A century for TXE4

In April 1980, Standard Telephones & Cables Ltd. handed over to the British Post Office the 100th TXE4 exchange built by the company. TXE4 is an electronic switching system developed by STC for large telephone exchanges and uses reed-relay switching with stored-program distributed control

by Sydney F. Smith

At the end of April this year, STC handed over to the British Post Office the 100th TXE4 telephone exchange to be built by the company, just four years after the first production TXE4 had been commissioned at Rectory exchange in Birmingham. The TXE4 electronic exchange system has a modular architecture with stored-program distributed control and uses reed relays as switching elements. These features make TXE4 a flexible and versatile system which is ideal for the modernisation requirements of a telephone network, especially as it can be installed either as a new exchange or to extend the older exchanges. Production of these exchanges by STC, now better than one every week, may perhaps overshadow the tremendous amount of work that has gone on, both within STC and the Post Office, for many years prior to the commissioning of Rectory exchange.

Back in the 1950s and early 1960s an intensive programme of research and development was carried out by the Post Office and its major exchange equipment suppliers. This evolutionary development was carried out under the auspices of the Joint Electronic Research Agreement. One of the results of this research was the decision that reed relays be used for the switching network of the electronic exchanges then planned. This type of relay is fast in operation, making it ideally suited for use in electronically controlled systems.

For technical and economic reasons it was decided that small and large exchanges should be developed separately. The original system developed for large exchanges was designated TXE1 and an experimental exchange was put into service at Leighton Buzzard in 1968. This was a 2500 line exchange and was installed some seven years after system design work on TXE1 had started.

Parallel development work continued on a small reed-relay electronic exchange design which was known as TXE2. Work on TXE2 progressed quite rapidly and in 1966 the first production exchange was opened in Ambergate, Derbyshire.

During the development work on TXE1, a number of improvements were identified and introduced. More standardised network modules were used, and stored-program control was introduced. This modified system was called TXE3. A model was built in the Post Office laboratories in London and was proved in a two-year public field trial from 1968 to 1970. The system, although technically quite satisfactory, was not considered sufficiently economical to justify its use as a replacement for the Strowger system.

At about this time the Joint Electronic Research Agreement ended. This could have signalled the end of development work but STC decided to continue alone with the development of a cost-reduced version of TXE3. And so TXE4 was born.

Among the various stored-program control systems that were being produced, TXE4 was unique in its concepts of sectionalisation and distributed control, by means of which relatively few uncomplicated subsystems are used to give a high standard of technical performance.

In 1969 a TXE4 system went into public service at Tudor exchange in North London on a field trial. The Post Office carried out an extensive evaluation of the system on technical and economic grounds, and as a result of these investigtions a decision was taken to adopt TXE4 for large local exchange applications.

In 1970 STC started to engineer the system for production, and in 1971 the Post Office took the decision to adopt TXE4 as the medium to large exchange element in its United Kingdom telecommunication network modernisation programme. It was in May 1971 that the Post Office awarded STC a £12½ million contract for the development and supply of an initial batch of TXE4 exchanges. The first to be installed was Rectory exchange in Sutton Coldfield, near Birmingham. Others followed quickly in a large number of towns and cities and quickly demonstrated the versatility of TXE4 to meet a wide range of size and traffic requirements.

System description

The TXE4 system is designed for exchanges ranging from 1500 to 40 000 lines. It uses a switching network of electrically held reed-relay crosspoints with stored-program control. The switching and control areas are each sectionalised and make use of standard functional building blocks which provide a system simple in concept, versatile in application and fundamentally fault-tolerant.

To understand the operation of the TXE4 system it is useful to divide it into four main areas as shown in Fig. 1:

- the *switching network* consisting of reed-relay crosspoint matrixes
- the *interface* between this network and the control system
- the cyclic *data store*
- the *main processor units* which constitute the control system.

