Maintenance News

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Contents

Editorial	1
Letters	2
Reliability – terminology and measurement	4
Ringing, pulsing and VF machines	6
Desk-top equipment for RSCs	8
Beware of testjack lamps	10
Modular power plants	11
NCC news	13
Processors and software for telecommunications	14
Overcoming problems on the Loudspeaking Telephone 4D	16
NNCC – a finger on the network's pulse	18
PCM network for BBC sound	19
MOS chips – handle with care	22
Mac the life	23
Housing estates on trial	26
Private circuit maintenance	28
Experimental packet switched service – the facts	30
Send your contributions to . . .	33

Editorial

You will recognise from the cover colour that we are into our Blue Period, or period of austerity : cuts are being made everywhere and *Maintenance News* cannot escape. We have even made a cut in the numbers issued. Regions and Areas will have to make do from now on with half the copies they have been receiving previously.

There is a new policy for distribution from this issue onwards : we will be satisfied if each member of the maintenance staff sees a copy in good time and reads what interests him ; but every man who wants a copy to keep should have it wherever possible.

Further we have decided to make each issue slimmer and to come out only twice a year. So you won't see issue nine until about February 1976. There could be one or two cartoons in it, we think, to brighten it a bit.

I hope you will agree that the quality of our contents has not suffered. We are now a success : we send copies to Australia, South Africa, Guyana and the Resident Representative of the United Nations Development Program in Teheran, Iran.
I keep on getting requests for back numbers. Have any Areas say 50 copies of issues one to five they could let me have, please ?
Editor.

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Letters

Provide THQ with feedback

From the former Deputy Director, Service Department

Dear Colleagues

Although I am no longer concerned full time with maintenance, having now to deal with matters 'across the board' in SWTR, I am glad your editor has given me this opportunity of saying farewell to *Maintenance News* readers, for I can claim to have sponsored the magazine in the beginning.

It seems to me to be doing quite well and achieving most of what I had in mind and I have some regret that in future I shall be only a reader (possibly a critical one). It is a little disappointing that so far the editor has not received back from readers as much correspondence as he would like, for maximum benefit will follow if the publication produces a lively interchange of ideas on how to deal with the problems of today and how to avoid problems in the future. THQ cannot function properly in an ivory tower and it is up to us in the field to provide them with feedback about things that worry us. Moreover, wherever we are, we can always learn from each other through the medium of *Maintenance News*.

I shall always be deeply interested in maintenance, on which I have spent so long and interesting a time, and shall doubtless regret having to restrain myself from putting my maintenance oar in on visits to SWTR exchanges in the future. However, I am very happy to be back where I started – in the South West Region.

Yours sincerely

T F A Urben

TFA Urben

It did not seem right to let Mr Urben go without a word. We on the editorial board wish him well in his new post as Director of SWTR and are encouraged to learn that our publication matches up fairly well to the original gleam in his eye. As editor, I must endorse what he says about letters. Reaction varies widely from issue to issue and it is difficult to see why, for we do try to maintain a uniform level of interest.

Editor (01-432 1380)

Microphonic Noise

The disappointing results from the trial reported in issue six on the use of a detector for microphonic noise in Strowger exchanges were, in the light of my own experience, only to be expected. I think the time has come for the oiling of selector banks using bank cleaning tape 3. But where contacts are tarnished, *TI E6 H5312* should continue to be followed.

G H Phillips, LTR/South

It has been demonstrated that oil on selector banks becomes impregnated with dust and forms an effective grinding paste, much increasing wiper wear. Applied to P banks it can lead to double switching. It is therefore allowed, on old banks, only in exchanges where wiper to bank connections have been proved to be the source of microphonic noise; and it is restricted to line banks. Oil must be applied only sparingly, by using bank cleaning tape 3, and banks must first be thoroughly cleaned. Banks with varnished fibre insulation in certain early ATE exchanges must not be lubricated under any circumstances.

A once only light lubrication of banks by bank cleaning tape 3, after brushing out all

debris, vacuum cleaning, and dry cleaning using bank cleaning tape 1, has also been recommended to Regions for new banks before they are brought into service. This is because with modern methods of bank assembly the brass used for contacts has to be completely degreased and, unless the 'grease' is replaced rapid wear occurs (see 'Maintenance News', issue one).
N J Paine, Sv6.5.6 (01-432 1343)

Encounter with the unknown

The secret dread of any subs app maintenance man is to be confronted, in some plush office, by an angry company executive complaining about his new PO gadget not working, and to realise that you are completely ignorant of what the 'thing' is, what it does, and how it does it! A rapid decision must be made. Do you come clean and say you must consult the necessary document (a TI five or ten miles away at the TEC), undo every screw in sight and pray, or tell the customer it is Telephone Rental equipment and beat it fast?

It seems only reasonable for demonstrations to be given and diagrams and notes to be issued to all staff, before new equipment is let loose on the public, not months afterwards.
W McKnight, Margate

The difficulties have been appreciated for some long time, but it is fair to say your letter has given a fillip to those seeking solutions. We are considering the issue of training bulletins and the use of Regional Engineering Training Centre staff to give demonstrations in Areas and we know of some Regional initiatives.

In 'Maintenance News' it is our policy to help with publicity about new products on trial, for instance keyphones in issue three and new style residential telephones in issue four. It is one of our aims to let you know what's coming.

THQ do, of course, aim to get TIs and N diagrams into the field before a new item is introduced. You will also have seen that most of the new-style N diagrams do include a line drawing. Illustrations in TIs are mostly confined to the descriptive C Division TIs in the type 2 file at your headquarters, but we will consider including them in maintenance TIs – perhaps the 'running TI' or the proposed maintenance bulletins discussed in our issue seven.
Editor (01-432 1380)

Incentives and efficiency

I read with interest Mr Golothan's letter in issue seven of *Maintenance News* in which he stresses the importance of maintenance in running the telecommunications system at peak efficiency. One cannot help but wonder why, so often, maintenance standards go by the board in the interests of what non-maintenance people call productivity. New equipment is fitted which falls far below accepted maintenance tolerances; recovered equipment is fitted without so much as a wipe-over. Surely maintenance people should not be the only ones concerned with service? I think a drive from the *top* is needed to put back into the system the incentives to maintenance efficiency.
B J Rolston, Bude, Cornwall

I cannot agree that maintenance standards have gone by the board in the interests of so-called productivity: results show otherwise. As in all service industries, we constantly have to balance the quality of the service we give against the costs of giving it, remembering that in the end the customer always pays. Our quality of service however, is improving steadily and almost all the statistics at our disposal show that, nationally, there has been steady improvement in the automatic service – local and STD – and the figure for fault reports has been reducing year by year.

As to installation of new equipment, our standards for factory inspection and acceptance testing on site are pretty stringent, though sometimes only operational experience can bring out all the 'bugs'; and there often has to be a compromise made between prolonging the testing and getting the new plant into service and earning revenue as soon as possible.

I agree with Mr Rolston that recovered equipment almost always needs overhaul before being put back into service. Sometimes this is a matter best taken care of by local management, but where recovered equipment is to be used on a wider scale we enlist the aid of Factories Division.

I fully support his statement that quality of service should be kept in mind by all staff, and everywhere from small UAXs up to the largest Director exchanges. Insofar as maintenance incentives are lacking at any point, I accept my responsibilities for trying to get them put right. I am confident I shall get enthusiastic support wherever action is shown to be necessary.
J E Golothan, DSv

Reliability-terminology and measurement

by **J F Bampton,** Head of Sv7

'Reliability' is a word we have been using for many years in a very general way to cover certain aspects of the performance of equipment and systems. In recent years, however, there has been an increasing need to establish definite terminology for discussing reliability matters. We find we need three terms – reliability, maintainability and availability.

Reliability

If we say an item of plant has a high reliability, we imply that its failure rate is low and, on average, there is a long time between failures. In maintenance, reliability is measured in terms of *failure rate* (symbol λ) and its reciprocal, the *mean time between failures* (MTBF). As an example, let us assume that we are responsible for maintaining 1000 audio amplifiers, and over a period of three years, 15 have gone faulty and they have been replaced by spares.

As the failure rate of the amplifier is given by:

$$\lambda = \frac{\text{number of failures}}{\text{number of amplifiers x number of operational years}}$$

then:

$$\lambda = \frac{15}{1000 \times 3} = .005 \text{ failures per amplifier-year}$$

Doing the calculation in a different way to determine mean time between failures (MTBF), which is the *reciprocal* of the failure rate, we have.

$$\text{MTBF} = \frac{\text{number of amplifiers x number of operational years}}{\text{number of failures}}$$

$$= \frac{1000 \times 3}{15} = 200 \text{ years}$$

It would of course be very useful to calculate the failure rate or MTBF of the amplifiers before they were put into service so that we could estimate the number of spares required. And this can be done by listing all the components in the amplifier. The failure rate of each type of component can then be determined from manufacturers' information or other published data, which usually give the number of failures in 10^9 component-hours. Continuing the example of the audio amplifier we can make a table as shown.

For amplifiers of this type, therefore, the expected failure rate is given by

λ = 500 failures in 10^9 hours or 0.0044 failures per amplifier-year, and the

$$\text{expected MTBF} = \frac{1}{\lambda} = \frac{1}{.0044} = 228 \text{ years.}$$

These figures are close to, but not exactly equal to, the figures in our first example. This difference between what is expected and what is measured is typical of what happens in practice.

Two further points need to be made about reliability. The first is that when a large number of amplifiers is brought into service for the first time it is likely that for the first few weeks a disproportionately high number of failures will occur. This period is called the 'burn-in' period. Similarly, in theory at least, there will come a time after many years

Audio Amplifier – List of Components and Failure Rates

Component (a)	Quantity used in amplifier (b)	Component Failure Rate (Failures in 10^9 component-hours) (c)	Total Failure Rate (b) x (c) (Failures in 10^9 component-hours) (d)
Capacitor	17	10	170
Inductor	5	5	25
Resistor	10	10	100
Transformer	5	1	5
Transistor	2	100	200
		TOTAL for amplifier =	500

when the number of failures starts to rise because the equipment is becoming worn out. This is called the 'wear-out' period. If we ignore what happens in the burn-in and wear-out periods then the failure rate and MTBF are, both in theory and in practice, substantially constant. The period between burn-in and wear-out is therefore called the 'constant failure rate' or 'random failure rate' period. The figures we have just calculated apply to this constant failure rate period.

Secondly, although we have said that reliability is measured by failure rate or MTBF, there is a more philosophical concept of reliability which defines it as the probability that an item of equipment will operate for a given period of time without failure. It may be interesting to note that this concept is expressed by the mathematical formula

$$R(t) = e^{-\lambda t}$$

where R(t) is the symbol for reliability, and t is any period of time.

In the example we considered, λ for the amplifier was .005. Let us assume we need to know the probability that any one particular amplifier will survive for a period of 10 years; so that t in the above formula is 10. Hence:

$$R(t) = e^{-.005 \times 10} = e^{-0.05} = 0.951$$

In other words, there is a probability or chance of 95 per cent that an individual amplifier will survive for 10 years.

In transmission maintenance we are normally more concerned with failure rate than with reliability expressed as a probability of survival. An astronaut starting on a 20-day mission is very much more concerned with reliability expressed as the probability that the equipment on which his life depends will last for 20 days.

Maintainability

Maintainability is measured by the average time taken to repair equipment after it has gone faulty. The term used to describe maintainability is *mean time to repair* (MTTR). It is obviously desirable that when equipment such as a radio terminal, computer or telephone exchange is designed, attention should be given to the actual construction and arrangement of equipment so that the maintenance man can quickly locate and replace a piece of faulty equipment. Equipment has a good maintainability if it is designed with these points in mind. Here we would expect it to, have a low MTTR.

As maintenance experts, we are concerned with the total time necessary to restore service after a failure and this is called the *down time.* Down time includes repair time, but also includes the time during which staff and stores are being assembled before actual repair can begin.

