop, all metal parts are sent to the finishing shop. Here the parts are sprayed and stove enamelled after being cleaned and if necessary rust proofed. For uniformity in repeater stations, a standard grey colour is specified for the finishing coat.

The procedure for making up the complete rack

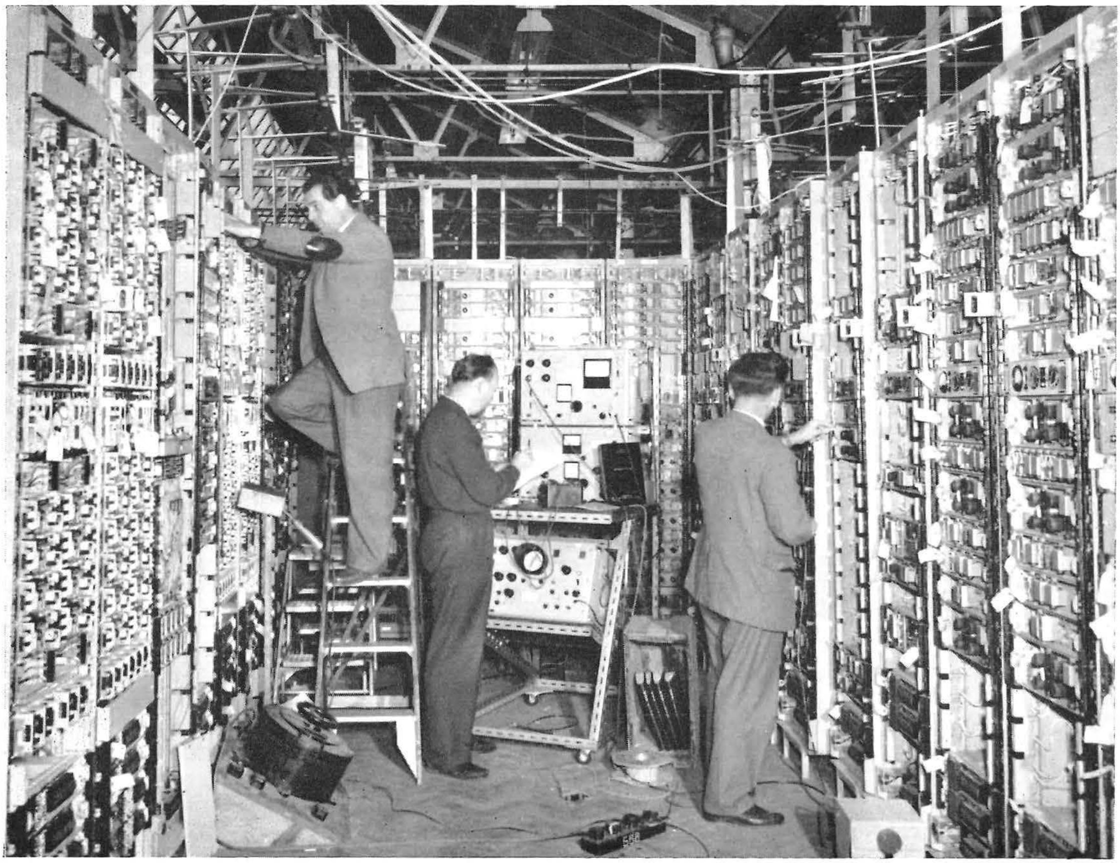

Fig. 8: Final testing of transmission equipment tests

varies slightly, depending on whether the equipment is O.E.P. or 51- and 56-type. For the O.E.P. type, fixed components such as transformers and valve holders are fitted on mounting plates, which are then screwed to O.E.P. frameworks, and operators wire the rack complete *in situ*. With the later forms of construction, however, the sub-assembly units are first made and later incorporated in the make-up of the 51-type panel or 56-type unit.

Whatever the construction however, all operators work to engineering drawings which show the actual layout of the component items and the point to point wiring. If sufficient wires justify a cable form, this is supplied as a complete item, having been made in another part of the factory.

Any necessary signwriting or engraving is also done at this stage, and coding labels are fitted to each panel, one showing the contractor's code and one the Post Office code.