The sectionalised switching network of reed-relay matrixes has the ability to accept a wide variety of calling rates and ratios of local to junction traffic. It uses standard switching units to provide a modular capability for growth to meet increases in traffic. Sealed-contact reed relays provide a balanced transmission path having better speech quality and lower noise than the existing electromechanical systems.

The interface between the switching network and the control system is formed by *registers, interrogators* and *markers*. The registers act as interfaces to particular main processor units. The interrogators and markers identify free paths in the network and set up connections through it.

The third main area is the data store, which works in cyclic mode and contains a library of information concerning subscriber numbers, class of service, state of line, trunk routings and transla-

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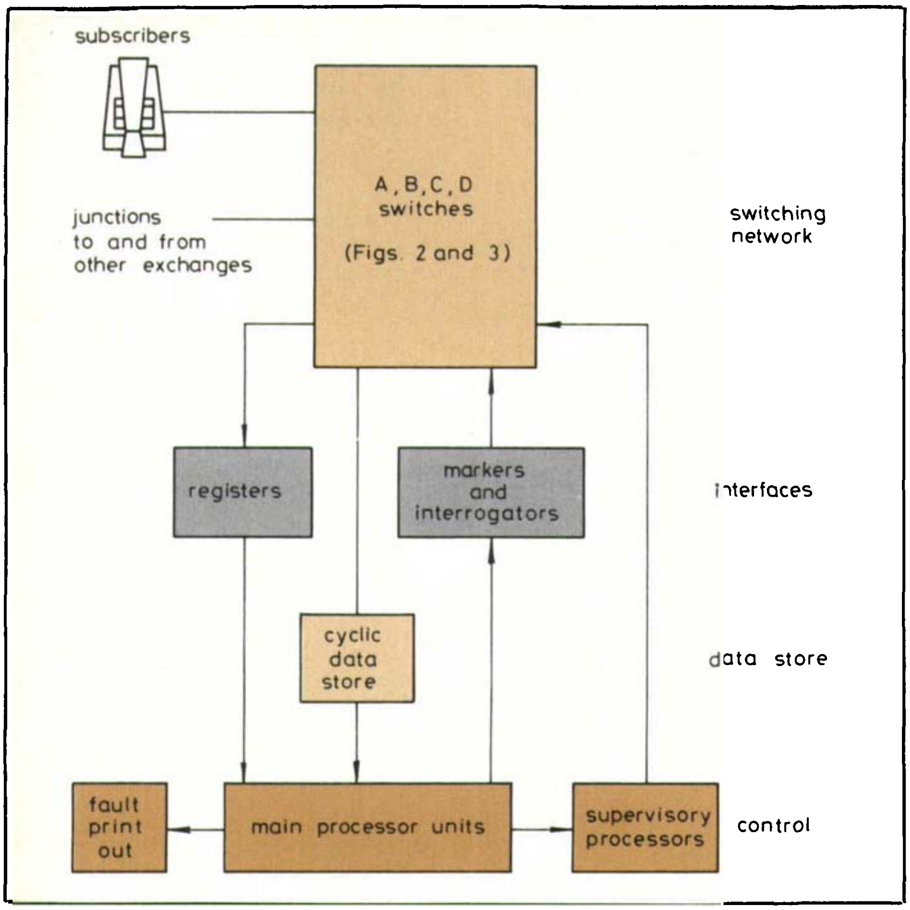
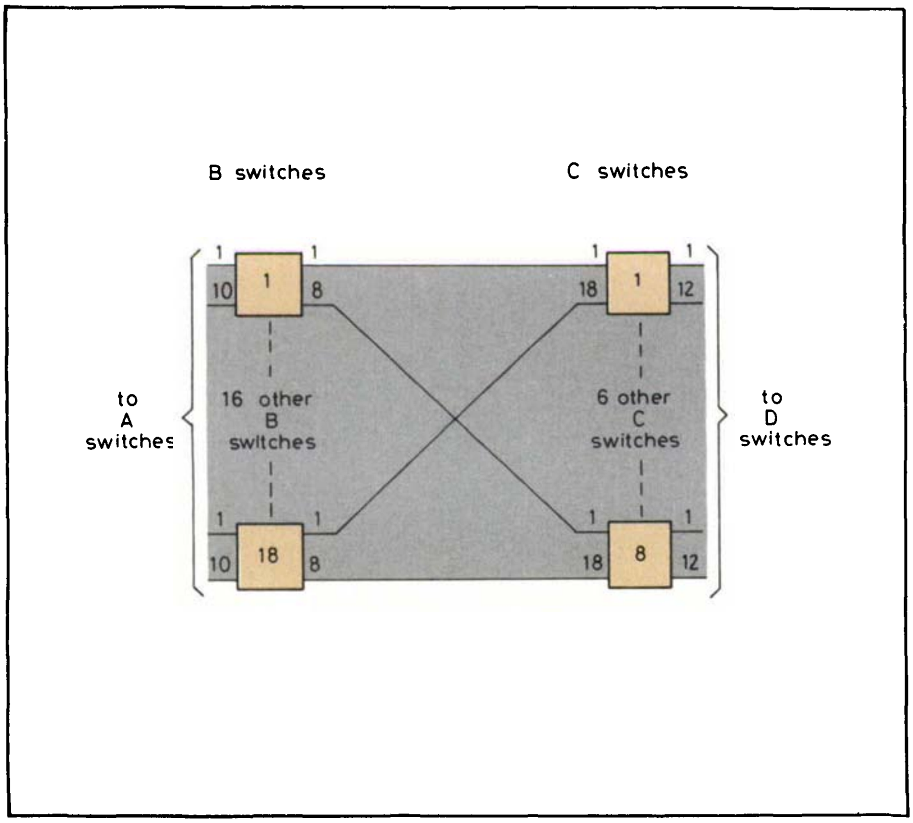


