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# Multi-Access Computers

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*Computing power alone is not a full measure of the value of computers to a research and development organization; it is also necessary to provide a fast turnround of work. Multi-access computing achieves this fast response. The article reviews the history of multi-access computers, describes some of the new facilities which may be expected and comments on some of the difficulties facing system organizers. It explains how the new Burroughs 5500 and later computers will keep the Post Office in phase with these developments.*

## INTRODUCTION

The computing power of the present Post Office computers used for general scientific and engineering application is considerable and approximately equivalent to one ATLAS[1] computer.

It was reasonable for the early computers to be operated directly by the user because the small power and comparatively slow operating speeds made the overheads of such an arrangement acceptable.

As speed of operation, computing power and costs of machines have increased, the method of operating has changed so that machines are operated by a manager who batches work so that it flows through the machines in the most effective manner. The user loses direct touch with the computer and the time taken to prepare a working program and get results increases.

As machines of greater computing power become available new facilities become possible—in particular, machine organization can permit time-shared use of a common processor by a large number of users working from remote access points. Because of the speed of operation, the users' impression is one of direct and immediate access whilst preparing programs and obtaining the results, although users have exclusive access to the machine for only 100 ms or so every few seconds.

The article reviews the history of multi-access computer developments, describes some of the new facilities which may be expected and comments on some of the difficulties facing system organizers.

## METHODS OF USING COMPUTERS

### User Operation

Small computers such as the Elliott 803B[2] are comparatively cheap, e.g. time on the machine at Dollis Hill costs £3 an hour and it has been quite normal for the user to have direct access to it. A booking system has been introduced and the user has complete control of the computer during his allotted time. The majority of users appreciate this direct contact with the machine since they have a set amount of time and within this period it is their own responsibility to organize their work load and the efficient use of the equipment. They are in direct competition for time with other users and this alone is normally an adequate spur for efficient usage. The disadvantages with the small machine are; firstly only small machine capability is available, secondly the only interchange between users is outside the machine, and thirdly the system tends to restrict booking to a maximum of one week in advance.

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### Batch Processing

Larger and more powerful computers, such as the Elliott 503,[3] are faster and able to process a larger work load, but need high-speed peripherals such as magnetic-tape handlers, line printers and ancillary or backing stores to ensure that the processor is not held up for an input, output, or data-transfer action. A task of straightforward computing which uses half an hour on the Elliott 803 computer will be completed in less than 30 seconds on the Elliott 503 machine. The 3 minutes to load and operate on the Elliott 803 is acceptable as an overhead on 30 minutes of processing but a similar overhead on the 30 seconds of Elliott 503 processing time would be indefensible. This has led to the operating system known as batch processing. Typically, a batch-processing system accepts programs and data initially on punched paper tape or punched cards and stores them on magnetic tape or magnetic disk; when the program is run it is taken from these high-speed media into the main store of the processor. The organization involves tasks being sent to the computer centre where they are handled by operating staff, who batch them together and prepare instructions to the operating system in the form of commands on punched paper tape; the actual running of programs thereafter is controlled by the operating system. The computer produces its output on the line printer and, after the batch run, operating staff sort the output and despatch results, listings and diagnostic information to the users. Some operating systems are not as comprehensive as the one described, while others include more facilities, such as the concept of input and output wells of the type used by the Burroughs B5500 operating system. Here the programmer gives his own operating commands at the head of his task information and, after it has been received at the computer centre and punched onto tape, it is fed into the computer in parallel with any processing which is currently occurring. This task information is stored on magnetic disk stores, together with other tasks, until the operating system decides to run it, using queue position, priority rating and availability of equipment as decision material to let the program into the main processor store. Should the line printer be engaged when required, the output is not delayed but is again stored on a magnetic disk or tape store until the line printer is free. It is then printed out automatically without operator intervention.

Despite improvements made to operating systems, batch processing will never be liked by users. They have lost direct contact with the machine, a feature which enables faults in a program to be quickly diagnosed and cleared, and the time elapsing before results are available, i.e. the turn-round time, is always too high. Even in installations where half-day turn-round is regularly achieved batch processing is still disliked by users; but with computers such as the Elliott 503 costing £25 per hour there is no possibility of reverting to direct control by the user for normal operations.

### Multi-Access

In recent years it has been shown that it is possible for a number of users to share the processing time of a computer by each being connected to the machine over telephone lines with a teleprinter-type device for communication. This promises to bring the user back into direct contact with an opportunity to control the destiny of his program, plus the illusion that he has the whole computer at his command.[4]

## HISTORY OF MULTI-ACCESS COMPUTERS

The concept of multi-access time-sharing use of computers was suggested in 1959 by C. Strachey[5] of Oxford University. Basically, the idea is that users have a terminal in the form of a teleprinter which is connected to a central computer. The time of this central computer is shared between the users; for instance each user could be connected for a time interval of 100 ms; thus if there were 30 simultaneous users then once every 3 seconds each user would get 100 ms of computing time. The computer concerned could have a cycle time of no more than, say, 1 $\mu$s so that a time interval represents 100,000 machine cycles which is a significant amount of processing. The obvious advantage is the facility of having direct access to a computer from office or laboratory and the apparently immediate response from the computer.

American Universities became interested in this idea and, with financial support from Advanced Research Project Agency (A.R.P.A.), a U.S. government agency, a large number of systems resulted, the most famous being Project MAC[6] (Machine-Aided Cognition) at Massachusetts Institute of Technology (M.I.T.). Others such as Berkeley University with the Scientific Data Systems 940 Computer, Dartmouth College with the General Electric 265 computer and the Rand Corporation system using the JOSS language are all successful. These early systems, although successful in providing multi-access time-sharing, are limited in their aims; in general no more than 40 simultaneous users can be accommodated and program size is limited.

The success of Project MAC led to the specification by M.I.T. of a new system capable of catering for hundreds of terminals simultaneously, each user having unlimited program size and access to a complex program-filing system. The contract was awarded to General Electric and since June 1965 work has been progressing on the system which is called MULTICS using a General Electric 645 computer. A similar contract was made between the General Electric Co. and Bell Telephone Laboratories and the development is shared between the three organizations, General Electric, M.I.T. and the Bell Laboratories. At about the same time International Business Machines (I.B.M.) announced a model 360/67 which covers a similar specification. Both the General Electric 645 and the I.B.M. 360/67 are still being developed. In January 1967, Edinburgh University announced a specification similar to that for the I.B.M. 360/67 computer but using an English Electric 4/75 computer.

## UTILIZATION OF A MULTI-ACCESS COMPUTER

With batch-processing systems, programs requiring large quantities of time can only be processed when significant machine time is available. With multi-access systems, programs requiring large quantities of time, e.g. several manhours, can still be handled in a batch-processing mode using spare time within the time-sharing cycle and, when this becomes scarce due to growth, a second shift can be introduced. Short programs taking minutes and programs under development would be handled in the multi-access mode, and when these demands have been satisfied, the remainder of the time cycle can be given to the current batch program. It follows that the service to batch-work will improve and the computer can be fully productive as long as work exists.

The development of small programs under batch processing can take several weeks. This is because of the turn-round time in the computer centre and the time taken to transmit paper to and from the centre. These overheads apply to each attempt made to run a program, and there may need to be six or more attempts. With multi-access facilities the user would:

(*a*) sit at a terminal and identify himself to the computer by teleprinting a password which establishes his authority to use the system, i.e. log-in,
(*b*) type in his program,
(*c*) have the syntax checked as each line is typed,
(*d*) give edit instructions to correct errors, as they are pointed out to him,
(*e*) on completion of programming ask for compilation, which would normally be successful, as syntax was checked and corrected during input,
(*f*) run and test the program for logical errors; the ability to have selective execution and the provision of facilities for error finding whilst the program is running would assist this operation,
(*g*) when the program is proved, run it and obtain results and
(*h*) log-out.

The whole of this operation is normally a continuous process so that a user approaches a terminal with a task and leaves it with an answer. However, at any stage the program state can be stored so that to re-start all that is necessary is to log-in and type the program name. Users will be free to store programs and data within the system so that running a developed program simply involves logging-in at a terminal, giving the correct password and typing-in the name of the required program. Then, by typing-in parameters, the program will run and the results returned directly to the terminal receiver as soon as they are available.

## ADDITIONAL APPLICATIONS STIMULATED BY THE PROVISION OF MULTI-ACCESS COMPUTERS

### Programming Facilities

The availability of terminals and the consequent easy access to a computer will result in existing regular users making more efficient use of their time to develop programs to meet their own needs. The ease of access and speed of turn-round will encourage a more scientific approach to problems which cannot be contemplated with simple batch-operating due to the slow user-machine communication. A multi-access system with good program-file manipulation will also encourage the interchange of programs between users. Users will simply need to ensure that any programs likely to be of use to others are adequately described. Thus, users will act as if they have their own computers but with the added facility of calling on the work of others to save duplication of effort.

### Desk-Calculation

The multi-access computer can provide a desk-calculator facility which could be used by everyone who is likely to encounter either repetitive simple arithmetic drudgery or complex calculations. This field of calculation should produce an increase in the number of users and result in faster preparation of information. Programming techniques are not needed to use the computer in this way, half an hour being sufficient to learn the system.

### Information Retrieval

Within a large organization an enormous amount of information is generated and stored at present on paper or in men's minds. Ignorance of the existence of information leads to duplication of effort, and the selective retrieval of information can be a frustrating and time-consuming operation. With mass storage media becoming cheaper it is feasible to store information within a computer system and, with multi-access facilities, it is possible to retrieve information very quickly. Information can be held in open files for general use, or in security files for limited access. This subject is attracting widespread interest and techniques are developing. A multi-access computing system is essential as a basis for a worthwhile information retrieval system.

**Mail Box Concept**

The "users mail box" concept is one where each user is provided with a file which can be written in by other users for the purpose of conveying messages. Normally, the first instruction after user identification is to call for the contents of the mail box. There are a number of uses for the mail box:

(*a*) General information regarding the system can be sent to each user by the computer manager typing a message into the computer storage system and requesting general circulation.
(*b*) Comments and questions regarding a particular program can be made to its originator and he will find them on his next use of the computer.
(*c*) Users co-operating in a development can correspond and advise one another of changes.

**Design Automation**

Design automation is an all-embracing expression. At one end of the range it includes the use of a program to design a low-pass filter where the user types in parameters and the program produces the design. At the other extreme it offers the facilities for a designer sitting at a specially-equipped terminal to do the following:

(*a*) Draw a circuit on a cathode-ray tube with a light pen. A light pen responds to light, and since the system knows where the spot is, a signal from the light pen can be interpreted as a command.
(*b*) Obtain optimum design by using programs to test the functioning of his design.
(*c*) Allow other engineers to check the project at any stage and possibly add their requirements.
(*d*) Automatically bring dependent drawings and specifications up to date.
(*e*) Prepare physical layout diagrams and specifications, including choice of components.
(*f*) Produce instructions on computer media for automated ordering and manufacture.

As multi-access terminals are provided, engineers will learn design automation by preparing their own files of programs and gaining immediate access to some general-purpose programs. Further development will depend on specialist groups providing additional general-purpose software as well as programs oriented towards individual needs.

It follows that design automation is not a complete system which is provided in one move but entails a steady increase in the use of a computer both as additional software is provided, and user experience develops. Design automation will reduce paper flow, speed developments, enable a more thorough examination of a proposed design, increase the rate of interaction between different sections engaged in a project and generally make better use of staff as routine chores are transferred to the machine.

## LANGUAGE REQUIREMENTS FOR MULTI-ACCESS COMPUTING

Multi-access systems demand new facilities in the form of additional computer languages.

**Remote Job Entry**

When a program is put into the computer from a remote terminal it is referred to as remote job entry. This may be done by either typing the information into the computer or by using pre-punched paper tape. When the program is in the computer a command such as RUN will cause the program to be compiled and run, the results or errors being typed out from the computer at the terminal. This system has the advantage that the user has access to a computer in his office, and his facilities and inter-action with the machine are similar to those of a conventional computer operator.

**Remote Job Entry with Text Editing**

An improvement on simple remote job entry is to add a text editing facility. This allows the programmer to correct errors in his program as he sees them when typing, or as his attention is drawn to them when the computer attempts to compile the program or run the program. The general approach is to number all lines of program so that if the programmer wishes to alter, say, line 120 he types "120" followed by the new statement. It is common practice to number lines in tens so that insertion of two lines between lines 130 and 140 can be achieved by labelling them 133 and 136, say. The better quality text editors allow decimal numbering of lines so a line can be inserted between lines 86 and 87 by calling it line 86·1. Another facility is to instruct the computer to renumber the statements in a program.

**Checking the Program Grammar**

Checking the grammar of a program as it is typed is possible and introduces greater interaction between the user and the machine. The checks can be as comprehensive as the tests made by a compiler, and the information to the user can range from a simple indication that something is wrong to a direct statement of the error. An objection to checking the grammar is that it is almost as expensive in terms of storage and time as complete compiling.

**Compiling and Running the Program Line by Line**

An efficient compiler looks at a group of statements and codes them as efficiently as it is able. It is therefore impossible to use a normal compiler for line by line compiling. However, interpretive compilers can be designed to deal with a line at a time and, although they are inefficient in that the object code is far greater than a normal compiler would produce, they are suitable for line by line compiling, and if required, they may run the program line by line.

If the program is compiled and run line by line the programmer has a high degree of interaction with the computer since he can have each statement compiled directly he has typed it. Errors, with the exception of those of omission, are immediately brought to his attention. At the completion of programming, the program will be proved in terms of correct grammar and the next step would be selective line by line running to test the logic of the program. When this is proved the program can be recompiled, using a conventional compiler, to produce an efficient object-code program.

Errors of omission that do not conflict with the grammar of the language will not be detected until reference is made to the omitted item at a later stage in the program. When this type of error has been corrected it is necessary to recompile the program from the beginning, but this is inevitable under any system.

**Conversational Languages**

There is no definition of a conversational language; quite simple remote job-entry systems have been claimed to be conversational. A good-quality conversational language should give:

(*a*) a high degree of interaction between the user and the machine,
(*b*) indications of all errors at the time that the program is being run with an unambiguous statement of the nature of the error, and
(*c*) a comprehensive command language to control the course of the program and allow interrogation to determine the exact state of any part of a program.

### Desk-Calculator Languages

An additional feature for a time-sharing system is a very simple language which can be learnt in half an hour, or even learnt at the console using a teaching program held in the computer. This type of language is usually referred to as a desk-calculator language, examples being JOSS and CITRAN. All that is necessary to use these languages usefully is a knowledge of elementary algebraic expression. For instance, a simple calculation such as determining salary in terms of weekly amounts, knowing the monthly payment (say £130 10s 0d) will involve typing the following:

**Set** $x = 130{\cdot}5$ (where $x$ is the monthly salary in £'s)
$y = (x * 12)/52$ (where $y$ is the weekly salary in £'s).
**Type** $y$

This simple example illustrates the ease of using a desk-calculator language. However, this type of language is not limited to trivial use and large calculations such as Harper's† formula for the response of a rhombic aerial can be handled quite easily. The advantage of this facility is that the user has no need to be a programmer in order to obtain the services of a computer.

## STORE MANAGEMENT

### General

Time on a multi-access computer is shared by the users and a typical time interval allotted to each user on time-sharing systems is 100 mS; on machines with cycle times of the order of 1 $\mu$S this represents a large computation. For the central processor to be efficiently occupied, the next program to be processed must be in the main store at the end of a time slice. However, to maintain all active programs in main storage would be prohibitive in terms of store size and the normal practice is to use a store big enough to ensure that the central processor is fully employed, and then to move programs in and out of the main store using a fast magnetic disk or drum for secondary storage. There are a number of ways of managing storage for this purpose ranging from simple direct transference from one storage media to another (sometimes known as swapping) to quite complex paging.

### Swapping

In its simplest form, swapping is achieved by dividing the main store into three sections; one contains the software that controls the system, one the program being processed, and the other either the last program to be processed while it is being returned to its secondary store, or the next program to be run as it is being brought into the main store. This system has the great virtue of simplicity but imposes severe limitations on program size; for example if the size of the main store is 64K words and the software takes 32K, then only 32K words are available for the two program areas which restricts the program size to 16K words. (In practice, stores are built of elements which can be conveniently addressed by binary coding methods, e.g. 32 bits × 32 bits ≡ 1024 bits. Hence, where reference is made to store sizes, etc., of $x$K words the intention in this article is that K = 1024).

A refinement sometimes adopted with this type of system is to label one section of the main-store program area odd and the other even and to label all programs odd or even. The restriction of a program to one section of a store allows fixed addressing, thus avoiding the time spent in relocation techniques.

Store swapping can only be efficient if the programs are such that the whole of the time interval is spent within the central processor. If a program makes demands on peripherals, such as the line printer, such a demand might occur only a few micro-seconds after the start of a time interval, and the central processor will be held up during such an input or output request, since, having initiated the transfer to or from peripheral devices, it is not able to turn its attention to another program until the swapping has been completed. This delay time is an overhead on the system.

### Swapping and Segmentation

Segmentation is a method of overcoming some of the disadvantages of simple swapping. Programs are divided into, say, 4K word segments; assuming the same store size as before (64K words with 32K reserved for software) eight 4K word segments could be held in the program area. These eight segments could all be from different programs so the probability of the central processor being held up, because seven programs are involved in input or output functions and the eighth area is engaged in swapping, becomes very small. Segmentation unfortunately introduces additional difficulties; most programs are not processed serially from beginning to end but jump from area to area of the program as conditional requirements are met and, when a program is segmented, demands will often be encountered requiring addresses in other segments. When this occurs, the system will note the demand and arrange to swap in the required segment at some convenient point. This requirement for a segment which is not in the main store is in effect an input–output request and therefore segmentation increases the occasions when the processor is interrupted before the end of the time interval. This can be minimized by choosing a segment size which is greater than the average size of program being processed so that effectively segmenting only applies to large programs. The price to be paid is that of a large main store, which is not necessarily efficiently used.

It is inherent in segmentation that a program will occupy different parts of a store from time to time which means that addresses will have to be relocated whilst the program is proceeding. In addition to relocation, addresses must be checked to ensure space is available in the store, otherwise other segments in main store could be corrupted and the call for another segment would not be recognized. It is essential that relocation and the within bounds check does not slow down the rate of processing. It must, therefore, be performed by logic elements which are very fast compared with a machine cycle.

The disadvantage of simple segmentation is that interactions between sections of program not in the same segment result in frequent movement of information in the store. This can be improved by allowing two segments of the same program to be in the main store at the same time which

† Harper's formula for the response of a rhombic aerial:

$$G = 20\log_{10}\left\{0{\cdot}7\left[\frac{\cos(\phi-\beta)}{1-\sin(\phi-\beta)\cos\Delta}+\frac{\cos(\phi+\beta)}{1-\sin(\phi+\beta)\cos\Delta}\right]\left[\sin\left(\frac{2\pi H}{\lambda}\sin\Delta\right)\right]\left[\sin\frac{\pi L}{\lambda}[1-\sin(\phi-\beta)\cos\Delta]\right]\left[\sin\frac{\pi L}{\lambda}[1-\sin(\phi+\beta)\cos\Delta]\right]\right\}$$

where $G$ = relative gain of rhombic aerial to max. field of half-wave dipole above earth in dB
$\phi$ = semi-side angle of rhombic (degs)
$\Delta$ = vertical angle of shoot (degs)
$\beta$ = horizontal angle for line of shoot (degs)
$H$ = mean height of aerial
$L$ = side length of aerial
$\lambda$ = wavelength

means that 8K words of the main store is devoted to one program. It has been assumed so far that fixed length segments are used which naturally results in a wastage of main storage space in the last segment of each program. Variable length segments overcome this wastage but result in odd-sized gaps being left in the main store as segments are swapped and requires additional software to repack the program in the main store so that gaps are closed. The programmer can help by arranging his program so that interacting sections are in the same segment. This has the disadvantage that a certain amount of main-store space would be wasted in each segment and, on occasions, programmers would under-estimate the size of their object code which would entail rearrangement of program segments by the programmer. This system overcomes difficulties within the machine at the cost of imposing a discipline on the programmer.

### Paging Using a Memory Map

Paging, as applied to computers, is a technique whereby the programs and the stores are fragmented into fixed length blocks. A technique known as memory mapping allows each programmer to have a fixed maximum directly addressable area of, say, 16K words on a machine with 64K words of main-store memory, the programs and the memory being divided into 2K sections called pages. No effort by the programmer is required in this process. The advantage is that only the active pages need to be held in main-store memory and they can be located in non-contiguous blocks of memory, thus allowing the 64K words of the main store to contain the active pages of a large number of programs. The disadvantage is that on a machine with 64K words of main store a program is limited to 16K words although it is possible to overcome this by reusing the software to make the machine believe that a program of 32K words is two separate programs of 16K words each.

A translation is needed to turn an address specified by a program into the actual store location holding the required word at any instant. This is done by first identifying each of the eight 2K word pages which comprise the maximum size of program by three bits. The division of 64K words of main store into 2K word blocks similarly requires five bits to identify the 32 sections of the main store. The programmer's address structure is thus 14 bits to enable him to have access to 16K words and the machine's address structure is 16 bits to give access to 64K words. To make the translation, therefore, the mapping system must replace the programmer's page address with an actual machine location. This is achieved by the use of eight hardware registers of five bits each. The three most significant bits of the programmer's address identify the page number and are used to select one of the eight registers. The contents of the selected register contain the upper five bits of a 16-bit word which is the actual address of the required page. These five bits replace the original upper three bits which selected the register and together with the least significant or lower 11 bits of the programmer's address constitute an actual 16-bit address. This action of selecting a register and replacing the upper bits takes place within the machine cycle and does not add any time to instruction execution. The only overhead incurred is the initial loading of the registers with the page addresses at each commencement of a program run.

Memory mapping is efficient where program size is within the allowed bounds. Provided the majority of programs being run require less than this limit the software for handling larger programs may not be significant.

### Paging whilst the Program is Proceeding

The introduction of paging means that the relationship between main-store size and program size disappears. With memory mapping a discipline of limiting the program to a quarter of the main-store size gives an efficient mix of active program pages in the main store which can be accessed without adding to instruction time. Another method of using pages is to allow the program to be larger than the main store, as only active pages need to be in main store. This second approach is adopted on the larger systems, the practical limit to a program on the General Electric 645 system being 68,719 million words; this is generally referred to as the infinite-store concept.

Programs which are much larger than the available physical storage can be written if the programmer specifies how his program and data may be divided into segments for assembly in the computer secondary storage and relies on the machine to page the segments into appropriate lengths. In the General Electric 645 computer segments are limited to 256K words in size and there can be up to 256K segments in a program: pages are 1K words long.

As with memory mapping the programmer's or virtual address is used by the machine to determine the physical location of a program page. The machine has a store on which program, segment and page-address information is held in tabular form. Reference to the program table gives the address of segments in the program and this is known as the base address. The bits relating to the segments added to this base address select the base address of the page table which gives the addresses of pages in the segment; the addition of the page bits to the base address of the page table give the base address of the required page and, finally, the addition of the remaining address bits to the page base address produces the actual physical store location. At each stage, after adding to a base address, a check is made to ensure that the next step will be within bounds. If this drill were necessary for every instruction the system would be grossly inefficient, since it could not be carried out within the machine cycle, but once a page base address has been obtained through the tables it is held in an associative register and all address requirements first check the associative registers before undertaking the full routine of using the tables. The principle of paging the program as it is being written is shown in Fig. 1 and is known as dynamic paging.

The number of associative registers and the size of page are crucial points in the successful implementation of a dynamic paging system. To date no successful system using dynamic paging has emerged: some difficulty has been experienced using eight associative registers and later developments are specifying 16 registers.

A large page size results in less application to paging tables but less likelihood of another page of the same program being in main store when required. A small page size will result in more applications to paging tables but a greater possibility of other pages of the same program being in main store when required. Variable-length pages would theoretically be the best solution but since this is very difficult to implement manufacturers are simulating paging to determine optimum size.

## PROGRAM-FILE MANIPULATION

It is undesirable to have program and data files on storage media such as cards and tape, because they are not directly accessible to the computer. On the other hand, if all users were able to retain as much information as they wished on machine-accessible secondary storage then little-used information would have to be transferred to devices with longer access times, to allow ample space on the faster devices for more frequently-used files.

A user of a multi-access computer needs to have access to programs and data held within the filing system for use with the program he has developed. This ability to link programs reduces the time and effort for a particular task and greatly improves the interaction facilities. A system which handles the organization of files without user intervention and provides efficient and simple-to-use file linking is essential for

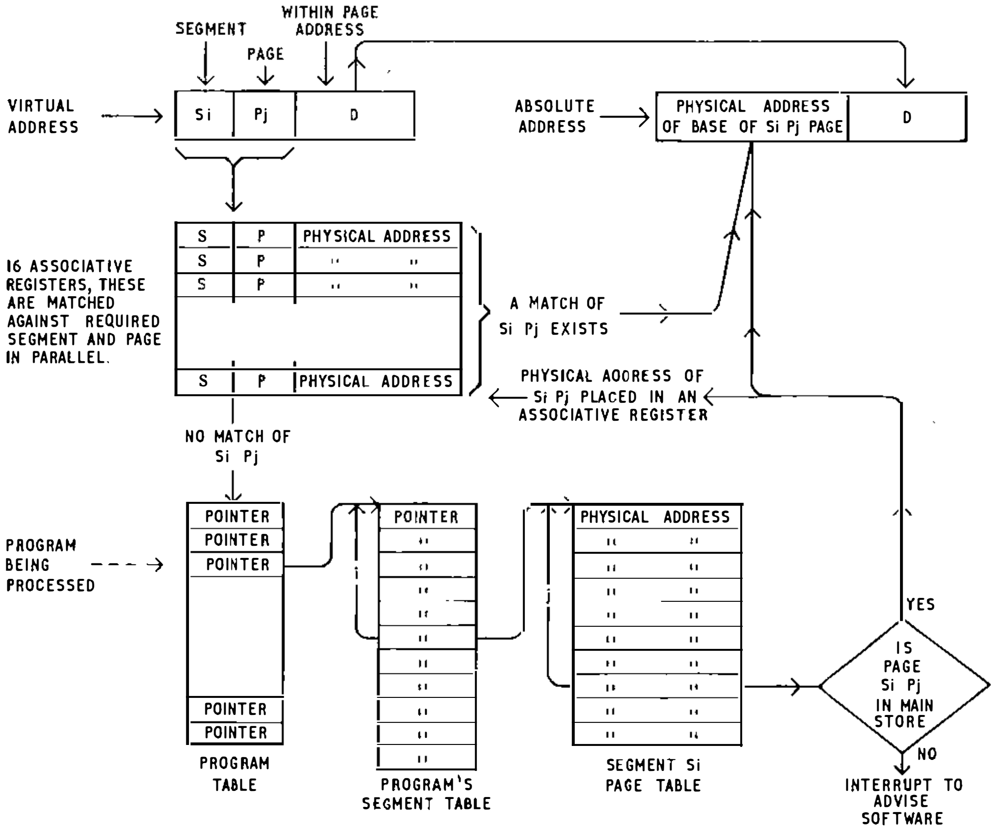


FIG. 1—Page addressing system

viable multi-access working. In any system for the Post Office, the file-handling organization will need careful scrutiny for, apart from normal programming requirements, a good file system is essential for information retrieval and automated design.

## TERMINAL EQUIPMENT

In a multi-access configuration, with tens and possibly hundreds of terminals, the cost of the terminal typewriter becomes significant. Comparatively cheap teleprinter devices are used by most systems: these are character by character machines and being mechanical are noisy. An alternative terminal is the alpha-numeric video display with a keyboard. This type of terminal has the following advantages:

(*a*) Quietness.
(*b*) Less liability to faults.
(*c*) Fast display of information.
(*d*) When provided with a local store, it only requires service from the central system for significant demands, whereas a teleprinter makes a demand for each character typed.
(*e*) It represents a big step forward in the elimination of paper.

At present the price of display terminals is far higher than teleprinters but as the market expands this situation will change.

## RESPONSE TIME

For adequate man/machine interaction the machine must seem to react instantly. When the user knows his demand is trivial he expects a response time of no more than two seconds or so because a longer time than this upsets the rhythm of interaction. Although two seconds to a man is fast, to a modern machine it is 2,000,000 machine cycles.

When a command such as RUN is given, the user expects that his program is being compiled and run. He senses that his part in the operation is completed for the time being and that the task is now with the machine. Consequently he is more tolerant of the response time. There is, however, a limit because the user has some idea of the time his program should take and, if this is exceeded, he either becomes worried that the program has gone wrong or exasperated at the delay.

Good response time is a major facility and must be carefully specified. It is no advantage if the system gives a fast response time to trivial demands at the expense of slowing down the rest of the program. Response timing is an important part of the system, and the power of the machine, the rules for allocating time intervals and the number of active terminals and their traffic pattern must be carefully balanced to obtain optimum response time. This ideal situation is not practicable, so the approach must be to over-provide and use the spare capacity for batch-processing. When the load grows the design response-time can be maintained at the expense of the batch-processing, which can be completed at some time when less users are connected. The power of the configuration must, of course, be increased before the stage is reached when batch-processing is regularly fully displaced, otherwise the essential flexibility of the system is lost.

## COMMUNICATIONS

Multi-access computing is obviously heavily dependent on telecommunications: it has been estimated that 50 per cent of a large system consists of communications equipment. This includes terminals, modems, lines and multiplexers. The communications load on this type of computer complex warrants the use of a processor dedicated to handling the message switching aspects and relieving the main system of comparatively trivial tasks.

## MULTI-ACCESS COMPUTERS IN THE TELECOMMUNICATIONS HEADQUARTERS

In the Telecommunications Headquarters (THQ) there are now two Elliott 803, two Elliott 503 and a Burroughs 5500 computers as well as three terminals connected to commercial bureaux. The Burroughs B5500 machine has nine terminals and the total computing power is at present approximately the same as one ATLAS computer. By 1972 it is estimated that the computing power needed for research and development will be three ATLAS computers, and a multi-access system is obviously the way to meet this type of load. A large computer complex is being planned for the new research station site at Martlesham Heath, and although specification is not complete, the general plan is that this machine will serve the whole of THQ with research, development and management computing facilities. Initially, 100 terminals, preferably of the video type, and at least two terminals with light pens, each with its own local computer (one situated at Martlesham Heath, the other in London) are being planned. There will also be remote line printers and graph-plotting stations for fast hard copies service (the number and location being determined by traffic) and interfaces for coupling to on-line equipments and control devices. This computer complex must be capable of expansion both in power and connexions, since it is anticipated that up to 400 terminals will be needed.

## CONCLUSION

The use of computers in the Post Office is rapidly increasing and one way of keeping up with this growth is by using multi-access computing. The stage when every engineer, manager and scientist has a video terminal as well as a telephone on his desk will possibly arrive in the not too distant future.

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# Book Reviews

"Tape Recorder Servicing Mechanics." H. Schroder. Iliffe Books, Ltd. 122 pp. 62 ill. 21s.

This book, first published in Germany in 1961, is divided into two main sections describing, respectively, the mechanical and electronic aspects of tape recorders. The author confines himself to domestic recorders, with occasional references to studio machines where these help to illustrate different techniques.

The first chapter describes the basic mechanics of tape transport, starting with the various types of motor-drive units and progressing to the methods employed to obtain constant tape tension and braking of the feed and take-up spools. The statement that "domestic machines usually only have one motor" is true of many European machines but U.K. manufacturers have, in general, favoured multi-motor techniques. Examples are given showing the extent to which cyclic changes in tape speed are influenced by such factors as the eccentricity of the capstan and variations in the thickness of driving belts. The short second chapter is concerned with methods of measuring the mechanical parameters discussed previously.

The "electronic" section deals with the characteristics of record, playback and erase heads and the associated requirements of equalization, amplification and high-frequency bias. There is a description of the methods employed in balancing the various, often conflicting, parameters to achieve optimum performance. Liberal use is made of graphs showing, for example, the influences on high-frequency and low-frequency performances of gap size and face width in playback heads and the effect of bias current on frequency response and distortion. A number of circuit diagrams are reproduced showing typical valve-operated record/playback amplifiers and high-frequency bias oscillators. There are no diagrams of solid-state circuits. The section concludes with a chapter devoted to electrical measurements, ranging from the use of instruments such as valve voltmeters, oscilloscopes and distortion meters to wow and flutter indicators.

A brief appendix completes this small but informative volume, which, although written with the service engineer in mind, would also be of value to the technical user of tape recorders.

A. D. S.

"Plastics Insulating Materials." I. M. Mayofis. Iliffe Books, Ltd. 320 pp. 84 ill. 55s.

This book is a translation by Scripta Technica, Ltd., of the original edition published in the U.S.S.R. in 1963. The declared aim of the book is to provide an introduction to the technology of plastics used as insulating materials for the benefit of undergraduates or recent graduates in chemistry. This function the book performs extremely well. The author's approach to the synthesis, characteristic structure and properties of plastics is essentially chemical in outlook and presupposes at least first-year final-degree knowledge of chemistry in the reader. This basically chemical approach is the first drawback that this book has for the electrical engineer wishing to brush-up his knowledge of plastics. The second is that, despite the generally high quality of the translation, some 20 or so technical terms have been translated literally from the Russian idiom into expressions which cause difficulty even to experienced plastics chemists. Typical examples are the use of the term "laced spatial polymer" instead of the English expression "cross-linked polymer," and "porophore" for "blowing agent."

To summarize, the engineer with some knowledge of chemistry, who is prepared to correct the occasional idiosyncrasy of the translation, will find this a useful book; the majority however would almost certainly prefer something with a much greater emphasis on the mechanical and electrical properties.

J. C. H.

# Two New Cable-Drum Trailers

E. W. CHARLTON, C.ENG., M.I.MECH.E.†

U.D.C. 621.315.292:621.114.3

*This article describes two new cable-drum trailers, which have been developed to meet the needs of the smaller cabling party. Therefore, the designs incorporate features which give ease and safety of operation.*

## INTRODUCTION

The cable-drum trailer used by the British Post Office at the present time is designed to accommodate cable drums up to 7 ft 6 in diameter, 3 ft 8 in wide and weighing up to 4 tons. This trailer, shown in Fig. 1, was first introduced in 1956 and has given excellent service.* It is compact and weighs less than one ton unladen, making it ideal for large cabling jobs, but it can be inconveniently heavy for small cabling parties using the smaller sizes of cable drum. To cater for such parties, two new cable-drum trailers have been designed, an 8-cwt trailer of simple construction and a larger 30-cwt trailer.

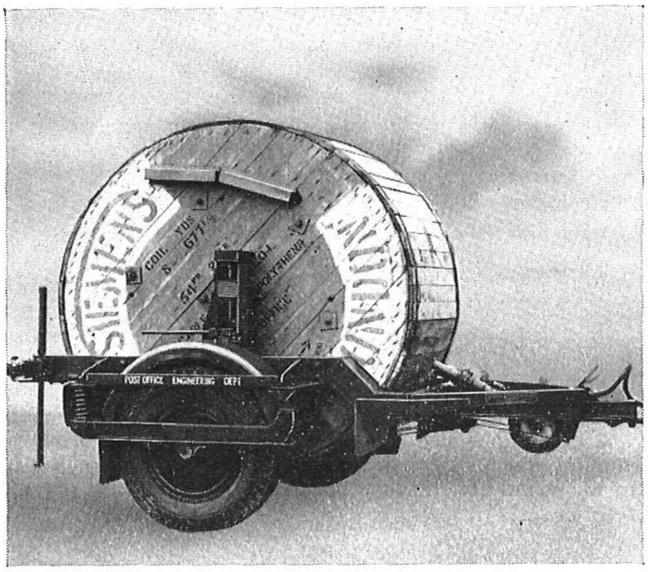


FIG. 1—The 4-ton cable-drum trailer

## THE 8-CWT CABLE-DRUM TRAILER

The 8-cwt trailer is designed to carry, as its maximum load, a 3 ft 6 in diameter cable drum, fully wound with polythene-sheathed cable and weighing approximately 8 cwt. This drum size is the maximum diameter permissible, but two or three reels of cable may be carried together on the spindle, provided their combined weight does not exceed the 8-cwt limit. The unladen weight of the trailer is only 3 cwt, and its dimensions are 9 ft 9 in long and 6 ft 3 in wide.

The trailer is self-loading; the wheels are used as a fulcrum and the length of the towing frame as a lever, to obtain a mechanical advantage such that two men can easily pick up the largest cable drum (Fig. 2).

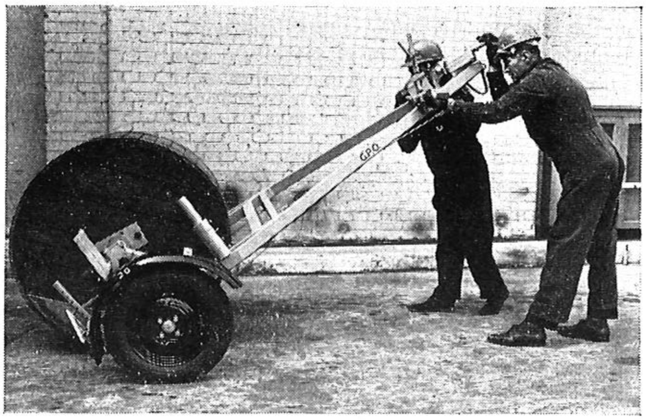


FIG. 2—The 8-cwt cable-drum trailer; loading

### Construction

The main framework of the trailer is a simple all-welded construction of light-weight steel box-sections. Cable drums are supported on a tubular-steel spindle, which rotates in bearings with hinged retaining plates secured by pins, and closed ends to prevent lateral movement of the spindle. Two

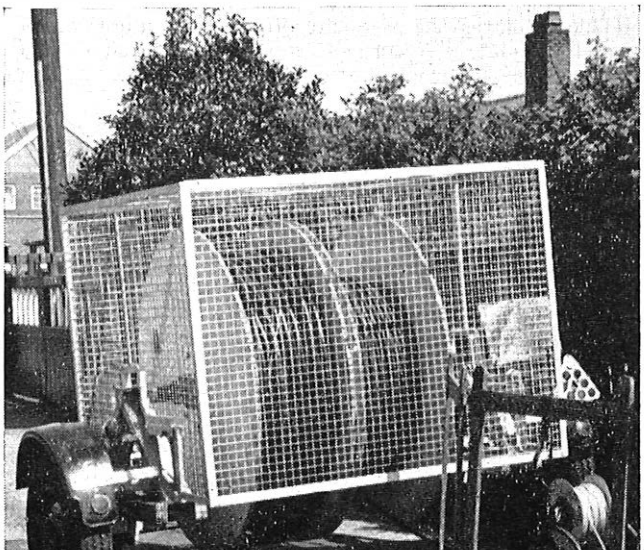

FIG. 3—The 8-cwt cable-drum trailer; the wire-mesh guard

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* MOFFATT, J. J. A New Cable-Drum Trailer. *P.O.E.E.J.*, Vol. 48, p. 202, Jan. 1956.

extensible legs at the rear of the trailer give stability when paying cable off a drum. A safety feature, particularly important as the trailer is to be used by small cabling parties, is a wire-mesh cable-drum guard (Fig. 3) to protect the public (especially children) from possible injury when cabling is in progress, and the trailer is unattended. Other features of the design are as follows:

(*a*) The road wheels are independently sprung by rubber torsion-type suspension units.

(*b*) Over-run brakes and an independent hand brake are provided.

(*c*) The towing-bar is equipped with a forged-steel towing-eye and handles for use during manual manoeuvring and loading operations.

(*d*) Spacing collars are carried on a fixing on the trailer, and are used for centralizing a cable drum on the 2 in-diameter cable-drum spindle. Adapting collars are also provided, and are used when cable drums with 3¼ in diameter holes are encountered.

The trailer may be towed by a vehicle of 15 cwt or larger.

## THE 30-CWT CABLE-DRUM TRAILER

For carrying the intermediate sizes of cable drums, a trailer with a capacity for drums up to 5 ft diameter, 3 ft 8 in wide and weighing up to 30 cwt has been designed, and is shown in Fig. 4. The unladen weight of this trailer is 11¾ cwt,

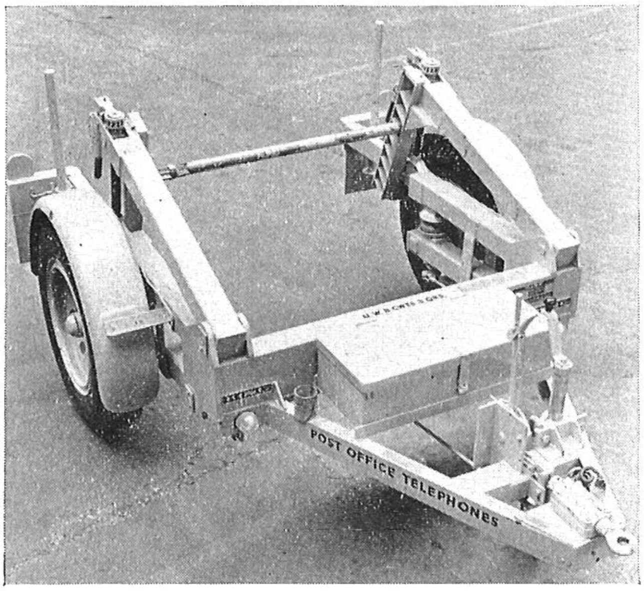

FIG. 4—The 30-cwt cable-drum trailer

and its overall dimensions are 9 ft 6 in long and 6 ft 6 in wide.

The trailer is again self-loading, but the mechanism is necessarily more complicated than that of the 8-cwt trailer, due to the greater weight of cable drum to be handled.

### Construction

The main framework is constructed of welded steel box-sections for lightness and strength. The rear of the frame is completely open to facilitate drum loading, and two substantial adjustable steady-posts are provided to give stability during cabling operations. A castor wheel is provided on the tow-bar to permit manual manoeuvring of the trailer. The wheel is retracted when the trailer is under tow, and can be adjusted vertically to facilitate coupling of the trailer to the towing-hitch of a vehicle. Suspension is by trailing links, pivoted at the front cross-member of the main frame, and sprung by rubber compression units.

Over-run brakes are used as the gross weight of the trailer is less than the legal 3½-ton limit permitted for this type of brake mechanism. A hand brake is provided, which can be locked with the brakes applied when the vehicle is temporarily parked and unattended.

### The Jacking Mechanism

The alloy-steel cable-drum spindle engages, on either side, with one of seven steps of a spindle rack. Hinged retaining plates, locked with pins, secure the spindle in the racks. The racks, which are carried on arms pivoted at the front cross-member of the main frame, are raised and lowered by screw-jacks. These are operated, from a position outside the road wheels, by ratchet levers with reversible pawls.

In operation, the spindle is passed through a cable drum, and the drum positioned between the framework of the trailer. The screw-jacks are operated until the spindle is engaged by suitably positioned steps on the cable racks; the steps engaged depend on the cable drum size. The retaining plates are secured and the screw jacks are then operated to raise the drum to the travelling position. Thus, the loading is rapidly completed for all sizes of cable drums.

Split clamps are carried on the trailer for centralizing drums on the drum-spindle, and for adapting the 2-in diameter spindle to take cable drums with 3¼ in diameter centre holes.

## CABLE-DRUM SPINDLE BRAKE

To control the paying out of cable from a drum safely, a brake has been developed which fits on the cable-drum spindle (Fig. 5). It consists of an 8 in diameter vehicle drum-

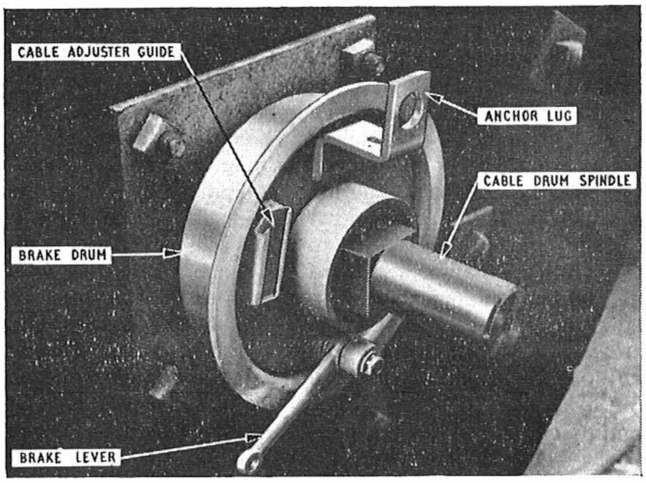


FIG. 5—The cable-drum spindle brake

type brake, which has been bored out and a centre bush fitted to suit a square portion of the cable-drum spindle. A lug welded on to the back plate of the brake is designed to fit over an anchor pin on the trailer. The brake is applied by means of a flexible cable and hand lever, which may be locked at any desired brake pressure.

This brake is at present used on the 4-ton cable-drum trailer, but modifications to the design will enable it to be used with both the new trailers.

## CONCLUSIONS

The two new cable-drum trailers, together with the existing 4-ton trailer, will enable all sizes of cable drums in common use by the Post Office to be carried. They will serve all sizes of overhead and underground cabling parties by providing them with the correct size of trailer for the job in hand, thus speeding work and improving safety.

# A Data Transmission Network for the Ministry of Social Security

H. MARSH and G. C. J. BALLS†

U.D.C. 681.3:621.372.01.

*A data network has been provided by the Post Office for the Ministry of Social Security to connect a number of the Ministry's public offices to a computer at Reading. Eventually this scheme may be extended to provide similar facilities for about 800 offices throughout the United Kingdom with an appropriate increase in computer capacity. A description is given of the equipment provided at each outstation and of the operating procedure and utilization of the network.*

## INTRODUCTION

The Ministry of Social Security (then known as the Ministry of Pensions and National Insurance), decided in 1964 to install a computer for recording, controlling and issuing insurance payments. The Ministry required direct access to the computer from selected offices in S.E. England (mainly London), via 50-baud telegraph circuits, with special six-unit code versions of the Creed Teleprinter No. 444 and Creed tape and card readers at each office. Basic specifications and operational requirements for the outstation control units, and for the line signalling conditions, were determined by the Ministry; the Post Office designed and developed control units to meet these requirements and undertook to provide and maintain all the lines inter-connecting the computer and the outstations, together with all the telegraph equipment at the outstations.

Two separate types of teleprinter equipment are used at each outstation; off-line equipment (Fig. 1) for the preparation of perforated tape and on line equipment (Fig. 2) for the transmission of signals to line. A data-reader is provided with each equipment, and is used to read cards when used with the off-line equipment and to read tape when used with the on-line equipment. The perforations in the card or tape are read as parallel signals from the data-reader and are converted to sequential signals by the teleprinter. Several off-line 75-baud teleprinter equipments are provided at each office in order to match the capacity of the single 50-baud on-line equipment, as the procedure involved in producing tape is relatively slow.

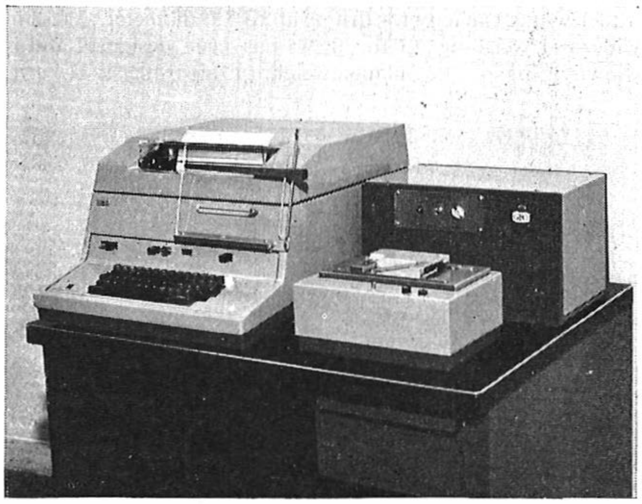

FIG. 1—Off-line equipment

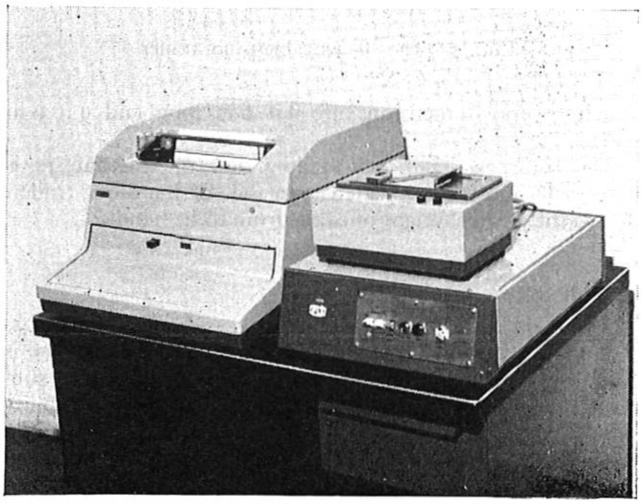

FIG. 2—On-line equipment

## THE 6-UNIT CODE

Telegraph signals normally consist of characters arranged according to the International Alphabet No. 2 using the Murray 5-unit code. This alphabet has only one redundant character and cannot be used if parity error-detection facilities are to be provided. A 6-unit code (Fig. 3) is used, therefore, with the normal Murray code for character elements 1 to 5, with the sixth element of start or stop polarity such that the total space and mark polarity elements in each character are an odd number.

Incorrect interpolation of a single element of any combination produces an error which can be detected by the even number of start or stop elements in that character. At the computer, the detection of an error results in a request for a re-transmission; at the outstation, the reception of an out-of-parity code causes the teleprinter to leave an unprinted

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| LETTER-CASE SYMBOL | FIGURE-CASE SYMBOL | AS PUNCHED IN TAPE FOR SENDING | | | | | | | SERIAL CODE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 4 | 3 | F | 2 | 1 | P | 1 | 2 | 3 | 4 | 5 | 6 |
| A | – | | | | o | O | O | O | M | M | S | S | S | M |
| B | # | O | O | | o | | O | | M | S | S | M | M | S |
| C | ◇ | | O | O | o | O | | | S | M | M | M | S | S |

F = FEED-HOLE IN TAPE
P = PARITY ELEMENT
M = MARK OR STOP ELEMENT
S = SPACE OR START ELEMENT

FIG. 3—Sample of the six-unit code

space in the message. Certain out-of-parity codes are used for functional control of the machine, e.g. punch-on, punch-off and colour change.

## DATA-READER

The data-reader has been developed from the Creed Model 35 Tape/Card Reader, and is capable of reading either perforated paper tape or edge-punched, 3 in wide cards with 5, 6, 7 or 8 fully perforated tracks.

When the data-reader is used as a card reader, the operator inserts the cards into a chute; the leading edge of the card depresses a contact to initiate the feed action, causing the card to be gripped between a friction pad located on the feed-rake and a roller on the underside of the card chute. The card is moved forward until two feed-rake pins locate the card feed holes, when the normal feed mechanism takes control and the card is carried into the reading position under the gate.

The receipt of a trip signal from the teleprinter initiates a combined FEED AND READ cycle. During the first half of the cycle, the drive cam lowers the feed rake out of engagement and away from the feed holes in the tape or card, and then moves it backwards by one character pitch. In the second half of the cycle, the feed-rake is lifted so that the pins re-engage the feed holes in the tape or card, and move the tape or card forward one character pitch. Subsequent repetitions of this cycle of operation cause the tape or card to be advanced character by character.