As with reliability, there is a mathematical concept of maintainability. This defines it as the probability that a repair can be completed within a specified time. Maintainability has a formula which very approximately can be given as

$$M(t) = 1 - e^{-\frac{t}{MTTR}}$$

where M(t) is the symbol for maintainability, and t is any period of time.

Availability

Lastly we come to *availability.* Availability expresses the idea of the general usefulness of a piece of equipment and combines the concepts of reliability (how frequently the equipment fails) and maintainability (how long the equipment is out of service when it fails).

We often refer to *steady state* availability as being the proportion of time that a continuously operating device is in service during, say, one year.

$$\text{Availability (A)} = \frac{\text{Up time}}{\text{Up time} + \text{Down time}}$$

Up time is the total time the equipment is operational and *down time* is the total time that the equipment is out of service due to faults. For example, if a coaxial system is out of service during one year for three periods, one of 13 hours because of a cable fault, one of two hours for a line amplifier fault, and one of 30 minutes for a power unit fault, the down time in the year is $15\frac{1}{2}$ hours and the up time is 8744.5 hours.

$$A = \frac{8744.5}{8744.5 + 15.5}$$

$$= 0.99823 \text{ or } 99.823 \text{ per cent}$$

Another measurement giving what is called the *instantaneous* availability is defined as the probability that a device will operate when required. CCITT are extending this definition to a switched connection in a telephone system and are proposing to define the availability of a switched connection as the probability of the successful completion of a call at the first attempt. This is very close to our concept of 'Quality of Service'.

So – we have defined reliability, maintainability and availability, and shown how they are measured. These terms are creeping into everyday technical language where they will probably remain.

Sv7 (01-432 9017)

Ringing, pulsing and VF machines

A question frequently asked by exchange staff, and by visitors, is why ringing, pulsing and tone supplies are still being generated by rotary machines in this age of advanced solid-state technology. We are in fact beginning to introduce this technology and there is now a new single frequency solid-state oscillator for SSAC9.

There are studies to see whether ringing current, supervisory tones and pulses can also be provided by using solid-state methods. The new technology has still to be proved technically and economically so, until solid-state generators have been shown to be better than existing machines, no changes will be made.

Machines may look old-fashioned and inefficient, but most of them have proved highly reliable over many years service at modest capital and maintenance costs. Out of the 40 different types of common services machine in the field there are only three that have proved troublesome over the last few years. I will deal with these later, but first I want to emphasise the point that machines only stay reliable if they are given regular, routine attention.

Routines

In some cases the performance of routine maintenance on common services machines is not being given the priority and attention needed to ensure security of service. Machines have been allowed to grind to a halt before being returned to the Regional Repair Depot (RRD) and this means expensive major overhauls which place a heavy burden on the RRD. Here clearly 'a switch in time will save nine'. If a machine and its associated control equipment are allowed to deteriorate below a safe level and maintenance staff have become unfamiliar with them, there is real danger of exchanges being isolated for prolonged periods when even minor faults occur. Machines cannot be included in those classes of equipment for which the policy is 'if it is working well leave it alone'. Carbon brushes, springsets, bearings and gears have limited lives and must be inspected at the prescribed frequencies, and action taken before the performance of the machines is affected. If the machine is running irregularly or noisily, then the indication is that the bearings or gears need attention in the RRD; serious damage can be sustained by such machines if they are allowed to continue in service for long periods, and consequently there is risk to the service.

We now come to measures for improving the performance of the three types of machine that have given us trouble.

Ringing machines

Apart from minor difficulties, ringing machines in main exchanges have given excellent service over the years. In UAXs and SAXs, however, there have been many maintenance and service difficulties with pulsing and ringing machines 2A, of one particular make. The main cause was found to be unsuitable material used in the manufacture of the plastic gears. Replacement gears were developed urgently and are now expected to give long and reliable service.

Routiner pulse machines

Pulsing machines 14A, and the now obsolescent 18A and 19A, have been the most troublesome routiner pulse machines. These machines were originally designed for intermittent use but since the introduction of night routining they have been subjected to almost continuous running. They have consequently become unreliable, and have needed much maintenance effort to keep them in service.

Pulsing machines 14A will be of new design to meet the requirements of continuous running. Design changes include an electronic speed governor which will require only minimal maintenance attention and will keep the speed of the motor stable to within closer limits than the mechanical governor on machines now in service. Also included in the new design will be a belt drive from the motor to the camshaft in place of the present gears and this, together with resilient machine mounts, will ensure quieter running. Machines in service will shortly be modified in the field to meet the new design specification.

VF tone generating machines

Dynamotor 48A, the tone generating machine for signalling system MF2, has been, with its associated machine control and changeover equipment, the source of considerable difficulties in service because of circuit design weaknesses. Works specifications will be issued shortly giving details of the necessary modifications to ensure reliable performance from the machines and control equipment.

Tariff pulse machines

These machines provide meter pulses for STD and ISD and have given very little trouble in service over many years ; but the maintenance effort they require will be greatly reduced by fitting an electronic governor similar to that on the new routiner pulse machines. New tariff machines are now being provided with this governor and machines in the field will be modified shortly.

Spare parts

It is essential that adequate (but not excessive) local stocks of the necessary piece parts are held for machines in use.

Spare fuses should be held in readiness for machines and control equipment. Note particularly that the fuses for dynamotors 48A are of a special, fast-acting, type and on no account should fuse wire be used in place of them. Serious damage could be sustained by the inverter components under fault conditions during the time taken to rupture the fuse wire.

Use the A646 !

Service and development groups in THQ rely greatly on feed-back of information from field maintenance staff. If a machine or its associated control equipment develops a fault, other than from normal wear and tear, a report should be made on form A646 (report of unusual difficulty or defect). An early warning of design problems can prevent serious service difficulties.

Finally

It can be very uncomfortable working under pressure to get machines back into service, especially when the exchange has been isolated. It doesn't pay to be complacent because even though there may be a standby machine ready to be automatically switched into service if the working machine fails, both machines are still liable to fail at any time if the regular maintenance routines have been overlooked. The RRD cannot always guarantee to supply spare machines immediately – so the failure of both working and standby machines can result in an exchange being isolated for many hours.

J McAllister, Sv5.4.3 (01-739 3464 x225)

Desk-top equipment for RSCs

by **W L Bowdidge,** Sv5.1.3

At the end of the article about the development of future RSCs in *Maintenance News* 7 it was said that new RSCs installed before the final standard is reached would get the benefit of interim developments. One such development is the provision of test-desk facilities for each Repair Control Officer by means of three units – for call reception, test access, and testing – on an office-type desk. We consider this is ergonomically and environmentally better for staff than the old upright test-desk and gives improved flexibility in layout of RSCs. The first such installation is now working at Ilford.

This article describes the latest pattern of desk-top 'modules', now being made up locally in various Areas to meet early requirements. Production of modules and associated rack equipment for later installations should become available from Factories Division during the first half of 1976.

Physical design

The modules are in sets of three as shown in the illustration of an RSC desk. As shown, the right-hand module is for call reception, the left-hand one for getting test access to the customer's line and the centre one for making tests. This last one incorporates new designs of voltmeter and dial test display and illuminated push-button keys for the main test functions. The modules can be arranged differently if the RCO finds it suits his method of working. For fault distribution work, card filing facilities must be provided and, for the short term, we are considering using a table designed for rental records clerical duties, having space in the table top for eight inch by five inch cards.

The latest modules we have called mark III. They are each 128mm high, 368mm wide and 242mm deep. If you compare them with the mark I version, now working at Ilford (illustrated in *Maintenance News* 3), you can see that they look much better – and they have improved facilities.

Call reception module

This module (on right of drawing) receives fault reports from the manual board and from customers on a regular appearance and two auxiliary appearances. There is also a queue lamp, which lights when all staffed reception positions are engaged. If two calls are waiting in the queue, further callers receive busy tone or a verbal announcement that all circuits are engaged. Customers reporting faults dial 151, and operators dial 051 or 151 depending on the type of manual board. Calls in the queue receive

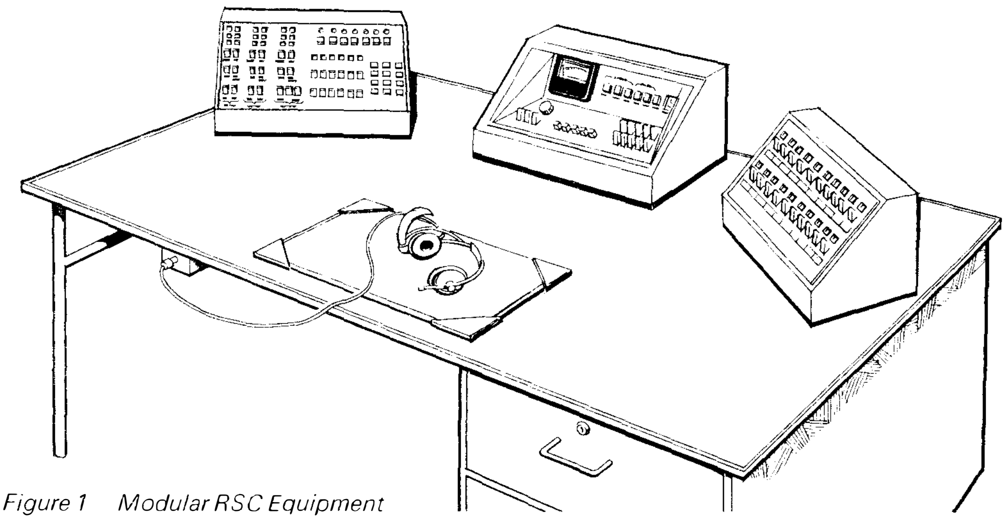


Figure 1 Modular RSC Equipment

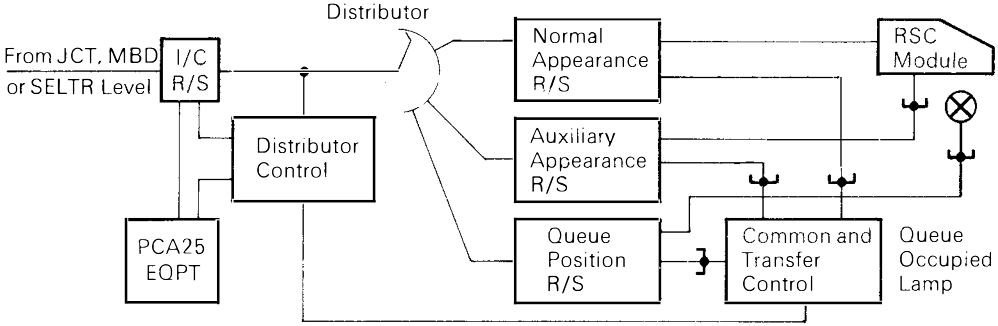


Figure 2 151/051 Call Distributor

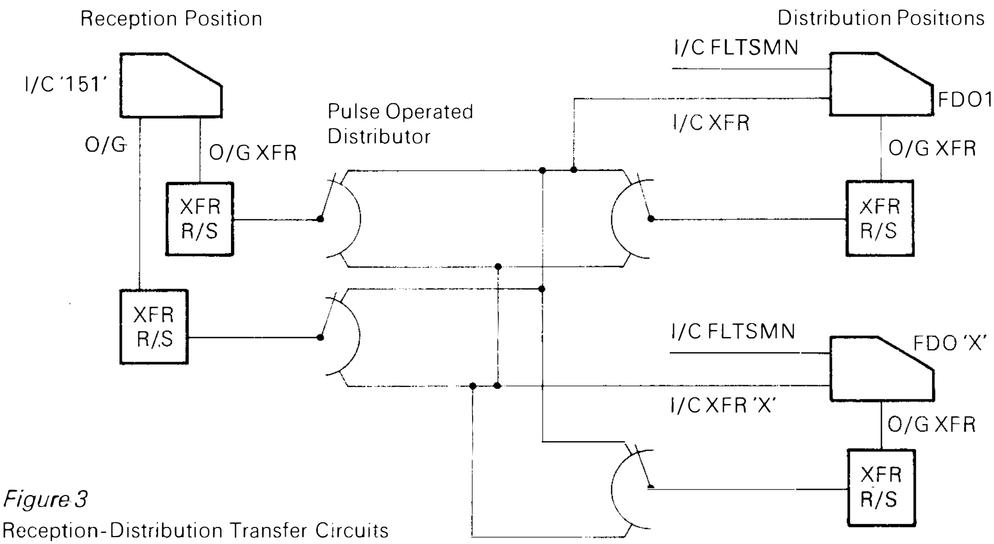


Figure 3
Reception-Distribution Transfer Circuits

ringing tone and are taken out of the queue in order of arrival, taking precedence over any further incoming calls when a reception position becomes free.