Before the 51-type panels or 56-type units are fitted to the rack framework, they are tested both mechanically and electrically; any sealed can units will have been tested already for leaks and dried out as described earlier.

The final stage in constructing the complete 51- or 56-type equipment is fitting the rack cable form to the rack framework, and fixing the panels or units in their appropriate positions Connexion is made between the panel or unit and the rack by means of connecting links. Incidentally, the rack side connectors are fitted as part of the rack cable form.

The completed rack or rackside, whether it be pre-51, 51- or 56-type equipment is now thoroughly tested by specially trained testing engineers.

The author would like to thank both Standard Telephones and Cables Limited and the General Electric Company Limited for their help.

New E-in-C

Mr. A. H. Mumford, O.B.E., B.Sc.(Eng.), M.I.E.E., became Engineer-in-Chief of the Post Office on the retirement of Brigadier Sir Lionel H. Harris on January 31.

At the same time Captain C. F. Booth, C.B.E., M.I.E.E., and Mr. R. J. Halsey, C.M.G., M.I.E.E. became Deputy Engineers-in-Chief. Mr. Halsey was recently appointed Director of Research and a Director of Cable and Wireless Ltd.

Mr. Mumford, who entered the Post Office as a Probationary Assistant Engineer in 1924, has

Mr. A. H. Mumford

specialized in radio throughout his career. After a short period in the Engineer-in-Chief's Office he went to the Dollis Hill Laboratory, returning to the Office in 1938 as Staff Engineer in the Radio Branch. During the war he had considerable responsibility for the country's civil and military communications. He has represented the United Kingdom at several international radio conferences and was one of four members of the Atlantic City Radio Conference in 1947 to be entrusted with drafting the Frequency Allocation Table. He has been a member of the Council of the Institution of Electrical Engineers for many years.

Since his appointment in 1954, Sir Lionel H. Harris has seen practical results from four projects with which he has been much concerned as Engineer-in-Chief and, previously, as Controller of Research. The model electronic exchange is a working model, handling, within limits, live traffic. But the first transatlantic telephone cable has been in service since 1956, CANTAT, using the new lightweight cable developed by Post Office engineers, is being manufactured for laying, and only ultimate Government sanction is needed to make and lay the Pacific telephone cable, second link in the projected round-the-Commonwealth chain. Subscriber Trunk Dialling is working in Bristol and in November began, at Bodmin, to extend throughout the country. Automatic telex is open at London, the North East and Scotland and should cover the whole country this year. And, finally, the first all-electronic exchange—see pages 58-62.

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OUR CONTRIBUTORS

S. W. BROADHURST ("An Experimental Electronic Telephone Exchange") is an Assistant Staff Engineer in the Engineering Department Research Branch. After a period in Canterbury Telephone Area he joined the Engineer-in-Chief's Circuit Laboratory in 1929 and later became a lecturer in the Training School. He joined the Research Branch in 1938. Mr. Broadhurst has been concerned with switching problems for most of his career and was associated with the development of the Electronic Traffic Analyser and ERNIE. He is now Secretary of the Joint Electronic Research Committee.

A. C. CROISDALE ("Automatic Error Correction") is a Senior Executive Engineer in the Engineering Department Telegraph Branch. After four years with Reyrolle's, the electrical engineers, he entered the Post Office as Probationary Inspector in 1937 and after a year at Newcastle-on-Tyne, joined the External Plant and Protection Branch. From 1939 to 1946 he served in the Royal Signals in France, Belgium, North Africa, Sicily and Italy. In 1953 he was promoted Senior Executive Engineer on Extra-European Services, Telegraph Branch. He has been nominated as one of the two United Kingdom members of a Working Party on Data Transmission being set up by the C.C.I.T.T.

A. V. HUGHES ("The Manufacture of Transmission Equipment") is a Senior Executive Engineer in the Main Lines Development and Maintenance Branch (LMD) of the Engineering Department. He entered the Post Office in 1937 as Youth-in-Training in the Liverpool area, and in 1944 transferred to the Engineer-in-Chief's Office in London where he was employed on maintenance and circuit provision duties. Later he joined the Main Trunk Cable and Equipment planning group and was concerned with Main Trunk Network planning for North West, North East and Midland regions. At present, he is in charge of a group dealing with the standardization of Wideband Transmission Line and Terminal Equipment and the development of Line and Terminal Equipment for television links.

