Maintenance News

11

Spring
1977

Contents

Editorial

This issue brings a change of editor. Dave Manning has now moved on to Sv5.3.4 where he will be concerned with the reliability of customer apparatus. As was the case with Dave, I am doing this job on a part time basis. The rest of my work is to do with the maintenance of telecommunications power plant.

Please continue to send in your views and suggestions about *MN*. This is a way for you to communicate with its contributors and for me to judge the magazine's effectiveness.

Derek Knight

Letters

Maintenance quality

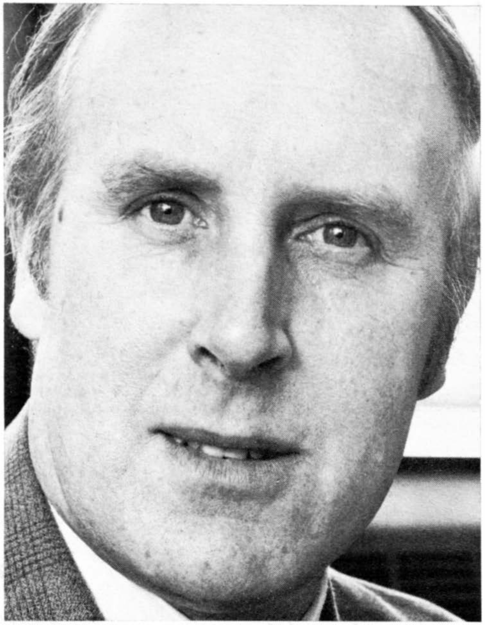
From the new Director, Service Department

Dear Colleagues

I was very pleased when the Editor asked me to write a few words for this issue of *Maintenance News* because it gives me an opportunity to set down some thoughts on the importance of the maintenance side of our Business. It seems to met that the difficulties of the past year or so have re-emphasised the paramount importance of service to the customer. The message is a simple one – the customer expects a good service if he pays a fair price – but it has very important implications for us all if we want to see PO Telecommunications expanding and continuing to meet the communications needs of the country.

Maintenance quality is one of the most important aspects of good service and can be directly influenced by readers of this publication. The importance of the contribution by each person cannot be overstated. The view a customer has of our service is built up from a number of isolated incidents and one unsuccessful call or a single occasion when our response was not as prompt and helpful as it should have been is remembered far longer than the many successful occasions.

To go forward with our plans for expanding existing services and introducing new ones, sometimes in direct competition with private suppliers and operators, we



Mr Ron Back, the new Director of Service Department

need to have public support and confidence which can only be built from a basis of satisfaction with the service already provided.

In my new task as Director Service I shall be trying to carry these thoughts into action and I hope that I shall have the active support of every one of you.

Yours sincerely,
Ron Back

Abbreviations

May I be allowed to make a plea for fewer unnecessary abbreviations in future issues? The increasing use of such jargon – TOLD, MAC and so on – makes PO circulars and the like difficult to read.

I appreciate the need for some abbreviations but please do not allow them to spoil *Maintenance News.*

J D Campbell
Stockport, Cheshire

I'm in sympathy with Mr Campbell's plea. But like it or not abbreviations are now used in the written and spoken aspects of all technology, and this practice is likely to increase. Sometimes it causes confusion although this can apply to words as well. More usually abbreviations save time and space for people who are familiar with the subject in question.

My test as to their usefulness in this magazine is as follows. If any particular abbreviation is or will become familiar to the maintenance specialists concerned then it is reasonable to use it. In all cases an abbreviation should be explained on first appearance unless it is so common that even non-specialists can be expected to be familiar with it, for example, STD.

If you're ever really stuck TI AI A0010 has a useful list of abbreviations – and meanings, although I suspect the author group has trouble in keeping it up to date! Other TIs with lists of abbreviations are – H1 A0011 K1 A0012 and K1 A0106.

Editor

TIs for TOLD

With reference to the editorial in *MN10* it would seem timely to criticise the distribution of TIs for the TOLD system. They have been restricted to Type 2 and Type 3 files. As AEE in charge of datel maintenance I have the only Type 3 file in the area, and there is no Type 2 file at all which needs these TIs. My field staff work remote from my office and hence the concern.

E W Castle, Sittingbourne (Canterbury TA)

I have had other similar protests.

There are four maintenance TIs on TOLD so far. E8 B4103, Paras 4 and 6.3.2 say what is to be done by PO maintenance officers on site. If they were working instructions, they would have to be extracted into a separate TI for Type 1 files, according to the new ruling mentioned at the foot of the first column of the MN10 editorial. TI E8 B4110 is a safety instruction needed on site, and so does go to Type 1 files.

The field cannot have it both ways. If they criticise the excessive number of TIs in Type 1 files, (the MN10 editorial shows I agree with them), they must co-operate in remedial measures. If we reduce Type 1 files to working files only, the staff must have ready access to Type 2 reference files. So I would say your field staff need basic duty 421 added to strategically located Type 2 files round the area, if they cannot get the non-working information they want by contacting the datel test centre.

D J Manning, E Div TI Adviser

As mentioned in this edition's Editorial, Dave Manning has now moved to Sv5.3.4. Ron Quinney is now the E Division TI Adviser – Sv5.4.2, Room 4089, Tenter House, Moorfields, London EC2 Y9TH.

Editor

SAVE IT – In the Telecommunications Business

by **Ron Smith,** OP6.3.2

The Telecommunications Business has been actively concerned with fuel economy since the fuel crises of 1973/4. Since that time an energy conservation group has been established in THQ/OP6 whose objective is to economise energy demand throughout the Business by a number of wide-ranging managerial and engineering measures. As everyone knows the cost of energy has risen steeply in recent years. Electricity, gas, heating oil, coal and petrol all cost more and their price is likely to continue to rise. This rise is caused principally by the foreseeable end of the world's fuel stocks if consumption continues to rise at the present rate.

By all standards it is wrong to use more of an energy source than is necessary. From a global viewpoint economy in the use of energy will extend the period during which supplies of fossil fuels will be available. Nationally, energy sources should be used as efficiently as possible, both to reduce the use of costly imported fuels and to conserve stocks of indigenous fuels. As an industry, economy in the use of fuel will reduce PO costs and help the Business to make the profit required to finance its modernisation and other programmes.

The two main sources of energy in the Telecomms Business are electricity and oil. The proportions of use for all services within our buildings are – electricity 58 per cent; fuel oil 34 per cent; natural and manufactured gas six per cent; solid fuels two per cent.

In 1972/3 the total cost of energy to the Telecomms Business was £8 million; by 1975/6 this had risen to £23.7 million, an increase of almost 200 per cent in three years. The amount of electricity used directly by telecomms equipment represents only 40 per cent of our total telecomms building load. The remainder is spent on such uses as heating, cooling, lighting, cooking and hot water. These uses are all unavoidable but we need to make efforts to reduce our consumption to a minimum. So plans were made to save at least £2 million in 1976/7 and to continue the saving in subsequent years.

Everyone can help to save energy by switching off unneeded lights or better still, not switch them on in the first place. The electricity used by a 100 watt lamp during the average number of hours worked each year by a PO employee costs £3.70. Multiplying this by the 240 000 employed by the Telecomms Business makes almost £900,000. This shows how easy it would be to make the saving if everybody co-operated in the economy campaign.

How can maintenance staff help? Apart from the individual contribution that anyone can make towards energy economy you are in a unique position to make savings. Well maintained plant is economical plant. Everything, from the humble electric lamp to the most sophisticated computer will work more efficiently, and usually consume less energy, if kept clean and correctly adjusted.

Here are some examples where savings can be made.

☐ Ensure that room thermostats are correctly adjusted. A 1 °C rise in a heating thermostat setting can require an additional 10 per cent of fuel oil.

☐ Set domestic hot water thermostats no higher than 49 °C (120 °F).

☐ Switch off lights in suites of apparatus racks when maintenance is not being done.

☐ Clean buildings in daylight wherever possible, otherwise only minimum lighting and heating should be provided.

☐ The efficient maintenance, and correct adjustment, of boilers is essential for economic operation. Boiler maintenance is a dirty job but don't cut corners because of this. Follow carefully *TI H8 H4002* 'Routine maintenance for oil burners'.

□ Heat escapes through any gaps in the building fabric, so correct badly fitting doors or windows as soon as possible. Unfortunately many of our buildings have too many, often sizeable, openings in walls and roofs, but an investigation is now being made into this to bring about an economic solution.

□ Do not carry out battery charging at times when the electricity maximum demand could be exceeded and a penalty incurred.

□ During winter it is common for both cooling and heating systems to be operating at the same time ; windows can be unnecessarily open too. Such things are plainly wasteful. Often, when one person's coldness has been cured another will then complain of being too hot ! It needs the maintenance man's skill to both satisfy everyone and use energy economically.

□ When dealing with cooling equipment the efficient maintenance of evaporative towers and make-up water treatment plants is essential for economic use of energy.

□ The loss of illumination through dirt on windows, luminaire diffusers and lamps, and the loss of output from worn-out lamps can be as high as 50 per cent. Adhere closely to cleaning and lamp replacement programmes to keep this loss to a minimum.