The diagram shows the 151/051 call distributor, which distributes the calls over the staffed reception positions in cyclic order. While an RCO is dealing with a call, no other calls are presented to him until the caller has cleared and calls have been extended to all other free reception positions. In other words, he gets only one call in each cycle of the distributor. If, however, he has transferred the call to be dealt with by a fault distribution officer or the officer-in-charge of the RSC, he will be presented with a call on an auxiliary appearance on the next cycle of the distributor. The two auxiliary appearances cater for the possibility of his having transferred two calls that have still not cleared. The PCA25 equipment counts the number of calls answered within 25 seconds, the number answered in more than 25 seconds, the number abandoned within 15 seconds, the number abandoned after 15 seconds and the number meeting busy tone. From all this, the standard of customer service provided by the RSC on report reception can be calculated. (See *TI E13 B0012*).

Studies have shown that one of the main factors preventing a reasonable answering service are long duration enquiries. These are often about the progress of faults in hand and have to be dealt with by the fault distribution officer who holds the necessary records, or by the officer-in-charge. Each call reception module has two outgoing transfer circuits and one incoming. The position that is to handle the long enquiry is called by selecting an outgoing transfer circuit and keying the position number using the keypad on the test access module. The incoming transfer circuit lamp lights on the called-position, the enquiry is passed forward without the caller hearing what is said, and the call then transferred by restoring the speak key.

The call reception module also provides for 12 incoming faultsmen's lines, tone demonstration circuits, and an exchange line.

Test module and test access module
These modules together (centre and left of drawing) provide test circuits with facilities similar to those given by the test cord and test distributor jack field on a test desk. The test access module has three 'line-to-test-access' circuits, each connected to a junction hunter accessing up to 48 test junctions in up to seven test junction groups to distant exchanges. At these distant exchanges, intermediate test selectors may be used to give access to further test junction routes.

To test a subscriber's line, the RCO selects one of the three lines-to-test-access circuits and operates one of seven junction group marking keys. He then keys the subscriber's number, preceded, if necessary, by routing digits to step intermediate test selectors. Tests using the test module can then begin. Keys associated with each lines-to-test-access circuit enable interrupted earth, interrupted ringing current, or graduated howler to be applied to any circuit under test.

There are 12 other keys on the test access module, providing access to speaker circuits to distant exchange MDFs and Special Faults Controls.
Sv5.1.3 (01-432 1379)

Beware of testjack lamps

Someone has recently been hurt while plugging in a tester TRT 172. The plug knocked the testjack lamp and he was showered with broken glass. A piece entered his eye but fortunately the injury was not too serious.

The trouble is that the tester plug is 12-way, and needs some force to be inserted into the jack. As it has to be moved from side to side when being plugged or unplugged, there is a real chance that the plug might hit the lamp, which protrudes from the testjack to be visible from a distance when alight. The risk is greatest when having to stretch to reach a relay-set on an upper shelf, and there is still a risk when using testers other than the TRT 172.

Redesign of tester plugs and relay-set testjacks is not justified, but it is important for staff to be careful when inserting or removing tight-fitting tester plugs. So do take up a comfortable and safe working level before doing so. Labels CC17/E, available from the PO Factory Label Centre at Cwmcarn (on requisitions A1097) carry a suitable warning and should be affixed to each tester plug. The labels are self-adhesive and each is supplied with a piece of self-adhesive clear film for added protection against wear.
J A Wood, Sv6.5.6 (01-432 1342)

Modular power plants

In the past power plants were developed to supply a variety of output voltages to meet the requirements of different equipment. A recent study of power systems has led to a decision to operate all new telecommunications installations from a single power supply of —50V, regulated within the limits of 46 to 52V. Any equipment requiring a different operating voltage has its own regulator or converter. To provide the 50V power supply a 'modular' power plant has been developed which supplies the load from one or more 'modules' as shown in the diagram. As the installation grows, modules are added to match the increased load. Some power plants of this kind (power plants 233) are already in operation.

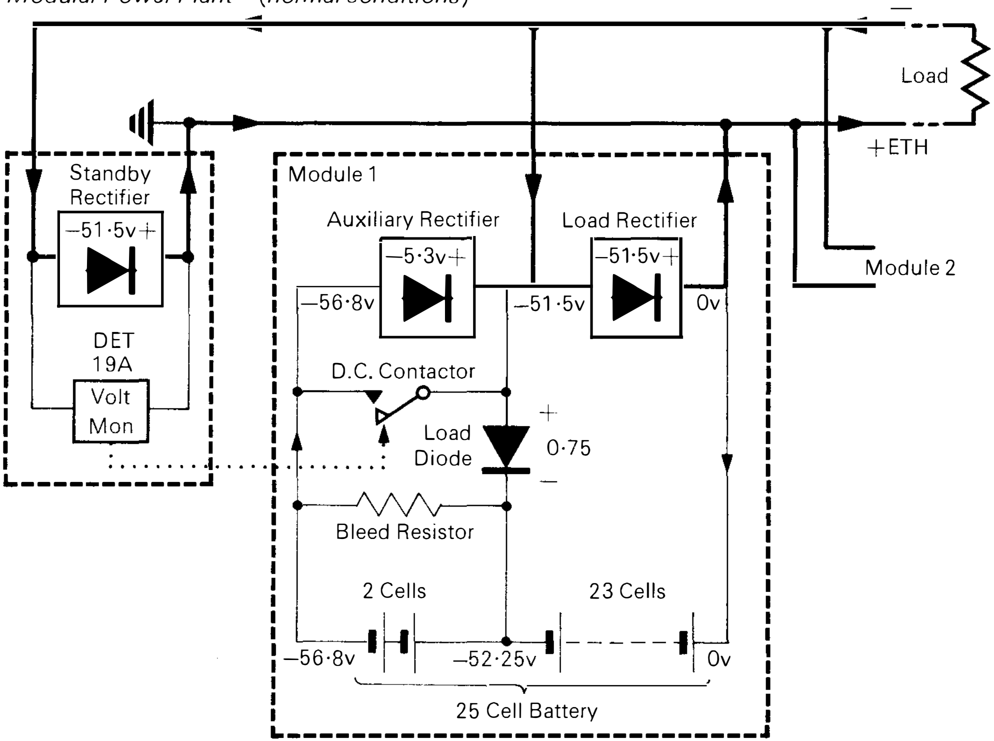
The diagram shows that the power plant consists of a standby rectifier and a number of modules. Each of these modules has a load rectifier supplying the equipment load and a 25 cell battery trickle-charged by the load rectifier and an auxiliary rectifier at 2.275V per cell. Under normal conditions the module battery does not supply the load because the load diode is virtually non-conducting. The principle of operation thus differs from earlier systems, in which the battery floats across the busbars and provides smoothing of the rectifier output ripple. It will be appreciated that for simplicity the diagram omits the mains connections to the rectifiers and other detail.

Load diode

The heart of the new system is the load diode which, in normal conditions as shown in the diagram, has a small forward bias of 0.75V and is virtually non-conducting. This bias is developed by the bleed resistor current.

The bleed resistor also prevents the two end cells being overcharged. If the mains supply fails the rectifier outputs fail. In each module the 23 cells of the battery supply the load, and the forward bias voltage across the load diode is then increased to one volt

Modular Power Plant – (normal conditions)



so that it conducts. This voltage drop across the load diode gives an initial busbar voltage of 51.25V but, with the module batteries now supplying the load, the busbar voltage drops. When the voltage monitor (detector 19A), fitted in the standby rectifier cubicle, detects a busbar voltage of 46V the dc contactors in each module close, connecting the 25 cells of the battery to the load. In this condition the load diode is reverse-biased by the two end cells. These apply approximately four volts across it and consequently it does not conduct.

Standby ac generator
The designed capacity of all module batteries together is only one hour at peak load and a standby ac generator, usually a diesel engine generator set (power plant 426), is necessary. To economise on the size of the set its output is connected only to the module rectifiers. An earth from the engine set keeps the dc contactor in each module operated and the 25 cell battery floats across the load rectifier at 51.5V (2.06V per cell). The auxiliary rectifier delivers full output current into a short circuit, the current being limited to the designed maximum.

Restoring the mains
When the ac mains supply is restored the outputs of the standby and load rectifiers are biased one volt high by the voltage monitor, which also keeps the dc contactors operated, so that the 25 cell batteries continue to float across the outputs of the rectifiers. The battery voltage – and hence the busbar voltage – rises and when it reaches 51.8V the voltage monitor removes the one volt bias from the standby and load rectifiers and opens the dc contactors. All conditions are now restored to normal, with the batteries being restored to the trickle-charged condition at 2.275V per cell.

Routines
TI E12 P2330 schedules the routines to be done by station staff and by specialist power staff.

Reliability
Even with only one module provided there are two rectifiers (load and standby) supplying the load and the probability of both failing is remote. With a one hour battery reserve the probability of failure of the dc plant is negligible and the overall security of the power supply is a function of the reliability of the ac supply. This depends on two factors – the failure rate of the public ac mains and the reliability of the ac standby set.

It has been stated that on average the ac mains supply will be interrupted 30 times a year and only one such interruption will last longer than the one hour battery reserve. The failure rate of the standby engine set is estimated to be one failure in every 200 demands for start. With only 30 demands for start a year and only one failure to start being of any consequence, it has been shown that complete power failure can be expected once every 200 years. The probability of the power supply remaining available throughout any year in the life of the equipment is therefore very nearly unity, or 100 per cent. (See also *Reliability – terminology and measurement* elsewhere in this issue).
J O West, SWTR/Sv1.1.4

NCC News

SPN progress

Access and switching equipment (ASEs) and associated broadband switching equipment (BSEs) are now being installed as part of the Service Protection Network (SPN) facilities described in *Maintenance News 2*.

Most of the initial line sections dedicated for the SPN have been provided. Using special patching arrangements, temporarily spare links and radio protection channels, they have been used to provide alternative hypergroup links after main link failures.

Service restoration

Make-good routes are used mainly for restorating service after failure of coaxial regulated line sections. More hypergroup link failures are now being restored by re-routing, with less time being taken to effect these re-routes.

Figure 1 shows the proportions of failures in which service was restored by re-routing, and also the mean time to restore service (MTTRS), for 12-month periods, moving by quarters since 1971. Thus, in 1971, 16 per cent of hypergroup failures were restored by re-routing, and in the 12 months to the end of March 1975 36 per cent were so restored. In the same period the MTTRS fell from about 2.6 hours to 1.2 hours.

These improvements are the result of an increasing number of make-good routes becoming available and through staff in the field and the NCC organisation becoming increasingly familiar with the possible ways of using them. With full SPN facilities and the development of standard hypergroup re-route plans it can be expected that the mean restoration time will continue to fall and that staffed stations should be able to restore service within half an hour.

Figure 2 shows the distribution of restoration times expressed as the percentage of restorations taking less than any given time, and is shown for the two years ending March 1974 and March 1975. In those years the mean restoration times were 1.40 hours and 1.23 hours; other comparisons are shown in the table.

