AN INTRODUCTION TO THE TELEX SYSTEM

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INTRODUCTION

Definition of Telex

"A telegraph service enabling its subscribers to communicate directly and temporarily among themselves over lines by means of start-stop apparatus".

History

Early in the 1930's a Telex service was introduced in the United Kingdom which utilized the existing telephone network. At each subscribers station the equipment provided, comprised a telephone instrument, changeover key, voice frequency signalling oscillator, v.f./d.c. converter, and a teleprinter. The signalling frequency to be used had to be within the frequency range of the existing telephone network and 1500 Hz was chosen to satisfy this requirement. To originate a call, the calling subscriber first dialled the required subscriber's number using the normal telephone network and associated apparatus, and having established the connexion, the calling and called subscribers then mutually agreed to "switch to teleprinter working" after which the hand-sets were replaced. Messages were then sent over the teleprinter circuit although the circuit could be switched back to telephone use simply by operation of the changeover keys at both stations.

In the mid 1930's an international telex service was opened to several European countries. The service became very popular and developed rapidly. However problems arose due to the use of telephone circuits and as a result it was decided to provide a separate switching system exclusively for the use of the Telegraph service. Due to the Second World War, this network was not completed until 1954.

In 1947 a manual telex exchange serving the London area was set up which provided London subscribers with an international service.

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On completion of the independant network in 1954, major provincial centres were served by manual switchboards having direct access to the London international switchboard.

The introduction of the manual telex service was only a temporary measure whilst the ultimate objective, that of providing subscriber trunk dialling on an inland and international basis, was being developed.

Meanwhile in 1935 it was decided to carry out a survey with regard to converting the public telegraph (telegram) service to automatic switching. The decision to automate the system was taken in 1937 but it was not until 1945 that the scheme was reviewed and the latest developments incorporated. The Teleprinter Automatic Switching (T.A.S.) system was completed in 1951.

Experience gained from the T.A.S. system was put to advantage when eventually deciding certain aspects in designing the Automatic Telex System.

LINE SIGNALLING ARRANGEMENTS

The line signalling arrangements are based on double-current working on two wires which form a two-way simplex circuit, and a signalling unit associated with each teleprinter at the subscriber's station connected by a 2-wire line (or a channel of an m.c.v.f.t. system) to a subscriber's line circuit (S.L.C.) at the switching centre.

Signals are sent from the subscriber's teleprinter over one wire which at the signalling unit is designated as the send, forward signalling, or S-wire; at the S.L.C. however, the signals are received over this wire and consequently it is termed the receive, backward signalling, or R-wire. The reverse conditions apply to the other wire of the pair, consequently it is termed the S-wire at the S.L.C. and the R-wire at the subscriber's unit. An explanatory diagram of a connexion over a switching system is shown in Fig. 1.

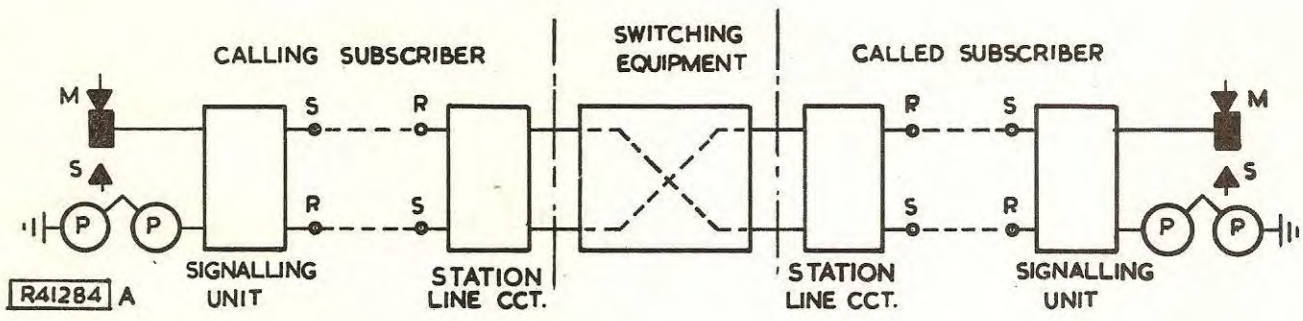

Fig. 1

It should be noted that the necessary reversal in the wires between subscribers is arranged for between the final selector bank and the called subscriber's line circuit.