The perforations in the tape or card are sensed mechanically by code seekers, which rise simultaneously as the feed-rake drops at the beginning of a feed and read cycle, and lower again as the rake rises to re-engage the feed holes in the tape or card. When the feed-rake is lowered, the tape or card is firmly held against the underside of the tape gate by four braking studs, which rise with the code seekers. The code output of each track is established on individual change-over contacts after about one-third of the cycle has been completed, and these settings are maintained until early in the following cycle.

A master contact is incorporated, which is timed to operate about 3 ms after the complete setting of the code contacts; this is used to indicate to the controlling equipment that reading may take place.

## OFF-LINE EQUIPMENT

Each off-line equipment consists of a 75-baud teleprinter, a card-reader and a control-unit. Each separate message is prepared by the operator using both an edge-punched card and the teleprinter keyboard. Information received in the public office from an applicant for social-security benefits is passed to the operator, together with the edge-punched card relating to the applicant.

The operator inserts the card into the card-reader and the characters are received in parallel form by the teleprinter, converted into serial form and transmitted to the receive magnet. The information contained in the perforated card is printed on the page copy in red characters, and a portion of this information converted into perforated tape by the teleprinter for later transmission to the computer. The functional characters PUNCH-ON and PUNCH-OFF in the card record select the information to be recorded on the tape. These characters are detected by the teleprinter, and are used to control the perforating mechanism.

The insertion of the card into the card-reader causes the card-reader motor to start, and energizes the colour-change magnet in the teleprinter to give red printing. The card is gradually moved forward under the control of the feed-mechanism until the first character punched in the card is in the reading position and the CARD-IN contacts operate to indicate that reading should begin. Six code-contacts on the card-reader detect the combinations in the perforated card and present a six-wire output to the teleprinter. This has a mechanism, which serializes the signal, and transmits it to the receive magnet and perforating mechanism. To prevent a mutilated card from giving a false signal, the first two characters punched on the card are all-space characters followed by a figure-shift character and the body of the message. The two all-space characters are suppressed in the control-unit, and are not transmitted to the teleprinter. If these characters and the following figure-shift character are correct, the figure-shift character and the remainder of the message are passed to the teleprinter. If the leading characters on the card are incorrect, the card is ejected and the teleprinter is disconnected.

## ON-LINE EQUIPMENT

The on-line equipment operates in a similar fashion to the off-line equipment, in that the perforated-tape is read in parallel form, and the signals are converted into sequential form and transmitted by the teleprinter. The equipment consists of a teleprinter without a keyboard, a tape-reader and a control-unit. The control-unit contains all the necessary keys and lamps for the control of the circuit to the computer, together with the power unit and connexion points for the machines. Incoming messages may be printed in red or black depending on the receipt of the appropriate colour-change character.

### Transmission of Data

In the idle condition, positive 80-volt potential is connected to the send line and positive potential is received on the incoming receive line. To transmit a message, the operator inserts the prepared tape in the tape-reader and depresses the PREPARE key on the control-unit. This starts both the teleprinter motor and the tape-reader motor and when the teleprinter is on speed the send-line potential is reversed from positive to negative. The multiplexor equipment at the computer terminal detects this change of polarity, and in turn reverses the receive-line polarity, causing the LOCAL lamp on the control-unit to light, thus assuring the operator that the line to the computer is in working order. The operator depresses the REQUEST TO TRANSMIT (RTT) key on the control-unit, lighting the COMPUTER lamp, and automatically generating an RTT character which is transmitted by the teleprinter. At the same time the tape-reader is stepped once to bring the first character of the message into the reading position. The character under the reading-head before stepping is absorbed by the control-unit and is not transmitted.

The computer receives the RTT character, and when it is ready to receive the message, transmits a START TO TRANSMIT (STT) character to the outstation. This character is recognized by the receive mechanism of the teleprinter, operating a character-detection contact, which starts transmission from the tape. The teleprinter works in a duplex mode, in that no local record is taken of the transmitted message, and messages may be simultaneously transmitted and received. The end of the transmitted message is marked by an END OF TRANSMISSION (EOT) character on the tape. This character is identified on the tape-reader code contacts in the control-unit, an EOT signal transmitted and further transmission stopped. The computer returns an acknowledgement signal if the message has been received satisfactorily, and concludes the acknowledgement message with an EOT character causing the outstation equipment to clear down. If the computer has a message for transmission to the outstation, this is sent after the acknowledgement message.

Should congestion occur at the computer during the transmission of a message from the outstation, the CHARACTER ARREST signal is transmitted to the outstation. This stops the tape reader, which does not resume transmission until an STT code is received from the computer to restart the equipment.

Incoming messages are received in a similar manner, except that only the COMPUTER lamp lights, the absence of the LOCAL lamp indicating that it is an incoming call. The teleprinter characters are usually printed in black, but may be printed in red on the receipt of a specific character as part of the incoming message. The machine will revert to black printing on receipt of the character FIGURE-SHIFT and J or at the conclusion of the call.

An automatic motor-switch is fitted to the teleprinter which will switch off the motor and restore the equipment to normal if signals are neither sent nor received for 60-90 seconds. The switch is under the control of a re-set magnet, which causes the timing mechanism to re-set to zero with each transmitted character. The progress of outgoing and incoming calls is shown in Fig. 4 and Fig. 5.

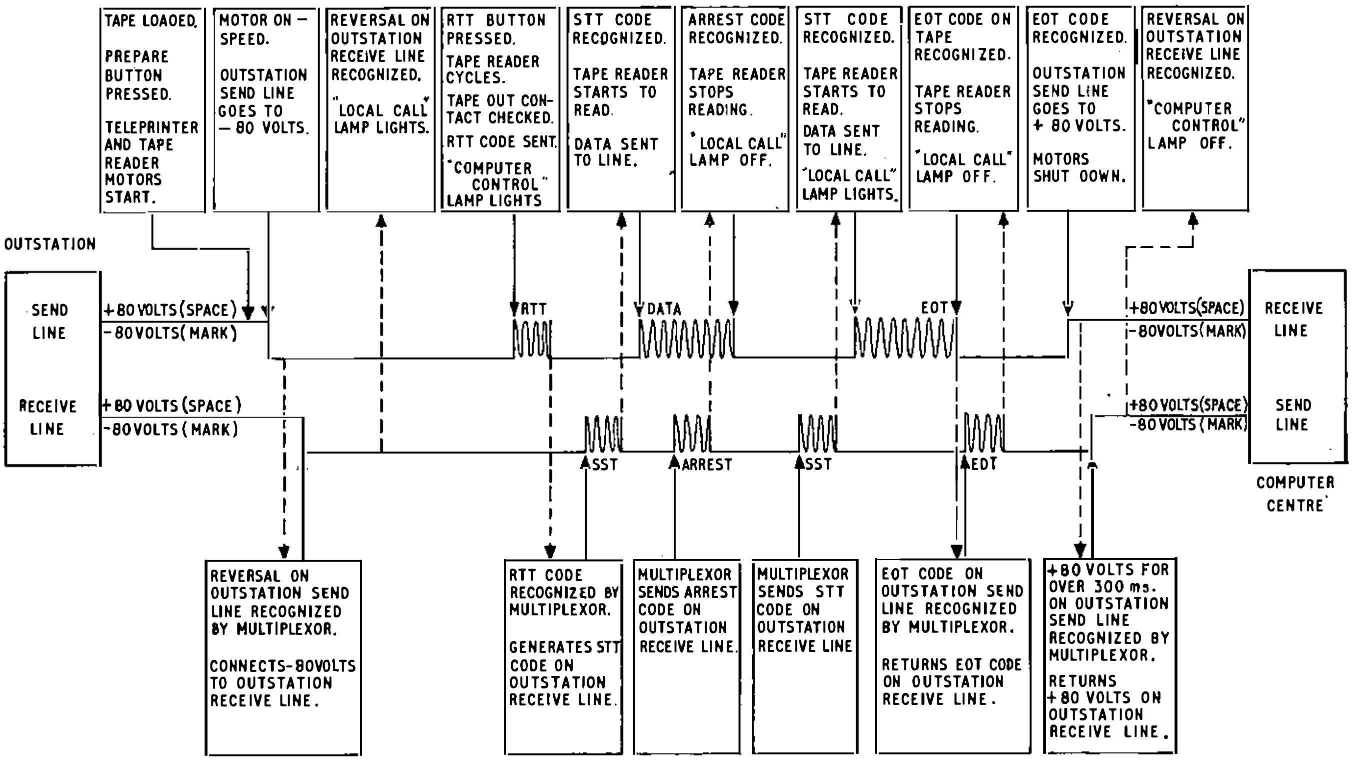


FIG. 4—Operational sequence for the transmission of data to the computer centre

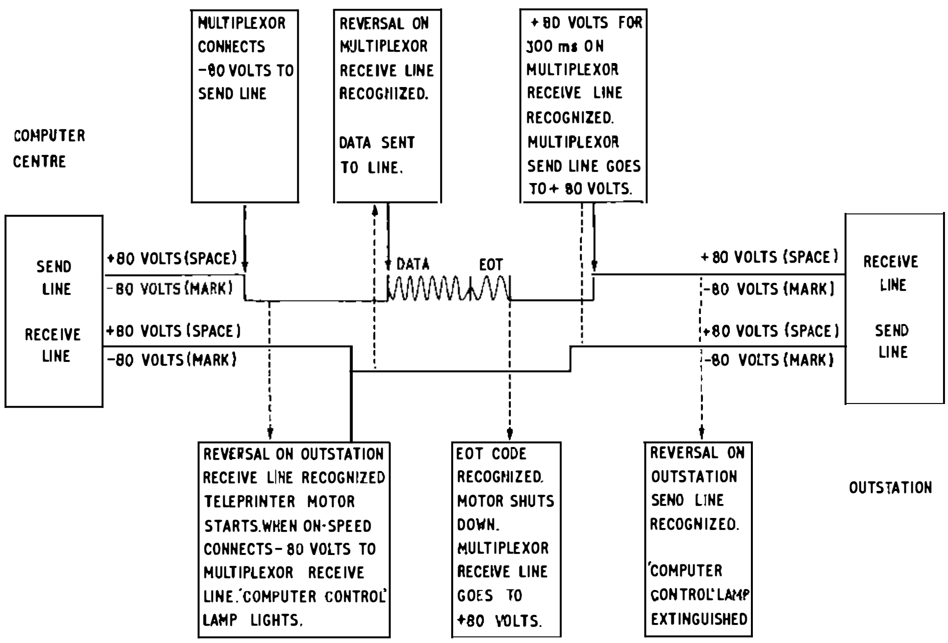


FIG. 5—Operational sequence for the reception of data from the computer centre

The equipment has an audible alarm, which may be re-set, to recall the operator under certain fault conditions. Alarm circuits are provided to detect the incorrect operation or loading of the tape-reader, the omission of the functional RTT, STT or EOT characters or the reception of premature-clearing conditions from the computer which may be due to line failure. The teleprinter will also detect characters which do not conform to parity, and this will be indicated on the printed copy by a space.

### Maintenance

A LOCAL switch is fitted in the control-unit for the use of the maintenance engineer. The switch cannot be operated unless the cover of the control-unit has been removed; operation of the switch permits the set to be connected in local, whereby any message transmitted over the loop is received by the teleprinter. Special test-tapes have been prepared, containing the necessary STT, ARREST and COLOUR-CHANGE codes together with the alphabetical and numerical characters such that a comprehensive test of the machine functions can be made. The equipment can thus be given a fairly rigorous test without having to rely on the co-operation of a distant test terminal. For tests which cannot be performed locally, and for overall control of the line network, specially designed equipment has been installed in the terminal at Reading to enable the maintenance engineer to intercept and test any outstation line and equipment. Facilities are provided for distortion measurements to be made, for the transmission of test messages, and for the measurement of line currents and potentials. A special 50-baud Creed Model 444 teleprinter has been provided with keyboard and reperforating attachment so that incoming signals from outstation machines may be recorded as perforated tape to check errors.

## CONCLUSION

The scheme should enable social-security payments to be made more quickly and also produce staffing economies; the system may eventually be extended to serve about 800 offices in the United Kingdom. Negotiations are in hand to give Employment Exchanges access to the network so that unemployment benefits may be processed in a similar way.

# A Telephone 'Waiting-Amplifier'—Amplifier and Loudspeaker, No. 5

J. S. GORE, C.ENG., M.I.E.E.†

U.D.C. 621.375: 621.395: 623.8

*This article describes a line-powered amplifier-and-loudspeaker unit for use by subscribers who wish to have both hands free whilst waiting for a call to be answered, i.e. waiting-amplifier facilities. The unit also enables incoming speech to be heard by a small group of people and, when this facility is required, a handset with a press-to-talk key is provided to permit one of their number to reply.*

## INTRODUCTION

The Amplifier and Loudspeaker, No. 5, also known as Speakerset 2, has been added to the range of subscribers' apparatus, primarily as a waiting-amplifier. When switched on, the amplifier and loudspeaker unit takes the place of the telephone as the line termination and reproduces incoming-speech signals and supervisory tones on the loudspeaker. This permits the subscriber to lay down his handset and attend to other matters while the waiting-amplifier keeps him informed of the state of the call, both when it is being set up, and while the distant party is away from his telephone. At the subscriber's request arrangements can be made to allow a small group of three or four persons to listen to a telephone conversation, while one of their number replies. To prevent howling, the microphone is cut-off when the loudspeaker is in circuit. For this purpose a handset with a press-to-talk key needs to be fitted.

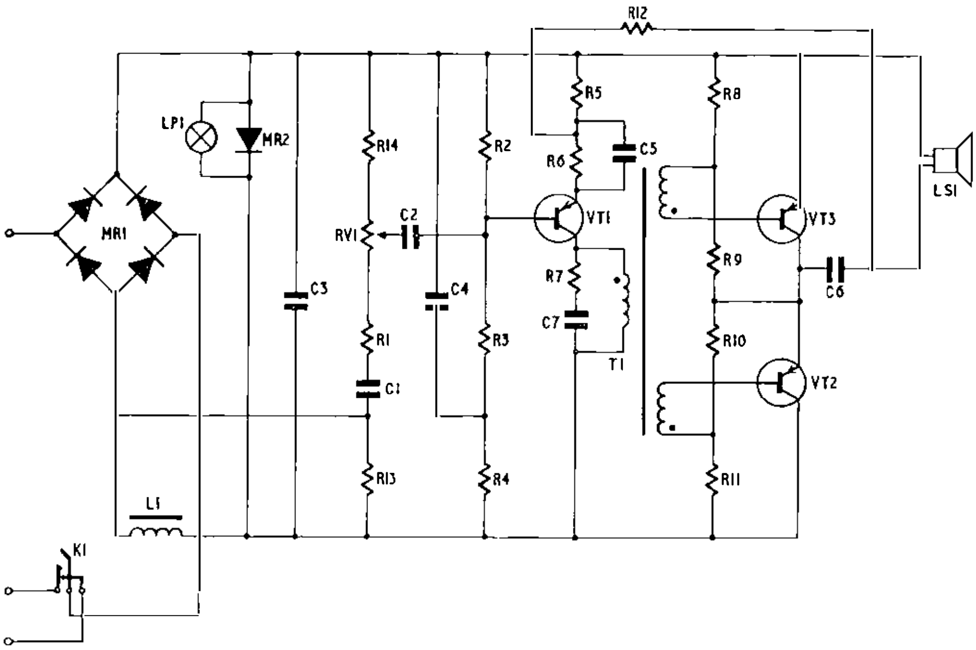


FIG. 1—Amplifier circuit

## PERFORMANCE

The primary functions of a waiting-amplifier are to,

(*i*) provide a holding loop for the exchange equipment,

(*ii*) terminate the line in a suitable impedance over the speech-frequency range.

(*iii*) amplify signals appearing at the line terminals and to reproduce them at an acceptable listening level which the user can, within limits, control.

The device derives its own d.c. power supply from the line current and indicates, by means of a lamp, that it is switched on.

The gain-frequency response of the amplifier is sensibly flat over the audio range, with permissible deviations of up to 3dB at 300 and 3,000Hz. With the volume control at its maximum setting the amplifier is fully driven by an input signal of −16dBm. Approximately 200mW is developed in the loudspeaker, and this produces conversational speech level at about 50cm from the unit. The volume-control range is 26dB, sufficient to allow the amplifier to be fully driven without noticeable distortion by input signals up to the maximum likely to be encountered on a local call. The amplifier terminates the line in a nominal resistive impedance of 600ohm and its d.c. holding-loop resistance varies between 140ohm and 250ohm depending on the value of line current.

## CIRCUIT DESCRIPTION

The amplifier circuit (Fig. 1) consists of a transistor common-emitter, driving stage, VT1, coupled to a class-B

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push-pull transformerless output stage, transistors VT2 and VT3, by means of a phase-splitting transformer, T1. The loudspeaker, of 35-ohm impedance, is connected between the junction of the two output transistors and the positive pole of the power supply via a $100\ \mu F$ capacitor, C6. This acts as a reservoir d.c. supply for the collector of the transistor VT3 during the half cycles when VT2 is cut-off and VT3 is conducting, thereby obviating the need for a centre-tapped d.c. supply. Transistors VT2 and VT3 are forward-biased by currents taken from the potential divider formed by resistors R8, R9, R10 and R11 to minimize cross-over distortion. A small amount of feedback is derived from the loudspeaker and applied to the emitter of transistor VT1 via resistor R12.

Power for the amplifier is derived from the line current, the supply voltage being held within the range 7·5–12·5 volts for line-current variations of 30–90 mA by the metal-rectifier voltage-regulator, MR2. De-coupling of the power supply from the amplifier is effected by inductor L1 and capacitor C3, which also acts as a reservoir d.c. supply to handle high peaks of signal. Full-wave bridge-rectifier MR1 ensures that the polarity of the power supply is correct irrespective of line reversals. Resistor R13 with inductor L1 in parallel form the bulk of the line-terminating impedance, while the holding-loop resistance is the forward resistance of the metal-rectifier, MR2.

## PHYSICAL DESIGN

The amplifier, loudspeaker and ancillary components are contained in a two-part, acrylonitrile butadiene styrene, (ABS) plastic case measuring approximately $4\frac{1}{4} \times 4\frac{1}{4} \times 3\frac{1}{2}$ in ($11 \times 11 \times 9$ cm), designed to harmonize with the 700-type telephone (Fig. 2). Colour schemes are available to match

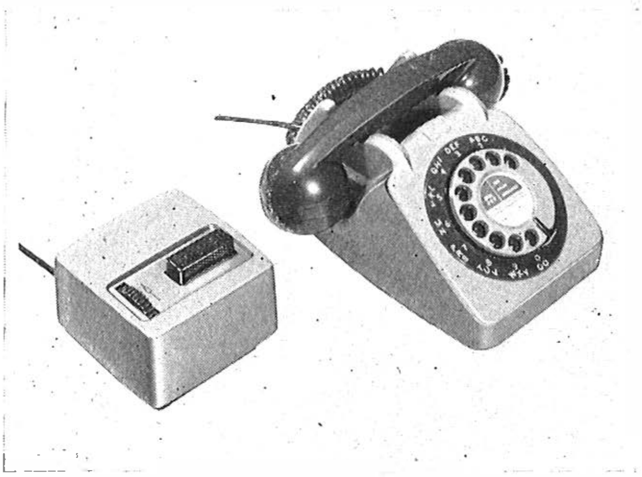

FIG. 2—Amplifier and Loudspeaker No. 5 with Telephone No. 706

three of the 700-type telephone colours; all-black, light french-grey cover with elephant-grey base, and ivory cover with buff base. The volume-control knobs for the three models are coloured black, elephant-grey and ivory, respectively. All models are fitted with a silver-satin anodized-aluminium control panel and a clear amber polymethyl-methacrylate lamp lens. An arrow engraved on the panel indicates the direction of rotation for increase of volume. The lens has been designed to extract maximum luminance from the lamp which is under-run on the majority of calls. The lens also acts as the press-bar of the on/off switch which has a press-to-operate, press-to-release action with make-before-break contacts.

The larger components, loudspeaker, inductor L1, volume-control bracket and terminal strips, are mounted directly on a synthetic resin-bonded paper (SRBP) base plate and this also supports the printed-wiring board on which the

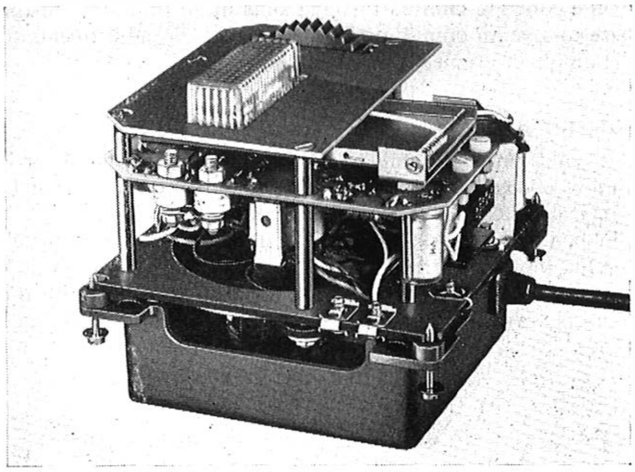

FIG. 3—Amplifier and Loudspeaker No. 5—cover removed

remainder of the components are mounted (Fig. 3). The whole assembly is gripped in position simply by screwing the base to the cover by means of four concealed captive screws, one at each corner. Dismantling for installation and maintenance is thus easily achieved.

For convenience, the loudspeaker is mounted with its cone facing upwards and sound waves generated by the rear

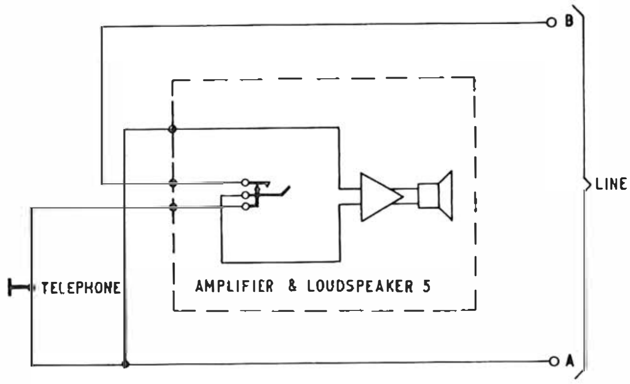


FIG. 4—Waiting-amplifier connexions

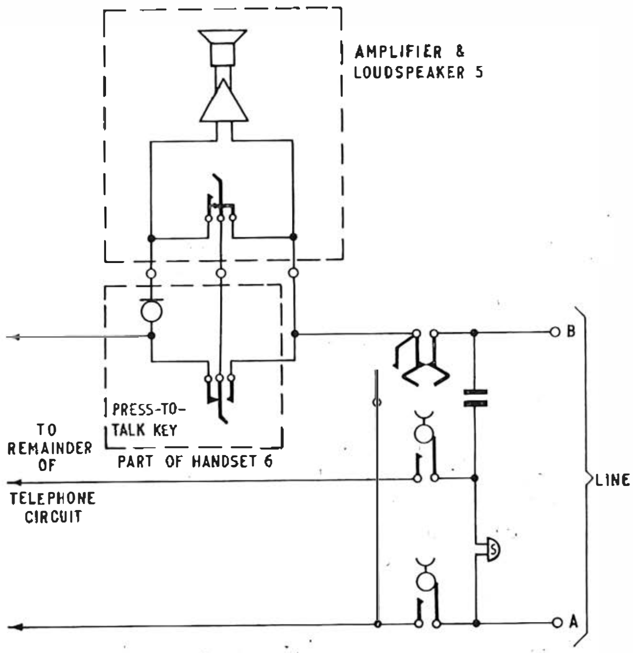


FIG. 5—Connexions when press-to-talk key is fitted

of the cone are emitted through slots in all four sides of the base to give an omnidirectional response. No adjustments to the amplifier are needed on installation.

## APPLICATIONS

Connexion of the unit to the line as a waiting-amplifier is simply effected by operating the make-before-break switch, which simultaneously cuts off the telephone (Fig. 4).

When a press-to-talk key is fitted, operation of the switch on the amplifier transfers control to the press-button operated, change-over switch in the Handset No. 6 (Fig. 5). With the handset switch normal, the microphone is short-circuited and replaced by the amplifier and loudspeaker; with the handset switch operated, the short-circuit is transferred from the microphone to the amplifier input to allow speech to be transmitted. Howling is thus prevented under all switching conditions.

This circuit arrangement was chosen to minimize changes in direct current flowing in the line when the handset switch is operated, and hence to render clicks virtually inaudible.

## ACKNOWLEDGEMENTS

Acknowledgements are due to Messrs A. P. Besson and Partner Ltd. who assisted in the development of the item.

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# Ladder Safety Devices

D. R. BISSELL, C.ENG., M.I.MECH.E.†

U.D.C. 621.595

*This article describes several modifications and new devices which are intended to contribute to the safer use of Post Office ladders. Accident statistics have been used to locate deficiencies in the existing designs and new items designed to be either automatic in operation, or simply and rapidly rigged, so that their consistent use is encouraged; a prime requirement for safety devices on items of equipment in everyday use.*

## INTRODUCTION

A large number of accidents occur annually to Post Office engineers through the misuse or shortcomings of ladders. In an attempt to reduce this accident rate, the Civil and Mechanical Engineering Branch, Telecommunications Headquarters, have developed several items to improve and assist in the safe use of ladders.

The new devices are an improved top-end fitting, a top-end lashing device, a lower-end lashing device and the use of castellated rungs on aluminium ladders. The first two items are still in the experimental stage and will be subject to minor changes and improvements based on the results of field trials which are now in progress.

## TOP-END FITTING

The present top-end fitting is a wire rung, the flexibility of which gives some security to the ladder when it is rested against a circular object, such as a pole. The shortcomings of this device are as follows:

(*i*) It does not grip the pole positively, so that unless the ladder has been erected on firm, level ground and securely lashed, climbing the ladder may cause it to rotate about the pole.

(*ii*) The ladder cannot easily be erected by sliding it up the pole as the wire rung tends to catch on projections such as cable cleats and splinters. Therefore the ladder is normally erected by balancing it in a vertical position with one hand, while raising the sections with the other hand, until the desired height is obtained; a hazardous method, particularly in windy weather.

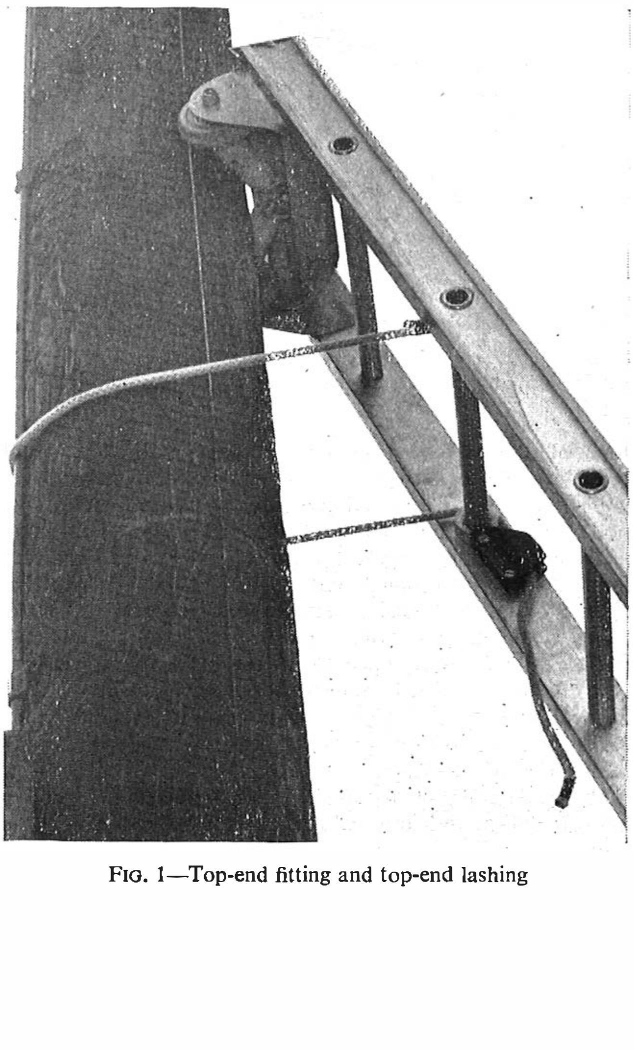

FIG. 1—Top-end fitting and top-end lashing

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(*iii*) The top 18 in of the stiles on the top section of the ladder are not braced by a solid rung.

The proposed new fitting has been designed to obviate the above shortcomings while satisfying the requirements of reasonable cost, long service life, ease of manufacture and facility of maintenance. The new fitting, shown in Fig. 1, comprises two nylon rollers with circumferential sharp-edged grooves mounted on steel axles to form a shallow V between the ladder stiles. Included on the axles are two rubber-tyred wheels, which function when the ladder is used on walls and other flat surfaces (Fig. 2). The assembly is attached to the top end of the ladder stiles by means of an extruded aluminium cross-piece, which also functions as a top tread.

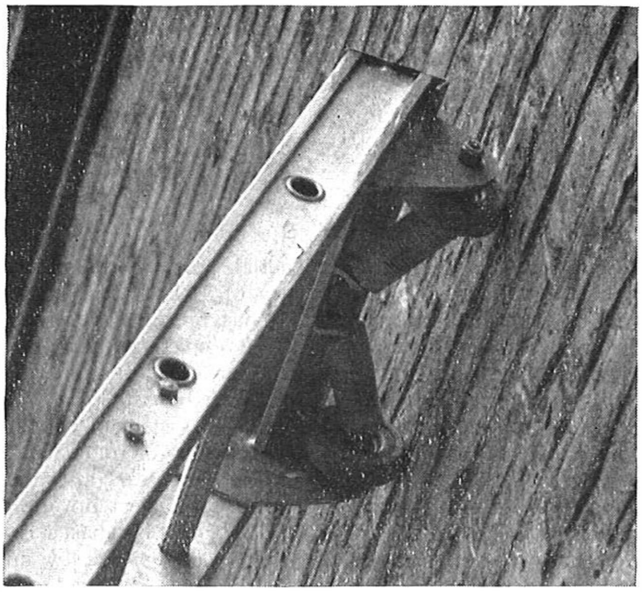

FIG. 2—Top-end fitting, ladder resting against a flat surface

## TOP-END LASHING

One feature of ladder accidents, which shows up fairly often in the accident statistics, is failure to lash the top of the ladder to a firm support, even though Post Office ladders have a lashing rope included in their construction. It is assumed that the slight inconvenience of the present lashing method, i.e. passing the rope one-and-a-half times round the pole, and then securing the rope to the ladder stile by a clove hitch, has led to the method not being used.

To simplify the lashing procedure, and thereby encourage its use, the use of a clam cleat has been investigated. Manufactured in moulded nylon, the clam cleat operates on a wedge principle, is self-locking and is claimed to be capable of withstanding a rope tension of up to 200 lb.

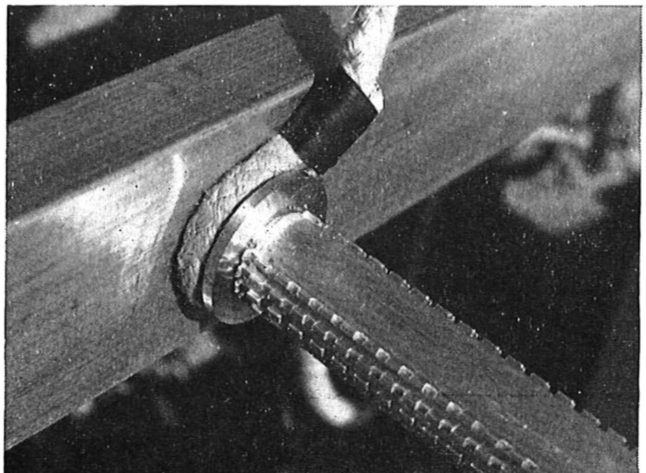

FIG. 3—Castellated rung and the top-end lashing

As shown in Fig. 1, the clam cleat is attached to the right-hand stile of the ladder and one end of the lashing rope to the opposite end of an adjacent rung (Fig. 3). With this device it is unnecessary to knot the rope to the stile, the rope merely being taken around the pole, passed through the cleat and pulled taut.

## LOWER-END LASHING

The object of lashing the foot of a ladder is to prevent it sliding away while it is being climbed, which is another prominent cause of ladder accidents. An alternative to this lashing is to have a second man footing the ladder, which is not always practical or convenient. Slipping tests carried out a few years ago indicated that if a ladder was erected at a slope of 1 in 4 on firm level ground, then the risk of ladder slipping was negligible. The use of this lashing allows the ladder to be erected and used safely at slopes of up to 1 in 3.

The lashing is simply a 23 ft length of matt-finish terylene rope, knotted and fitted with plastic stiffening sleeves at the free ends; the length of 23 ft was calculated to enable the lashing rope to be used in the majority of situations. The complete lashing rope will be supplied in a soft-plastic pouch on which the full instructions for the use of the rope are printed. The pouch has been designed to hang in a convenient and readily accessible position in the vehicle carrying the ladder. Fig. 4 shows the method of use, which is both simple and effective and should encourage its widespread use. The lashing rope has already been on extensive field trial, and the results have proved very encouraging. These ropes should be available for general use during 1968.

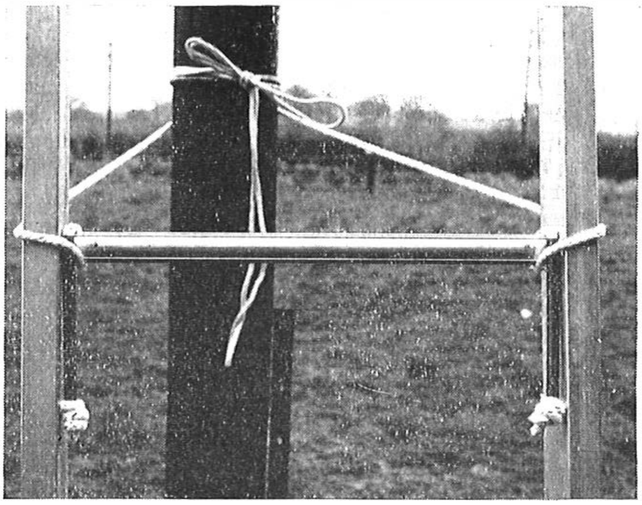

FIG. 4—Lower-end lashing

## CASTELLATED RUNGS

Occasionally accidents occur when the climber ascends or descends from a pole to the rungs of a ladder, especially when the soles of the climber's shoes are wet or slippery. Therefore, to improve the grip between the ladder rungs and the soles of the shoes, the top rungs of aluminium ladders, which are normally extruded with a fluted profile, have been cross cut to form serrations (Fig. 3). These rungs have been specified for all aluminium ladders purchased since the latter part of 1966 and have proved very effective.

## CONCLUSIONS

It is emphasized that, although these items will assist in improving ladder safety, they are only supplementary to the user's common sense and training. Attention to the published methods of erection and use is still the best guarantee of safety.

# The New Very-Low-Frequency Transmitter at Rugby Radio Station

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U.D.C. 621.396.7: 621.396.61: 621.3.029.4

*The high-power very-low-frequency radio transmitter at Rugby radio station has been replaced by one of modern design giving increased output power and improved signalling facilities. The basis of its design and the facilities provided are described.*

## HISTORICAL

The familiar call-sign, GBR, at 16 kHz, was unheard for the 11 months from 1 January to 1 December 1966, while modernization of the oldest British Post Office radio transmitter was carried out to bring up-to-date the world-wide telegraph service provided by the very-low-frequency (v.l.f.) transmitter installation at Rugby.[1] First put into service on 1 January 1926 the transmitter originally comprised a pair of tuned 2-stage radio-frequency (r.f.) driver-amplifiers, either of which could drive any three power-amplifiers, connected in parallel and selected from a group of five identical units. Each final power-amplifier unit contained 18 water-cooled valves of 10 kW anode dissipation, using 7 kV h.t. supply from d.c. motor-generators. An r.f. output power of 270 kW was produced to energize the aerial, and approximately 40 kW was radiated at a frequency of 16 kHz. The aerial system, which is shown in Fig. 1, has remained generally unchanged in configuration since its erection, and has 11 spans of 12 ft diameter aerial cages arranged in an irregular U-formation, supported by 12 stayed masts of 820 ft height, at quarter-mile spacing. An earth system of copper wires ploughed 6 in into the ground extends for some 800 ft beyond the aerial. Extensive repairs were necessary after the severe winters of 1940 and 1947, and complete renovation was carried out during 1957 and 1958, when all 180 mast stays were renewed and the aerial system was replaced by an improved design of 8 ft diameter cages.

The Rugby v.l.f. transmitter plays an important role in naval communications and also provides time-signal and stable-frequency emissions. During the second world war, one driver-amplifier and two power amplifier units were transferred to a stand-by v.l.f. station at Criggion, which

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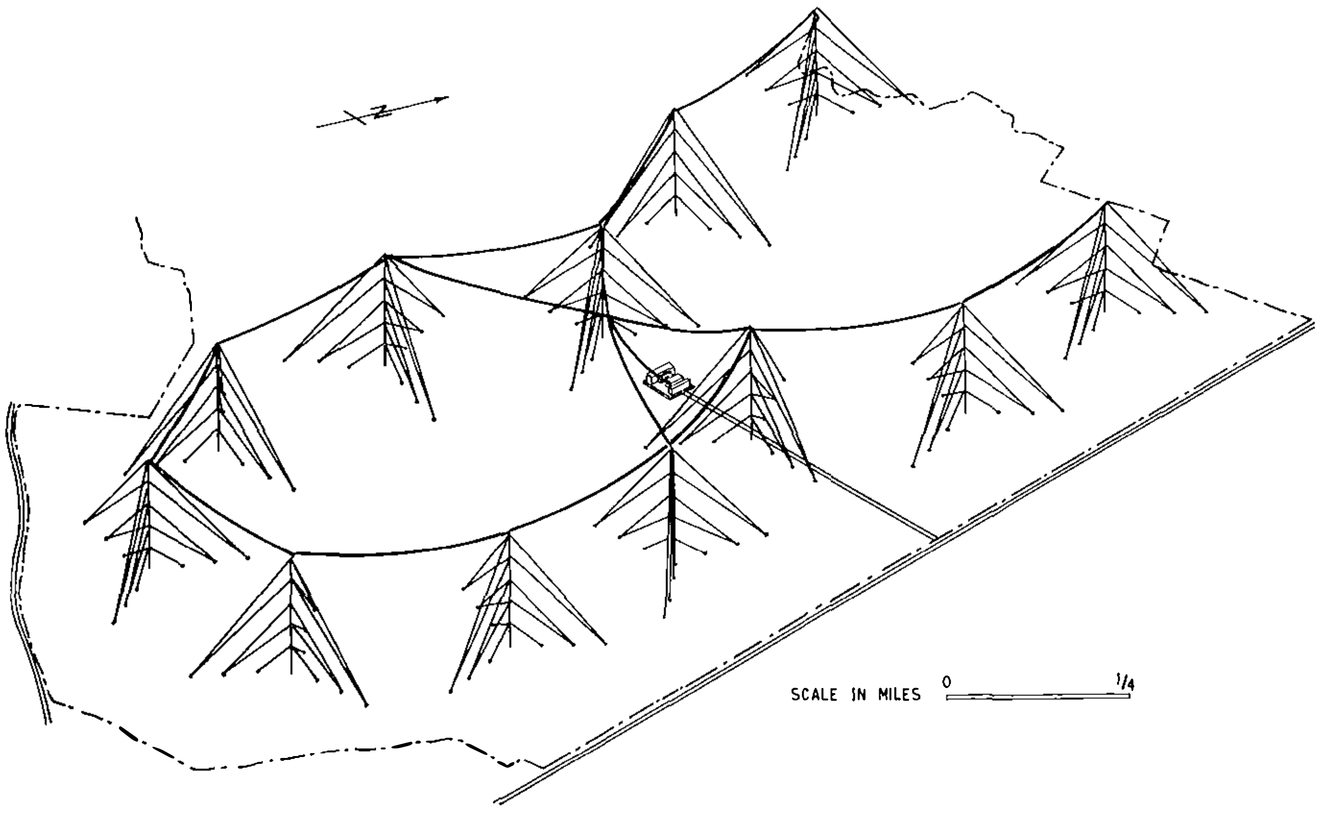


FIG. 1—Rugby aerial system

came into service in 1943 when the Rugby transmitter was severely damaged by fire. Arcing, caused by a fault developing in the bonding of lead-flashing, set fire to the wooden roof of the Rugby building and resulted in total destruction of the 16 ft diameter aerial-tuning coils and the anode-tuning coils in the upper storey, and the falling debris extensively damaged the amplifier units on the ground floor. The tuning coils had to be replaced, but the large oil-filled anode-circuit capacitors were undamaged and, although considerable repairs and re-wiring of the amplifiers were necessary, the transmitter was working again within 6 months.

In 1957, after 31 years' service, the high-tension d.c. motor-generators were replaced by grid-controlled mercury-arc rectifiers, which provided an increased anode voltage of 10 kV for more efficient operation. This enabled any two power-amplifier units to produce the required r.f. output of some 285 kW with a third unit in reserve.

## NEW REQUIREMENTS AND BASIC DESIGN

In the past, the narrow bandwidth typical of a long-wave aerial was acceptable for hand-speed morse signalling, but for modern communications a telegraph signalling speed of at least 50 bauds is necessary for teleprinter operation, and present-day techniques for controlling dynamic loading of the transmitter output and aerial circuits can achieve effective broad-banding while maintaining reasonable power efficiency. Modernization of the Rugby v.l.f. transmitter was required to increase the transmitter output power by 50 per cent and so provide a radiated power of 60 kW at telegraph signalling speeds of 50 and 72 bauds for on-off (A1) signalling and 50 bauds for frequency-shift keying (F1). In addition, improved controls for day-to-day adjustment, and facilities for changing the operating frequency rapidly without man-handling the heavy aerial-tuning coils, were planned.

Taking account of the growing difficulties of general maintenance due to the age of the equipment, and the increasing cost of manufacturing the obsolete 10 kW water-cooled valves, the amplifier stages were redesigned around modern valves and components. The very expensive tank capacitors were re-used, with the aerial-tuning inductors as fixed elements in a re-arranged output circuit that has motorized tuning variometers under remote control.

A modern wide-band amplifier of 5 kW output power was adapted as a linear class-B driver-amplifier to eliminate the four h.f. tuned stages that preceded the old power-amplifier stage. This considerably simplified the technique of changing the operating frequency, as only the grid circuit of each final stage, the common anode-circuit and the aerial circuit have to be tuned.

Construction of the new amplifiers commenced in 1965 alongside the old equipment, which continued in operation until 1 January 1966. The service was then transferred to Criggion while work was in progress on the new output circuit in the coil room in the upper storey of the building.

## R.F. AMPLIFIER STAGES

Fig. 2 shows the amplifier section of the new transmitter, which consists of four sections having three identical amplifiers in separate compartments. There is a mimic diagram and control panel on the right-hand end section, which also contains low-power transistor-type modulation equipment to convert telegraph signals from line to radio frequency to drive the transmitter with appropriate keying modulation (Al or F1). Each amplifier unit contains a 5 kW air-cooled wide-band amplifier, which drives a tuned power-amplifier stage consisting of a single vapour-cooled triode valve in Class C operation capable of providing a radio-frequency power output of 200 kW. The heat from the valve anode converts water into steam, which is cooled in an air-blast heat-exchanger in a separate cooler-room, and the condensate returns under gravity to the valve boiler-jacket. This utilization of the phenomenon of latent heat results in a cooling system that is more economical than one using direct water cooling.[2] Fig. 3 shows the valve and boiler and the 6 in copper steam-pipe leading to the heat exchanger from which hot air is exhausted to atmosphere.

All d.c. power supplies are derived from silicon-diode rectifiers except the e.h.t. anode supply to each high-power triode valve, which is obtained from the mercury-arc rectifiers operating at an increased voltage of 12·5 kV and at approximately 670 kW total output from three rectifiers.

The r.f. outputs of the three power-amplifier units are normally connected in parallel to the r.f. bus bars mounted on the rear wall (Fig. 2), to feed power into the tuned-anode circuit located in the coil room in the upper storey. Each amplifier unit is connected by the r.f. isolation switch-gear

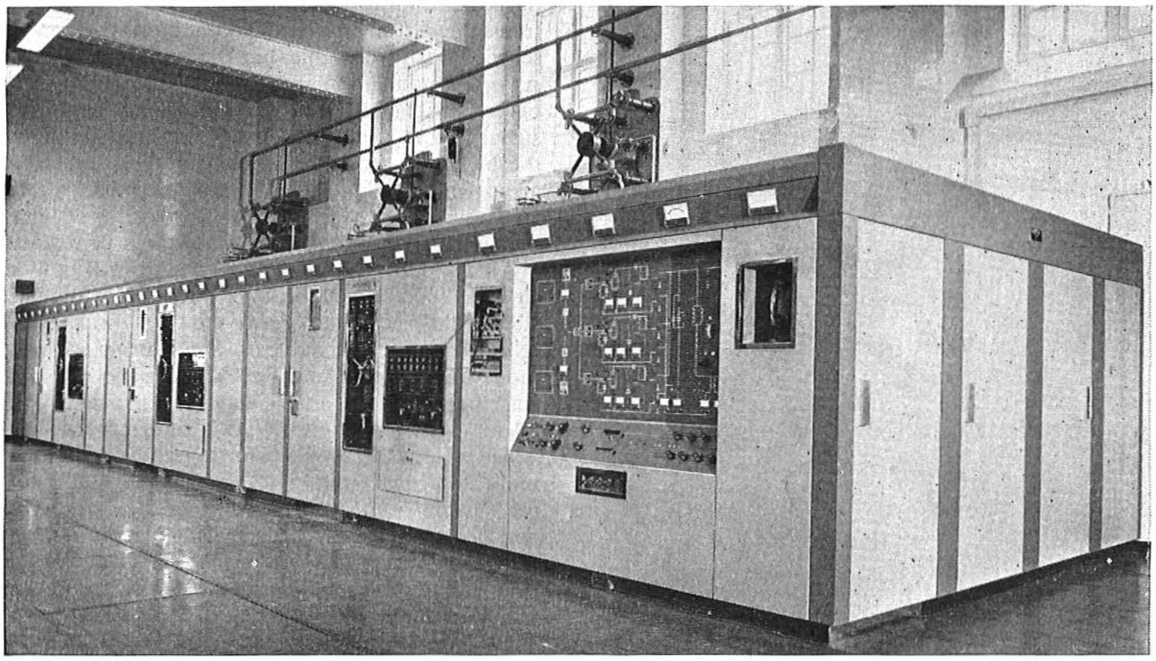

FIG. 2—Amplifier section of the new transmitter

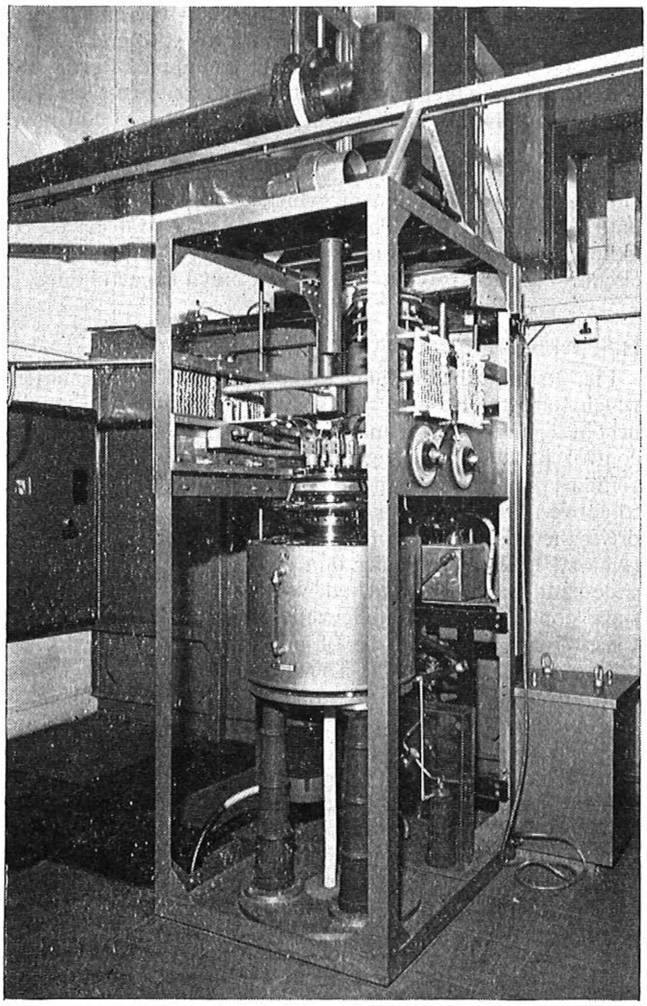

FIG. 3—Triode valve with boiler and 6 in steam pipe

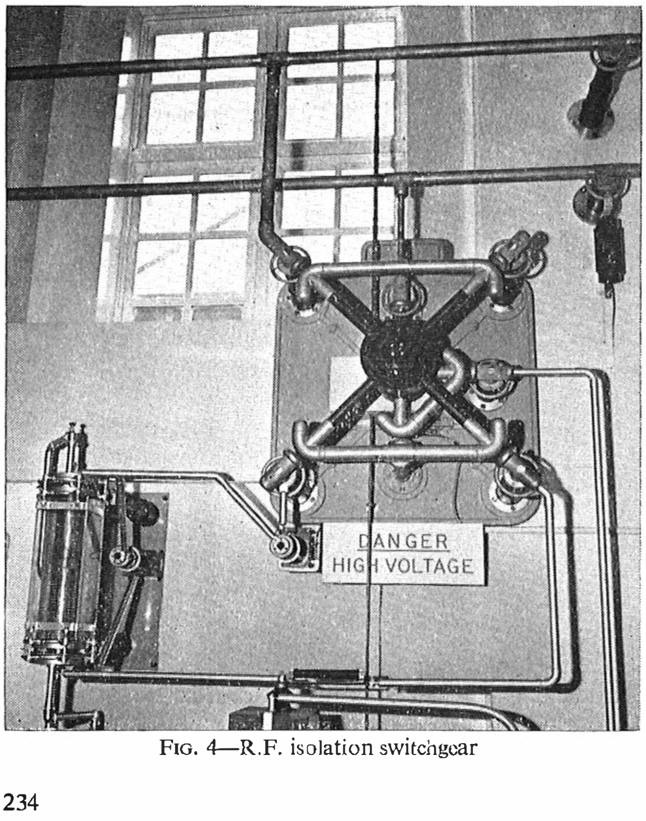

FIG. 4—R.F. isolation switchgear

shown in detail in Fig. 4. In the event of an overload, immediate automatic disconnexion is provided by a fast-acting vacuum switch, and the manually-operated isolation switch can then be opened to permit a faulty amplifier to be serviced. Continuity of traffic is maintained, with a corresponding reduction in output power of one third or, with a further amplifier fault, two thirds.

Because the signalling speeds are limited by the working characteristics of the final-stage valves and the aerial circuit, provision has been made for the inclusion of a water-cooled resistor in each anode circuit to increase the damping and, thus, the effective bandwidth of the output circuit. This will permit operation at signalling speeds greater than 72 bauds, with only a small reduction in output power.