□ Badly adjusted lift controls can waste large amounts of electricity. One particular investigation showed that when the building was occupied two lifts had a steady load of 30 amps per phase. But during unoccupied periods the load only dropped to 15 amps per phase. This was found to be due to faulty timing circuits which should have shut down the motor generator set soon after the last call had been dealt with. After the fault was rectified the load during unoccupied periods dropped to 1.5 amps per phase.

Eventually it was found that out of six lifts in the building four had faulty timing circuits, which when corrected reduced the energy consumed each day to 61 per cent of the previous value.

These are only some examples where maintenance staff can make worthwhile contributions to reducing our energy use. In many regions and areas staff have been appointed, or committees formed with the object of investigating ways of making savings. However, it is the local maintenace staff, better than anyone else, who know where energy savings can be made in a building and it is *YOU* the 'maintenance man' who can to a large extent decide if the energy conservation campaign is a success.
OP6.3.2 (01-628 7733 x537)

MAC updated - first measurement and analysis centre planned for early 1977

by **Brian Sapsford,** Sv7.2.3

An article in MN 3 described the basic concept of MAC. Events have since moved on to the extent that in July 1975 the first 10 MACs were authorised to serve, in all, some 11 telephone areas. Subject to financial approval the programme of installations will eventually be extended to provide MAC throughout the country.

MAC is a scheme devised by SvD for automatically measuring the quality of service provided by the public switched telephone network by sending patterns of test calls over the network under the control of mini-processors. At the same time it will provide early warning of network failures for immediate corrections by local staff. The miniprocessors will be located in centres to be provided ultimately on the basis of one for every telephone area.

What's wrong with TSOs?

Service observations successfully perform their original purpose but present needs are not all fulfilled.

□ It takes several months to find out if a change in maintenance methods is having the desired effect. The sample size of the present observations allows only long term changes to be determined accurately.

☐ The majority of calls observed originate from one exchange and terminate in another making it difficult to assess an exchange as an individual unit. The performance of a common control exchange, which should have a lower fault rate than surrounding Strowger exchanges, may thus be masked by the overall result.

☐ The present level of sampling for both the local and STD network does not enable the variations in performance, especially in TXE and TXK exchanges, to be detected with sufficient accuracy.

☐ The performance of STD links from local exchanges, ISD and transit routings are not measured mainly because of the high cost in obtaining a meaningful sample of such traffic.

☐ While the present measurement is reasonably representative of performance trends within the constraints already mentioned, it is essentially historical; indeed results are rarely available less than two weeks after the end of the month to which they relate. They are therefore of limited value as a means of day to day management of the network.

MAC's purpose

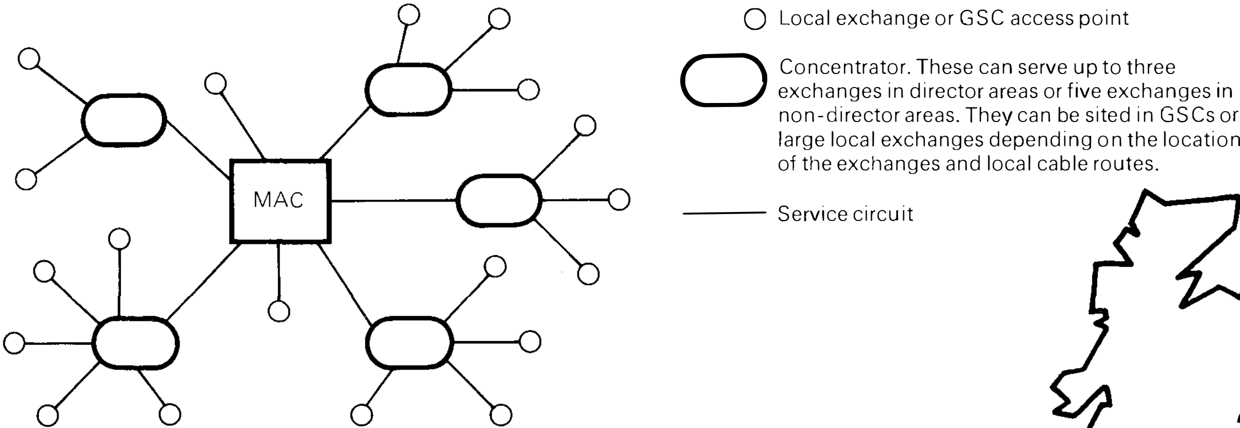
MAC has been designed to provide continuous surveillance of the service throughout the day. The aim is to achieve a performance measurement for every exchange of 1000 lines and over and each GSC. Test calls will be directed through all plant available to the customer and the resulting measurements will be sensitive enough to detect small changes in performance. This will enable MAC staff to inform exchange staff immediately the performance on a particular exchange or routing deterioriates.

How MAC works

The diagram shows a typical arrangement of a MAC system within a telephone area. All the measurement and analysis centre equipment is contained within the square shown at the centre. Service circuits are shown connecting the MAC to the exchange access equipment via concentrators where appropriate. Only one test call can be in progress on each service circuit at any one time. Where a number of exchanges are connected to a concentrator the test calls are passed in sequence. The maximum number of exchanges served by a MAC is 90, with up to 30 service circuits terminating at the MAC.

To measure the quality of service of the network MAC will generate a series of test calls which will be sub-divided into nine measurement sequences. These are as follows:

Sequence	*Function*	*Calls per month*
1	Own exchange – from line circuits to test numbers within the multiple of the same exchange.	1000
2	Local dialling area – from line circuits to test numbers in the multiple of exchanges to which non-STD access if provided.	480
3	STD – from line circuits to distant exchange test numbers obtained via the 2-wire switched STD network.	280
4	STD originating – from line circuits to test numbers in the GSC served by the local exchange.	480
5	STD terminating – from incoming trunk selectors at GSCs (or incoming trunk units) to test numbers in the multiple of exchanges served by the GSC (or incoming trunk unit).	1000
6	ISD originating – from register access relay-sets in a GSC to test numbers in the UK international switching centres.	200
7	Tandem – from first selectors in tandem exchanges (DIR areas only) to test numbers in the multiple of local exchanges connected to the tandem exchange.	1000
8	Transit access – from a register access relay-set in a GSC to test numbers in exchanges served by that GSC but routed via the serving transit switching centre.	480
9	Transit multi-link – from register access relay-sets in a selected GSC each month to test numbers in the multiple of local exchanges obtained via the transit network.	1000



The customer's line circuits and test numbers are for the most part dedicated for MAC use.

Measurement Sequences will be run from 0800 hours to 1800 hours Monday to Friday and in addition it will be possible to run some sequences during the evening from 1800 hours to 2100 hours. Call failures detected during the measurement sequence will be analysed by the processor into failure groups to provide a monthly performance index similar to that given by the present TSO main summary. The call failure data will also be passed to an analysis sequence and up to 10 test calls will be passed over the same routing used by each failed call. Should any of these calls fail they will be held and the details printed out for subsequent action by the officer in charge of the MAC.

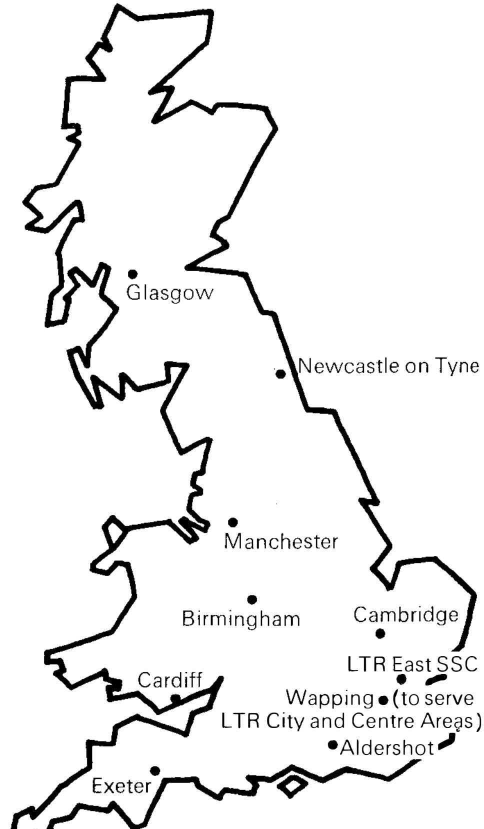
MACs benefits

To the customer:
An improving service will result from quicker concentration of attention on exchanges and routes having poor performance. Checks will also be made of the transmission performance and the accuracy of metering.

To exchange maintenance staff:
Less time will be spent on diagnosing faults in other exchanges, leaving more time to localise and correct faults in their own exchange.

To the area management:
There will be ready access to precise information on the current performance of individual switching units and the network controlled. This will also include new and extended installations.

To regional and THQ managers:
Precise information on the performance of more parts of the overall network.
Sv7.2.3. (01-432 1364)



First MAC centres

Local underground line plant improvements in Scotland

by **Douglas Robb,** STB

The serviceability of the local cable network in Scotland has been a cause for concern for sometime. In 1973/4 the region's yearly rate of faults for every working circuit exceeded the overall figure for the UK by 39 per cent. The techniques which had accompanied the introduction of polythene sheathed cable were not proving satisfactory and were having an increasing effect on the fault rate as the network expanded. Heavy rainfall in Scotland during the winter of 1973/4 made a poor situation still worse. Temporary methods of fault clearance were themselves a source of trouble and caused a backlog of faults to persist long after the wet weather had ceased.