There are two main reasons why some restoration times exceed two hours. If a failure occurs outside the normal working day there may be delays in getting staff to attend to set-up re-routes. In the case of a fault causing several hypergroups to fail, a number of separate re-routes may be required which of course takes longer. In both cases the difficulty is aggravated if devious re-routes have to be employed; on occasions five or more line sections have to be strung together.

T S Farres, Sv7.1.3 (01-357 2643)
National Network Co-ordination Centre

	1973/74	*1974/75*
Mean time to restore service (hours)	1.40	1.23
Percentage of restorations less than 1 hour	49%	60.3%
Percentage of restorations over 2 hours	23%	18.1%
Number of hypergroups re-routed	343	431

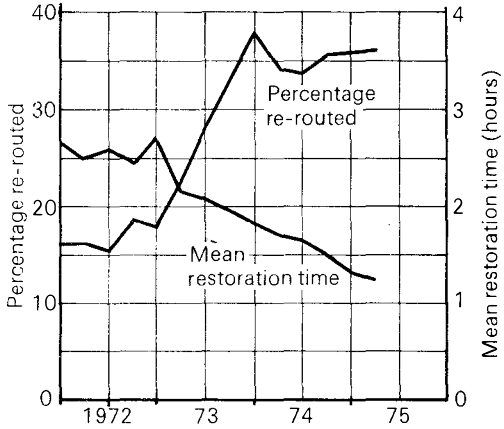


Figure 1 Hypergroup link failures: percentage restored by re-routing of mean time to restore

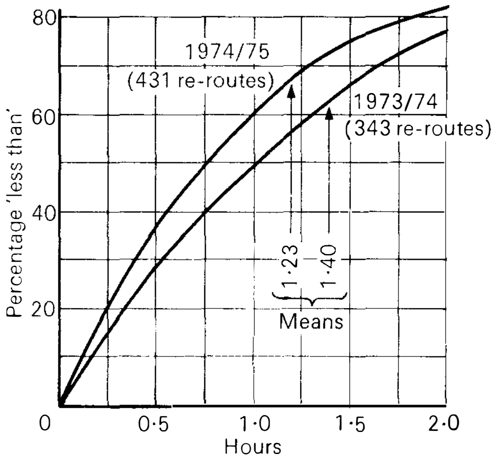


Figure 2 Distribution of restoration times

Processors and software for telecommunications

The operation of an exchange can be divided into two main functions, 'switching' and 'control'. The switching function is performed by the switches that establish a path through the exchange, and the control function by the equipment that directs the switches during set-up and clear-down and supervises established calls.

Processors for exchanges

In Strowger exchanges, if we neglect localised controls used only during call set-up (directors and register-translators), the control function is distributed throughout the exchange, each two-motion selector having a small part of the control function associated with it – for example the P-wires, pulsing and tone feed relays. As a rule, calls arriving together can be handled in parallel, the switches responding individually to control signals such as dial pulses or called-sub answer.

In crossbar and electronic exchanges more of the control function is achieved by using common equipment independently of the switching function. Signals from originating or incoming calls do not operate directly on the switches but are accepted and stored by a register. When the register has enough information, it applies for access to the control apparatus. Being common, the control apparatus can handle only one call at a time, but it operates so quickly that this is not noticeable to customers. The concept of common control is not new: a recent example, about to enter service in the PO, is the TXE4 exchange. In this and earlier systems, changes in facilities or functions are made by wiring modifications to the common control.

The development of computers to control continuous processes for example, in a steel mill or generating plant, has led to the idea of using a computer, or 'processor', to perform the control functions of a common control exchange. These functions and the facilities given by the exchange could be altered by changing the 'program' controlling the processor.

A program may be defined as 'a logical sequence of instructions which enable a desired task to be carried out by hardware (equipment)'. A program can be 'realised' directly in hardware (by wiring, straps, switches, relays or integrated circuits) or by storing the program instructions in an electrically alterable store. Control by the latter method can be said to be 'stored program control' (SPC). With SPC, modifications to facilities and functions are made by putting in a revised program. The old version is erased and control of the processor is taken over by the new version without physical change to wiring or components.

The first public SPC exchange was the ESS (electronic switching system) no 1, designed by Bell Telephones in the United States; this has been in service since 1965. There has been only a limited introduction of similar systems outside the USA. One reason for the slow introduction of SPC is the very high degree of reliability required for continuous 24-hour working to match that provided by existing electromechanical exchanges. Within the PO several experimental system trials using SPC processors have been undertaken, including the PCM tandem exchange at Moorgate, the CCITT no 6 signalling system at Wood Street, and the radiopaging system at Reading (see *Maintenance News 5*).

The first PO use of a computer-like control system employing wired programs, was the equipment developed to replace electromechanical register-translators in Strowger Director exchanges – often inaccurately called the SPC Director. Installation, which began with Birmingham Highbury in 1973, is now well under way, and is scheduled to have 70 installations completed by 1976. The first SPC system in service in the UK was the IBM 2750 PABX, which has been working since 1970 at the IBM (UK) headquarters in London. Eight IBM 3750 PABXs have since been installed and a further four are expected by the end of 1975. These PABXs are the only true SPC systems currently in service in the UK.

Processors for monitoring and assistance

There are several schemes under investigation which use processors as monitoring or assistance devices. These include the 'computer aided maintenance project' (CAMP) at Leicester and the 'measurement and analysis centre' (MAC) scheme (see *Maintenance News 3*). Both these schemes use a processor to monitor existing switching units, including Strowger.

In the more modern switching systems call failures are recorded by printing out a report of the equipment in use when the failures occur. As it would waste staffs' time if every single report were to be investigated processor assistance is being developed so that the equipment block containing the faulty item can be identified. A similar system is being developed for use in Sector Switching Centres. In this case each switching unit will have a local processor to collect information and provide a printout of all urgent reports. The remainder of the data will then be transmitted to a central processor at Colindale exchange for more detailed analysis.

The use of processors in monitoring and assistance roles is still in the early stages of development, but, the lessons learnt from the above schemes will be incorporated in future switching systems.

Maintenance

In general, business data-processing computers are maintained by the manufacturer under a maintenance contract and require constant attendance by operating staff. The machines are taken out of service at frequent intervals (in many cases daily) for preventive maintenance and, by telecommunications standards, the serviceability record is poor. This situation is unacceptable for processors forming an integral part of the telecommunications network. For this type of work the processors are designed for unattended operation and are controlled and maintained by telecommunications' grades normally employed in the maintenance of switching units. Maintenance techniques will, in general, follow the pattern envisaged for electronic exchanges.

Software

'Software' means all the information necessary to make the hardware work. It consists of all programs and supporting documentation required to control a computer. There are new problems in 'software maintenance' and 'software security'.

The term maintenance, as we understand it, means putting right something that has gone wrong. 'Software maintenance' means putting right something that has always been wrong, ever since the program was designed. In practice most software errors – called 'bugs' – are eliminated during the development and trial stages before introduction into service ; but quite often they are only found after a long time, when particular conditions arise that were not foreseen in program design. Another meaning of 'software maintenance' is the addition of new facilities or making changes to existing facilities. But here it is more correct to talk of 'software modification'.

The 'security' of software is the protection of programs and data against unauthorised access from human or hardware sources. The 'integrity' of software is the protection against corruption of stored information.

To standardise the use of system software, to maintain the security and integrity of the network and to minimise the cost of amendment and enhancement, a central software organisation is foreseen. This organisation will be the sole authority for updating system software. Once software is generated no local amendments will be permitted. The only local software maintenance function will be to reload the system in the event of corruption and to load new versions of system software supplied by the software organisation.

The next 10 years

In the immediate future is the 'Experimental Packet Switched Service' (EPSS). This is introduced to readers in a separate article in this issue. The system depends on SPC processors located at 'packet switching exchanges' (PSEs). The processors – Ferranti Argus 700E – not only form the control but also carry out the switching function by using 'store and forward' techniques.

System X, the PO's projected all-electronic telecommunications plan for the 1980s, will be processor-controlled. The processor is expected to be of GEC design, a development of the processors used for the CCITT SS6 trial at Wood Street.

To achieve the high degree of reliability required in an exchange, already reached in

Strowger switching units, it is desirable that the control area should have a probability of failure of not more than once in 50 years. With present day components this requires a multi-processor control installation with a high level of duplication and spare capacity, so that a viable control system is relatively expensive. This implies that there is a minimum economic size for an SPC exchange. However, there is no fundamental reason why several smaller switching units should not be controlled over data links from a centralised processor installation.

Changes in maintenance work

Advances in technology, moving from mechanical to electronic and from discrete components to large scale integrated circuits (LSI), and the introduction of processor control will inevitably mean changes in the work pattern for maintenance staff. Traditional tasks such as adjusting, oiling and cleaning, so usual in an electro-mechanical exchange, will largely disappear.

SPC exchanges will have improved 'self-healing' capability, minimising the effect of faults on the service to customers while remedial action is taken by maintenance staff. There will be better diagnostic facilities to aid fault finding. The maintenance man will thus become an overall system specialist rather than a specialist dealing with the maintenance and repair of particular areas of an exchange.

R P Myhill, Sv6.4.1 (01-432 1329)

Overcoming problems on the Loudspeaking Telephone 4D

The LST 4D is a voice-switched loud-speaking telephone. It switches from send to receive and back again according to the levels of the signals being sent and received. Switching from one state to the other is done by the comparator, which compares sending and receiving signal levels. The comparator operates a trigger which provides 'hysteresis', a kind of electrical inertia switch which at any moment tends to remain in the send or receive state, thus helping to bridge the gaps that occur in normal speech. The signal level at which it switches to send, for example, is greater than the lowest level at which it will stay in send. There is also a built-in delay to help bridge the gaps in speech.

Operation

There are four operating buttons. The first, which is marked with a single dot, produces a low receive gain for local calls. The second, marked with two dots, gives a higher receive gain on quieter calls, and the third is for very faint calls. With the third button operated, the LST automatically reverts to receive whenever the user is not speaking, and the receive gain is further increased. This button should be operated only when really necessary. The fourth button, marked MIC OFF, cuts off the LST microphone and so enables the user to confer with others in the room without being overheard at the distant end.

Difficulties

A faultsman called in has to decide whether the customer is misoperating the instrument, or whether the difficulties are environmental – these can greatly influence performance – or whether he really does have a fault on his hands.

One of the most common difficulties is speech 'clipping'. This can be caused by the way the customer uses the LST. Best results will be achieved when the customer speaks directly at the instrument from about 45cm away, and the button giving the lowest gain acceptable on the call is operated. If the customer switches to a higher gain and settles back away from the instrument, speech will be mutilated without him realising it.

If it is difficult for the customer to place the LST close enough, an extension microphone (microphone unit 1B) and an extension loudspeaker (loudspeaker unit 4B) can be provided.

If the customer has no LST 4D operating instructions (card A3748), Installation Control can supply one. With new LST 4Ds the practice is to enclose a card with the instrument.

Faultsmen may easily come up against LSTs installed in unsuitable environments. An acoustically 'dead' situation is desirable, with soft furnishings to minimise echo. Background noise should be low, for high levels will cause false switching, mutilating incoming speech. The environment should also be electrically quiet, that is devoid of high strength electric and magnetic fields. Electrically noisy machines can cause noise on LST calls, and apparatus such as radio transmitters and microwave ovens can also produce false switching.