W. E. READY ("Closed Circuit Television for Stock Exchange Dealings") entered the Post Office in 1937 as a Youth in Training in the Liverpool Telephone Area and served there until he was transferred to the Engineering Department on promotion to Assistant Engineer in 1951. He was promoted to Executive Engineer in 1956 and since that date has been employed in the Main Lines Planning and Provision Branch dealing with the provision of television facilities for the broadcast authorities and industrial users.

J. E. YOUNG ("Other People's Jobs") wrote "Post Office Operates Hull Toll and Trunk" in the Summer 1957 *Journal*, and his career was outlined in that issue. He has now returned to the Post Office in Taunton Telephone Area.

Telephone Arrangements in Lighthouses: R. M. Watson's career was outlined in our Winter 1959 issue.

Publication and Price. The *Journal* is published in November, February, May and August, price 1/6. The annual postal subscription rate is 6/6 to any address at home or overseas.

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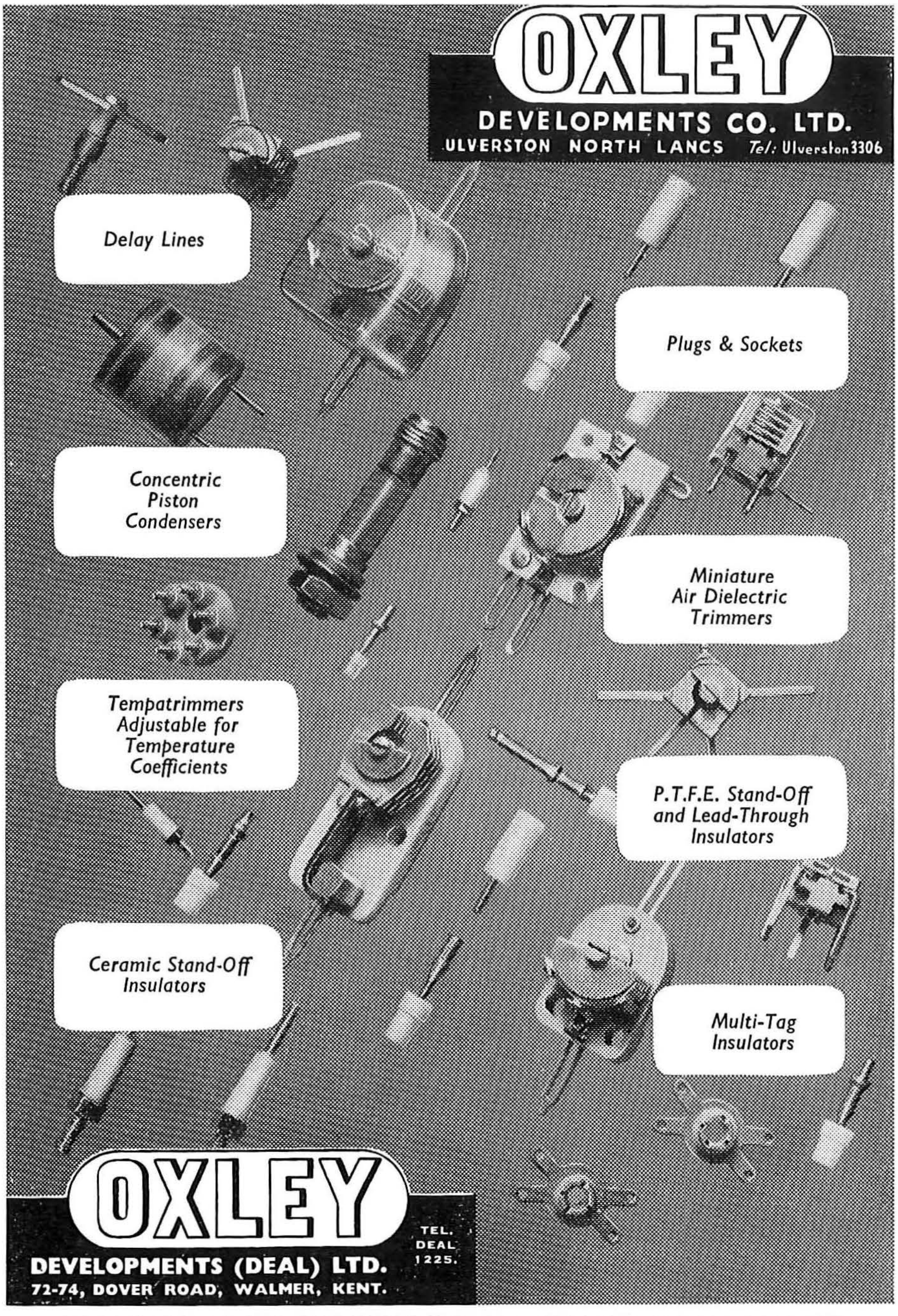