Increased time spent on correcting faults meant that less time was available for UG plant maintenance and renewal. The high rate of construction activity also contributed to the fault incidence. The consequence of all this was an unacceptably high fault rate and a steadily lengthening backlog of outstanding renewal work.

The improvement plan

As a first move towards improving the situation an additional allocation of man-hours was made for local cable maintenance and renewal. This was to apply for the latter part of the year 1974/5 and for 1975/6 with further allocations for the next year should it prove necessary. The staff needed for this work were to be transferred from construction activities while a check was to be kept to ensure that such moves did not create deficiencies elsewhere. A plant improvement committee was set up in each area whose task was to allocate resources, plan for their most effective use and monitor progress. Annual works orders were issued and a programme drawn up covering expenditure on provision, roadworks, renewals, ongoing maintenance and plant improvement.

Improvement work was due to start in January 1975 but wet weather again took its toll and work schedules were such that staff transfers were fewer than expected. So it was not until March that a limited start could be made. All available effort was then concentrated on a pre-determined programme of activities. Plant known to be faulty was renewed.

Statistical information contained in the A51 form was used as a means of establishing priorities of action.

The system of reporting faults using A1024 form was re-vitalised and the defects so revealed were attended to.

Having largely fallen into disuse, local line insulation routining (LLIR) was re-introduced as a method of network surveillance. Testers were repaired and modified and the test access circuits were checked. To relieve the tedium of processing the routiner outputs, STB headquarters designed a unit which gives an output on a page teleprinter and staff in one area designed a circuit to give an output on a printer meter check. Where the use of LLIR was not possible UG maintenance staff identified 'black spots' by scanning through fault reports.

Achievements

The methods used in the improvement plan were not new. They have been discussed at external plant job conferences and elsewhere for some time. But the awareness that a determined effort to improve UG plant was being planned brought a good response from the staff involved. By the end of the first year a great deal had been accomplished. The average time for a repair was reduced as also was the incidence of repeated faults. Within this period Scotland's UG fault rate was improved by 17 per cent which was double to that achieved overall in the UK.

More can be done

The later results of the programme are expected to reveal further improvements but some weaknesses will remain and will require more consideration if they are to be overcome.

LLIR was a job which, understandably, RSCs were reluctant to undertake at first. Indeed, it would often have been sufficient to have routine tested invidiaul cabinet areas, had such a technique been available, rather than an entire exchange underground network. The analysis of LLIR results was then done by UG maintenance staff but a procedure needs to be devised which is sufficiently improved to enable RSC staff to do this quickly and willingly.

Vandalism is an increasing problem. In large towns the improvements have been offset to a large degree by the mindless destruction of PO plant including the repeated cutting of cables at distribution points. In such circumstances renewal of plant in the same form and situation merely invites repeated damage. New thinking needs to be applied here.

When lightning storms occur UG plant is damaged if protection is ineffective, but safeguarding by the use of an earth electrode system is difficult and expensive to apply in districts where soil resistivity is high. It seems a pity that the longitudinal choke method of protection has not undergone further development even after its apparently successful trial. It doesn't interfere with electrical tests and, as a result, is not prone to inadvertent removal.

Better prospects

The introduction of new style cabinet assemblies and the grease filling of cables and joints have helped to reduce the fault rate in the local cable network. If the epoxy resin putty wipe as a method of sheath closure can be replaced in the near future the polyethylene cable should begin to lose the poor reputation it has acquired over the past decade.

Overall, a deteriorating situation has now been reversed and the signs are that the improvement will be maintained. Our objective must be to make still further gains.
STB/S1.4.1 (031 222 2213)

Quality of service –

Setting our targets and measuring up to them

by **Des Mason,** Sv7.2.2

What is meant by 'quality of service'? Perhaps it depends on who you are.

A PO customer would most likely relate it to the number of times he finds his telephone service deficient in some way although unless he's very honest, he doesn't make allowances for his own errors such as misdialling.

The PO defines quality of service more precisely in its published 'annual report and accounts' as:

Local automatic service – percentage of calls which fail due to system.

STD service – percentage of calls which fail due to system.

Most PO maintenance engineers are responsible for a particular type of equipment and may justifiably be preoccupied with the performance which that equipment alone provides.

Agreeing the targets

PO management uses telecommunications improvement plans (TIPs) to help exercise control over the quality of service of the network overall. Each year MD.T agrees TIP targets with each of his regional directors who then collaborate in similar terms with their area general managers.

TIPs 1-4 relate to the quality of service of the inland network and are defined as:

* TIP 1 – fault incidence – fault reports per station per annum (excluding public call offices)
* TIP 2 – fault clearance – percentage of all fault reports cleared by the end of the next working day.
* TIP 3 – local automatic service – percentage of calls failed due to plant defects or congestion.
* TIP 4 – STD originating – percentage of calls failed due to plant defects or congestion.

Targets are not set without considering the cost of achieving them so there are other TIPSs which, for example, are concerned with the manhours expended on maintenance. On this occasion though we shall confine our attention to the first 4.

How do we know if our targets are achieved? Currently, there are two sources of information, the repair service control and the telephone service observation centre.

The repair service

The information for TIPs 1 and 2 is obtained from customers fault report dockets. Each repair service control (RSC) keeps a weekly check of these dockets for all exchanges under its control and categorises the results under various equipment headings on form A29. At monthly intervals the form is sent to area headquarters and from here its information, together with the total count of stations is sent via a teletype on line to a computer at Harmondsworth. The computer produces an A51 form for each RSC. This gives separate details of exchange, overhead plant, underground plant, customers apparatus and PABX faults. It also produces area, region and UK summaries which are used directly to assess TIP performance.

Now that we are using a computer to analyse the fault reports, it is economical to obtain an 'exceptions report' In addition to printing the normal A51, the computer prints a series of indices drawing attention to those parts of the network which are abnormally bad or particularly good.

Call failures

The failure rate of calls in both the local automatic and STD networks is assessed by a process of call sampling known as telephone service observations (TSOs).

This gives us an indication of how many calls fail due to both plant defects and call congestion. It is this information which produces our statistics for TIPs 3 and 4.

For the local automatic service calls are sampled at the first selector in non-director exchanges and at the first code selector in director exchanges. In the case of the STD service samples are taken at the register access relay set in either GSCs or outgoing trunk units. These samples are extended to an observation centre where their progress is monitored by trained observers and the results recorded on punched cards ready for monthly analysis by computer. This produces a summary of results on an exchange basis for both the local automatic service and the STD service, showing the percentage of calls failing due to plant defects, plant engaged, calls wrongly metered and calls ineffective due to the customer. Area, region and UK summaries are also produced

1979 will however, see the beginning of a change in our method of assessing TIPs 3 and 4. A completely new concept for measuring the quality of service is described by Brian Sapsford in his article on measurement and analysis centres (MACs) elsewhere in this issue. These centres, due to become operational in the first 11 areas during 1978, will direct artificially generated traffic through all plant in the public network thus providing tests for STD, local dialling area and own exchange calls. So by 1979 the areas concerned will base TIPs 3 and 4 on MAC measurements rather than TSOs. TIP 3 will be related to MAC local dialling area calls and TIP 4 will concern MAC STD calls originated from local exchanges. Eventually we should see MACs operating in all areas. MAC based TIPs are expected to show an increase in calls which fail due to PO plant because, contrary to the TSO method, the results will include STD calls which fail before reaching the register access relay set and own exchange calls will not be included in TIP 3.

TIP results

Let's take a look at telecommunications improvement plans for the UK overall and see to what extent our achievements have matched our targets in recent years.

TIP 1

The number of faults and RWTs for every station has got steadily less since 1973. There are numerous reasons for this since all types of plant have shown an improved performance. In the case of external plant local line insulation routining (LLIR) and the reduction of overhead open wire have been contributory factors, while in exchanges common control equipment and night routining have also had a good effect. The increasing proportion of residential customers, who tend to use the phone less than businesses and, as a result have fewer faults, has also helped our performance.

TIP 2

Our method of assessing the effectiveness of the repair service was changed in May 1976. Previously our target concerned the percentage of class A fault reports which were cleared during the day of reporting whereas now we consider both class A and class B reports which are cleared by the end of the next working day. (These classes of fault are defined in *TI E13 B0010* but broadly, class A reports concern service affecting failures while class B reports concern less important faults.

This change was brought about to enable the workload to be distributed more efficiently. Beforehand the performance appeared to be generally deteriorating but improvements in the fault rate of exchange equipment have been more rapid than those for underground plant, which usually takes longer to repair. This means that the customer is less likely to experience a fault than in the past but could wait longer for a service affecting fault to be repaired.

TIP 3 and 4

The call failure rate in both the local automatic service and STD has generally been better than our targets but, although the rate of failures due to plant defects has been reduced, the main reason for this trend is a marked reduction in call congestion. Tariff increases together with the business recession since the end of 1974 have resulted in a reduced rate of growth in traffic which was not foreseen when new equipment was planned. So for the time being we have more equipment capacity than we expected a couple of years ago.

Night routining has played a part in reducing call failures due to plant defects, although reduced congestion may have influenced the figures here also – since during periods of light traffic the frequency at which some faults are monitored by service observations equipment will have been reduced.