## OPERATIONAL CONTROL

Overall control of the transmitter is effected at the mimic diagram and control panel shown in Fig. 5. A simplified schematic diagram of the transmitter circuit is shown in white on a blue background, with the switching points outlined from the rear by lamps. Meters are inserted at significant points of the circuit diagram with lamps to display the condition of the transmitter at a glance. The basic controls for the choice of modulation, for the control and adjustment of the variometers, for tuning the anode and aerial circuits and for other variable elements, are mounted on the associated control panel below the mimic diagram, with each control connected by a black guide-line to its appropriate circuit element, to show the electromechanical function.

The low-power drive equipment is provided in duplicate and is housed in the cubicle behind the mimic-diagram section of the transmitter. Two independent chains of controls and adjustments are provided, so that alignment settings for the different types of emission, or for two different radio frequencies, can be pre-set. The transmitter automatically tunes and comes up to full output power under remote control from a central operating position, close to the mimic diagram, when the appropriate control and drive chain have been selected.

## DRIVE AND MODULATION EQUIPMENT

The 16 kHz emission from Rugby is required to be very stable in both frequency and phase for standard-frequency purposes and for time-signal services.[3] Time signals are transmitted, using A1 modulation, four times each day during scheduled gaps in traffic, but traffic emissions may use either A1 or F1 modulation and, for the latter, 16 kHz is the resting, or stop, signal (Z) and 15·950 kHz is used for the start signal (A). This is the inverse of conventional practice, where the higher frequency is chosen for the start signal, but the arrangement adopted for Rugby permits emission of the 16 kHz frequency for a greater proportion of the time, since the stop signal corresponds to intervals between traffic.

All standard-frequency emissions from Rugby are derived from a 100 kHz source controlled by a rubidium atomic standard. For the v.l.f. service the 100 kHz signals are divided to 4 kHz and lock a stable oscillator, using a 16 kHz flexural-mode quartz crystal, whose output is keyed to provide A1 start signals or F1 stop signals. To provide the 50 Hz frequency shift the 4 kHz signals are further divided to 50 Hz, which is used, by wave-distortion and crystal-filtering technique, to produce the 15·950 kHz start signal. The r.f. signals for F1 emissions are derived by gating the two outputs in response to telegraph line signals. To avoid keying transients caused by abrupt changes in phase at each frequency transition, gating of the two oscillators is effected at times of zero amplitudes of the two signal frequencies, 16·000 and 15·950 kHz, which coincide at the 20 ms intervals required by 50-baud telegraph signalling. Differences of speed between the incoming line telegraph signals and a true 50-baud signal

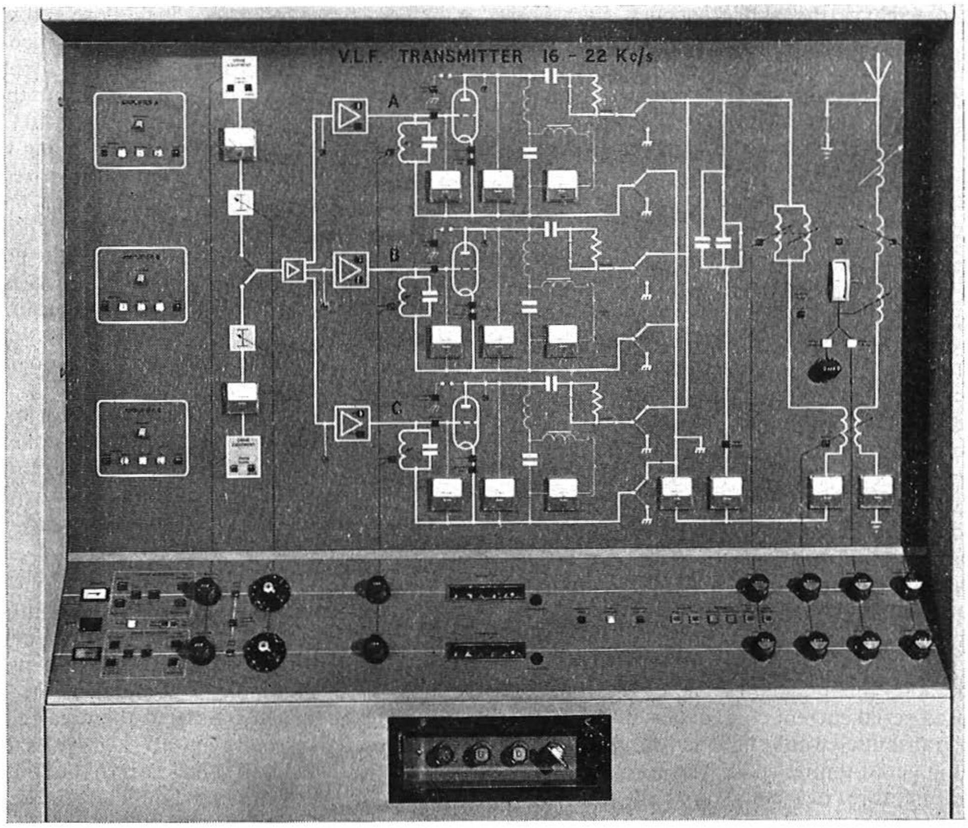


FIG. 5—Mimic diagram and control panel

are eliminated by the use of a buffer store whose output is gated under the control of pulses derived from the master oscillator.

### Phase Control

Overall phase-control is provided for the 16 kHz emission, whereby the signal in the aerial circuit is compared continuously with a reference, and the phase of the input signal to the transmitter amplifier is automatically adjusted to maintain the phase of the radiated signal constant to within about 1°. This is necessary to compensate for variations in reactance of the high-$Q$ aerial circuit and other factors which can cause fluctuations in phase. For F1 modulation, the overall phase-control equipment is rendered inactive during start-signal elements.

For operation at other frequencies in the range 16–22 kHz, where the stability requirements are not so critical, use can be made of general-purpose phase-locked synthesizers in the frequency range 4–5·5 MHz, adjustable in discrete steps of 125 Hz. The synthesizer output is divided 250 times to give any desired v.l.f. signal in the range 16–22 kHz, in steps of 0·5 Hz. Alternate gating of the output frequencies from a pair of synthesizers provides an F1 signal which can be set to give the desired shift frequency and, since both synthesizers are phase-locked to the same very-stable 100 kHz source, v.l.f. signal frequencies that are very stable in both frequency and phase are produced. Scintillations* in phase are reduced to less than 1°, due to the large frequency division employed. However, momentary fluctuations in phase of the radiated signals can occur, because overall phase correction from the aerial circuit is not applied with this method of frequency derivation.

*Scintillations—unwanted momentary deviations in the frequency of a carrier wave, caused by the process of modulation.

## AERIAL-TUNING CONTROL

Varying weather conditions affect the electrical constants of the aerial, and the aerial circuit is self-tuned to ensure maximum aerial current during traffic. The automatic-tuning system must respond within the duration of a telegraph signal element. The phase of the aerial current is compared against a reference-voltage signal by a phase discriminator controlling a servo-system driving the aerial fine-tuning variometer. The aerial is tuned to resonance at the assigned frequency of the emission, i.e. for normal operation it is tuned to the carrier frequency of 16 kHz for A1 modulation and, for F1 modulation, to the mid-band frequency, 15·975 kHz. For F1 modulation the input to the discriminator is gated at telegraph

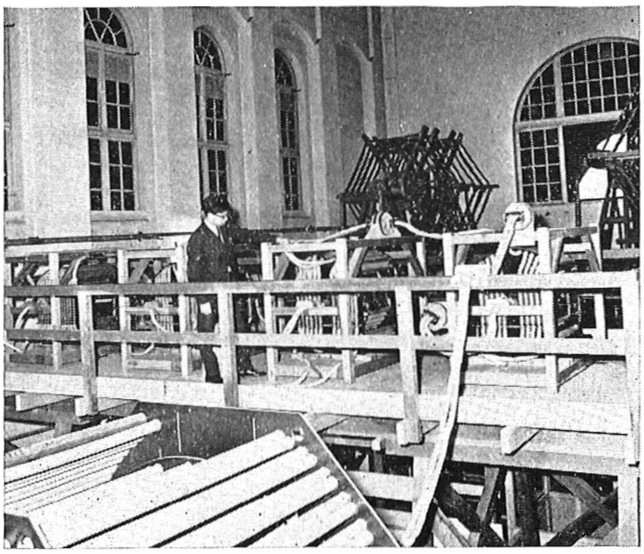

FIG. 6—Variometers in upper storey of building

signalling speed to exclude the shift-frequency signals at 15·950 kHz, and the discriminator-tuning control is off-set by −25 Hz from the 16 kHz control setting. Similarly, for operation at other frequencies in the v.l.f. range, one of the pair of F1 frequencies is gated to provide control, and an off-set adjustment is made to suit the shift in frequency employed.

## COIL-ROOM EQUIPMENT

The anode tuned-circuit and the aerial-coupling and aerial-tuning inductors are housed in the upper storey of the building, and Fig. 6 shows a view of the five variometers employed. Two of the variometers on the platform are parallel connected to 10 of the original tank-circuit capacitors, which have been rearranged to give a total capacitance of 1 $\mu$F with a radio-frequency rating of 1,000 A r.m.s. A manually-operated switch is used to disconnect three capacitor units at operating frequencies above 19·5 kHz. The gross weight of the whole capacitor bank exceeds 20 tons.

The other two variometers on the platform provide, respectively, adjustment of the aerial coupling to the tank circuit and fine tuning of the aerial circuit, under automatic control. In the foreground, part of the fifth variometer used for coarse aerial-tuning is shown. The controls for the variometers are brought out to the mimic diagram and control panel to provide remote-tuning facilities.

Since the increased aerial current consequent on the higher power of the new transmitter would have led to greater heat losses in the existing aerial-tuning coils, with a resultant rise in running temperature, three new coils were built, and Fig. 7 shows the new arrangement of three series-connected coils each comprising a paralleled pair of hexagonal spiders of 16 ft overall diameter. Each spider is wound with eight turns of Litz cable consisting of 6,561 insulated wires of 0·0076 in diameter laid up in bunches of three wires to form 81 separate cables each of 81 wires to make up a cable of 1·25 in external diameter. To minimize movement of the individual turns and of the spiders as a whole, the cable is run in synthetic-resin-bonded paper (s.r.b.p.) tubing, and the spider assembly is stiffened by braces. This form of construction greatly reduces fluctuations in phase caused by flexing of the coils by electromagnetic reaction forces during rise and decay of the signals. The three coils together have a resistance value at 16 kHz of about 0·058 ohms. The inductance of the coils, determined by the number of turns in each and the mutual coupling between them, is approximately 0·85 mH.

Together with the tuning and coupling variometers the new coils give a total of 1·25 mH for series-tuning the aerial, which is represented electrically, at 16 kHz, at the aerial lead-out as a capacitance of 0·8 $\mu$F. Under these conditions, and with an aerial current of 900 A, the peak radio-frequency voltage at the aerial lead-out terminals is some 170 kV and the power lost in heat dissipated in the aerial-tuning inductors is 47 kW.

The aerial-tuning coils terminate on large steering-wheel terminals on the beam shown in Fig. 7. These terminals provide tapping points for adjustment of the inductance by short-circuiting one or two of the coils by means of Litz cable links so as to provide continuous tuning coverage of the aerial from 16–22 kHz in conjunction with the coarse aerial-tuning variometer.

## SAFETY PRECAUTIONS

The transmitter as a whole has been fitted with all the safety devices necessary to comply with modern standards.[4] The safety system is based on the use of captive keys to make it impossible to approach components at dangerous voltages without having first isolated the areas concerned and made them safe by earthing all high-voltage connexions. For example, in order to gain access to the coil room it is necessary to obtain keys from each amplifier; the keys are only released after the mains power supply has been disconnected and the isolating switches manually operated. After insertion of the three keys into an exchange box, an access key to the coil-room door is freed; but to gain access to the coils or tuning capacitors, the aerial must first be earthed to release the keys required to unlock the aerial-coil gantry door and the door to the capacitor enclosure. The action of unlocking the latter door automatically earths the capacitor terminals, and this condition is visible to anyone entering. As a further precaution, manual earthing sticks are also provided at appropriate places in each high-voltage compartment, and, after

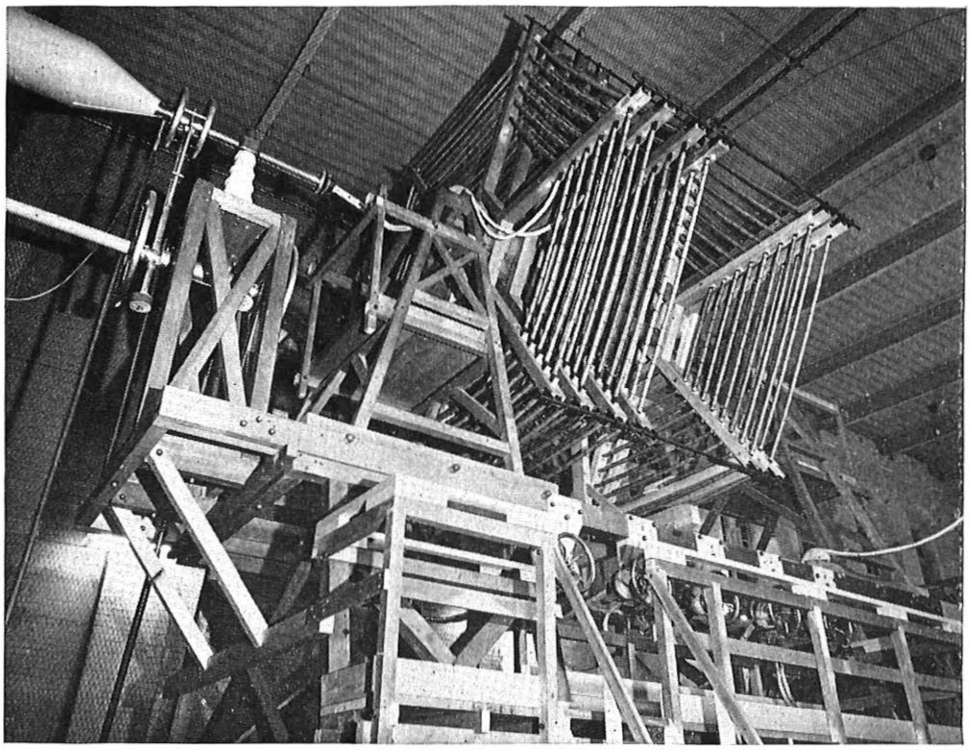

Fig. 7—Aerial-tuning coils

use, these must be replaced on their switch hooks to complete a control circuit before the transmitter can be brought up on power.

## CONCLUSIONS

The new v.l.f. transmitter at Rugby radio station provides an output power at 16 kHz of 450 kW and a radiated power of some 65 kW at telegraph signalling speeds of up to 72 bauds, using A1 emission, and of 50 bauds with Fl emission. The power amplifier efficiency is around 67 per cent.

The up-to-date operational arrangements using remote control and modern instrumentation include automatic aerial-tuning to ensure that maximum output is maintained during changing weather conditions, and motor-driven variometers having a fast response-time have been developed for use with the servo-control systems. Although the aerial-tuning inductors appear similar to those previously in use, parallel windings have been used to provide twin Litz cable paths for the increased aerial current so as to reduce power losses and to limit the temperature rise.

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# Book Reviews

"Techniques of Pulse-Code Modulation in Communication Networks." G. C. Hartley, P. Morrct, F. Ralph and D. J. Tarron. Cambridge University Press (I.E.E. Monograph Series) 110 pp. 36 ill. 30s.

The I.E.E. Monograph series of books is intended as a means of keeping the practising engineer up to date on new advances, and is written at a level which assumes a fundamental knowledge of the subject. This, the first book in the series, surveys in about 100 pages the potentialities of pulse-code-modulation techniques as applied to line-communication networks. The publication is timely for Post Office engineers who are, or shortly will be, meeting p.c.m. equipment in the telephone junction network throughout the country, for this book answers many questions about the ways in which p.c.m. techniques may be exploited in the future without confusing the reader with excessive detail.

After an all too brief chapter entitled Historical Review, the principles of p.c.m. are discussed in outline in a chapter occupying about a third of the book; this includes an introduction to tandem switching and subscribers' line concentrators, and the chapter ends with a useful assessment of the advantages offered by p.c.m. The growing importance of data transmission is recognized in a chapter which explains how data services covering a vast range of bit rates may be integrated within a digital network. The final third of the book covers much of the same ground as in earlier chapters, but gives a more detailed description of the various elements of an integrated transmission and switching system. Here the emphasis is on design considerations and the concepts involved rather than circuit detail. The importance of an agreed glossary of terms relating to p.c.m. is recognized in the final chapter where some definitions are offered.

The authors have succeeded in writing a most useful book on this fast-developing topic and have set a good standard for the start of this new series.

J. R. J.

"Logical Design Manual." D. Zissos, B.Sc.(Hons.), A.M.I.E.R.E., and G. W. Copperwhite, B.Sc., H.D.E. Pitman and Sons, Ltd. 181 pp. Numerous ill. 40s.

The art of logic design has not yet been brought to the state that, say, linear circuit theory has reached, so that any advance in the logic field is indeed welcome. This book, which is based on a course of lectures given at the Liverpool College of Technology, represents a useful contribution to the art of logic design.

After a brief but comprehensive introduction to Boolean algebra and Karnaugh maps, the book describes in some detail a procedure for the design of absolute minimal switching circuits using NAND/NOR gates. This is a welcome approach in view of the increasing use of integrated circuits for logic applications. However, the term "absolute minimal circuit" should be treated with some caution since the criterion given does not necessarily result in a minimum number of integrated circuit packages. Later chapters deal with race hazards and techniques for designing hazard free circuits are described.

The design of sequential logic circuits is well established but the book does introduce some new techniques concerned with the elimination of race hazards. The procedure is a useful one, although waveform diagrams might have been introduced with advantage to explain the operation of the circuits used as examples.

This book is not one for the student but it can be used to advantage by the practising engineer with some experience of logic design.

C.J.H.

# Trunk and Junction Cable Pressurization: A Note on Progress

A. F. G. ALLAN, C.ENG., M.I.E.E.†

U.D.C. 621.315.211.4

*This article describes the progress and effects of the cable pressurization program at the present time. For the trunk network, the overall maintenance costs have been reduced and the network reliability improved as a result of cable pressurization.*

## INTRODUCTION

Early in 1964 air pressurization[1] had been applied to less than 20 per cent of the 80,000 sheath-miles of the trunk and junction cable networks which then existed in the United Kingdom. Long-distance coaxial cables provided the bulk of this 20 per cent, but some enthusiastic supporters of the newly-available technique applied pressure to cables of other types. As a direct result of cable pressurization there were improvements both in serviceability and in the reduced demand for cable renewals, and it was decided that both new and existing trunk and junction cable networks should be pressurized. Certain cables, e.g. older types with non-standard wax-filled joints, could not be pressurized without incurring excessive cost and effort, and others, principally those scheduled for early recovery, did not justify the work required. Even so, around 95 per cent of the combined networks could be pressurized, and a target date of 31 March 1968 was set for the application of some measure of compressed dry-air protection to 76,000 miles of cable.

## PROGRESS

To carry out all the tasks involved in the retrospective pressurization of some 60,000 miles of cable in not more than four years called for an immense effort at a time when there were heavy demands on resources for clearing the waiting list and endeavouring to meet the very rapid growth of business. Nevertheless, all the mechanical work, installation of compressor desiccator equipments, gauges, flowmeters, making of air-blocks, fitting of thousands of valves and numerous other items has been completed and virtually the whole of the combined network is now protected, to a degree, by air pressure within the sheaths.

In many cables the protection is still inadequate, either because a static pressure has not been achieved, or the static pressure is too low. This was expected, and it was known that several years' work beyond March 1968 would be required to reach the objective of a fully static system, i.e. an air pressure of 9 lb/in$^2$ (above atmospheric) throughout each cable with an air loss not exceeding 1 lb/in$^2$ in any four week period.

It had been anticipated that the number of cable defects detected as pressure was applied would be somewhat greater than in pre-pressurization times because existing faults, many of which might otherwise have lain dormant and unsuspected for years, would immediately become apparent. This period, 1964–1968, also saw an upsurge in new cable installations and a large increase in duct-track and jointing-chamber reconstruction projects. As a direct result of this greater human activity the number of defects detected in each unit of 100 miles of cable rose much more than had been expected. Fig. 1 illustrates the rising defect rates, and

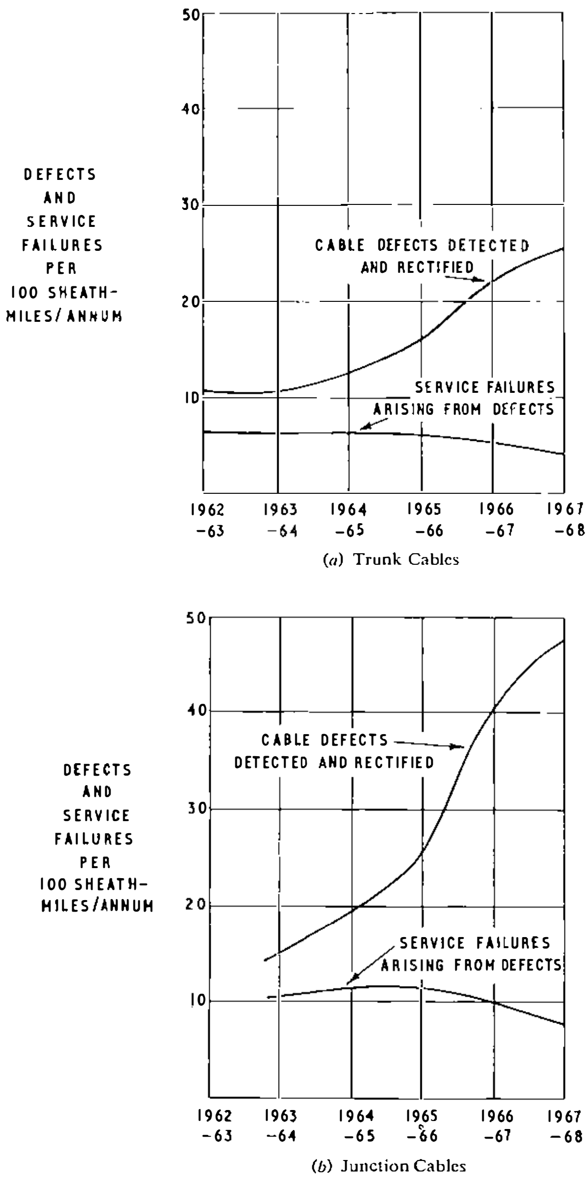
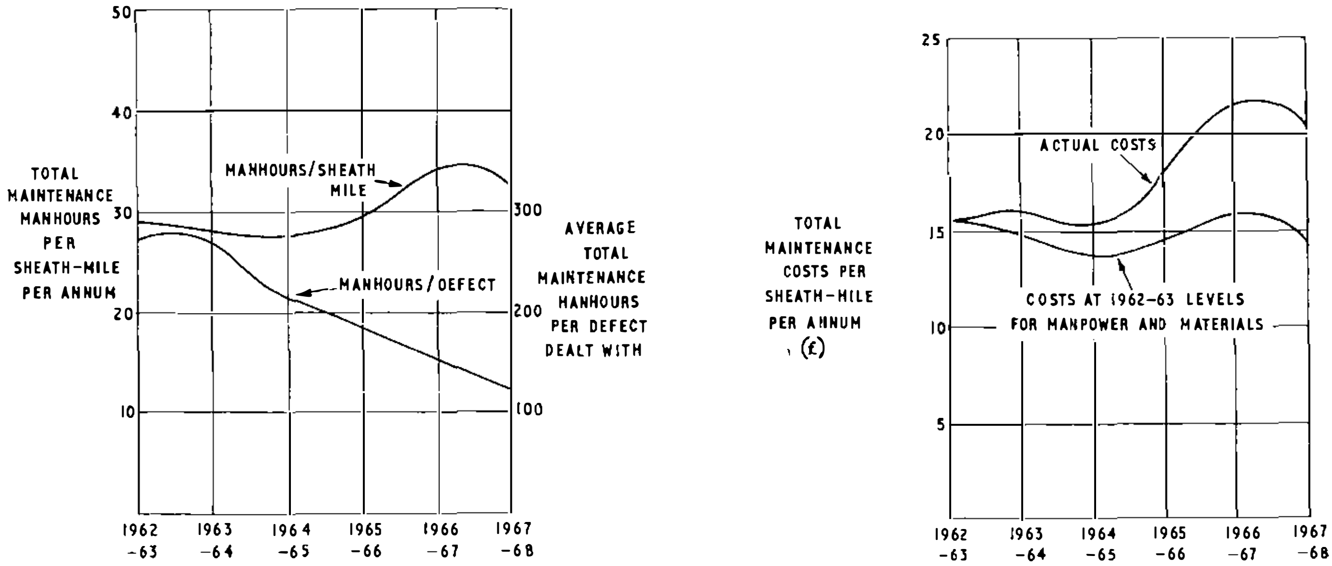



FIG. 1—Comparison of defect and service failure rates

† Customer's Maintenance Services Branch, Service Department, Telecommunications Headquarters.




(*a*) Manpower (*b*) Costs

Note: Includes cost of materials, e.g. renewal cable less recovery value of faulty length

FIG. 2—Maintenance manpower expenditure and costs for trunk cables

shows how pressurization, even to admittedly low standards, has contained and in fact reduced the service failure* rates in spite of this rise in troubles. It is indeed fortunate that the initial pressurization program was pressed forward with vigour at a most critical time. Had this not been done there would have been a serious deterioration in network reliability.

## COST OF THE SCHEME

Cable pressurization is improving the serviceability of the plant, but at what cost? Fig. 2 shows the total of the manhours spent on the trunk network on normal day-to-day maintenance, i.e. localization and repair of defects, on cable renewals, and on the repair of damage inflicted on existing cables in the course of new work. True overall manpower expenditure on maintenance has begun to fall; the service failure rate is also falling, and all in spite of a continually rising trouble rate.

The reason for the overall fall in manhour expenditure per mile of trunk cable maintained is clearly indicated in the average manhours per defect statistic. Routine observation of air pressure enables maintenance staff to be made aware of cable troubles at a much earlier stage so that in many cases a simple repair can be made rather than a ruined length replaced. The reduction in the number of renewed cable lengths is an important factor in reducing maintenance costs, and there are fewer interruptions to service whilst the cable pairs are changed over. Maintenance costs on junction cables are not yet showing a similar downward trend, but this is probably due to priority having been given to the trunk cables, and because a greater proportion of the junction cable network lies in extremely congested duct-tracks and jointing chambers.

* A service failure is any defect which develops to such an extent that one or more public or private circuits are rendered unserviceable.

## CONCLUSIONS

Confidence in the ultimate downward trend of maintenance costs for the national trunk and junction network is supported by the experience, extending over some years, in those parts of the combined network where conditions of really static pressure already apply .The pneumatic standards must now be maintained at the best level so that the potentially large service and cost advantages of cable pressurization in the rest of the network can be achieved.

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# Guarding of Roadworks

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U.D.C. 625.76

*The proper guarding of engineering works and working parties is of paramount importance as the volume of road traffic continues to increase. This article highlights some of the tragic results of inadequate guarding of engineering works and describes the diversity of available guarding equipment which, if properly used, greatly improves safety. The article concludes by illustrating how the available equipment could have been used in situations where accidents had occurred.*

## INTRODUCTION

The increasing volume of traffic on roads that are already congested, places a direct responsibility on Post Office engineers to ensure that roadworks are guarded in a manner that will give a high degree of safety to workmen, and members of the public using the highways.

## INCORRECT USE OF GUARDING EQUIPMENT

A wide variety of guarding equipment is available, but, unless used correctly, its effectiveness is considerably reduced and, in certain circumstances, it is possible that incorrect use of guarding equipment may create additional hazards to traffic, or confuse drivers, and consequently worsen the situation. In many instances this equipment, which represents a capital expenditure to the Post Office of well over a million pounds, is used in a haphazard fashion, or is not used at all. A Road Works Ahead sign, which should be sited well ahead of the works, and is intended to warn drivers that an obstruction lies ahead, becomes useless when it is propped against a jointer's tent situated on a carriageway used by vehicles travelling at high speed.

## INSTRUCTIONS AND REGULATIONS

Instructions to British Post Office personnel on the use of guarding equipment are contained in official instructions, which are based on the London Traffic Statutory Regulations, 1927, and the recommendations of the Traffic Safety Code for Roadworks, 1957, as the authorized procedure for works in streets. The code has no statutory force but has been prepared with the object of achieving uniformity in guarding and lighting of obstructions.

The introduction of the Traffic Signs Regulations and General Directions, 1964, which will become law in January 1969, and the proposed Ministry of Transport Traffic Signs Manual, which, although a code of practice rather than a statutory instrument, has made necessary a complete revision of Post Office instructions on the guarding of roadworks.

This important problem, involving the safety of Post Office staff and the public, can only be solved with the co-operation of the man on the job, who could be helped by a comprehensive illustrated manual which dealt with almost every conceivable situation, and explained the correct procedure to be observed, from the simplest to the most complex situations.

A memorandum was sent to Telephone Managers requesting photographs and diagrams of dangerous or difficult manhole situations within their Areas. From the large response to this memorandum, a selection was made of particularly difficult situations, and a series of meetings arranged with officials at the Ministry of Transport to decide on the best method of guarding. An artist was employed to illustrate the various situations correctly guarded and the resulting manual, The Roadworks Guarding Manual, should be available early in 1969. It is believed that it will be the first book of its kind and may attract the interest of Local Authorities and civil engineering contractors at home and abroad. The need for better standards will be apparent from a study of five selected accidents to Post Office workmen.

## FIVE ACCIDENTS

Five accidents involving Post Office engineers are described.

(*a*) A joint box was situated on the footway 12 in from the kerb at the intersection of a main road and a narrow minor road frequently used by heavy vehicles travelling to an industrial area.

A jointer erected his tent and took no precautions for the safety of the public using the footpath, or his own protection from the possibility that the wheels of vehicles turning into the minor road would mount the kerb. One hour after darkness a vehicle turned into the minor road and its near-side wheels mounted the kerb and crushed the tent. The jointer received spinal injuries and died several days later.

(*b*) This accident took place at a manhole where the entrance was situated on the footway 18 in from the kerb. A drum of cable was erected on jacks placed on the footway and two men were turning the drum. Members of the public were well protected by joint-box guards and red flags, but the engineers had provided no protection from vehicles passing in the adjacent carriageway.

A third man working in the manhole required a hammer to deal with a troublesome shackle. One man left the drum, and kneeling beside the manhole shaft, he lowered the hammer to his colleague. As he did so his right foot and ankle were extended into the gutter of the carriageway and an approaching double-deck omnibus with its nearside wheels close to the kerb, passed over his right foot and ankle. He was crippled for life.

(*c*) In this accident a jointer was setting up a joint and required more slack cable, which could only be obtained by freeing the cable at an adjacent manhole. Before entering the manhole, situated on the footway near the kerb at a cross-road, he made the prescribed tests for gas and foul air. He carefully erected a joint-box guard to protect the public, and entered the manhole.

As he emerged from the manhole shaft, a light van making a right-turn at the adjacent cross-road caused a heavy lorry (with a slightly overhanging load on its nearside) to overtake the van on its nearside whilst turning left close to the kerb.

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It is not known exactly how the jointer was struck by the passing lorry, but it can be assumed that his head and shoulders emerged from the manhole, and were over-hanging the kerb at the moment the lorry passed the manhole. He was struck on the face and killed instantly.

(*d*) This accident involved two men who were closing a manhole at a wide T-junction near the centre of a large city. Referring to a letter T the manhole was on the horizontal portion to the right. It was raining and both men were wearing dark coats as they bent to replace the cover. A joint-box guard was their sole protection against slow-moving traffic.

A trolley-bus turned right from the vertical portion of the T and passed within inches of the guard. The 'bus was followed by a large articulated lorry, also turning right, which went through the guard and struck the men. Both were seriously injured, one remaining unconscious for eight days.

Legal proceedings were taken against the lorry driver whose solicitor argued that the joint-box guard was inadequate, and the dark coats acted as perfect camouflage when viewed on a wet day from the cab of a heavy lorry. The driver claimed that he could not see the men; nevertheless he was held guilty because he had no right to take any risk, or to drive if he could not see clearly. Since this accident high visibility jerkins have been made available and should always be worn by staff when working in daylight on the carriageway. This accident highlights the danger of assuming that because the carriageway is wide, and the traffic moving very slowly, there is no need to implement full guarding precautions.

(*e*) This incident concerned a jointing chamber which was situated in the carriageway at a T-junction controlled by traffic lights. The position of the chamber was such that it was partly screened by traffic lights and control boxes to drivers moving from the vertical to the horizontal part of the T. The joint-box cover had been removed and placed at the edge of the joint box. Joint-box guards with a red flag attached had been erected round the joint-box cover. The working party's vehicle had been parked some 20 yards from the work, and not as a physical barrier, owing to the requirements of traffic using the junction. The cable jointer was standing in the chamber engaged in the location of a fault, and the depth of the chamber is such that he was waist-high to the carriageway.

Both roads are normally busy and the young man driving the car had made the left-turn at that time of day on many occasions. As he approached the junction he may have glanced to the left and it is possible that the work was screened by the control boxes. He was certainly watching the lights for they were changing as he turned left and accelerated. Too late he tried to avoid the guard. His nearside front wheel struck the guard and the heavy cover, which was propelled violently forward pinning the jointer to the side of the chamber and inflicting severe internal injuries that were fortunately not fatal.

This case illustrates the need to expect indifferent driving and cater for it in any guarding system. All five accidents could have been prevented with a little more fore-thought, and a more liberal use of the available guarding equipment.

## GUARDING EQUIPMENT

The following items are available to Post Office staff for the guarding of roadworks and form a comprehensive list from which to choose the items suitable for particular works.

### Electric Beacon No. 1

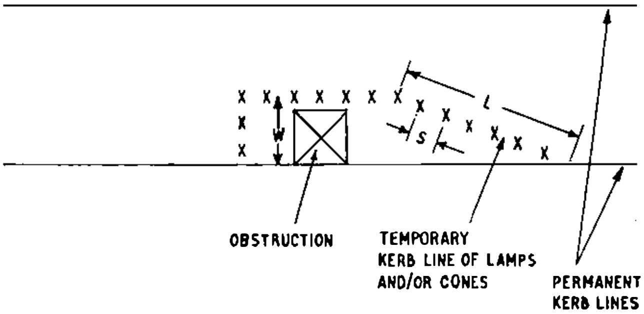
Electric Beacon No. 1 consists of a translucent red plastic tube 10, 20 or 40 ft long, which is sleeved at 12 in centres with white reflecting material to give the tube an alternately red and white banded appearance. The exposed lengths of red tube are internally illuminated by 24-volt 6-watt lamps. An electronic flasher is fitted to the beacon. The beacon may be used in many ways to supplement other signs when special traffic control or direction is required. It may be looped above a jointer's tent to indicate the tent position more clearly. It may be hung on an extendible guard, to block a traffic lane or placed diagonally across a traffic lane to guide traffic into another lane, or it may be used to show the outline of a stationary vehicle. It may also be used in conjunction with an extendible guard and hazard barrier where a sharp deviation of traffic is required.

### Electric Beacon No. 2

Electric Beacon No. 2 has an amber lens and is mounted on a tripod. The beacon has a stationary lamp round which a reflector revolves. It is suitable for warning traffic at any site where exceptional danger exists due to an obstruction, or where it is desirable, due to the speed of traffic, to give warning at a considerable distance. This beacon is adjusted for height and level to focus the flash on the approaching traffic. The siting of two beacons, so that they are viewed in line by approaching traffic, reduces the effectiveness of the warning and should be avoided.

### Reflecting Cones

Reflecting cones are used to delineate a temporary kerb line. For day and night working they are used in conjunction with road caution lamps, cones and lamps being placed alternately round the obstruction (see Fig. 1 and Table 1).




Note: See Table 1 for values of W, L and S.

FIG. 1—Diagram of typical layout of cones and/or lamps to form a temporary kerb-line round an obstruction.

**TABLE 1**

**Temporary kerb-line round an obstruction: spacing of lamps and/or cones and length of temporary kerb for different traffic speeds**

| Speed of Traffic mile/h | Spacing of Cones and/or Lamps, S ft | Width of Hazard, W ft | | | | |
|---|---|---|---|---|---|---|
| | | 8 | 9 | 10 | 11 | 12 |
| | | Length of Temporary kerb, L yards | | | | |
| 20 | 9 | 17 | 19 | 21 | 23 | 25 |
| 30 | 9 | 33 | 37 | 42 | 46 | 50 |
| 40 | 27 | 50 | 56 | 63 | 69 | 75 |
| 50 | 27 | 66 | 75 | 83 | 92 | 100 |
| 60 | 27 | 83 | 94 | 104 | 115 | 125 |
| 70 (un-restricted) | 54 | 100 | 113 | 125 | 137 | 150 |

For obstructions that will be removed before darkness, only cones should be used to guard the area. Where cones are laid at right angles to approaching traffic, there must be a spacing of 4 ft between cones.

Cones will withstand a certain amount of rough handling and, since they are hollow, they may be stacked inside each other to reduce storage space.

Red flags may be used in an emergency, or where it is necessary to erect overhead wires over a quiet residential road. In such circumstances, staff should wait until the road is clear of traffic, then a flagman should display a red flag as the wire is being run out across the road and erected. On main roads or busy roads, red flags are inadequate and traffic control by a Stop-Go board is necessary.

### Electric Floodlights

Electric floodlights are mounted on a folding frame which supports the lamps. The frame has a tubular-steel upright with a folding tripod stand and a tubular cross-arm, which can be fixed horizontally at various heights, and folds against the upright for packing. The upright has a telescopic centre, which is extendible to a height of 10 ft. Ten yards of flexible cable and three lampholders are supplied, one for the head and one for each arm. They can be adjusted to any required angle.

The power supply for the floodlights, is a petrol-engine-driven electric generator. The weight is 541 lb plus three floodlights, which weigh a total of 26 lb.

Floodlights are for night use during breakdowns and excavations. Care has to be taken to direct the lights downwards to avoid dazzling motorists.

### Extendible Guard

The extendible guard is a telescopic metal guard mounted on a stand. It can be extended from 2 ft 6 in to 6 ft 6 in, and is fitted with hooks in order that two or more may be joined together to guard a long obstruction.

Extendible guards can be used as a stand to display the hazard barrier or an Electric Beacon No. 1. They can also be used to fence obstructions from pedestrian access, or to set up a temporary footpath intruding into the carriageway.

### Joint-Box Guard

The joint-box guard is a portable wooden frame which is used to guard an open joint box or footway manhole entrance, and is painted red to improve visibility.

### Hazard Barrier

The hazard barrier is a plastic sign with alternate red and white chevrons. The purpose of this sign is to indicate a sharp deviation to either left or right and is used when the obstruction is concealed, or partly concealed, from approaching traffic, and should be positioned close to the obstruction. Typical examples of the use of a hazard barrier would be at an obstruction on the bend of a road, or an obstruction partly concealed at a T junction, or where a motorist will make a right-angled turn and come suddenly upon the obstruction, having been given previous warning of its presence. There is no reason why a hazard barrier should not be used on a long straight road, where other warning devices will amply protect the obstruction, but its main use is for situations where the words are concealed, or partly concealed.

The hazard barrier is normally tied to an extendible guard, and may be reversed to denote a right or left deviation.

### Keep Left and Keep Right Sign

The Keep Left and Keep Right sign is a plastic sign showing a white arrow in a blue circle. It is a mandatory sign, and it is used to indicate to drivers that they should pass the sign on the side indicated. Where this sign is positioned ahead of the works, it should be sited on the footpath and at an angle that will make it most noticeable to the approaching driver. Where it is necessary to position this sign on the carriageway at night, it should be guarded by a road caution lamp placed at the base of the sign on the side nearest to traffic.

### Road Caution Lamps

Road caution lamps are used with reflecting cones to delineate a working area or obstruction by night. Cones and lamps should be placed alternately round the works (see Fig. 1 and Table 1) except where lamps are placed at right angles to the line of traffic, where there must be spacing of 4 ft between lamps. These lamps require frequent cleaning, and a check is necessary before use to ensure there is sufficient paraffin oil and the wick is satisfactory.

### Road Works Ahead Sign

The Road Works Ahead sign is the first warning the motorist receives that he is approaching an obstruction. It must, therefore, be positioned well ahead of the obstruction as shown in Table 2.

**TABLE 2**

**Distance between obstruction and Road Works Ahead sign for various traffic speeds**

| Speed of Traffic mile/h | Distance to Sign ft |
|---|---|
| 30 | 150 |
| 40 | 500 |
| 50 | 625 |
| 60 | 750 |
| 70 | 1000 |

The distances are chosen to give sufficient time for action, but not too long for drivers to loose interest.

The sign is placed, where possible, on the footpath and at an angle that will be most easily seen by the motorist. Where the footpath is narrow, and this sign may cause an obstruction, it should be positioned in the channel of the carriageway, and guarded by one road caution lamp by night and one reflecting cone by day, placed at the base of the sign on the side nearest to the traffic. Where headlamps are not normally used, this sign may require illumination by night. In windy weather, stability can be improved by suspending a bag filled with sand, earth or ironwork from the hook beneath the tripod.

### Stop-Go Signs

Stop-Go signs are supported and rotated on a tripod. Control has to be intelligently exercised so that no additional hazards are created. This type of control is suitable at small obstructions of short duration provided the traffic is light.

Where it is not possible for the operator to control traffic approaching from both sides, owing to a bend in the road or some other difficult situation, it will be necessary to provide two Stop-Go signs which will be operated simultaneously.

The operator of a Stop-Go sign should wear a high visibility jerkin by day; by night the jerkin is reversed to exhibit the white side.

### Traffic Control Ahead Sign

The Traffic Control Ahead sign is positioned midway between the Road Works Ahead sign and the obstruction, and is used to warn drivers that there is manual control of traffic ahead by use of a Stop-Go sign. It is never used to warn drivers of control by light signals.

### Traffic Signals Ahead Sign

The Traffic Signals Ahead sign is also positioned midway between the Road Works Ahead sign and the obstruction, and is used to warn drivers that there is traffic control ahead by means of traffic signals. This sign is always used when traffic is controlled by signal lights.

### Electric Traffic Signals

Portable electric traffic signals are suitable for traffic control on roads where traffic is dense, or the work prolonged. They are capable of operation by manual control, or by an automatic timing unit from a 24-volt d.c. supply. Each set of signals comprises one control cabinet and tripod, two 3-light signal heads and tripods, and two cable reels, each wound with 125 yd of cable. The signals have been designed in units to enable one man to erect and dismantle the entire system.

The control unit consists of an automatic timing and switching device and a manual control, which is completely independent of the automatic system except for the signal-light switching circuit. The control unit provides automatic timing adjustments for each signal light, except that the amber is fixed at 3 seconds. The timing controls are continuously variable, and have a range of 10 to 100 seconds; a scale engraved on the control dial is accurately marked in steps of 10 seconds. When setting up controls an estimate should be made of the time necessary to clear traffic in both directions, and the timing then adjusted in accordance with the flow of traffic. It is important to make frequent checks to ensure that traffic is not building up in one direction, in which case the controls must be re-set to clear this build up.

Police have to be informed when signal lights are required for traffic control, and in some areas the police insist on setting the controls. In most areas the police are willing to set the timing if required to do so.

Regulations require that a lighted road caution lamp be placed on the ground beside the tripod during hours of darkness when the signal light is positioned outside the guarded area.

## EXAMINATION OF ACCIDENTS

The five accidents described earlier are examined to determine what equipment could have prevented the tragedies.

Accidents (*a*), (*b*) and (*c*) involved Post Office staff employed on the footway who assumed they were safe from vehicles using the carriageway.

A procedure which has now been agreed with the Ministry of Transport to meet this situation is shown in Fig. 2, and it

FIG. 2—Layout of guarding equipment: plant in the footway; daytime working

will be used by day when working in a jointing chamber, or on other plant less than 18 in. from the face of the kerb.

Fig. 3 shows the agreed arrangement where day and night work is in progress in a footway jointing chamber and a trailer tool cart is in use. There are no statutory requirements concerning the distance apart that road caution lamps should be placed on the footpath, but a high degree of safety to members of the public should be the aim. Road caution

FIG. 3—Layout of guarding equipment: plant in the footway; day and night working

lamps and reflecting cones are positioned as shown. The extendible guards form a barrier at both ends of the obstruction, and are positioned at an angle in order that the works may be safely negotiated by the blind.

In accident (*d*) the men were struck by a slow-moving lorry at a T junction, their sole protection being a joint box guard. Fig. 4 shows the procedure agreed with the Ministry

FIG. 4—Layout of guarding equipment: plant in the carriageway; day and night working

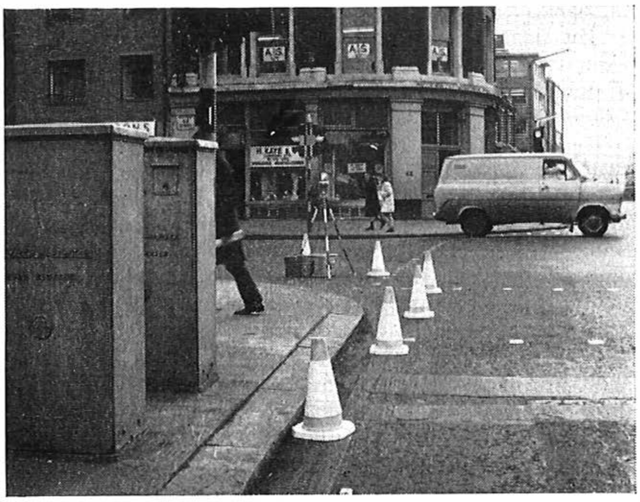
of Transport when it is necessary to guard a carriageway works which is situated near the kerb. The majority of Post Office jointing chambers situated in the carriageway have an entrance within 6 ft of the kerb, and this will therefore be the situation most frequently met with in the carriageway. Had the unfortunate men at the T junction used this system they would have been seen readily by the lorry driver despite the bad conditions. In Fig. 4, a vehicle, in gear and with the handbrake applied, forms a physical barrier 5 yd from the manhole. The Road Works Ahead sign is positioned well ahead of the obstruction. Road caution lamps, spaced as in Table 1 and supplemented by reflecting cones, delineate a temporary kerb line suitable for day and night work. A Keep Right sign is erected, and during hours of darkness or by daylight an electric beacon may be introduced to give advanced warning to isolated vehicles approaching at maximum speed.

The scene of accident (*e*) has been partially reconstructed in Fig. 5 which depicts a manhole in a similar situation. Fig. 5(*a*) shows the view from a car approaching the traffic

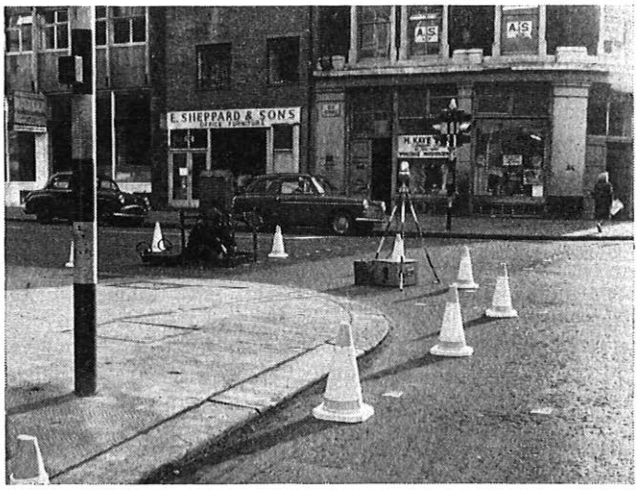

(a) View from car approaching the traffic lights


(b) Point at which the obstruction becomes visible

FIG. 5—Reconstruction of accident (*e*): incorrect guarding



(a) View approaching the traffic lights




(b) Full view of the obstruction with the guarding arrangements

FIG. 6—Reconstruction of accident (*e*): correct guarding

lights; the driver is unable to see anything of the obstruction 15 yd away round the corner. Fig. 6(*a*) shows the same view as Fig. 5(*a*), but this time the driver cannot fail to see the flashing beacon and cones even though the obstruction is screened. The complete obstruction is shown in Fig. 6(*b*).

## ROAD WIDTH AND ACCIDENTS

It is not possible in this article to mention the many hazards dealt with in the manual, but the question of road widths is considered particularly important.

Work on the actual carriageway may sterilize a part or the whole of a traffic lane or lanes, but a road width of at least 10 ft (single-traffic lane) on major roads must be left open for alternate one-way working to be controlled by police, traffic lights or a Stop–Go sign. The character of minor roads, and traffic using them, may permit the minimum for alternate working to be 8 ft 6 in, but local knowledge will determine whether this is practical. Where it is intended that two-way traffic should continue, a road width of 18 ft must normally be left open on major roads, but on minor roads this may be reduced to 16 ft.

Care should be taken not to leave a width of 13–16 ft, which, although too narrow for two-way working, may encourage drivers to try to use it for this purpose, thereby endangering themselves and Post Office engineers. In these circumstances the extra width should be closed so as to leave a single 12 ft wide lane and alternate working introduced.

## CONCLUSIONS

The proposed manual, now in course of preparation, should do much to make Post Office roadworks safer, but it cannot be a substitute for thought by the man himself, or for a supervising officer who makes an effort to know difficult situations within his area, and has agreements with both the Local Authority and the police on how they should be dealt with.

It must also be recognized that there are a number of specially difficult situations which cannot be dealt with by improving guarding. In such circumstances access to a manhole can often be provided by means of a side-shaft (subway) entrance, from verge or footway, which will allow prolonged jointing work to be carried out in reasonable safety.

# Direct Dialling-in to P.A.B.X. Extensions

S. C. TAYLOR†

U.D.C. 621.395.636.1: 621.395.24

*At a number of P.A.B.X.s calls incoming from the public network can now be routed directly into P.A.B.X. extensions without the aid of a P.A.B.X. operator. For various reasons extension numbers which can be directly dialled need to be integrated into the numbering range of the public exchange and methods of carrying out this operation in both director and non-director areas are described.*

## INTRODUCTION

The facility of dialling directly into P.A.B.X. extensions from exchanges in the public network is likely to be attractive to certain large commercial and public undertakings, particularly to those receiving a high proportion of their calls from persons who are either members of their staff, or, who are familiar with the internal organization concerned. Such callers already know the extension number of the person to whom they wish to speak and, since they do not normally require the services of the P.A.B.X. operator, it is obviously an advantage if they can connect themselves by directly dialling the required extension number. Under these conditions the number of operators required at the P.A.B.X. can be reduced, although operator assistance can still be obtained, when necessary, by dialling enquiry numbers allocated to the P.A.B.X. switchboard itself.

It is likely, therefore, that there will be an increasing demand for the direct dialling-in (D.D.I.) facility in future and it will be necessary to take account of this in public-exchange planning and design.

## CHOICE OF METHOD OF GIVING D.D.I. ACCESS

One method of giving the facility is to arrange for the caller to dial the normal directory number of the P.A.B.X., followed by the extension number. The British Post Office does not use this method for the following reasons:

(*i*) Existing subscriber trunk dialling (S.T.D.) controlling register-translators do not have sufficient dialled-digit storage to cater for the increased number length of calls to D.D.I. numbers. Expensive modifications to increase this storage capacity would need to be carried out to all register-translators throughout the country. Since the number of S.T.D. calls to D.D.I. extensions is small in comparison with the total number of S.T.D. calls handled by the register-translators, this would be uneconomic. Similar considerations would also apply to the directors at local director exchanges.