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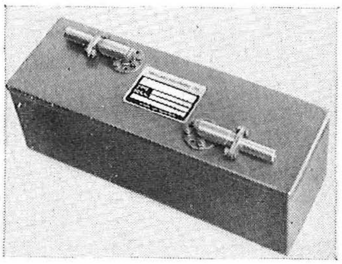

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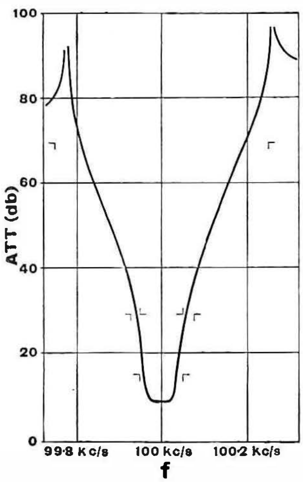

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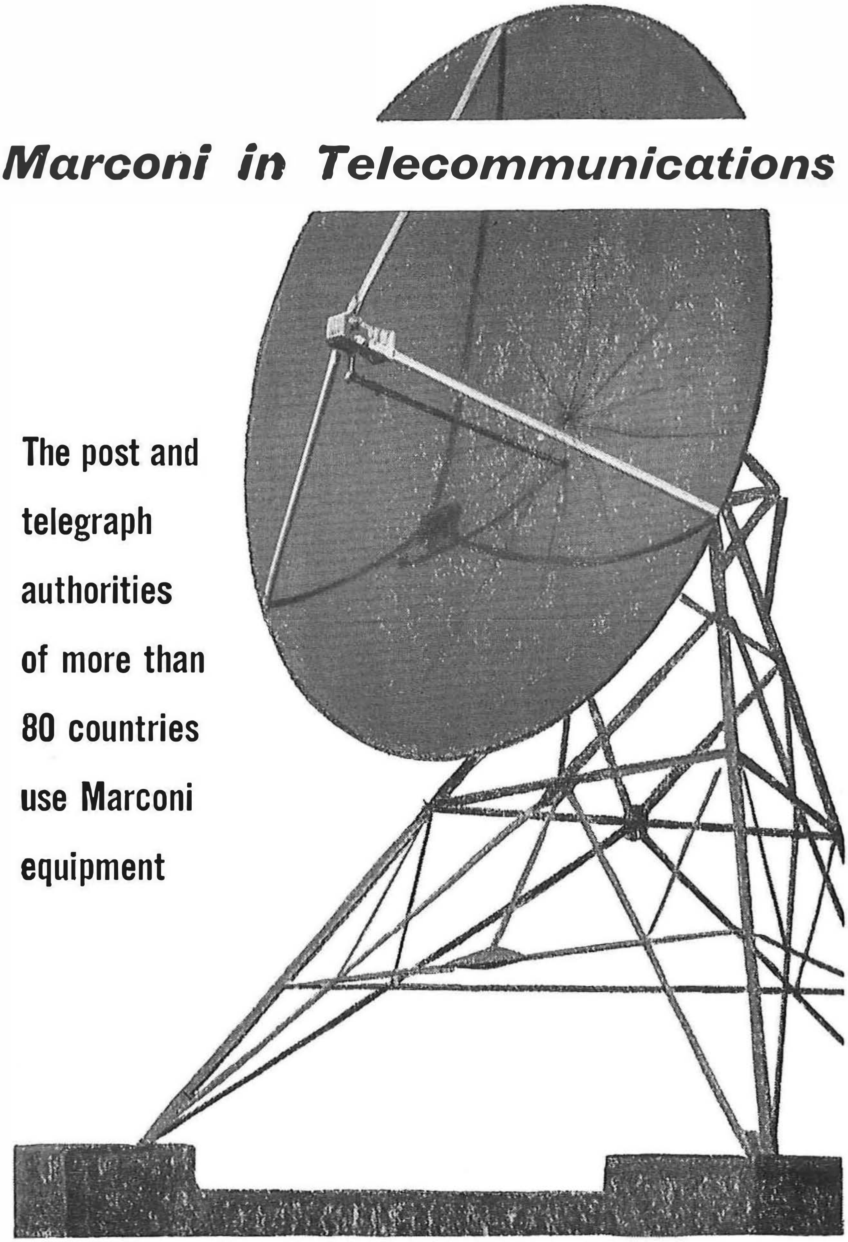