Technical difficulties

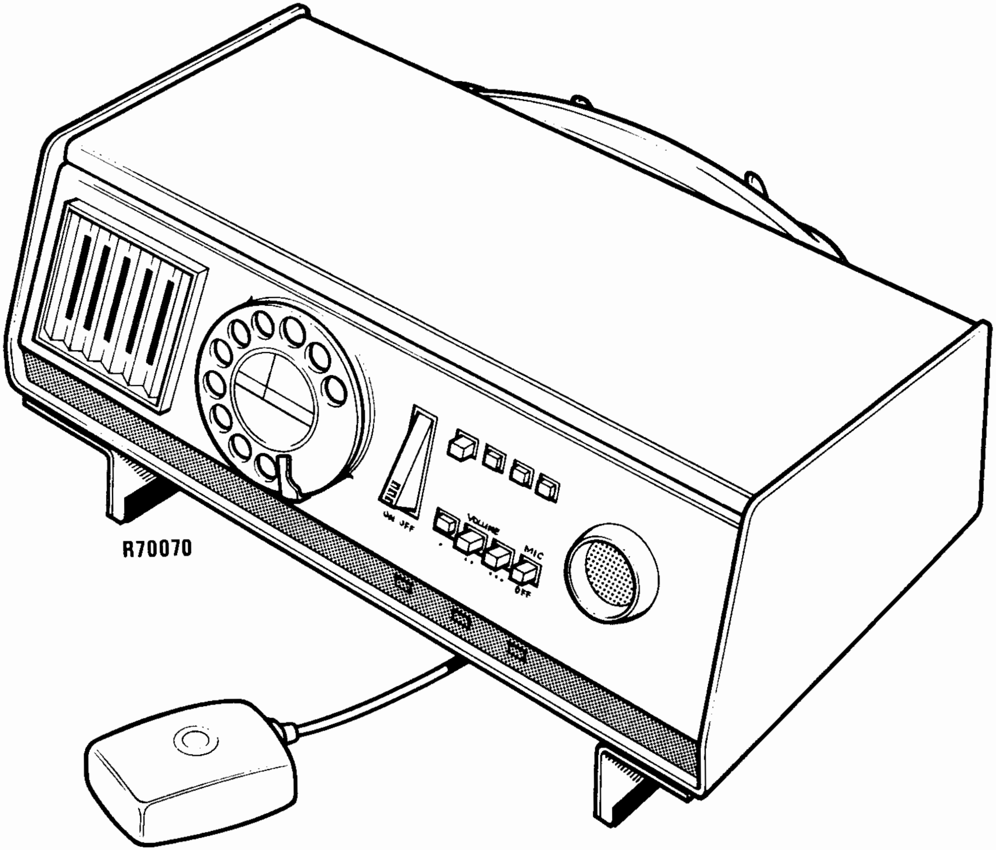
The original switch mechanism (switch 31-A) was prone to fail through distortion of the locking pin. A new switch (switch 31-B) has been introduced with a stronger pin and small quantities can be obtained from Regional service groups. The new switch can be identified by its red plunger.

Speech clipping should be reduced in new production LSTs 4D because they have a modified amplifier (amplifier SA 4286). This has two printed circuit boards, whereas the earlier amplifier (amplifier SA 4260) had four. The new amplifier will be a separately replaceable item.

The fixed part of the handset rest has a tendency to work loose. This can be corrected by tightening the retaining nut and applying a small amount of 'Loctite' nut lock. All new and repaired LSTs are now so treated.

With these changes there should be a marked reduction in the rate at which LSTs are changed out in maintenance.

J S Alcock, Sv5.3.2 (01-432 9283)



R70070

NNCC-a finger on the network's pulse

Every time there is a fault in the telephone network involving 50 or more circuits, the National Network Co-ordination Centre gets to hear about it – quickly. This article examines the work of the NCC system, and how it first came to be set up.

In the mid-60s, the telephone network expanded rapidly. At the time, there was no way of knowing the overall state of the network, and for this reason it was difficult to control. Under breakdown it was especially difficult to identify faults accurately, or to use available resources efficiently.

Today communications are better, with NCCs providing rapid information about the state of the network. There is a two-tier structure: each Region operates a Regional NCC, co-operating with local TMCCs, reference centres, and repeater and radio stations; the RNCCs are co-ordinated by the National NCC, from its office in THQ, 2-12 Gresham Street.

Reg Moulds runs the NNCC office – chosen for his many years of transmission experience. He began working on transmission systems in 1936, moved to the HQ Transmission Training School at Cambridge in 1942, and remained in this field until 1967 when he was transferred from Stone to set up the NNCC, virtually single-handed.

The importance of the NCC system was quickly recognised, other NCCs came in by late 1968, and national records were gradually built up. In the national NCC office, Reg Moulds today heads a staff of 15. "NCCs are now linked by an omnibus speaker-circuit system, connecting RNCCs with each other and with the NNCC" explained Reg "If, for example, somebody has lost a lot of circuits in Scotland, the RNCC reports come in over the speaker, and very quickly we know exactly where the fault is".

As soon as a fault has been located, the appropriate local specialists are called out – switching, power, radio or transmission men – so that the fault can be put right.

Responsibilities of the NCC go beyond monitoring major service failures on the telephone network. It also deals with failure of ITV and BBC TV picture links, as well as ITV sound; in certain cases it also deals with submarine cable links. This means that the NCC network has to be in close contact with ETE, NP5 and NP6 (for submarine cables) as well as with the TV Network Switching Centres.

In the case of multiple failures the NCC network decides the order of priority for restoring service. This can be particularly important in the case of submarine cable repairs, where there may be two faults yet only one repair ship available at the time.

Each week NCCs provide a summary of faults, relating faulty circuit and hypergroups to equipment. Further summaries are made every month and again every three months.

All major service failures are handled by EE, D H (Griff) Griffiths; another member of Reg Moulds's staff, Harry England, looks after another aspect of NCC work – the planned interruptions to service to allow engineering works to be done.

Before Areas take anything more than a group of circuits out of traffic for planned works, authorisation has to be obtained from the NCC organisation. This enables circuit controls to be advised through the A60 procedure before their circuits are lost – service to customers is naturally better than it would be if this information was not available. Four-fifths of work is now done without breaks in service and wherever possible other work is done during preferred hours, during low traffic periods. On any particular route NCC never authorises more than two-thirds of the circuits to be taken out of service at one time.

With 1300 hypergroups within its control, the NNCC has an obviously large records task. Not only does it need to keep up to date with any new routes being brought into service, it also needs to know about special circuits or groups and those conditions affecting any re-route during maintenance. For instance some CEGB control circuits must never be made good over mains-dependent routes, as the information they carry would be vital in the event of a mains failure. Certain defence circuits cannot be routed over radio links, and air navigation and gas control circuits cannot be interrupted at any time without first informing the customer. Each of these constraints is recorded in the NNCC files ; and when planning make-good routes, possibly using the service protection network, these facts are all taken into consideration.

Faults still occur each day as they did before the NCCs were set up. But Reg Moulds and his team know that nowadays, with assistance from the RNCCs, they help field-management to plan and run the network more efficiently.

Jeremy Knighton, TMk3.2.1 (01-432 1888)

Reg Moulds (left), his finger on the pulse, discusses a problem with one of his staff

PCM network for BBC sound

by **P R Watson,** Sv7,3,3

The BBC has ordered a distribution network from the PO for their new PCM system for sound programme channels. The PO is meeting this order by providing 625-line monochrome TV channels routed on microwave radio links and standard PO 62-type coaxial video links. When complete, the new PO distribution network will provide sound coverage for the West of England, Midlands, North-West and North-East England, Wales, Northern Ireland and Scotland. The remainder of the UK will be covered by the BBC's own distribution network. We expect that once the reliability of the new system has been proved, the BBC will relinquish a large number of the conventional analogue sound programme circuits that they now rent from us.

BBC system

The BBC system enables 13 audio signals, each of 15 kHz bandwidth, to be sent simultaneously. Each channel has a signal to noise ratio of 70 dB. The audio signal is sampled at the sending terminal at 32 kHz, and the measured amplitude of each sample is converted to a 13-digit binary code by a 'ramp-and-counter' analogue-digital converter. The 13 bits, plus one parity bit, from each of the 13 channels are combined in a multiplexer to form 'frames', each of which lasts for 31 μS. To the 182 bits from the 13 channels are added a digital synchronising signal of 9 bits to locate the start of each frame, and a 5 bit 'data' signal which can be used to control mono-stereo switching at transmitters. The total 'bits per frame' is thus 196 ; and as there are 32 400 frames per second, the overall 'bit rate' is therefore 6.336 Mbit/s.

The frame make-up and an example of signal format appears in figure 1. The bit stream sent along the link represents each binary digit by the presence or absence of a sine-squared pulse (1.5T 625-line) At the receiving end, the bit stream is limited, synchronously detected and the frame synchronising pulse pattern is located. The reverse of the process at the sending end then takes place and results in the reconstitution of the audio signal.

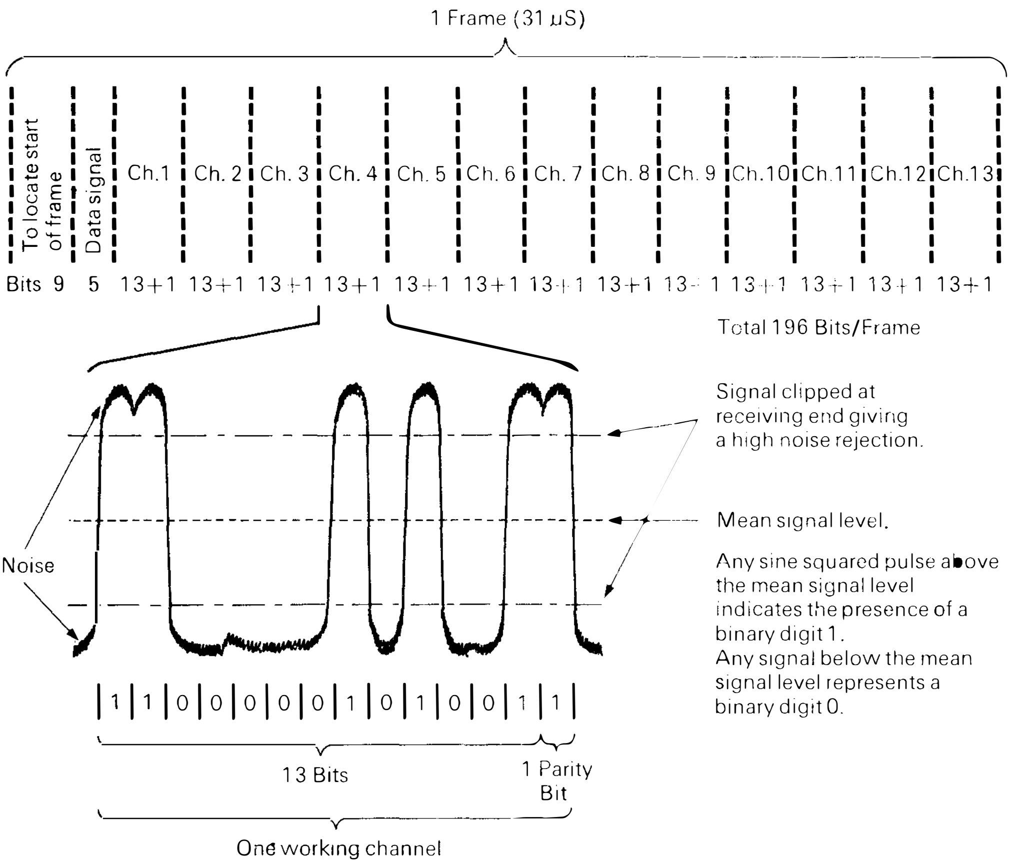
A significant error rate on the bit stream will cause the audio channel outputs to be muted and transmissions to be switched to a conventional PO sound programme circuit.

One stereo transmission would use two of the possible 13 channels. The signal to noise ratio and bandwidth of the stereo signal are independent of the characteristics and length of circuit used.

