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**The Institution of Post Office Electrical Engineers**

# **THE AUTOMATIC TELEX SERVICE**

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**A. E. T. FORSTER, A.M.I.E.E., R. W. BARTON, A.M.I.E.E.**  
and **W. A. ELLIS, A.M.I.E.E.**

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**A Paper read before the London Centre of the Institution on  
10th February, 1959, and at other Centres during the Session.**

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# The Automatic Telex Service

## 1. INTRODUCTION

Prior to 1947 telex in this country was an ancillary facility of the telephone service, telex subscribers being provided with voice frequency converters so that teleprinter signals could be transmitted over approved connexions established via the public telephone network<sup>1</sup>. In 1945 plans were put in hand to convert the telex system to an independent network providing universal interconnexion over exclusive telegraph circuits, the first step being the setting up in 1947 of a manual exchange in London giving international service to subscribers in the London area<sup>2</sup>. In 1954 the independent network was extended to include the inland service by the opening of switchboards in the major provincial centres. The next step, the subject of this paper, is the bringing into service of an automatic switching system offering facilities for subscriber dialling of both inland and international calls. This development was foreseen when the interim manual service was established but has been rendered imperative by the high rate of growth of telex in this country and the rapid progress of continental countries in the automatization of their telex services. The fulfilment of present plans will enable U.K. telex subscribers to dial all inland calls and most international calls.

## 2. SOME INTERESTING CHARACTERISTICS OF TELEX TRAFFIC

Although the switching techniques used for telex in most countries have, for obvious reasons, followed the techniques used for telephone switching, telex traffic has many special characteristics which do not arise with telephone traffic and which must be borne in mind in considering the details of a telex switching system.

Telex is a service used primarily by commerce and industry, and will inevitably have a much smaller penetration than the telephone service. It is likely, that by 1970 there will be some 20,000 telex subscribers in this country, although the new system is being planned to be able to accommodate growth well beyond this level. It is probable that about 50 per cent. of subscribers will be concentrated in London and 40 per cent. in the eight or nine main provincial centres. Exchanges will vary in size from about 30 lines in the smaller centres to 10,000 lines or more in London.

It is interesting to note that the average area served by a telex exchange will be about 4,000 square miles, compared with the 10-20 square miles average for telephone exchange areas.

Because of the relatively high rental necessary to cover the cost of the telex subscriber's apparatus and line, a high calling rate per line seems inevitable if the

overall cost per call to the subscriber is to be kept at a reasonable level. An average busy hour calling rate of 0.1 erlang originated traffic per subscriber has been assumed in the design of the new system. One important effect produced by this high level of traffic in the station lines is that, since most subscribers will rent only one line, a high proportion of calls will fail because the called party is busy. This effect is aggravated by the tendency of subscribers to recall immediately on encountering a busy condition, so that the proportion of ineffective calls to be allowed for is much higher than that indicated by conventional considerations (based on pure chance traffic) of the probability of finding the called party engaged. This is an important point in relation to the loading of equipment held only for the period the call is being set up, since an analysis of this problem indicates that during the busy hour only one call attempt in two is likely to be effective.

There is a marked difference between the telephone and telex services in the proportions of local, trunk and international calls. This is shown clearly in Table 1.

TABLE 1  
*Distribution of Types of Call (1957)*

	Telephone %	Telex %
Local Chargeable Calls ...	92.06	22
Inland Trunk Calls ...	7.89	42
International Calls ...	.05	36

The high proportion of international traffic in the telex service is reflected in Fig. 1 which shows the growth over the past few years of telex and telephone traffic from this country to other countries in Europe. Although telex calls tend to be of shorter duration than telephone calls, it is clear that, if present trends continue, telex traffic will exceed telephone traffic in the international service from this country in the very near future. It is interesting to note that the current average international calling rate of 1.5 international calls per telex station per working day is not very much less than the average daily calling rate per telephone station for all calls, including local and trunk.

International traffic is clearly of paramount importance in the telex service, and considerable progress has been made by the International Telegraph Consultative Committee (C.C.I.T.)\* in agreeing the standards to be adopted for a fully automatic international service. These have had to be taken into account in the detailed design of the inland component of the new system.

\* The C.C.I.T. has now been combined with the C.C.I.F. to form the C.C.I.T.T.

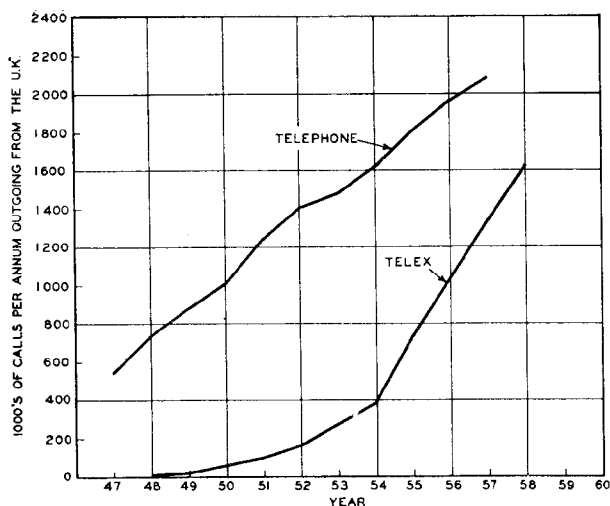


FIG. 1.—GROWTH OF TELEPHONE AND TELEX TRAFFIC TO THE CONTINENT.

### 3. GENERAL FEATURES OF THE SYSTEM

#### 3.1. Type of Switching System

A teleprinter switching system can be engineered in a number of different ways depending, for example, upon the switching mechanism used, whether or not registers are provided, and whether the teleprinter keyboard or a telephone dial is used to signal the number required. In deciding the switching principles to be adopted for the telex service, experience with the Inland Teleprinter Automatic Switching System (T.A.S. System)<sup>3</sup> confirmed that the 2000 type selector was well suited to the requirements of telegraph switching, and that by using step-by-step methods with dial selection, a relatively simple and reliable switching system could be designed. In view of this, similar switching principles have been chosen for the telex service. However, because of the differences in facilities there are considerable variations in the switching equipment and signalling arrangements for the two systems.

#### 3.2. Numbering Scheme and Arrangement of Charging Areas

The T.A.S. System was designed around an area numbering scheme with code list dialling. The application of this form of numbering scheme to the telex service was not practicable because, although it would probably have been acceptable for the inland service, obvious difficulties would have arisen on incoming international calls. For this reason it was necessary to set up a linked numbering scheme in which the directory number only is used for routing calls. However, in order to simplify the switching arrangements a simple code list will be used for some traffic at the smaller exchanges.

A systematic numbering plan was also necessary so that the metering equipment could be designed to discriminate on the minimum number of digits of the called subscriber's number.

Fifty charging areas have been established, the boundaries being more or less aligned with the boundaries of the Telephone Managers' Areas, the most important exception being in London where there is a single charging area aligned with the boundaries of the London Telecommunications Region. A single charging point has been established in each charging area and each area allotted a single two-digit code, apart from the London charging area which has been allotted a number of codes because of the large number of subscribers it serves. Charging areas have been allocated codes in the range 10 to 89 (apart from 20 which is used for access to the international exchange), codes 90 to 00 are spare, and codes 00-09 are used for service points. Fig. 2 shows the charging area boundaries and code allocation.

#### 3.3. Inland Tariff

The tariff is based on the principle of proportionate time metering in which the meter is stepped at intervals throughout the call, the frequency of stepping varying according to the chargeable distance as shown in Table 2.

TABLE 2  
*Inland Tariff (Metering Unit 2d.)*

<i>Chargeable Distance Miles</i>	<i>Number of Seconds for 2d.</i>	<i>Charge for a Call of 3 Minutes Duration</i>
Under 35	60	6d.
35 - 50	30	1/-
50 - 75	20	1/6
Over 75	15	2/-

The periodic pulses are not synchronised with the commencement of chargeable time but in order to ensure that short duration calls are always charged at least one unit, the first periodic pulse is suppressed and replaced by a single pulse when connexion is established, as shown in Fig. 3. This is a somewhat simpler arrangement than has been adopted for telephone subscriber trunk dialling in which a "divide by 6" element is used to obtain a fair degree of synchronism between the stepping of the meter and the commencement of chargeable time.

Reduced rates are not available for telex calls outside the normal busy hours.

#### 3.4. System Layout

The trunk network is based on six fully interconnected zone exchanges located at London, Birmingham, Bristol, Glasgow, Leeds and Manchester. This basic network is required both for transmission purposes and to enable the linked numbering scheme to be set up using direct selection principles. Area exchanges are established in charging areas where the

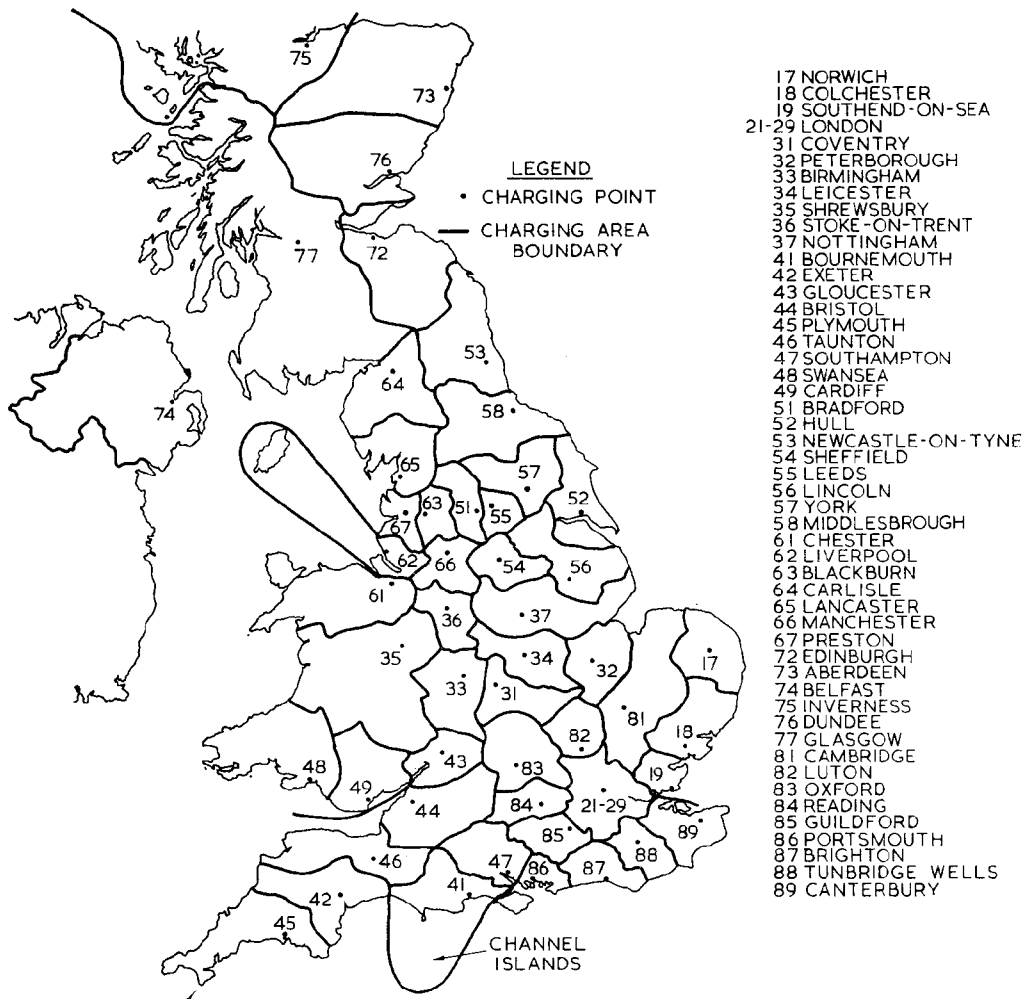


FIG. 2.—CHARGING AREA BOUNDARIES.

concentration of subscribers is sufficient, and are connected by means of trunk routes direct to their parent zone exchanges. In addition, direct routes will be provided between any two exchanges between which there is sufficient traffic and on this basis trunk

routes will be provided between London and all the exchanges at present planned. Fig. 4 shows the exchanges and the trunk network planned for the initial program.

To provide service in those telex areas where a physical area exchange is not justified, hypothetical exchanges will be set up within the zone exchange. This arrangement allows the subscribers concerned to use numbers corresponding to the two-digit code allocated to the charging area and so permit calls to be metered accordingly.

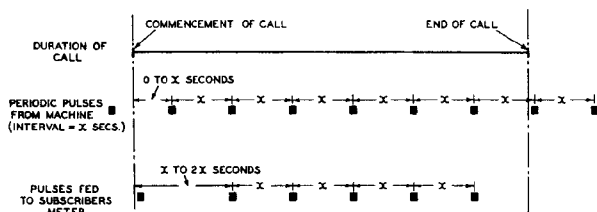


FIG. 3.—TIMING CHART FOR THE REGISTRATION OF METER PULSES.

### 3.5. Trunking Principles

The switching system is built up around the six zone exchanges which are fully interconnected to form a linked numbering scheme. A characteristic digit is allocated to each zone, trunk routes being extended from first selector levels to second selectors in the appropriate distant zone exchange.