1 Simplified block diagram of a TXE4 exchange showing the four main areas of the system



2 Subunit of fully interconnected *B* and C switches

tions. This embodies line-scanning and data-storage equipment with a high level of security, and provides discrete blocks of exchange line capacity.

The main processor units provide the 'operator' functions of identifying callers, determining what sort of connection is required, and in conjunction with the interrogators and markers, selecting and establishing a suitable route through the network. The number of processors and registers provided depends on the number of call attempts to be handled by the exchange.

Switching network

The primary function of the switching network is to provide a metallic connection when required for a telephone call between any one subscriber or junction and any other. It is designed to be secure against the effects of component failure and to be readily extensible to provide for traffic growth during the life of the exchange.

A modular design is adopted to make the necessary provision for growth. The basic module or *subunit* is a standard size of switch block consisting of two ranks of switches, *B* and *C*, fully interconnected as shown in Fig. 2, each switch consisting of a matrix of reed relays. Security is achieved by having six or eight parallel but independent subunits combined to form a *switching unit*, the smallest step by which the exchange traffic capacity can be extended. Up to 48 of these switching units can be provided.

The provision of parallel switchblocks is known as *sectionalisation* and the set of corresponding subunits in all switching units constitutes a *plane*. Each plane has its own interrogating and marking equipment, and all subscribers and junctions have access through the *A* switches to all planes. In the event of failure in one plane, the traffic can therefore be carried by another plane.

To set up a connection between two terminations (subscriber or junction) a path is established through an *A* switch and the *B* and *C* switches of one plane for one termination and through an adjacent plane for the other termination. A fourth rank of switches *D* is provided to connect together the *C* switches of the different planes and units (see Fig. 3). A complete connection thus involves seven switches *A-B-C-D-C-B-A*.