The necessary information for setting up a connexion is contained in the form of start polarity (positive) or stop polarity (negative) signals generated either by means of keys and a dial mounted in the subscriber's unit, or by the teleprinter transmitter. The function and circuit condition of certain signals employed in the telex system are as follows:

Functional Signals and Conditions - An Explanation of Terms Used

Free line condition	The condition of the circuit when not seized but free to originate or receive calls.
Calling the exchange signal	The signal extended over the S-wire (the forward signalling path) to indicate the desire to originate a call.
Call confirmation signal	The signal extended over the S-wire from the exchange (backward signalling path) after the receipt of the calling exchange signal, to prove the correct functioning of the equipment.
Proceed-to-select signal (P.T.S.)	The signal returned over the backward signalling path to indicate the distant equipment is ready to receive selection signals.
/Note: Some systems combine the call confirmation and P.T.S. signals into one function/.	
Selection signals	The signals transmitted over the forward signalling path to route the call to the number required. (These may be dial pulses or five unit code from the keyboard.)
Call connected signal	The signal returned by the called subscriber's equipment over its S-wire (backward signalling path) when seized for an incoming call by the exchange.
Called subscriber answers in response to the 'Who are you?' (WRU) signal	The 'call connected' signal causes the exchange to apply a 'who are you?' signal to the called subscriber's telex station unit, receipt of this WRU signal causes the 'answer back' code to be transmitted over the S-wire from the called subscriber.
Clearing signal	The signal used to initiate the release of a connexion. The connexion can be released by either party.
Idle circuit condition	The condition of a circuit when a connexion has been established but message signals are not being transmitted.
Service signals	The signals which indicate circuit conditions /e.g. OCC (occupied)/.

Functional Signals and Conditions - Polarities and Duration

Free line	A start-polarity signal condition is applied to the S-wire at the subscriber's unit, and via a rectified relay loop in the SLC, is returned on the R-wire. There is, therefore, a positive potential on both wires of the circuit when the subscriber is free.
Calling the exchange	Operation of a key at the subscriber's unit causes the start-polarity condition on the S-wire at the unit to be replaced by a stop-polarity signal condition.
Proceed-to-select (P.T.S.) signal	Stop-polarity (mark) of between 50 to 100 ms returned from the exchange equipment causing the teleprinter motor to start and the 'dial lamp' to glow, indicating that dialling may commence.
Selection signals	The pulses from the subscriber's dial are double-current signals transmitted over the forward signalling path. The 'break' period of each dial pulse is 60 ms start-polarity (space), and the 'make' period is 40 ms stop-polarity (mark).
Exchange calling subscriber	The condition on the S-wire at the called S.L.C. is changed by the switching equipment from start-polarity to stop-polarity.
Call connected	When the called subscriber receives the "exchange calling subscriber" signal, a stop-polarity condition is returned over the called subscribers S-wire to the calling subscriber to indicate to the calling equipment that the call has matured.
Who are you? (WRU)	When the called circuit returns the call connected signal the WRU signal is extended to the called teleprinter. The signal consists of 300 ms stop-polarity followed by the figure shift and WRU (secondary D) teleprinter signal combinations. The WRU trips the answer-back unit in the called subscriber's teleprinter. A phasing pulse is associated with the commencement of each 'Who are you?' signal cycle.
Clearing	Operation of the 'clear' button at the calling subscriber applies start-polarity signal to the S-wire at the subscribers unit. The condition is extended to the R-wire at the called subscribers unit, and if it persists for more than 325 ms, a clear down condition is set up in the switching equipment.

PRINTED SERVICE SIGNALS

The following printed service signals are automatically returned to the calling subscriber under the conditions stated.

CCC	Subscriber busy (station circuit already in use).
NP or NA	Spare or barred line or level.
NC	Trunk lines busy.
DER	Called subscriber's line faulty.
MOM	Wait-switchboard busy (or while test message is phased in).
ABS	Subscriber's station is closed (i.e. switched off).

Each of the above service signals consist basically of 300 ms stop-polarity (mark), followed by the appropriate teleprinter signals; causing the service signal to be printed on the calling subscriber's teleprinter.

On all except the "MOM" signal a clearing condition (start-polarity) is automatically applied 1500 ms after the commencement of the service signal to release the connexion.

SWITCHING ARRANGEMENTS AND PRINCIPAL EQUIPMENT

The U.K. telex trunk network is based on six fully inter-connected zone exchanges.

For the purpose of call charging the United Kingdom is divided into some fifty charging areas and the charging is carried out on a time and distance basis. The switching network is based on a 5- and 6-digit linked numbering scheme in which the first two digits of a subscriber's number indicate the zone and charging area.

The following signalling conditions occur between the subscriber's telex station and the telex exchange.

WORKING CONDITION	'S' WIRE	'R' WIRE
Free line and local copy	Positive	Positive from 'S' wire via station line and station line circuit (S.L.C.)
Outgoing call	Negative	
Proceed-to-select	Negative	Negative followed by earth
Call matured (Idle circuit)	Negative	Negative
Clear	Positive	Disconnected or earth
Incoming Call	Negative	Negative
Station Closed	No current	No current

The automatic telex system is a Strowger step-by-step system which employs the same types of selecting mechanism as used in automatic telephone exchanges. The trunking principles are similar in many respects to those used in a standard non-director telephone system, but routing-translators are used on certain connexions in the telex system to facilitate junction routing.