PO network

Since the required bandwidth falls within that of a 625-line TV link, standard PO analogue 625 monochrome TV links were the obvious choice. The new links are routed in the existing television network, so

Figure 1 Frame make-up and signal format



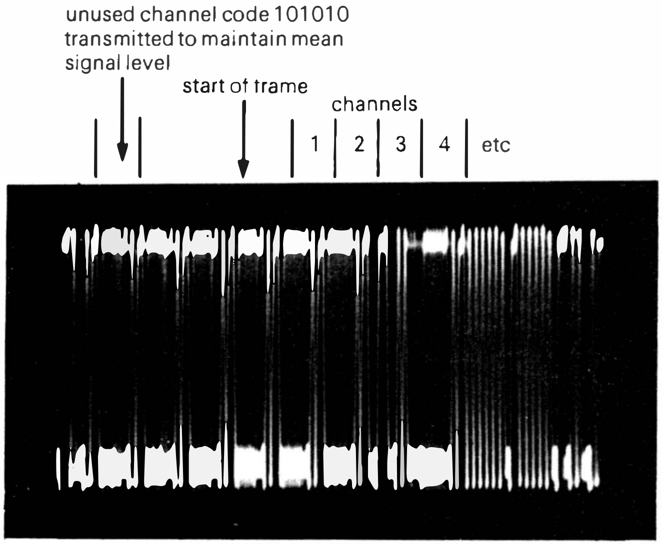
obtaining physical advantages in providing them and allowing for them to be controlled at Network Switching Centres (NSCs).

The present PO network consists of a northbound feed from BBC Holme Moss to BBC Kirk O'Shotts providing coverage for parts of NW England and Scotland, and a second westbound feed from BBC Sutton Coldfield to BBC Wenvoe providing coverage for the Midlands, West of England and Wales. When complete, spur links off the Holme Moss to Kirk O'Shotts link will provide coverage for the remainder of NW England, NE England and Northern Ireland. The BBC provides its own microwave link between London, Sutton Coldfield and Holme Moss.

The PO links are standard 625-line monochrome TV links lined up to carry a one volt peak-to-peak TV signal. In practice it was found necessary to reduce the PCM signal level by 8dB, from 1V peak-to-peak to 0.4V peak-to-peak before transmitting it over these links. This was necessary to prevent overloading on the microwave radio links causing malfunctioning of the supervisory and control circuits. Also the energy content of the PCM signal is fairly constant over the passband, and when the PCM signal was transmitted at 1V peak-to-peak, breakthrough was experienced on the adjacent radio channels. (A typical TV signal has most of its energy content at the lower frequencies and therefore nearly all the significant sidebands are contained within the 10MHz radio channel spacing). It was necessary to adjust the video supervisories to function to the lower level signal.

No PCM regenerators are used on any part of the distribution network, including the BBC links and BBC/PO interface, the signal being treated by analogue means throughout. This has been possible because of the high quality of the TV links and relative immunity of the PCM signal to distortions. It also enables the links to be tested using established TV testing techniques.

Figure 2 PCM signal showing individual channels. (Timebase 1 µS)



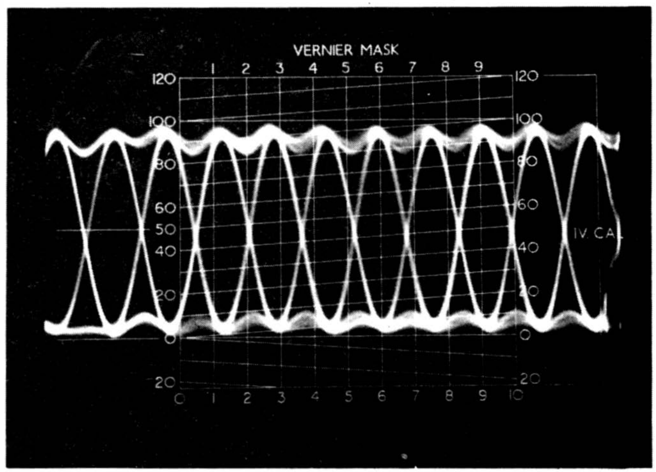
Maintenance methods

Conventional TV testing techniques using line repetitive test signals as for other 625-line monochrome links are used to routine test individual sections of the distribution network. Since the BBC require a continuous 24-hour service, it is necessary to switch a main radio link to a standby or protection channel and similarly switch a working coaxial video link to a specially provided standby video link.

On-line tandem measurements of the PCM signal are made when checking fault reports, localising faults and making routine tests of link performance. Two parameters are measured – the PCM envelope amplitude, expressed in volts peak-to-peak, and the 'eye' height, expressed as a percentage of the envelope amplitude.

A typical oscilloscope display of the PCM signal is shown in figure 2. This shows the start of frame signal and individual channels. A display of 'eye' height is shown in figure 3. The display is obtained by overlaying trains of individual pulses. The method of measuring eye height is shown in figure 4. The height decreases with increase in distortion and/or noise level. An eye height

Figure 3 'Eye' display for an undistorted PCM signal. (Timebase 0·05 µS) 'Eye' height approx. 82%



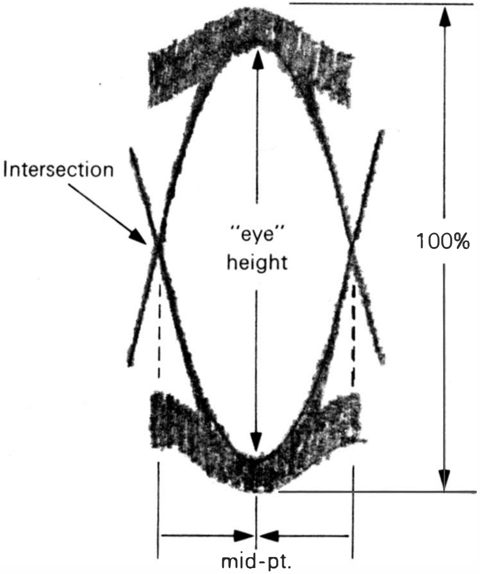


Figure 4 Measurement of 'eye' height

of 30 per cent is regarded as indicating a probable fault and is the criterion used by the customer in making a fault report.

Fault location
All fault reports from the BBC are in the form of a request to investigate poor eye height, overall signal amplitude, impairment or loss of service of the PCM signal. The PO then attempts to localise the fault by measuring or observing the PCM signal at various parts of the distribution network. Once the faulty section has been localised the section is made good using the facilities described above. If no definite fault can be found on the PO network the BBC are advised and asked to test the complete northbound or westbound link using conventional line repetitive TV test signals. The fault may then be reported in terms of agreed tandem TV limits.

Conclusions
The first section of this new service has now been in operation since October 1974. The maintenance arrangements have worked well, in particular the PCM measurements used as fault indicators. The use of TV channels has been satisfactory and no additional test equipment has been necessary, beyond that already available at NSCs.
Sv7.3.3 (01-432 1428)

MOS chips-handle with care

Many of you are now having to handle MOS chips. These are metal oxide silicon devices used, for instance, in the regenerator 5A for storing and re-transmitting dialled pulses, in the sender 9A keypad replacing the operator's dial, in 'self-contained' keyphones, and in IBM 3750 PABXs. They are mechanically protected, often in hermetically sealed cans, but the active devices inside are very vulnerable to static electricity. Therefore they must be handled with great care.

An MOS chip may contain a thousand field effect transistors (FETs) on a piece of silicon a few millimetres square or only two, as in the case of the 'dual transistor' used in PCM equipment. All chips are vulnerable to static, because they have a capacitative input with dielectric of microscopic dimensions, which can be easily ruptured. Therefore you have to be earthed before you touch any part of a circuit connected to an MOS device.

These devices are mounted on printed circuit boards, or 'cards', along with 'discrete' components such as capacitors, inductors, resistors, and other transistors. You can make a card useless if you touch any termination connected to a chip. So, before you work on a card at all, do follow these four golden rules:
1 Disconnect power from the card.
2 Discharge yourself by touching an earth

bar *immediately* before touching the card. Remember your static can build up quickly.
3 Use special packaging when moving or storing cards or individual MOS devices. There are packs with dummy sockets, all terminals of which are short-circuited to ensure that they are all at the same potential. The card to be moved or stored is plugged into the dummy socket, which is bonded to a screened box for transportation.
4 Do not work on a card except on a bench having an earthed plate. Benches for such work have a light earthed wrist chain connected to the plate and you should put it on your wrist before touching the card.

Sometimes unsuitable floor coverings, such as nylon cartpeting, can be a hazard to MOS chips in equipment. High room humidity and the design of the equipment itself can also present problems.

The greatest hazard, however, is what might be called 'personal static', and in maintenance work we have to be careful. Plessey are affixing warning labels to their equipment, and other manufacturers will probably follow suit. The warning reads :

WARNING
MOS device – see circuit notes before handling

The general problem is being looked into by TDD in THQ and they will probably line up with the British Standards Institute, who are also investigating.

MOS chips are produced by an intrinsically simple manufacturing process involving photography. The technique is called 'large scale integration' (LSI) and is capable of high yields. Costs are therefore relatively low. Moreover, LSI devices have low power consumption. The technology offers considerable advantages to equipment designers, and we can expect to see much more of it. The transition from assembling discrete components into circuits to using LSI techniques may well cause more dramatic impact, in a shorter time, than the earlier step from valves to transistors.

Faulty MOS chips can only be thrown away and it may not be economic to repair cards containing them. It depends on the cost of associated discrete components on the card. For instance, a faultsman who proves a fault into the push-button unit or associated electronics of a self-contained keyphone, must change the complete instrument (see *TI E5 B2830*).

J C Wills, Sv5.3.1. (01-432 9150)
with acknowledgements to
ETR Service Division

Mac the life

I first met Frank McLellan – Mac to his friends – on a cold dismal May day, in the fine oak-panelled library of the Mansion, the administrative centre of Bletchley Park Regional Engineering Training Centre.

Mac, now a lecturer in coaxial studies, was the king-pin in the Bedford Area housing estate trial, which was set up in 1972 to study and identify the causes of the abnormally high fault rate being encountered on new residential estates. The trial, which lasted for two years, is described fully elsewhere in this issue.

In his late forties, Mac struck me as having a very balanced view of the PO – and indeed, of life in general. The library seemed an ideal setting to discuss Mac's approach to his work and leisure activities – which I was later to discover were many and varied.

I asked Mac about the recently completed trial in Bedford Area. How did it all come about ?

Mac: For some time, THQ had realised that the fault level on new housing estates, whether the 'frontage tee' system or the 'radial' system of distribution had been used, was very high. To get more information, THQ decided to look for an Area where there was a high rate of residential growth. Bedford fitted the bill and had another advantage – it was near to London. This meant that THQ staff could visit regularly

and keep an eye on progress.
MN: But why were you chosen as the Field Trial Liaision Officer?
Mac: Perhaps it was because I know the Area so well. I like meeting people and my varied experiences as Inspector on field installation, mechanical aids, major works jointing and cabling meant that I knew everyone involved anyway. I was aware that the fault rate was high on these estates – and this seemed an ideal opportunity to come to grips with this problem. And as THQ pointed out, Bedford's problem was typical of many other high-growth residential areas throughout the country.
MN: I suppose it meant a lot of work?
Mac: Indeed it did. In the two years of the trial I dealt with over 40 estates – involving over 4000 properties. I explained to all the staff I met that the purpose of the trial was to eventually help them by identifying the causes of the faults. This would help the development of new plant and techniques which could overcome many of the problems.

One of my briefs was to catalogue all the faults. Working closely with Luton EPMC, I arranged for subscribers' fault cards to be specially marked 'field trial estates'. This enabled a check to be made on all faults reported to the RSC so that an investigation could be carried out.
MN: Were there any developments during the trial?
Mac: Yes. New joint boxes were introduced. One, the 23A, was made of fibreglass, and was a lot less fault-prone than earlier designs. The joint box 23A is designed to be used with jointing sleeves 31A, and is capable of taking cables up to 100 pair. Another innovation

Frank 'Mac' McLellan, left of picture, sorts out a problem on one of his 40 housing estates

was PETAP, or Polyethelene Annular Protected cable, which is manufactured with its own duct. We will just have to wait and see whether the introduction of these two items influenced the fault rate in any way.