The subscribers' *A* switching stage provides traffic concentration. That is to say, it provides connection from a large number of subscribers to a smaller number of *B* switch outlets. The design allows this concentration to be adjusted to match the calling rate to the fixed traffic capacity of the switching unit to which it is connected.

A number of *B* switches from each subunit are connected via their associated *A* switches to subscribers. The remainder are connected to junctions and other circuits. The proportion of subscriber-to-junction *B* switches is variable and depends on the proportion of subscriber to junction traffic.

Data stores

The cyclic data stores provide a library of information about every exchange termination. This includes everything connected to the *A* switches, e.g. subscribers, junctions, registers, tone circuits etc. Each of these stores holds the information for 480 subscribers, together with a proportion of junctions, miscellaneous equipment and code translations. The number of cyclic data stores is dependent on the number of lines required, up to a maximum size of just over 40 000 lines. These data stores operate in conjunction with scanning equipment, to provide all the information relating to a particular termination. It is provided simultaneously, in coded form, via highways to all the main processor units.

This technique of broadcasting the data to all processors continuously enables a common set of stores to serve all of them without the problems of store contention encountered with some other multiprocessor configurations.

Main processor units

The main processor units are special-purpose computers employing stored-program-control techniques. Up to 20 of these units are provided and they operate independently in a load-sharing mode. In the event of a fault, the unit concerned is automatically 'busied out' and the total traffic is carried by the remaining units. This gives better protection against complete exchange failure than can be provided by dual processor operation.

The main processors are concerned only with the setting up of calls. The supervision of established calls is handed over to a simpler unit called the *supervisory processor* which controls answer, metering and release conditions.