The control and arrangement of the selector stages and subscriber's line circuit is similar to normal 2000-type telephone switching practice with the following important exceptions.

(i) Battery testing is employed at each switching stage.

(ii) The line relay, LS, in the station line circuit is normally held operated.

(iii) Both wires of the pair are used as signalling paths, one forward, the 'S' wire, and the other backward, the 'R' wire.

(iv) The selector pulsing relays are polarized to respond to negative current, and are connected to the forward signalling path.

(v) Either party clearing is provided. The connexion is supervised, or held, in the forward direction by relay A in the final selector, and in the backward direction by relay LA in the time-zone (TZ) metering equipment.

An explanatory basic trunking diagram of a Telex Zone exchange and associated equipment is shown in Fig. 2. A characteristic digit is allocated to each zone; trunk routes to other zone exchanges are taken from first selector levels /at the London Zone exchange, to satisfy international signalling requirements, it is necessary for the trunk routes to be taken from second selector levels/.

The following descriptions of the call connecting equipment is given to provide a basic knowledge of the function of the equipment. It should be appreciated that the details have been simplified to facilitate description. Also, it is assumed that the teleprinter stations are connected to the exchange by exclusive physical circuits.

Subscriber's Station Equipment and associated line circuit

The station equipment consists of a page pattern teleprinter, and a mains-energised signalling unit; a dial, two supervisory lamps and a number of keys (or buttons) are fitted on the face of the unit for circuit control purposes. The teleprinter may be fitted with a reperforating attachment and an automatic transmitter.

The normal condition from the station equipment is a positive battery on the 'S' wire, this being when the station is disengaged.

In the station line circuit, a line relay in series with a rectifier unit and a contact of a switching relay, is connected between the forward and backward signalling paths, these being the 'S' and 'R' wires respectively. When the 'DIAL' key on the subscriber's signalling unit is depressed a calling signal, which is a negative battery, is extended over the 'S' wire. The negative battery allows the line relay in the line circuit to release, the release of this relay causing a uniselector associated with the line circuit to hunt for a free time zone metering equipment and first selector.