During the last three months of the trial, there was a dramatic drop in the level of housebuilding. This meant that materials were being dumped or withdrawn from site, with the resultant danger that cables were subject to being cut, pulled up, or being left in the open to deteriorate. Again, it remains to be seen whether this downturn in the rate of building has had any significant effect on the fault rate.
MN: Have you had any feedback from THQ yet?
Mac: About two months ago, there was a meeting in the Area, between Area staff including the GM, the Region and THQ. At this meeting, THQ presented a report, based mainly on the information that I had been able to supply. But of course it is going

to take some time before any conclusions can safely be drawn. You see, there are so many factors at work, that unless they are all correlated correctly, it will be easy to draw wrong conclusions.

MN: Did you enjoy your spell as the Field Trial Liaison Officer?

Mac: Immensely. I met lots of people, and was able to discuss their problems with them. The work also gave me an insight into the problems faced by THQ.

Many of our problems are caused by a lack of communication, so I am particularly pleased to be given the opportunity to discuss aspects of my work – as I see them.

MN: What do you consider to be the most important part of your work with the PO?

Mac: Undoubtedly safety. As a former member of the Area safety committee, it is evident that a PO employee who has no consideration for his own safety is usually a danger to everyone else. Many injuries are caused by a lack of regard for safety instructions. Of course everyone suffers – not least the family of the injured and the PO. A few years ago, I was working in the office when it was brought to my attention that a couple of staff were working outside and not wearing their safety helmets – in circumstances where it was obvious they were essential to safety. The leading hand, a temporarily promoted T1, was asked to see me. After a preamble about the job, and how he was getting on, I dropped the bombshell. "While I'm responsible for preparing your report, you won't get made up". His face fell a mile. I explained why he should be wearing a helmet and pointed out that on his report form there was a section on safety. I explained that his disregard for his personal safety and the man under his charge did not reflect the qualities required for a T1 post. He quickly put on his helmet. He got the job. But I would *always* try to stress the importance of safety in a working environment.

MN: Turning now from business to leisure, how do you relax?

Mac: I like music. Not having a television, I find that I can listen to music and become totally immersed. I particularly like Beethoven, Wagner and Mozart. But also, background music helps me to concentrate on my other activities.

MN: What are your other activities?

Mac: I like to be interested in everything that goes on around me. I suppose my special hobbies are ornithology, photography and microscopy. I also like to spend time in the garden and under the car. My interest in car maintenance stems from necessity – I like things to work properly. Another speciality is the study of church architecture. I recently visited an old village church, deep in the heart of the Cotswolds. As I entered the church with my wife, we noticed a group of schoolchildren at one end who, with their teacher, were busily engaged on brass rubbing. We found out that she was an expert on these brasses and that by looking at the figures on them, was able to tell who they were, what they were doing – in fact exactly what they represented. Now I feel I know a little about that subject.

I left Bletchley Park in the afternoon much warmer than when I arrived. Here was a man who was intensely interested in life – and not only that, was able to project his enthusiasm into everything he attempted. And it was not a false enthusiasm. His quiet confidence left me thinking that if just a small part of his attitude could be imparted to the many students who pass through the training school, then the PO was sure to benefit.

Richard Beet TMk3.2.1 (01-432 5299)

Biographical note

Frank McLellan was born in 1927 at Walthamstow. Educated at Wickford in Essex, Mac can claim to have seen life before entering a career with the PO. He has dispensed medicine, worked in coal mines on conscripted service, looked after patients in a mental hospital, laboured on a farm and maintained electrical equipment for a London hotel. He joined Cable and Wireless at Ongar after the war, and in 1951, joined the PO as a member of a cable gang at Chelmsford.

In 1959, Mac was accepted as a Demonstrator at Bletchley Park RETC, and in 1963 was promoted to Inspector at Luton, in Bedfordshire. His responsibilities over the next few years included Minor Works – field installation; External Works – mechanical aids; Major Works – jointing; and Major Works - cabling.

In October 1972, the housing estate field trial began, known as THQ/ECOPC Field Trial 426. Mac was put in charge locally, for which he earned a temporary AEE post. And in January this year, Mac returned to Bletchley Park after an absence of over 11 years – only this time as an AEE lecturer in coaxial studies.

Housing estates on trial

by **E N Harcourt,** Sv5.1.1

The current methods of providing telephone service on new housing estates were described in an article in issue five of *Maintenance News*. For a number of years however there has been increasing evidence that the performance of the underground plant installed on these estates is unsatisfactory; so, in April 1972, it was decided that a special study should be undertaken, to be completed within two years, and covering all aspects of housing estate work in one Telephone Area.

Arrangements for trial

With such a time scale it was of course impossible to follow the progress of individual estates from initial planning to ultimate acceptance into maintenance.

It was therefore arranged for the field trial to be conducted in an Area which had a large programme of housing estate work and where estates in differing stages of development could be studied. Bedford Area was chosen and the trial began in October 1972.

To avoid imposing too much extra work on local staff in collecting and analysing the information required, and possibly dislocating normal field operations, a member of the Area staff was appointed as Field Trial Liaison Officer and seconded to THQ. Known to everyone as 'Mac', his knowledge of the local geography, his contacts in the various disciplines involved in housing estate work as well as among the staff working on the estates, all played a major part in the smooth running of the trial. There is more about him elsewhere in this issue.

Scope of trial

A total of 41 estates, covering a planned development of over 4 000 dwellings, were included in the study. Some of these dwellings already had telephones before the trial began, and a further 2 000 were provided with service during the two year period. The building of about 500 of the dwellings originally planned was either in progress, or had been deferred, at the time that the study was completed. As information on alternative types of plant and methods of installation was required, estates served by both 'frontage tee' and 'radial' systems were included in the study. The frontage tee system was the one predominantly used – 74 per cent of the planned dwellings. A further 24 per cent were served by the radial system and the remaining 2 per cent, which were fed by overhead distribution, were included for comparison of costs.

Costs

The total cost of providing service by each system was obtained by adding costs incurred in clearing faults to bring the plant into service to the actual construction costs. This showed that the cost per dwelling of providing service by the radial system was 73 per cent more than that of the overhead system. And the frontage tee system cost 93 per cent more than the overhead system. It was also found that in the radial system the cost of clearing faults was 8.3 per cent of the construction costs but in the frontage tee system it rose to 12.4 per cent.

Faults

During the trial detailed information on more than 600 faults was recorded and studied. Initial analysis of this information showed that the builder was responsible for 56 per cent of the faults, the PO directly responsible for a further 32 per cent and other authorities such as Water, Gas, and Electricity jointly responsible for the remaining 12 per cent.

Study of the fault clearance particulars showed a very high incidence of service cables cut or left short. There are many reasons for this, one being misinterpretation of instructions by the builders. It appears that by re-examining details of the methods of installation, and their timing, it would be possible to reduce the inevitable risks associated with early installation of cables. Cables laid at shallow depth, (see figures 2, 3 and 4) lead to a high proportion of faults such as damage to sheath and conductors and pulled joints. The pulled joint type of fault may only show up after the line has gone into service.

Conductor faults

Conductor faults in joints were the major cause of faults which could be directly attributed to the PO. This category was 24 per cent of the total faults and included cable pairs unjointed or incorrectly jointed, faulty crimped connections, and cable pairs broken or short-circuit within the joint. The incidence of incorrectly jointed cable pairs and the high cost of subsequently correcting the errors justified a review of testing methods. A simple technique has been introduced for identifying the termination point of each pair, and detecting simple disconnection and short-circuit conditions. This technique should improve the accuracy of records and reduce the risk of mis-appropriated or faulty cable pairs delaying the provision of service. Further details of the method, which requires the use of cable pair identification equipment 2, are given in *External Plant News 36*.

Lead-in ducts

It was found during the study that in more than 50 per cent of the houses in which the builder had installed a lead-in duct this duct was either damaged, blocked or incorrectly positioned within the building. Although service had not been directly affected, there were many cases in which the floor had been chased and the duct bent or bedded into the concrete to reach the required position, a practice which would create a maintenance problem if cable renewal became necessary.

Further action

As a result of this trial we now have a wealth of information, the study of which is resulting in recommendations and action aimed at improving the performance of the plant and reducing costs. Although these are based on information gathered from one Area, there is reason to believe that the information is fully representative of the national situation. This is to be verified, however, by a second trial now in progress in another Area, where the radial system is the preferred method of providing underground service.
Sv5.1.1 (01-432 1378)

Figure 1

Figure 2

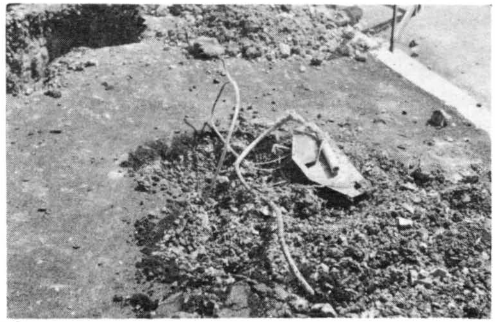


Figure 3

Figure 4

Private circuit maintenance

A PO private circuit can be defined simply as a permanent communication channel provided between two points for the exclusive use of the customer who rents it. It may be a simple two-wire circuit between points a few kilometres apart or, at the other extreme, a long-distance broadband transmission link for television or radar. Some large and complex networks of private circuits are nationwide or international in extent. In some countries private circuits are called leased circuits.

Historically, private circuits long preceded what we call public circuits. The first circuits ever provided for telecommunications were private circuits used for point-to-point telegraphy. Exchange switching techniques came much later as did circuit economies resulting from sharing common circuits interconnecting exchanges. In a sense, of course, every exclusive service exchange line is a private circuit, since it is a permanent channel between the customer's premises and the exchange, and is provided for his exclusive use; but we distinguish such circuits giving access to the public switched network by calling them exchange lines. Like private circuits, they are rented. Unlike private circuits, renters pay an additional amount whenever they are used for successful calls, for we make a charge for the caller holding exchange equipment and junction and trunk circuits. We charge for allotting him a temporary communication channel between exchange lines for his exclusive use, – a temporary private circuit as it were – and he is quick to complain if the privacy of the connection is invaded by double switching or overhearing.

By contrast, the private circuit user does not pay for each call. He pays for having a permanent connection 24 hours a day between two points whether he is using it or not; it might be said he opts for a telecommunications season ticket. If that connection fails he is in trouble. He cannot make a second attempt hoping for an alternative routing; he cannot call in an operator for assistance; and he may not be able to divert his operations to the public switched network. Often the private circuit is the only way the PO can provide the facility he wants and so he has to wait for attention to his circuit. Private circuit customers therefore tend to be much more heavily reliant than exchange line customers on reasonably fault-free service and swift and effective maintenance action when things go wrong, and so it is understandable that they tend to be more critical. Moreover, the main users of private circuits are important business, commercial, industrial, public utility and Governmental undertakings and this increases the need for urgent treatment of faults.

It is in this light that statistics about private circuits have to be considered and maintenance effort directed. Private circuits total only about three per cent of the 12.5 million exchange lines. The predominant category are speechband circuits, a UK total of about 300 000; of these, about 85 per cent are short distance unamplified circuits, each of which is the equivalent of two exchange lines permanently connected either directly or over a short junction circuit. Most speechband circuits are used for speech, but there are many other uses, such as for alarm systems, telemetry and data transmission to and from remote on-line computers (see article in *Maintenance News 7*).

Customers choose to rent private circuits for a variety of reasons. A customer may have so much business to transact between two terminals that the traffic justifies private circuits between them. Circuit parameters in the public switched network may not meet his technical requirements. He may require continuous monitoring and rapid control signalling, as in the remote control of electricity or gas distribution. Private circuits are not, however, simply classified according to the uses made of them; they are categorised and paid for according to their technical specification. Thus telegraph private circuits (dc to 300 Hz) are Tariff H and Tariff J circuits; speechband circuits (300 to 3400 Hz nominally) are Tariff S1, S2, S3 or T; music circuits (50 to 15 000 Hz) are Tariff M; wideband (48 kHz or 240 kHz) are Tariff W/B; and broadband (5.5 MHz) Tariff V, used for television. Tariffs vary with distance and other factors. For example, the rental for a seven kilometre Tariff S1 circuit is £135 a year; for a 75 km circuit it is nearly £1,000 a year.