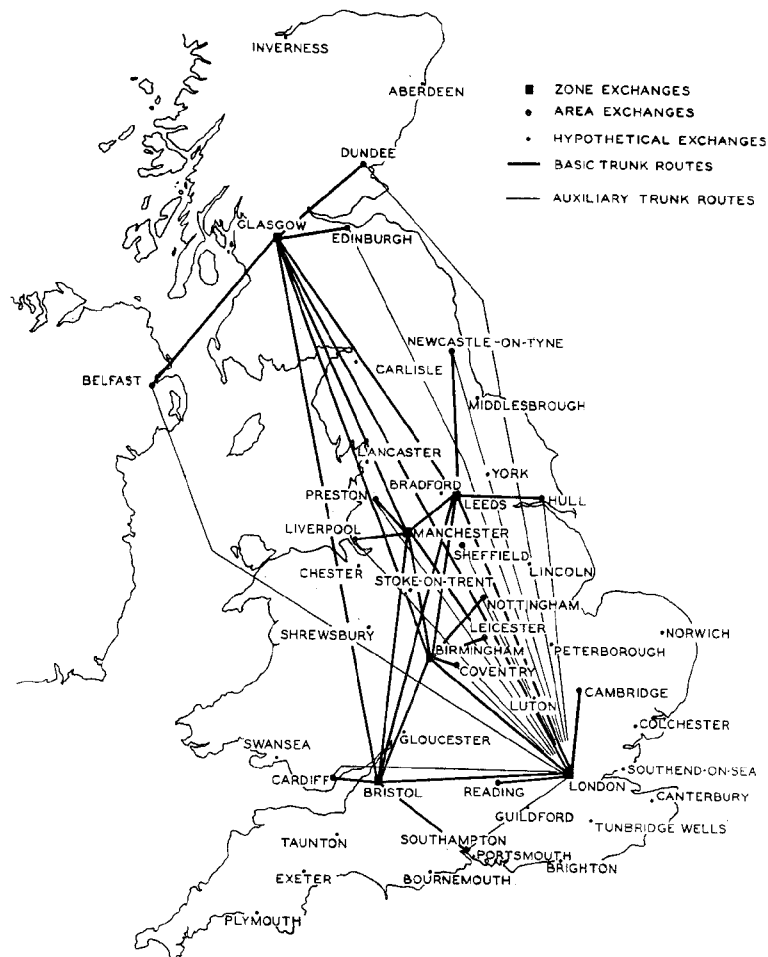


FIG. 4.—INLAND TRUNK NETWORK (1961/62).

A group of area exchanges is parented on each zone exchange and since these are trunked from parent zone second selector levels, zone subscribers are able to reach all other subscribers in the network by dialling only the directory number.

At area exchanges the parent zone trunk route is connected to level I of first selectors and terminates on first selectors at the zone exchange. Thus, for calls passing via the parent zone, area subscribers must dial the prefix digit 1 followed by the directory number. It is necessary, therefore, to supply area exchange subscribers with a simple code list indicating when the prefix digit should be used.

If a direct route is required between an area exchange and a zone exchange other than the parent zone, the route is trunked from the appropriate first selector level at the area exchange. Area exchange subscribers can then reach subscribers served by the distant zone exchange by dialling only the directory number.

At the non-parent zone exchange access to this direct route must be gained from the appropriate level

of the rank of second selectors. In these circumstances special arrangements are necessary to avoid the provision of direct routes from the non-parent zone to all other area (and hypothetical) exchanges which must be reached from the remaining levels of these second selectors. A device, termed a routing translator, has been developed for this purpose and its use is illustrated in Fig. 5.

By connecting to the routing translator those second selector levels which correspond to routes not justified by traffic, calls are directed over the trunk route to the parent zone and thus to the required area exchanges.

The routing translator, which remains in circuit for the duration of the call, functions as a simple level seized register; the registration function is limited to noting the level from which it is seized, the simple translation (see Section 3.5.2) routes the call onward to its destination over a trunk circuit selected by the associated trunk hunter. A mechanical pulse regenerator is used as a storage element to permit simultaneous pulsing in and pulsing out.

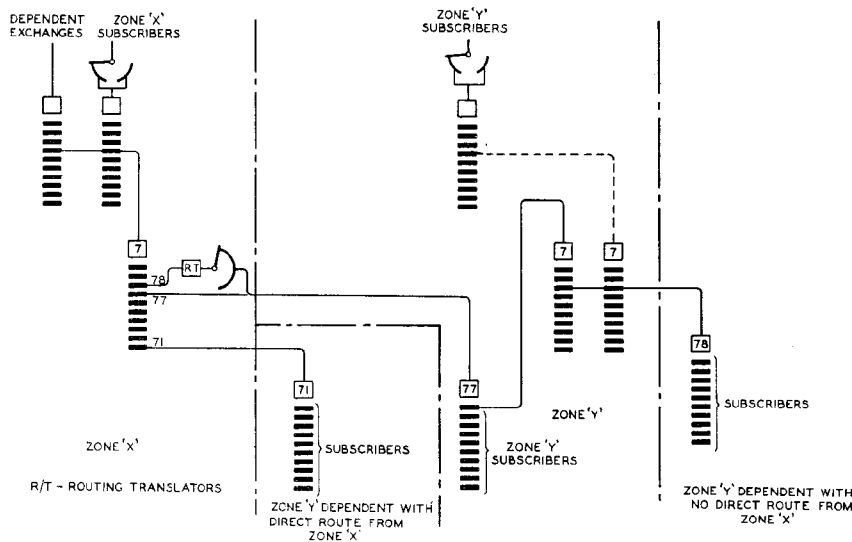


FIG. 5.—TRUNKING ELEMENTS ILLUSTRATING THE USE OF ROUTING TRANSLATORS.

Routing translators are used also to allow the charging areas dependent on the London zone (characteristic digit 2) to be allocated characteristic digits 1 and 8. At provincial zone exchanges, levels 1 and 8 of first selectors are connected to routing translators which route the traffic from these levels over the trunk route to London.

The foregoing scheme is slightly cheaper and basically simpler than one using conventional registers and has the additional advantage that, whereas with a register scheme it would have been economically necessary to develop special non-register equipment for small exchanges of less than about 100 lines, the scheme adopted allows a uniform design of equipment to be used throughout the system.

The use of routing translators provides an economic solution only if the network is laid out to handle a small amount of traffic in this way. For the telex service it has been estimated that only 1 or 2 per cent. of the total traffic in the inland network will need to pass through routing translators.

### 3.5.1. Trunking of Area Exchanges

The trunking of typical area exchanges is shown in Figs. 6 and 7. Fig. 6 illustrates a large area exchange and shows the use of the prefix digit 1 to route calls to the parent zone as well as the provision of direct routes to a distant zone exchange for which the prefix digit is not required. It will be noted that a rank of selectors is provided to absorb a digit on local calls. Because of the very low level of local traffic (about 1 per cent.) likely to arise at area centres, it is preferable to use standard selectors for this purpose rather than to provide special digit absorbing facilities. Fig. 7 illustrates the trunking of a small area exchange

in which the local train is omitted and the local traffic switched on a trombone basis via the parent zone exchange.

Level 0 is used for access to service points, a rank of second selectors being provided where services other than engineers are required. The codes standardised for local inland services are shown in Table 3.

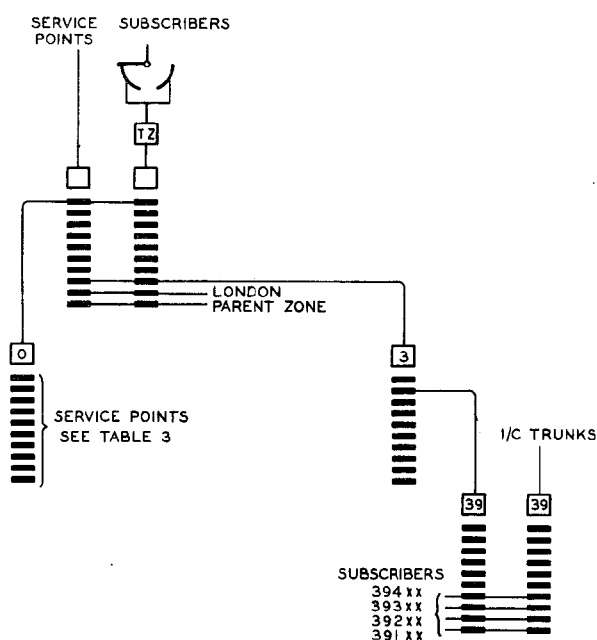


FIG. 6.—AREA EXCHANGE TRUNKING.

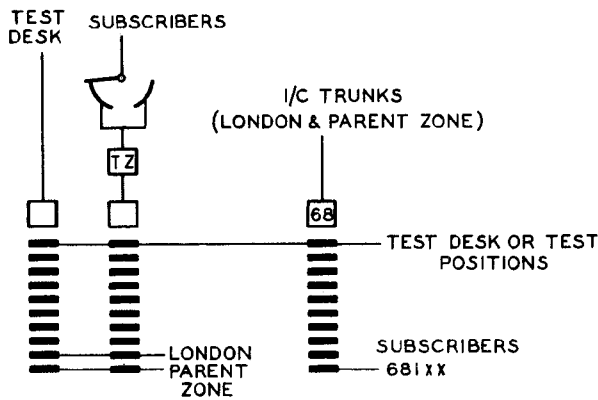


FIG. 7.—AREA EXCHANGE TRUNKING. LOCAL TRAFFIC TROMBONED VIA PARENT ZONE EXCHANGE.

TABLE 3

Dial Code	Service Point
01	Printergrams (Inland)
02	Printergrams (Inland Inquiries)
03	Telex Inquiries (Inland)
04	Printergrams (Overseas)
05	Spare
06	Test Desk (New Subs.)
07	Test Desk (Faults)
08	Test Signals
09	Spare
00	Engineering Test Positions

### 3.5.2 Trunking of Zone Exchanges

Fig. 8 illustrates the trunking of Glasgow zone exchange incorporating hypothetical exchanges for Aberdeen and Inverness. The trunking arrangements are typical of all zone exchanges other than London.

The hypothetical exchanges are created by setting up separate groups of final selectors and time-zone metering equipment as shown. The diagram also illustrates the use of routing translators to switch the outgoing traffic to London dependent and hypothetical exchanges off levels 1 and 8 and in addition indicates the path taken by traffic routed to Aberdeen and Inverness hypothetical exchanges under the control of routing translators located in London. The routing translators in London route the calls via levels 770 and 05 (both levels being barred if dialled directly by ordinary subscribers), to level 7 second selectors and thence to the appropriate final selector unit. Assuming a routing translator in London to have been seized from level 73, the translation transmitted would be 053 followed by the remaining digits of the required subscribers number. The translation comprises fixed digits 05 and digit 3 which is variable and corresponds to the level from which the routing translator is seized. The routing translator translation can comprise of up to four digits one of which is dependent upon the level from which the routing translator is seized. This digit can be inserted at any point in the translation.

The routing translator paths which are barred to ordinary subscribers by the time-zone metering equipment, allow the intercommunication of service points (e.g. inquiries and printergrams) since time-zone metering equipment is not associated with these lines. The adoption of a uniform pattern of level allocations enables any distant service point to be reached from any other service point by dialling the two digit charging area code followed by the required service code.

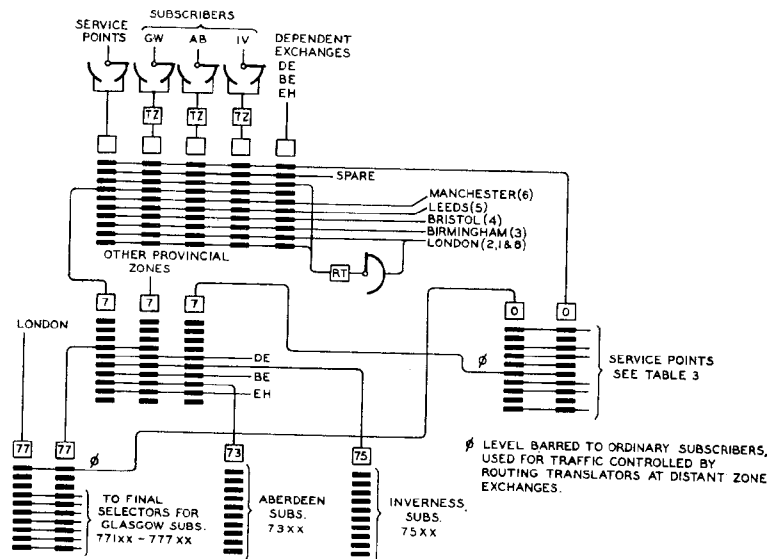


FIG. 8.—TRUNKING OF GLASGOW ZONE EXCHANGE INCLUDING ABERDEEN AND INVERNESS HYPOTHETICAL EXCHANGES.

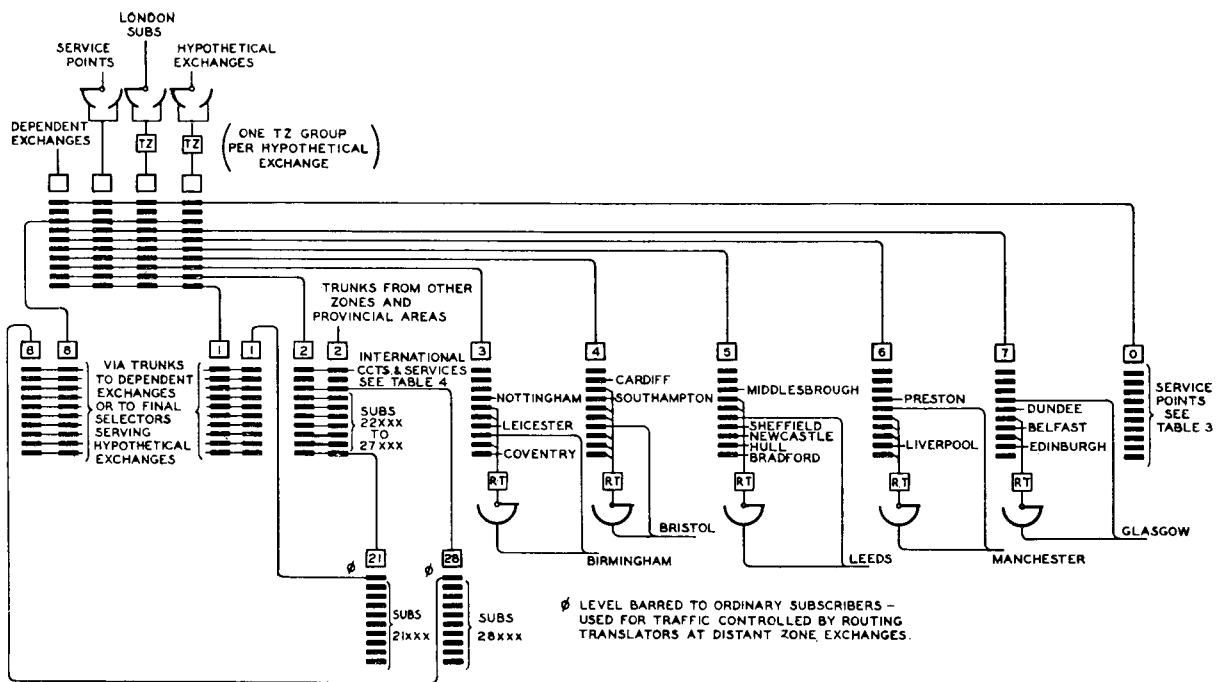


FIG. 9.—TRUNKING OF THE INLAND COMPONENT OF THE LONDON EXCHANGE.