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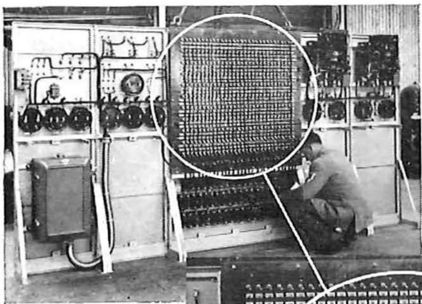

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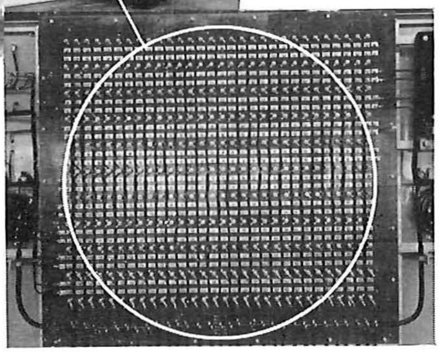

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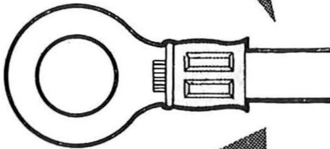

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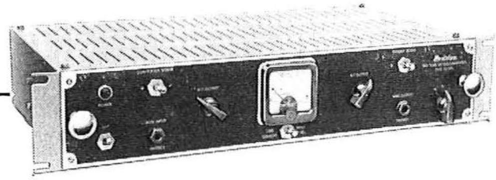

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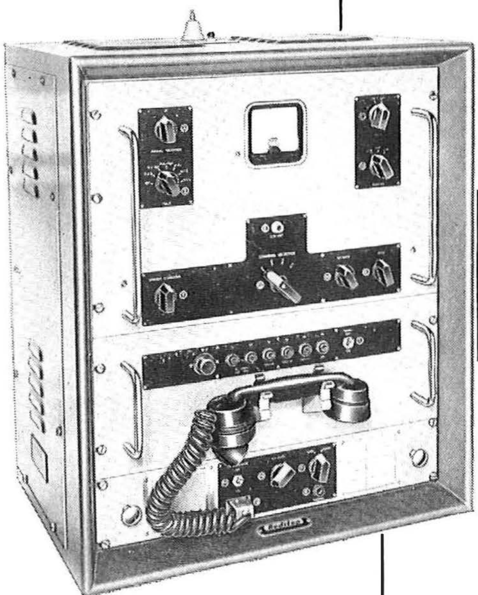

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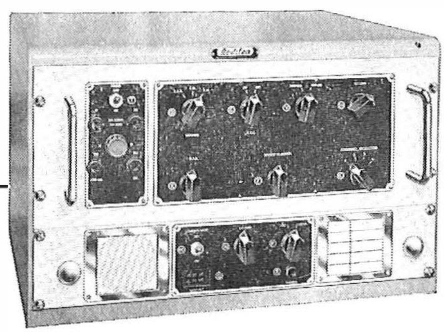