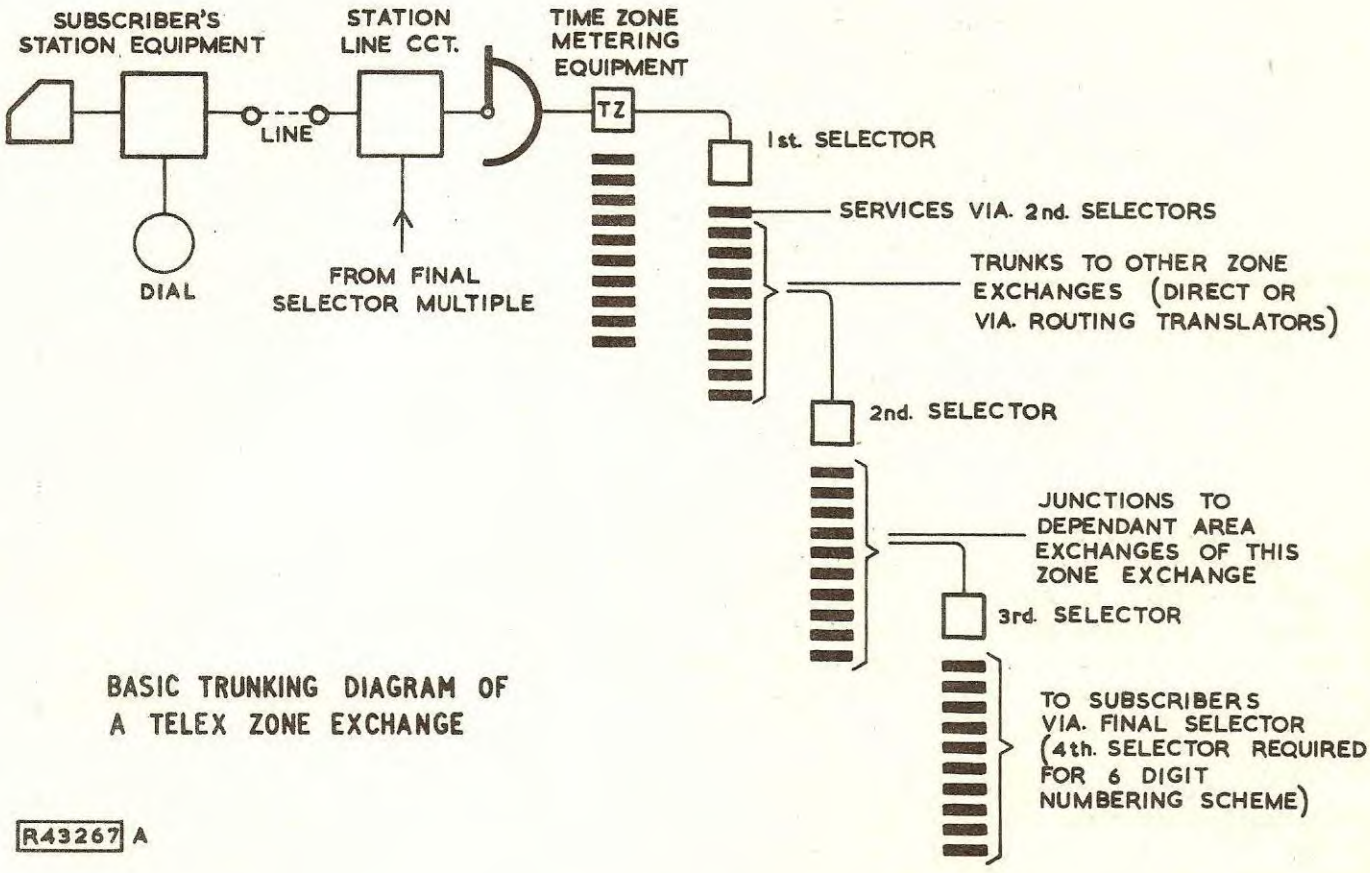

Fig. 2

The proceed-to-select signal, which is a pulse of negative battery, is then received over the 'R' wire from the exchange equipment to start the teleprinter motor and light a green supervisory lamp, indicating that dialling can commence. The dial pulsing spring assembly is a changeover unit arranged so that each complete pulse transmitted consists of a 60 ms space condition (break period) and a 40 ms mark condition (make period). The pulse interruption rate is 10 pulses/s; this conforming to international standards. When dialling is completed the subsequent connexion to the called subscriber is indicated by the automatic return of the answer-back from the called teleprinter.

Facilities are provided to enable the teleprinter to be run in local without busying the line to incoming calls by the operation of a 'LOCAL' key; if a call is received whilst the teleprinter is in local, a red supervisory lamp glows and an audible alarm is given. The operation of the 'local' key is then overridden and the connexion is completed, the alarms are extinguished when the local key is restored.

When the call is completed either party can clear the connexion by the operation of a 'CLEAR' key which is held operated until the green lamp is extinguished and the teleprinter motor stops.

The signalling-unit power supply provides for ± 80V signalling voltages and a -50V for relay operation.

Time zone metering equipment (TZ)

The time-zone metering equipment is permanently associated with a 1st selector as will be seen by the diagrams of Fig. 2. Time-zone equipment, as the name suggests, controls the metering operation on telex calls. It consists essentially of a two motion selector, a uniselector and the associated relays. The two motion selector is controlled by the uniselector and the associated relays; it is stepped vertically and rotarily by the first two digits of the national number dialled or in the case of an international call by the two digits determining the country dialled. The outlets of the selector banks are connected to the meter pulse lead appropriate to the call set up.

As the connexion of a large proportion of calls involves routing over trunks by group selectors before the final selector is seized, the usual functions of a final selector such as recognizing that the connexion has been completed, forwarding the WRU signal, and controlling the metering are carried out by the time zone metering equipment.

A relay in the TZ equipment monitors the digits dialled and pulses to the first train of digits (positive pulses). The digits are repeated (via the first outlet of the uniselector) to step the vertical magnet of the two motion selector. During the inter-digital pause the uniselector steps to outlet two and then self drives to outlet four. On outlet four the uniselector wipers provide a path for the rotary magnet of the two motion selector to be energised, upon which the wipers cut into the bank and remain on the first outlet.

The uniselector wipers step to outlet 5 and set up conditions which check the first outlet of the level to which the two motion selector wipers have been positioned. If the route as signified by the first digit is barred, the code NP followed by the immediate release condition is applied to the backward signalling path. When the route is non-chargeable the TZ equipment plays no further part in the connexion. If the route is chargeable, the uniselector wipers step on and route the second digit dialled to the rotary magnet, thereby positioning the two-motion selector wipers on a rotary outlet one in excess of the digit dialled. During the inter-digit pause the uniselector wipers take a further step and again test the selected bank contacts for the charge and barred conditions.

Assuming that the call is chargeable, the third digit dialled steps the uniselector wipers to check the third digit. If the third digit is 0, the call is barred and NP followed by the immediate release is applied to the calling circuit. When the third digit is not an 0 the uniselector self-drives to outlet 17 and awaits completion of the connexion. The remaining digits dialled do not affect the TZ equipment.

When the 'call connected' signal is received in the TZ equipment over the backward signalling path, the uniselector steps to outlet 18 under the control of the WRU phasing pulse. The WRU is then applied to the forward signalling path.

At the end of the WRU signal the uniselector wipers take three steps, to outlets 19, 20 and 21, at 600 ms intervals under the control of the WRU phasing pulse. If the answer-back signal is not received by the TZ equipment before the uniselector steps to outlet 22, the OCC signal followed by the intermediate release signal is applied to the calling circuit. When the answer-back signal is received correctly, the uniselector wipers continue to step to outlet 23. The meter circuit is then checked, and if satisfactory, it is extended to the meter pulse rate appropriate to the call.