Trunking of the London Inland exchange is shown in Fig. 9 with routing translators used to allow the provision of direct routes to provincial area exchanges. It will be noted that level 20 is used to give access to the international exchange for switching outgoing international traffic. This level is also used to give access to service points which are to be provided on a national basis. The codes allocated for this purpose are shown in Table 4.

TABLE 4

*National Service Codes*

<i>Dial Code</i>	<i>Service Point</i>
201	International Switchboard
2001	Spare
2002	Printergrams (International Inquiries)
2003	Telex Inquiries (Inland)
2004	Printergrams (Overseas)
2005	Printergrams (Europe)
2006	Telex Inquiries (International)
2007	Spare
2008	Spare
2009	Multitelex
2000	Assistance

#### 4. TRANSMISSION PLAN

The transmission performance of the system has to be considered from the standpoint of both inland and international traffic. The basis of planning is that, between any pair of teleprinters, the telegraphic distortion should not be worse than that of five normal Multi-Channel Voice Frequency Telegraph (M.C.V.F.T.) circuits connected in tandem. For the inland service the basic trunk network adopted ensures that all the zone exchanges will be fully interconnected by direct trunk routes. Since these trunk routes will invariably be routed over direct V.F.T. systems so that each trunk will be composed of a single V.F.T. circuit, the desired transmission performance can be met, provided the subscribers' lines at area exchanges are routed over the equivalent of not more than one V.F.T. circuit, and at zone exchanges over the equivalent of not more than two V.F.T. circuits.

However, for the international service, it will not be possible for all subscribers in this country to reach all subscribers overseas within the limit of five V.F.T. circuits and it has been necessary to arrange for the insertion of regenerative repeaters<sup>4</sup> where the transmission standards would otherwise not be met.

In this country the network is being planned so that every subscriber can reach the London international exchange over the equivalent of two V.F.T. circuits or better. This plan, which is illustrated in

Fig. 10, ensures that as long as other countries have similar standards, satisfactory transmission will be achieved on international calls provided that the international link is not worse than one V.F.T. circuit. This latter condition is met on the routes carrying most international traffic from this country and for which direct V.F.T. systems have been provided. For the comparatively small number of routings in which the distortion in the international link is worse than that of one V.F.T. circuit, the plan assumes that regenerative repeaters will be included in the international link.

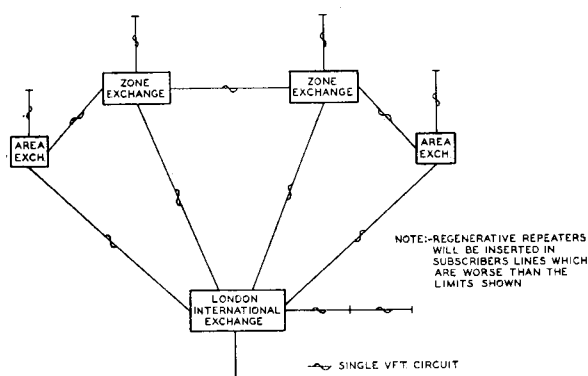


FIG. 10.—TRANSMISSION PLAN OF U.K. TELEX SYSTEM.

In order to meet the requirement that every subscriber in this country can reach the international exchange in London with the equivalent of not more than two V.F.T. circuits it is necessary for all subscribers' lines at provincial exchanges to be not worse than the equivalent of one V.F.T. circuit and for all exchanges to have a direct trunk route to London. Subscribers' lines on the London exchange can be the equivalent of two V.F.T. links or less. For those subscribers' lines which do not meet these requirements it will be necessary to insert regenerative repeaters in the subscribers' lines at the exchange concerned. Since the repeaters are not designed to transmit dial pulses, an auxiliary relay set will be provided so that the repeaters are switched in only when teleprinter signals are being passed. The switching unit will be controlled by the call connected and clearing signals (see Section 5) and will enable the dial pulses to by-pass the repeater. Regeneration of the dial pulses will not be necessary. The number of cases in which regenerative repeaters will be required in subscribers' lines in this country is likely to be extremely small.

Since subscribers' lines will always include at least a short length of physical line, it has been necessary to specify the maximum length of physical line which can be used either alone or as a physical extension of

a V.F.T. circuit to enable the foregoing standards to be achieved. The limits are summarised in Table 5. It is also necessary to limit the line resistance in order to ensure satisfactory signalling. In general, however, the transmission requirement is the critical factor in determining the maximum length of line which can be permitted.

TABLE 5

Transmission and Signalling Limits

Note. The transmission limits are expressed as the maximum length of 20 lb/mile conductor which can be used to connect a telex subscriber either to an automatic exchange or to a V.F.T. terminal where the line includes a V.F.T. circuit. For other weights of conductor these mileages should be modified by the following factors :

40 lb/mile	4/3
10 lb/mile	7/10
6½ lb/mile	1/2
4 lb/mile	3/10

The signalling limits are expressed as the maximum resistance in ohms of the line loop.

Type of Line	Physical Line Direct to an Exchange		Physical Line to a V.F.T. Terminal for Station Lines which include one V.F.T. Circuit			
			Provincial Exchanges		London	
	Miles	Ohms	Miles	Ohms	Miles	Ohms
Non-Relayed	20	3000	10	3600	25	3600
2-Wire Relayed	40	8000	20	3600	40	3600†
2 Loop-Relayed	*	4000	*	6000	*	6000

\* No limit specified

† The higher limit applies where relay units are fitted in both send and receive legs (30-40 miles)

5. SIGNALLING ARRANGEMENTS

In considering the signalling arrangements to be used for the inland system it is necessary to take into account the standards which have been agreed for the international service. The C.C.I.T.T. has standardised a number of signalling functions for use on international telex trunks, and corresponding signalling functions are also required on subscribers' lines and inland trunks. These are summarised in Table 6.

TABLE 6  
*Signalling Functions for Telex Circuits*

<i>Signal or Function</i>	<i>Detail</i>
Free Line Condition	The condition of the circuit when not seized but available for traffic
Calling Signal	The signal transmitted over the forward signalling path to indicate seizure for a call
Call Confirmation Signal	The signal transmitted over the backward signalling path following the initiation of a call, to prove the correct functioning of the line and terminal equipment
Proceed-to-Select Signal	The signal returned over the backward signalling path when the distant equipment is ready to receive the signals indicating the number required <i>Note.</i> The functions of the Call Confirmation and Proceed-to-Select Signals may, with some systems, be combined into a single signal
Proceed-to-Transmit Signal	The signal returned over the backward signalling path from a manual switchboard to indicate that the switchboard teleprinter is connected to the line
Selection Signals	The signals (e.g. dial pulses) transmitted over the forward signalling path to indicate the number required
Call Connected Signal	The signal returned over the backward signalling path to indicate that the called subscriber is connected. For automatically completed chargeable calls this signal is used to start the metering equipment
Idle Circuit Condition	The condition of a circuit when a connexion is established but signals are not being transmitted
Clearing Signal	The signal used to initiate the release of the connexion. Clearing can be by either party and is followed by reversion to the free line condition
Service Signals	The signals used to indicate busy, spare line, etc.

### 5.1. Signalling on Subscribers' Lines

The signalling arrangements for subscribers' lines are based on double current working, giving a two-way simplex circuit. However, the provision of local record working normally prevents the exploitation of the duplex facility inherent in this arrangement.

For the automatic telex service, the proportion of subscribers served by physical lines is likely to be as high as 90 per cent. and it is worth while therefore to use the third condition (i.e. "no current") in addition to negative (marking) and positive (spacing) currents for signalling on physical station lines in order to reduce the amount of equipment which would otherwise be required at subscribers' stations.

This does, however, result in some increase in the complexity of the arrangements for subscribers' lines routed over M.C.V.F.T. circuits.

#### 5.1.1 Physical Lines

The circuit elements for signalling on subscribers' lines are shown in Fig. 11.

In the free line condition, the subscribers' set extends forward + 80v potential to operate the line relay LS looped across the line at the exchange. This arrangement is used in order to ensure that, in the free line condition, no current circulates in the exchange earth electrode system and also that power is not drawn from the exchange battery.

For outgoing calls, the calling signal is - 80v potential which causes the release of relay LS. When the call has been extended to a first selector the proceed-to-select signal is returned over the backward signalling path as a pulse of - 80v potential of 50 to 100 ms duration which operates relay PD. The selection signals are double current dial pulses of nominal 60/40 ratio at 10 p.p.s., the dial used on the teleprinter set being fitted with changeover contacts which conform to the standards of ratio and speed agreed for the international service (ratio 1.2:1 to 1.9:1, speed 9-11 p.p.s.). The call connected signal is indicated by the return of - 80v potential to operate relay CM which connects the teleprinter magnet to line in readiness to receive the answer back signals of the called party.

Service signals take the form of - 80v potential for 200 ms (to operate relay CM) followed in sequence by teleprinter signals and the clearing signal. The texts used are shown in Table 7.

TABLE 7

#### *Printed Service Signals*

<i>Text</i>	<i>Significance</i>
OCC	Subscriber Busy
NC	Trunk Busy
NP	Spare Line or Level
DER	Subscribers' Line Faulty (Plugged Up)
ABS	Station Closed (Power Switched Off)

For incoming calls the calling signal is - 80v potential from the exchange to operate relay CM which starts the teleprinter motor at the station. When the motor has reached governed speed, - 80v potential is returned over the backward signalling path to act as the call connected signal.

The idle circuit condition is indicated by - 80v potential on each transmission path.

Either party clearing is provided, the clearing signal being transmitted from the station as an inversion to + 80v potential for at least 325 ms, and from the exchange to the station as the third condition (no current) to release relay CM.

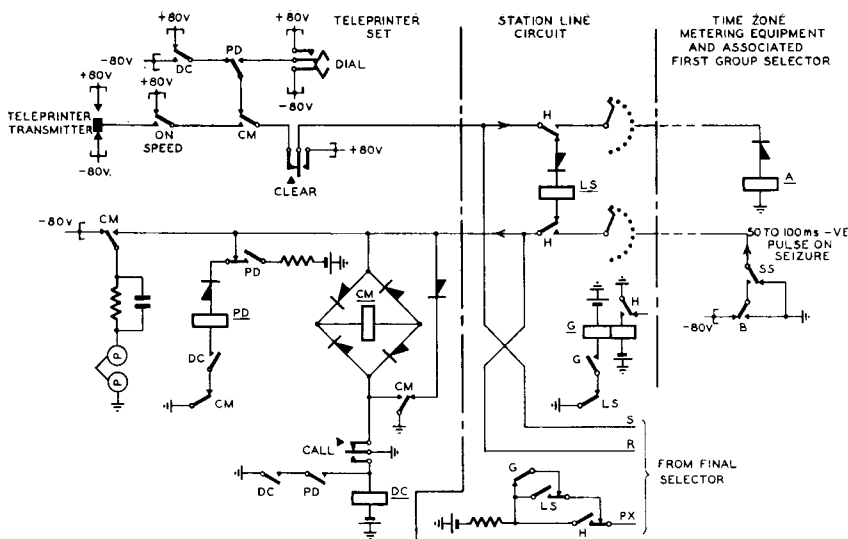


FIG. 11.—SUBSCRIBER'S LINE—CIRCUIT ELEMENTS FOR SIGNALLING.

To close the station, the power is switched off so that there is no current in the line; relay LS releases and, as described in Section 8.2, the exchange equipment is able to discriminate and cause the ABS signal to be returned to callers.

5.1.2 Lines including V.F.T. Circuits

Because the standard M.C.V.F.T. system cannot transmit the third condition, it is necessary on subscribers' lines routed over V.F.T. circuits to provide a small signal conversion relay set at the V.F.T. terminal adjacent to the subscriber to allow the third condition to be used for signalling between the subscriber's teleprinter set and the V.F.T. terminal.

The clearing signal from the exchange to the subscriber is transmitted over the V.F.T. circuit as a long

spacing signal and when this has persisted for at least 325 ms it is recognised by the signal conversion relay set which then transmits the third condition (no current) over the physical line to the station.

The switching off of the power to close the station causes the signal conversion relay set to apply a marking condition to the V.F.T. circuit. This simulates a calling signal, but in the absence of pulses the exchange equipment, after 12 to 24 seconds, identifies it as the station closed condition (see Section 8.2). Fig. 12 shows the circuit of the signal conversion relay set fitted at the V.F.T. terminal.

5.2. Signalling on Inland Trunk Lines

Inland trunk lines may be arranged for either both-way or unidirectional working. They are normally routed over V.F.T. circuits, but exceptionally, relayed physical lines are used between nearby exchanges. Double current signalling is used throughout.