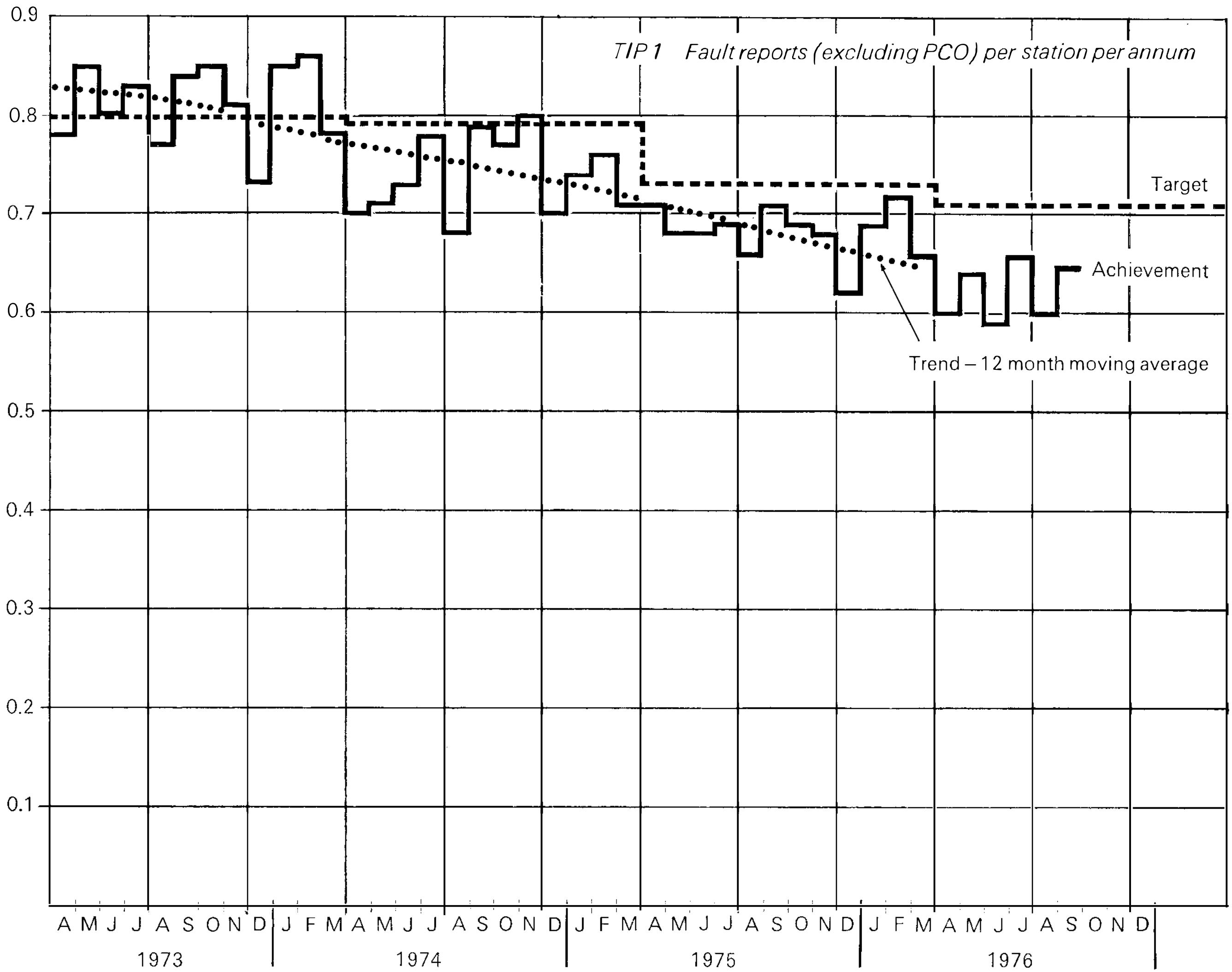
The importance of plant performance

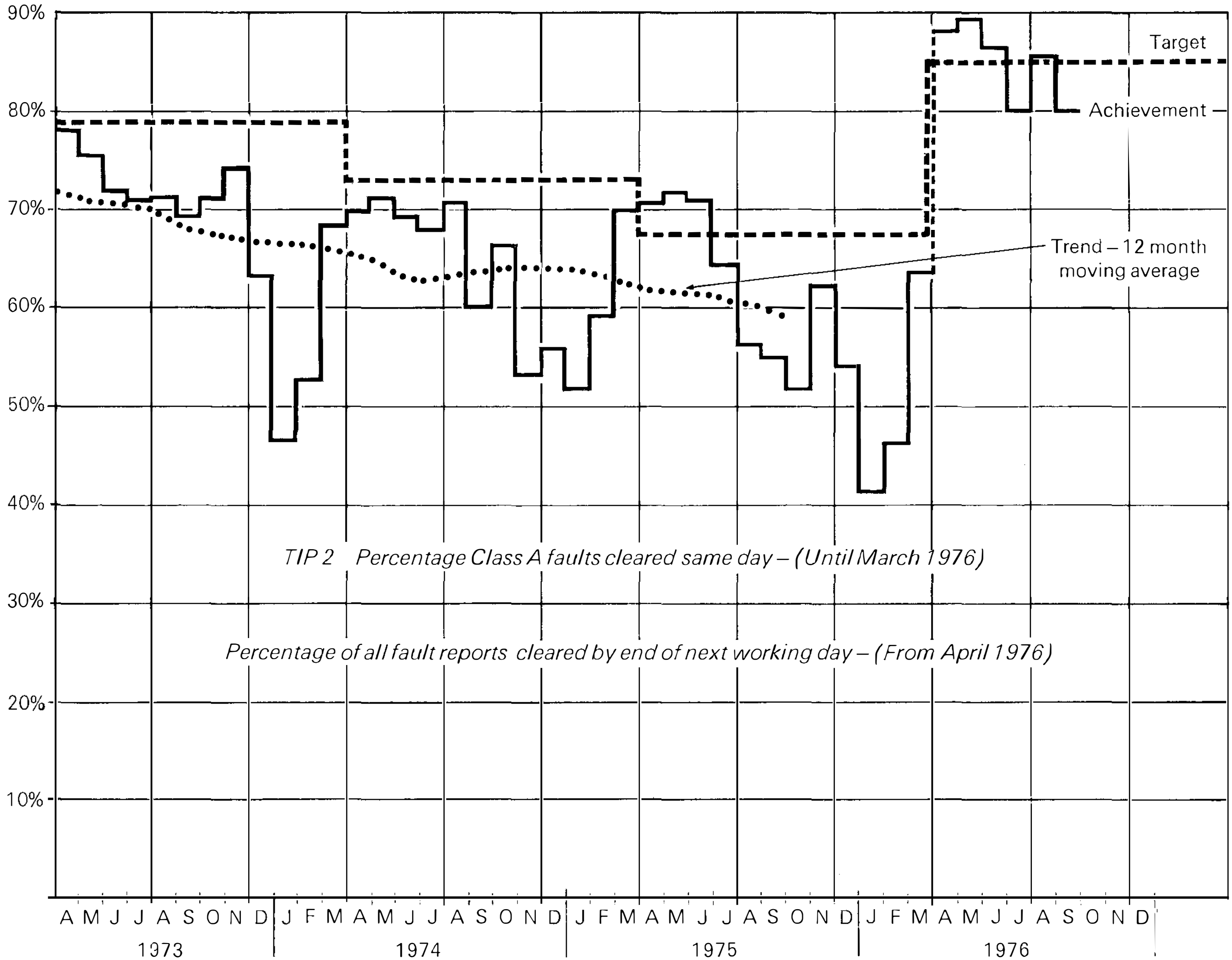
TIPs measurements are concerned with the quality of service of the telecommunications network overall but few of us have such a wide involvement. Most maintenance engineers have responsibilities for particular types of plant and will be more concerned with performance records which relate directly to their work. Here the A51 form, derived from RSC records, plays an important role in giving a breakdown of faults as described earlier and it is important to remember that the overall network performance is affected by each type of plant which it contains. Besides the A51 form there are, of course, many other performance measurements relating to particular types of plant. Most of these give details in terms of faults per item per year. We can't deal with them all here but some have already been referred to in previous *MN* articles as the following examples show:

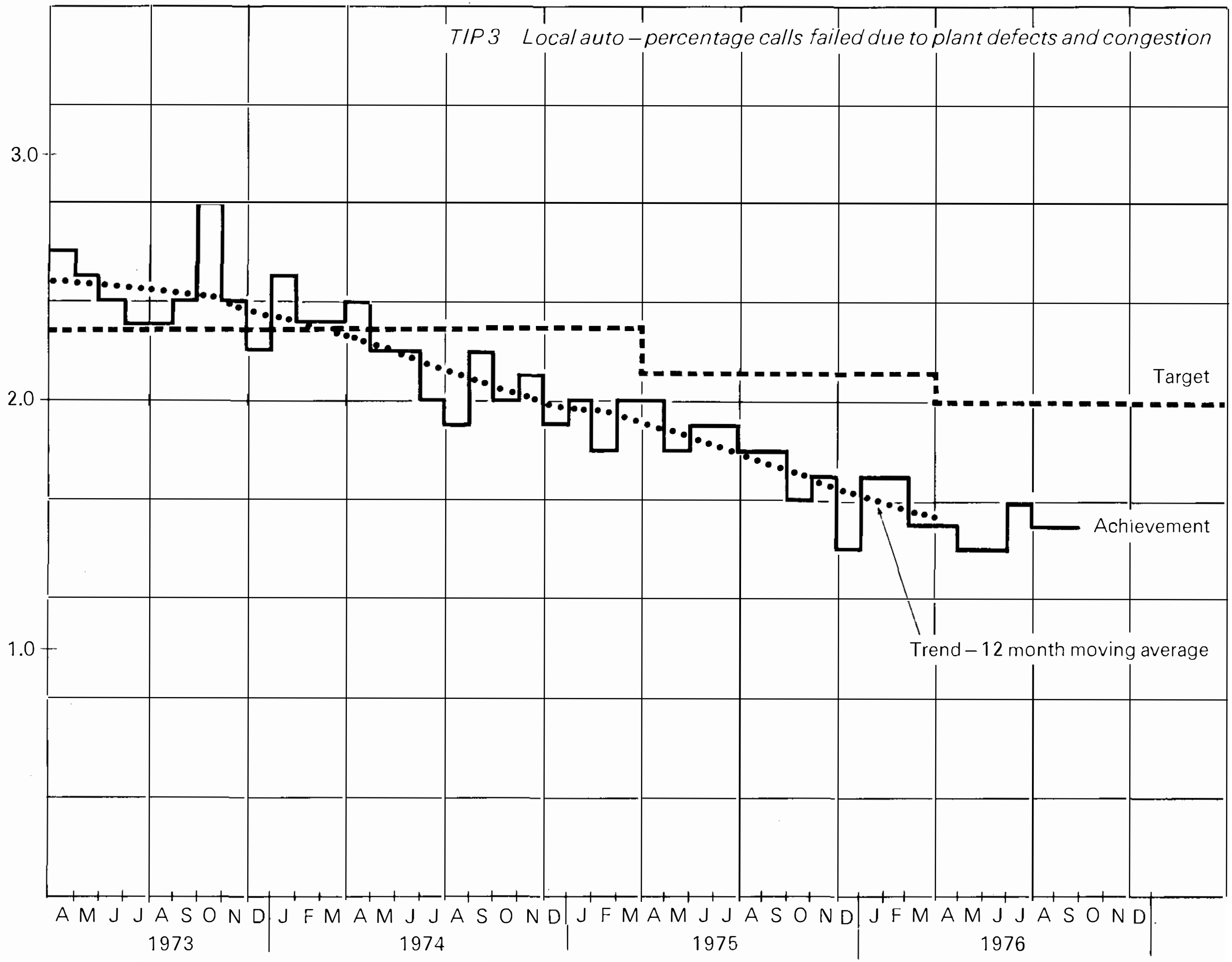
Plant improvement plans	issue No 1
Maintaining Power Supplies	issue No 1
Trunk and junction cable maintenance	issue No 5
Subscribers meters	issue No 5
Coaxial cable failures – NCC news	issue No 7

So keep an eye on the performance trend for the plant which you work on and remember that an improved quality of service will help to increase the numbers of satisfied customers – those who pay for our bread and butter.

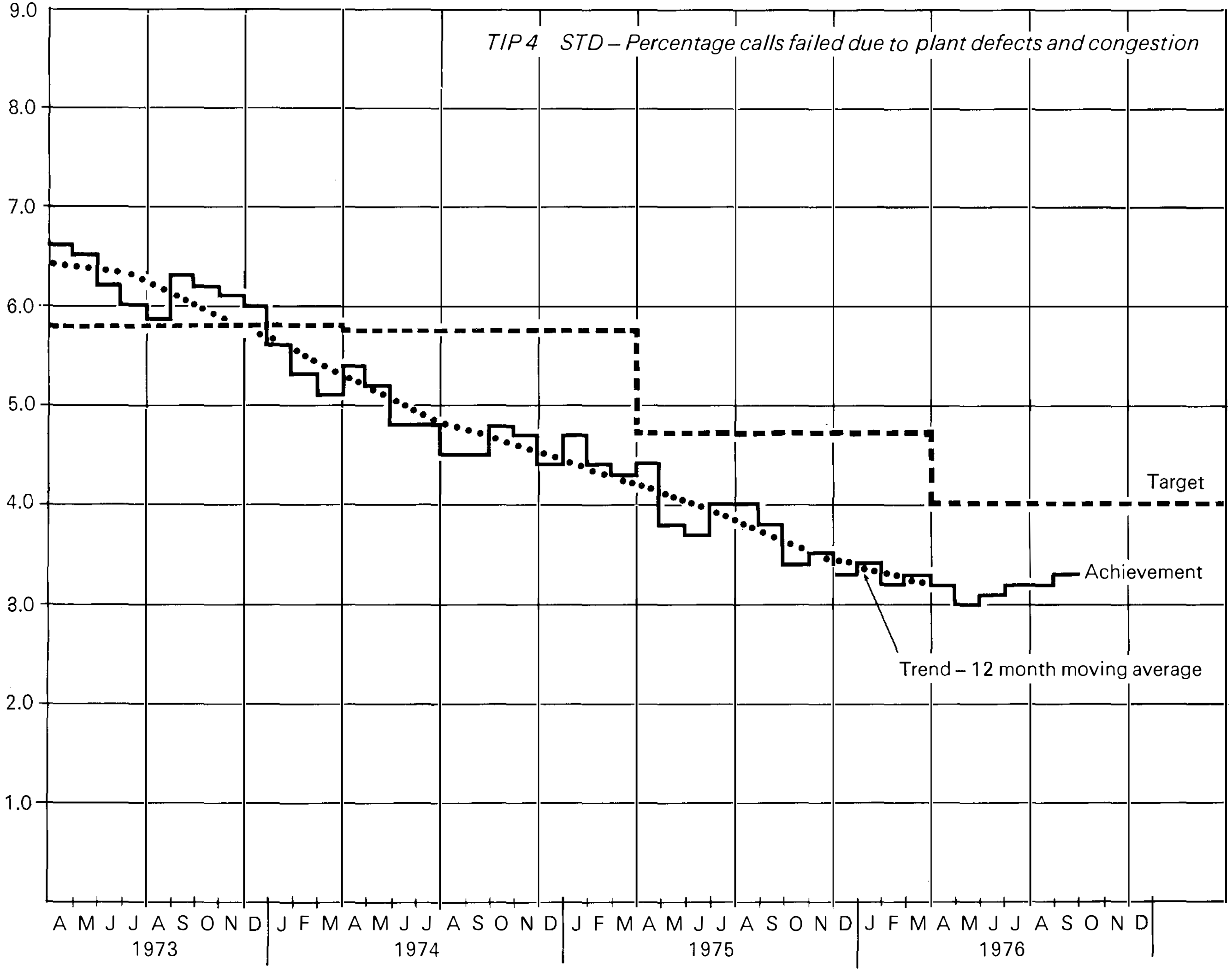
Sv7.2.2 (01-739 3464 x7717)


TIP 1 Fault reports (excluding PCO) per station per annum
Target
Achievement
Trend – 12 month moving average
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1973
1974
1975
1976


90%
80%
70%
60%
50%
40%
30%
20%
10%
Target
Achievement –
Trend – 12 month moving average
TIP 2 Percentage Class A faults cleared same day – (Until March 1976)
Percentage of all fault reports cleared by end of next working day – (From April 1976)
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1973
1974
1975
1976



TIP 3 Local auto – percentage calls failed due to plant defects and congestion
3.0
2.0
1.0
Target
Achievement
Trend – 12 month moving average
A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1973
1974
1975
1976


TIP 4 STD – Percentage calls failed due to plant defects and congestion
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
Target
Achievement
Trend – 12 month moving average
A M J J A S O N D
1973
J F M A M J J A S O N D
1974
J F M A M J J A S O N D
1975
J F M A M J J A S O N D
1976

STD metering – revenue losses due to faults

by **Ken Savage,** SWTR

The telephone service observation (TSO) print-out will be familiar to many service engineers. Much effort and ingenuity is expended in sustaining and improving plant performance and capacity as indicated by item four in the STD main summary – 'attempts ineffective due to PO', but nothing like as much interest seems to be shown in item six of the summary – 'calls wrongly metered'.

Are the figures shown against this latter heading worth worrying about?

The percentage of observed calls on which metering defects are recorded is divided into two categories, those which are over-metered and those which are under-metered. These figures may not seem to merit much attention as they appear to be quite small – typically 0.2 per cent and 0.3 per cent respectively – and tend to cancel each other making two seemingly insignificant figures even more so. But an analysis of the metering error print-out would quickly dispel this illusion. A comparison may be made between the units gained or lost on all calls involving errors over a representative period. The following summary of such an analysis over a six month period in 1975 gives a clue to where we could be losing quite large sums of money.

Over-metered	*% Calls affected*	*average charging error (units)*
1 Metering incorrect rate	0.07	+10
2 Metering commenced early	0.065	+2
3 Metering to failed call	0.065	+2
4 Occasional added pulses	—	—
Under-metered		
1 Metering incorrect rate	0.095	—10
2 Initial but no subsequent meter pulses	0.075	—12
3 Failed to meter	0.195	—13
4 Occasional missed pulses	—	—

It can be seen that the metered units involved in calls affected by under-metering considerably exceeded those involved in over-metering. No metering took place at all on more than half the total number of under-metered calls.