(*ii*) Modification of the public-exchange final selectors to permit dialling through the transmission bridge presents a number of technical problems and would also be costly.

These difficulties are avoided by integrating the D.D.I. extension numbers into the numbering range of the public-exchange or linked-numbering scheme concerned. Thus, callers dial what appears to be a normal final-selector number, although a public-exchange final selector is not in fact included in the routing. An example of the type of trunking required for this method is shown in Fig. 1.

The D.D.I. traffic is routed via a special group of uni-directional circuits trunked directly into the P.A.B.X. from a suitable level of the public-exchange group selectors.

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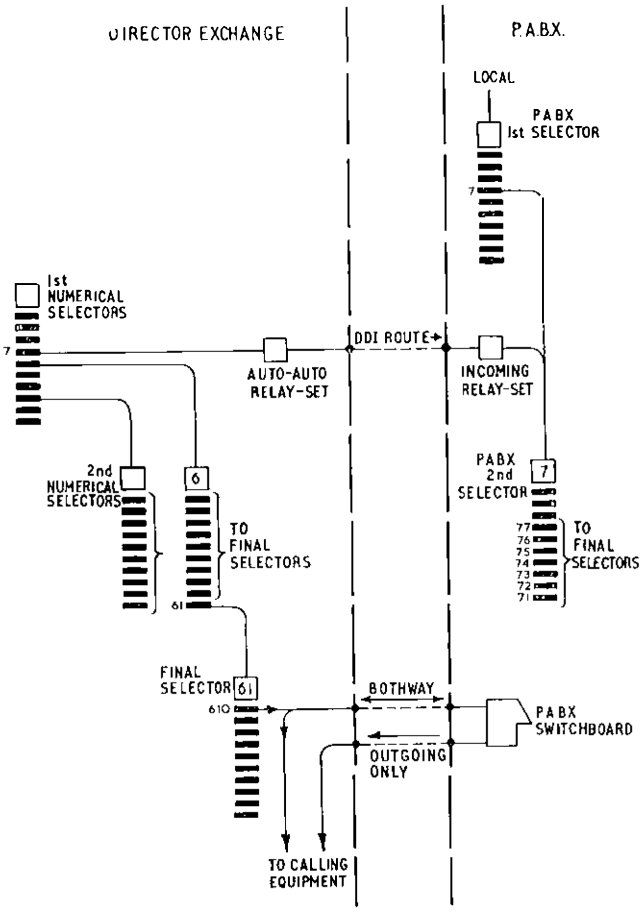


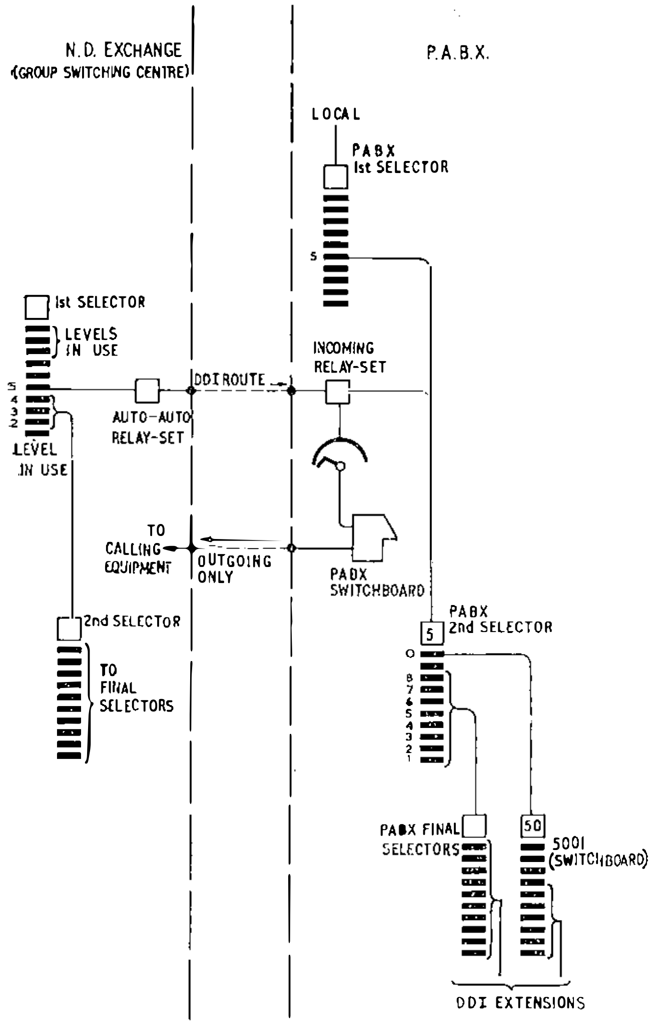

Numbering scheme:
D.D.I. Extensions: 7,100-7,799 (700 multiple)
Switchboard: 6,101

FIG. 1—Typical D.D.I. trunking for P.A.B.X. served from a director exchange

Separate groups of exchange lines are provided for outgoing unidirectional, or both-way service as shown in Fig. 1. However, incoming traffic to the P.A.B.X. operator can be passed over the D.D.I. route if required, under the arrangements described in a later paragraph, and shown in Fig. 2.

## DIALLING AND SIGNALLING CONSIDERATIONS FOR THE D.D.I. ROUTE

Auto-auto relay-sets have to be provided on the D.D.I. level at the public exchange, to enable holding, guarding and pulse-repetition facilities to be given in the absence of a public-exchange final selector. A further transmission bridge and pulse-repetition stage is encountered in the incoming line relay-set at the P.A.B.X. end of each D.D.I. circuit and, for dialling and signalling purposes, the D.D.I. route must be treated as an additional link, which is not normally encountered on an incoming call to a subscriber. This makes the choice of auto-to-auto relay-set important, and a new type, particularly suited to D.D.I. requirements, has been developed.



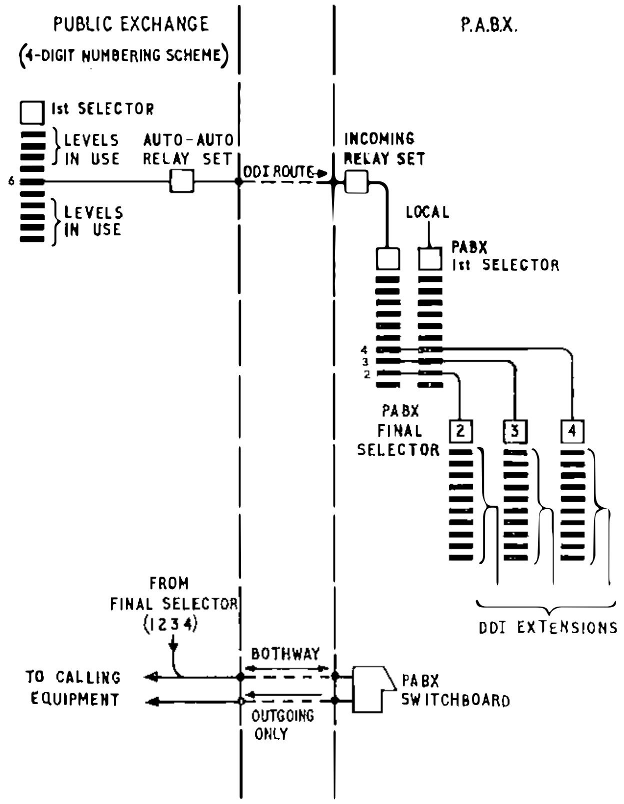

Numbering scheme:
D.D.I. Extensions: 5,010–5,079 (70 multiple) and 5,100–5,899 (800 multiple)
Switchboard: 5,001

FIG. 2—Typical D.D.I. trunking for a P.A.B.X. served from a small N.D. (G.S.C.) exchange (with incoming switchboard traffic routed via D.D.I. route)

## D.D.I. REQUIREMENTS AT THE P.A.B.X.

At present, the types of P.A.B.X. suitable for D.D.I. are the Post Office types P.A.B.X. No. 3 and P.A.B.X. No. 4. Under D.D.I. conditions, the allocation of selector levels at these P.A.B.X.s will be influenced by the choice of available public-exchange selector levels for giving the required D.D.I. access. Thus, in the example given in Fig. 1, level 7 of the P.A.B.X. first selectors is made to correspond with level 7 of the public-exchange first selectors to enable the same range of extension numbers to be used both for D.D.I. calls, and for local calls within the P.A.B.X. For an existing P.A.B.X. requiring D.D.I. facilities, therefore, the subscriber may have to be asked to arrange with the P.A.B.X. contractor for changes to be made to the existing numbering and trunking scheme of the P.A.B.X. to enable it to correlate with that of the public exchange. This is more likely if the choice of spare selector levels at the public exchange is limited. Most P.A.B.X. No. 3 and 4 installations are privately owned, but, where they are rented from the Post Office, any trunking changes required will usually be carried out by Post Office labour.

The D.D.I. route may terminate on first, second or final selectors at the P.A.B.X. At some P.A.B.X.s the D.D.I. facility may only be required for a limited section of the extension multiple, incoming traffic to the remainder being routed via the P.A.B.X. operator.




Numbering scheme:
D.D.I. Extensions: 6,200–6,499 (300 multiple)
(Note: Initial digit 6 not dialled on internal calls)
Switchboard: 1,234

FIG. 3—4-digit public exchange serving a P.A.B.X. with 300 D.D.I. extensions (arrangement A)

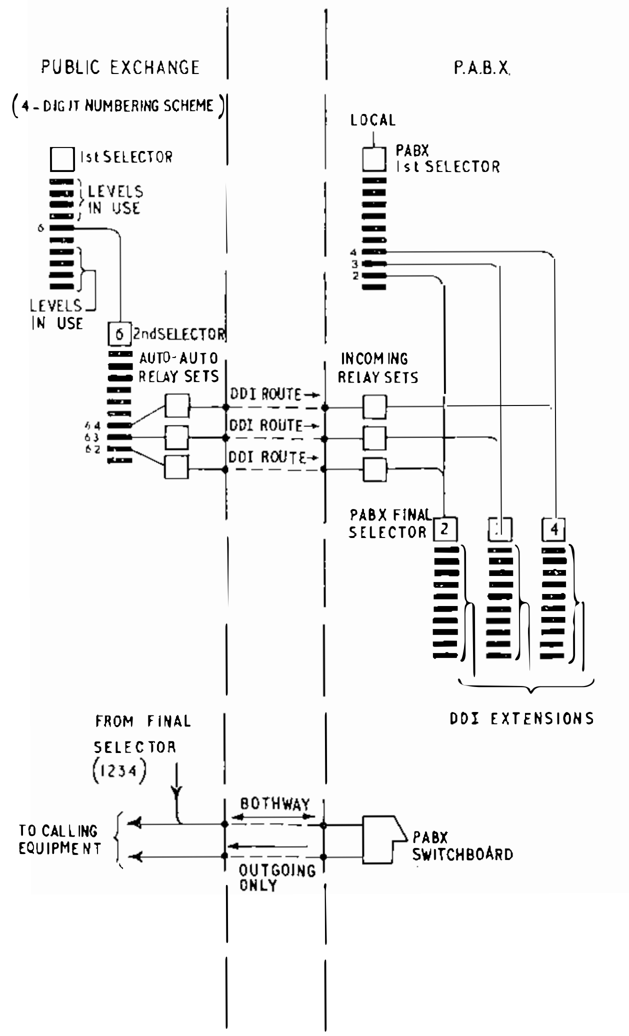
## ACCESS TO THE P.A.B.X. OPERATOR

The normal method of incoming access to a P.A.B.X. switchboard, i.e. via a final selector in the public exchange (as in Fig. 1) may still be employed at P.A.B.X.s with D.D.I. facilities if, for example, the subscriber wishes to retain an existing switchboard number. Alternatively, it is possible to route the incoming switchboard traffic via the D.D.I. route. The latter method has the advantage that any subsequent change in the relative proportions of the D.D.I. and incoming switchboard traffic does not affect the number of circuits required on the common D.D.I. route whereas, if the two traffic components are separated, adjustment of the size of both groups of circuits will be necessary if the ratio of D.D.I. to incoming switchboard traffic changes.

A further advantage offered by the combined route is that provision of an 11-and-over final-selector unit, which is usually required to serve a large P.A.B.X., is obviated. If such a unit serves the subscriber's installation prior to provision of D.D.I. facilities, it can either be retained to serve other P.A.B.X.s without D.D.I. facilities, or it can be recovered and re-used elsewhere.

A typical arrangement, in which incoming switchboard traffic is extended via the D.D.I. route, is indicated in the second example, shown in Fig. 2. A single multiple number in the D.D.I. range (5001 in the example shown) is allocated to the switchboard for incoming access and, on receipt of this number, the P.A.B.X. final selectors drive to the 11th step, thus operating S springs, which return a reverting signal to the incoming relay-set. This signal automatically reverts the call to the incoming line relay-set, and thence to the switchboard, and is immediately followed by automatic release of the P.A.B.X. selector train.

It is also possible to revert the call to the switchboard via the incoming relay-set from any spare level of a P.A.B.X. group selector by providing special digit-absorbing and reverting relay-sets on that level. These relay-sets can be arranged to absorb the last two or three digits of the switchboard number and, on receipt of these digits, to apply the reverting signal.



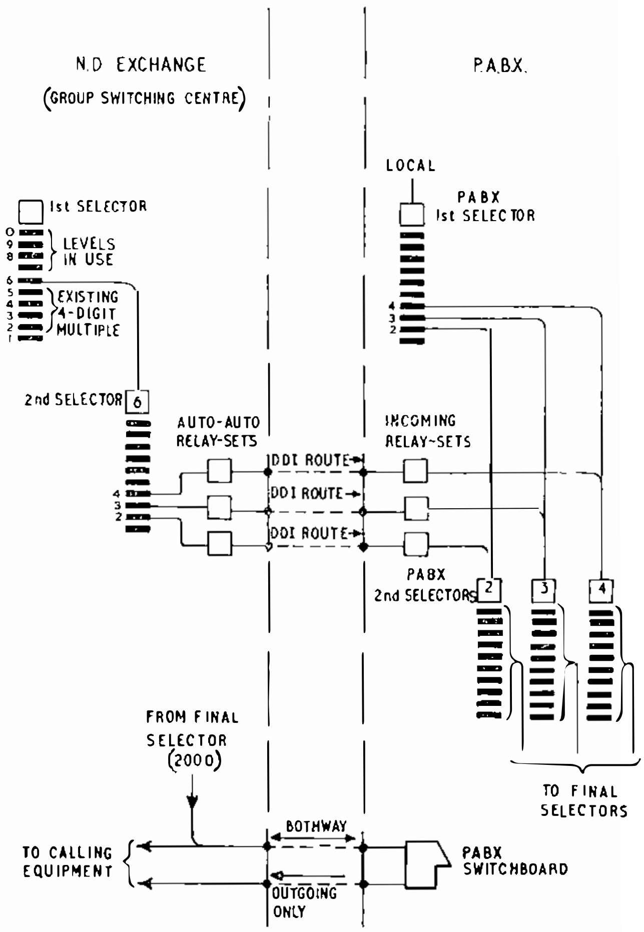

Numbering scheme:
D.D.I. Extensions: 6,200-6,499 (300 multiple)
(Note: Initial digit 6 not dialled on internal calls)
Switchboard: 1,234

FIG. 4—4-digit public exchange serving a P.A.B.X. with 300 D.D.I. extensions (arrangement B)

## TRUNKING AND NUMBERING ASPECTS

One result of the decision to allot D.D.I. numbers from the public-exchange numbering range is the need, from the planning aspect, to treat D.D.I. numbers on the same basis as normal multiple numbers. Thus, the accepted design principles for public-exchange numbering schemes are followed, although certain differences arise.

For example, if a public exchange with a 4-digit numbering scheme is required to serve a P.A.B.X. with D.D.I. facilities for 300 extensions, it would be possible to trunk the D.D.I. route direct from a first-selector level (assuming that one was spare) into selectors at the P.A.B.X., i.e. arrangement A in Fig. 3. This appears attractive, since no additional, i.e. second, selectors are needed at the public exchange, as would be so if 300 normal multiple numbers were being added. The saving in space and labour is, however, at the expense of 700-lines multiple capacity, and, although this might not be urgently needed at the time, it would bring forward the exhaustion date of the current numbering scheme, and earlier expenditure would be needed to expand the numbering range. The unused multiple capacity could be recovered at a later date, but this would not always be a practical proposition, particularly if the P.A.B.X. were privately owned. To recover the unused multiple, the trunking would have to be rearranged as shown in Fig. 4, i.e. arrangement B, and for this it would be necessary to divide the D.D.I. route into three portions. This would reduce the traffic-carrying efficiency of each circuit and an increase in the total number of circuits would be necessary to carry the same traffic, together with additional P.A.B.X. final selectors to terminate the extra circuits. Furthermore, the P.A.B.X. incoming first selectors, which previously terminated the D.D.I. circuits, would become surplus and it is unlikely that the subscriber could re-use them. It would thus be unreasonable to ask the subscriber to have work carried out by his contractor, which would result in a less advantageous arrangement from his point of view.




Numbering scheme:
D.D.I. Extensions: 62,000-64,999 (3,000 multiple)
(Note: Initial digit 6 not dialled on internal calls)
Switchboard: 2,000

FIG. 5—Provision of D.D.I. facilities by the introduction of mixed 4-digit and 5-digit numbering at a previously 4-digit exchange (G.S.C.)

The preferred method of giving D.D.I. facilities is to adopt arrangement B at the outset, even though this involves provision of a rank of 2nd selectors. This leaves the unused second-selector levels free for normal multiple growth without the need for later modification of the P.A.B.X.

## D.D.I. IN NON-DIRECTOR AREAS

Primarily because of the limited number of levels available, D.D.I. facilities will not be provided from U.A.X.s or small automatic exchanges (S.A.X.s). P.A.B.X.s served from these exchanges will normally be small in size, and arc therefore unlikely to require D.D.I. facilities.

As previously mentioned, the numbering ranges allocated for D.D.I. must conform to the rules which apply to normal numbering schemes. For example, the incoming register-translator equipment, which will be employed in Non-Director areas for routing calls incoming from the trunk transit network, will determine the number length by examination of the first two digits of the local number received, i.e. the two numerical digits following the number-group code. It follows that the first two digits of, say, a 5-digit D.D.I. number must not be the same as the first two digits of an existing or planned 4-digit number.

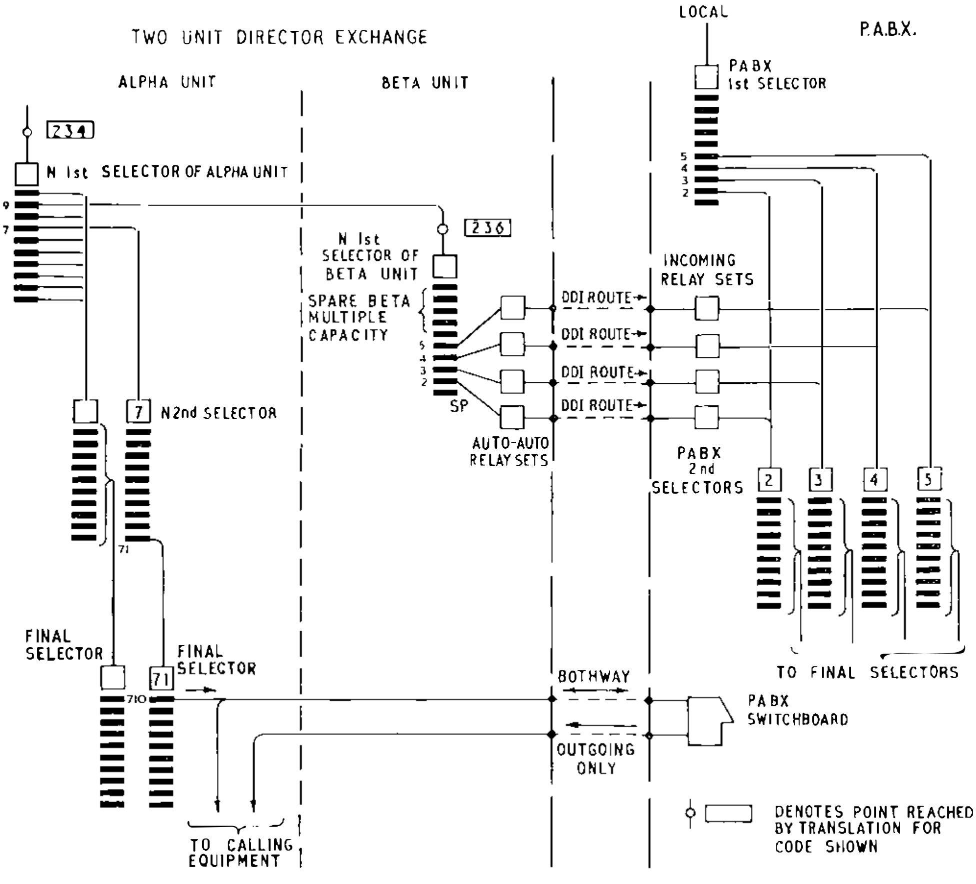
Additionally, the length of a D.D.I. number on a local non-director exchange must take account of the number of digits in the national code for that exchange, e.g. if the national code for a local exchange is 0222 82, the length of the D.D.I. number cannot exceed four digits, since the storage capacity of national controlling register-translators is limited to 9 digits.

Non-director numbering schemes have a useful flexibility for the provision of D.D.I. access in that a 4-digit numbering scheme can be expanded into a mixed 4-digit and 5-digit scheme, or a 5-digit scheme into a mixed 5-digit and 6-digit scheme. An example of the use of this flexibility is shown in Fig. 5, where a heavy demand for D.D.I. at a large P.A.B.X. is met by extending a small, non-director, group switching centre (G.S.C.) exchange which has a 4-digit numbering scheme, to mixed 4-digit and 5-digit working. The scheme shown in this example again makes economic use of the public-exchange numbering capacity, i.e. level 6 is not trunked directly into the P.A.B.X. first selector, since this would make 7,000-line multiple capacity unusuable on that level.

Where a sudden unforeseen demand for D.D.I. facilities arises at a very large P.A.B.X. served from a local non-director exchange with a 4-digit numbering scheme it might only be possible to provide the facility by expanding the numbering scheme from 4-digit to 5-digit. This, however, would have repercussions at the group switching centre exchange serving the numbering group in which the local exchange is situated, since the S.T.D. coding and numbering scheme for the numbering group would probably have been planned on the assumption that a 4-digit numbering scheme would be sufficient for the local exchange for twice the 30-year multiple requirements. It would be necessary either to rearrange the trunking at the G.S.C., which would involve national number changes, or to serve the P.A.B.X. as an out-of-area installation direct from the G.S.C. or other suitable exchange.

## D.D.I. IN DIRECTOR AREAS

In director areas, D.D.I. numbers take the same form as the normal numbers, i.e. a 3-digit code followed by a 4-digit number and, as in the non-director exchange, any public exchange numbering capacity which is utilized for D.D.I. purposes is used as economically as possible by careful choice of the available spare levels at the public exchange. If there are not sufficient spare levels, or if the available levels are unsuitable to cover the required numbering range, it is usually possible to give the D.D.I. facility by allocating numbers associated with a different 3-digit code from that used for the normal connexions in the area. In this way the difficulty of




Numbering scheme:
D.D.I. Extensions: 236 2,000–5,999 (4,000 multiple)
Switchboard: 234 7,101

FIG. 6—Provision of D.D.I. facilities from a director exchange by the introduction of a second director multiple unit, used both for D.D.I. and normal numbers.

providing D.D.I. facilities at a large P.A.B.X. served by a public exchange with a 4-digit numbering scheme can usually be avoided in a director area. The principle of trunking known as Alpha-Beta working, which is sometimes used for providing additional multiple for normal purposes, can also be applied for D.D.I. requirements. Briefly, this scheme involves the use of the first (or exceptionally first and second) numerical selectors of the director unit associated with the normal 3-digit code as tandem selectors for access to a second director unit associated with a different 3-digit code. An example of the use of this method for D.D.I. and normal multiple is shown in Fig. 6. The trunking arrangement again enables economic use to be made of the numbering range, i.e. in addition to giving D.D.I. access to 4,000 extensions, 6,000 spare multiple-capacity, which may be used later for normal multiple growth, is created on the Beta unit by providing a rank of Beta first numerical selectors.

The D.D.I. access could be given by routing level 9 of the Alpha first numerical selectors directly into the P.A.B.X. first selectors, and using the Beta code for the P.A.B.X. only, thereby delaying for a time the provision of Beta first numerical selectors. However, this would make it difficult to introduce the Beta unit when it was eventually required for normal growth.

The Alpha and Beta codes shown in Fig. 6 are in the new 'all-figure' form recently introduced in director areas. These permit greater flexibility in Alpha-Beta working than was previously possible with letter-type codes, since the latter formed the first three letters of pronounceable names, of which only a limited number were suitable. With all-figure numbering, the numbering capacity of a typical director area will increase from about three million to approximately eight million, since the number of usable codes will increase from 300 to about 800. This increased capacity will be particularly useful in meeting D.D.I. demands.

## D.D.I. FACILITIES AT CROSSBAR AND ELECTRONIC EXCHANGES

The crossbar and electronic local exchanges now being introduced into the Post Office network are capable of giving D.D.I. facilities if required. D.D.I. numbers at these exchanges will be taken from the normal public-exchange numbering range in the same way as for Strowger-type exchanges, and hence the numbering-scheme planning considerations of D.D.I., mentioned in an earlier paragraph, will also apply to crossbar and electronic local exchanges.

## CONCLUSION

The D.D.I. facility can, in most instances, be given with little difficulty and without jeopardizing the public-exchange numbering scheme. However, the absence of reliable forecasts as to the penetration of D.D.I. can present a number of planning problems. For this reason there may be instances where the facility cannot be supplied on demand and subscribers may have to be asked to wait for service until it is possible to rearrange the public-exchange numbering scheme.

# The Schools-Television Distribution Network

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*The provision of closed-circuit television facilities for schools is proving increasingly attractive as the need grows to provide lessons in an economic manner to a growing number of students. Large distribution networks have already been provided in London and Plymouth, and other authorities are showing interest. A general description of a typical transmission network is given, and articles of a more specialized nature will be published later.*

*A number of sound and vision channels in the frequency range 40–140 MHz can be transmitted. The vision signals may be either monochrome, or colour, to 625-line standards. Robust cables with solid-polythene dielectric have been developed, and all equipment uses transistors throughout for reliability. A 140 MHz pilot signal monitors the network.*

## INTRODUCTION

Television as a teaching aid has been under consideration for some time. Both the B.B.C. and I.T.A. broadcast educational programs that are watched by a large number of pupils, and the function of the teacher in the class is to enlarge on the program material. The broadcasts are on a national basis, and local authorities have little say in the choice of subjects or the production.

Some educationists consider that with intelligent use of the television medium a higher standard of teaching can be achieved: they claim that students progress more rapidly, the scope of the school syllabus is increased, experiments requiring costly or dangerous apparatus can be demonstrated to all schools, and the teachers benefit by becoming part of a teaching team rather than functioning as an isolated unit. Other educationists claim that the benefit gained by the student is marginal, but admit that the time required for presentation of an illustrated television program is approximately half that necessary for delivery of similar information by conventional methods.[1]

In many countries various systems have been installed in an attempt to overcome the shortage of skilled teachers. In the U.S.A. there are numerous closed-circuit networks, and, in 1952, 242 radio frequencies in the 2,500 MHz band were allocated for educational television broadcasting to schools, the programs being produced locally. The number was increased to 632 in 1965.

In this country, some single-channel point-to-point circuits have been provided by the Post Office, and in 1967 an extensive on-site network was provided for Leeds University.[2] The first large city network was provided by British Relay, Ltd., for the Glasgow Education Authority[3] to some 315 schools and Colleges of Further Education.

Although many reasons might be given for the growth of educational television, only two factors need be considered here. Firstly, the local council must be convinced that, educationally, they are getting value for the money, which comes out of the rates, and, secondly, the network must be reliable. The Post Office, with its extensive underground-cable network in all towns and cities, and its long experience and accumulated knowledge of transmission techniques, is well equipped to provide closed-circuit television networks at a reasonable rental.

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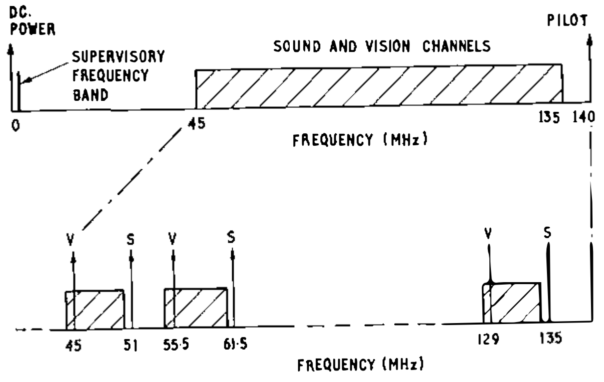
## DISTRIBUTION SYSTEM

Initial enquiries showed that the educational authorities were planning schemes which required from one to six channels. Two systems were developed, therefore: a single-channel video system for use if only one channel was likely to be required, and a frequency-division-multiplex system capable of transmitting up to nine channels. The equipment for these systems was developed by, or under the control of, the Post Office.

The video system is based on techniques developed over several years in providing high-quality circuits for the broadcasting authorities. Relatively-inexpensive amplifiers that can be used with either coaxial or pair-type cables are provided; a separate circuit is required for the sound channel.[4]

For schemes requiring more than one channel the multiplex system was considered to be more economical. The nine channels that can be provided are frequency-spaced by 10·5 MHz, and the total band occupied for the educational programs is from 40–140 MHz (Fig. 1). For each channel the




| Channel No. | Frequency (MHz) | |
|---|---|---|
| | Vision | Sound |
| 1 | 45 | 51 |
| 2 | 55·5 | 61·5 |
| 3 | 66 | 72 |
| 4 | 76·5 | 82·5 |
| 5 | 87 | 93 |
| 6 | 97·5 | 103·5 |
| 7 | 108 | 114 |
| 8 | 118·5 | 124·5 |
| 9 | 129 | 135 |

V—Vision S—Sound

Fig. 1—Frequency spectrum of 9-channel distribution system

vision carrier is amplitude-modulated and the sound carrier is frequency-modulated, the two carriers being spaced by 6 MHz. The v.h.f. signal conforms to C.C.I.R.* recommendations, and it can be received on any normal-type receiver provided the input tuning unit is adapted to receive the appropriate frequency band. This means that receivers can be relatively inexpensive and easy to maintain.

At the sending end of the system the modulators accept standard 1-volt peak-to-peak video signals from the studio equipment and sound signals at a level of 1 milliwatt in 600 ohms. The amplitude of an unmodulated vision-carrier signal at each amplifier output point is 50 millivolts, and the input level to the schools receiver will be between 1 and 3 millivolts. This is comparable with the signal received by a domestic receiver using a standard type of aerial. It is, therefore, essential that the distribution network, and the cabling within a school up to the input terminals of the schools receiver, should be adequately screened so that broadcast signals in the same frequency band do not interfere with the educational program. For this reason the maximum capacity of the system has initially been quoted as seven channels although, in practice, if no interference is encountered, all nine channels will be made available.

The usual British Post Office practice for private communication services is to deliver to the customer a signal in the same form as was accepted from him, regardless of how the signal might be transformed on route. If a customer sends speech, telegraph, or on-off data signals, then his received signal will also be speech, telegraph, or on-off data. With schools television, however, although video signals are received from the camera and sound from the associated microphone, demodulation is unnecessary at the receiving end, and the v.h.f. signal is fed direct to the receiver.

Only the distribution system is provided by the Post Office, to convey the sound and vision signals from the studio to the receiver inputs, because cameras and receivers are not part of normal Post Office telecommunications equipment, and there are competent contractors who can supply these items.

The standard of transmission is based on C.C.I.R. recommendations for a broadcasting network, and the quality of the received picture should be equal to, or better than, that displayed when receiving a broadcast signal in a region of good field strength. Educational experts have found that a high-quality picture is required, otherwise the pupils lose interest.[1] The system has been designed to transmit either monochrome or colour signals to 625-line standards.

A 140 MHz pilot signal controls automatic-gain-control units in the power-feeding amplifiers as well as supervisory signals, in the frequency band 20–50 kHz, which give an alarm at a staffed telephone exchange if any part of the network fails, so that out-of-service time can be reduced to a minimum. Pilot lights in the schools indicate whether the a.c. mains supplies are on or off and if the pilot signal is being received satisfactorily. Hence, if a picture is not displayed, the teacher can report this immediately to the Schools Control Centre, who will probably know whether the fault is likely to be in the distribution network or in the receiver. If it is deduced that the fault is in the network the Schools Control Centre will inform the Post Office.

The system is designed to have amplifiers spaced up to half a mile apart and to give the required standards of transmission with as many as 40 amplifiers in series. The maximum range of the system, is, therefore, 20 miles; in practice, it will be somewhat less. A block schematic diagram of a typical network is shown in Fig. 2.

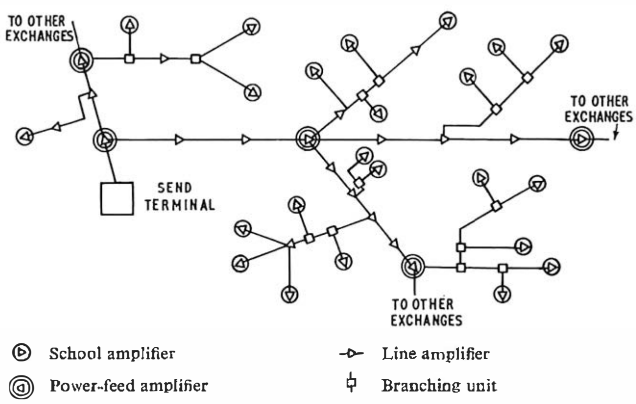



FIG. 2—Block schematic diagram of typical network

## Cables

Early cost studies showed that one of the controlling factors was the cost of standard-type cables then available, and an attempt was made to develop a cheaper and more suitable cable for the job. Electrical characteristics similar to those of Post Office Type 375E coaxial cable were required, along with a robust construction. The design eventually adopted is shown in Fig. 3 and is based on a submarine-cable type of construction. The inner conductor is a solid-copper wire having a diameter of 0·093 in, and the outer conductor consists of a tape of soft copper 0·01 in thick formed into a tube of 0·62 in internal diameter with a welded longitudinal seam. The dielectric is of high-density solid polythene, and for protection the cable has a solid-polythene sheath 0·06 in thick. The overall diameter of the cable is 0·81 in. The welded outer conductor ensures a near-perfect screen, and the tough dielectric gives adequate strength and resistance against crushing.

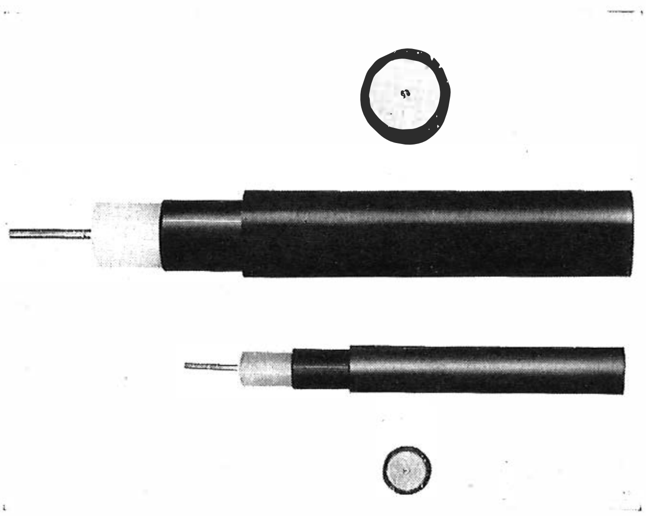


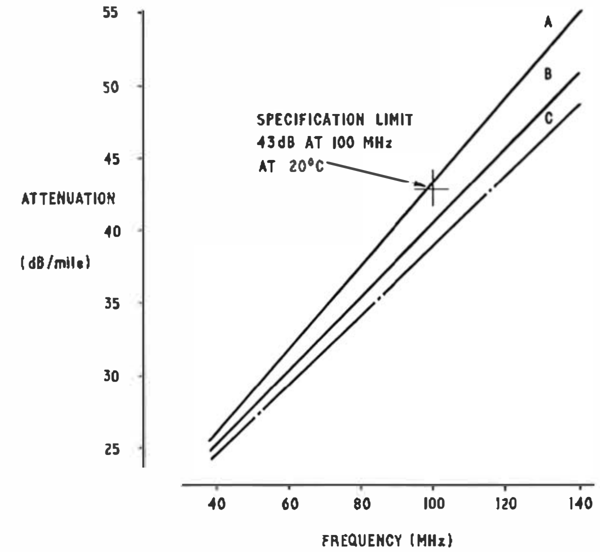
FIG. 3—Construction of coaxial cables

A similar cable, but with an inner conductor of 0·053 in diameter and an outer conductor of 0·345 in internal diameter, was developed for use where more flexibility is required and the greater attenuation would be of little consequence, as, for example, in a short lead into a school.

The attenuation/frequency characteristics of the 0·62 in cable are shown in Fig. 4, which gives the average attenuation found on measured lengths of cable produced during a calendar month. The attenuation has decreased throughout the manufacturing period, and recently-manufactured cable has an attenuation at 100 MHz approximately 2 dB/mile less than that manufactured 12 months earlier. An even lower attenuation can be obtained if a higher-grade polythene dielectric is used.

In practice, many difficulties have had to be overcome. The first production lengths of cable had a higher attenuation than

* C.C.I.R.—International Radio Consultative Committee.




A—Cable manufactured in Spring 1967
B—Cable manufactured in Spring 1968
C—Cable with higher-grade polythene dielectric

FIG. 4—Attenuation/frequency characteristics of 620-type coaxial cable

expected, probably due to impurities in the polythene dielectric, but, as mentioned above, there has been a steady improvement over the production period. One of the most disturbing features found when drumming the cable, and later when laying it, was the tendency for the outer conductor to wrinkle due to too-severe bending, and repeatedly flexing the cable could fracture the outer conductor under the sheath. However, if the bending radius when handling is greater than 2 ft 6 in no damage will ensue, and, in fact, after laying, the cable can safely be set with a radius of 12 in. Similarly, for 0·345 in cable, the bending radius should not be less than 1 ft 6 in when handling, but it can be set with a 6 in radius.

Special jointing tools have been developed, and jointers trained in the new techniques. Apart from the special tool, all other items required, e.g. for clamping, brazing, applying pressure, etc., are part of the normal tool kit for jointing coaxial cables.

### Send Terminal

The send terminal equipment (Fig. 5) consists mainly of nine modulators, which accept the vision and sound signals from the studio and assemble them in the v.h.f. band along with a 140 MHz pilot signal.

### Line Amplifiers

The line amplifiers (Fig. 6) have a gain of 25 dB over the operational frequency band, i.e. from 40–140 MHz. Power to operate up to six amplifiers is taken from the exchange batteries and fed over the coaxial cable. Each amplifier is enclosed in a cylindrical brass case designed to be watertight so that it can be mounted on bearers in joint boxes and manholes. Connexions are made via the end-cap, and the flexible tails are jointed to the main cables, provision being made for one input connexion, and four outputs. A transmission level-measuring point is also provided.

### Power-Feed Amplifiers

Power-feed amplifiers (Fig. 7) are installed in telephone exchanges. The basic amplifier circuit is similar to that of the line amplifier, but facilities are provided for feeding current from the exchange batteries to the input cable and to four output cables. Automatic gain control, supervisory, and monitor units are also included. The amplifier can be mounted on a wall in the exchange cable chamber if conditions permit, in order to keep the cable losses within the exchange to a minimum. The monitoring point can be extended to a suitable position in the exchange so that the maintenance engineer can check the levels easily. If the amplifier is not

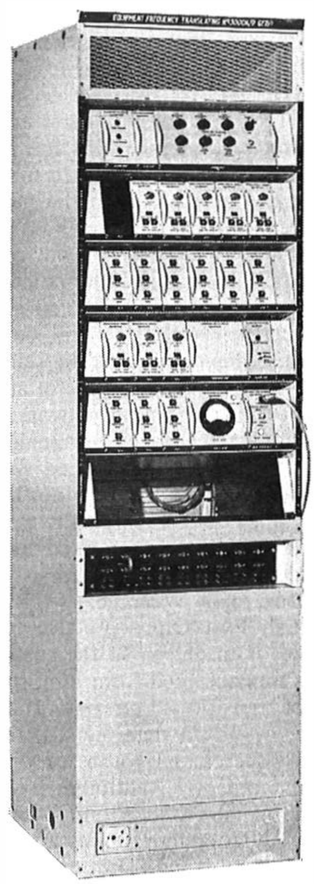


FIG. 5—Send-terminal equipment

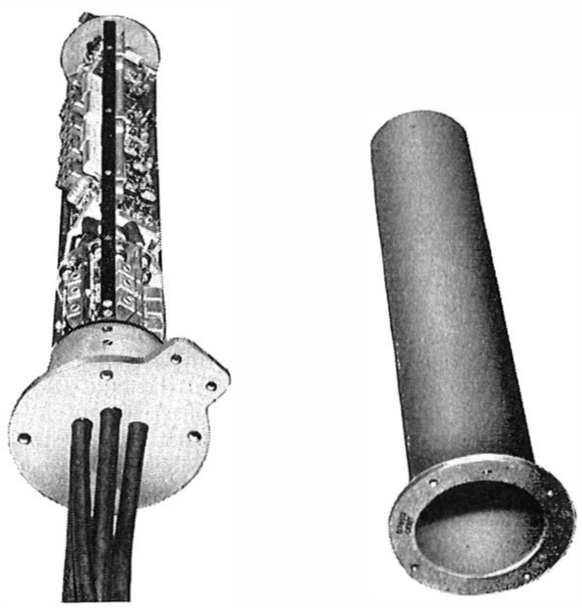


FIG. 6—Line amplifier with cover removed

mounted in the cable chamber, care has to be taken to ensure that the cabling to the amplifier is kept as short as possible.

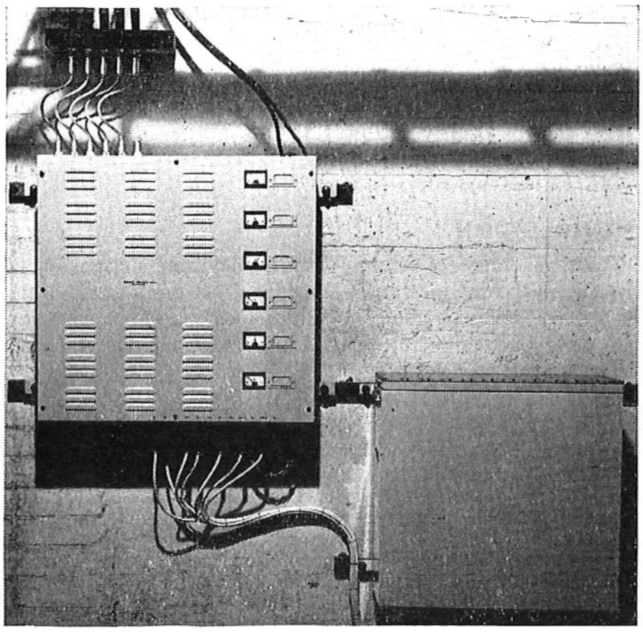


FIG. 7—Power-feeding amplifier fitted in exchange cable chamber

### Branching Units

Passive branching units are used in the spur cables, if circuit splitting is required in addition to that provided by the line or power-feeding amplifiers. Two types are available: the first has a loss of 3 dB in each outlet, and the second has a loss of only 1 dB in the forward path and 11 dB in the branching path.

### School Amplifier

The school amplifier (Fig. 8) is basically the same as the line amplifier, but it is operated from the school a.c. mains supply. If monitoring equipment is included with the amplifier at the school, arrangements are made for feeding power from the exchange instead of from a local a.c. mains-supply unit, so that, in the event of a mains failure, maintenance staff are not called out unnecessarily.

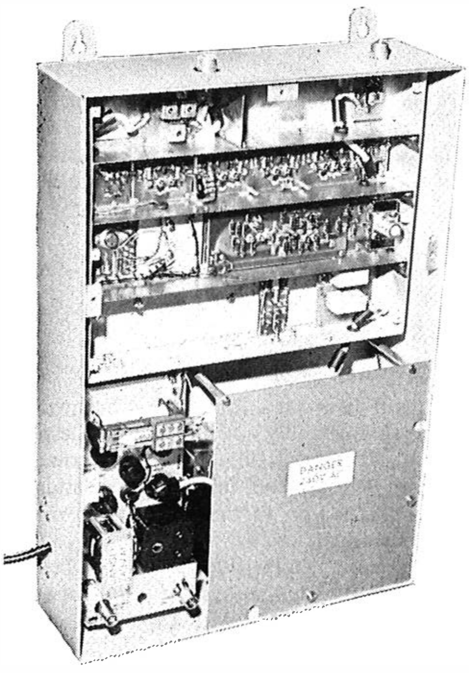


FIG. 8—School amplifier

### School Wiring

The wiring on the school premises must be of a high standard, otherwise there is a risk that it will pick up radiated signals which will interfere with those received from the studio. Tests have been made to determine the best wiring methods to ensure that pick-up is reduced to a minimum. It is possible to feed several receivers in any one school, and it is only rarely (where cable runs are extensive or where there is a large number of receivers to be connected) that any additional amplification is required within the school. The education authorities are at liberty to wire schools themselves, but it is essential that they maintain the necessary standards.

## PLANNING AND PROVISION

A v.h.f. distribution network to approximately 300 schools in London[5] was completed in September 1968, and is being extended to a further 1,000 schools within the next 2 years. A similar network to 100 schools has been provided in Plymouth. The Inner London Education Authority studios are in Laycock School, Islington (a school no longer used for teaching), but as the school is due to be demolished soon, a new studio, due to be in service by September 1969, is being built at Tennyson School, Battersea.

The schemes in London and Plymouth were planned at Post Office Telecommunications Headquarters, the cabling and installation being done by the London Telecommunications Region and the South Western Telecommunications Region, respectively. When other education authorities become convinced that teaching by television has decided advantages, it is expected that more networks will be required.

Any schools-television network has to be flexible, and the planner must take this into account when deciding the main-link paths, spur paths, and the spur connexion points. As the years pass and school buildings become obsolete and disused, they will have to be disconnected from the network and new schools added. Even with a school life of as much as 100 years, on average one school in London would be removed from the network and replaced each month.

## COMMISSIONING

Lining-up and commissioning a large branching network introduces many problems not normally met on the usual point-to-point type of Post Office circuit. Main branches and spurs of the network must be clearly defined: from the cable length and the known attenuation of the cable, the section loss must be calculated so that the required equalizers can be fitted to the line amplifiers at a central depot, where they are tested and sealed before being sent to site and jointed into the cable. This is a successful technique, and it has not been necessary to measure the cable attenuation/frequency characteristic after it has been laid in the ground, or to make measurements over the cable and amplifier sections. Measurements are made only between power-feeding points and between the studio and the schools; final adjustment of the overall characteristic is made by equalizers inserted in the power-feeding amplifier at the exchanges and in the school amplifiers.

Communication between testing engineers spread over the network presents a problem; engineers in the London Telecommunications Region solved it by designing telephone sets that translate speech signals so that they can be transmitted over the network itself. Intercommunication radio sets may also prove useful, although their range and application might be limited.

## COST

The cost per school is dependent on the density of the schools in an area. Thus, in towns and cities, the annual rental per school is reasonably small, probably less than one-tenth of a teacher's salary, but, in the country areas where schools are widely spaced, the cost of provision is higher. Even so, if an education authority can utilize all the channels provided, the annual charge per channel per school is probably less than a teacher is paid for one week. For a very small rental, therefore, teachers can be given a valuable aid.

## THE FUTURE

As time goes on it will be advisable to review the planning and provision of this type of network. It was thought, initially, that nine channels would be more than adequate, because of the enormous amount of program material required to fully utilize these channels, and because organization of the timetables for all the schools requires careful attention. So far there is no reason to think that any education authority is likely to require a larger number of channels, but with the rapid growth of closed-circuit television it will probably prove advantageous and less costly to utilize spare channels on a common wideband network serving offices, banks, factories, etc., as well as schools. The Post Office scheme for distribution of television in new towns has been developed and is being installed at Washington.[6] In future, schools television could be provided along with the common services, either by utilizing channels in a distribution network such as that being provided at Washington, or by providing a second network, whichever proves to be the more economical.

Schools-television schemes are essentially local, and most of the appeal is the presentation of good lessons by local teachers and the ability to control and operate the scheme to suit local needs. It seems unlikely, therefore, that a widespread network or the linking of different authorities will be required. Nevertheless, should the need arise, the necessary links can be provided, and so far no limit has been set to the geographical expansion. As an example, a county scheme might be achieved by setting up distribution networks in the large towns, each with its own studio or control centre, and then to link them together by main trunk circuits.

## CONCLUSION

The demand for closed-circuit television networks will inevitably grow, and the Post Office must prepare to discuss schemes with local education authorities, who appear to have no central advisory authority, and to meet the demand when it arises.

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# Re-equipping Goonhilly Aerial No. 1


V. C. MELLER†



U.D.C. 621.396.67.005: 621.396.7



*Aerial No. 1 at Goonhilly is being re-equipped to provide telephony and television channels, via a new satellite, to countries in the East. Modifications are being made to the receiving amplifier and auto-tracking arrangements. The recently completed second aerial has already taken over the transatlantic traffic via Early Bird. With similar satellites over the Atlantic and Pacific Oceans, the new satellite will complete the global system of satellite communications.*


## INTRODUCTION

In April a contract worth approximately £400,000 was let to G.E.C./A.E.I. (Electronics) Ltd., Stanmore, Middlesex, for re-equipping Aerial No. 1 at Goonhilly. The changes will enable it to carry commercial telephony traffic and television programs between the United Kingdom and countries in the East via a communication satellite over the Indian Ocean. This satellite, in conjunction with similar satellites over the Atlantic and Pacific oceans, will enable a global system of satellite communications to be established early in 1969.


† Space Systems Branch, Telecommunications Development Department, Telecommunications Headquarters.