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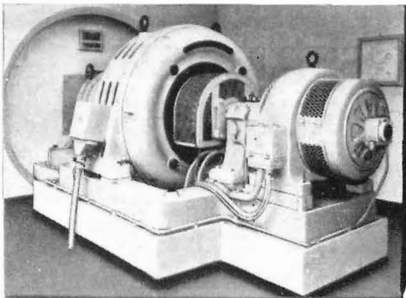

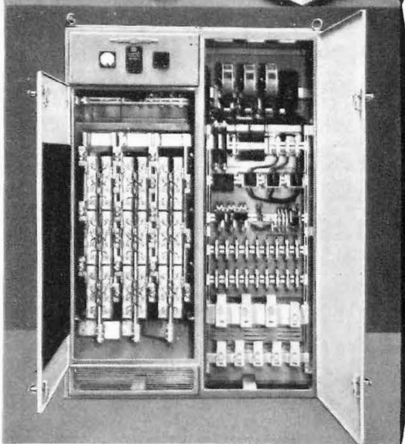

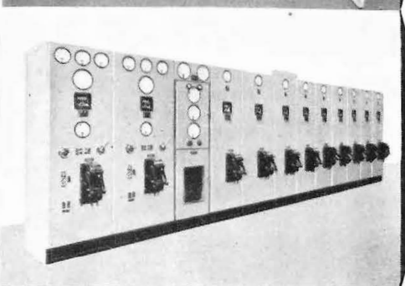

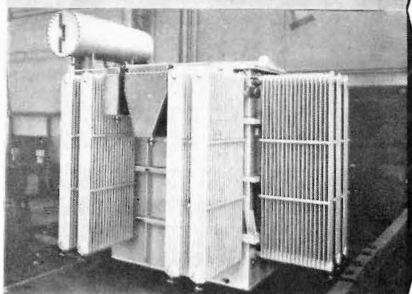

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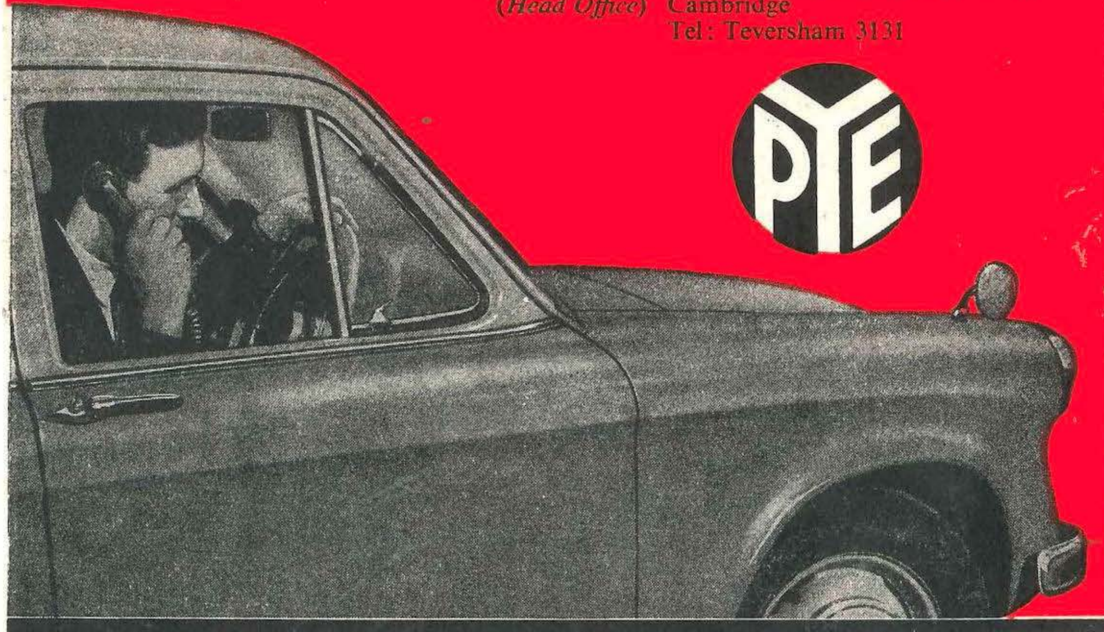

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