At the end of the call, the uniselector steps to outlet 24 on receipt of the clear signal; the two-motion selector then restores to normal, the uniselector then stepping to the home contact thus placing a free condition on the incoming P-wire.

If the TZ equipment does not detect the receipt of dial pulses after 12 to 24 seconds from the receipt of the calling signal, this occurring when the station closes down, a forced release condition is set up which causes the release of the group selector, the line circuit and the TZ equipment. The station line circuit is then in the 'station closed' condition and the service signal 'ABS' will be returned to any calling station.

The operation of the TZ equipment to international dialling codes will not be considered in this pamphlet.

Group selectors

The 1st group selector is seized by the calling signal which is extended directly from the station line circuit R-wire through the TZ equipment to operate the pulsing relay. Conditions are then sent back to the TZ equipment over an auxiliary circuit to initiate the proceed-to-select signal.

The selector wipers are stepped to the appropriate level by the train of alternate mark and signal pulses from the calling subscriber's dial and, at the end of the train, the wipers are stepped automatically over the level contacts until a free outlet to the next group selector is obtained. When the wipers rest on a free outlet the signalling paths are extended to the next selector which returns a holding condition.

The second and third digits dialled actuate the 2nd and 3rd group selectors respectively and so route the connexion through to a final selector. The 2nd and 3rd group selectors and the final selector take over the holding of the connexion as it proceeds. (In some numbering schemes (6-digit) a 4th group selector is used).

If there is no outlet on any particular level of a group selector, the wipers are self-driven to the eleventh step, where the appropriate service signal followed by the release condition is returned over the backward signalling path to the calling subscriber.

Final selector

There are two types of final selector in use, one for 2-10 and the other for 2-20 auxiliary line groups. The 2-10 final selector uses the 200 outlet principle and is the one usually employed; the 2-20 final selector is not very often installed.

The 2-10 final selector is arranged to provide access to 200 subscribers on an individual line basis or on a 2 to 10 line auxiliary group basis. The mark signal extended over the forward signalling path operates the pulsing relay, which in turn returns holding conditions to the preceding equipment. The last two digits, that is the 4th and 5th, of the called subscriber's number dialled by the caller, actuate the pulsing relay and thereby cause the selector wipers to be positioned on the bank outlet connected to the called subscriber.

The called subscriber's line circuit is then tested and if the line is free, relay contacts in the final selector extend the signalling paths to those of the called line, the necessary reversal being introduced between the final selector multiple and the called line. The mark condition on the forward signalling path, is extended to the called signalling unit and there operates a relay, which causes the teleprinter motor to start, when this is running at correct speed, a mark signal is returned over the backward signalling path. The mark signal is the 'call connected' signal and this operates a relay connected to the backward signalling path in the final selector. A contact of this relay extends the backward path to the TZ equipment where the call connected signal operates a relay, LA, which initiates the connexion of the WRU signal to the forward signalling path and the return of the call connected signal to the calling subscriber's signalling unit.

The receipt of the call connected signal in the calling signalling unit operates a relay, which connects the transmitter of the teleprinter to the forward signalling path.

The receipt of the WRU signal at the called teleprinter operates the answer-back mechanism and so causes the answer-back code to be returned to the calling teleprinter.

The TZ equipment is arranged by means of the phasing pulses associated with the WRU signal, to time the period before the carriage-return character in the answer-back signal is received. Relay LA releases to the 80 ms space period in the carriage-return character, and if this is received within 1.9 seconds it initiates the operation of the call metering circuit.

The connexion is now established and messages can be passed between subscribers.

If the called number is the first line in an auxiliary group and it is found busy, the wipers automatically step to the next line, which is of course connected to the next outlet. When an individual line, or the last line in a group, is found busy circuit changes occur which cause the CCC signal and the release signal to be applied to the backward signalling path.

If the called subscriber is free but is operating the teleprinter in local the mark condition is extended to the called signalling unit as previously described and relay CM operates as before. An audible and visual alarm condition is established, the local copying circuit is disconnected and the receive relay of the teleprinter is connected to the forward signalling path. Under local conditions the backward signalling path is connected to a space condition and consequently relay CT in the final selector does not operate.

There may be some delay in the operator restoring the local circuit to normal, with a consequent delay in the return of the call connected signal. In the final selector, the failure of relay CT to operate sets up a circuit condition which ensures that a mark condition as a substitute for the call connected signal, is returned within 4.8 seconds to the TZ equipment. The subsequent WRU signal operates the answer-back unit and, independent of the local key, establishes the connexion.

When the called subscriber is closed to traffic a particular condition exists on an auxiliary test lead in the line circuit and this causes the final selector to apply the ABS signal and release signal to the backward signalling path.