## SYSTEM ORGANIZATION

The system will cater for a total of 264 bothway telephone channels between Goonhilly and 12 different destinations via an INTELSAT III-type satellite. In the outgoing direction, the channels will be assembled into two basebands which will modulate two s.h.f. radio carriers, each with a capacity of 132 channels. These carriers will be received by many distant stations, each selecting only that part of the baseband that contains its own traffic. Similarly, the equipment at Goonhilly will enable up to 12 carriers, with capacities of 132, 60 or 24 telephone channels to be received. Additional transmitting and receiving equipment for television will cater for 625-line colour system video and sound program channels as well

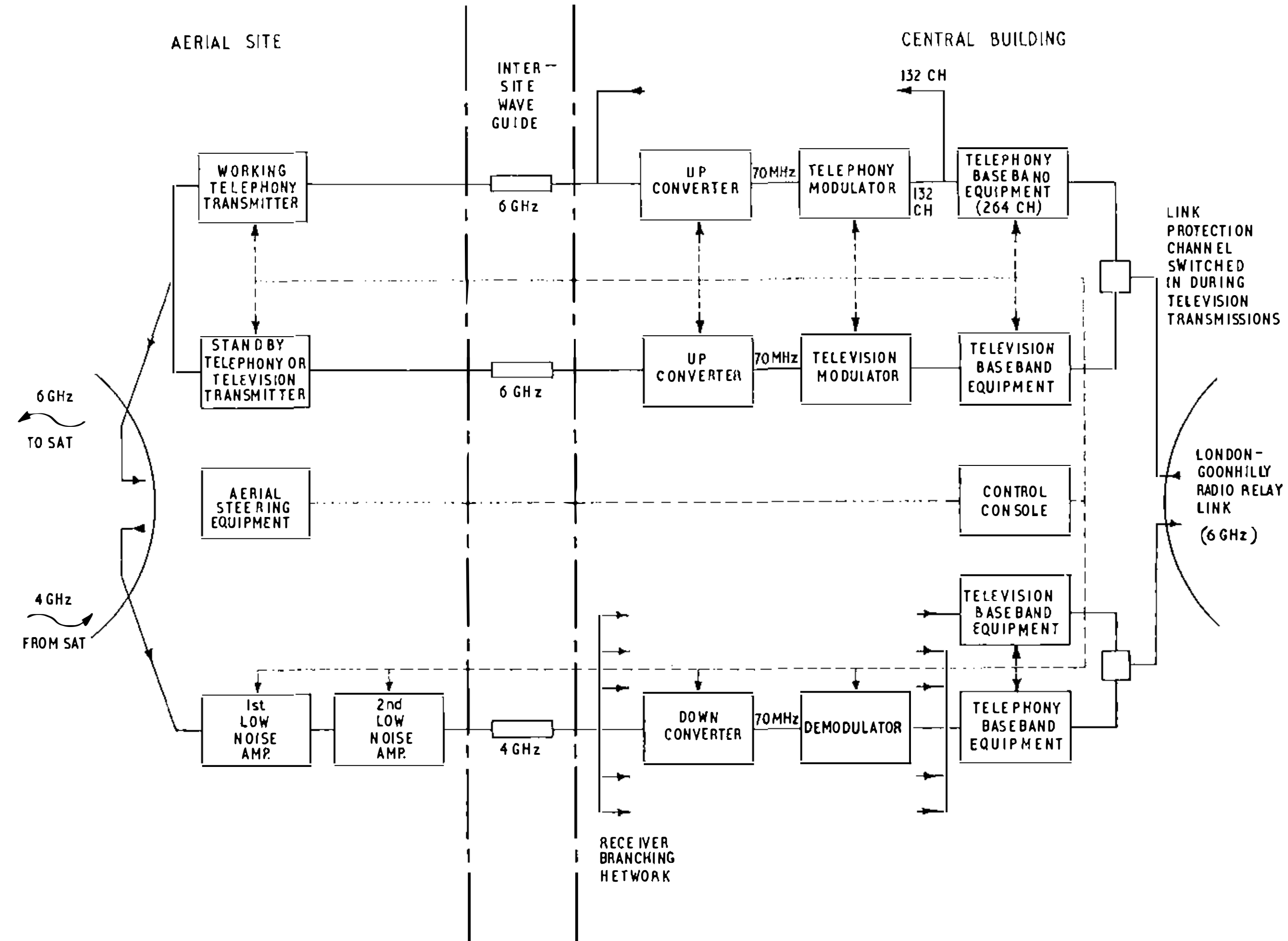


Fig. 1—Block diagram of system

as cue and order-wire circuits. All the equipment is duplicated and controlled automatically for continuous operation with a very high standard of reliability, see Fig. 1.

To reduce the amount of apparatus that otherwise would be needed in the limited space on the aerial itself, the connexions between the aerial and the central control building, a quarter of a mile distant, will be by means of a semi-flexible waveguide operating at 4 GHz and 6 GHz for the receiving and transmitting direction respectively. The contract included tests to establish the technical feasibility of this arrangement.

The apparatus to be provided in the central building will include modulators and threshold-extension demodulators, frequency convertors, and a comprehensive control, supervisory and test system integrated with that recently installed for Goonhilly Aerial No. 2.

Drive amplifiers and output stages of the transmitters will be included in the main apparatus cabin on the aerial. The wideband, high-power, travelling-wave tubes used in the transmitting system will enable all the telephony channels to be handled simultaneously by one transmitter whilst the other is carrying a television program. During failure of the telephony transmitter, however, the telephony system will be kept in service automatically by switching to the television transmitter. The system has been designed, and space is available, to permit the addition of a third transmitter later, if required.

In order that the launching failure of the Atlantic Intelsat III satellite should not delay the release of Aerial No. 1 from its operational role with EARLY BIRD, the new Aerial No. 2 system has been modified to carry telephony traffic between Goonhilly and Canada. When a replacement Intelsat III is available, early in 1969, it will interlink all the earth stations in the Atlantic Ocean Zone.

## OTHER WORK

Other work that is in progress for the Aerial No. 1 System, in parallel with the G.E.C./A.E.I. contract, includes provision of new low-noise parametric amplifiers with a bandwidth of 500 MHz to enable carriers to be received on any frequency in the internationally agreed band. These amplifiers have been designed and developed by the Mullard Research Laboratories in conjunction with Research Department.

Contracts for the modification of the aerial-control system to simplify the auto-tracking arrangements and to facilitate maintenance during continuous operation have also been let. Program Evaluation and Review Technique (PERT) is used to control and co-ordinate the activities of the various contractors and the Post Office teams.

# Renewing the Traction Ropes on a Lift at the Post Office Tower, London

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U.D.C. 69.026.6:621.86.078.004.67

*This article gives a brief description of the normal procedure for renewing traction ropes and leads on to the particular problems associated with the lifts in the Post Office Tower, London. The two main problems, minimizing the out-of service time and handling the extraordinary lengths of traction rope in a confined working area, were solved by the design and construction of special equipment.*

## INTRODUCTION

A description of the Post Office Tower lifts has already been given in this Journal*, and it will suffice to briefly describe the roping arrangement for this type of lift.

As shown in Fig. 1, starting from the anchorage on the top of the car, the six traction ropes pass up and over the driving sheave to an idler sheave, which diverts the ropes back to the underside of the driving sheave. The ropes then turn upwards and wrap around the driving sheave for the second time, lead back to, and over, the idler-sheave (diverter-sheave), and thence down to the anchorage on the top of the counterweight.

This double-wrapping system of roping, employed on modern high-speed gearless lifts, allows the use of U instead of V grooves in the sheaves without incurring excessive rope slip, and by so doing, removes one of the main causes of rope wear, which is caused by the gripping of the rope in a V groove.

The employment of six ropes instead of the usual four, as on V grooved sheaves, allows the use of smaller and more flexible ropes, which are better suited to the additional flexing action that occurs due to the double-wrapping method of roping. The ropes are, of course, subject to wear and tear and have to be regularly inspected and periodically renewed.

The renewal of lift ropes not only immobilizes the lift for the duration of the job, but also entails the movement of large drums of rope and bulky equipment within the building. Fortunately, this work can usually be carried out during a week-end period so that disruption of service and inconvenience to the users of the building are minimized.

The general procedure and the equipment used when renewing ropes are basically the same for all types of lifts, and the particular problems associated with the Post Office Tower lifts can be brought out by first briefly outlining the normal procedure in a conventional type of building.

## NORMAL PROCEDURE FOR RENEWING ROPES

It is necessary to remove all tension from the traction ropes by providing alternative means of supporting both the car and counterweight, whilst ensuring that each is located in the lift shaft to facilitate access to the rope terminations.

This is done by lowering the counterweight on to suitable baulks of timber, or stumps, which extend to the base of the lift well and are of a length that will bring the top of the

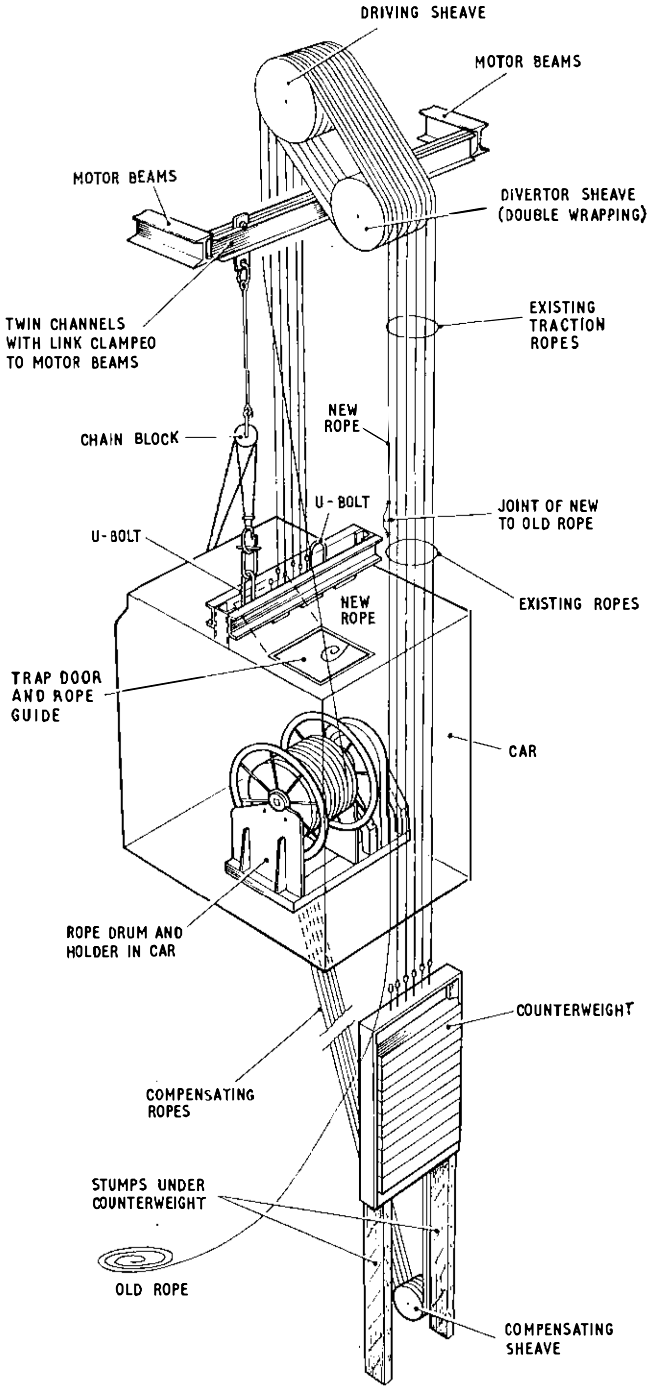


FIG. 1—Lift-roping arrangements and location of the equipment used for the rope-renewal operation

* MARRIOT, P. E. Passenger Lifts in the Post Office Tower, London. *P.O.E.E.J.*, Vol. 58, p. 228, Jan. 1966.

† London Telecommunications Region, Power Section. Now with Systems Performance and Maintenance Branch, Telecommunications Service Department, Telecommunications Headquarters.

counterweight level with the floor of a landing. Access to the rope terminations by means of staging from the landing across to the top of the counterweight can then be provided. The car is raised by means of chain block and slings, which extend from the top of the car usually to a beam situated over the lift motor. The car is raised rather more than is necessary to slacken the ropes in order to allow for the initial stretching of the new ropes when first installed. As a safety measure an additional suspension is provided for the car, either in the form of tackle or by making use of the car safety device. With the car held in this position there is access to the rope terminations from the top landing, and it is on this landing where each drum of new rope is mounted during the actual rope change.

Replacement of the old rope by the new is effected by disconnecting the old rope from the car and counterweight, and hitching the top end of the old rope to the end of the new. The new rope is fed up and around the sheaves and down the shaft to the counterweight. The weight of the rope suspended in the lift shaft is more than sufficient to draw the rope over the sheaves and a certain amount of checking is necessary to permit an orderly recovery of the old rope at basement level.

Final adjustment and anchorage of the new ropes, removal of temporary tackle and a test run are then carried out before putting the lift back into service.

## PROBLEMS ASSOCIATED WITH THE POST OFFICE TOWER LIFTS

In anticipation of the first renewal of the traction ropes on a Post Office Tower lift, it was necessary to consider some unusual features associated with these lifts which are not normally encountered in the more conventional type of Post Office buildings.

The first, and perhaps the most obvious of these, was the abnormal length and weight of rope involved and the height from which it had to be lowered down the shaft. In fact, it entailed the controlled lowering of some one and a half miles of rope down the lift shaft whilst half of this amount (the original rope) was being recovered at the lower ground floor level some 500 ft below; the weight of the rope suspended in the shaft during this operation was of the order of 350 lb. Rope drag, around the sheaves, would reduce the actual pull on the rope drum to some 120 lb, but it was essential to have something more than an improvised braking system on the drum whilst feeding out the rope.

Secondly, the six drums of new rope and the bulk of the other equipment required to carry out the work would have to be taken through the kitchen, which serves the Tower restaurant, but without interfering with the normal kitchen service. Due to lack of space each drum of new rope had to be accommodated in the lift car whilst feeding the rope into the lift shaft. Compactness and ease of mobility had therefore to be achieved in the design of the rope drums and other equipment.

Unlike the majority of lifts in Post Office buildings, both Tower lifts are direct revenue-earning items of plant providing a 15-hour-a-day, 7-day-a-week service to the public. It was very important, therefore, to reduce the out-of-service time to a minimum by designing the rope-changing equipment and working methods to give expedient installation, operation and recovery.

## EQUIPMENT DESIGNED TO OVERCOME THE PROBLEMS

In order to meet the requirements, four items of equipment were designed and constructed.

(*i*) Six rope drums, each having the minimum permissible core diameter and having a width and outside diameter such that transit through the kitchen, accommodation, and operation from within the lift car is possible.

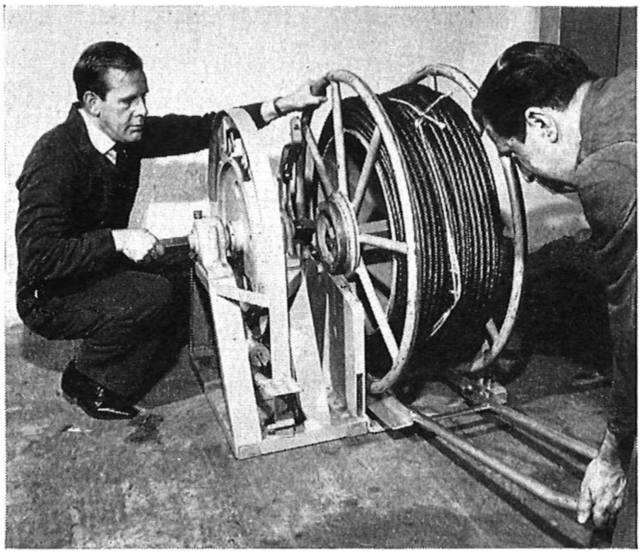

FIG. 2—Loading a rope drum into the drum holder

Each drum was made from steel tubing and sheet steel and mounted on a hollow-square steel hub. Concentric machine-finished shoulders, one on either side of the drum, serve the dual purpose of supporting the drum whilst it is being rolled up on a ramp on the drum holder (Fig. 2), and as journals when the drum is located in its bearings on the drum holder. A forked lever further assists in mounting the drum on the holder.

(*ii*) A drum holder comprising four pedestal-mounted bearings in alignment on a common base. Two of the bearings carry the brake drum and the other two, the top halves of which have a hinge and wing-nut fastening, carry the rope drum. As a safety measure the brake is of the fail-to-safety type consisting of two Ferodo-lined shoes, each pivoted at one end and held against the brake drum by a spring at the other end. It is foot-operated by a brake-release pedal operating against the tension of the springs as shown in Fig. 3. A rope drum, when in position on the drum holder, is coupled to the brake drum by means of a square steel shaft, which is a sliding fit in both drums. This shaft is shown in the disengaged position in Fig. 2.

The combined weight of the drum and holder is sufficient to obviate any need to anchor the holder in the car whilst in use.

(*iii*) A beam clamp and two shackle holders for fixture

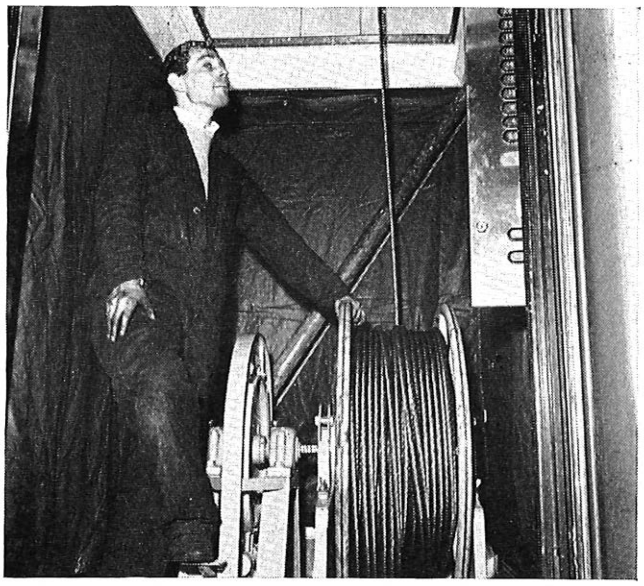

FIG. 3—Paying out the new rope from within the lift car

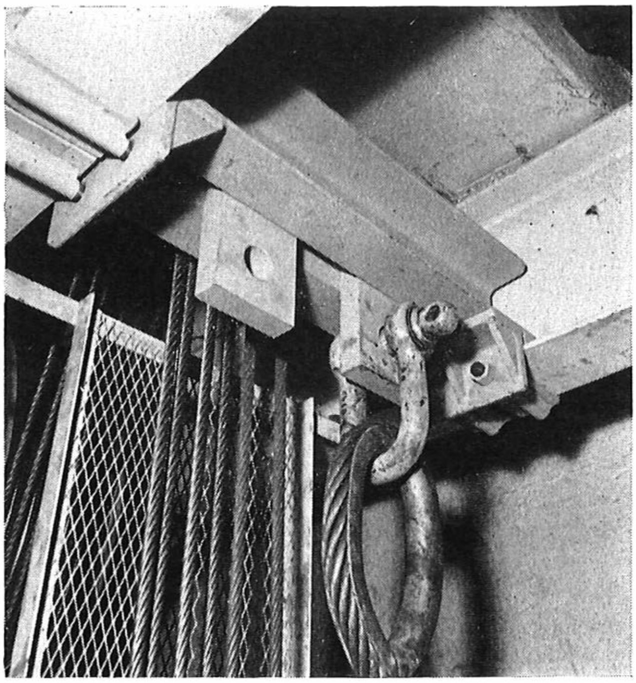

FIG. 4—Beam clamp and shackle holders fitted at the top of the lift shaft

directly over the lift shaft (Fig. 4) and two U bolts for fitment on the top of the car. These items form the attachment points for the chain blocks used to support the car during the rope-renewal operation. These items were made permanent fitments because, although it is common practice to use temporary slings to support the lift car, the initial cost and work required to provide permanent fitments is outweighed by the increased safety and cumulative time saving on future rope-renewal operations.

(*iv*) A rope-guide attachment which, when clipped to the frame of the escape hatch in the roof of the car, prevents damage to the car and eliminates oscillations of the rope as it is fed up to the sheaves.

## THE FIRST ROPE-RENEWAL OPERATION

The first rope renewal was carried out on 19–20 September 1967 by which time the lift concerned had travelled 30,325 miles. Using the items of equipment described in the previous section and shown, diagramatically, in their operational positions in Fig. 1, the renewal operation was completed in approximately 38 hours; half the time originally estimated for carrying out the job without the special equipment. The objective of minimizing the out-of-service time was therefore achieved and it is expected that the cumulative reduction in labour costs will more than offset the initial cost of the special equipment. Another important factor was the increased safety obtained by using purpose-built equipment. There was no interruption to service in the Tower restaurant during the renewal operation.

## CONCLUSIONS

It is intended to use this equipment for rope renewals at other lift installations to achieve a higher standard of safety and a reduction of labour costs.

# Programmed Learning—A Programmed Initial-Installation Training Course

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U.D.C. 371.67:374.6

*An initial course has been programmed for adult recruits who are to be employed on the installation of telephone apparatus in the London Telecommunications Region. Several of these courses have been held at the Regional Engineering Training School, and an evaluation can now be made as to the degree of their success. A general description of the course is given, with the results obtained, and inferences are drawn for future development.*

## INTRODUCTION

The course has been designed after analysing the work of a telephone installer in the London Telecommunications Region (L.T.R.). It was written for new recruits to the Post Office who are to be employed on the installation of the simpler types of telephone apparatus; they will normally have had a short period of field experience. No lectures or demonstrations are incorporated, the students obtain the information and skills that they require with the aid of programs.* Both linear and branching programs are used, and the method of presentation is either in book form or by Canterbury teaching machine. An instructor is required to mark and assess the student's work, and is always available to give assistance if necessary.

As the skills to be learned arc of a practical nature, most of the programs arc used in conjunction with practical work on telephone apparatus. Diagrams and ancillary information, used as directed in the programs, are kept in a separate folder and brief notes are written down by the students where necessary. Practical work is given at various stages throughout the course, and this is completed with the information and skills learned from previous programs.

The use of different methods of presentation, combined with practical work, and the use of ancillary information give a varied and interesting content to the course.

## COURSE SEQUENCE

Eight of the programs are presented by a Canterbury teaching machine and nine are in book form. The total of 17 programs, plus 12 practical sessions, imparts the requisite skills. The course content is shown in Table 1.

After the administrative details of the course have been settled, a short introductory talk is given, and the students then commence with program 1. Each session is given in sequence, although programs 13, advice note procedure, and program 15, customer co-operation, can be used at any time after the second day. Program 3, cabling and wiring, because of its size, is given in two halves with practical work between. The practical work reinforces the knowledge learned in the first half before new facts are learned in the second.

It became apparent during the early studies, that the skills an installer requires depend to a certain extent upon the Area of the L.T.R. in which he is employed. Some Areas, for instance, have very few shared-service lines, but install a large number of switchboard extensions; in other Areas the reverse is true. This has been catered for by providing two alternative paths through the course. Each of these involves the same amount of work, but the skills learned are tailored to the student's needs. This is illustrated in Fig. 1.

† Engineering, Telecommunications and Management Training Section, Personnel Branch, London Telecommunications Region.

* HOLMES, A. C., and CROOKS, K. R. Programmed Learning—A New Design for Training. *P.O.E.E.J.*, Vol. 60, p. 253, Jan. 1968.

**TABLE 1**

**The Course Content**

| Session | Title | Session | Title |
|---|---|---|---|
| Program 1 | Introduction | Program 11 | 2-Wire Extension |
| Program 2 | Tools and Uses | Practice 6 | 2-Wire Extension |
| Program 3 (½) | Cabling and Wiring | Program 12 | 4-Wire Extension |
| Practice 1 | Cabling and Wiring | Practice 7 | 4-Wire Extension |
| Program 3 (½) | Cabling and Wiring | Practice 8 | Faulting |
| Program 4 | Service Requirements | Program 13 | Advice Notes |
| Program 5 | Telephone No. 706 | Program 14 | Extension Plan 4 |
| Program 6 | Diagrams | Practice 9 | Extension Plan 4 |
| Practice 2 | Telephone Installation | Program 15 | Customer Co-operation |
| Program 7 | Faulting | Program 16 | Extension Plan 1A |
| Practice 3 | Faulting | Practice 10 | Extension Plan 1A |
| Program 8 | Shared Service | Program 17 | Telephone No. 710 |
| Practice 4 | Shared Service | Practice 11 | Extension Plan 1A, Shared Service |
| Program 9 | Faulting | | |
| Practice 5 | Faulting | Practice 12 | 2-Wire Extension, Extension Plan 1A |
| Program 10 | Block Wiring | | |

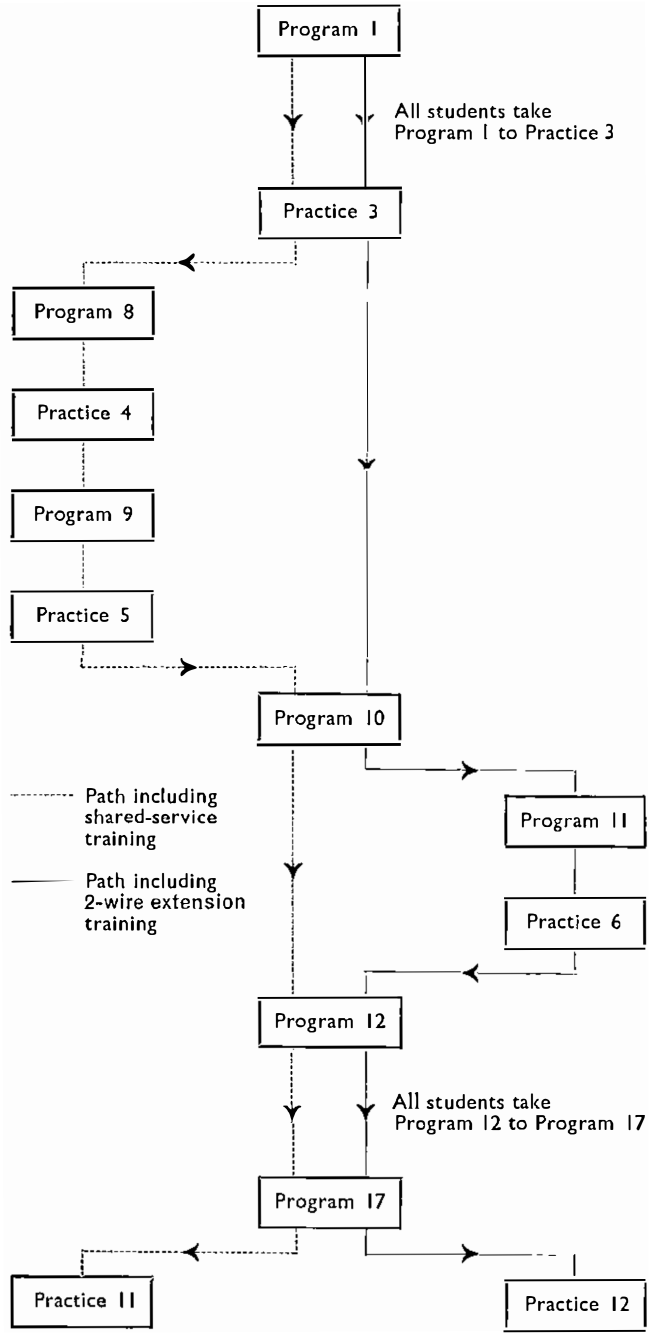



FIG. 1—Course sequence showing alternative paths

All the students commence with program 1, introduction, and work through to practice 3, faulting. If they require training on shared-service lines, they then continue with program 8, shared service, while the others go on to program 10, block wiring. A further division is made on this basis after programs 10 and 17.

With the students taking different programs, and their progress being determined by the rate at which they learn, some check must be kept of their relative positions on the course. The instructor uses a progress sheet for this purpose, which lists all of the programs and practical work on the left-hand side of the sheet and the student's number is listed across the top. As he finishes a session, he is marked off on the sheet, thus his progress can be ascertained at any time.

## THE COURSE IN PRACTICE

When the students attend on the first day, they are unlikely to have had any experience of a programmed course, and a short introductory talk is necessary. This explains how it is to be run and what is expected of them as students. During this talk two points are emphasized:

(*a*) An instructor will always be available should they require any help.

(*b*) The time that they take to complete the course will depend upon their previous experience and their rate of learning.

Any ancillary apparatus or diagrams required are shown at the appropriate point in the program, the students are told the location of these aids, and obtain them for themselves. As they finish a session, they report to the instructor who marks it off and gives them fresh instructions. The tenor of the course becomes one of organized activity with each student engrossed with his own particular job.

As the course progresses, the different learning rates soon become apparent, and the discrepancy between their relative positions becomes wider. This discrepancy can be used to advantage by reducing the number of copies of programs and the amount of apparatus necessary for the course; as a student finishes with the material for a particular session, there is another ready to use it. For a course of 24 students only 6 copies of some of the programs have been found to be necessary.

The assessment of the students on the course is made on the same basis as in the conventional course, i.e. there is no written test, but students have to demonstrate that they can reach a satisfactory standard in their practical work. If the standard is not reached in a particular job, the opportunity is given to attempt it again if it is felt that this would be beneficial. As the students finish they return to their respective Areas, while those who remain carry on until they too have finished.

## EVALUATION OF THE COURSE

Several of these courses have been completed and the results from each have been similar. To obtain an evaluation, a comparison was made with the established initial-installation course, which uses the conventional lecture and demonstration method. The conventional course is of nine days duration, and is staffed by one lecturer and three instructors. Lecture room and workshop facilities and small demonstration rooms are used. The pattern of the course is one of lectures to 24 students, demonstrations to groups of eight, followed by practical work; all of the students finish on the ninth day.

The programmed course uses the same workshop facilities, but the demonstration rooms are not required. When a comparison was made between the two, the following points were noted:

(*a*) Additional information and more practical work is given on the programmed course.

(*b*) Students started completing the course at the end of the fifth day; most had finished by the end of the seventh.

(*c*) Training time was reduced by an average of over 25 per cent (this includes the additional work.)

(*d*) As the quicker students completed the course, the instructors had spare time available in which to help the slower students.

(*e*) The number who failed to reach a satisfactory standard was reduced to below 1 per cent.

(*f*) Students who had time off, e.g. sick leave, were able to resume the course where they had left off.

(*g*) Less staff are required to run the course as no lectures or demonstrations are given.

(*h*) All of the students stated their preference for this type of training, and seemed particularly to like the freedom it gave them to use their own initiative.

The course content was increased as a result of the analysis work, and several items are dealt with which are not included in the conventional course; these include block wiring, wall-type telephones, 4-wire switchboard extensions and the earth clip. With the improved efficiency of the teaching method it was possible to include these additional items, and still have a substantial reduction in training time. Although all of the students took the time that they needed, only one student has required the full nine days.

As the course progresses and the students begin to leave, the instructor/student ratio improves, and those who are having difficulty in reaching a satisfactory standard are able to have extra tuition. This, in part, accounts for the low failure rate.

The lecturer is now only required for normal administrative work, and is able to devote himself to other duties. Three instructors are still used at the commencement of the course, but this number can be reduced to two after five days, and then to one until the last student leaves. Some unnecessary work is being done by the instructors, because of deficiencies in the programs, but when these have been eliminated further reductions in staff may be possible.

The students' reactions have been very favourable and, of course, they like to work under the freer conditions that the new method makes possible. At no time has this been abused; in fact the reverse has been true, and they tend to drive themselves much harder than on the conventional courses.

It is estimated that the preparation of this course has cost £13,500, and that this outlay will be recovered when 1,000 students have been trained. Thereafter, a saving of £1,000 for every 3 courses will be made in comparison with the cost of running conventional courses. Programming this course, by virtue of its experimental nature, has been more costly than is likely to be the case for subsequent similar courses. A quicker return of outlay can therefore be expected from courses programmed in the future.

## OBSERVATIONS ON THE TECHNIQUES USED

Useful information and experience has been obtained during the progress of these courses. The degree of success of the various techniques used has been observed, and this gives a guide to future developments. Some of the more important aspects are given below.

### Program Presentation

Two types of teaching machine were originally used for presenting the programs, but it was decided that little advantage was gained by using a teaching machine for the linear type of program. Subsequently, the Canterbury teaching machine was retained for the branching programs and the linear type were re-written in book form. The response required from a student to the linear frames of the program is either to fill in a missing word, or to perform some action on a piece of telephone apparatus. Cheating occurs with the missing word response, especially in the initial programs. The use of a teaching machine would have helped to prevent this, but the real answer is to convince the student that it does not benefit him. It is preferable to associate the required response very closely with the objectives of the program. The general objective of this course is for the student to acquire skills that will enable him to install telephone apparatus to a satisfactory standard, and a simple response involving the use of this telephone apparatus seems more logical to the student than filling in a missing word in a sentence.

The Canterbury teaching machine was well liked, and there is no doubt that it adds interest. An attempt to use the usual method of presenting branching programs in book form, i.e. scrambled text, was unsuccessful. The students did not like having to turn the pages backwards and forwards to make their response, and stated their preference for a forward progression.

An alternative method of presentation was tried with more success. This involves the selection of choices by means of corners cut from the pages of the book, and the students found it much more acceptable. The pages used are cards which were printed for the Canterbury teaching machine; thus, after printing, they can be prepared for either machine or book. Both methods give the same facilities, and a comparison of results shows no appreciable difference. The book form shows promise, but further tests are required to determine to what degree it is an alternative to the Canterbury teaching machine. It is possible that a well-written program, using telephone apparatus to provide mechanical interest, would be equally as satisfactory in either method.

### Sharing Programs

Program 7, faulting, is used in conjunction with apparatus mounted on a wooden base. With two students sharing, only six of these prepared boards are required for a course of 24 students. Sharing seemed to work well and, after investigating current research on this aspect, it was introduced for the first 4 programs. This helps to overcome the student's initial nervousness and suspicion of a new training method, because he now has a partner to work with. It also reduces the number of copies of programs needed, and teaching machines required for the complete course.

The pairs tended to work at the speed of the slower partner, and some savings in time are lost because of this, but the standard of practical work, still done individually, is unaffected. Where it has happened that a student with a fast learning rate has been paired with one who is much slower, difficulties have arisen, and they have been separated. The students were questioned as to whether they liked sharing, and it appeared that although they appreciated it at the beginning of the course, they were not in favour of it for longer periods; they prefered working as individuals.

### Types of Student

The abilities of the students who have taken this course range from those who are in the final year of the Higher National Certificate, to some who have difficulty in extracting information from the written word. The course has also been used for students who have been employed on other engineering duties in the Post Office, but who now require training on installation work, thus the range of Post Office experience has varied from 2 weeks to 33 years. These extremes of abilities and experience are very much wider than was anticipated, but the self-pacing aspect of the technique has helped to cater for this. Table 2 gives an example of the fastest, slowest and average times of 24 students on the first six sessions.

**TABLE 2**

**Times taken by 24 typical students on the first six sessions of the experimental course**

| Session | Minutes | | |
|---|---|---|---|
| | Fastest | Slowest | Average |
| Program 1 | 50 | 75 | 60 |
| Program 2 | 25 | 45 | 35 |
| Program 3 | 75 | 120 | 90 |
| Practice 1 | 60 | 120 | 85 |
| Program 3 | 55 | 115 | 85 |
| Program 4 | 40 | 100 | 70 |
| Program 5 | 45 | 100 | 60 |
| Program 6 | 40 | 95 | 55 |

### Accommodation

A lecture room and workshop have been available for these courses, and the students are allowed to use either to work through their programs. Demonstration rooms are not required, but a lecture room has been necessary because of the nature of the subject matter. As the students are all at various stages of the course, some are engaged with their programs while others are fixing cables and making a certain amount of noise. On courses where this problem did not occur the lecture room could be dispensed with.

### Training Administration

This type of training creates other opportunities for increases in efficiency, which will involve new thinking and organization on the administrative side.

As vacancies occur due to students finishing early, it may be possible to fill these with others who require training, thus a continuous course would evolve with vacancies being filled as they occur. As other courses are programmed, they too could be incorporated in the scheme, there being no necessity for all of the students in a group to be engaged on the same program or the same course.

Another possibility is an extension of programmed learning methods to local training. It may be more economical to send the programs to students than to bring the students to the programs.

The administrative problems of residential schools are more complex and, initially, it might be preferable if suitable parts of courses were programmed and completed by the students locally. The length of the school courses could then be reduced, and a set standard attained by students before attending.

### CONCLUSIONS

The work done on this course has been mainly experimental, and the experience gained in its preparation and use has been valuable. It has shown that programmed-learning techniques could produce substantial savings in time, staff, and accommodation. As experience is gained, training standards should also benefit considerably. The process is one of experiment, and elimination of unsatisfactory methods.

The cost of preparation of the programs is high, especially while experience is being gained. Planning and organization are required so that the costs of preparation and reproduction are more than offset by the considerable gains which can be achieved.

# Book Reviews

"Telex—Detailed Exposition of the Telex System of the British Post Office." R. W. Barton, C.Eng., M.I.E.E. Pitman and Sons, Ltd. vii + 384 pp. 186 ill. 70s.

The Telex network is primarily for business use. It is much smaller than the telephone network, nevertheless its 22,000 subscribers make more international calls each day than all the 7,500,000 telephone subscribers. This book by R. W. Barton is one of the few books on this subject in the world, certainly the first in English, and is therefore welcomed in making the facilities, problems, and, possibly, the technical complexities of the Telex network more widely known. It is a truly world-wide network and interconnexion of each country's national network has created many problems. Different types of signalling systems are in use in many countries, different methods of call selection, dial or keyboard, as well as different forms of service signals.

The book commences with an historical survey, followed by discussion on the problems of the selection of an automatic system. This is followed by a broad outline of the United Kingdom telex system and is enlarged on in detail in other chapters. Descriptions are given of the subscribers' telex equipment as well as that of the exchange equipment. It continues with detailed information of the equipment for international working to Europe and for intercontinental traffic, including the problem of working over radio systems fitted with automatic error correcting (ARQ) equipment. This is followed by a description of the United Kingdom telex cordless switchboard, since in spite of the fact that 95 per cent of all international calls are subscriber dialled, 100 switchboards are required to handle the remaining 5 per cent together with the transit traffic. The book concludes with a chapter on quality of service and one on looking ahead which briefly mentions data transmission over the telex network and the problem of world international transit connexion employing the new Type C signalling. It is fortunate that the book has appeared at this time as it provides valuable detailed information of telex development up to the present. The network will continue to grow for many years, but discussion has already started as to whether it shall have a brother, a data transmission network, and whether it will merge with this brother at some time in the future. The book can be well recommended to the student who finds it necessary to study the subject in detail. It is also valuable to the specialist in view of the great interest now being shown in a data network.

J.R.

"Worked Examples in Basic Electronics." P. W. Crane, A.M.I.E.R.E. Pergamon Press, Ltd. vii + 282 pp. 198 ill. 40s. (hard cover) 25s. (flexible).

From the title of this book the student might expect to find a high proportion of examples involving semiconductors. This is not the case, however, as this book is intended to be complementary to a book entitled "Worked Examples in Semiconductor Circuits" by Abrahams and Pridham. The main subjects covered are valve amplifiers, oscillators and networks but a small section is devoted to transistor characteristics.

The author has struck a reasonable balance between the theoretical approach to circuit analysis and the practical application of theory to typical examination questions. Approximately one third of the book is devoted to the derivation of basic formulae: the approach is conventional and concise, all assumptions being clearly stated. A statement given in the text dealing with phase-shift oscillators that each CR branch introduces a 60° phase advance should have been qualified as an approximation. Many additional points that can be derived from the basic formula are stated after each section, and the student would find it useful to prove a number of these points.

The book contains over 200 questions chosen from past H.N.C. or graduate examination papers of the I.E.R.E., and approximately a quarter are worked examples. Answers are given to all of the questions. This book will be particularly useful to part-time students who often find it difficult to apply the theory taught in the classroom to the questions set in examination papers.

C. J. M.

# Electrical Contacts in Telephone Exchanges: Contact Opening and Closing Phenomena and Quenching Techniques

## Part 1—Contact Switching Phenomena and Quenching Techniques

W. L. SCOTT, C.ENG., M.I.E.E.†

U.D.C. 621.316.54.066.6 : 621.784

*The onerous nature of modern requirements in telephone switching equipment, together with developments in materials and components, have made essential a review of the practices followed to ensure satisfactory performance and adequate working life for switching contacts. The aim has been to improve loading and quenching techniques, to eliminate or minimize service failures, and to extend contact life. Part 1 of this article describes general aspects of contact switching phenomena, quenching principles and quenching devices; Part 2 will deal with practical applications.*

### INTRODUCTION

In the mid-1920's the British Post Office carried out a series of investigations[1] into relay-contact switching and quenching phenomena to meet the requirements of the forthcoming program of telephone-exchange automation. Although these investigations involved relays and magnets different from present standard types, the general conclusions still stand, and the work provided an extremely useful guide in predicting the behaviour of modern equivalents.

In recent times the requirements of subscriber trunk dialling have demanded very high standards of reliability for switching contacts, while at the same time imposing on them very onerous load conditions. Circuit elements have become more complex and more critical in their operation, and not infrequently incorporate sensitive electronic devices. It is necessary to ensure that the functioning of these is not affected by electrical interference generated by switching contacts. New standard relays[2, 3] that have longer mechanical lives than the Post Office 3,000-type relay have been developed, and it is essential to ensure that the contact life should be correspondingly extended. Furthermore, advances in design have extended the range of components suitable for the quenching of contacts in telephone-exchange equipment.

To meet this changing situation, practical aspects of contact loading, switching and quenching have been further investigated with the object of selecting preferred types of quench, which would make quenching economically possible on a wider basis. A simplified procedure based on rationalized values and components has been developed for the specification of contact loads and quenches for the more common circuit applications.

### TERMINOLOGY

The terminology in use in the literature to describe contact-switching phenomena tends to be loosely applied, with meanings sometimes varying, depending on the context. Discussion of the principal terms employed in the article will indicate the practical sense in which they are used later.

† Exchange Equipment Design and Installation Standards Branch, Telecommunications Development Department, Telecommunications Headquarters.

#### Quench

In telephone-exchange practice a quench comprises a component or components connected to contacts, and the load they control, with the object of diverting and dissipating energy which might cause harmful effects during switching.

#### Spark

A spark is a discharge current across the air-gap between contacts; it is caused by a high voltage developed across the load controlled by the contacts. Conduction across the gap is by ionization of the air and vaporization of the contact metal. For practical purposes it may be assumed that spark breakdown will not occur unless the voltage across the air-gap exceeds 300 volts. Extinction of the spark occurs when the gap voltage is too low to maintain the discharge.

#### Arc

An arc is a relatively-large discharge current across the air-gap between contacts. For the duration of the arc the voltage across it is stabilized at approximately 15–20 volts. Conduction is largely due to vaporized contact metal. Arcing may be a momentary continuation of the load current after the contacts have opened, or may be a re-establishment of current following spark breakdown of the air-gap. Extinction occurs when the energy transmitted via the contacts to the arc is insufficient to maintain the discharge. Depending on the circuit parameters and the rate of separation of the contacts a number of spark and arc discharges may occur during a single opening of switching contacts.

#### Glow

A characteristic violet-blue glow, sometimes termed a glow spark or glow discharge, may occur at contacts interrupting an inductive load circuit. Glow discharge in air requires a minimum maintaining voltage of approximately 300 volts.

#### Minimum Arc-Current

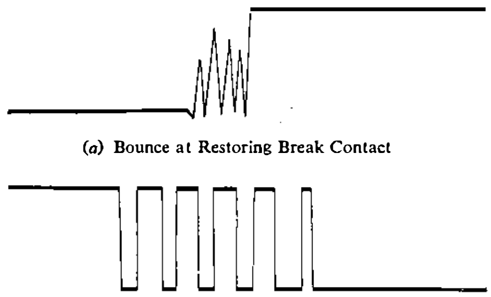
Each contact metal has, for a given applied voltage, a characteristic value of current which, if exceeded, will cause arcing to occur when contacts of that material open an electrical circuit, the load impedance being resistive. To avoid arcing, this value, termed minimum arc-current,[4] should not be exceeded at the working voltage.

### Contact Bounce and Chatter

Bounce refers to one or more re-openings of contacts after closure, usually following the rebound of the armature or actuating device. The contact re-openings are generally, but not always, clearly defined and of relatively long duration.

Chatter is a more sustained and generally, but not always, a more rapid opening and closing of contacts, caused by variations in the coil current or flux, or by mechanical vibration.

Bounce and chatter are equivalent to a substantially-increased number of contact actuations. Oscillograms of bounce and chatter at relay contacts are shown in Fig. 1.



(a) Bounce at Restoring Break Contact

(b) Chatter at Restoring Make Contact

FIG. 1—Oscillograms of contact bounce and chatter

Careful reference to the circuit conditions is essential when inspecting such oscillograms to determine whether irregular contact action is due to bounce or chatter.

## CONTACT-SWITCHING PHENOMENA

The simple circuit element shown in Fig. 2 illustrates the phenomena which occur when contacts close or open electrical circuits in telephone switching equipment.[5]

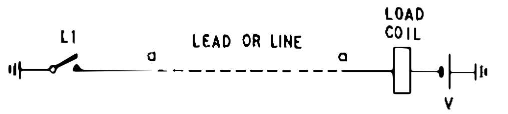


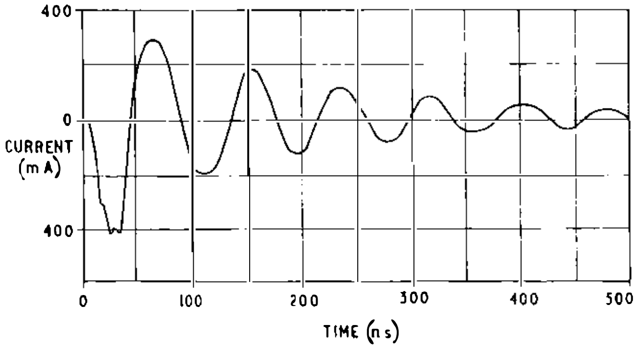

FIG. 2—Energization of load coil over lead or line

### Closing Contacts

*Preclosure of Circuit.* When contact L1 (Fig. 2) is closing and the distance between the contact points becomes extremely small, the electric field may cause a cold discharge of electrons to bridge the gap and prematurely complete the circuit. The bridge is usually ruptured by a relatively heavy discharge current from the wiring, as described below; this sequence may be repeated a number of times before final closure. This phenomenon, referred to as preclosure, inevitably causes contact damage, which becomes more pronounced as the working voltage is increased.

*Wiring Discharge Current.* Lead a–a in Fig. 2 forms a transmission line of surge impedance $Z_0 = \sqrt{(L/C)}$, for exchange wiring, of approximately 100 ohms, charged to the potential of the supply voltage. When the circuit via contact L1 is closed, either prematurely by field discharge or, finally, by metallic contact, the transmission line is discharged by a damped oscillatory current of peak value $V/Z_0$, i.e. $50/100 = 0 \cdot 5$ ampere for 50-volt equipment. The frequency of the discharge current, determined by the distributed inductance and capacitance values of the wiring, may be of the order of megahertz.

Fig. 3 shows an oscillogram of a typical discharge via closing contacts in a 50-volt exchange.




Frequency of oscillation approximately 12 MHz

FIG. 3—Discharge current at closing contacts

### Opening Contacts

*Arcing and Sparking.* If the circuit current interrupted at contact L1 (Fig. 2) exceeds the minimum arc-current value for the material and voltage concerned, an arc will occur. The current should, therefore, be kept well below this value. Inductive circuits require a greater margin, as the induced voltage and stored energy make conditions more onerous. Other forms of arcing may occur with currents well below the minimum arc value, but these are not normally taken account of in practical design.

The mechanism of arc formation may vary, depending on the parameters. During contact opening there is a reduction in contact force, an increase in the resistance and temperature of the areas in contact, and melting of the contact metal. A molten bridge forms between the contacts, and this maintains the circuit current until ruptured mechanically or by boiling of the contact metal.

With inductive loads the induced voltage charges the line and raises the contact potential well above the supply voltage. At small separations this may cause a field discharge and re-closure of the circuit by an arc, which discharges the wiring by a heavy oscillatory current of the order of amperes. Separation of the contacts eventually ruptures the arc, and, unless the rate of opening is slow, no further re-closures occur. Following rupture of the re-closure arc the line is again charged, and the contact voltage can, with appropriate load conditions, eventually exceed the minimum air-breakdown value of 300 volts, causing a spark. This increases the conductivity of the air-gap and, at small separations, a further arc can be established, which again discharges the line and, as before, is extinguished as the contact voltage falls and the gap increases.

If the contact potential is raised sufficiently to spark across the increased gap, now requring a voltage in excess of 300 volts, further sparks and arcs may occur. When sparking ceases, the remaining energy is dissipated as circuit losses in an aperiodic discharge or low-frequency oscillation.

The number of sparks and arcs at each opening may run into hundreds, with current and voltage peaks exceeding 10 amperes and 1,000 volts. High-frequency oscillations may be set-up, involving not only the line characteristics but also the capacitances to earth of the load coil and the switching contacts and springs.

Fig. 4 shows a voltage-waveform oscillogram for arcing and sparking contacts. In such oscillograms the high-frequency response of the instrument and the time-scale affect the apparent significance of the trace; a single line may represent an envelope enclosing a high-frequency oscillation.

*Glow Discharge.* Glow discharge is common at opening contacts, but is more clearly observed on a contact which is rapidly pulsing an inductive load, e.g. a selector pulse-accepting relay. A characteristic feature is stabilization of the contact voltage at approximately 300 volts as long as the glow persists. Glow is less damaging than sparking and arcing, but is an indication that the associated coils, contacts and wiring are being subjected to a high voltage, which may need to be limited.

The characteristic waveform of glow discharge is shown in Fig. 4.

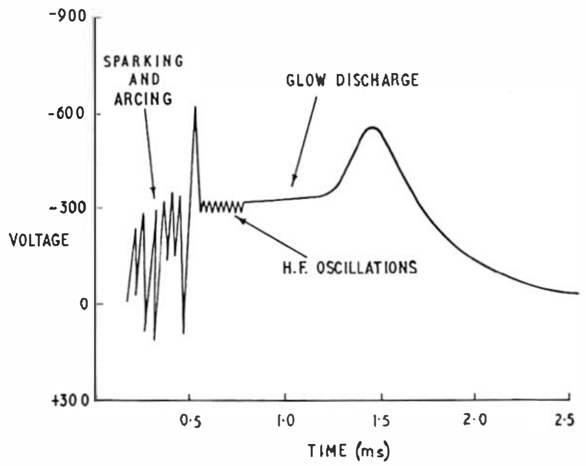



FIG. 4—Voltage waveform at opening contacts

## PHYSICAL FACTORS AFFECTING CONTACT PERFORMANCE

Contact performance is affected by not only the circuit parameters but also a number of other physical factors, some interrelated, which cause appreciable variations in behaviour in different situations.

### Contact Material

Some of the more important properties of the four principal contact metals[6] employed in standard Post Office equipment are given in Table 1.

(*i*) Silver is the general-purpose material for low-current, lightly-worked applications. It is cheap and has high electrical and thermal conductivity, but its low melting and boiling points and low hardness figure indicate proneness to marked damage and erosion if the rated current and voltage limits are exceeded.

(*ii*) Platinum is hard, has high melting and boiling points and appreciably better minimum arc-current limits than silver, indicating suitability for heavier loads and higher rates of operation.

(*iii*) Palladium is superior to silver in hardness, melting and boiling points and minimum arc-current limits, but not to quite the same extent as platinum. It is, however, much cheaper than platinum.

(*iv*) Tungsten has high melting and boiling points, is very hard and has higher minimum arc-current and voltage limits than the other three materials. These properties make it suitable for heavier loads at high rates of operation, but it is prone to the formation of high-resistivity oxide films.

### Contact-Surface Films and Particles

Contact performance is critically dependent upon surface films and other matter in the conducting path.[7] Two important types of film are due to the catalytic action of platinum or palladium.

In the presence of organic vapours, e.g. from plastics, the energy of the rubbing action of the contacts without any load connected, may produce substances of very low conductivity. Fig. 5 shows such a substance formed on the unloaded platinum contacts of a polarized relay.