The free line condition is + 80v potential on each transmission path, and the calling signal is - 80v potential on the forward transmission path. The functions of the call confirmation and proceed-to-select signals are combined into a single signal comprising a pulse of - 80v potential of 20 ms duration returned from the selector at the incoming end. The clearing signal, which can be originated from either end, is transmitted as inversion to + 80v potential and is effective when it has persisted for at least 325 ms.

The remaining signals used on trunk lines are the same as those already described for subscribers' lines.

The signalling arrangements used on international circuits are described in Section 12.

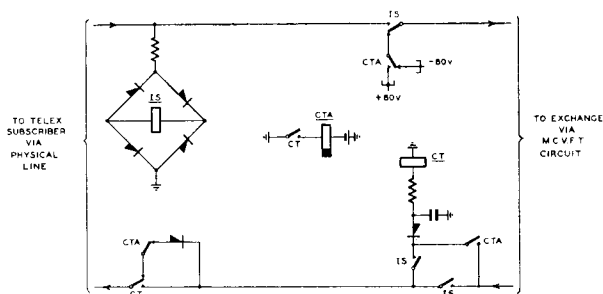


FIG. 12.—SIGNAL CONVERSION UNIT FITTED AT M.C.V.F.T. TERMINALS IN SUBSCRIBERS' LINES.

## 6. SUBSCRIBERS' STATION EQUIPMENT AND FACILITIES

### 6.1. Station With Teleprinter Only

The teleprinter is normally of the page pattern (Teleprinter 7D or 7E) although frequently it may be fitted with a reperforating attachment (Teleprinter 7D/RP or 7E/RP). Exceptionally, where the telex service is being used by the subscriber to feed traffic into a tape-relay system, a printing reperforator (Printing Reperforator No. IA) is used in place of the page teleprinter. For controlling the teleprinter, a mains energised signalling unit is provided and is illustrated in Fig. 13(a) and (b). It will be noted that the face of the unit accommodates a number of press keys, two supervisory lamps and a dial.

For outgoing calls depression of the DIAL key transmits the calling signal to the exchange and, when a first group selector has been seized, the proceed-to-select signal is returned to start the teleprinter motor and light the green supervisory lamp as an indication that dialling can proceed. Connexion to the called subscriber is indicated by the automatic return of the answer back of the called subscriber. The two subscribers are able to exchange messages in either direction, the local record facility at each end ensuring that each machine prints a complete record of the message recorded on the other machine. Either party can clear by the operation of the CLEAR key, which is held depressed until the green lamp is extinguished and the teleprinter motor stopped.

For incoming calls seizure of the line causes the green lamp to light and the teleprinter motor to start.



FIG. 13 (a).—TELEPRINTER SET FOR STATION WITH TELEPRINTER ONLY. ON TABLE NO. 5A.

FIG. 13 (b).—TELEPRINTER SET FOR STATION WITH TELEPRINTER ONLY. ON OFFICE TABLE.



A buzzer alarm is provided for incoming calls, but a switch at the rear of the unit enables the alarm to be temporarily disconnected if required. Alternatively the buzzer can be silenced for each incoming call by the depression of the RESET key. J-bell alarm facilities are provided so that the attention of the distant subscriber can be attracted by transmitting the "Figs" and "J" combinations in sequence to light the red lamp, and operate the buzzer alarm inside the unit.

An "in local" facility is provided so that the teleprinter can be operated without busying the line. This facility is used to allow additional copies of messages to be made and, in those cases where the teleprinter is fitted with a reperforating attachment, for the preparation of perforated tapes for subsequent transmission at automatic speed. To enable the teleprinter to be operated in local, the LOCAL (locking) press key is operated to start the teleprinter motor and light the green lamp. To switch the teleprinter off and restore the teleprinter set to normal, the RESET key is depressed to release the LOCAL key.

Should a call be received whilst the teleprinter is being operated in local, the local record is cut, the red lamp lights and the buzzer operates. If the RESET key is immediately operated to release the LOCAL key, the call is received in the normal way. If however, the LOCAL key is allowed to remain operated, the taking of the answer back is delayed for 2.4 to 4.8 seconds as described later. This delay is necessary in order to allow the subscriber sufficient time in which to respond to the alarm and cease teleprinting and so avoid mutilating the answer back signals and thereby causing confusion. Furthermore, if the local facility is being used to produce a perforated tape, the delay

allows time for the reperforating attachment throw-out lever to be operated to prevent the incoming signals being reproduced in the tape, and thus spoiling the tape already prepared.

The signalling unit, which has been designed for use with mains energised teleprinter motors, has its own self-contained power pack producing  $\pm 80v$  for line signalling and  $-50v$  for relay operation. It contains all the equipment necessary for controlling the teleprinter apart from a relay fitted on the teleprinter and connected across the governor contacts to provide an indication when the teleprinter motor has reached governed speed.

For a.c. installations a 230v a.c. teleprinter motor is used and, for voltages outside the 230-240v range, the motor is supplied via an auto-transformer. For d.c. installations a d.c. motor is fitted and a small d.c./a.c. vibrator is provided to supply the necessary a.c. power to the signalling unit.

The signalling unit has been designed so that it can readily be arranged for relayed line working, by plugging in a polarised relay, without requiring an external relay unit.

## 6.2. Station With Auto Transmitter

Installations with auto transmitters use a different signalling unit (Fig. 14) which incorporates the equipment for controlling both the teleprinter and the auto transmitter. In addition to the keys provided for controlling the teleprinter and catering for the normal signalling functions, two extra press keys are provided on the unit for stopping and starting the auto transmitter motor.

When starting the auto transmitter motor, it is necessary to ensure that signals from the auto



FIG. 14.—TELEPRINTER SET FOR STATION WITH AUTO TRANSMITTER.

transmitter are not fed to line until the motor has reached governed speed, in order to prevent spurious clearing signals being generated by the auto transmitter reading the tape whilst the motor is turning slowly. This is achieved by means of an "on speed" relay connected across the governor contacts; a contact of the relay controls the circuit of the auto transmitter clutch, so that reading of the tape commences only after governed speed has been reached.

The text of the auto transmission is reproduced on the local teleprinter by means of the local record facility. For some special requirements, however, a switch is provided to disconnect the local record circuit from the auto transmitter so that whilst auto transmission is in progress without local record, the teleprinter can be used for preparing local copy from the keyboard, or when a reperforating attachment is provided, for preparing further tapes for transmission.

Auxiliary contacts are fitted to the auto transmitter to enable the "tape out" and "tight tape" conditions to be indicated by stopping the auto transmitter motor and causing the red lamp to light and the buzzer to operate. An alarm is also given if the call is cleared from the distant end during automatic transmission.

Auto transmitter installations are provided with a facility whereby if teleprinter signals are received during an auto transmission, the red lamp flashes and the buzzer operates. This enables a subscriber, by operating his teleprinter keyboard, to attract the attention of another subscriber who is sending from his auto transmitter. This does of course mutilate the message, but interruption is only likely to be required in circumstances in which mutilation is not a serious consequence.

The auto transmitter can be operated in local, the teleprinter motor being controlled from the LOCAL key in the normal way, the auto transmitter being controlled from the START and STOP keys. If an incoming call is received whilst the auto transmitter is working in local the call is switched as for a normal teleprinter position, and in addition the auto transmitter motor is stopped to prevent the text of the tape being transmitted to line.

### **6.3. Auto Transmitter Switching Facilities**

A facility is available for switching an auto transmitter between a number of teleprinter sets, and is used where the volume of outgoing tape traffic is small enough not to warrant the provision of an auto transmitter for each teleprinter set and it is not possible to set aside specific circuits for outgoing tape traffic. The switching arrangements allow two auto transmitters to be switched between up to six teleprinter sets, comprising telex and private wire stations.

## **7. MISCELLANEOUS SERVICES**

### **7.1. Interworking with the T.A.S. System**

The extent to which the automatic telex service should be integrated with the T.A.S. System was carefully studied because of the potential economies likely to be achieved by combining the two systems on to a common trunk network and switching train. However, because of the detailed differences in the

facilities provided by the two systems and also because some of the major T.A.S. switching centres have had to be installed in buildings remote from the business centres of the towns in which they are located, complete integration would have been difficult and not very remunerative. It was decided, therefore, to set up an independent network for the telex service, but where the buildings housing T.A.S. centres were suitable, they would also accommodate the telex switching plant in order to obtain the economies offered by sharing power supplies, testing facilities, etc.

In order to provide facilities for the disposal of telegrams direct to telex subscribers, access will be provided from suitable T.A.S. selector levels into the telex system. This will enable inland telegraphists to set up calls from T.A.S. positions by dialling a code followed by the required subscriber's number. For such calls the answer back code will not be returned automatically (unlike calls between T.A.S. positions for which the answer back is returned automatically) and the calling telegraphist will be required to take the answer back manually. This difference in procedure will considerably minimize the risk of a telegraphist accidentally delivering a telegram to a telex subscriber instead of a T.A.S. office.

In setting up the telex network independently of the T.A.S. system some allowance has been made for the T.A.S. System to be absorbed into the telex system should the decline in the public telegraph service continue to the point when separate networks cannot be justified.

### **7.2. Printergrams**

Printergram centres will be established for both inland and overseas services.

For the inland service, local printergram centres will be set up only for the larger exchanges. Subscribers connected to area exchanges not having a local printergram centre will dial to the printergram centre at the parent zone.

Inland printergram positions will be equipped with tape teleprinters (Teleprinters No. 11) and apart from minor differences, the station equipment will be the same as that provided for the T.A.S. System and will have similar facilities.

For the overseas service, printergram centres will be established in the principal provincial cities and towns, but the major centre will be in London (Electra House) which will serve not only London, but all provincial exchanges not provided with a local overseas printergram centre.

The overseas printergram positions will be equipped with page teleprinters (Teleprinter No. 7D), the position equipment being the same as that provided for the private wire switching system<sup>5</sup>, since similar facilities are required.

Calls from subscribers to printergrams will not be charged for, apart from the charge levied in respect of the telegram.

### **7.3. Inquiries**

Inquiry centres for the inland service will be set up in London and the main provincial centres. In addition an inquiry centre for the international service will

be set up in London and will be available to all subscribers in this country.

The inquiry positions will be equipped with page teleprinters, and will use the same type of position equipment as for the private wire automatic switching system<sup>6</sup>.

#### 7.4. Assistance Traffic

Auto manual switchboards will be provided for dealing with difficulties met by subscribers in dialling calls. It is likely that the volume of traffic requiring the assistance of an operator in this way, will be small, and a single suite of auto manual positions in London may eventually suffice for the whole of the country. However, the experience gained during the initial stages of the program will be taken into account before a final decision is taken on the number and location of the assistance switchboards required for the system.

### 8. EXCHANGE EQUIPMENT AND FACILITIES

#### 8.1. Supervisory Principles

The switching circuits, like those of the T.A.S. System, employ battery testing with backward holding. Fig. 15 shows the supervisory elements concerned in a trunk call. Clearing is controlled from the forward transmission path, and for this purpose supervisory elements are located in the final selector and trunk relay set. If a clearing signal is initiated by the called party, the signal is transmitted over the

backward signalling path to be recognised in the time zone metering equipment. This releases the calling station which in turn transmits a clearing signal over the forward path to release the switching train.

The supervisory circuits use polarised relays having a high sensitivity to ensure negligible attenuation of the signalling currents. The timing elements have limits of 325 - 475 ms which determine the minimum duration of spacing signal required to produce a clearing signal. These figures are somewhat higher than those for the T.A.S. System (250 - 350 ms) and have been chosen in order to meet the requirements of international working. The timing elements use 3000-type relays with resistor capacitor networks, and are capable of discriminating against a signal of 15 ms marking and 135 ms spacing continuously repeated, thus ensuring that there is adequate margin against false release by teleprinter signals.

#### 8.2. Station Line Circuit

In addition to the conventional incoming and outgoing call functions, the station line circuit (S.L.C.) has to recognise the line signal indicating "station closed" so that the final selector can return the ABS signal to callers.

To enable this discrimination to be effected, the S.L.C. is arranged so that following release from a call, the guard relay G (Fig. 11) remains operated until relay LS re-operates to +80v potential on the line from the station. If +80v potential is not received, relay LS cannot operate, and the combination of relay G operated and relay LS normal is used to characterise the "station closed" condition.

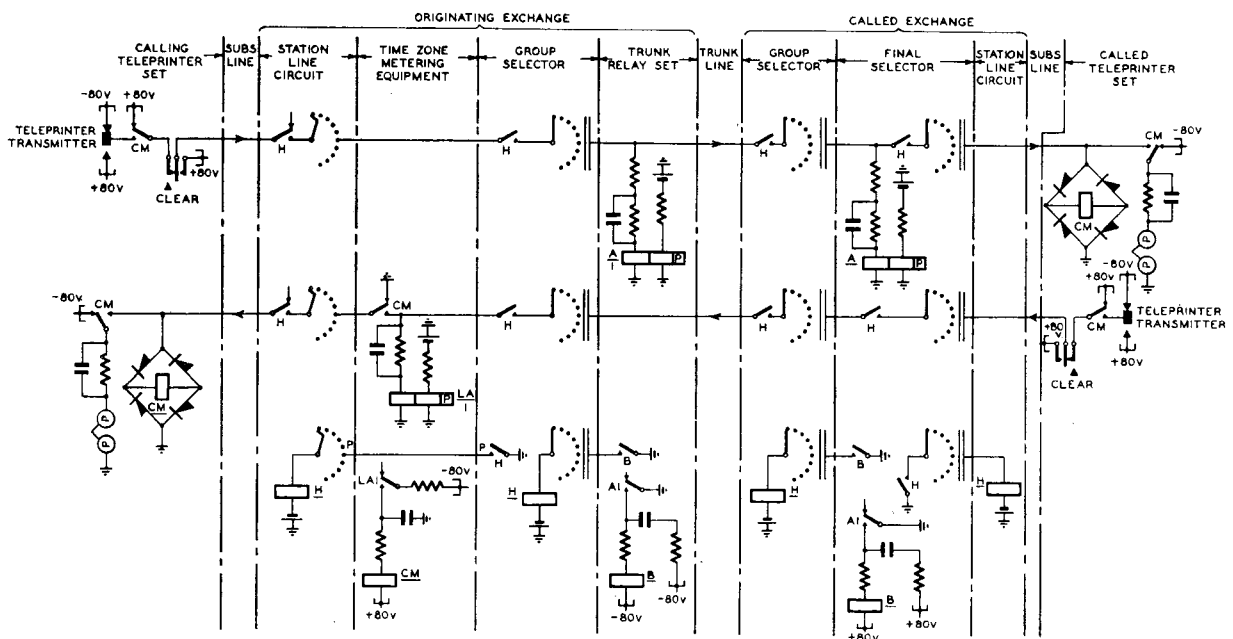


FIG. 15.—SUPERVISORY ELEMENTS OF A TRUNK CALL.