The final selector band outlets appropriate to spare numbers are connected to the NP service signal. When a spare number is dialled, the final selector switches to it and the NP signal under the control of phasing pulses is applied to the backward signalling path, followed by the release of the connexion.

An established connexion is monitored in the forward direction by the A relay in the final selector, and in the backward direction by relay LA in the TL equipment. The relays are polarized and respond to the normal character signals, but their associated clear features remain inoperative until a space signal persists for a particular period, i.e. the clear signal of a minimum 325 ms duration.

It has been stated that either party clearing is a feature of the switching system. However, the mechanical release of the final selector, does not occur until the called subscriber's station equipment is normal.

TRUNKING PRINCIPLES OF THE INLAND (NATIONAL) TELEX NETWORK

Introduction

As previously stated, the U.K. Telex network is based on a 5- and 6-digit linked numbering scheme in which the first two digits of a subscriber's number route the call to the appropriate charging area. For the purpose of call charging the United Kingdom is divided into fifty charging areas the boundaries of which are more or less aligned with 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 Telecommunication Region. A single charging point is established in each area. Fig. 3 shows the charging area boundaries and code allocation.

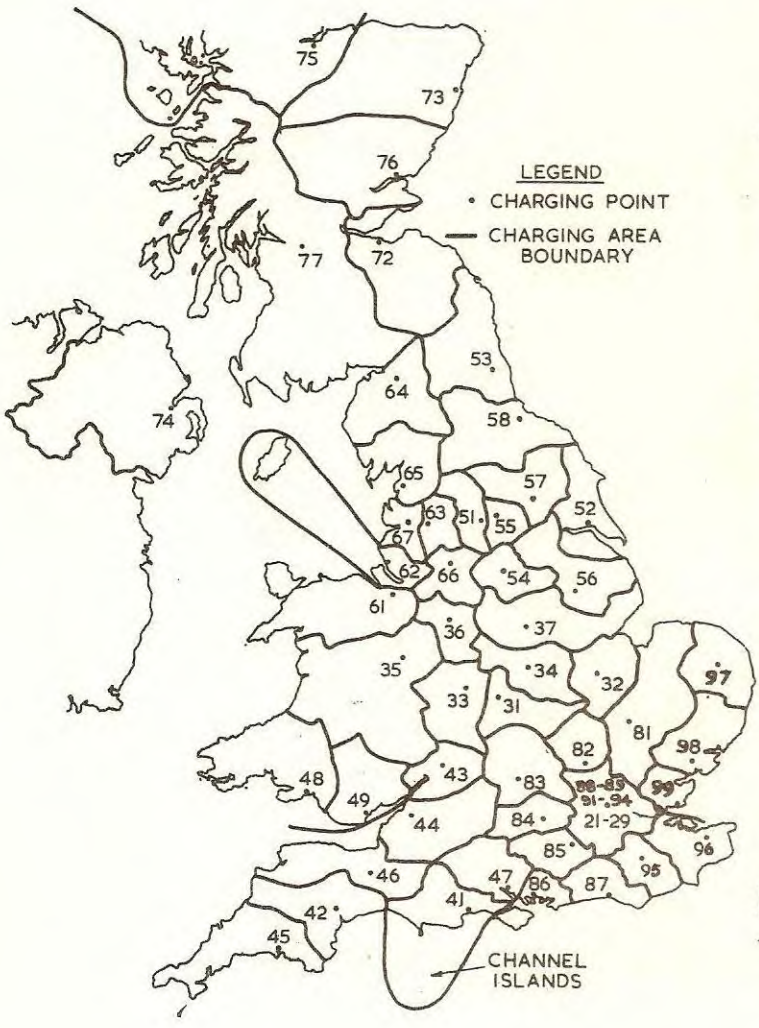

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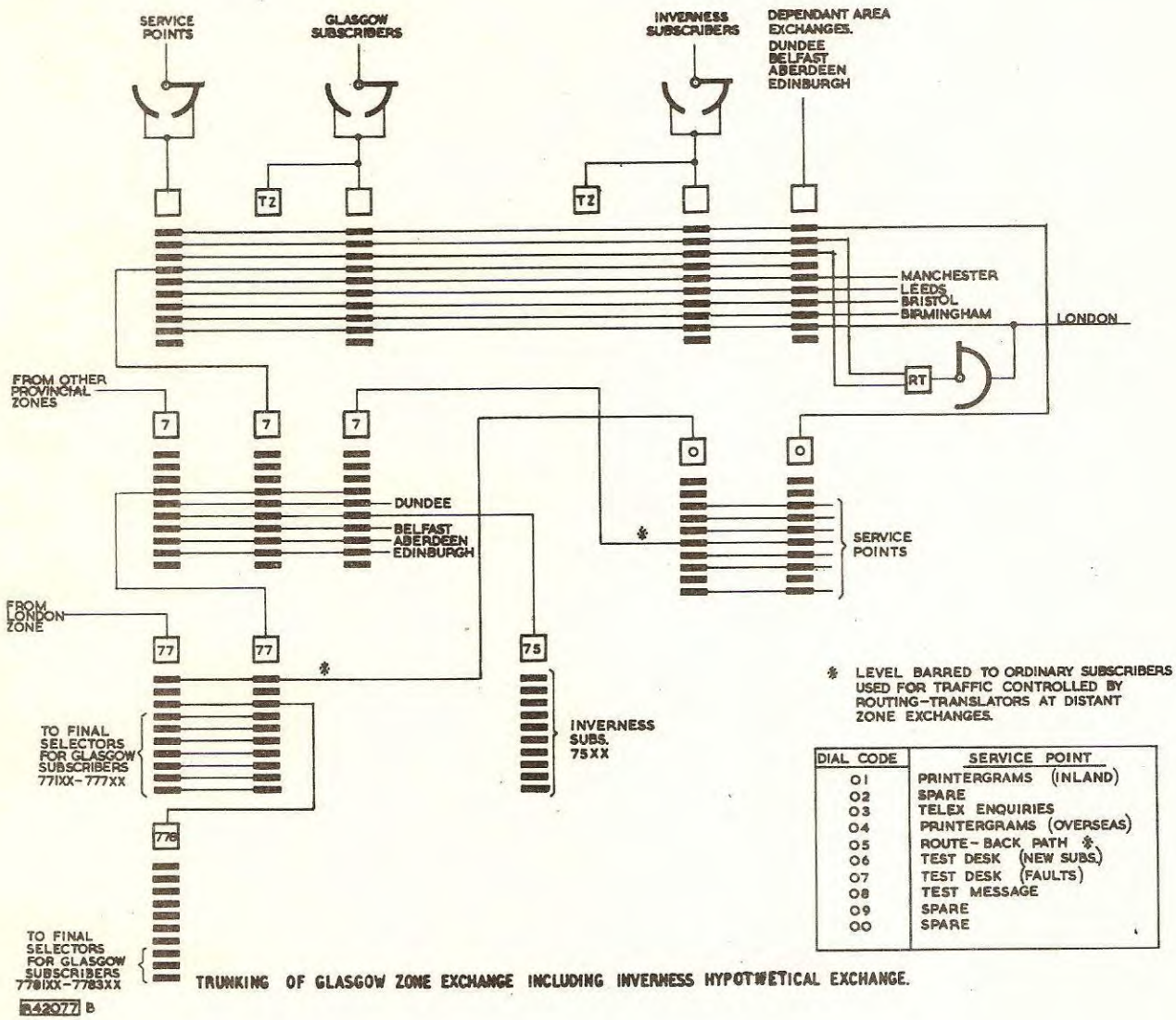
Fig. 3

ZONE EXCHANGES