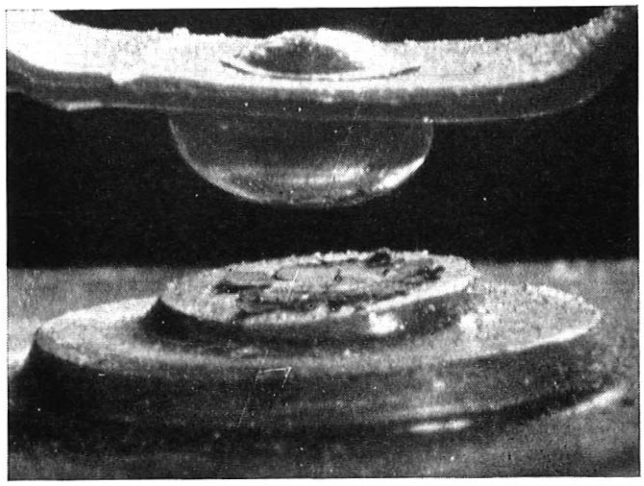


FIG. 5—Substance formed on unloaded contacts by rubbing action

Hydrocarbon vapour, e.g. from certain floor polishes, may be decomposed by sparking and arcing, producing a film which makes the surface extremely prone to arcing and damage.[8] This is due to a notable reduction in the minimum arc-current limit, generally to one-tenth of the normal value, or less.

Silicone vapours in even minute concentration can, in the presence of sparking and arcing, deposit, on the contact surfaces, substances of very low conductivity, such as silica and silicon-carbide. These vapours may originate from lubricating oils and greases, plastics mould-release agents or wiring-sleeves, and as far as possible this form of contamination is avoided on Post Office equipment.

In addition to reducing conductivity, surface films cause heating, sparking and arcing at the contacts. However, the effects are not all adverse. Clean contact surfaces, particularly in sealed containers, tend to adhere by bonding forces that act across the interface: surface films tend to mitigate this effect. A degree of sparking and arcing is also sometimes relied upon to improve conductivity at low-voltage, low-current switching contacts by breaking down films and dislodging particles.

**TABLE 1**

**Properties of Four Principal Contact Metals**

| Metal | Symbol | Maximum Circuit Current (Resistive Load at 50 volts) (amp) | Melting Point (°C) | Boiling Point (°C) | Conductivity: Thermal (C.G.S. Units) (Note 1) | Conductivity: Electrical (per cent I.A.C.S.) (Note 2) | Relative Vickers Hardness (Annealed) |
|---|---|---|---|---|---|---|---|
| Silver | Ag | 0·3 | 961 | 1,950 | 1·0 | 106 | 26 |
| Platinum | Pt | 1·0 | 1,769 | 3,910 | 0·17 | 15 | 65 |
| Palladium | Pd | 1·0 | 1,552 | 2,540 | 0·17 | 16 | 40 |
| Tungsten | W | 3·0 | 3,400 | 5,400 | 0·39 | 31 | 290 |

Notes: 1 Calorie per cm² per second per °C per cm
2 International Annealed Copper Standard (annealed copper = 100 per cent)

### Atmospheric Environment

The rate of film formation and the chemical products produced on contact surfaces vary depending on the locality and the degree of atmospheric pollution. High relative-humidity aids film formation but also assists arc quenching and reduces contact wear. Controlled relative-humidity has been employed by some administrations to improve contact performance, but not by the British Post Office. It is interesting to speculate on the extent to which variations of contact life in different localities has been due to differences in the prevailing humidity.

Organic vapour contaminants, to which platinum and palladium are particularly susceptible, are more likely to be present in significant quantities in new equipment.

Immediately after sparking or arcing, the small volume of air surrounding the contacts contains residual metal vapour and ionization products that lower the gap-breakdown voltage. Rapidly-repeated operation of contacts is thus conducive to increased damage, but this is partially offset by the tendency for exhaustion of the oxygen in the gap to favour glow discharge rather than arcing.

### Contact Shape, Contact Springs and Method of Actuation

Smooth contacts are less liable to sparking and arcing than those of roughened surface, as gap de-ionization after breakdown occurs more readily. Thus damage accelerates with use.

Contacts standardized for British Post Office equipment are either flat or dome-shaped, each shape having its range of application and characteristic behaviour.

Contact springs all possess some degree of flexibility, which implies liability to vibration and, possibly, to contact bounce and chatter. Modern spring systems are designed to eliminate vibrations or to minimize their effects. Vibration energy may be absorbed in compliant damping springs, and transverse movements of the contacts avoided by locating them at nodal points, permitting a longitudinal rubbing action which assists conductivity without opening the circuit. Even so, bounce and chatter are not entirely eliminated.

The method of operating a spring-set considerably affects contact performance. Springs may complete their movement smoothly, or may momentarily oscillate in an intermediate position. This is usually due to an abrupt change in the mechanical load on the armature during actuation. Thus, on operation of a relay, the armature load may rise abruptly when the pressure of buffered springs is encountered, and armature movement momentarily ceases. Similarly, during release, relief of buffered-spring load may stop or slow the armature. Oscillation of the armature and springs is usually present, particularly during release. The term armature, or spring, hesitation is used to describe this phenomenon, which is common but difficult to detect. The operating method may involve high acceleration and velocity of the springs, with appreciable kinetic energy at the end of their movement, so increasing the possibility of contact bounce.

Slow opening of contacts causes chatter, described as hesitation chatter if it occurs during momentary pauses in the spring movement. Although high acceleration and velocity of spring movement may cause bounce, rapid opening aids arc extinction. Fast operation is also helpful in pulling apart contacts which have become interlocked or welded.

## HARMFUL EFFECTS DURING SWITCHING

Harmful effects which may occur during switching can be grouped into contact damage, breakdowns from high surge voltages and circuit failures or difficulties caused by interference.

### Contact Damage

Purely mechanical wear at switching contacts is usually negligible, but under electrical load some degree of damage is inevitable. Heavily-worked contacts such as magnet interrupters are subjected to onerous mechanical and electrical conditions simultaneously.

Contact erosion results in a progressive deterioration in performance by reducing the contact force and increasing the susceptibility to poor-conductivity faults. The form and rate of erosion depend on the factors discussed earlier. Contacts may be eroded completely without any visible sparking. Typical eroded contacts are shown in Fig. 6(*a*).

Material transfer, bridging and contact adherence occur during switching. The transfer may be in irregular fashion, sputtered over the surface, or, more importantly, may be in the form of a spike or growth. These may vary from thin whiskers to irregular projections, often long enough to bridge the gap between contacts. A remarkable example of this is shown in Fig. 6(*b*). Almost always a corresponding hole appears in the surface of the partner contact, and the pair tend to interlock. The terms selective transfer or unbalanced transfer of contact material are used to describe this phenomenon.

Adherence of contacts, apart from that due to spike and hole interlocking, may be caused by either adhesion between extremely clean surfaces or by welding. Clean-surface adherence of contacts exposed to the atmosphere is rare, owing to the inhibiting action of surface films and the opening force of the springs. Failures due to welding occur on closure of the contacts, when they may either be welded firmly or be likely to separate at the least disturbance. This latter condition, described as "freezing," is due to the formation of a minute metallic bridge between the contacts. This is very common indeed when contacts close and complete an electrical circuit, but is usually overcome by the opening force. Contacts interlocking by small spikes are often wrongly assumed to be welded. An example is shown in Fig. 6(*c*).

If not guarded against, contact damage sufficient to cause failures, may occur surprisingly early in the life of contacts. Closing failures may be caused by severe burning and erosion of the contacts as shown in Fig. 6(*d*). This is sometimes due to sparking and arcing being increased by environmental conditions. Opening failures are usually due to interlocking, freezing or welding, which may occur intermittently and may only delay the opening of contacts, causing erratic functioning and elusive faults.

### Surge-Voltage Breakdowns

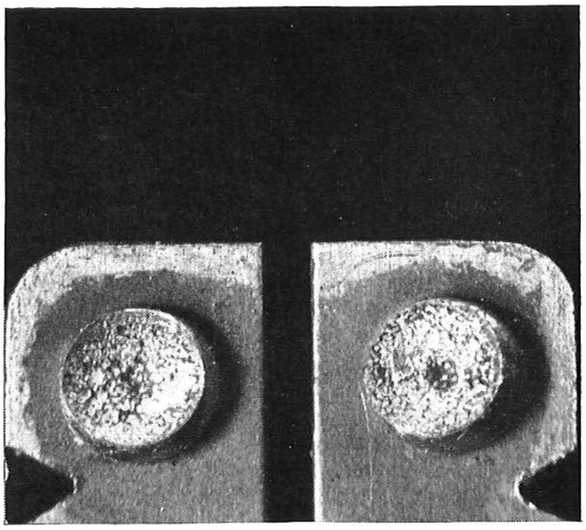
High surge voltages are produced during the operation of exchange equipment, as many of the contact loads are highly inductive. Unless protective quenching is applied, these surges may cause breakdown of wiring and components.

### Interference

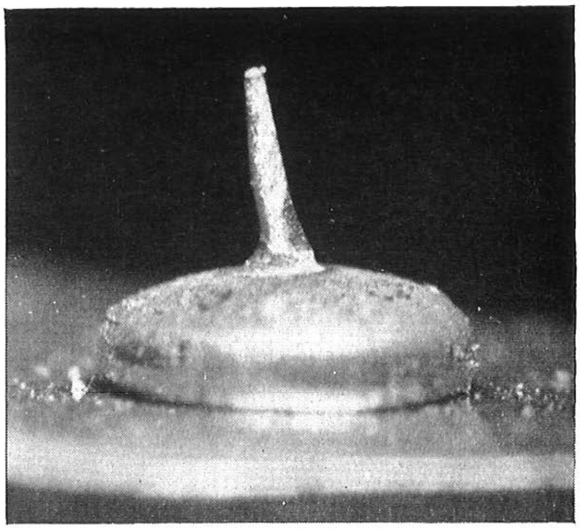
Radio and television interference complaints arising from the operation of automatic telephone-exchange equipment are few, largely due to the location of most exchanges in situations of high signal field-strength, together with the shielding effect of the exchange metalwork, cables and apparatus. Moreover, the quenches fitted to the switching equipment effectively suppress, or limit, most potential interference at source. As circuit and quench design is aimed at eliminating undesirable interference effects inside the exchange, the level of external interference is generally acceptable.

*Sources of Interference.* Fig. 7 shows in generalized form the main causes of interference in exchanges, the modes of propagation, and typical equipment likely to be affected. The main sources are induced voltages, high surge voltages and surge currents in wiring and cabling, and local high-frequency oscillations at sparking and arcing contacts.

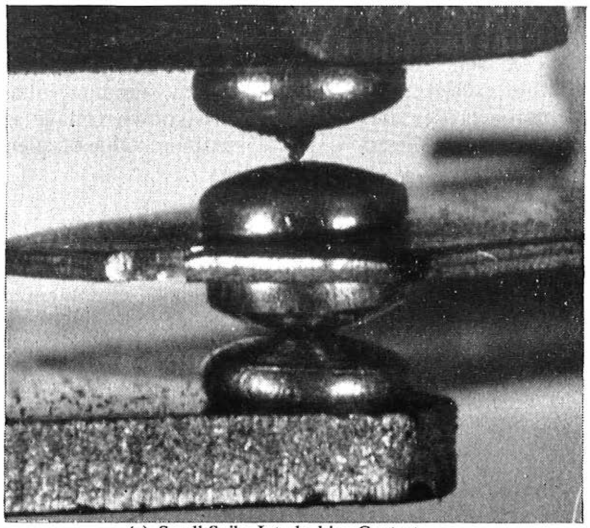
*Propagation of Interference.* An interference source may affect its own circuit, other circuits, or both, with energy transferred by common-impedance coupling, inductive or capacitive wire-to-wire coupling or radiation. Common-



(*a*) Eroded Contacts



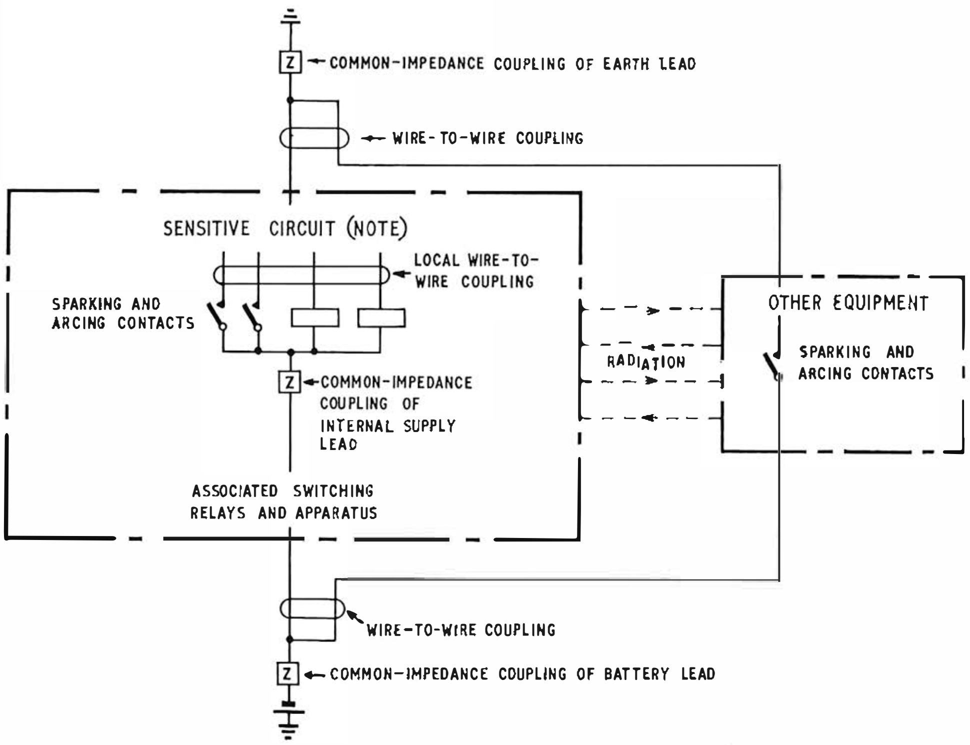
(*b*) Material Transfer



(*c*) Small-Spike Interlocking Contacts

(*d*) Severe Burning

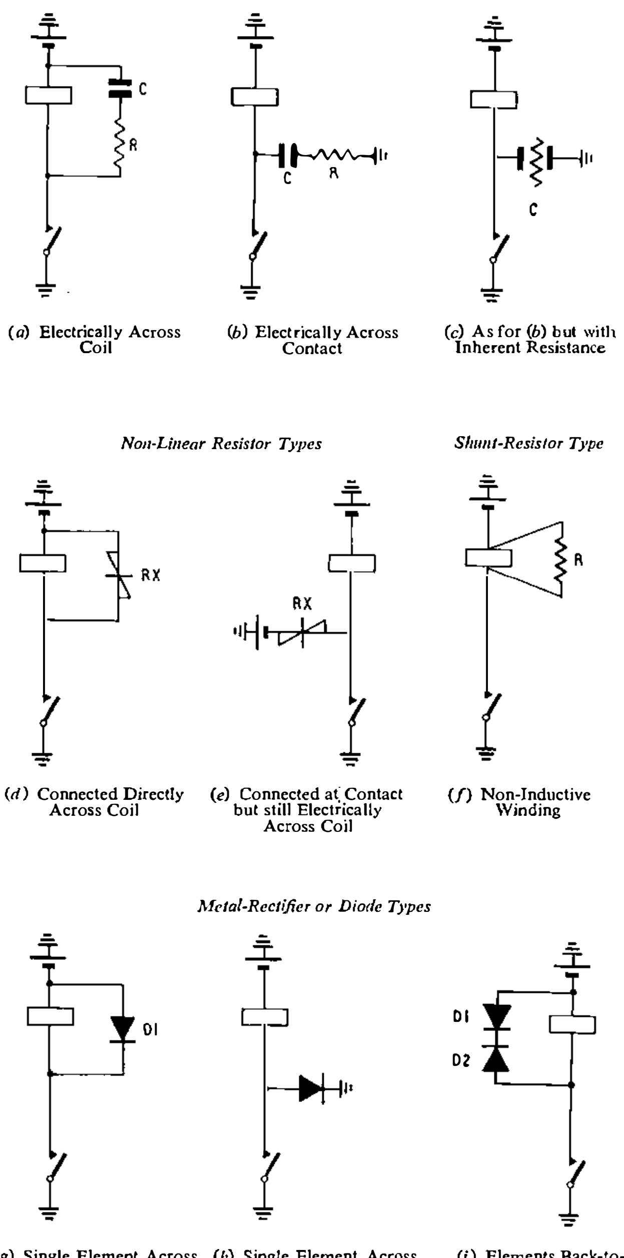
FIG. 6—Examples of contact damage




Note: Voice-frequency receivers, multivibrators, amplifiers, gates, toggles, etc.

FIG. 7—Sources of interference and modes of propagation in exchange equipment

*Capacitor-Resistor Types*




*Capacitor-Resistor Types*: (*a*) Electrically Across Coil; (*b*) Electrically Across Contact; (*c*) As for (*b*) but with Inherent Resistance

*Non-Linear Resistor Types*: (*d*) Connected Directly Across Coil; (*e*) Connected at Contact but still Electrically Across Coil

*Shunt-Resistor Type*: (*f*) Non-Inductive Winding

*Metal-Rectifier or Diode Types*: (*g*) Single Element Across Coil; (*h*) Single Element Across Contact; (*i*) Elements Back-to-Back Across Coil

FIG. 8—Quench devices

impedance coupling occurs via battery or earth commons. Inductive or capacitive coupling arises from parallelism between wires or cables or proximity effects between adjacent components. Radiated interference originates from arcing and sparking contacts, and the associated springs and wiring. *Undesirable Effects of Interference.* The principal undesirable effects of interference are noise voltages in speech paths and functional failures of the equipment. Noise is usually due to transients, caused by coil-induced voltages, and sparking and arcing surge currents. Circuit failures may be caused when interference gives rise to spurious signals, or incorrect operation of relays, electronic gates, or toggles. An obscure example, which nevertheless occurs in practice, is that in which induced surge voltages change a discharge at switching contacts into a more harmful form, e.g. from glow to arc. The extent to which interference is troublesome is determined by its characteristics, i.e. its magnitude, frequency range and energy content, relative to the response characteristics of the affected equipment.

## QUENCHING PRINCIPLES

Contact protection is the most common quenching requirement for electromechanical exchange equipment, and the subject is discussed mainly in relation to this type of application, with appropriate references to surge-voltage breakdown and interference.

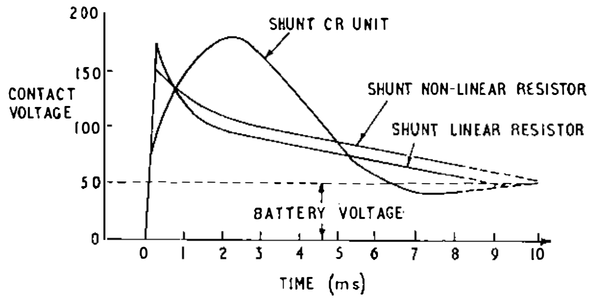
### Design Aim

The aim is to limit the voltage across opening contacts to not more than 300 volts, the minimum spark breakdown value for air, thus preventing all discharges except those due to reclosure at small contact openings. The value of 300 volts usually includes a standing supply potential, i.e. for 50-volt equipment the maximum permissible voltage is 250 volts. It is often possible to reduce the contact voltage to lower values provided that the armature-release time of the device is not unduly increased.

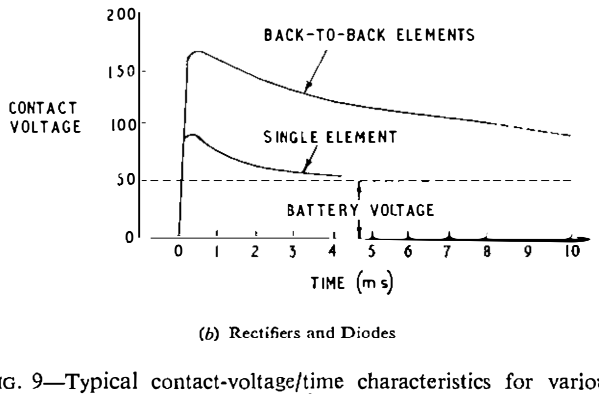
For practical purposes, quench action may be discussed by assuming that, when the contacts open, the load current $I$ amperes is diverted instantaneously into the quench. For satisfactory quenching, the voltage $IR$ across the resistive element $R$ ohms of the quench, i.e. the contact voltage, should not exceed 300 volts, including any standing voltage. This approach uses the 300-volt air-breakdown voltage as a limit to determine the approximate maximum value of quench resistor for particular load conditions.

## QUENCHING DEVICES

Quenching devices employed on standard equipment are the capacitor plus series resistor, the non-linear resistor, the shunt resistor and the metal rectifier or diode. The various quenches are shown in symbolic form in Fig. 8, and contact-voltage/time characteristics are illustrated in Fig. 9.




(*a*) Capacitor-Resistor, Linear and Non-Linear resistor Quenches




(*b*) Rectifiers and Diodes

FIG. 9—Typical contact-voltage/time characteristics for various quenches

### Capacitor-Resistor Quenches

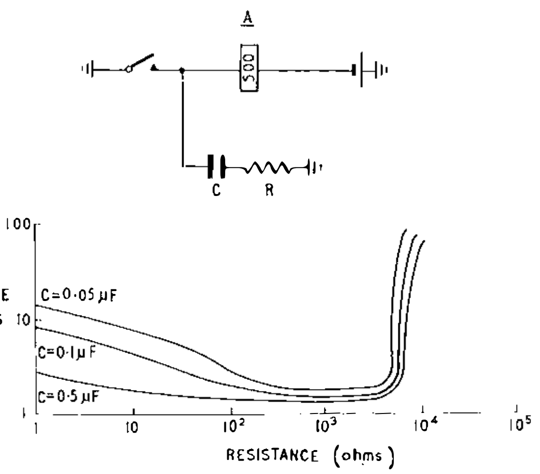
Capacitor-resistor quenches have been used for many years; cost and size have tended to limit their use to magnets or special circuits, but the recent development of low-cost miniature capacitors has widened the scope of the capacitor-resistor quench. With suitable component values capacitor-resistor quenches are very effective, particularly in reducing contact erosion; unsuitable values or wrong applications cause contact damage.

The capacitor-resistor quench provides a bypass for continuation of the circuit current after it has been interrupted at the opening contacts. Provided that the minimum air-breakdown voltage of 300 volts is not exceeded, the contacts will open without sparking or arcing, and the energy diverted into the quench will be dissipated as circuit losses. The resistor reduces the voltage-limiting action of the capacitor, but is essential to limit the capacitor current on closure, as otherwise contact welding may occur.

The $C$ and $R$ values relative to the other circuit parameters may considerably affect the release-time of an armature actuated by the load coil. As arcing prolongs the load current at practically full value, and thus delays armature release, a quench which just eliminates the arc will reduce the release-time. So will $C$ and $R$ values that ensure a more rapid decay of coil current and flux by permitting an oscillation to be set up via the coil and quench. A possibility to be guarded against is re-operation of the armature to a reverse surge during this oscillation. On the other hand, the release time may be extended by appropriate quench values, e.g. increase of capacitance. Both features are employed in quenches designed for pulsing-relay circuits, as they provide a means of controlling the characteristics of the output pulses.

The complex factors in contact switching make circuit analysis for the determination of capacitor-resistor quench values difficult to carry out in practice.

The requirements for the $C$ and $R$ values are somewhat incompatible; $C$ should be large to prevent sparking and small enough to avoid excessive closure current: $R$ small enough for adequate quenching and large enough to avoid excessive closure current. Experience has shown, however, that for most applications the $C$ and $R$ values are not critical. This is illustrated in Fig. 10, which shows the relative heating effects




Relay A operated for 240 pulses at 15 pulses/sec with 70 : 30 make-to-break ratio

FIG. 10—Heating effects at pulsing contacts with various quenches

at contacts being pulsed, with various combinations of $C$ and $R$ values used as the quench. Taking the degree of heating as the criterion, optimum quenching is achieved over a wide range of $C$ and $R$ values. Experiments by many workers have shown that, provided the contact-opening speed is not abnormally slow, the minimum value of $C$ in $\mu$F, for satisfactory quenching, may be taken as equal to the value of current, in amperes, disconnected at the contacts. With this value of $C$ the rate of rise of contact voltage, relative to the rate of contact separation, is sufficiently slow to ensure that spark breakdown of the air-gap does not occur. At least twice this capacitance is recommended to ensure a safe margin. Resistance $R$ is made approximately equal to the resistance of the load coil. This limits the instantaneous rise in contact voltage, on opening, to that of the supply. Where conditions are onerous, such as for selector magnets, comparative tests are usually necessary, using a range of values determined by the simple rules.

During quenching, a relatively-high voltage is developed across the capacitor, and it is essential that its rated peak value should not be exceeded. This imposes limitations on the use of capacitor-resistor quenches for highly-inductive, heavy-current loads. Ignoring losses, the peak capacitor voltage may be taken as $I\sqrt{L/C}$, $I$ and $L$ being the load current and inductance, respectively. Thus, with heavy currents and large inductances, the capacitance may have to be unduly increased to limit the peak capacitor voltage. Calculation of the voltage is virtually impossible, and onerous applications are checked under simulated working conditions.

As shown in Fig. 8(*a*) and 8(*b*) capacitor-resistor quenches may be connected across the coil or across the contacts. With zero-impedance supply leads the method should not, theoretically, affect quenching, but connexion across the contact has the following advantages.

(*a*) As the majority of load coils are battery-connected the quench resistor is earthed, which is preferable for maintenance.

(*b*) Adverse effects of supply-lead impedance on quenching are avoided.

(*c*) The coil prevents noise due to discharge currents on contact closure from being fed back to the supply leads. This is important for quenches fitted to self-drive selector mechanisms.

Connexion across the coil facilitates wiring; the supply voltage does not add to the surge voltage across the capacitor, and breakdown of the capacitor does not energize the load.

The preferred British Post Office method is connexion across the contact, if possible immediately adjacent to it, as this minimizes radiated interference.

Capacitor-resistor quenches may provide some advantage, when switching resistive loads, by momentarily limiting the contact voltage to a value less than that of the supply, depending on the resistance. Due to the low voltage, arcing is less likely during the early stages of contact opening than without the quench, thus permitting disconnexion of a higher load current than indicated by the relevant minimum-arc-current value. Spark breakdown need not be considered, as inductive surges do not occur. The resistance value should be less than with inductive loads, as the contact voltage at opening needs to be limited well below that of the supply. The capacitor should be of adequate capacitance but need not be rated above the supply voltage.

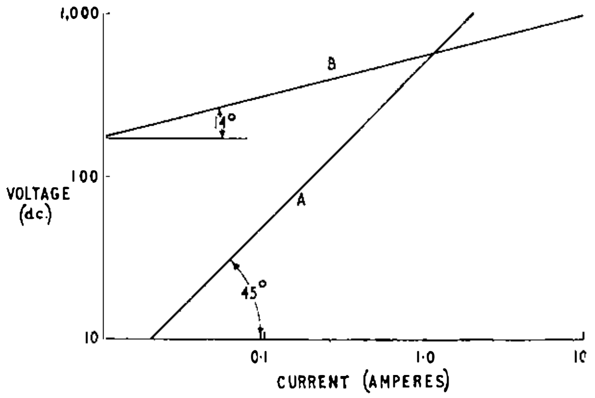
### Non-Linear Resistor Quenches

Non-linear resistor quenches are so called because of the non-linearity of their voltage/current characteristics. The basic material is silicon-carbide, which has rapidly-decreasing resistance with increase of voltage. Experimental forms were tested as early as 1934, and the device was first used on British Post Office equipment in 1939 as a voltage suppressor. Their use has expanded rapidly in recent years.

The resistors are in the form of plastics-insulated disks with wire-end leads protected by sleeving. They are cheap and easy to fit on the wiring side of mounting plates without obstructing maintenance access.

The non-linear resistor is less effective than the capacitor-resistor quench, particularly as regards contact wear, giving approximately half the working life. Nevertheless, in light-load applications, it can usually extend contact life to parity with the life of other parts subjected to mechanical wear. It is reliable in its action, but the tolerances for mass production may slightly vary efficiency and the extent to which armature-release time is extended.

The voltage/current relationship for the non-linear resistor is expressed by $V = KI^B$. $K$ is a constant depending on shape and size, and is generally defined as the voltage at which a current of 1 ampere is passed; $B$, the slope of the $V/I$ characteristic curve, is a constant depending on composition and manufacture. The $V/I$ characteristics for a non-linear resistor and a linear resistor are plotted logarithmically in Fig. 11.




A — Linear resistor
B — Non-linear resistor

FIG. 11—Voltage/current characteristics for linear and non-linear resistors

The d.c. resistance at the working voltage is also used as a design parameter. For 50-volt equipment this is termed the R 50 value. The action of the non-linear resistor in limiting contact voltage is discussed in more detail in the Appendix.

Armature release is inevitably delayed by a non-linear resistor quench, but to a less extent than with a linear resistor giving comparable quenching. The increase depends on the characteristics of the coil and of the non-linear resistor and the mechanical adjustments. If the basic release time is very small, as with a high-speed relay, a proportionately large increase may often be tolerated without any detrimental effects on circuit functioning, e.g. a 1ms high-speed relay release time increased by 100 per cent to 2ms.

Under working conditions the non-linear resistor passes a leak current which, although small, cannot be neglected. It limits the method of connexion to across the coil (Fig. 8(*d*) and 8(*e*)). Connexion across the contact would allow a leak current with the circuit idle, would cause armature release to be further delayed and the supply voltage to be added to the surge across the quench. Short-circuit failure of the resistor would energize the load coil.

The use of a non-linear resistor quench may be precluded in some situations. Owing to its effect in increasing armature-release time it cannot be used where timing is critical. Its negative temperature coefficient makes it unsuitable for use in situations of high ambient temperature or where there is any risk whatever of continuous voltage overload. As the wattage dissipation is proportional to the fifth power of the voltage, an increase to twice the rated value increases the dissipation 32 times, i.e. $2^5$.

### Shunt-Resistor Quenches

The shunt-resistor quench is simple, stable and reliable, and its performance can be accurately predicted. These advantages are offset by undesirable features; when the associated coil is energized the resistor also passes a current and there is a waste of energy; the resistor current increases the contact load and makes opening conditions more onerous; also, armature-release time is considerably increased. To save space the quench resistor is often included in the coil as a non-inductive winding, as in Fig. 8(*f*).

The shunt-resistor quench provides a discharge for the energy in the load coil. When the circuit is opened the induced e.m.f. sets up a circulating current via the coil winding and quench resistor. Decay of coil current thereafter follows Helmholtz's law, and there is a substantial reduction in the rate at which the flux collapses, thus limiting the contact voltage. By assuming, as earlier, that the load current continues instantaneously into the quench, the maximum value for the quench resistor may be determined from the expression $E + iR \not> 300$, where $E$ is the supply voltage, $i$ the instantaneous load current (amperes), and $R$ the quench-resistance value (ohms). The shunt-resistor quench always appreciably increases armature-release time to an extent which can be accurately calculated, particularly for relays, and this device is therefore suitable where the need for closely-controlled timing precludes the use of other techniques.

### Metal-Rectifier and Diode Quenches

Metal rectifiers were first suggested as quenches for British Post Office equipment in the mid-1920s,[1] and since then copper-oxide and, later, selenium types have been extensively used; in recent years modern semiconductor diodes have been preferred. Rectifiers and diodes are effective quenches, comparable in many respects to the shunt resistor, but without any significant addition to the load current, without any wasteful energy dissipation, and also without the harmful charge/discharge effects which occur on closure with capacitor-resistor quenches.

A single rectifier or diode quench, connected as in Fig. 8(*g*), does not pass any significant current with the controlling contacts closed, as the voltage across the device is in the reverse, or high-resistance, direction. On opening of the contact the induced coil voltage across the quench is in the forward, or low-resistance, direction, providing a discharge path for the coil energy. The forward resistance of the device increases as the induced voltage falls towards the end of the quenching action. Assuming the 300-volt gap-breakdown limit, the following relationship holds: $E + IR \not> 300$ where $E$ is supply voltage, $I$ load current (amperes) at break and $R$ ohms the forward resistance of the quench at the instant of break.

Armature-release time is notably increased, but, owing to the non-linearity of the resistance of the discharge path, it cannot be calculated as accurately as with a shunt-resistor.

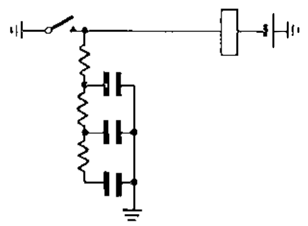
With the quench connected across the contact, as in Fig. 8(*h*), quenching takes place only during the period that the coil voltage exceeds the avalanche breakdown value of the device. The quenching period is shorter than with the other method of connexion and less efficient, but the increase in armature-release time is smaller. An alternative arrangement (Fig. 8(*i*)), which functions in a similar way, comprises two quench elements connected back-to-back across the coil, which is thus not energized should short-circuit failure of the quench occur. Quenching action takes place only when the induced coil-voltage exceeds the avalanche-breakdown value of the quench element, D2. Quenching is less effective than with a single diode across the coil, but the delaying effect on armature release is limited. Rectifiers or diodes for these latter two applications should be capable of passing an appreciable momentary reverse-current. This limits practical applications to selenium rectifiers and silicon diodes; the latter are preferred for British Post Office equipment.

## SPECIAL QUENCHING TECHNIQUES

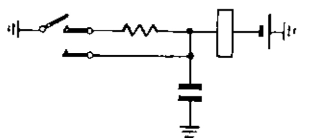
At various times special quenching techniques have been proposed as improvements on existing methods or as being suitable for onerous circuit conditions for which the more usual devices are considered inadequate.

### Reduction of Quench Charge or Discharge Current

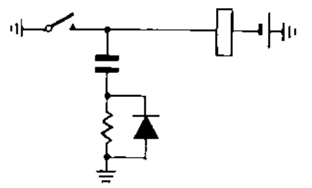
Quenches have been designed with the object of eliminating, or minimizing, the charge or discharge current on initial make of the controlling contacts. Jacquest and Harris[1] investigated the effect of sub-dividing the capacitance as in Fig. 12(*a*) and also an alternative scheme (Fig. 12(*b*)), employing subsidiary contacts, which had the additional advantage of reducing the current before the load circuit was finally opened. Cost and space limitations militated against the use of this form of device, but the essential principle of distributed capacitance and resistance was embodied in a more practical and compact way in the now well-known inherent-resistance type of quench, shown symbolically in Fig. 8(*c*).



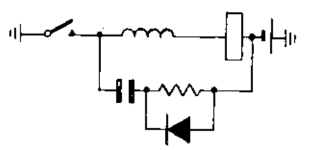
(*a*) Sub-Division of Capacitance



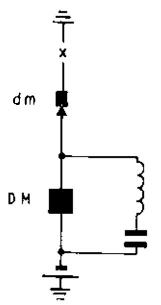
(*b*) Subsidiary Contacts



(c Diode Permitting Higher Value of Quench Resistor



(*d*) Composite Quench




(*e*) Resonant Quench

FIG. 12—Special quenching techniques

Composite capacitor-resistor quenches have utilized the unidirectional conducting properties of the diode and metal rectifier in association with *CR* elements (Fig. 12(*c*)) to minimize charge or discharge effects without using subsidiary contacts. This arrangement permits the use of a higher quench resistance as, during quenching, the resistive element is shunted by the diode.

British Patent 957,721,[9] covering a Swedish invention, describes a composite quench comprising a capacitor, resistor, diode and inductor, connected as in Fig. 12(*d*). The function of the inductor is to limit discharge currents from the wiring.

### Use of Oscillatory Properties of Quench Circuit

Ingenious suggestions have been made to employ an inductor in place of, or in association with, the resistor of a capacitor-resistor quench with the object of utilizing the oscillatory properties of the *LC* circuit to ensure that when the controlling contacts are opened the voltage or current is effectively at minimal value, thus reducing the possibility of contact damage. A quench based on this principle was patented in Germany as early as 1912.[10] British Patent 686,187[11] by Ericsson Telephones, describes an arrangement suitable for self-drive mechanisms (Fig. 12(*e*)). When the self-drive contacts, dm, open, the load current and *LC* current are equal but in anti-phase, and the current interrupted at the contacts is zero. Similar forms of quench have been successfully used to protect teleprinter-broadcast contacts, giving a contact life of more than $300 \times 10^6$ operations compared with less than $10^6$ with ordinary capacitor-resistor quenches.

The oscillation involved in this type of quench action is of relatively low frequency. As described in Part 2, variation of the low-frequency oscillatory properties of the *LCR* circuit comprising load-coil inductance *L*, quench capacitance *C* and circuit resistance *R* is sometimes used to control the release performance of the associated armature, in particular with pulsing relays.

### Elimination of High-Frequency Discharges

Elimination of high-frequency discharges at contacts results in a marked reduction in contact damage and in interference. Inductors, resistors, or capacitor-resistor decoupling networks, used singly, or in combination, may be used to reduce discharge effects, provided that signalling limits are not affected by the additional resistance. Inductors are particularly effective where contacts are closed and opened at high-repetition frequencies, as on self-interacting tone-generating relays, because these conditions usually give rise to pronounced radio-frequency (r.f.) discharges and to contact damage. Filter networks of various forms have proved very effective for dealing with severe contact erosion and r.f. interference when connected in the transmitting-contact circuit element of teleprinter broadcast systems, and in series with contacts carrying out similarly onerous line-signalling functions.

Circuits involving high-frequency discharges usually require individual analysis and confirmatory tests.

(*To be continued*)

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[10] Burstyn, Dr. Walther. Stromunterbrecher mit Löschkondensator. German Patent No. 274771, Dec. 1912.
[11] Ericsson Telephones, Ltd., and Wilman, C. V. Improvements in or Relating to Self-Interrupted Drive Circuits for Electromagnetically Operated Devices. British Patent No. 686,187, Jan. 1953.

## APPENDIX

### Action of Non-Linear Resistor Quench

The action of the non-linear resistor in limiting contact voltage to less than the 300 volts air-breakdown value is illustrated in the following example (Fig. 13).

A 1,000-ohm coil is energized at 50 volts and has a non-linear resistor quench. The characteristics of the quench, are: $B = 0{\cdot}25$, and the R50 value is 50,000 ohms: the $K$ value is not specified.

Before the contacts open, conditions for the non-linear resistor may be represented by $V_0 = KI_{\mathrm{D}}^{B}$, where $I_{\mathrm{D}}$ = leak current via quench.

As the contacts open, assume that, instantaneously, the load current $I_{\mathrm{L}}$ is diverted via the quench. Hence, the voltage across coil and non-linear resistor quench, $V_c$, $= KI_{\mathrm{L}}^{B}$.

Thus, $$\frac{V_c}{V_0} = \frac{KI_{\mathrm{L}}^{B}}{KI_{\mathrm{D}}^{B}},$$

and $$V_c = V_0 \times \left(\frac{I_{\mathrm{L}}}{I_{\mathrm{D}}}\right)^{B}$$

Therefore, $$\log V_c = \log V_0 + B \log\left(\frac{I_{\mathrm{L}}}{I_{\mathrm{D}}}\right).$$

In the example $$V_c = 50 \times \left(\frac{50}{1}\right)^{0{\cdot}25}$$

so that $\log V_c = \log 50 + 0{\cdot}25 \log 50$,

and, hence, $V_c = 133$ volts.

Contact voltage $= 133 +$ supply (50 volts)

$= 183$ volts.

It will be noted from the above that the quenching action is more effective the smaller the slope of the voltage/current characteristic, i.e. the smaller the value of $B$.


(*a*) Conditions Before Contact Opens

(*b*) Conditions After Contact Opens

Fig. 13—Action of non-linear resistor to limit voltage at contacts to less than 300 volts

# Press Notices

## Post Office Business in 1967–68

### *POSTAL SERVICES*

Postal income in 1967–68 was £359·9 million, 5·7 per cent up on the previous year while expenditure at £355·9 million showed a 6·6 per cent rise. Expenditure on fixed assets rose by 16 per cent to £27·6 million. There were no tariff increases during the year.

Fully-paid inland letters made a profit of £11·2 million and overseas letters, postcards and surcharged air mails made £5·1 million; apart from small profits from inland parcels recorded delivery services, other services incurred losses, the heaviest being on printed papers and samples (£8·2 million).

The total for correspondence posted rose another 0·9 per cent to 11,500 million items; parcels handled fell again to 217 million (down 2·3 per cent). Letters and cards posted during the Christmas-New Year period rose slightly to 1,050 million.

Despite dislocation of rail services by 1967's industrial disputes, and the bad weather of early 1968, quality of service for fully-paid letters was maintained, with 92 per cent delivered on the day of posting or next working day. About 79 per cent of parcels were delivered inside two working days (compared with 81 per cent in the previous year).

Although there was only a marginal increase in letter traffic hundreds of additional staff had to be provided for collection and delivery in new housing areas. Nevertheless, there was an increase in productivity and the number of man-hours used in handling mails fell by the equivalent of some 500 jobs.

The postal-mechanization program accelerated and £2 million was invested compared with £1·5 million the previous year. This year capital investment above £5 million is planned. Fourteen more major towns were given postcodes; this year parts of London and 25 further provincial towns will be coded.

To allow more time for using up stocks of non-standard envelopes, an extra charge for non-Post Office Preferred (POP) envelopes will not be imposed before Autumn 1969.

Sales from the Philatelic Bureau in Edinburgh, from philatelic counters in the London Chief Office and Glasgow Head Post Office, and by the StanGib agency opened in New York in September 1967, totalled £1,473,500 compared with £884,500 in 1966–67. A marketing section was set up to study and advise on the postal services from a business viewpoint; part of its work is promoting philatelic marketing overseas.

### *National GIRO*

Despite the magnitude of the task, arrangements for launching the Giro service went ahead satisfactorily and the Prime Minister opened the service on 18 October 1968. Applications for jobs with Giro on Merseyside reached an extremely encouraging level. Many businesses have quickly seen the advantages of this cheap, speedy money-transfer service and market surveys show that it will be widely used by the general public; it is expected that Giro will quickly become commercially viable.

### *Staff*

While shortage of staff persisted in London and the Midlands, continued employment of part-time staff and women helped to meet the deficiency. Recruitment of counter staff remained difficult, but improved methods of working resulting in reduced staff requirements relieved the situation.

### *Outlook*

With the new inland letter service and National Giro beginning in the autumn, 1968 is a momentous year for the postal business: the main emphasis in the immediate future will be on making these new services a success. The increases in postal tariffs in September are designed for stability in postage rates.

### *TELECOMMUNICATIONS*

Income rose by 9·8 per cent to £485·1 million. Expenditure went up by 11·3 per cent to £449·8 million and capital investment by 20·1 per cent to £290·7 million. The £43·3 million rise in income was mainly due to increased business, offset by reduced charges to customers (£10·2 million) mainly from the extension of S.T.D. Handling the increased business cost £30 million and with pay awards accounting for an extra £11·3 million and higher prices for £4·4 million the net effect was a £2·4 million reduction in profit.

The same general pattern of profitability was seen with profit on trunk calls of £59 million, offset by £21 million loss on telephone rentals and £19 million loss on local calls.

Of total capital requirements of £309 million, 43·6 per cent was met from internal resources compared with 52·9 per cent in 1966–67.

Over the five years for which the Post Office target was an 8 per cent net return on capital, telecommunications averaged 8·1 per cent return, with no major tariff increases since the raising of trunk call rates in 1963.

Changes in the economy were reflected in demand for telephones with a modest rise in the first six months but a very high level of demand and rapid expansion in trunk traffic in the second half of 1967–68.

Demand for exchange connexions was 9·9 per cent up on the previous year. The number of connexions in use rose by 6·6 per cent to 7,338,000.

At the end of March plant was available for 80 per cent of new orders but the waiting list increased to 137,000—1·9 per cent of working connexions—because of continued shortage of exchange equipment. A special review of the list is in hand. An appointment scheme, under which the customer names the day of installation (subject to plant being available) was introduced and by March four out of 10 orders were being handled in this way, most for completion inside a fortnight. Of other orders, six out of ten were completed within four weeks.

Local calls rose by 6·7 per cent, trunk calls by more than 14 per cent and overseas calls by 16·5 per cent. The proportion of trunk calls dialled by subscribers on S.T.D. rose from 59 to 65 per cent while 49 per cent of oversea calls were subscriber-dialled.

At the end of the year nearly three-quarters of exchange equipment and telephones and nearly one-fifth of stores was manufactured in Development Areas.

A record 322 new buildings and extensions—including 294 telephone exchanges—were started, 50 per cent more than 1966–67 and 184 new buildings and extensions—including 162 exchanges—were completed. Added during the year were 7,700 long-distance trunk circuits and in March there were twice as many circuits in operation as in 1962; nevertheless there was still some congestion in the busiest parts of the day. 42,000 shorter-distance circuits were also added. Contractors began installing equipment for 157 new major exchanges and extensions of 395 existing exchanges.

Reorganization of Regional and Area offices centred on teaming-up staff of different grades to work to common ends. The productivity drive continued and a system growth of 6·3 per cent and a 14 per cent rise in trunk traffic were handled by only 1·5 per cent more staff. There was again marked improvement in productivity in installation work with 37,000 more telephones installed by 1,500 fewer staff. S.T.D. extension and further conversion to automatic working reduced the number of inland operators by 2,000. By the end of March when 67 more manual exchanges had been converted, automatic local service was available to 97 per cent of subscribers. S.T.D. was extended to a further 364 exchanges and was available to 5·6 million subscribers—76 per cent of the total.

By the end of the year about one in four or five of subscribers was receiving bills prepared by computer.

Plans were completed for using computers and phototypesetting for producing telephone directories, reducing overall time for compilation and production to meet rapid system growth and changing public needs.

The proportion of local automatic calls not completed at first attempt was again reduced; on S.T.D. the overall failure rate was slightly higher because of congested plant. Average time-to-answer answering time of daytime operators was reduced for the fourth year in succession. Eighty per cent of all faults in customers' installations were cleared on the day they were reported.

The telephone information service attracted 250 million calls of which 225 million were to the speaking clock.

Trials began of the Confraphone which enables two groups of people to confer by telephone and orders were placed for the Card Callmaker, a repertory dialler using punched cards.

An experimental digital electronic exchange was built at the Post Office Research Station and installed in the Empress exchange building in London. First of its type in the world, it will switch traffic over pulse-code modulation junctions between three exchanges. The exchange was opened in September 1968.

*Telex*

The Telex service grew by 14 per cent to reach over 22,000 subscribers. Telex calls—one in three went overseas—increased 16 per cent. By the end of the year customers could dial 19 countries, with 92 per cent of oversea calls directly dialled.

*Datel*

Data-transmission services continued to expand and there were 1,900 Datel stations at the end of the year—an increase of 50 per cent.

*Outlook*

The Telecommunication service should continue to expand rapidly, the report predicts. "Efforts to minimize costs and increase profitability will continue to be pursued vigorously.... Improvements in the quality of service to existing customers will continue to have first priority."

*SAVINGS*

The total managed by the Department for National Savings rose to £6,033 million compared with £5,975 million in 1966–67. In the conversion of Savings Bank processes to a computer system the first phase, involving mechanization of Postmasters' accounts from all regions, was fully implemented in the new Glasgow HQ. The second phase, for new accounts to be processed by computer, was to go into operation in about the second half of 1968. Savings Certificate repayments were transferred from the Kensington Computer Centre to the Centre at Lytham St Annes. A good deal of preparatory work has been done to ensure a smooth changeover to decimal currency in 1971.

*N.D.P.S.*

There was steady progress on 20 data-processing projects for other Post Office services including the National Giro, the Savings Bank and telephone billing. By the end of the year over 10 per cent of N.D.P.S.' total machine time was sold to outside customers at rates corresponding to those of the private computer bureaux.

*GENERAL*

In its general section the Report recalls N.B.P.I. comments on the G.P.O.'s cost-analysis system and notes that the Post Office "agrees with the Board's recommendation that greater emphasis should be placed in future on long-run marginal costs in tariff fixing and intends to carry out the necessary studies".

Pointing to the Board's statement, in its report; "In many minor ways and a few ways that are not so minor we agree that criticisms are justified but we think that the very substantial merit of the Post Office should be recognized," the Post Office report concludes: "We realize there is much to be done to make our services as good and efficient as our customers and we ourselves think they should be. As we tackle this task these words reassure us that we have a firm basis on which to build for the future."

### Lincompex—A Baker's Dozen

The thirteenth telephone circuit between London and abroad to use Lincompex was opened on 8 October with a telephone call from the Postmaster General, the Rt. Hon. John Stonehouse M.P., in London to Mr. Dalton F. Sheers, Minister of Transport and Communications for Sierra Leone, in Freetown.

The word "Lincompex" is derived from the names of the system's components—LINked COMPressor and EXpander and describes a new type of radiotelephony terminal equipment developed and designed by British Post Office engineers to improve quality and efficiency of radiotelephone circuits and make a smoother flow of conversation possible. British firms manufacturing the equipment have already exported it to 36 different countries, and it is at present in use on circuits from London to: Nairobi, Johannesburg, Colombo, Televiv, Lagos, New Delhi, Bahrain and Buenos Aires.

The G.P.O. expects that within the next six months Lincompex will be brought into service on a further 24 overseas telephone circuits. The system has been used successfully on the liner Caronia and Cunard are to equip all their liners, including the Queen Elizabeth 2, with Lincompex.

Manufacturers are Standard Telephones, General Electric Company and Marconi.

### Mobile Telephone Exchange for Nigeria

Two mobile automatic telephone exchanges are to be given to Nigeria by the British Post Office to help the Nigerians to recover from the damage to their country's telecommunications services caused during the war.

The mobile exchanges will be employed by the Nigerian Ministry of Communications to maintain services until new equipment can be provided by manufacturers.

The two 400-line exchanges have been in service at Oldham where an equipment extension to the permanent exchange has recently been completed.

### Goonhilly Satellite Station Relays Live Television Coverage of the Mexico Olympic Games

The Post Office satellite earth station at Goonhilly Downs in Cornwall was Europe's receiving point for television transmissions—live and in colour—direct from the Mexico Olympic Games.

The television pictures were beamed across the Atlantic by a new earth station at Tulancingo, Mexico, to the United States National Aeronautics and Space Administration's ATS-III satellite in orbit 22,300 miles above the equator, and received at Goonhilly, then routed by Post Office microwave links to London and fed into the British and European television networks. Most of the programs were in colour as well as black and white. Conversion from the American colour system to the PAL system used in Britain and most continental countries was undertaken by the B.B.C.

It was originally planned to use Goonhilly's brand new second aerial to receive the television transmissions via the first INTELSAT III satellite, but the failure on September of the Thor-Delta rocket carrying the satellite into orbit immediately brought into play the previously planned alternative use of ATS-III. This involved reverting to the old No. 1 aerial which was modified to work with the ATS satellite. Adapting this aerial to cater for the alternative plan was yet another demonstration of its versatility. Commissioned by the Post Office in 1962 for the first Transatlantic experiments with TELSTAR it has been in regular commercial use since 1965, relaying telephony and television transmissions via the INTELSAT I (Early Bird) satellite.

The Mexico Olympic Games were the last major role of the now familiar aerial No. 1 installation. After the Games it was taken out of service and re-equipped to work with another INTELSAT III satellite to be placed over the Indian Ocean towards the middle of next year, providing Britain with satellite communications to India and the Far East as far as Australia and Japan. Meanwhile, the new No. 2 aerial is being adapted to take over the Atlantic service, working to INTELSAT I until the next INTELSAT III is placed successfully in orbit.