A second exercise produced even more dramatic results. This involved estimating the actual revenue which is lost due to under-metering and required a knowledge of the total number of effective calls, the proportion of these calls which were under-metered and the average holding time. The total number of effective calls for a 13 week period was obtained from the TSO main summary for the STD unit concerned by multiplying the weighting factor by 10 000. (This factor applies to any STD unit.) The average holding time in metered units was calculated from information provided by the print-out of the trunk call sampling equipment (TCSE).

An estimate of lost revenue each year for a given STD unit was then calculated as follows:

$$\text{effective calls per 13 weeks} \times 4 \times \frac{\%\ \text{under-metered calls}}{100} \times \text{average holding time in metered units} \times \text{cost per unit (currently £0.03)}$$

On this basis, total South Western Region losses could be about £160,000 each year; but this result should be treated with caution. A significant proportion of the apparent metering errors is due to discrepancies in and failures of the observation circuitry which result in no meter pulses being seen by the observer. Inadvertent gains due to over-metering would also offset this apparent loss to a small extent although this in itself represents a disturbing situation. Also the statistic represents errors at source and does not include the effect of failures within the local switching network, customer's meters and so on.

But it is clear that a problem has been identified and the question needs to be asked – how can it best be tackled? The first requirement must be to assess whatever information is available.

Details of metering errors do not appear in the route analysis print-out but it is possible for regions to obtain ad hoc analysis of card detail and arrangements can be made for exchanges to be supplied with details of failures using the procedure described in *TI D2 H5004*. The number of incidents per month per GSC is small and it is usually necessary to build up a fault pattern over several months to ensure that the situation is handled realistically. The trunk call sampling equipment exceptions report can be used to supplement observed failure detail for those GSCs with TCSE.

The list of fault conditions which have been found during investigations is lengthy but it may be useful to list the most frequent causes of over or under-metering.

TSO equipment faults

☐ Incorrect strapping of the "D" tags on TSO equipment according to the type of register access relay set being observed. This is frequently overlooked when new relay sets are installed and results in 'failed to meter' being recorded on an observed call.

☐ Adjustment of high speed relays MC and MCC. Incorrect adjustment may result in erratic metering being recorded.

☐ Intermittent failure of the monitor units, resulting in loss of meter pulses, or incorrect routings being recorded. When this is suspected a change to the superseding items, monitor unit 4A or 9A as appropriate, is advisable.

Main equipment faults

☐ Translators strapped incorrectly. Individual metering errors are so few that translator strapping for the codes concerned can easily be checked on all translators for home and adjacent charge groups. It is not unknown for the original strapping information to be incorrect!

☐ Metering commencing early or a failed call metered in error due to premature reversal being encountered. Systematic use of TRT 94 and TRT 303 can dramatically reduce this type of incident.

☐ Tariff pulse feed to a register access relay set disconnected resulting in no subsequent metering. The routiner AT 60372 checks the pulse distribution but works specification TE 9369 with addendums 1-3 must be completed and of course the test of subsequent metering must not be inhibited! Routiner AT 5533 does not check the pulse distribution.

Many other faults have been found and more, no doubt, remain to be discovered. The PO could be losing considerably large sums of money overall. The benefits to be obtained from putting these matters right could far exceed the effort involved.
SWTR/Sv1.1.2 (0272 295564)

Wot! No spares?

by **Bill Larman,** Sv5.1.1

Before 1969 paper-insulated local line main underground cables were manufactured with more pairs than the nominal cable size required. When the provision of these 'spare pairs' was abolished some maintenance field staff doubted the wisdom of the decision.

Spare pairs in local cables meant that given a predictable fault rate during manufacture the PO had a reasonable assurance that their full nominal capacity would be available. This was achieved by jointing the 'spare pairs' in the normal manner and substituting them for any normal pairs found faulty during installation. As examples, paper core unit twin (PCUT) cable actually had 204 pairs in the 200 pair size and 2016 pairs in the 2000 pair size.

In practice, however, the number of pairs required for working circuits when a cable is installed rarely matches its full nominal capacity since an allowance is normally made for future growth. This being so, why should we have been concerned about a few 'spares' adding to those not used at first? The trouble was that the terminating arrangements cater only for the nominal cable size and when, as was usually the case, there were very few or no faults found on installation, the good pairs left over were unusable. These had to be paid for – they were not a gift to the PO from the manufacturer as compensation for not making a perfect cable. So by not having spares in our new paper-insulated cables we are assured that every good pair is available for use.

In spite of this, many people have remained concerned about faults found when installing cables, but the only way to ensure the minimum number of faulty pairs when jointing lengths in tandem is to test and identify each pair at every joint. This would be the case whether 'spares' were provided or not, but the practice would defeat the advantages of the present technique of random jointing which is a far more economic approach overall.

Nevertheless, we have had to face a complication on the question of renewals. Since the introduction of cable pressurisation, the rate of renewing large cables has declined to the extent that it would have been uneconomic to make the old type cable available for use in such cases. What happens then if working circuits are found to exist on the 'spare pairs' of the old cable and all pairs in the new cable have already been jointed through? With no spares available in the new length these circuits would be left disconnected. We overcome this by firstly using test tones to establish if any of the 'spares' have been terminated on the MDF and then re-routing on to normal pairs any circuits which are found. Usually a sufficient margin of unused pairs in the local network exist to absorb such re-routings. Cable records are amended accordingly.

On the whole, cables without spares are proving to be better value for money.
Sv5.1.1 (01-432 1374)

The IBM 3750 stored program control PABX

by **Dave Stoate and**
Alan Cartwright, Sv5.3.1

The introduction of common control telephone exchanges in the 1950s followed by computers in the 1960s were innovations which have since been combined and developed still further. Stored program control systems and the PO designed 'System X' are examples of this. Now a similar technology has appeared in the form of a private automatic branch exchange (PABX). In 1976 the PO, after four years of evaluation, 'type approved' the IBM 3750 PABX for connection to the public network and to date there are nearly 70 in operation in the UK.

The IBM 3750 PABX is described as a 'stand alone' switching system for voice and data communications and for contact monitoring. We are all familiar with voice communication because this has been our business over the last 60 years. Data communications is, however, a relatively new aspect although it has been a vital part of the world of business communications during the last decade. The 3750 data handling facilities amount to the short or long term storage of data which is processed by some other unit connected to the PABX. The contact monitoring functions incorporated in the 3750 provide elementary control and supervision of customer's equipment.

Examples of such equipment are:
Alarm systems
Air conditioning systems
Lighting systems
Automatic gates
Engines and production machinery

The stored program control
All line switching and signalling in this PABX are controlled by the stored program which is called the 'operational program'. It continually scans all lines connected to the system, detects events taking place, and decides the actions required. This program is prepared by the manufacturer (who is responsible throughout the life of the PABX

for all the software) and contains information which defines all system functions required for a particular installation. The program is loaded during installation and runs continuously.

There are many advantages in using stored program control for exchanges. Two important ones can be mentioned here:

Extension numbering
Whenever personnel are moved from one office to another they may need to keep the same extension number and the same call facilities. The PABX supervisor can make such program changes simply by typing a message on the printer/keyboard attached to the system. In this way we avoid any hardware or wiring changes which would require the visit of an engineer.

Class of service
Placing this facility under the control of software has enabled any particular class of service to be made available to each individual extension rather than groups of extensions. This is done at the planning stage but the customer can make changes at any time in the same way as above.
Fig 1 shows a block diagram of the IBM 3750. Here it can be seen that the operational program forms the brain of the 3751 controller unit. The controller units are duplicated, one being active while the other acts as a standby and carries out self checking in readiness to accept control of the exchange. The controllers are normally changed over by automatic switching every 24 hours. The controller unit incorporates control processing logic, a main storage and