For physical lines the disconnection of the power at the station releases relay LS which causes the unselector to hunt and switch to a free first selector. In the absence of the calling signal the group selector is not able to maintain an earth on the P wire to hold the S.L.C., which releases and immediately takes up the "station closed" condition.

For V.F.T. lines (see Section 5.1.2) the marking signal transmitted over the V.F.T. circuit acts as a calling signal which causes the S.L.C. to seize a first selector and its associated time-zone metering equipment. After 12 to 24 seconds, because no dial pulses have been received, the S.L.C. is forcibly released by the time-zone metering equipment and as long as the marking signal is maintained on the V.F.T. circuit relay LS cannot operate and the S.L.C. remains in the "station closed" condition.

To enable calls to "closed" subscribers' stations to be acknowledged with the ABS signal, the S.L.C. marks the PX lead to the final selector, as described later. For auxiliary line groups the ABS signal is returned only when all lines in the group are closed. When some of the lines in an auxiliary group are closed and the remainder are busy, callers receive the OCC signal. This facility requires the station line circuits in a group to be interconnected by a simple strapping system.

Fourth-wire metering is used, the meters being of the five wheel type to accommodate the charges for both inland and international calls. In order to minimize the risk of spurious metering due to contact faults, etc., the metering circuits are designed so that the meter is always short-circuited except at the instant it is being pulsed. Although this guard feature tends to slow the release of the meter, the required maximum metering speed of two steps per second is readily achieved.

### 8.3. Time-Zone Metering Equipment

Metering is controlled by the time-zone metering equipment (Fig. 16) which is permanently associated with a first selector.

The time-zone metering equipment uses a two-motion selector mechanism to discriminate on the two digits of the charging area code, and so determine whether the call is chargeable, non-chargeable, or is to be barred. When the international access code is dialled, the selector restores to normal and the following two digits reposition the selector to enable the appropriate discrimination to be effected.

To provide for discrimination when the prefix digit is used the equipment functions in the following manner. The prefix digit steps the selector to level 1 to operate a discriminating relay as an indication that the prefix digit has been dialled. The first pulse of the next digit train is then absorbed by the unselector and the remaining pulses are fed to the vertical magnet. The selector thus stands on the level corresponding to the first digit of the called subscriber's number. The next digit is used to pulse the rotary magnet so that the wipers take up the position corresponding to the charging area code.

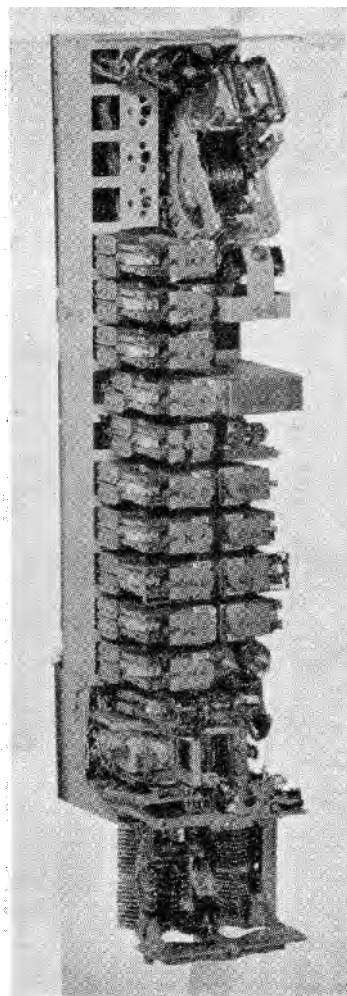


FIG. 16.—TIME-ZONE METERING EQUIPMENT.

In order to avoid charging on ineffective inland calls, the commencement of metering is delayed by about three seconds from the receipt of the call connected signal. This allows time for a short service signal text to be received and printed and for the subsequent clearing signal to release the connexion before metering can start. On chargeable inland calls, the time-zone metering equipment transmits the "Who Are You" (WRU) signal to trip the answer back of the called teleprinter, and before metering is allowed to commence, a check is made that signals have been returned over the backward path. If no signals are received by the time-zone metering equipment within 1800 ms of the transmission of the WRU signal, the OCC signal is transmitted to the caller and the connexion cleared without metering. This provides a useful check of the transmission performance of the connexion before metering is allowed to commence.

The transmission of the WRU signal and the timing of the return of the answer back signal, as well as the timing of the delay in the commencement of metering, are controlled by the unselector which is stepped at

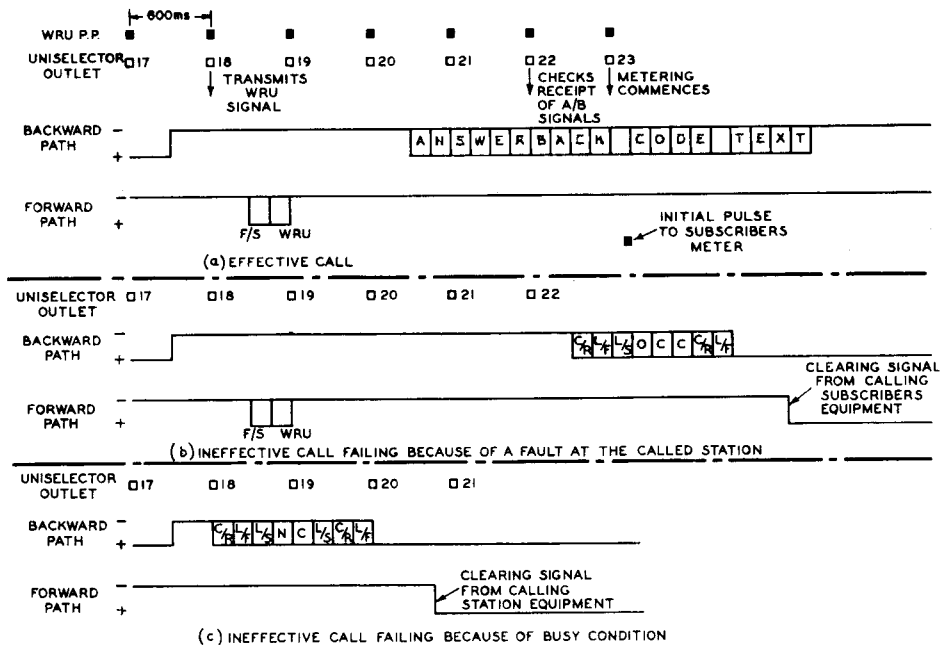


FIG. 17.—TIMING DIAGRAM OF THE METERING FUNCTION FOR EFFECTIVE AND INEFFECTIVE INLAND CHARGEABLE CALLS.

600 ms intervals by the WRU phasing pulses, as shown in Fig. 17.

For non-chargeable inland calls the time-zone metering equipment discriminates on the digits dialled and does not transmit the WRU signal because of difficulties which would arise in working to switchboards and other outlets which return the MOM (waiting) signal. Answer backs of service points, e.g. printergrams, inquiries, etc., are returned automatically under the control of WRU signals injected at the relay set connecting the service line.

In addition to being able to bar on any two digit inland code, the time-zone metering equipment also incorporates barring facilities to prevent subscribers irregularly setting up calls over the switching paths provided for the routing of traffic controlled by routing translators. This is achieved by barring on digit 0 following a two digit inland chargeable code except, of course, code 20 which gives access to the international exchange. The corresponding selector levels are used for traffic from routing translators and are also available for controlled access to other services. Calls to barred codes are answered by the NP signal followed by automatic release of the connexion.

At area exchanges the time-zone metering equipment also prevents calls being routed via the parent zone exchange when a direct route is provided from the area exchange. This is effected by barring on the relevant codes when they are preceded by the prefix digit.

The time-zone metering equipment includes a number of self checking features to ensure that equipment failures are brought to light quickly. Thus, on

chargeable calls, a check is made that the circuit back to the meter pulse supply is continuous. If this is not so the time-zone metering equipment is busied and an alarm is given. Only one equipment per rack can be locked out in this way, thus preventing congestion should a common lead be faulty. This check also includes the wiper to bank connexion of the selector in the time-zone metering equipment and therefore constitutes a useful safeguard against mechanical failure of the selector.

In addition to the foregoing metering and barring facilities, a forced release facility is provided to deal with false calls due to line faults and misoperations, and to apply the station closed condition on station lines routed over V.F.T. circuits.

The facilities provided in the time-zone metering equipment for dealing with subscriber dialled international traffic are described in Section 12.1.2.

#### 8.4. Selectors

The group selectors are of the 200 outlet type giving an availability of 20 on each level, a single basic design of group selector being used throughout the system.

Two final selector types have been standardised with facilities for 2-10 and 2-20 auxiliary line groups respectively. The latter type is likely to be required only very infrequently. For the 2-10 version the 200 outlet principle with conventional wiper switching is adopted.

The final selectors include facilities for switching to lines operating "in local" as well as for busying and "alarming" subscribers' lines found to be faulty. If a call is made to a subscriber's line not operating in local,

the call connected signal is returned from the station as soon as the teleprinter motor has been started and is running at governed speed. When a call is made to a station operating in local, the station is unable to return the call connected signal and after a wait of 2.4 to 4.8 seconds the final selector returns this signal to the time-zone metering equipment to initiate the transmission of the WRU signal. Meanwhile at the called station the local record is cut and an alarm given, the teleprinter magnet being automatically connected to the line. The answer back is tripped by the WRU signal and the auxiliary contacts associated with the answer back drum, allow the call connected signal to be returned to the final selector which then switches through the backward transmission path to allow the answer back signals to be transmitted to the caller. If the station is faulty, so that the call connected signal is not returned after the WRU signal has been transmitted, the final selector locks on to the called line and raises an alarm until the fault condition is removed. Meanwhile the time-zone metering equipment, having failed to receive answer back signals in response to the WRU signal, returns the OCC signal to the caller and releases the switching train up to the final selector. Faulty subscribers' lines are intercepted and connected to plugging up circuits by the exchange staff. The plugging up circuit returns the DER signal to callers.

The PX arc is used to control group hunting for auxiliary line groups as well as determining whether the called station is closed or busy.

+ 80v potential on the PX lead is used to indicate that the line is not the last one in a group and the selector is conditioned to hunt. The PX lead of the last line in a group is connected either to - 80v or zero potential (i.e. disconnected) to indicate whether the station is closed or not. When the station is closed zero potential is present and the final selector discriminates and returns the ABS signal to callers. When the station is not closed the last PX lead in the group is connected to - 80v potential which causes the final selector to return the OCC signal on calls failing to find a free line. By connecting a metering circuit in parallel with the protective resistor in series with the negative battery supply it is possible to obtain a record of the number of calls to the subscriber's line or group of lines which encounter the OCC signal.

### 8.5. Bothway Trunk Relay Set

The facilities provided by the trunk relay sets are similar in many respects to those provided for the T.A.S. System.

A single design of trunk relay set is used for outgoing and bothway inland trunk circuits. For incoming circuits the line terminates directly on an incoming trunk selector without requiring a relay set.

The trunk relay set has been designed so that by suitable strapping it can also provide access to manual switchboards, and so enable the conversion of the system to automatic working to be carried out without the need to provide special relay sets for auto-manual access.

For auto-to-auto working, the relay set checks the return of the call confirmation signal (20 ms pulse of - 80v potential) from the selector at the incoming end. If this signal is not received within 300 ms of the calling signal being transmitted, the trunk is regarded as faulty, the NC signal returned to the caller, and the connexion up to the trunk relay set released. The trunk line is automatically busied, and is connected to the Trunk Circuit Hold and Retest signal (TCHR) in the same way as in the T.A.S. System. The TCHR signal initiates a fresh call at 30 second intervals so that if the fault clears, the call confirmation signal is returned and the trunk restored to service. If, after 2½ minutes, the trunk is still faulty an alarm is given and the TCHR signal disconnected.

For trunks to manual switchboards the foregoing facility is strapped out and replaced by one which provides for the return of the MOM signal to callers until the operator answers. When the trunk relay set is seized, the signal on the backward path is initially a steady + 80v potential which causes the relay set to return the MOM signal at six second intervals. When the switchboard operator answers the call, a proceed to transmit signal consisting of inversion to - 80v potential followed by teleprinter signals is transmitted over the backward signalling path. This is received by the trunk relay set which disconnects the MOM signal and connects the backward path through to the calling subscriber.

As in the T.A.S. System the bothway trunk routes are arranged so that the order of testing at one end of the trunk route is opposite to that at the other end, thus minimizing the risk of simultaneous seizure from both ends.

### 8.6. Routing Translator

In considering the facilities provided by the routing translator it is convenient to divide it into four parts, viz.: an input relay group which indicates the level from which the routing translator is seized, a sending element which transmits a simple translation comprising a predetermined code together with the digit corresponding to the level from which it is seized, a mechanical dial pulse regenerator as a storage element, and a trunk hunter for selecting an outgoing circuit. Fig. 18 is a block schematic of the routing translator.