The Post Office terminal at Goonhilly is one of the first in the world capable of two-aerial operation and when both aerials are in service, Britain will have direct communications by satellite to all parts of the globe.

### Important Trunk Telephone Service Development New £1 Million Exchange Opens in Manchester

A major new £1 million trunk telephone exchange, designed to meet the rapid development of the trunk telephone service and to improve the quality and reliability of trunk calls, was opened in Manchester on 7 October by the Lord Mayor, Alderman Harold Stockdale, JP. With the Lord Mayor was the Postmaster General, the Rt. Hon. John Stonehouse, M.P.

The new exchange will handle about two thirds of the trunk calls to the greater Manchester area from other parts of the country. It has over 2,000 incoming trunk circuits and more than 3,000 circuits to local exchanges in south Lancashire and north Cheshire.

Manchester is one of the largest trunk centres in the country and serves a large part of the North of England. Trunk switching centres in the city have to handle not only calls from subscribers in and around Manchester but also all the calls coming to the region from other towns and cities and a vast amount of traffic coming from other parts of the country and being connected through to other destinations.

To meet the growth of the trunk service, the Post Office is installing two additional trunk switching units to handle calls to and from Greater Manchester, of which the new exchange is the first. The second, costing £1,500,000 at Salford, will be brought into service in 1970 and within the next five years will be providing 4,000 new outgoing trunk circuits from the city.

### Progress on P.O. Parcels Plan

Parcel-sorting machinery to cost £1¼ million is now being installed at the new Birmingham Sorting Office—one of the biggest of a planned network of parcel "concentration centres" throughout the country.

By the mid-1970s, the Post Office plans to concentrate parcel sorting on 34 of these centres, each serving a large surrounding area. At present, parcel sorting is done at about 1,200 different offices.

This reduced handling of parcels should, it is hoped, lead to a more reliable service.

The new Birmingham combined letter and parcel office is due to open in July 1970. Ultimately, it will have 20 "tilted-belt" parcel-sorting machines, together with conveyors and other associated equipment.

Similar equipment is being installed at Nottingham, where there will eventually be seven machines, and a start will be made soon on equipping another large concentration centre at Manchester, which will eventually have 15 sorting machines.

The tilted-belt machine can handle up to 2,700 parcels an hour. An operator presses a button to open a small gate, directing each parcel from the belt into its appropriate channel.

Under the new plan, parcels will be taken first to one concentration centre for sorting, then dispatched to one of the other 33 for a second sorting operation and distribution. For the larger traffic flows, wheeled containers will be used.

The provisional list of concentration centres is Aberdeen, Glasgow, Edinburgh, Carlisle, Newcastle, Preston, Liverpool, Manchester, Leeds, York, Sheffield, Birmingham, Nottingham, Derby, Leicester, Peterborough, Shrewsbury, Chester, Cardiff, Plymouth, Exeter, Bristol, Southampton, Brighton, Reading, Ipswich, Watford, Croydon, London East, Central, West and South, Slough and Belfast.

Parcel-sorting machinery is already in use at Aberdeen, Brighton, Edinburgh, Leeds, Liverpool, the North-West and Western Parcels Offices in London, Preston, Southampton and Worcester.

At Liverpool, the Post Office has installed two modern aids which will be standard features at most of the new centres —closed-circuit television to enable the central control point to keep a close watch on the amount of parcels in the storage devices, and a radio paging service for two-way contact between the controller and his supervisors.

Wheeled containers, which will play an important role in the concentration plan, are in use now to carry parcels by road from the Eastern District Office in London to 27 sub-districts, by freightliner between London and Glasgow, and between Leeds and Manchester by road.

### New Giant Cables for North Sea Routes

Three submarine cables with the largest capacity in the world are to be laid between Kent and East Anglia and Belgium, the Netherlands and West Germany in 1971 and 1972 under the GPO's current £2,000 million five-year plan for expansion. They will more than double the number of UK–European cable circuits in operation today.

The new cables will run between Broadstairs and Ostend (64 nautical miles); between Aldeburgh and Domburg (82 nautical miles); and from Winterton to the Friesian island of Speikeroog (285 nautical miles).

Decisions to lay the new cables followed the seven-nation London conference held in May 1967 on the initiative of the British Post Office. Each will carry 1,260 circuits, with two-way transistorized repeaters at intervals of just over seven miles.

At the end of 1967 there were just over 1,900 cable circuits in operation between Britain and the Continent; cables completed since then have brought the present total to 2,880 circuits giving United Kingdom customers communication with Europe (in addition to 1,200 microwave radio circuits).

With telecommunication traffic between Britain and the Continent—including telephone calls and data-transmission and Telex messages—growing at about 14 per cent annually, the three new cables are expected to cover expansion over the next five years.

All the deep-sea sections will probably be laid by GPO cableships. Contracts for manufacturing the cables and repeaters, and all terminal equipment, have been placed with Submarine Cables Ltd. The overall cost of the three projects—in the region of £3¾ million—will be borne pro-rata by the British, Belgian, Dutch and German administrations.

### Post Office Transistors for New Undersea Cables

A new generation of ultra-long life transistors, now being made by the Post Office, will be used in three North Sea telephone cables planned for the early 1970s.

Guaranteed to last 25 years, the transistors will form the "heart" of a series of repeaters at seven-mile intervals along the cables, which will run from Kent and East Anglia to Belgium, the Netherlands and West Germany.

Each transistor, made from a chip of silicon smaller than the head of a pin, will be able to amplify 1,260 telephone conversations—making it the largest-capacity submarine telephone cable in the world.

The transistors mark a new phase in the development of high-reliability devices, which the Post Office began about 16 years ago with the production of long-life thermionic valves for undersea cables.

The first Post Office long-life transistors—a smaller-capacity 480-circuit type—were installed this year in earlier North Sea cables. Others have been supplied for new cables between the United Kingdom and Portugal, Italy and Greece and Canada and Bermuda.

Now among the world leaders in this field, the Post Office began making its own valves and transistors and encouraging parallel industrial development bceause devices with a high enough reliability for deep sea use were unobtainable. A single repair in such cases could cost over £250,000 in lost revenue alone.

With Post Office work now concentrated on the new transistors, production of the smaller-capacity type is to be carried out by industry.

#### *Stringent Checks*

At the Post Office's Dollis Hill research station, where the transistors have been developed and are at present made, extraordinary steps are taken to make sure they come up to the guaranteed standard that not more than one in 500 will fail in 25 years.

The wastage is inevitably high: for every 500 transistors needed, up to 10,000 have to be made. The rest are used up or discarded in a series of stringent checks and high temperature tests aimed at showing fault-free production batches. A failure in one device could mean a whole batch has to be rejected.

The 1,300 transistors for the new North Sea cables will be given a six months' laboratory "systems trial" (equivalent to about four years' operation), while others from the same batches are put through a series of tougher tests.

One lot go through destruction tests—the equivalent of over 1,000 years' use. About half survive even this.

Meantime another batch, three times the number required, begin a six months' test to simulate many times the expected system life of 25 years.

*Sneeze Hatch*

In the temperature and humidity-controlled laboratory where the transistors are made, engineers have to change into special clothing. Filtered air is blown across their benches—one speck of dust could ruin a transistor. If anyone wants to sneeze he has to go to a special "sneeze hatch" in the laboratory's air exhaust system.

Each transistor is numbered and colour-photographed to aid checking and identification of possible faults. A computer helps with calculations.

Of the 3,000 long-life valves made by the Post Office over the years and put into service in deep water, there has been only one failure in 145 million valve hours of service.

Transistors offer advantages of even greater reliability and circuit capacity.

Long-life, high-performance transistors have, with other technical developments, reduced tenfold the cost of providing submarine circuits since the first trans-Atlantic cable went into service in 1961.

## Co-ordination of Underground Services – Common Trenching

The Directorate of Building Development of the Ministry of Public Building and Works, as part of its overall interest in the construction industry, is studying the problem of site works.

The study has revealed a pressing need for much better co-ordination between the public utilities and the builder when distribution mains and service connextions are installed. There is a particular need to rationalize existing means of installing underground mains and connextions to meet current trends in site layout and methods of construction.

*Technical Bulletin*

One form of rationalization, "the common trench", in which different types of mains are layer-stacked in close proximity to each other, has been studied in detail by a group representing the public utilities, the builder, the developer and his design staff. The results of the study so far are published in a Ministry of Public Building and Works technical bulletin, "The Common Trench," on sale through H.M.S.O. price 3s. 6d.

The bulletin gives guidance on such matters as design, working and safety distances between the services and alternative methods for making house connextions. The feasibility of common trenching is shown in the bulletin to be dependent on operating a zoning system on either side of the centre line of the trench which gives the statutory undertakers space to install valve pits, fire hydrants, disconnecting boxes, jointing pits etc.

*Common Trenching*

Common trenching—two or more utilities distribution mains in a single trench—has been developed principally to overcome the problems of providing underground services in high density, low rise, vehicle/pedestrian segregated layouts where space is often limited and routes not clearly defined. The main claims for common trenching are:

(*a*) Installation of underground distribution mains and service connextions can be more effectively co-ordinated with the building process.

(*b*) Distribution mains are installed to a definite line and level in relation to each other and their surroundings, thus reducing the likelihood of damage during construction and making location for maintenance easier.

(*c*) Mechanical plant can be used to a greater extent than is possible when mains are laid individually in adjacent trenches.

*Joint Labour Force*

To reap maximum advantage from common trenching calls for a degree of co-ordination between the public utilities in laying mains not generally achieved with existing methods. The close knit organization required could, however, be provided either by the emergence of the multi-skilled contractor approved for laying all types of distribution mains needed on building sites or by a joint public utilities labour gang under unified direction.

*Designer's Role*

The designer's role, as the initiator of the project, centres round the need for consultation with the public utilities at an early stage in the development of the site layout, to clear problems peculiar to the site and the type of construction proposed.

*Builder's Role*

The building contractor should make realistic allocations of time in his building programme for the installation of distribution mains and service connextions. Once agreed, the builder should keep to the program, apart from unavoidable changes which must be notified to the public utilities in sufficient time to minimize disruption of their work schedules.

*Management Studies*

Site studies have shown that co-ordination is most likely to run into difficulties over day-to-day communication between the builder and individual utilities. This and related problems of co-ordination are receiving close attention and will be the subject of further bulletins.

*Post Office Considerations*

The Post Office has had a representative on the study group which produced this Bulletin. Copies of the Bulletin are being sent to each Area and Region for comment.

## Computer to Study Humans

A computer is to help shape the telephone of the future—by aiding research into "human factors".

The on-line process control equipment, embodying an Elliott 900 series system, will be installed within the next few months at the Post Office's Dollis Hill research station.

By taking over aspects of experiment control and the laborious task of processing and analysing results, it will enable the Post Office to speed up its human factors research in telecommunications.

Among the computer's first jobs will be experiments, using volunteers, aimed at showing the best design for a push-button telephone—still some years in the future.

Factors such as the layout of the keys and their "feel" (how soft should the spring be, how much movement when it is pressed?) will be studied.

Knowledge gained about the duration of each keying "contact" and the time lapse between them, will be invaluable to engineers designing future electronic exchanges.

Studies already started into the time it takes people to key or dial numbers, and their error rate, will be continued by the computer.

Another experiment—part of an extensive program of research planned—will be to see whether it would be worth while having a display unit to tell a subscriber calling a long number what digits he has dialled.

Human-factor research at Dollis Hill has already resulted in a change in the design of coinboxes, making the dial two inches lower and tilted at a shallower angle.

The new computer will be the third at Dollis Hill, and the fifth to be used by the Post Office for research purposes.

# Notes and Comments

## L. R. F. Harris, M.A., C.Eng., M.I.E.E.

The appointment of Roy Harris as a Deputy Director of Engineering provides the first leader of the Advisory Group on System Definitions. This is a new joint Post Office/Industry body charged with finding methods of specification for telecommunications plant suited to the changing needs of the Post Office, Post Office customers, and export business, and to the emerging technologies affecting telecommunications, notably microelectronics and computers. To his new post he brings over twenty years' experience in electronic switching research and development, including the early time-division systems, reed-relay space-division systems and, most recently, p.c.m. switching. His inventions and papers have earned him international recognition.

His specialist knowledge will be valuable in his new field for, though he will be concerned with all aspects of telecommunications, it is in the complexities of switching system organization that the problem of specification are most severe and the potential benefits are perhaps greatest.

A man of vision, with a high sense of service, he is demanding of himself; with others he is patient and always helpful. Direct in manner, fluent and with a great capacity for close reasoning, tempered with humour and understanding, he has gained the respect and affection of colleagues in Post Office and Industry. We wish him well in his important new work and we hope that it will leave time for bridge, cricket and Wagner.

H. B. L.

## T. Nicholson, C.Eng., M.I.E.E.

Many readers of this Journal will be meeting Tom Nicholson across the Promotion Board table in the coming years, since, on promotion to Staff Engineer, he has taken up duties in the Telecommunications Personnel Dept. of T.H.Q.

Few men could have come from a background more suited to the demands which the new job will make on him. Starting as a Youth in Training in Peterborough he stayed in the Midlands until the War, by which time he was an Inspector in the Superintending Engineer's office, Nottingham, dealing with installation, trunking and grading.

The War years were spent in the R.A.F., working on the Home Radar Chain and, after a short spell in the old Equipment Branch Economics Group, he returned to the R.A.F. as a liaison officer throughout the 1950s and early 1960s. During this period he held the rank of Senior Executive Engineer. In 1962 he joined Local Lines Branch on Long Term Planning and was Secretary of the Terms and Symbols Committee. The following year he was promoted to Assistant Staff Engineer and his involvement in personnel work began—first on Recruitment of Open Competition Engineers and then as Regional Engineer (Staff) in the Eastern Region.

Tom Nicholson brings to his new job a shrewd ability to judge men and a somewhat irreverent sense of humour. Both will be invaluable to him in his new post.

C. A. M.

## F. C. Haliburton, M.I.E.E., M.B.I.M.

Mr. F. C. Haliburton, who has been appointed Telephone Controller in Northern Ireland, entered the Post Office as a Probationary Inspector in 1928. After a short training period, he joined the Superintending Engineer's Office of the North Midland District in Nottingham, where he dealt with line plant and other matters. In 1936 he was promoted to Chief Inspector, and later, in 1937, Assistant Engineer (Old Style), in the Lines Branch of the Engineer-in-Chief's Office in London where his speciality was the economics of line plant provision. On his promotion to Executive Engineer (Old Style) in 1944 he was seconded to the Contracts Department as a Senior Technical Costs Officer, an experience which brought him into close touch with industry. In 1948 he was appointed Area Engineer in Canterbury in charge of maintenance and installation and in 1957 he was promoted to Regional Engineer North Eastern Region, responsible for external planning and works and financial estimates. In 1965 he was promoted to Regional Engineer and Telecommunications Controller in Northern Ireland.

Fred Haliburton is a kindly man who throughout his career has shown a profound interest in the well-being and development of all ranks in the Post Office. From the early 1940s until 1952 he held office in the Society of Post Office Engineers in which he had the unique distinction of serving successively as General Secretary, Editor, and President. In what spare time he gets, he plays golf (Captain of the Northern Ireland Post Office Golfing Society in 1968) and pursues his hobbies of photography and reading.

Northern Ireland is indeed fortunate to have a man of such wisdom and experience to take charge of the reorganization of its telecommunications business at this time.

G. H. C.

### Board of Editors

Mr. R. P. Myhill has resigned from the post of advertisement manager and the Board wishes to express its appreciation of his services. The Board are pleased to appoint Mr. N. G. Crump as the new advertisment manager.

### Binding the Journal

The service that we have been able to offer Journal readers who require their Journal bound has become slower and slower in recent years, and this has led to many complaints. One of the causes of delay has been that it is necessary to collect together a minimum quantity for binding by a wholesaler. To give readers a better service it has been decided that in future the Journal will not handle orders for bindings, but readers are recommended to send their volumes direct to the bookbinders, Messrs. Press Binders Ltd., 4 Iliffe Yard, London, S.E.17. A remittance for £1 17s. 0d. should be included (£1 12s. 6d., for binding plus 4s. 6d. return postage). This is higher than that previously charged by the Journal, because the old price was partly subsidised and also because it is necessarily more expensive to make a book from the type of binding now used for the Journal.

### Supplement

Students studying for City and Guilds of London Institute examinations in telecommunications are reminded that the Supplement to the Journal includes model answers to examination questions set in all the subjects of the Telecommunication Technicians' Course. Back numbers of the Journal are available in limited quantities only, and students are urged to place a regular order for the Journal to ensure that they keep informed of current developments in telecommunications and receive all copies of the Supplement.

The City and Guilds of London Institute have now included three new subjects in their Telecommunications Technician's course. They are Computer Technology A, B, and C. Because of the importance of these subjects it is proposed to publish model answers to the 1969 and later examinations in the appropriate issues of the Supplement to *The Post Office Electrical Engineers' Journal.*

### Model Answer Books

Books of model answers to certain of the City and Guilds of London Institute examinations in telecommunications are published by the Board of Editors. Details of the books available are always given at the end of the Supplement to the Journal. The books at present available include recently published editions of Telephony and Telegraphy A (February 1967) and Telecommunication Principles A (January 1968).

A new book, providing answers to recent questions set in Line Plant Practice A has now been prepared and it is expected to be available in January 1969. In addition to helping students, the book brings together information useful to those working in the field. The book contains 128 pp. and the price is 10s. (post paid).

# Regional Notes

## South Eastern Region

*Computerized Production of Exchange Performance Data*

With the current emphasis on management by objectives, it was felt that some benefit could be gained by displaying the fault statistics for each exchange in the form of pillar-graphs every month, and exhibiting them in the exchanges. This would enable abnormal trends to be detected at an early stage and appropriate remedial action taken.

Form A51 is normally produced quarterly and requires the calculation of 13 fault indices using data consisting of 21 figures from each exchange. Figures for individual U.A.X.s are not calculated, U.A.X.s being treated as a group. In addition, totals are required for individual repair-service controls and the Area as a whole, and these totals are also required to be expressed as sub-totals of U.A.X.s, non-director exchanges, and large manual exchanges. Reports carried forward also have to be expressed as percentages.

Although the calculations are simple, the quantity of work involved is considerable and to do this monthly—particularly for individual U.A.X.s—would entail an immense amount of clerical labour. It was, therefore, decided to experiment with the use of a digital computer to produce the figures, which could then be copied straight onto the standard forms.

Brighton College of Technology agreed to rent computer time to the Area, at an average cost of £4 per month. The necessary program was produced in the Area at an expenditure of some 48 hours of an executive engineer's time. The project began in April, and has been working successfully since that date. In addition to producing the monthly figures, it produces a quarterly summary every three months, and for the Area sub-totals and grand total it also gives the running average from April to the end of the preceding month.

At present the necessary input data is obtained from forms A29 submitted by the repair-service controls. A field trial is about to be run by Telecommunications Headquarters to produce forms A29 by computer, and it is hoped that some means of interconnecting these two programs may be possible so that the A51 can be produced from the original fault dockets, using mark sensing techniques, with a minimum of intermediate processing.

G.M.B. and R.B.

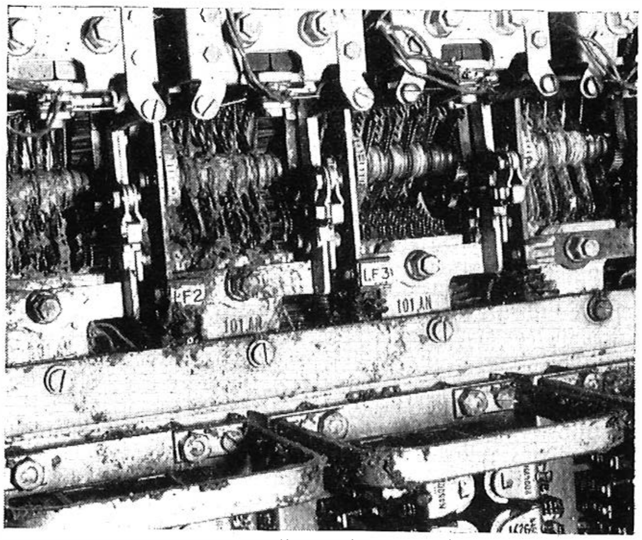
## Eastern Region

*Scole Exchange—Isolation by Flooding*

On the morning of Monday, 16 September 1968, after a period of very heavy rain, the U.A.X. at Scole, Norfolk, was flooded, and all telephone communication was cut. Over 4 in of rain had fallen in less than 24 hours, but there was no sign of any trouble until the incoming junctions at Diss ceased working at about 0820 hours. By this time a member of the staff had managed to get to his headquarters, and report that there was about two feet of water around the U.A.X. building.

Scole U.A.X. during flooding

The maintenance A.E.E. reported the use of a mobile U.A.X. was out of the question, as the exchange footway jointing-box was under water, which was still rising. There was nowhere that water could be pumped from the box as the whole surrounding area was flooded.




Damaged line-finders at Scole

Fortunately, a small automatic exchange (S.A.X.) was being installed at another site in the village, to meet increased demand and to provide S.T.D. facilities. This had not been tested, and no junctions were connected, although construction was at an advanced stage. It was decided to open the S.A.X. since the underground cables had been cut in and transfer arrangements had already been made by the construction staff. S.T.D. could not be provided as this awaited further work by contractors in Diss exchange. At this stage it was not known which cables were affected by the floods, and the exchange maintenance lineman was sent to test from the new S.A.X. Fortunately there were no cable faults, and immediate steps were taken by the construction staff, working in close co-operation with the maintenance staff at Diss exchange, to get some junctions working. Meanwhile customers' lines were being checked, and the exchange equipment given a simple functional test by other members of the staff.

Lines were restored in priority order, emergencies first, and then those listed in the traffic list of preference lines. A skeleton service was provided by 1425 hours when emergency customers could dial Scole and engineers could pass messages on an exchange line that had been connected to Diss, via the junction cable.

By 1645 hours, level 100 was available from the S.A.X., and by 1830 hours, level 9 circuits and an incoming service were in operation. At 1930 hours all coin boxes had been given service. This had been delayed because the necessary relay-sets had not yet been provided at Diss exchange. To overcome this, the staff at Diss modified relay-sets to take the coin box O-level traffic. Since a change was being made from U.A.X. 12 to an S.A.X., a completely different junction arrangement was necessary as well as a change of code from 0 to 100 for calls via the operator.

Throughout the period from 1645 hours, customers were being called and advised of the change, and by about 2200 hours 80 per cent of the 130 lines had been connected. In view of the hour, no more were called until the next morning. By 0400 hours on the next day, all lines had been reconnected and by 0900 hours all customers, except six with faulty lines, had been contacted.

To save time, the meters were photographed, and cards advising customers of the change of dialling were taken to the postmaster at Diss for delivery first thing on the Tuesday.

It is interesting to note that service had been restored so quickly, that many of those called, expressed surprise that their lines had been out of order. The area served is 100 per cent rural, and straddles the busy A 140 road from Norwich to Ipswich. The work done by our engineers was speedy and efficient, and great credit is due to them for their efforts to restore service.

L. D. B. and J. K. R. S.

### Northern Ireland

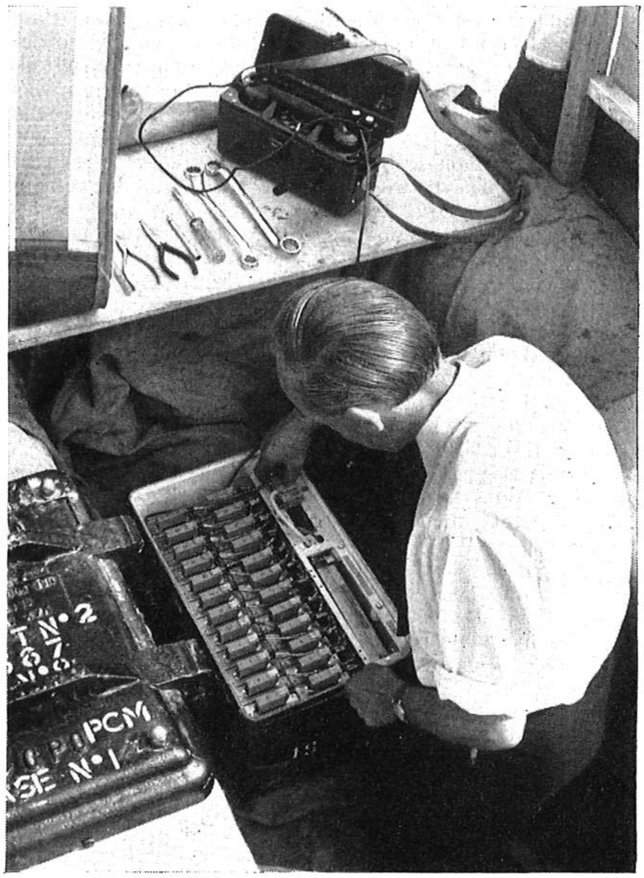
*First P.C.M. Route Installed by P.O. Labour*

The first route selected for initial p.c.m. trials was between Belfast and Bangor with director exchanges served by a 294-pair cable provided in 1960, and due for circuit relief. The route mileage is 12·6 miles with loading at 2,000 yard intervals.

Eight p.c.m. groups were provided using single-cable working. The interception of 48 cable pairs at 11 amplifier points provided for maximum future development of the route without further cable interception work.

As the loading coil manholes are located in the carriageway, surface jointing-chambers were built adjacent to the manholes to contain two repeater cases. It is considered that the cost of these additional joint boxes was amply repaid by the savings achieved during installation and commissioning.

Insufficient spare cable pairs existed to provide the total requirement of 32 digital-link sections (D.L.S.) in a single operation, and commissioning was therefore carried out in two stages by providing three p.c.m. groups on eight D.L.S.s and transferring circuits into these groups to free the remaining cable pairs. Cable testing on regenerator sections was carried out with mains-operated test equipment for which the power was obtained from 110-volt portable sets. During these tests, air blowers were used to maintain a good insulation standard in the repeater cases.




Installing a repeater

During stability tests digital-link errors were discovered. Cable crosstalk or noise spikes on the 50-volt exchange power supply were suspected and the terminal equipment No. 2000A at each end of the route was then power-fed by car batteries and power units 52A. The link sections were then monitored and found to be free of errors. A subsequent modification was carried out to the terminal equipment to render it less sensitive to noise spikes in the power supply.

During call-through tests it was discovered that calls set up via signalling system D.C. No. 2 and p.c.m. links in tandem caused relay interaction on called-subscriber answer conditions. A temporary modification in the outgoing p.c.m. signalling units eliminated this difficulty.

These defects have been advised to Telecommunication Headquarters who have made arrangements for retrospective modifications to be carried out on the items of equipment concerned.

The planned program of operations was maintained throughout all stages of the work and the first groups were ready for service on 30 July 1968. This is the first direct-labour installation to be brought into service in the U.K. and for this achievement we are grateful for the close co-operation given by local and THQ staff and the equipment manufacturer who delivered all stores on target.

J. M. P.

### North East Region

*Experimental Use of 174-Type Coaxial Cable as a Subaqueous Cable between Grimsby and Hull*

The standard 174A-type coaxial cable was chosen for the Grimsby–Hull No. 7 Humber River crossing between Lincoln and York Telephone Areas. The only additional protection given to what was otherwise a standard cable was a heavier lead sheath and a single steel-armoured layer covered with hessian.

Only once previously had this type of cable been used, when a 500-yard length was laid across the river Tamar in 1967. The Humber project involved the contractor, B.I.C.C., in producing a single drum length of 3,345 yards of cable. This presented the cable contractor with manufacturing problems and the Post Office needed to develop methods to deal with the difficult Humber crossing.

Submarine Branch arranged the charter of a 260-ton craft as a cable vessel, together with a 40 ft launch to be used as a tug. Special sheaves had to be fitted to pay off the cable from the stern of the cable craft. An up-to-date sounding survey was obtained from Humber Conservancy Board as well as a survey launch to assist in piloting the course of lay. The board also arranged to maintain contact between the pilot launch and Hull Radio for information on river traffic during the operation.

Before the operation, Lincoln Telephone Area was required to bury two existing carrier cables on the south side of the river to avoid damage by the cable-laying craft. The existing cable-marking beacon was also to be used as a temporary anchor during laying of the cable. Temporary mooring posts had also to be provided on either side of the beacon.

A new joint box with armour-clamp anchorage had to be provided to a specification by Submarine Branch. The Lincolnshire River Board stipulated that ducting of cable through the river bank should be done in such a manner that not more than half the bank be cut through at a time and back-filling should be employed.

York Telephone Area was committed to provide two beacons, one permanent and one temporary, to give line of sight to the cable-laying craft. The temporary beacon was to be used as a mooring post, but two additional mooring posts were also to be provided to meet contingencies. Additionally, in case of adverse weather, floodlighting was to be made available to illuminate the beacons. As on the Lincolnshire side, a new joint box had to be built and the cable had to be trenched from this box down to low-water mark.

The drum of cable from B.I.C.C. works was delivered to Hull docks on 13 September 1968. The gross weight of the cable and drum was slightly in excess of 20 tons; the weight of cable alone was 17·8 tons. The drum dimensions were 11 ft 6 in overall diameter, width 6 ft 3 in with flange width of 6 in.

Off-loading from the drum into the craft commenced at 0800 hours on Monday, 16 September. After jacking-up, the drum was turned by a plummet winch, using an endless rope with a double bight round the drum flange. Loading was completed by 1900 hours.

The cable was laid from Barrow Haven on the south side of the Humber to New Clough on the north side of the river. Laying commenced at 1330 hours, approximately, at Barrow Haven, two hours before high-water mark. After landing the shore end of the cable, some difficulty was experienced due to strong tide and adverse fresh-water conditions, which tended to slew the craft off course. The main concern was to avoid excessive bends in the cable, which was susceptible to damage because of the dielectric structure of the tubes.

The craft left Barrow Haven at approximately 1430 hours and made faster time on the crossing to New Clough than had been anticipated, with the result that, instead of meeting slack water as planned at the York side of the river, the tide was still making. This again caused some difficulty in mooring in the correct position for paying-off the cable; however, the craft was finally moored some 30 yards from the water's edge.

With the help of the launch the cable was fed off the craft in a large bight, handed to the shore personnel, and the end finally brought ashore at approximately 1600 hours. The cable was continuously tested fron Barrow Haven during the lay of the cable. Excess cable was cut off and end-to-end tests made with satisfactory results.

After having successfully accomplished this crossing, Submarine Branch have indicated that this method might be standardized for water crossings.

F.M.

*Leeds and Its Trunk Circuits*

The opening of the Leeds Westgate automatic trunk exchange with 6,000 trunk circuits calls to mind how Leeds led in the past with the provision of trunk circuits. One of the earliest, if not the first, successful trunk line to be brought into use for commercial purposes was provided by overhead wires between Bradford and Leeds in 1880. It took two years to complete the arrangements between the United Telephone Company and the Postmaster-General, and the circuit was put into service in 1882. In 1886 a Leeds–Manchester circuit was provided.

In the early days the licences issued by the P.M.G. to the telephone companies strictly limited their operations to a definite radius of three, four or five miles from a stated centre; they were not allowed to provide circuits to exchanges in other towns. It was feared, even at that time, that the telegraph service might suffer from the competition of the telephone, particularly on long-distance routes.

Before 1890, provincial towns had more trunk circuits than London. In 1889, London had only one long-distance circuit—to Brighton; but towns in northern England, the midlands and southern Scotland, were well interconnected. Later a trunk line was set up from London to Birmingham, which required a new pole route for 130 miles. Four pairs of 150 lb/mile copper wires were erected to give two circuits to Birmingham, one to Liverpool and one to Manchester. In 1896, the Post Office planned a backbone trunk system. The longest and most important circuits, such as Glasgow–London, Leeds–London, Glasgow–Leeds, Carlisle–Leeds and Belfast–Dublin, required 800 lb per mile conductors—as thick as a pencil!

The first telephone exchange in Leeds was provided by a Halifax firm, Blakey and Emmott. It opened in the Royal Exchange building in July 1880 with 30 subscribers and the annual subscription was £12. Then the United Telephone Company came along and wanted to provide a telephone exchange, but the Mayor would not allow two exchanges. The upshot was that the United bought out Blakey and Emmott and their systems at Bradford, Halifax and Leeds. In August 1880, their exchange was opened in Commercial Buildings and Blakey and Emmott's exchange and subscribers were gradually absorbed in the U.T. Co.'s system.

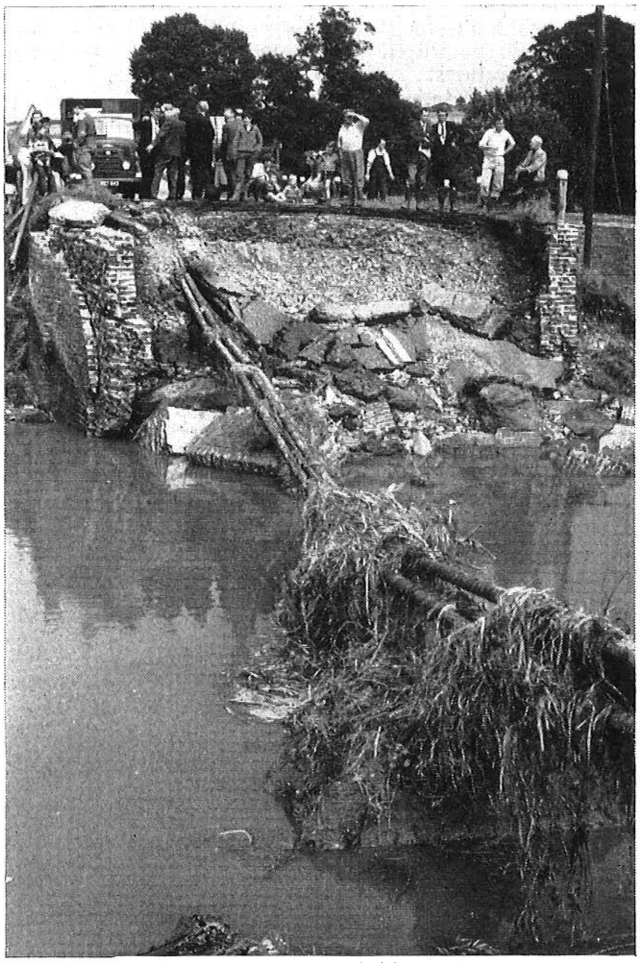
J.A.H.

## South West Region

*Fenny Bridges' Storm Damage, Exeter*

Late at night on 10 July, the small leat bridge carrying the main A 30 trunk road was washed away by flood water from the nearby Otter river, following torrential rain. The following morning, an 85-foot gap, spanned only by five twisted and bent steel pipes containing six main cables, interupted the main holiday route for the West Country. The Exeter–Honiton No. 3, on the west side of the gap had a spur to nearby Feniton U.A.X., which was isolated by the failure.

The remaining cables were still working, although endangered by the weight of debris and steel pipes still surrounding them, and further widening of the gap. Inspection of the



The damaged bridge

manhole on the east side revealed a serious crack in the wall, the manhole being almost at the edge of the gap. The cables, especially the coaxial cable, were quite taut. Transatlantic cable channels were in the carrier cables and their other route was also known to be on temporary cables, due to the North Devon–Bideford bridge collapse some months earlier.

Arrangements were made to get interruption cable on site, and staff tried to secure the steel pipes in their existing position until some better means of supporting them could be devised.

The first essential was to restore service to the stricken village. By another stroke of good fortune, a new cable had been laid and was not yet in service. It was changed out with the faulty cable and the isolation cleared at approx. 1600 hours the same day. Meanwhile, two temporary poles were erected to carry the coaxial and carrier interruption cables, and some coaxial lengths laid out and jointed ready for use as interception cable. Other coaxial interruption cables were being sent from the Plymouth Area. The steel pipes were initially supported by lashing 14 s.w.g. steel strand around them in the manner of a lashed aerial cable, and anchoring it back to the anchors in the manholes; only slight lift was provided at this stage, pending the availability of better support. The manholes on either side of the bridge position were likely to be covered by the new Bailey bridge and so interruption cable was continued to the next manholes to the east and west of the incident.

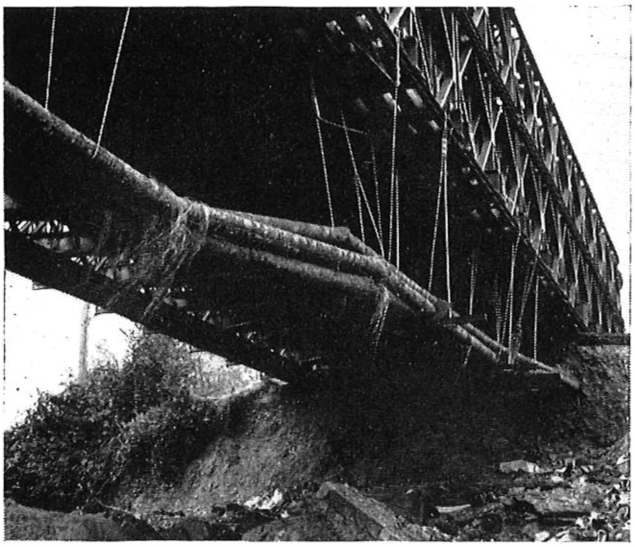
Friday saw the Royal Engineers commencing the erection of the Bailey bridge from the eastern side.

Opportunity was taken to excavate for a replacement manhole clear of the temporary bridge structure on the west side. This was to provide the termination point for a new duct track when the final replacement bridge was provided, and to enable the road to be crossed to the south side with four steel pipes to accommodate the interim interruption lengths that would be required.

The south side was chosen when it was known that the Devon County Council were to provide another temporary diversion road on the north side. Footway outriggers were also to be fitted to the Bailey bridge on the south side, which could provide improved cable supports clear of final bridge erection operations.

The existing cables therefore had to be intercepted in the six-weeks period before the permanent bridge repairs started. The coaxial cables were intercepted in the early hours of Saturday and a watch kept upon the bridge building operations immediately above the damaged track. Temporary polythene-sheathed cable to substitute the carrier cables, if this proved necessary, was erected over the gap until the steel ducts had been supported. It was later recovered on the grounds that a proper cable laid from the new manhole and via new interim bridge supports would be less disruptive to service.

On Saturday morning the Bailey bridge was seated in its correct position, and we were able to attempt to support the steel ducts and cables. The broken one was cleared away and a series of aerial-cable bolts and bollards hung from the underside of the bridge; loops of steel suspension wires were passed around the pipes and taken via their pulleys to either end of the bridge (three to each half) and attached to chain-pullers. Second chain-pullers were also attached in order that individual wires could be tensioned as required. Before lifting commenced, careful inspection was made of the cables exposed at the gaps in the steel-pipe joints.



Steel pipes supported by the Bailey bridge

Once the loops were under tension the original lashing was recovered and lifting started satisfactorily. It was soon observed, however, that the bolts holding the pulleys were bending and liable to fracture, and open loops were then made direct from the bridge structure to hold the steel pipes whilst each was raised separately. It was hoped that the steel pipes would marry up with each other as the lifting proceeded, and this happened in most cases. Two of the steels were so badly bent that lifting beyond a certain height only aggravated the difference between the pipe ends and a compromise had to be reached. Originally it was proposed to support the steels on stay rods beneath the bridge, with four-way arms forming a cradle for the rest of the pipes. It was only possible to provide four of these, one at the east end and three at the west end; the centre and bent pipes were left suspended by a combination of individual and full-loop suspension steel wires. The operation was performed quickly and extemporary adaptations made to meet the problems as they arose. Whilst the supports were not elegant, they did afford reasonable security for the six-week period required to complete a more permanent interruption ductway across the bridge. Permanent bridge renewal is expected to take at least 18 months. The Bailey bridge was open to traffic at 1545 hours on Saturday, 13 July. The willing co-operation of road authorities, army, villagers, and all staff concerned is most gratefully acknowledged. It is worth recording the comment of an onlooker: "It's a pity the bridge hadn't been built like G.P.O. cables."

Later, 10 days after this, another bridge collapsed near Stockland Repeater Station, leaving the main cable route exposed again. This time, damage to Post Office cables was avoided completely and the old track was secured temporarily in preparation for inclusion in the new bridge under construction.

O.P.M.

## Scotland

*Opening of the First Electronic Automatic Telephone Exchange in Scotland*

The first electronic exchange in Scotland was brought into service at Bishopton, Renfrewshire, in the Glasgow Area on 16 September 1968.

To mark the occasion, the Assistant Postmaster General, The Rt. Hon. Mr. J. Slater, M.P. was invited to open the new exchange and to make the inaugural call to Lord Hughes, Joint Parliamentary Under Secretary of State for Scotland at Dundee.

The exchange, which is of the TXE 2 type, was installed by G.E.C. and has an equipped capacity of 1,000 subscribers with an ultimate capacity of 4,000. The 700 subscribers who are now connected to it were previously served by a U.A.X. 13 and already had S.T.D. facilities.

The Lord Lieutenant of the County, along with some 50 or more people representing local interests, members of the Post Office and contractor's staff, staff-side representatives, the press and television reporters, attended the opening ceremony and reception.

As the exchange building was too small to house a function of this size and there was no suitable accommodation in the vicinity, the reception and ceremony were held in a 60 ft by 30 ft marquee, hired from a local firm and erected in the grounds of the telephone exchange. In addition, provided in the marquee, there were a number of displays publicizing the work of the Post Office. The opening of the exchange to the public on the day following the transfer drew forth a very enthusiastic response, and considerable interest was shown locally.

There were two very anxious moments during the two or three days prior to the opening. On the Friday evening before, a fault condition developed, which prevented any calls being routed through the exchange, and which took some time to locate. Circuit modifications have now eliminated this source of trouble. Furthermore, a few hours before the opening ceremony, there was a radio-link failure which affected outlets from Glasgow to Dundee. However, this was cleared in time and the opening proceeded without further mishap.

The opening of the exchange, and the ceremonial arrangements, required the co-ordinated efforts of many members of the staff, and the success of the operation was a measure of the standard of co-operation and effort given.

At the time of writing, the exchange has been in operation for more than a fortnight, and is working satisfactorily.

S.T.M.

*Diversions for Road Works in North West Scotland*

Interruption cables laid during the extensive road reconstruction in the north west have been subject to considerable damage due to blasting and earth-moving machinery. A policy is now being adopted to lay the interruption cable as much as half a mile away from the line of the road operations. With the kind of terrain encountered, however, this brings problems of its own. For instance, conditions reminiscent of the Burma jungle were encountered by the external working parties recently, when called upon to lay interruption cables through the dense forest, bog and waist-high undergrowth near Loch Maree. Three cables (including Scotice) were laid in surface polythene duct over a 3-mile stretch about half a mile up the hillside, away from the road operations. It was extremely heavy going for the men engaged on it, and to add to their discomfort, it was very hot weather. The use of mechanical aids was limited because of the conditions, nevertheless a caterpillar tractor with winch and a portable Plumett winch mounted on a sledge took some of the back-breaking work. The drums of cable on sledges were hauled by the tractor as far up the hillside as it could go, and with the tilt sometimes taken by the tractor, this was a breath-taking operation. When the drums were required to be moved further, the tractor winched the sledges through a snatch-block fixed to a tree higher up. The draw rope was manhandled over 250-yard sections and the tractor winch, or the Plumett winch, depending on which could be got to the next pulling point, then pulled the cables through the undergrowth and across ravines. Finally, split polythene duct was levered over the cables. Extensive use of portable radio was made, in fact was essential to keep the various parties in touch in the forest. Use has also been made of the "Snow-Track" vehicle on similar jobs, but where there was less undergrowth.

J.J.L.

*Prefabrication Applied to U.A.X.* 13 *Installation*

The internal works program, especially that of U.A.X. conversions, is frequently bedevilled by stores shortages. When the buildings in which to install the limited stores available are also delayed, the problem of providing a continuity of work for the allocated labour force arises. Such was the case in the Aberdeen area and it was decided to hold a trial in order to assess the potentialities and practicability of prefabrication to U.A.X. 13's in standard Bl wooden buildings.

Echt exchange, approximately 14 miles from Aberdeen, was chosen. At present it is a U.A.X. 12 in a standard A-type building and is due to be converted to U.A.X. 13 housed in a Bl type building erected on the same site. Two A units and a C were assembled at the Telephone Engineering Centre, bolted together, and all inter-unit cabling, wiring and terminating was done *in situ*. An additional length of angle iron with two lifting shackles was bolted along the top and, other than doubling the number of inter-unit bolts to provide added longitudinal rigidity, no special measures were taken.

The dimensions of such a combined structure were such as to preclude erection by conventional methods. It had, therefore, been decided that installation would have to be carried out during the building erection stage by either leaving an end wall, or the roof, off and hiring a crane.

The external works supervisor maintained a close liaison with the builder who readily agreed to co-operate, stipulating only that, once installed, the structure should be capable of movement to allow fixture of floor tiles and internal cladding. Once the erection date was known the problem was merely one of logistics. The units were taken to the site on a low-loader and a hired crane with a 30 ft jib, capable of lifting 2 tons, dropped them in position in a matter of minutes (the combined weight of the units was ¾ ton). To allow the mobility required by the builder, each end was supported on a pair of wheels capable of being inserted and jacked up on site by two men. Added lateral stability was provided by a stabilizer bar bolted under the middle unit. The whole was encased in a polythene sheet and covered by tarpaulins, and by the following day the outer shell of the building had been erected.

In conclusion, it may be found that measures adopted as an expediency may sometimes prove generally useful if the volume of work is sufficient and they also demonstrate some worthwhile cost saving. In this case, the saving in ineffective time of £15 per week more than offset the additional expense of £7 10s. 0d. for hire of crane. It is thought that the large numbers of similar buildings in the future program could warrant further trials, although it is appreciated that each case needs to be examined beforehand and some degree of organization and liason is necessary. It would appear reasonable that one C and three A units could be safely installed together, and there is no reason why other units could not be erected simultaneously with the maximum amount of pre-wiring and cabling carried out at a central depot.

In addition, much of the backbreaking work required to manœuvre the individual units into the building is avoided, with less staff and greater safety.

J.C.M.

# Associate Section Notes

### Ipswich Centre

Our Summer program got off to a good start once again, with a visit, in May, to the offices and printing works of the *East Anglian Daily Times* in Ipswich. This East Anglian newspaper has one of the largest circulations in the provinces and we were very interested in the many up-to-date techniques, such as computerized type-setting, employed in this industry.

In June we visited the factory of the British Aircraft Corporation, Weybridge, Surrey, and spent a fascinating afternoon touring the production lines of such aircraft as the VC10, BAC One-Eleven and, of course, the Concorde. Despite all the hustle and bustle of the modern factory, one kept getting glimpses of the past such as the old Brooklands motor-racing circuit, within which the factory was built, and disused and rusting airframe jigs for such famous aircraft as the Spitfire and the Wellington.

A motor treasure hunt also took place in June and, although the evening was chilly, most members were warmed by the barbecue which awaited them at their destination.

In July, we had an outing to Great Yarmouth for members and friends, to see a summer show; this has proved a popular item in our summer program for several years.

Our travels took us to the Felixstowe Dock and Railway Company in August, where we were able to see how a family business has grown into a thriving port handling many tons of container traffic and petroleum products every day.

The last visit in our program was to the Guinness Brewery, Park Royal, London, in September. Here, after walking what seemed like miles viewing the various stages of brewing, our members were compensated by a generous sample of the products and hospitality of the Company.

R.L.B.

### Hemel Hempstead Centre

The inaugural meeting of this new centre was held on 15 May 1968. Mr. J. H. Facer (President) and Mr. F. Weston gave an interesting talk on "Future Developments of Telecommunications in the Bedford Area."

The following officers were elected: *Chairman:* Mr. G. Thompson; *Secretary:* Mr. J. D. Doggett; *Treasurer:* Mr. P. G. Freeman; *Committee:* Messrs. Crowley, Foward, Gingell, Shirley.

Membership now stands at over 60. The winter program began with a film evening which included the G.P.O. award winning film *Night Mail.* A trip to Southampton docks and, in October, a tour of the *Queen Elizabeth* proved very successful.

Future events include visits to: B.B.C. Television Centre; Post Office Tower; *Daily Express*; Control Tower, Heathrow Airport, London. These are open to all members of the centre. Anyone wishing to join may obtain an application form from any of the committee members.

P. G. F.

### Aberdeen Centre

The 1968-69 session commenced with a day visit to Standard Telephone & Cables Ltd, Crossbar Division, East Kilbride, on 18 September. Seventeen members took part and all enjoyed the interesting three-hour tour of the factory. In the factory we saw the complete process of construction and assembly of crossbar switches from the winding of relay coils to the final testing of the equipment.

R. M.

### Exeter Centre

The 1968 Summer program has been a great success. In addition to the evening visit reported in the last issue, the assistant secretary arranged mid-week visits to the Oxford factory of the British Motor Corporation and to Pirelli-General's cable works at Southampton. Although these mid-week trips involve annual leave they remain extremely popular. Hence the visit to B.M.C., which was organized to accommodate those members who were unable to attend the 1967 visit. These visits are recommended to other centres in search of a really interesting and enjoyable day out, as they do much to encourage participation in centre activities.

The committee have many suggestions for the 1969 summer program, and would like to thank members for their enthusiasm and interest in the centre activites. They hope they will continue to submit their ideas for both summer and winter programs.

The 1968–69 winter program started as follows: 20 November: "Deterioration of Plastics in Service," by Dr. P. E. Taylor; 10 December: "Power Supples for Telecommunications Services," by Mr. D. A. Spurgin and presentation of Exeter Associate Centre T.T.A. Award.

The rest of the program is as follows: 23 January: "British Castles," by Mr. G. F. Cload; 6 February: "Steps Towards Exchange Maintenance by Direction," by Mr. A. Scott; 12 March: Four short talks by Exeter Associate Centre Memhers, "The Growth of the Scout Movement," by Mr. R. E. Allen; "The Work of a Volunteer St. John's Ambulance Driver," by Mr. F. J. Brown; "Talking Books for the Blind," by Mr. G. S. Steer; "Model Engineering," by Mr. N. H. B. West; 11 April: Quiz, Exeter v Torquay; 22 April: annual general meeting followed by "Modern Methods of Testing Motor Vehicles," by Mr. T. Taylor (Crypton Equipt. Ltd.)

With the exception of the quiz all meetings will be held at the University of Exeter, Queens Building.

The quiz will be held at "The Drive Inn," Newton Abbot. Eight volunteers to form two teams are required; will any members who are prepared to help in this direction please contact the Secretary.

T. F. K.

### Dundee Centre

At the annual general meeting held on 7 May 1968 the following appointments were made: *Chairman:* Mr. R. L. Topping; *Vice Chairman:* Mr. R. C. Smith; *Secretary:* Mr. R. T. Lumsden; *Treasurer:* Mr. D. L. Miller; *Committee:* Messrs. W. Bell, W. Hennessey, I. Morrison, J. McNeill, I. M. F. Smith and G. Stephen.

The Chairman and Secretary reported on the successful season just past and the treasurer on the secure financial position of the Centre. Mr. I. Morrison was congratulated on his success in the essay competition in which he gained a prize for his essay "A Layman's Introduction to Pulse-Code Modulation." Since the annual general meeting two additional members have been co-opted to the committee: Messrs. M. Williamson and W. Wilson.