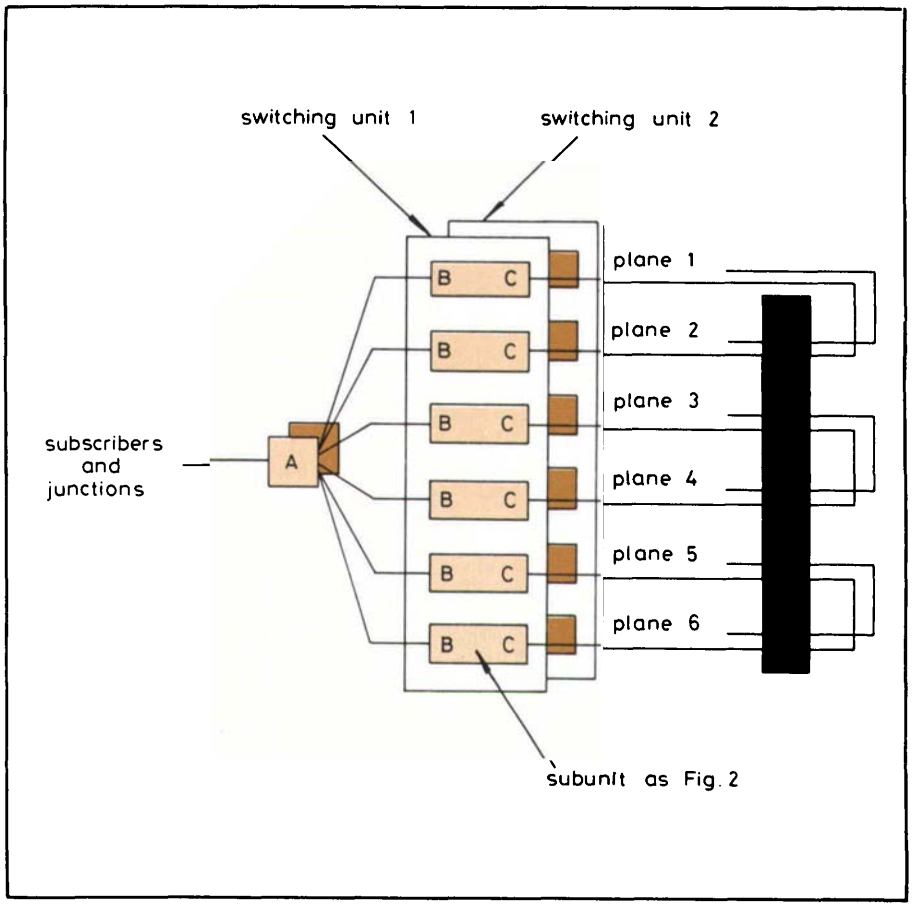
Interface equipment

The interface between the switching network and the control consists of registers, interrogators and markers. Registers are provided according to the number of calls expected and act as interfaces to particular main processor units on which they are dependent for their basic functions. They receive dialled or keyed digits from calling subscribers or incoming junctions and pass the information to the main processor units. On calls to outgoing junctions they transmit the called number information to the next exchange under the control of a main processor unit.

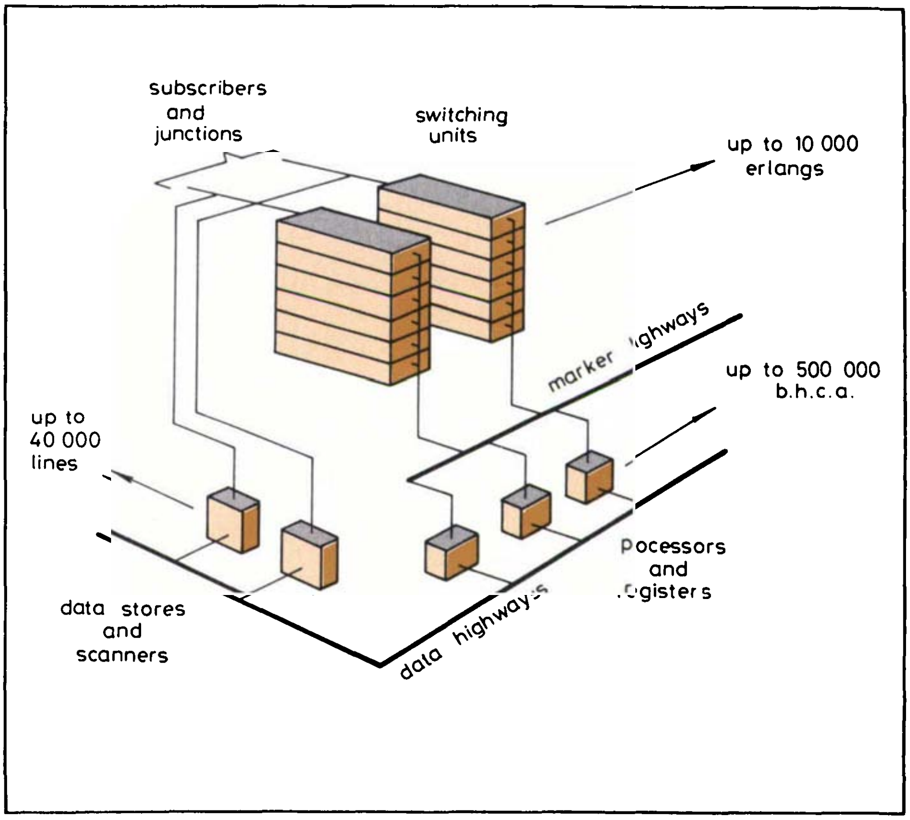
The interrogators and markers are provided with the switching subunits. On demand from the main processor units, they interrogate the network to identify free paths. They then mark the one chosen by the main processor from the available free paths, to establish a connection through the network.

System operation

When a telephone customer served by a TXE4 exchange lifts his telephone, a scanner detects this fact within one-sixth



3 Diagram of TXE4 switching network showing *A,B,C,D* switches and defining subunits, planes and units



4 TXE4 can be extended independently for lines, traffic and busy hour call attempts (the maximum values refer to the latest version, designated TXE4A)

5 Final adjustments being made to rack units in STC's 100th TXE4 telephone exchange at Bromley, Kent

of a second, and the data store adds this information to the data it is broadcasting over highways. The next free main processor reads this call request along with the calling numbers and class of service. It selects a free register by reading from the highway the data referring to registers. Any register within the set allocated to the main processor unit will do, because all customers and all other terminations have access to all registers through the switching network.