The input relay group comprises four relays which are operated either singly or in pairs to indicate the level from which it is seized. The sending element comprises a self pulsing relay driving a uniselector having two marking arcs so that by means of a four element code with the elements taken in pairs or singly, the translation digits can be set up. The use of this form of code enables the translation to be set up on the shelf jacks without requiring a special translation field, as well as simplifying the arrangements for marking from the input relay group. The translation can comprise 1, 2, 3 or 4 digits, and the digit corresponding to the input level can be inserted in any position in the train.

The trunk hunter is a 25-point uniselector the first 20 outlets being graded in with the outlets of the group selector level serving the route. The 22nd and 23rd outlets are used to return the NC signal under

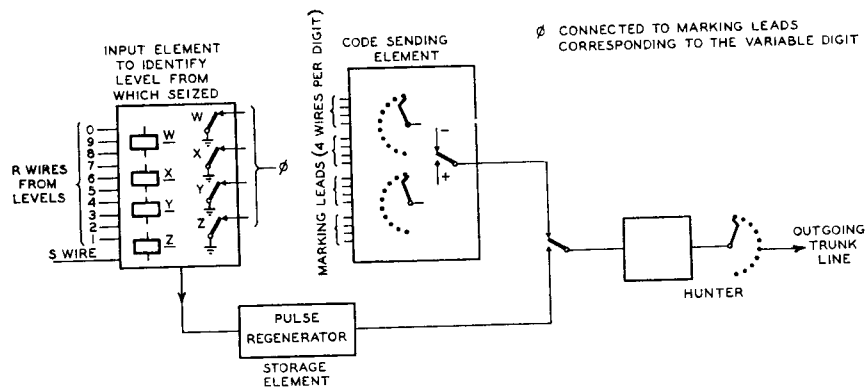


FIG. 18.—ROUTING TRANSLATOR. BLOCK DIAGRAM OF CIRCUIT ELEMENTS.

busy conditions. A routing translator is shown in Fig. 19.

### 8.7. Relay Set for Access to Service Points

A single type of relay set is available to provide access to services such as inquiries, printergrams, test desks, etc. The facilities provided include, in addition to the normal supervisory and holding functions, the automatic transmission of the WRU signal to take the answer back of the terminal teleprinter. Associated with this facility is a check of the return of answer back signals. If these are not returned within about 600 ms of the transmission of WRU signals, the circuit is locked out and an alarm given, the OCC signal returned to the caller, and the connexion released.

In addition, for circuits to the test desk, the relay set incorporates a facility for returning the MOM signal when the circuit is seized and the test desk teleprinter is not immediately available to answer the call. A single sequence of MOM is returned on seizure; additional sequences are returned in response to teleprinter signals transmitted from the teleprinter keyboard. When the test desk teleprinter is connected the answer back is returned automatically.

### 8.8. Meter Pulse Generating Equipment

The meter pulses are generated on a common basis by a motor driven pulse machine Fig. 20.

The machine has been designed so that it is capable of producing any 20 of the 30 pulse rates shown in Table 8. This number of pulse rates is necessary in order to cater for inland and international subscriber dialling.

TABLE 8  
*Outputs of Meter Pulse Machine*  
*Pulses per Minute*

1	6	12	20	36	72
2	7	14	21	42	84
3	8	15	24	48	96
4	9	16	27	54	108
5	10	18	30	60	120

Note. All the pulse rates shown can be made available, within the limit of a total of 20 outputs at any one time.

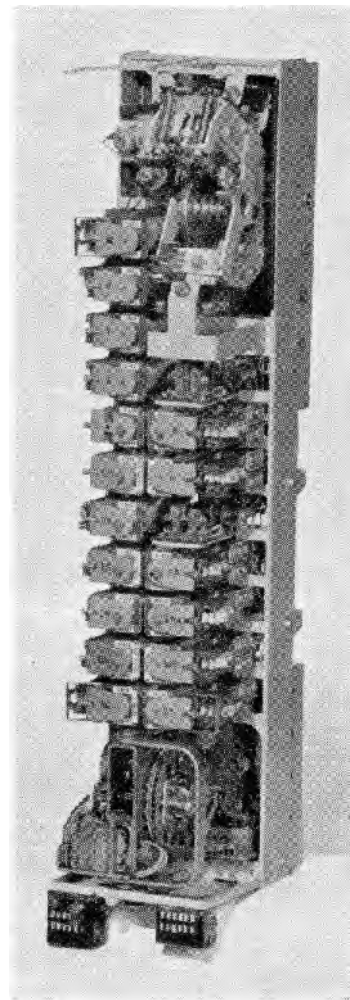


FIG. 19.—ROUTING TRANSLATOR.

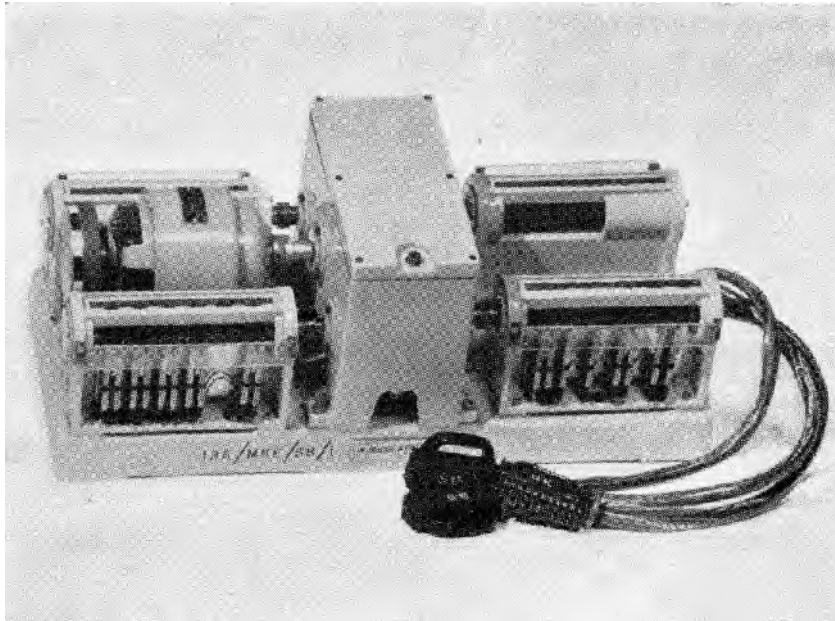


FIG. 20.—METER PULSE MACHINE.

The speed of the motor is controlled to an accuracy of  $\pm 0.02$  per cent. by means of a control circuit similar to that used for signal generators in the T.A.S. System, in which the phase difference of a nominal 50 c/s signal generated by a special commutator fitted to the machine shaft, and a 50 c/s signal produced by a valve maintained tuning fork, is used to regulate the excitation of the motor.

Because of the loss of revenue which could occur, particularly at the larger exchanges, it is necessary to guard against failure of the meter pulse machine or its standby. It is also important to check that no spurious pulses are injected into the pulse leads, and to facilitate this, the machine has a pair of independent outputs for each pulse rate. These are monitored by a differential relay circuit arranged so that the relay operates if the conditions on the two leads are different.

The loads on the pulse leads corresponding to the inland and certain overseas rates are such that repeating relays are necessary. For the remaining pulse leads the loads are small enough for distribution to be made direct from the machine contacts. This has the advantage of avoiding the use of repeating relays for the higher pulse rates. The monitoring circuits are arranged so that the more important points in the distribution chain are continuously monitored, whilst for the less important points the monitoring circuits are connected at intervals under the control of a monitoring uniselector.

### 8.9. Service Signal Generating Equipment

The service signals are generated on a common basis by a motor driven signal generator of the same general pattern as is used in the T.A.S. System.

One signal generator is used to provide all the signals required. The rings of the distributor are arranged to provide double current outputs by means of the circuit shown in Fig. 21. The sequences of the principal signals are shown in Fig. 22. It will be seen that two printed service signal sequences, e.g. ABS and OCC can be accommodated on one output, and by means of the ZA (or ZB) pulse the required signal can be fed to line. The switching circuits include a phasing relay (PP) which is operated by the SA (or SB) pulse to connect the signal to line at the commencement of the signal cycle, and on the termination of the ZA (or ZB) pulse the phasing relay releases, disconnects the service signal lead and connects  $+80v$  potential to line to act as a clearing signal.

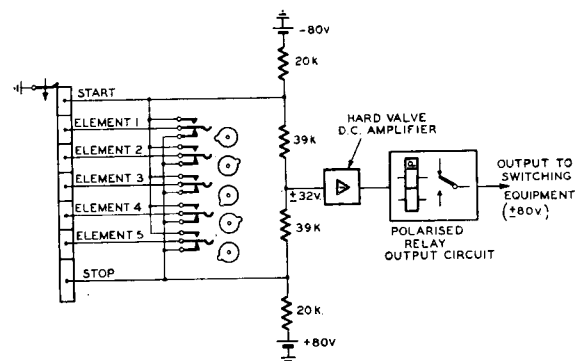


FIG. 21.—SIGNAL GENERATOR CIRCUIT ELEMENTS.

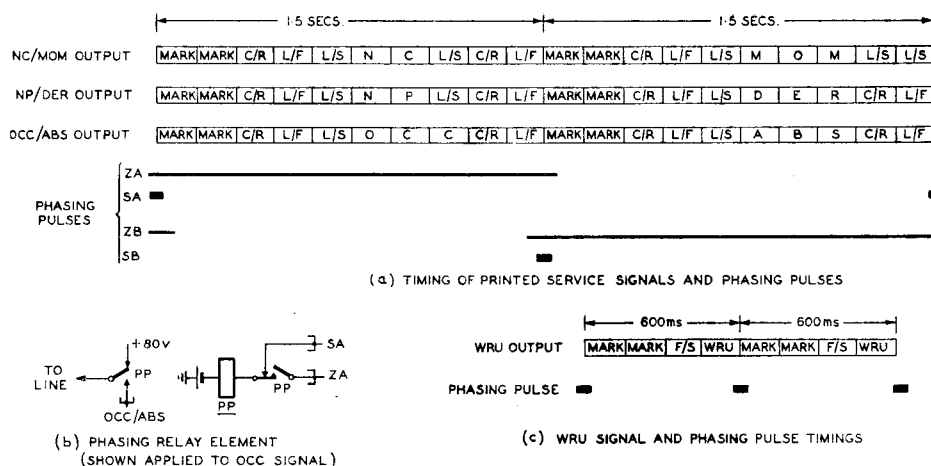


FIG. 22.—SERVICE SIGNAL TIMING CHART.

This sequence of alternate service signal texts and clearing signals continues until the connexion is released. Release normally occurs during the first clearing signal interval.

For the MOM signal the phasing relay, when released, connects  $-80\text{v}$  potential to line since this signal is not required to be followed by the automatic release of the connexion. For access to manual switchboards, for which the MOM signal is required to be repeated at six second intervals, an auxiliary relay group is used to count down from the three second intervals at which the signal is generated.

Since faults on the service signal phasing pulse leads could give rise to metering on service signals, the monitoring arrangements described for the meter pulse leads are also used for the service signal phasing pulse leads.

The double current service signals are distributed to the switching equipment racks, as in the T.A.S. System, by means of repeating relay circuits comprising a polarised relay in the output of a simple valve circuit driven from the distributor outputs of the signal generator.

The speed of the signal generator motor is controlled by the  $50\text{ c/s}$  valve maintained tuning fork in the same way as for the meter pulse machine. A standby signal generator with suitable changeover facilities is provided to facilitate maintenance.

### 8.10. Equipment Details

The exchange equipment is constructed on the same general lines as 2000-type telephone exchange equipment, the major differences in detail being the need to arrange for  $\pm 80\text{v}$  supplies and for the fitting of protective bulbs resistor on many of the racks.

The cream coloured finish standardised for both the exchange equipment and cabling has not only enhanced the appearance of the actual equipment but, together with the adoption of fluorescent rack lighting, has created an atmosphere of lightness and airiness

which should considerably improve working conditions.

## 9. SUBSCRIBERS' PRIVATE METER

A private meter facility has been developed and will be offered to subscribers on payment of an extra rental. It is likely to be required by subscribers who wish to know the charges for particular calls and have hitherto made use of the advise duration and charge (A.D.C.) service, offered with the manual system.

To provide the facility, the teleprinter set incorporates a pair of meters which step in synchronism with the subscriber's meter at the exchange under the control of tone signals transmitted over the line. One of the meters in the teleprinter set records the aggregate number of units charged on the last outgoing call made. This latter meter is fitted with a reset winding connected to the call key, so that whenever an outgoing call is made the meter resets to zero.

For signalling, a frequency of  $450\text{ c/s}$  is used, this particular frequency being chosen to avoid interference from the lower order harmonics of the teleprinter signals. Simple filters are used to prevent interference between the double current teleprinter signals which are transmitted on a single wire basis, and the tone signals which use the subscriber's line as a loop transmission path. The tone signals are transmitted with a power of  $5\text{ mw}$ , and in order to cater for long subscribers' lines (some of which may exceed  $40$  miles in length), an amplifier is incorporated in the teleprinter set. The gain of the amplifier is capable of being pre-set to one of three fixed levels to suit the loss of the particular line. A line attenuation of up to  $31\text{ db}$ . can be accommodated.

This method of providing the private meter facility cannot be used on station lines which include a V.F.T. circuit.