A program was drawn up and includes the following lectures: "Mountain Rescue," by a member of the team at R.A.F. Leuchars; "Computer Applications within the Post Office," by Mr. A. F. Dollman, Telephone Manager, Dundee; Dr. A. W. H. Coombes—subject to be announced later; "The Doctor in the Investigation of Crime," by Dr. Rushton, Department Forensic Medicine, Dundee University; "Transit Switching," by Mr. W. Sheldon, THQ, Scotland; "A Visit to the Netherlands," by Mr. J. M. R. MacBride, TMO, Dundee. A visit has also been arranged in the spring of 1969 to a trout farm at Almondbank.

R. T. L.

### Newport (Monmouthshire) Centre

The annual general meeting was held in April at the local Civil Service Club where a disappointingly small membership re-elected Mr. W. E. Wigmore as chairman. For personal reasons our secretary, N. J. Pullin, felt obliged to retire and Mr. T. Shepherd was elected in his place. The committee consisted of Messrs. T. Barry, R. Preece, N. J. Pullin, F. Riley, G. Smith, A. V. Thornhill. The elections were followed by a film show.

The first visit of the year assumed a decidely nautical flavour with a visit on 28 May to Newport Shipbuilding Co., Ltd. The tour followed the construction program from the laying of the keel to the launching. The members then spent an absorbing hour clambering over a completed trawler which was awaiting delivery to Ghana. Because of the limitation of numbers, a further visit was made to the shipyard the following week.

Visits followed, in June, to the Cardiff offices of the *Western Mail and Echo* newspaper group to see the composition and printing of the Welsh daily newspaper, and, in August, to the works of Finlay Engineering, a local firm manufacturing large hydraulic presses used in the shipbuilding industry.

The highlight of the year was the visit on 28 September to the Birmingham tower. To ensure that the visit would be as interesting as possible. Mr. J. R. Tipple, officer-in-charge of Birmingham tower, travelled down to Newport on the preceding Wednesday to give a lecture on its construction and use. The lecture was attended by over 60 members and guests. The members travelled by road to Birmingham, then spent the remainder of the morning visiting the works of Electric Construction (W'ton) Ltd., where they saw the manufacture of electric motors. Lunch was kindly provided by the Company. The afternoon was spent visiting the tower under the guidance of Mr. Tipple and staff. The trip was rounded off with dinner at a Worcester Hotel followed by a social evening.

Several visits have already been arranged for the winter months. It is also hoped to increase the social contacts with other sections in the area through various functions. With only half the year gone, 1968–69 promises to be the most successful since the section was formed ten years ago.

T. S.

### Edinburgh Centre

One meeting has been held so far this session and the subject was "The National Grid" given by Mr. E. N. Davies, System. Operation Engineer for the South Scotland Electricity Board, Mr. Souter, the S.S.E.B. Telecommunications Engineer also attended.

Mr. Davies, with the aid of diagrams, showed how the grid came into being and its present layout. Charts of the average loading were shown, and members were told how the load was anticipated and how co-ordination between different boards provided electricity by the most economic methods. Slides of the board's switching centre at Kirkintilloch were also shown. The role of the Hydro-Electric Board and the Cruachan scheme were explained in detail. The meeting ended with a lively discussion on subjects ranging from the Channel power link to off-peak domestic heating.

G. A. K. R.

### Middlesbrough Centre

During the last season, we had talks by our own members on "Modern Subscribers' Apparatus." Visiting speakers talked on "Football" and "Electronic Exchanges." We had films on a variety of subjects and visits to a brewery, an R.A.F. station and the Chrysler-Cummins diesel engine factory.

At the annual general meeting the members congratulated the following members on their essay successes:

Mr. Purvis on obtaining the 1st award in the N.E. Regional essay competition.

Mr. Jones, for the 1st prize in the new regional competition. for apprentices.

Mr. Campbell, for a special award in the National Associate Section Essay Awards.

The following officers were elected for the 1968–9 Season: *Chairman:* Mr. W. Outhwaite; *Secretary:* Mr. K. Whalley; *Treasurer:* Mr. R. G. Inns; *Asst. Sec.:* Mr. R. D. Purvis; *Librarian:* Mr. D. Watkins; *Auditors:* Messrs K. Roe and T. Pennock; *Committee:* Messrs K. Roe, T. Pennock, R. Oliver, D. Watkins, C. Carr and P. K. Harrison.

K. W.

### Stone Centre

A special general meeting was held on 21 August 1968 during which the following were elected: *Chairman:* Mr. C. Blundell; *Secretary:* Mr. C. G. N. Watts; *Treasurer:* Mr. K. C. Brook; *Asst. Secretary:* Mr. T. Ewart; *Committee:* Messrs. G. Avery, I. Nicholson, R. J. Loader, J. A. Reeves, Mrs. B. Barker and Miss S. Yates; *Auditors:* Messrs. L. Neesam and R. Freestone.

For the winter session a number of interesting films, visits, lectures and other events are being planned. It is hoped that these will include a lecture on the Post Office *GIRO* and remittance services, a colour television demonstration and a visit to the Royal Ordnance Factory at Cold Meece. Two other events, a lecture on the "Radiophonic Workshop of the BBC" and a quiz are being arranged as joint meetings with the Stoke-on-Trent Associate Section at Duncan Hall.

C. G. N. W.

### Oxford Centre

The season's activites began in September with a visit to the Morland Brewery in Abingdon. Those of us who attended discovered that there is more to brewing than meets the eye, or tongue.

October's talk was called "What Traffic Does" and was given by Mr. Humphreys, an S.T.S. at Oxford. This was a very interesting and informative talk on the purpose and future of the Traffic Division.

Other items in the program included a talk and demonstration of the "Artificial Kidney," by Dr. Oliver at the Churchill Hospital, Oxford, on 7 November and, on 5 December, a talk by Mr. West, of Horwood House College, Bletchley, on the "Swedish Telephone Organization."

On 23 January we are holding a land-line quiz between the centres of Oxford and Ipswich.

D. A. G.

# Institution of Post Office Electrical Engineers

**Additions to the Library**

Library requisition forms are available from Honorary Local Secretaries, from Associate Section Centre Secretaries, and representatives, and from the Librarian, I.P.O.E.E., G.P.O., 2–12 Gresham Street, London, E.C.2.

Members are reminded that Prize Essays, Associate Section Prize Papers, and various unpublished papers are held in the library for loan, and that a list will be sent on request. Field Medal award-winning papers are also held for loan and are listed in the Supplement to the Library Catalogue.

2963 *Mathematics for Technicians, Part 2 (Electrical).* R. H. Clarke (Brit 1967).
The syllabus for the third year of the Electrical Engineering Technicians' course has been closely followed in this text. It provides a progressive treatment for technical college students and should be acceptable over a wide ability range.

2964 *Understanding U.H.F. Equipment.* J. D. Lenk (Amer. 1967).
Provides the working technician with a handy reference book of valuable, basic information when he encounters some aspect of the u.h.f. field for the first time. Can also be used as part of a training course in u.h.f. at trade-school or technical institute level.

2965 *T.V. Tube Symptons and Troubles.* R. G. Middleton Amer. 1967).
Explains the functions of each section in a television receiver, and describes typical troubles which can be attributed to defective tubes in these sections. Contains a tube trouble-check chart list.

2966 *Colour Television: PAL System.* G. N. Patchett (Brit. 1967).
Specifically designed to explain the PAL system as transmitted in Great Britain. Principles of colour, basic colour-television systems, and apparatus used at the studio and receiver are dealt with. Detailed descriptions of the N.T.S.C., SECAM and PAL systems. Other modern systems are briefly described.

2967 *Modern Management Methods.* E. Dale and L. C. Michelon (Amer. 1966).
Brings together the important trends in management and the useful new management methods which are coming into favour. Intended for practical use by managers at all levels.

2968 *The Story of Jodrell Bank.* B. Lovell (Brit. 1968).
Sir Bernard Lovell tells this dramatic story lucidly and with candour and presents the technical problems to the average reader with disarming skill. An absorbing story, it is also this scientist's account of the most critical years in his life and the struggle to realize his dream

2969 *Plastics in the Building Industry.* P. Reboul and R. G. Bruce Mitchell (Brit. 1968).
Discusses the exciting future for plastics in building, but stresses the need for a better understanding and appreciation of existing applications.

2970 *The 1968 Insulation Handbook.* A. J. Allsworth (Ed.) (Brit. 1968).
Lists over 800 companies operating in the insulating industry, with lists of available goods, descriptions of various types of insulating products, and geographical lists of contractors so that local operators can be traced.

2971 *Corrosion and the Maintenance Engineer.* C. L. Wilson and J. A. Oates (Brit. 1968).
Presents in as simple a manner as possible, information to enable many causes of corrosion to be identified and eliminated.

2972 *Principles of Light and Optics.* R. A. Wheedon (Brit. 1968).
Provides a course in Light starting from the beginnings of the subject and leading up to the standard required by universities in open scholarship examinations. Should be useful to students preparing for G.C.E. at 'O' level and 'A' level.

2973 *An Introduction to Microelectronic Systems.* W. Gosling (Brit. 1968).
Intended as a first introduction to electronics from which students can quickly and easily learn to obtain desired functional properties from simple electronic subsystems using integrated amplifiers. Also useful to those wishing to learn to use integrated circuits.

2974 *Introduction to Electronics.* H. A. Romanowitz and R. E. Puckett (Amer. 1968).
Intended to meet the need for a clear and understandable presentation of the fundamental principles and concepts of electronic devices and circuits and specific applications of circuits in electronic systems.

2975 *Systematic Electronic Fault Diagnosis.* T. H. Wingate (Brit. 1968).
This book forms the basis of fault-finding teaching in the technical training establishment of the Royal Navy. The material is presented in a Programmed Instruction format.

2976 *General Engineering Drawing G1 and G2.* A. C.
2977 Parkinson (Brit. 1968).
For the First Year (G1) and Second Year (G2) Examination of the National Certificate General Course in Engineering Drawing.

2978 *Essentials of Sound.* F. J. H. Dibdin (Brit. 1968).

One of a series forming the "Essential of Physics". Meets the needs of students studying for 'A' level and is based on a careful study of the latest syllabi and question papers published by the various Examining Boards.

2979 *Transistor Audio Amplifiers.* S. J. Hellings (Dutch 1968).

The subjects in this book have chosen to be of maximum benefit to designers, users and radio amateurs. A section is devoted to the theoretical principles on which semiconductors are based.

2980 *Tape Recording.* C. N. G. Matthews (Brit. 1968).

Will appeal not only to the novice who wants to know how his machine works and how best to use it, but to the more experienced recorder who wishes to improve his versatility.

2981 *Worked Examples in H.N.C. Maths* (2nd Ed.). R. H. Clarke (Brit. 1968).

Primarily for electrical and mechanical engineering students taking the Higher National Certificate.

2982 *Information Theory and its Engineering Applications* (4th Ed.). D. A. Bell (Brit. 1968).

A straightforward presentation of this subject for Higher National Certificate and degree students as well as the professional engineer, with particular emphasis on its applications in telecommunications and data processing.

2983 *Amateur Radio Antenna Handbook.* H. D. Hooton (Amer. 1962).

Complete coverage of ham antenna systems, including theory and practical design applications, transmission lines, impedance matching, coupling, and towers.

E. DOHERTY,
*Librarian*



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**Model Answer Books**

Books of model answers to certain of the City and Guilds of London Institute examinations in telecommunications are published by the Board of Editors. Details of the books available are given at the end of the Supplement to the Journal.

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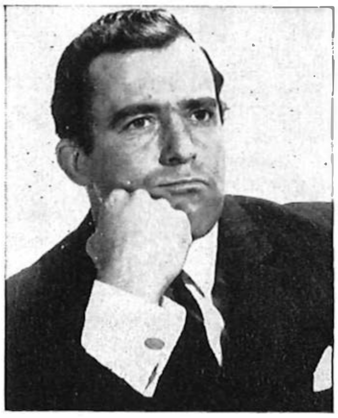

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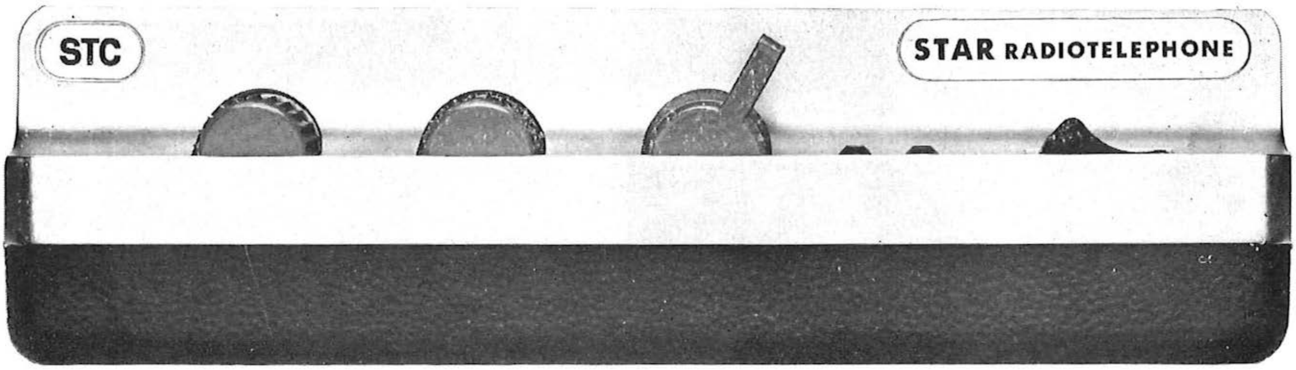


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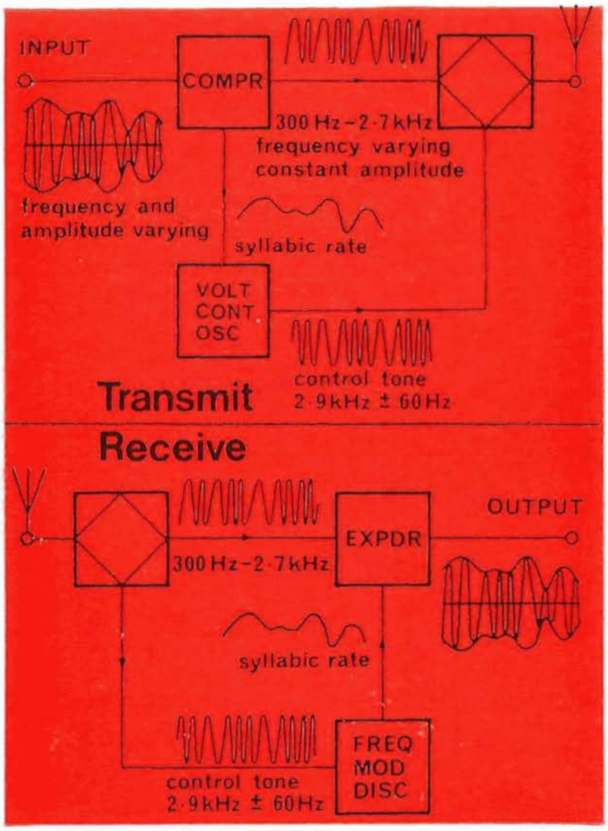


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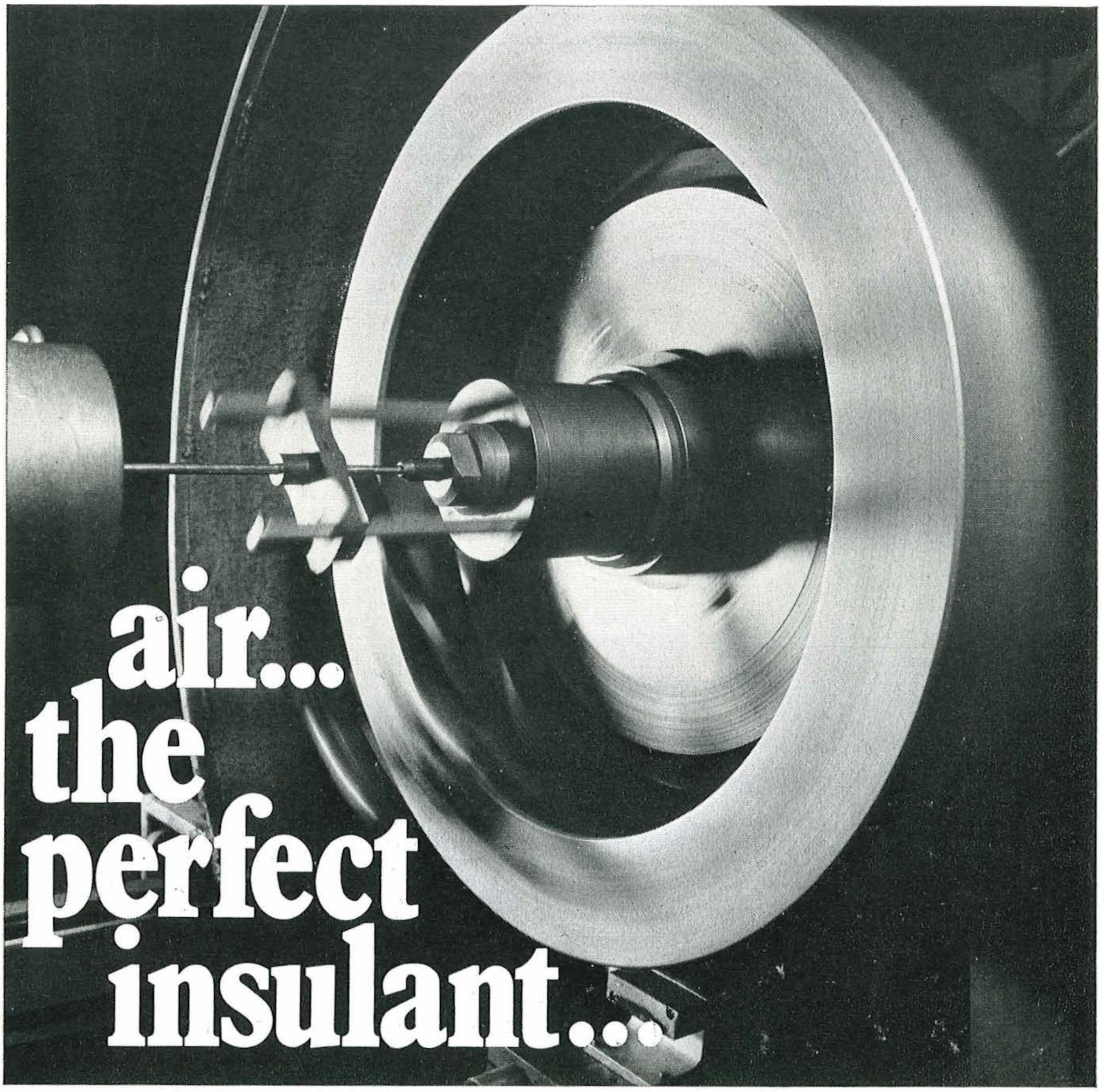


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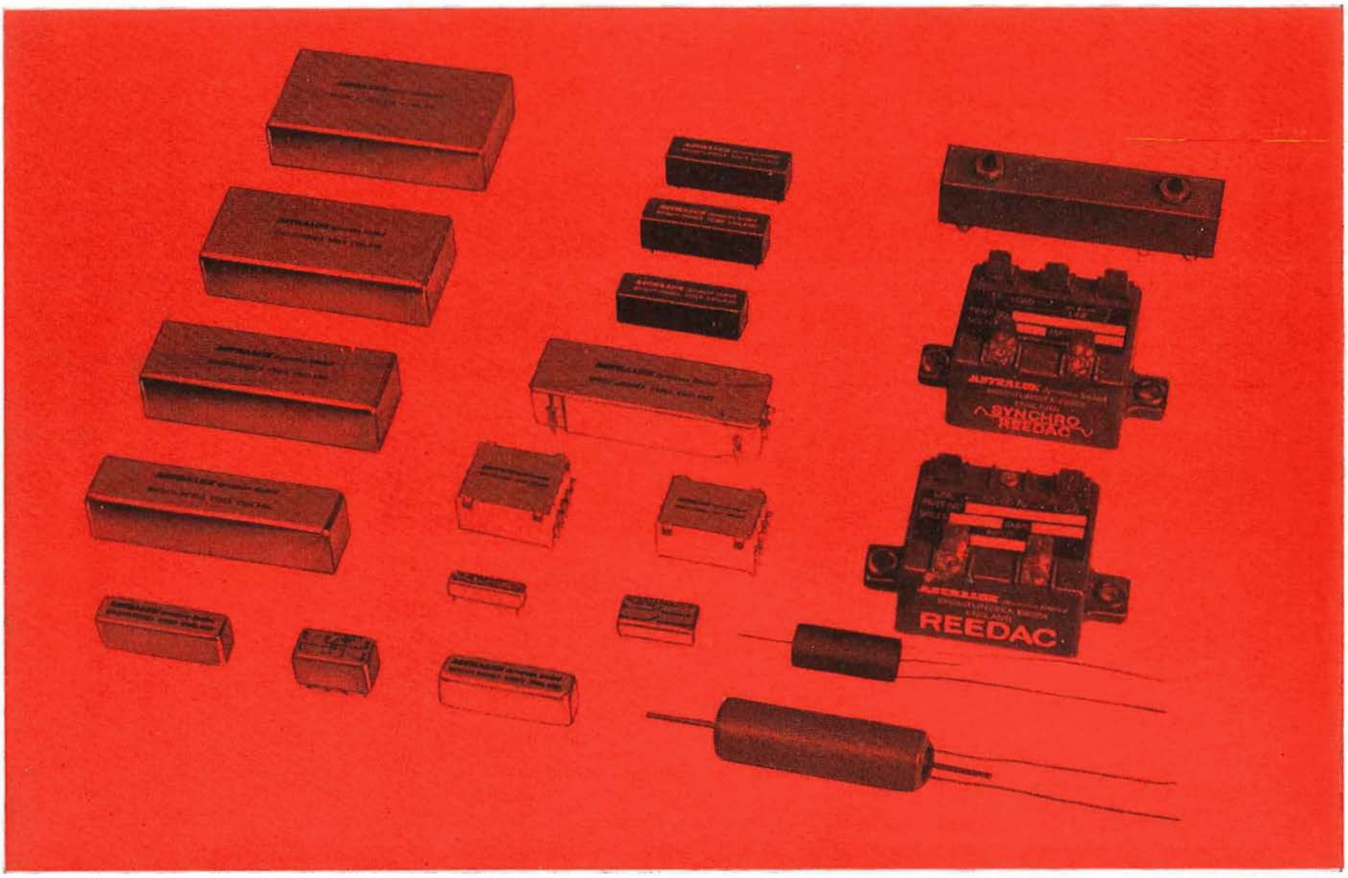


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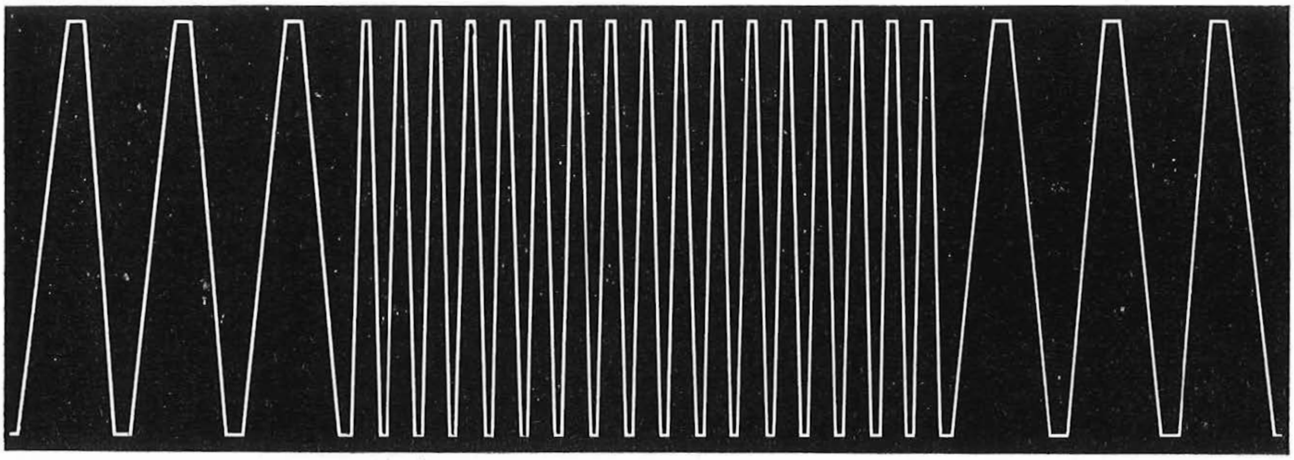

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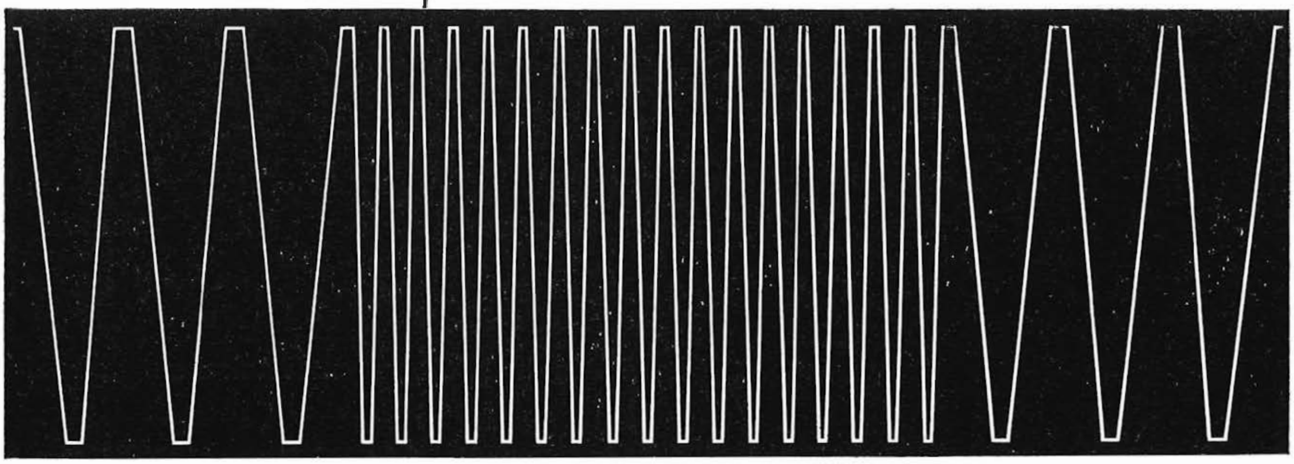

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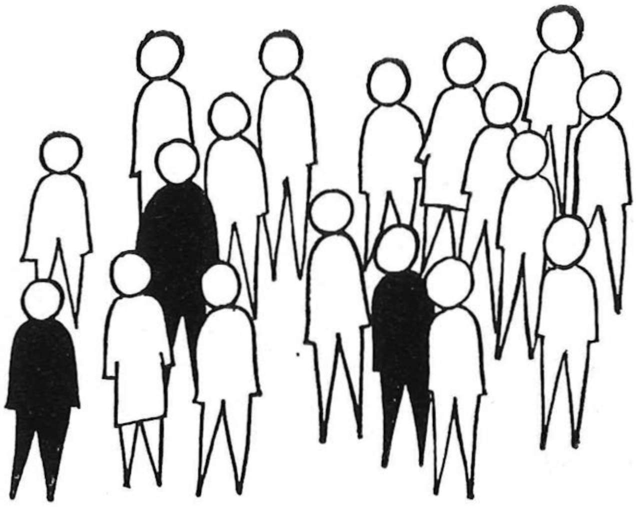

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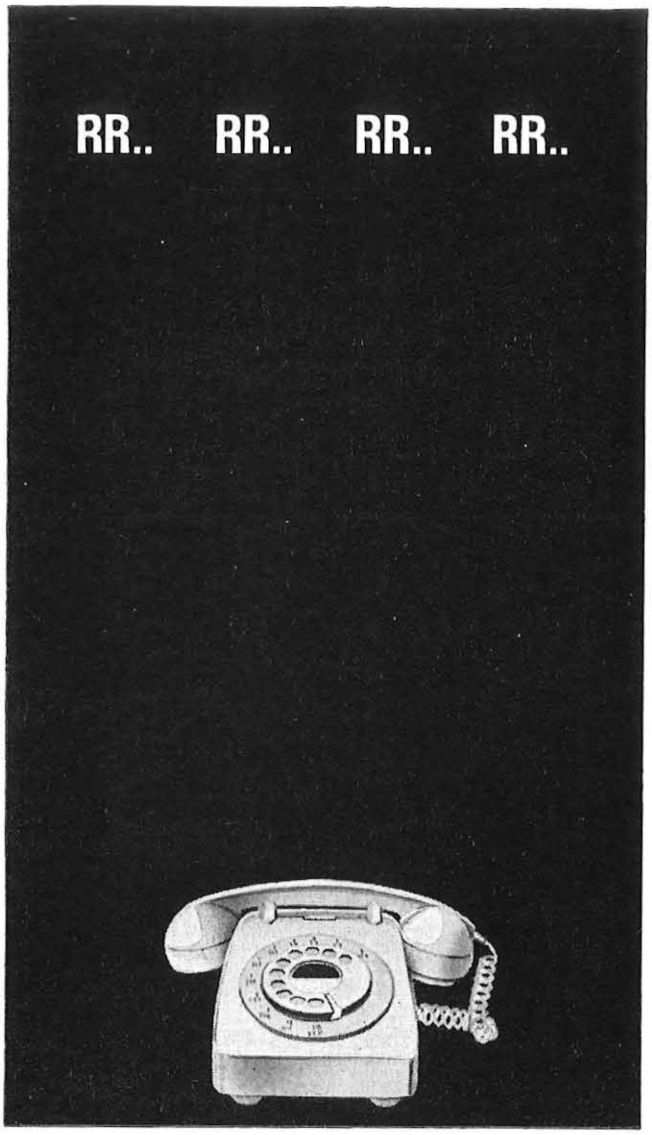


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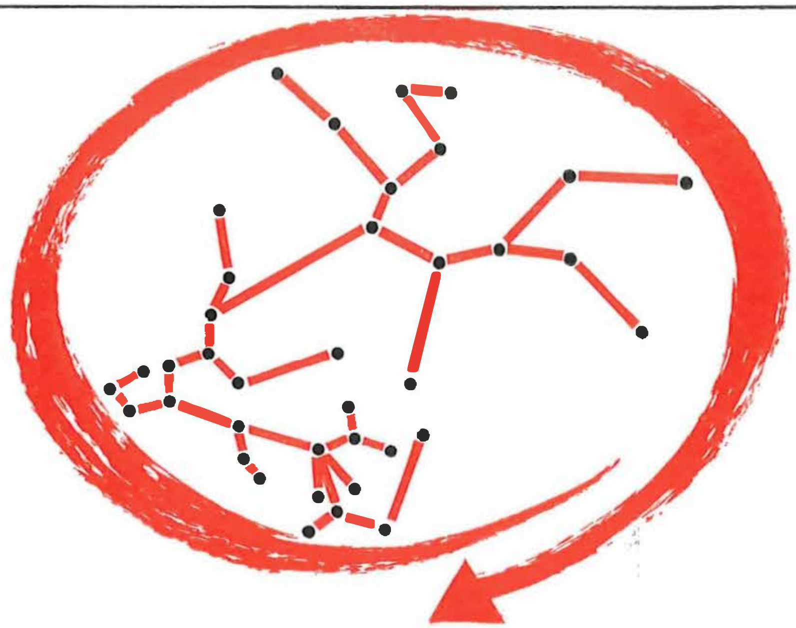
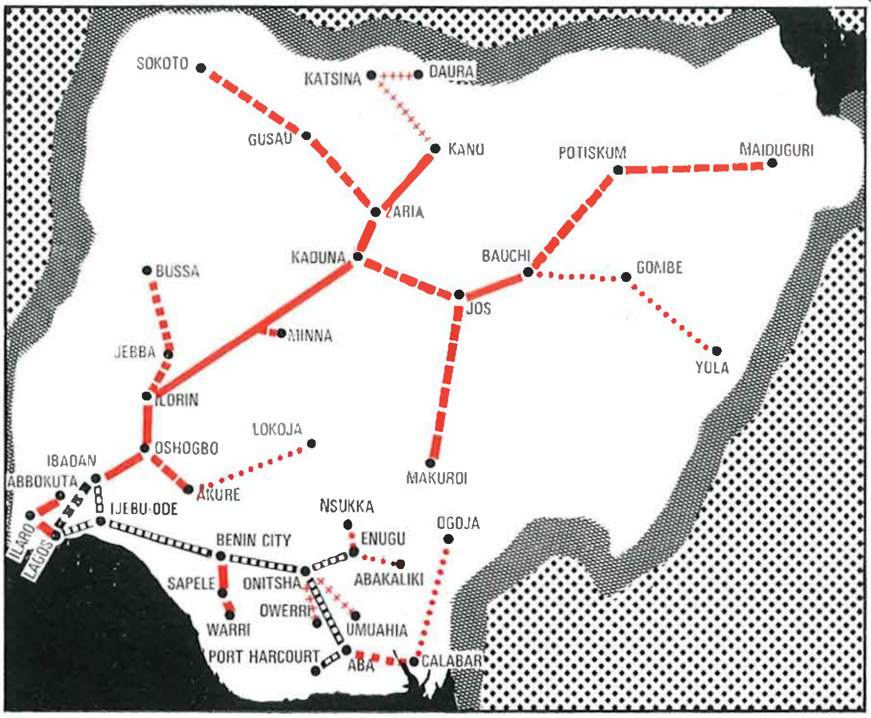


# the new telecommunications network by G.E.C. of England




# will fit Nigeria very well

The facts are impressive . . . a £9.6 million contract placed by Nigeria's Ministry of Communications with GEC-AEI Telecommunications Limited . . . a 2500 mile microwave and VHF radio network linking all twelve state capitals and many smaller communities . . . with about 100 stations en route to carry telephone conversations over Nigeria's vastly varying terrain . . . GEC to undertake all aspects of the project from route surveys to commissioning, including a comprehensive training programme and the use of computer-controlled critical path analysis to ensure the smooth progress of the contract.

Behind the facts is a long and close association between GEC of England and the Nigerian Ministry of Communications culminating in this development which will give Nigeria an advanced telephone service, the equal of any in the world.

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VHF narrowband radio systems
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# think of....

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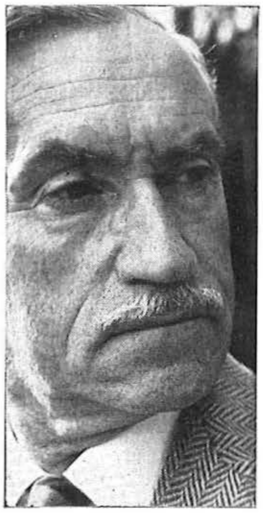

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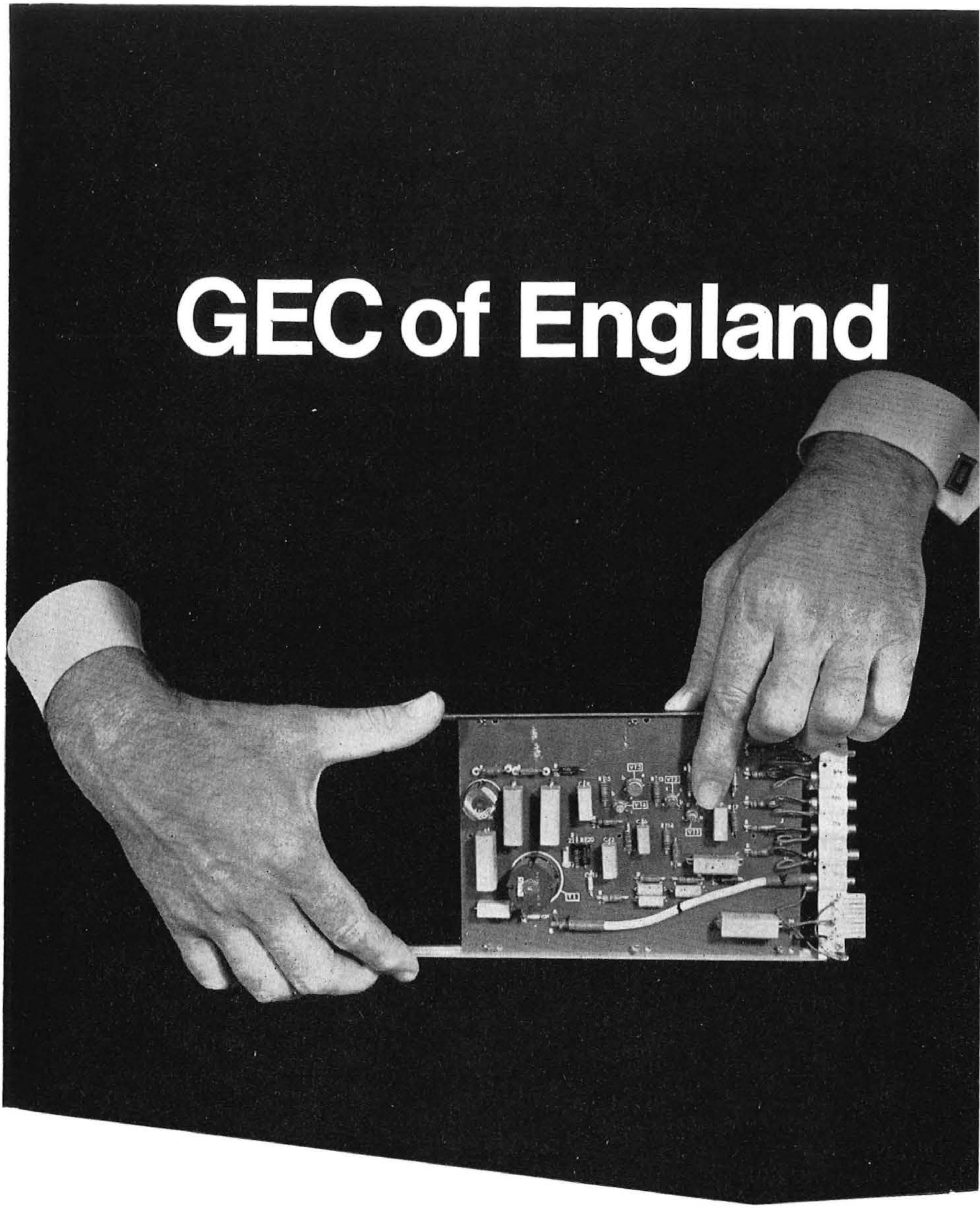


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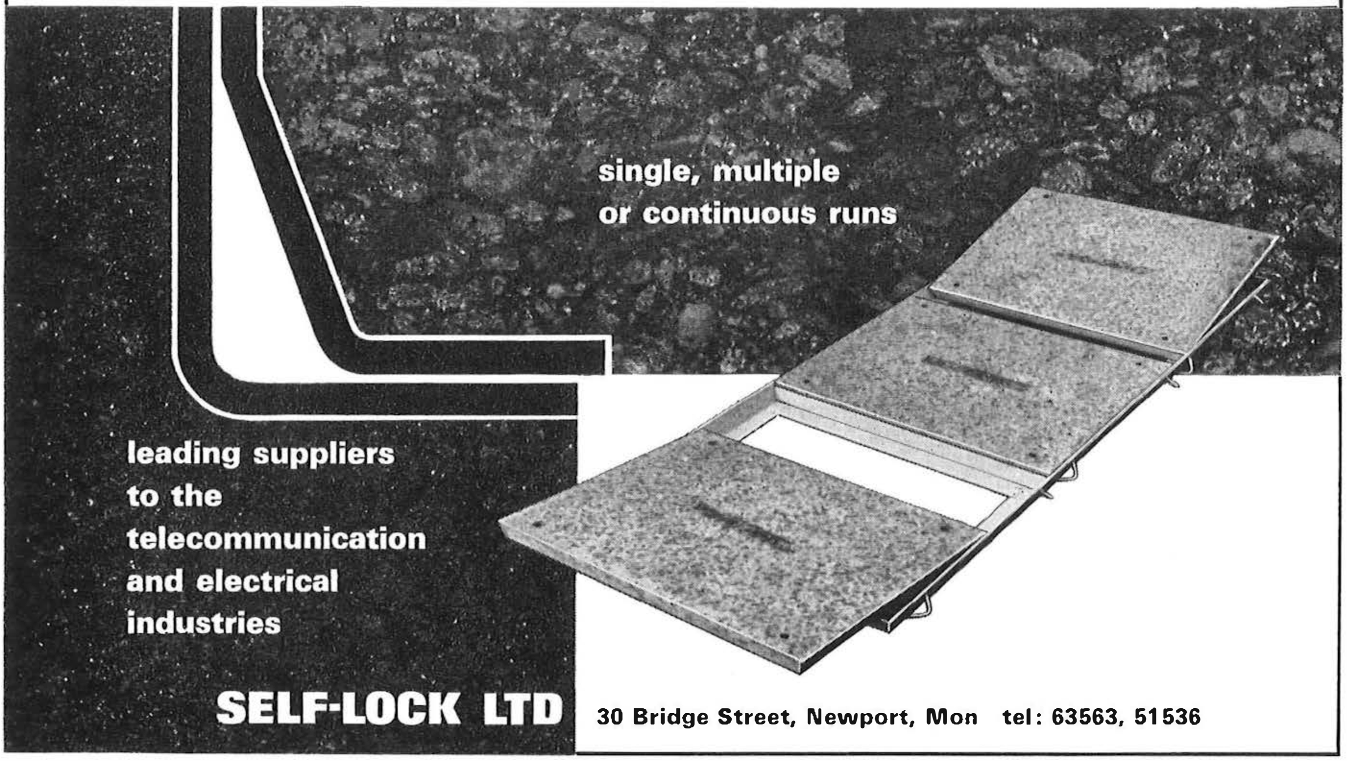


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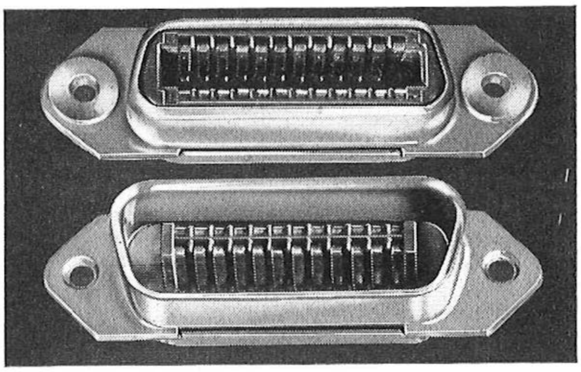

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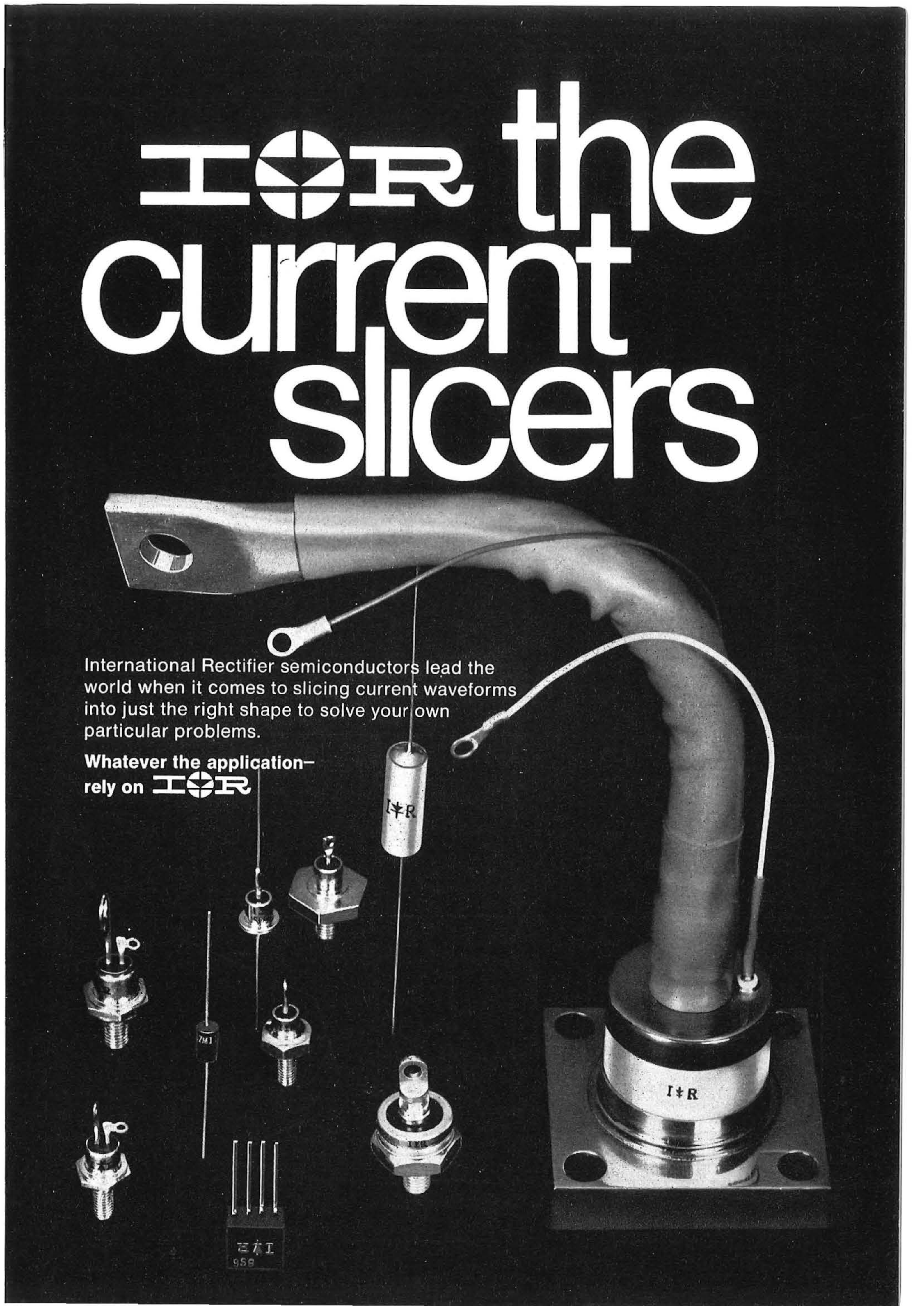
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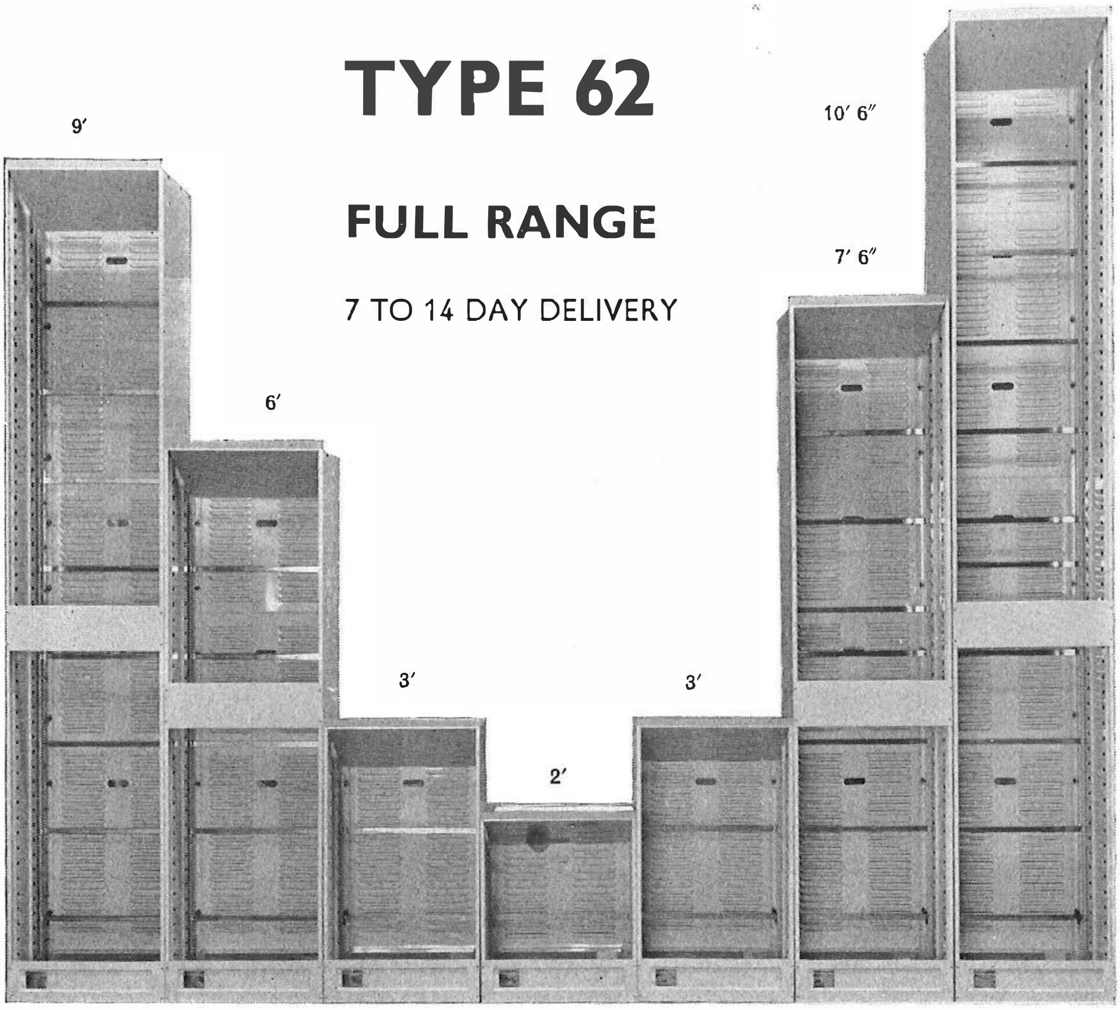


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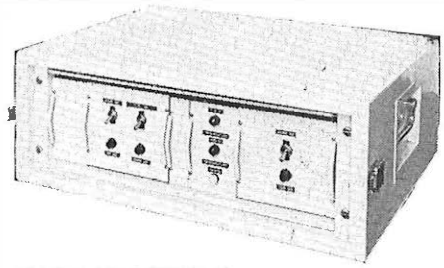

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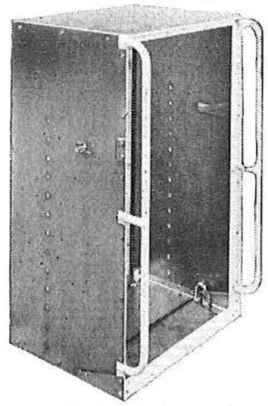

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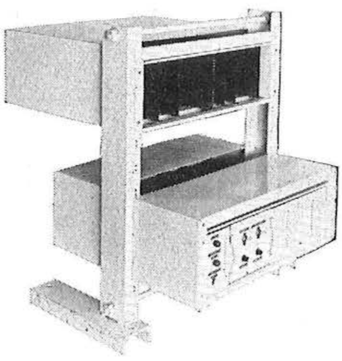

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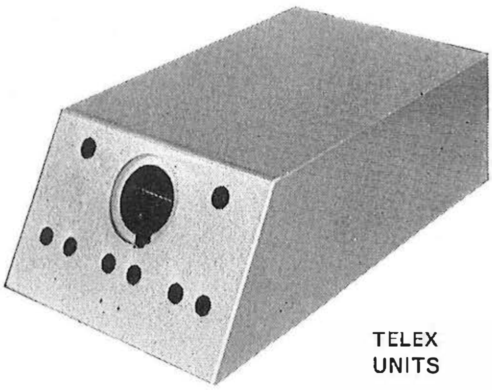

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