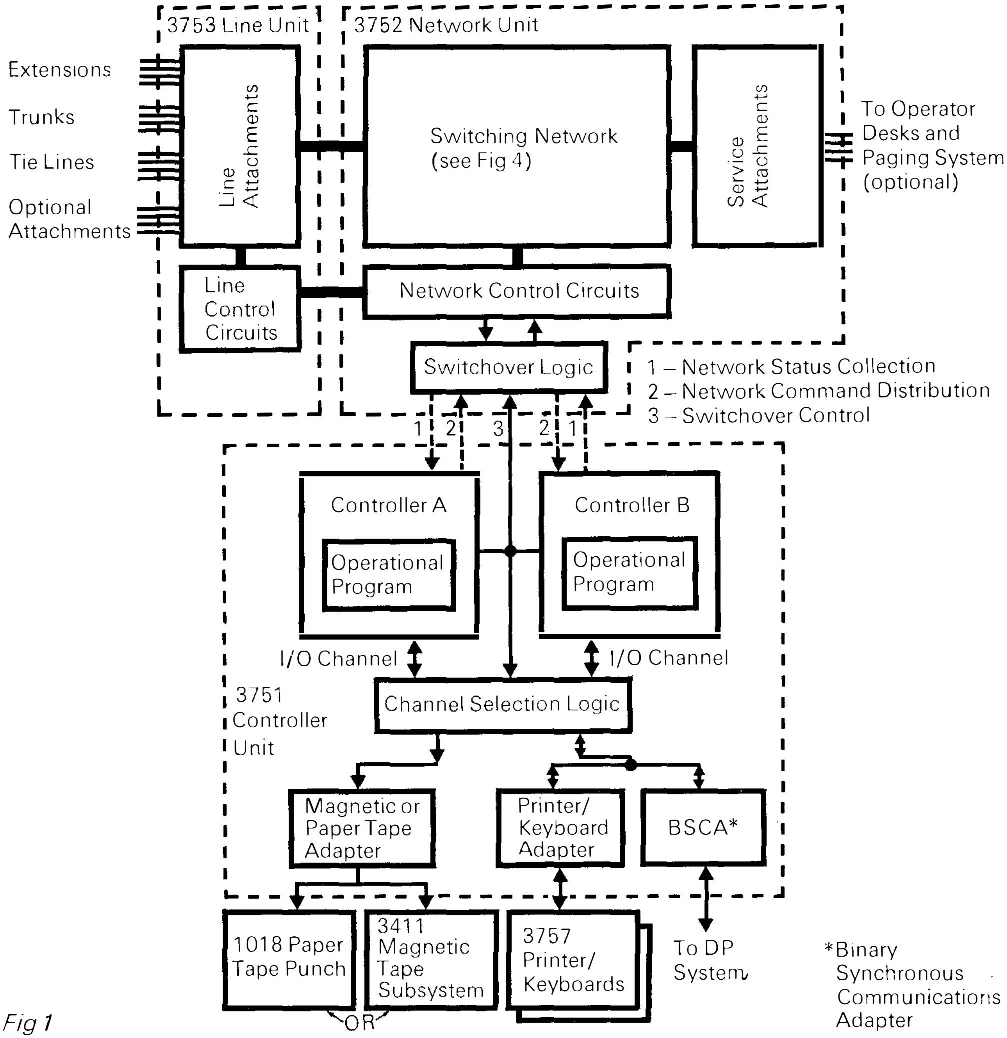


Fig 1

a magnetic disk providing additional storage for some parts of the operational program and for data buffering. It also contains adapters which serve as interfaces with various input/output devices.
Fig 2 is a semi-pictorial block diagram of a typical installation and gives some idea of the layout.

With the help of Fig 1 and 2 we can now look at the 3752 network unit which comprises:

The switching network
Network control circuits
Switchover logic
Service attachments

The section which will probably attract most interest is the switching network so, on this occasion, further description will be devoted to this.

The switching network

The switching network is made up of solid state crosspoints integrated, eight at a time, into micro-miniaturised modules about one centimetre square. The modules are arranged in matrices to form switching stages, which in turn constitute the switching network. The fact that the crosspoints are solid state means that they have the advantage of a fast inertia-free response allowing the 3750 to take full advantage of stored program control techniques.

The device used for the crosspoint is the thyristor or silicon controlled rectifer, (SCR). It resembles a semi-conductor diode but has three terminals and can be controlled so that it has either an 'off' state or an 'on' state. In its 'off' state it has a very high resistance in both directions and only leakage current of a

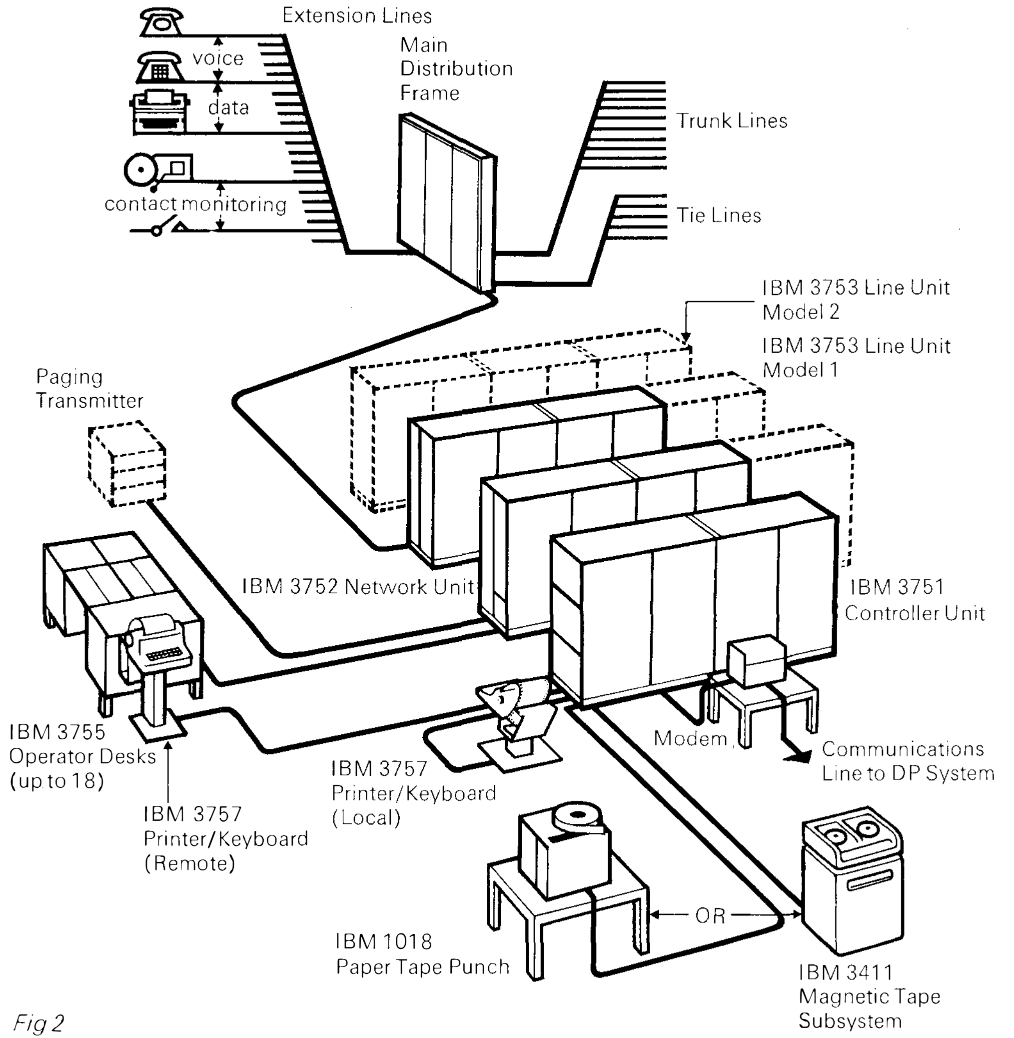


Fig 2

few micro-amps can flow. In its 'on' state it behaves as a conventional diode with a forward resistance of a few ohms. Fig 3 shows the symbol for an SCR and its forward current/voltage characteristic. The three terminals are referred to as the cathode (k), anode (a) and the gate (g).

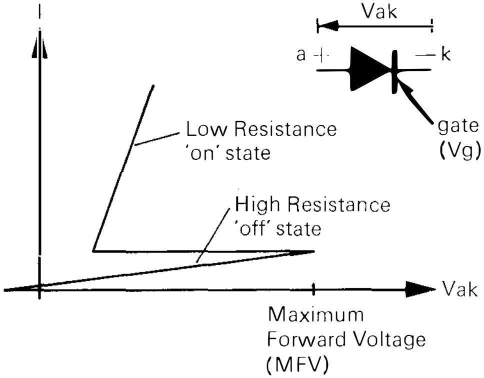


Fig 3 I-V Characteristic for SCR

With zero gate voltage and a small value of Vak the device remains in its 'off' state and no current flows. As Vak is increased a very small leakage current flows until the maximum forward voltage (MFV) is reached. Here the device switches into its 'on' state. Now the SCR is operating as a normal diode and the current flowing is determined by the value of the forward voltage and the load resistance into which the device is operating. The value of Vak at which switch-on occurs can be reduced by applying a positive potential (Vg) to the gate. An increase in Vg causes a decrease in MFV. Thus for a given value of Vak the device can be switched from its 'off' to its 'on' state by applying an appropriate value of Vg. Once in the 'on' state Vg has no further effect on the operation of the SCR and to return it to its 'off' state it is necessary to reduce the current through it to a value below that known as the holding current – usually a few milliamps.

The use of the crosspoint in the switching network is as follows. Paths are set through the network from junctors (service supervisories) to called and calling extensions via several stages in the network using one crosspoint from each. Final connection is achieved when the junctors are connected.

A typical four stage connection from junctor to calling extension is shown diagrammatically in fig 4.

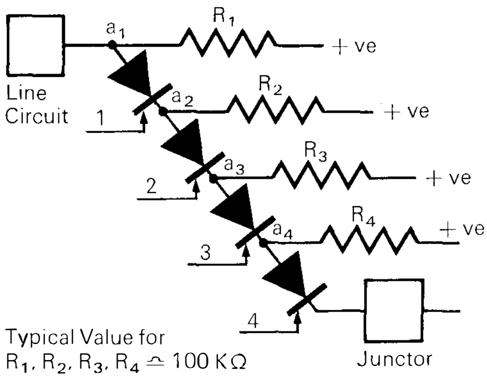


Fig 4 Connection through network

Initially all SCRs are 'off' with about 15-20 volts applied to their anodes via high resistances R1-R4. To make a connection the cathode of stage four is earthed by the junctor (on command from the processor), and a gate voltage is applied. The stage four crosspoint conducts and because of the high value of R4 and the low forward resistance of the corsspoint the voltage on the anode (a_4) drops to very near earth. By applying a gate voltage to the stage three crosspoint, it also can be made to conduct and (a_3) falls to earth. This process is repeated for stages two and one and final connection is made by connecting the junctor to one which has a similar path set to the called extension.