The exchange equipment for each line includes a relay which is connected to the meter wire in place of

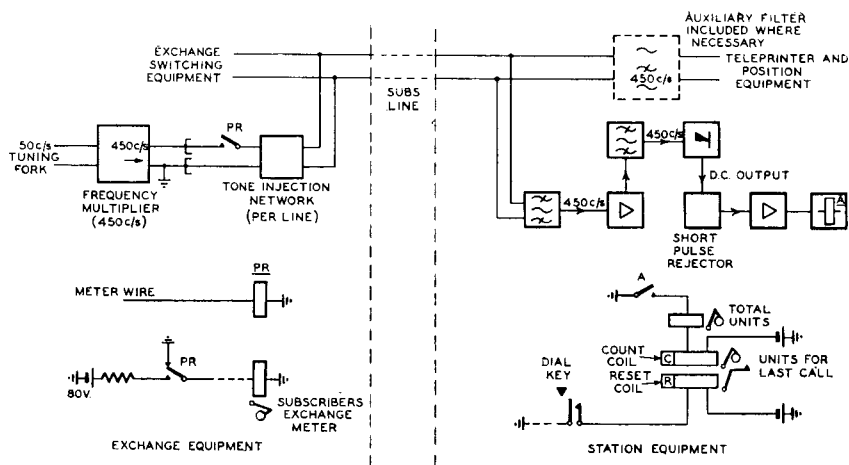


FIG. 23.—SUBSCRIBER'S PRIVATE METER—SCHEMATIC.

the normal subscriber's exchange meter. A contact of this relay permits the tone signals to be injected into the line by means of a simple transformer circuit, whilst another operates the exchange meter. The arrangements are shown in Fig. 23.

The 450 c/s signal is generated by a frequency multiplier driven from the output of the valve maintained tuning fork provided to control the speed of the meter pulse machine and signal generator.

## 10. MAINTENANCE

### 10.1. Test Desk and Associated Equipment

Test desks designed on the same general pattern as those developed for the T.A.S. System are provided for testing purposes. Fig. 24 shows a typical test desk suite.

In addition to the conventional d.c. testing facilities, the principal item of testing equipment is the electronic telegraph distortion measuring set. Test access to subscribers' lines is provided by means of test final selectors, whilst access to trunk lines is provided on the Engineering Control Board (E.C.B.) through which all the trunk circuits are routed. To provide access to subscribers' lines for plugging up purposes in those exchanges where it is not convenient to use the M.D.F., subscribers' lines are also routed through the E.C.B. Each test desk is equipped with a teleprinter which is used for testing as well as for speaking over the telegraph network. Telephone facilities are also provided.

### 10.2. Routine Testers

A range of trolley mounted semi-automatic routine testers has been developed for the maintenance of the more numerous items of equipment. Rack-mounted routiners will be provided at the larger exchanges.

## II. AUXILIARY EQUIPMENT

### II.1. Traffic Recording

Traffic recorders of a standard pattern are provided as necessary. Facilities are included in the traffic recorder so that, in conjunction with the time-zone metering equipment, a record of the distribution of traffic by charging codes can be made. In addition, each rack of first selectors is equipped with a call count meter to record the number of outgoing calls attempted.

In addition to the conventional overflow meters, meters can be associated with nominated subscribers' lines to record the number of calls which encounter busy conditions (see Section 8.4).

### II.2. Observation Equipment

Service observation facilities are being provided, initially, by means of observation equipment of the type developed for the T.A.S. System. Meter observation facilities are also being provided, and since the requirements in this connexion are substantially the same as those for telephone subscriber trunk dialling, similar equipment will be used for the telex service.

## 12. INTERNATIONAL TRAFFIC

The aim of the current program is to provide facilities for subscribers in this country to dial direct to subscribers in as many countries as possible. However, manual working will still be necessary for a small amount of traffic to those European countries still operating manual systems, as well as for inter-continental traffic over radio links. Fig. 25 is a map

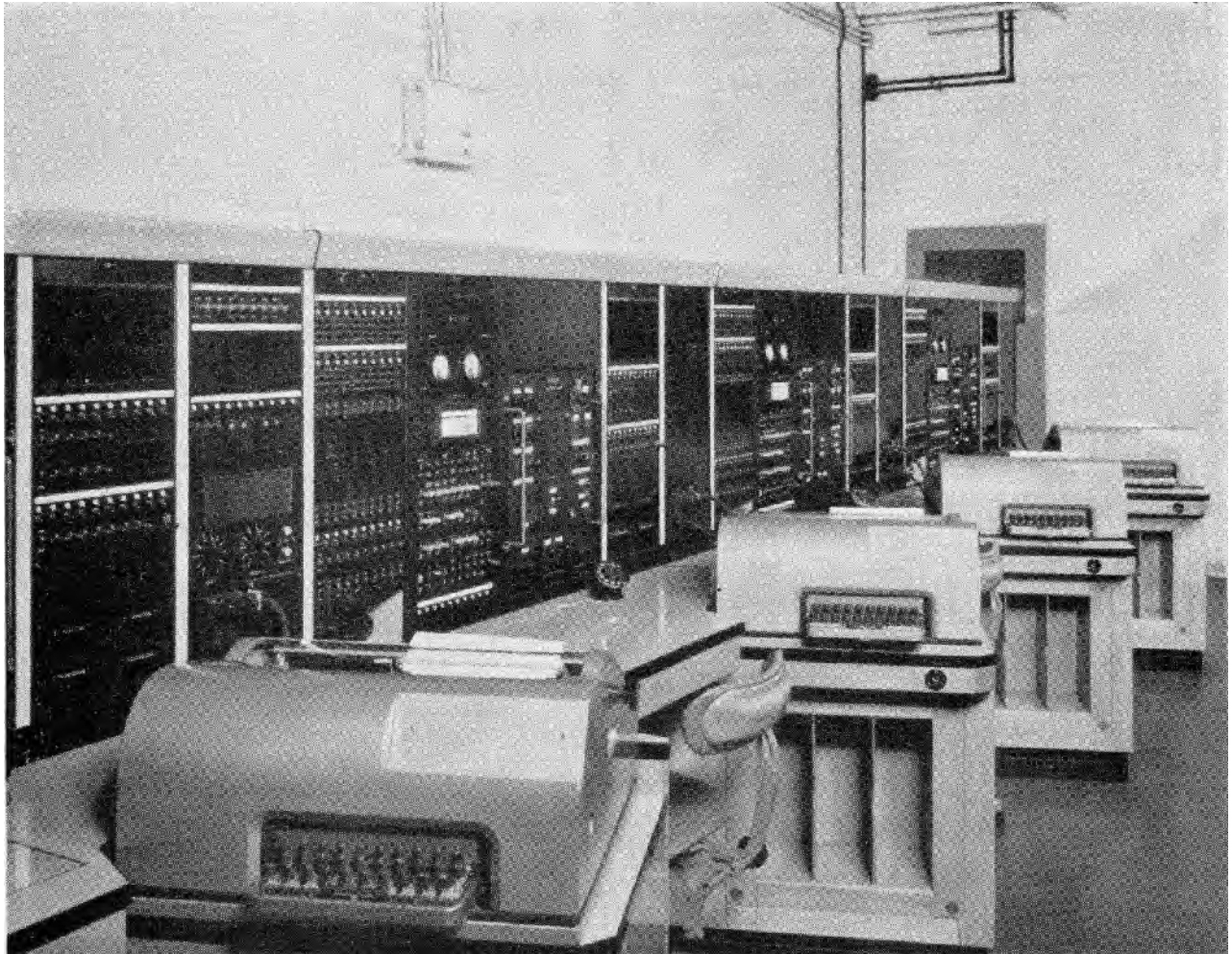


FIG. 24.—TEST DESK SUITE.

of Europe showing those routes from this country to the continent which are expected to be converted to subscriber dialling by 1962.

### **12.1. Subscriber Dialled International Traffic**

To provide the facilities for subscriber dialled international traffic an international exchange will be installed as part of the London (Fleet) exchange.

Access to the international exchange will be from level 20 so that for outgoing subscriber dialled calls, subscribers will dial 20 followed by a code of one or two digits to identify the distant country, followed by the called subscriber's number. For incoming calls the international trunks will terminate on special first selectors trunked in with the London inland exchange. A diagram of the trunking principles to be adopted for the international exchange is shown in Fig. 26.

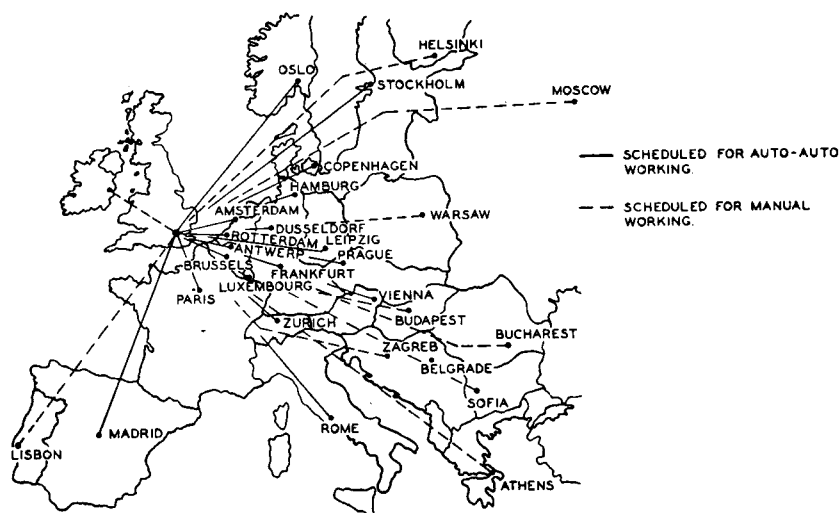


FIG. 25.—TELEX ROUTES FROM LONDON TO EUROPE (1961/62).

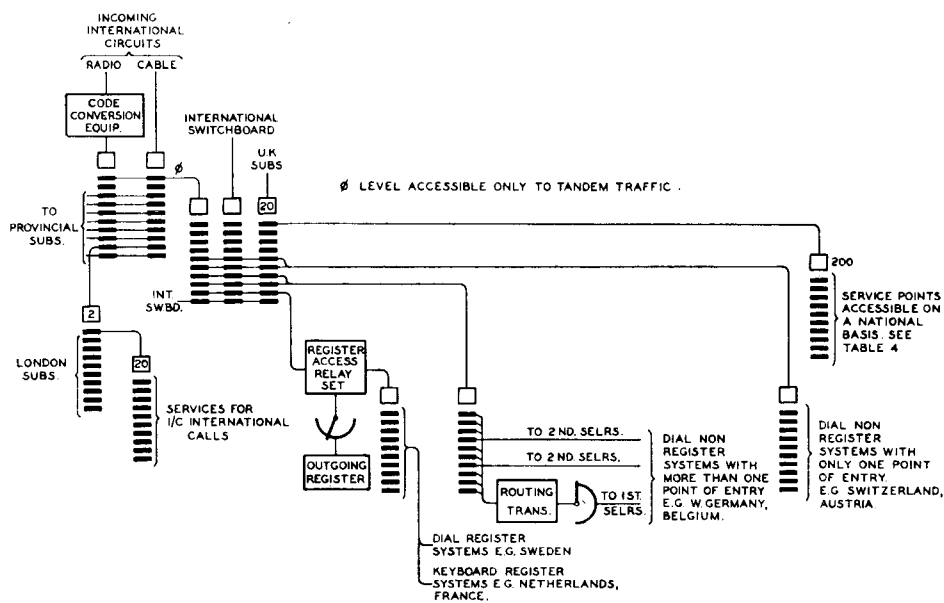


FIG. 26.—TRUNKING PRINCIPLES OF INTERNATIONAL EXCHANGE.

### 12.1.1 Signalling on International Circuits

The signals to be used on international telex circuits have been standardised by the C.C.I.T.T. which has recognised two different ranges of signals referred to as Type A and Type B Signalling respectively.

These two groups of signals correspond to the two basic types of signalling in use by administrations for their internal networks, and it has been agreed that where two countries using systems of different types

are to be interconnected, the calling country is normally required to adapt its outgoing circuits to conform to the signalling requirements of the incoming country, provided that the incoming country uses a signalling system of either of the two standardised types.

Both types of signalling system provide the same functional signals, the difference between the two being in the detailed signals used for a given function. These differences can be seen from Table 9.

TABLE 9

*Signalling on International Telex Circuits for Fully Automatic Working Between Subscribers*

*Note.* In this table the terms "stop" polarity and "start" polarity are used. This is customary in international practice because the alternative terms, e.g. positive or negative, spacing or marking, have a different significance in other countries. The terms "stop" and "start" refer to elements of the teleprinter code and in this country start = positive (spacing), stop = negative (marking).

<i>Signal or Function</i>	<i>Type A</i>	<i>Type B</i>
Free Line Condition	Start polarity on both transmission paths	Start polarity on both transmission paths
Calling Signal	Inversion to stop polarity on the forward transmission path	Inversion to stop polarity on the forward transmission path
Call Confirmation Signal	Inversion to stop polarity on the backward transmission path	25 ms pulse of stop polarity on the backward transmission path
Proceed - to - Select Signal (may be combined with the Call Confirmation Signal)	Either 40 ms pulse of start polarity, or inversion to stop polarity on the backward transmission path	25 ms pulse of stop polarity on the backward transmission path
Selection Signals	Teleprinter Signals	Dial pulses
Call Connected Signal	150 ms pulse of start polarity followed by two seconds stop polarity on the backward transmission path	Stop polarity for at least two seconds on the backward transmission path
Busy, etc.	On the backward transmission path, teleprinter signals followed by the clearing signal	On the backward transmission path, either, 200 ms stop polarity pulse followed by 1200 ms start polarity* or, 200 ms stop polarity pulse followed by teleprinter signals and start polarity for at least 1000 ms*
Out of Order and Spare Line	On the backward transmission path, clearing signal normally preceded by teleprinter signals	On the backward transmission path, either, permanent start polarity, or 200 ms stop polarity pulse followed by 1200 ms start polarity* or, 200 ms stop polarity pulse followed by teleprinter signals and start polarity for at least 1000 ms*
Idle	Stop polarity on both transmission paths	Stop polarity on both transmission paths
Clearing	Inversion to start polarity on one transmission path for at least 300 ms, followed by reversion to the free line condition	Inversion to start polarity on one transmission path for at least 300 ms, followed by reversion to the free line condition

*Note.* The signals marked \* may be repeated until the call clears

It will be noted that the main difference between the two signalling systems is the signal on the backward signalling path whilst selection signals are being transmitted. The Type B system, which was first used in the German TW 39 System, has the advantage that on bothway circuits lock ups due to line interruptions occurring during the free line condition are prevented by the signalling system without requiring special

facilities in the switching equipment. Furthermore, in the event of the partial release of a connexion by a line interruption, the Type B signalling system prevents the teleprinter signals extending the call to another subscriber. However, both of these difficulties can be overcome with the Type A system, by the inclusion of suitable facilities in the switching equipment. These facilities can be more readily incorporated in a key-

board register system and therefore Type A signalling has been generally adopted for keyboard selection systems whereas for dial systems, Type B is generally favoured. However, Type B signalling can be used with keyboard selection and such a system has been developed in Germany.