The trunk network is based on six fully interconnected zone exchanges located at London, Birmingham, Bristol, Glasgow, Leeds and Manchester. A characteristic digit is allocated to each zone, trunk routes being extended from 1st selector levels to 2nd selectors in the appropriate distant zone exchange, except in the case of the London zone exchange, where trunk routes are extended from 2nd selector levels to 3rd selectors at the distant zone exchange.

Each zone exchange acts as a parent exchange for a group of area exchanges and each area exchange is trunked from the parent zone exchange 2nd selector levels. A trunking diagram of Glasgow zone exchange is given in Fig. 4. This exchange is typical of a provincial zone exchange. It will be seen that in addition to the Glasgow subscribers, Inverness subscribers are connected in the same manner i.e. through uniselectors to 1st selectors, this latter exchange is called a hypothetical exchange and more will be said about this later.



TRUNKING OF GLASGOW ZONE EXCHANGE INCLUDING INVERNESS HYPOTHETICAL EXCHANGE.

Fig. 4

Area exchanges Aberdeen, Belfast, Dundee and Edinburgh have junctions which terminate directly on to 1st selectors. As previously mentioned, trunk circuits from other zone exchanges are terminated on 2nd selectors. Any telex call from any other zone exchange telex subscriber to a telex subscriber in Scotland or Northern Ireland will be routed over these trunk circuits by dialling an initial digit of 7; the call is then at the same stage as that of a call from a local telex subscriber who has also dialled 7.

AREA EXCHANGES

Access to trunk route circuits to the parent zone exchange, is obtained from level 1 of the 1st selectors at the area exchange. At the parent zone exchange these trunk circuits terminate on 1st selectors. Fig. 5 shows the trunking diagram of area exchange Aberdeen /served by Glasgow (parent) zone exchange/.