Thus private circuit renters yield significant revenue, and are entitled to value for money by way of a high standard of performance and maintenance, particularly because they may be wholly dependent on the services which the circuits provide. Even where it is technically and operationally feasible to fall back on the services provided over the public switched network, only a skeleton service may be possible (and every call has to be paid for) ; and the customer may suffer acute financial loss or embarrassment through impairment of his activities. He cannot readily suspend or alter operations merely to await our convenience, or carry on business from the nearest call office.

Of course it can be argued that the private circuit renter is immune from exchange faults, busy conditions, congestion and other impediments suffered by exchange line renters. He uses only the transmission element of our system, which is reasonably reliable. This is only a half-truth, for several reasons. With only a few exceptions, private circuits are routed via the same cables, cabinets, pillars, distribution frames, and line and radio transmission systems as exchange lines and public trunk and junction circuits. They are vulnerable in the same way to plant faults, working party interruptions and faults, damage and so on. The odd blown fuse, dry joint, solder splash, cut or reversed jumper or cable pair are no respecters of users and services. Whereas on the switched services they may mean no more than that a switch steps to the next free outlet, with the customer not inconvenienced and none the wiser, on private circuits they affect service directly and immediately and no use can be made of the circuits until clear.

In general we do not guarantee any PO services to be fault-free, though if a private circuit customer is prepared to pay the extra costs of alternative and separate routings we can provide something close to one hundred per cent availability. This means that the desired service is available nearly one hundred per cent of the time – see the article on reliability in this issue.

So what is the average fault incidence rate on private circuits – or more strictly, what is the fault report rate from customers ? Present statistics show that the UK average fault report rate is about 0.2 to 0.3 reports per circuit every year for unamplified circuits and 2.0 to 3.0 for amplified circuits. Not unexpectedly, the report rate depends on the amount of plant involved in providing the circuit and the longer the circuit the higher the report rate. It also depends to some extent on how and when the customer uses his circuit. If it is continuously, as for some telemetry, control and alarm functions, or for sound and television programmes, every impairment or failure is likely to be noticed and reported. If a circuit is used only during certain hours (customer's operational hours are not necessarily the same as PO normal hours) only faults occurring or extending into those hours are likely to concern him. On the other hand there may be particularly important times and occasions when he is more than usually sensitive to loss or degradation of facilities.

But to be concerned about fault report rates is not enough. What matters most to our customers is how quickly a fault is dealt with and service restored to normal. Here all maintenance staff have their parts to play, but it is particularly important for those dealing directly with the customer at fault reporting points, circuit controls and at his premises, to give prompt and effective attention to his report so that he knows something is being done. It is helpful for such staff to have some understanding of the customer's needs and the effect of the fault on his operations. If fault location and clearance looks like being prolonged, it is important to make an interim report so that he is not left wondering what is happening behind the scenes. To save wasting both PO and customer time, the officer accepting the fault report or dealing with the customer at a later stage should make sure he establishes the name and telephone number of the person to contact. So keep the customer informed and tell him when the fault is cleared and services restored. No news from the PO is not good news.

Staff at intermediate exchanges and other test points should give prompt co-operation with their colleagues 'at the sharp end'. It should be borne in mind that some 40 per cent of all fault reports are eventually classified FNF or RWT and it is particularly desirable to avoid long outage times in such cases, in our own interests as well as the customers'.

G E Richardson Sv7.1.1 (01-432 9148)

A future article will deal in more detail with the reduction of faults on private circuits and with maintenance procedures.

Experimental packet switched service - the facts

by **P D Aggus,** Sv7.1.2

A new method of providing for data transmission between our customers is going on trial towards the end of 1975, known as the 'experimental packet switched service' (EPSS). About 40 customers from commerce, industry and academic institutions will participate with the PO in evaluating the new service to assess whether it is economic and sufficiently attractive, and how it might develop. This article introduces EPSS, compares it with existing datel services, and shows how it will interwork with them.

Present services

At present, datel customers exchanging digital data either set up a call over the public switched telephone or telex network, or use a private circuit between their terminals. The two terminals have to operate at the same speed, or bit rate, and the circuit is continuously occupied whether data signals are being transferred or not.

From the PO point of view, the two terminals are 'bit rate compatible'. (Some customers, however, want their final equipment to operate at a different speed from the signals on the line. In this case, they have to introduce intermediate equipment such as multiplexers to arrange this.) It is a very important feature of EPSS that customers' terminals do not have to be bit rate compatible.

Principles of EPSS

In the experimental service, there is a packet switched network with three packet switching exchanges (PSEs) at London, Manchester and Glasgow. These PSEs are inter-connected by high-speed digital trunks, or 'data highways'; these transfer data signals at 48 000 bits per second (48 kbit/s). EPSS customers present data to the local PSE in self-contained blocks, or 'packets', each containing a destination address. The packets, temporaily stored in the PSE, are sent over the network at 48 kbit/s, whatever the bit rate of the originating equipment. These are then interleaved with other customers' packets using a system of time-sharing. The routing depends primarily on the destination address of each packet, but there is also provision for automatic alternative routing to cater for congestion and fault conditions. The principles of inter-leaving and routing are shown in figure 1.

It can be seen that in the case of packets being transmitted from terminal A to terminal E, packets may be handled by one PSE only. The network between PSEs is shared between all users, and a customer occupies it only when his data is being transferred – and not continuously as at present.

The bit-rate of transmission of a packet from the final PSE to its destination has to be compatible with the receiving customer's equipment, and this is arranged by the PSE, which consults its store of information about customers' bit rates.

The two terminals of any line have to be bit rate compatible, and this applies to any line in the total EPSS network. But PSEs can accept data signals at any prescribed speed from customers' terminals, switch them at high speed and finally transfer them at any prescribed speed to receiving customers' terminals. So PSEs look after compatibility, a valuable facility for the PO to be able to offer to customers. This is why the PO, other similar administrations, and computer users have become actively interested in recent years in various packet switching techniques for data transmission.

Packet terminals

Customers who assemble packets of data and present them to PSEs are said to have 'packet terminals'. These are the terminals marked PT in figure 1 and figure 2. Customers are called 'packet customers'. They have to assemble their data signals into data packets of an agreed format, each including an address, and communicate with and 'instruct' the system in an agreed manner, a process termed 'protocol'. Such users rent an access line direct to the nearest PSE, paying for one of the PO datel services giving them data transmission at the speed that they need.

Character terminals

PSEs also accept data signals in serial form, that is, not in packets, from customers with slower speed terminal equipment such as teletypewriters. The signals are assembled into data packets for routing to their destination. The serial data from such customers must, of course, contain addressing information. Such customers' terminals are known as 'character terminals', and are marked CT in figure 2. The PSE breaks down incoming packets into serial data form for transmission to the character terminal at the required speed.

Customers with character terminals can either rent access lines direct to the nearest PSE, like packet customers, or they can use PO datel services over exchange lines to their nearest telephone exchange and set up calls over the public switched telephone network (PSTN) to the nearest PSE, as is shown in outline in figure 2. Each of the three PSEs is connected to a nearby telephone exchange for this purpose.

Customers with character terminals do not have some of the facilities of packet customers, such as the ability to communicate

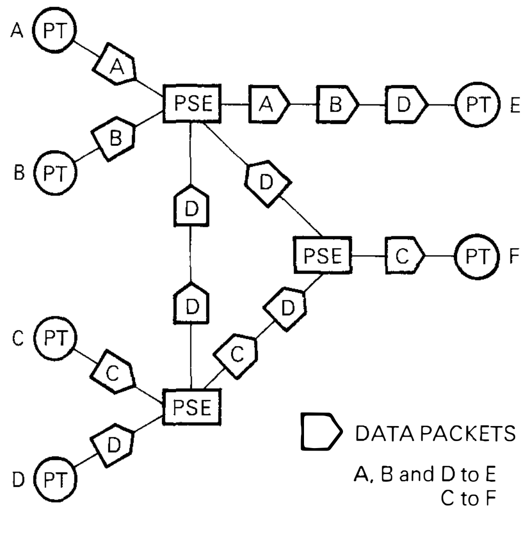


Figure 1

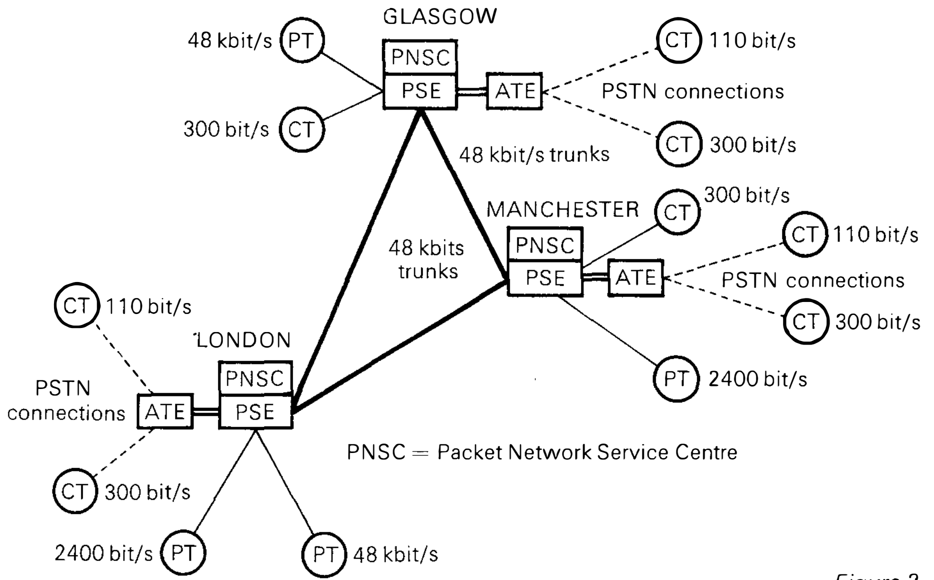


Figure 2

with several distant terminals at the same time by suitable addressing of sequences of packets. They do have some facilities, however, that present PO datel services cannot give such as allowing a number of low bit rate terminals to communicate simultaneously with a single high bit rate terminal without special bit rate conversion equipment.

Other features

When a packet is accepted from a packet terminal, or assembled from serial data supplied by a character terminal, the local PSE, and any PSE called onto relay the packet, store a copy of the packet and the copy is not destroyed until a positive acknowledgement of correct receipt by the destination is received. There is error-checking of the digital data signals at all stages and only if a packet is received error-free is the positive acknowledgement given. If the correct positive acknowledgement is not received, the packet is automatically re-transmitted. Poor performance of the system may result in slower throughput of data signals, but the customer is screened from most network faults, impairments and congestion.

Another function of the PSEs is, of course, to record the use made of the network so that customers can be charged for it.

The complex functions of a PSE are controlled by stored program control (SPC) equipment. What this is, in principle, can be found by reading the article about processors and software in this issue.

Unlike most existing PO datel services, the EPSS cannot provide for the alternative of using the network for speech purposes.

The 40 customers who have agreed to participate in the trial are to operate a total of about 60 packet terminals and a variety of character terminals in larger numbers, shared between all three PSEs.

Sv7.1.2 (01-432 9159)

Errata

We apologise to readers and to the author of the article in issue seven about new equipment for the recorded information services: there were two errors in the first paragraph on distribution problems.

line 6: 'since wave' should of course have been 'sine wave'.

lines 10 to 13 should have read: 'The investigation revealed that announcement levels as specified on the adjustment card THQ2084 were too high and resulted in serious distortion of speech and music'.

We also apologise to readers and author of the article on the cost of a fault report, for not indicating that the table applied to year 1973/74 and for printing AMH instead of annual on the two curves. They were intended to show the rise in the average man-hour rate assuming an increase at the possible rate of 30 per cent a year and what it would be if the rate of increase slackened to 20 per cent a year.

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