Next the main processor unit signals to the interrogators and markers details of the *A* switch locations of both the customer and the register. The interrogators identify all suitable free paths and one is selected by the main processor. This process of selection takes about one-thousandth of a second, and the chosen switches are then operated by the appropriate marker in about one-thirtieth of a second. The calling line is connected to the register and the caller receives dial tone.

The digits dialled or keyed by the caller are recorded by the register and compared by the processor with the data-store output relating to exchange codes and junction routes. Whenever a main processor needs more information to make a decision, it monitors the continuous cyclic output from the data store on its highways. From this one source it learns when a new call is needed and which of its own registers are free. It now identifies not only which exchange the call is for, but also which junctions to that exchange are free, so that it can select one and instruct the interrogators and markers to set up a path from the caller to the required junction.

If the call is for a number in its own exchange, the processor learns from the data-store highway which *A* switch outlet the called number is on and whether the line is busy or free, and instructs the interrogators and markers to connect the caller to a busy tone circuit or the called number as required.

A very important feature of the system is that the path is checked by the register. If the path is found to be faulty, the processor makes repeated attempts to set up a good connection. This happens so rapidly that the caller is unaware that a fault has been encountered. Details of the faulty path are printed out for the maintenance staff. Only then does the processor free its register to handle the next call.

What TXE4 offers

TXE4 was adopted by the British Post Office as the principal means of modernising its network, the largest in Europe and the third largest in the world. What then were the advantages which led to this decision?

The modularity of TXE4 is probably its most significant advantage. At the physical level, the modern plugin units and plugin cabling give ease of extension to the system. Much more importantly, the system concept permits independent growth of the three principal parameters, namely traffic (erlangs), number of terminations (lines) and processing power (b.h.c.a.) — see Fig. 4. With the rapid growth of the Post Office network these features are vital. The concept of modularity also allows the latest technology to be added to the system.

Sectionalisation provides security in the switching network, since if a fault appears which affects any one subunit it will not mean a loss of service to the other subscribers. The traffic will be carried by the remaining subunits. Automatic fault detection and printout facilities enable repairs to be carried out quickly with the replacement of faulty plugin units.

TXE4 is physically smaller than electromechanical exchanges, and so there are economies in transportation costs, installation costs, and in the space required — about 60% of an equivalent crossbar exchange.

The sealed contacts of the reed relays avoid contamination by the atmosphere or dust and provide a clean noise-free transmission path requiring no periodic cleaning or adjustment. The fast operation of the relays provides the capability of setting up connections very quickly. This enables repeated attempts to be made so rapidly that calls can be routed to avoid faults with no delay or loss of service to the customer.

A TXE4 exchange provides a full range of current Post Office facilities and is capable of having new facilities added to it — such as multifrequency keying and personal code calling.

Planned evolution — TXE4 A

Just as development work highlighted possible improvements to the TXE1 and TXE3 systems, so various possibilities for improving TXE4 have been identified. In 1975 the Post Office placed a further contract with STC for the ongoing development of the TXE4 system. This development is now known as the TXE4A. It is not an entirely new system, its architecture is the same as TXE4, so that TXE4 exchanges can be extended with TXE4A equipment.

The improvements in this new development of the system lie mainly in the reduction of cost and in the improvement of the control equipment. Developments in the control equipment include: greater use of integrated-circuit technology and microprocessors; the provision of man-machine interface facilities enabling the data store to be updated directly from a teleprinter keyboard either locally or from a remote location; and the increase of processing power in the main processor unit which gives the system a higher busy hour call attempt capability.

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