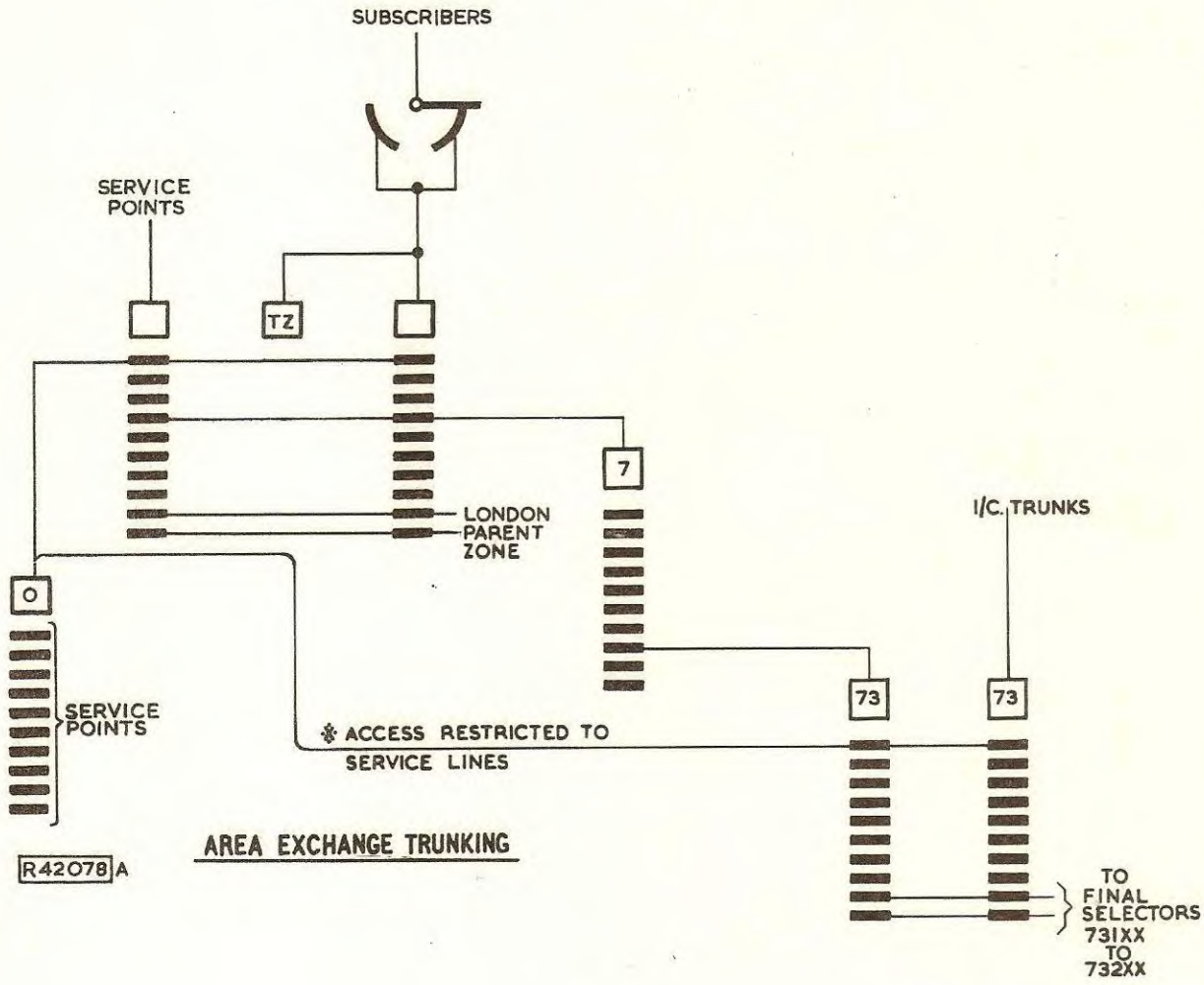


Fig. 5

It will be seen that for calls to subscribers in other zones and consequently routed through its own zone exchange, the 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 1 should be used. If however traffic is so heavy that a direct route is justified

between the area exchange and another zone exchange (other than the parent) then the route is trunked from the appropriate level of the 1st selector at the area exchange e.g. routes to London are taken off level 2. Area exchange subscribers can then gain access to subscribers served by the distant zone exchange by dialling only the directory number.

HYPOTHETICAL EXCHANGES

British Standard Definition

A hypothetical exchange is a projected exchange from the numbering scheme of which numbers are assigned to subscribers although the subscribers' lines are temporarily connected on these numbers in some other existing exchange.

Thus as the name suggests these are exchanges which do not actually exist at the place concerned. Their purpose is to enable an exchange network to be planned and developed even though an exchange building is not ready at the present time or is not justified from an economic point of view.

In Fig. 4, Inverness is a hypothetical exchange based on Glasgow i.e. all the associated exchange equipment is at Glasgow exchange, the connexions between Inverness and Glasgow being made by v.f. channels.

Study of Fig. 4 will show that Inverness is obtained by dialling 75, the final selectors for the group being in Glasgow exchange.

END