#### 12.1.2 *Time-Zone Metering Equipment and Metering for the Subscriber's Account*

The charges for dialled international calls will be recorded on the subscribers' meters and will be bulked with inland call charges.

To determine the rate for a particular international call, the time-zone metering equipment will discriminate on the international access code 20, to set up the conditions for dealing with international calls, then from an examination of the digits of the country code, the country can be identified and the appropriate rate applied.

In order that the metering rate to a particular country can be determined from an examination of the country code, it will be necessary to have a uniform rate to the whole of the country concerned. Hitherto, for the telex service to some countries, e.g. France and Germany, there have been a number of tariff zones each with a different rate for calls from this country. However, to simplify the equipment arrangements and thus avoid the need to examine the digits of the called subscriber's number to determine the charge for each call, the tariffs have been modified to provide for a single rate to each country.

Because of the differences in the call connected signals of the Type A and Type B signalling systems, it has been desirable to introduce a special signal for starting the metering on outgoing international calls. The signal used is a + 80v polarity pulse of 270 ms, following the inversion to - 80v polarity on the backward transmission path. The duration of this signal has been chosen to avoid printing a spurious character on the calling teleprinter, whilst providing a signal which can readily be recognised by a simple element which must not respond to teleprinter signals. The pulse will be transmitted from the international trunk relay set when the call connected signal is received from the distant country. This arrangement is preferred to the alternative of including in all the time-zone metering equipments, elements for discriminating on both types of call connected signal, together with facilities for indicating the type of signalling used for calls to a particular country.

On international calls, the time-zone metering equipment will not transmit the WRU Signal to take the answer back of the called teleprinter, since many overseas systems return the answer back automatically from their own equipment. For calls to countries which do not provide for the automatic return of answer back codes, the WRU signal will be transmitted from the outgoing international trunk relay set in this country.

#### 12.1.3 *Metering for the International Account*

In order to obtain data from which to prepare accounts to exchange with other administrations, meters will be associated with each international trunk

circuit to record the value of the outgoing traffic carried. A pair of meters will be associated with each outgoing circuit, one meter will record the number of chargeable calls, the other, the aggregate chargeable time in minute units. The trunk relay sets include a facility for suppressing metering on calls dialled out from the international switchboard and calls tandem switched through this country. For this purpose a discriminating condition is provided over the backward path to enable the metering circuits to be switched out for calls originating from particular points. Metering facilities will not be provided on incoming international circuits.

#### 12.1.4 *Routing of International Traffic*

The traffic to certain European countries will be sufficiently heavy to justify routes to more than one centre. Where more than one route is provided to a country it is necessary to discriminate on the digits of the called subscriber's number in order to decide the best routing. In view of the desirability of limiting the number of digits to be examined, the C.C.I.T.T. has specified that discrimination should be possible by examining not more than two digits of the called subscriber's number. In practice most countries have numbering schemes which permit discrimination on the first digit of the subscriber's number.

In planning the international telex service, the main emphasis has been on the provision of facilities for the switching of subscriber dialled traffic over direct routes, because of the small proportion of transit traffic likely to arise. However, it has been necessary to envisage the routing of tandem traffic over routes carrying subscriber dialled traffic. This could give rise to the risk of fraudulent traffic by subscribers, and the C.C.I.T.T. has this question under consideration. In the design of the U.K. System level 0 of incoming international first selectors has been set aside for tandem access through this country. The international first selectors are equipped with normal post springs so that any incoming circuit can be barred tandem access if so required.

#### 12.1.5 *Access to Non-Register Dial Selection Systems*

The non-register dial selection systems in use in Europe are generally of the TW 39 type using Type B signalling.

The TW 39 system does not normally provide printed service signals, ineffective calls being indicated either by forced release (by the pulse of 200 ms stop polarity followed by 1200 ms start polarity) or by failure of the teleprinter motor to start when dialling has finished (permanent start polarity on the backward signalling path). For effective calls, the answer back is not returned automatically, connexion to the called party being indicated by the starting of the teleprinter motor.

For calls from subscribers in this country it will be necessary to convert the non-printed signals into printed service signals for presentation to the calling subscriber. The busy signal (pulse of 200 ms stop polarity) will be converted into the OCC signal, and permanent start polarity on the backward signalling path converted into the NP signal. For the latter

conversion it will be necessary to indicate that all the digits have been dialled, and since, in general, the numbering scheme of TW 39 networks do not have a regular number of digits, discrimination will be effected 4.8 to 7.2 seconds after dialling has finished. With this method of discrimination there is, of course, some risk of slow dialling by subscribers resulting in the return of the NP signal.

Signal conversion will be effected in the international trunk relay set which will also incorporate facilities for taking the answer back of the called subscriber by transmitting the WRU signal after the call connected signal has been received. Failure to receive signals in response to the WRU signal will be interpreted as indicating a faulty line and the call forcibly released to prevent subscribers being charged for unsatisfactory calls. Because the provision of signal conversion facilities and the automatic transmission of the WRU signal would create difficulties on calls to manual switchboards, the conversion facilities will be made inoperative on calls to distant manual switchboards and to certain types of services. Since access to these outlets will only be required from switchboards and service points in this country, and will not be required from ordinary subscribers, it is convenient to arrange that signal conversion can be suppressed by the same signal which suppresses metering.

The international trunk relay set for working to Type B systems will be able to accept printed service signals from distant systems, but this will be possible only if the range of service signals returned does not include any non-printed signals. Where a mixture of non-printed and printed signals is encountered conversion of all signals will be necessary.

For access to non-register dial selection systems which have only one route from this country, the trunk route will be taken direct from the selector level corresponding to the code allocated to the country concerned. The use of direct selection methods is possible because the dials in this country conform to the standards recommended by the C.C.I.T.T.; furthermore, since the dial pulse signals are not unduly distorted during transmission over telegraph circuits, dial pulse distortion is not a problem.

To provide routing facilities to enter dial non-register systems at more than one point, routing translators similar to those of the inland service will be used as shown in Fig. 26. This arrangement allows for discrimination on the initial digit of the called subscriber's number. Trunk routes taken from the level of the selector preceding the routing translator will terminate on second selectors in the distant country, whilst traffic passing through the routing translator will have the initial digit restored by the routing translator, and the trunk route will terminate on first selectors.

#### 12.1.6 Access to Keyboard Selection Systems

Keyboard selection systems<sup>7,8</sup> in addition to requiring the digits of the called subscriber's number to be transmitted in 5-unit code also require additional characters to be transmitted to indicate such features as "class of traffic" and "end of selection." Class of traffic identification is required in those systems which

combine telex and other categories of traffic (e.g. public telegraphs) on a common network and in which the identity of the various classes is preserved so that intercommunication between the classes can be barred as desired. End-of-selection signals are used by some systems in order to simplify register design particularly for inter-working with other systems using numbering ranges with a varying number of digits. For calls to countries using keyboard selection systems, since the subscriber in this country will dial the number required, it will be necessary to use a register translator which will accept the digits as dial pulses and transmit them as teleprinter code, together with any auxiliary signals required by the distant system.

The register translator will also provide routing discrimination facilities where the distant network is entered at more than one point. In addition, in working to some systems it will be necessary to store all the digits before seizing the outgoing circuit so that the digits can be transmitted at automatic speed. This will minimise the holding time of the incoming registers, and avoid difficulties with the forced release features of registers, bearing in mind that the rate at which digits can be dialled is slower than the rate at which they can be transmitted by teleprinter code. The storage facilities will be provided by the outgoing register translator in this country.

Most countries using keyboard selection systems have adopted numbering plans in which the necessary discrimination can be made on the first digit of the called subscriber's number. This has allowed a design of electro-mechanical register translator to be produced with two-digit discrimination so that a group of registers can serve ten countries. Access to the registers will be gained from an access relay set connected to the selector level corresponding to the first digit of the country code. The access relay set will accept the second digit of the country code and subsequently transfer it into the register which will receive the remaining digits directly.

The register will commence translation when either the first digit of the called subscriber's number, or the full number of the called subscriber has been received, according to the requirements of the distant system. The first part of the translation will be a sequence of dial pulses to position the outgoing selectors in this country. When a free trunk has been found, the register will wait until a signal is given from the trunk relay set to indicate that the proceed-to-send signal has been received. The translation will then continue with teleprinter code signals direct into the distant system. The register will release when all the stored digits have been transmitted. Forced release facilities will be provided to avoid difficulties in the event of misoperation by subscribers or failures in the associated switching equipment.

Keyboard selection systems generally employ Type A signalling with printed service signals and automatic return of the called subscriber's answer back code. There will be, therefore, no need for signal conversion facilities and the automatic taking of distant answer backs to be included in trunk relays sets to keyboard selection systems using Type A signalling.

However, a facility is provided to detect the call connected signal (pulse of start polarity of  $150 \pm 11$  ms) both to start metering on the international trunk circuit for the international account, and also to enable the 270 ms pulse of start polarity to be returned to the time-zone metering equipment to start metering on the subscriber's meter.

#### 12.1.7 Access to Dial Register Systems

The general problems of access to dial register systems are the same as for access to dial non-register systems except that, because of the time required to connect the incoming register to the trunk line, it is necessary to use an outgoing register to store the dialled digits until the distant system is ready to receive them.

The outgoing register described in Section 12.1.6 will also be used for access to dial register systems. By discriminating on the digit identifying the country, the register will be arranged to transmit the called subscriber's number as dial pulses, and to release when an inversion to stop polarity is received on the backward path indicating connexion either to service signals, or to the called subscriber.

### 12.2. Intercontinental Traffic Over Radio Circuits

For the foreseeable future, traffic over radio circuits will be operator controlled. For traffic incoming to this country dialling-in facilities will be provided, whilst for outgoing traffic, subscribers will dial to a switchboard in London, from which the routes will be worked on a manual-manual, or manual-auto, basis according to the facilities available in the distant system.

Most radio circuits will be equipped with a synchronous transmission system incorporating error correcting facilities<sup>6</sup>, in which a 7-unit self-checking code is used over the radio path. This code provides 35 combinations which, in addition to the 32 combinations required for transmitting the International Telegraph Alphabet No. 2, provides three combinations for supervisory purposes. One combination is used to provide error correcting facilities and the remaining two termed "idle  $\alpha$ " and "idle  $\beta$ " are used to signal permanent start or permanent stop on the line respectively. It is apparent that such a transmission system can readily transmit neither dial pulse trains nor many of the pulse signals which are used on international telex trunks routed in M.C.V.F.T. systems. For this reason the C.C.I.T.T. has standardised a special range of signals for use over such radio circuits. These signals are shown in Table 10.

It will be noted that selection signals are transmitted in teleprinter code. In order to provide for dialling-in to this country over radio circuits it will be necessary, therefore, to provide equipment at the incoming ends of the radio circuits to convert the 5-unit signals into dial pulse trains to set up the selectors in this country.

Alternative designs of conversion equipment, using electro-mechanical, and electronic techniques are being pursued and will be subjected to a field trial. The electronic design uses ferrite cores and transistors, and, like the electro-mechanical design, will be

arranged on a common basis so that by means of unselector hunters it will be associated with the radio circuit only for the period the call is being established.

TABLE 10

*Telex Signalling on Radio Channels Using Synchronous Systems with Error Correction for Operator Controlled Traffic*

<i>Signal or Function</i>	<i>Detail</i>
Free Line	Combination $\alpha$ on the forward and backward signalling paths
Call	Transition from combination $\alpha$ to combination $\beta$ on the forward signalling path
Call Confirmation	Transition from combination $\alpha$ to combination $\beta$ on the backward signalling path
Proceed to-Select	On the backward signalling path—one or more teleprinter signals
Proceed-to-Transmit	On the backward signalling path—one or more teleprinter signals
Selection Signals	Teleprinter signals on the forward signalling path
Call Connected Signal	On the backward signalling path—one or more teleprinter signals
Idle Circuit	Combinations $\beta$ on the forward and backward signalling paths
Clearing	Appearance of combinations $\alpha$ in the direction in which the clearing signal is sent
Service Signals	Teleprinter signals (OCC., NP., etc.) followed by the clearing signal ( $\alpha$ signals)

*Note.* Combination  $\alpha$  corresponds to permanent start in the line

Combination  $\beta$  corresponds to permanent stop in the line

### 13. CONCLUSIONS

The conversion of the telex service to automatic working is an important step in the expansion of the telegraph services in this country. It is clear that telex is destined to play a vital part in the communication services of industry and commerce, particularly in the international field. Moreover, although the immediate plan provides only for subscriber dialling within Europe, the facilities which will become available with the extension of the trans-oceanic cable network must inevitably lead to intercontinental subscriber dialling. This course appears to be the logical outcome of the plans outlined in this paper.

Whilst with the coming age of automation in industry and commerce there will be an increasing need for means of high-speed intelligence transmission, there is no doubt that the telex service will provide the backbone of the industrial and commercial telegraph services for many years to come.

#### 14. ACKNOWLEDGEMENTS

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