Maintenance arrangements

When the IBM 3750 was first introduced to the PO in 1973 our staff maintained only the 3752 network unit and the 3753 line unit leaving the manufacturer to maintain the 3751 controller unit. But for all orders taken after April 1975 the hardware associated with the 3751 controller unit will also be PO maintained.

The technical training college at Stone have been running courses for the maintenance of the whole installation since January 1976. In view of the special approach to maintenance on this system maintenance officers who run into problems with service can ring THQ/Sv5 3.1 who act as a hardware support to all telephone areas. This group will help with the diagnosis of difficult faults. As our experience increases some regions are setting up their own back-up arrangements but this of course will depend on how many of these PABXs each region controls.
Sv5.3.1 (01-432 9145)

New MCVF systems use modern technology

by **Benny Goodman,** Sv6.4.2

Equipment containing integrated circuits is the latest in a long history of MCVF systems

Multi-channel voice-frequency telegraph (MCVF) systems enable up to 24 telegraph channels, signalling at 50 bauds, to be combined in a frequency band suitable for transmission over a single telephone speech circuit.

Early systems, developed in the 1930s, used frequency division multiplex (FDM) with 120 Hz spaced carrier frequencies each amplitude modulated by a telegraph signal. Thermionic valves and electro-mechanical frequency generators made the equipment very bulky by present standards. One rack was required for frequency generation and every six channels took up another rack.

During the 1960s the introduction of transistors to MCVF systems brought about a considerable reduction in size so that one rack could now accommodate five systems containing 120 channels. Amplitude modulation gave way to the more efficient frequency shift technique using integral carrier frequency generation. In the output circuit a compact relay with mercury wetted contacts and without the need for periodical adjustment replaced the earlier version. So although the equipment's design became more complicated it now gave a better performance and was considerably more reliable.

The latest equipment

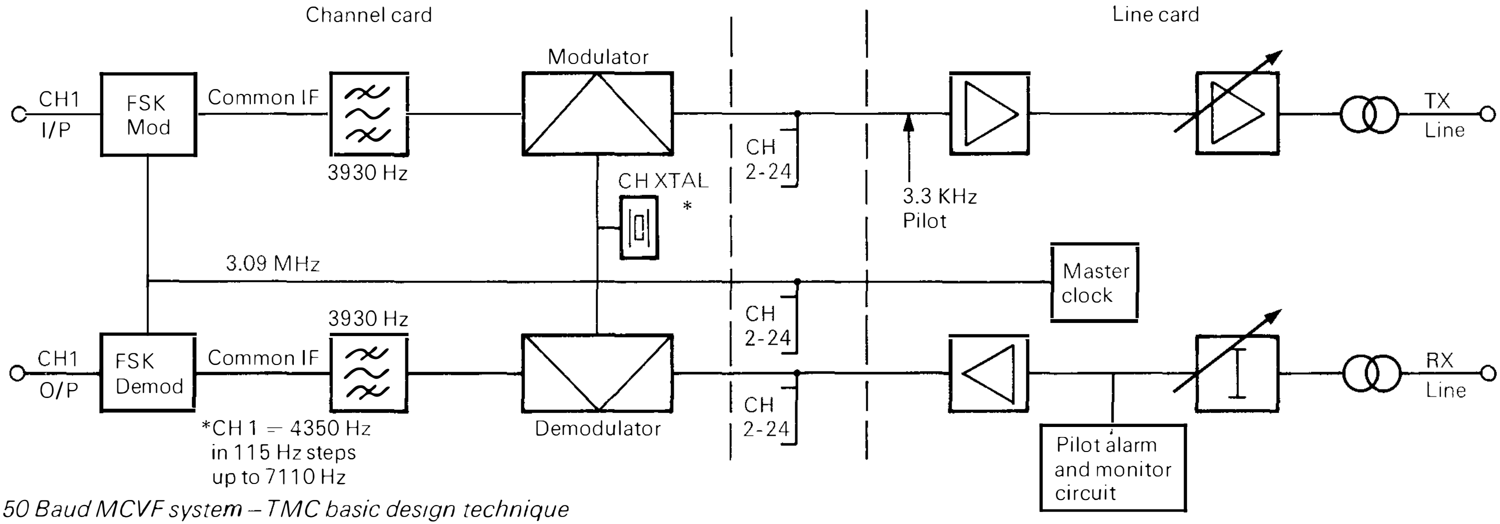
By using integrated circuits in the latest MCVF equipment, further reductions in size and relative costs have been achieved. Better maintenance facilities have been provided; for example it has now become economical to provide a 3.3 kHz pilot frequency with alarm and monitoring arrangements. At present two new designs have been approved for PO use.

The first is made by GEC and has already been brought into service. A distinctive feature is the method of carrier generation. A common 7.86 MHz crystal oscillator is used as a source from which each of 24 individual channel frequencies is derived. This is achieved by synthesising the frequencies using seven different pulse rates produced from the 7.86 MHz oscillator and mixing them together in specific combinations according to the channel frequency required. The resulting pulse trains are converted to the required sinusoidal carrier waveform by channel filters. In the receive direction conventional bandpass filters are used to separate individual channel frequencies which are then compared with a frequency derived from the pulse rate combination to produce a controlling signal for the dc output circuit. Here, a mercury wetted relay is still used.

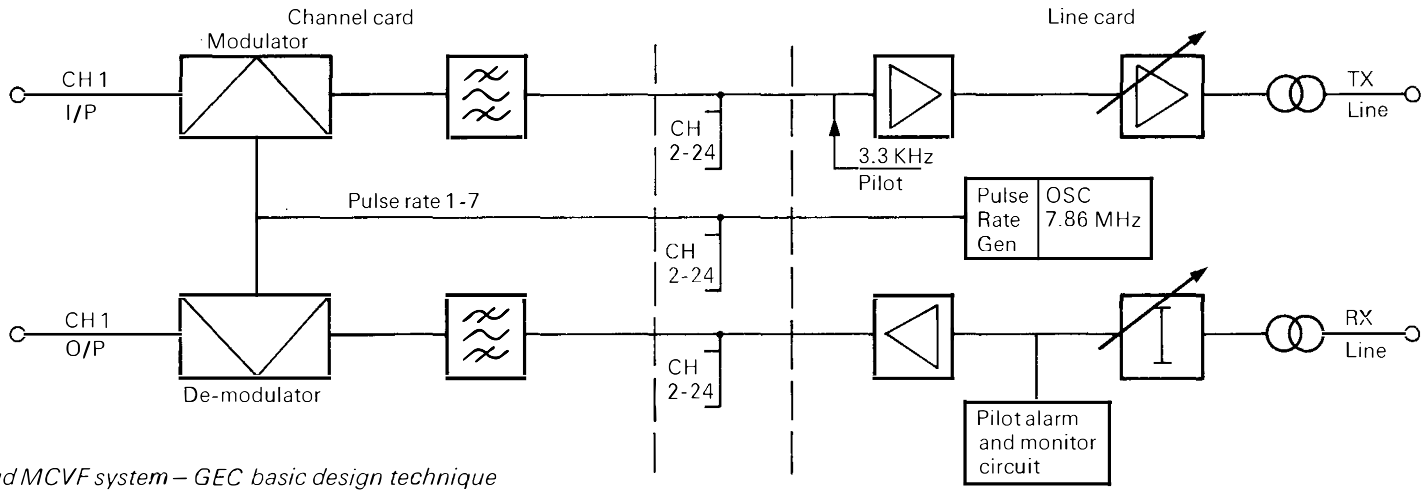
The second new design is being produced by TMC although we do not have any of these systems in service yet. A feature of particular interest is the two-stage method of modulation. At the first stage all channels produce an intermediate frequency of 3930 Hz by switching a common 3.09 MHz carrier. So to produce the 24 individual carrier frequencies which are sent to line a second stage of modulation is required which incorporates a crystal oscillator spaced at 115 Hz from its equivalent in the next channel. Demodulation is also a two-stage process. The advantage of this technique is that it avoids the expense of conventional band-pass channel filters.

Another innovation with this particular design is the replacement of the conventional relay in the dc output circuit by a solid state device.

This brief summary shows the effect that changes in technology are having on MCVF equipment design. Although the changes may increase the complexity of our plant, considerable improvements in reliability are expected. The additional maintenance facilities will assist the overall monitoring of system performance in a network which is expanding both in size and complexity.
Sv6.4.2 (01-432 1316)



50 Baud MCVF system – TMC basic design technique



50 Baud MCVF system – GEC basic design technique

Cable pressurisation equipment

by **Gordon Bays,** Sv5.1.2

A successful series of field trials during the 1950s led to the decision to pressurise all new and most existing air-spaced trunk, junction and local exchange cables. During the 1960s we saw this decision take effect. Here we deal briefly with how our cable pressurisation systems work.

To prevent the ingress of water, pressurisation equipment installed at exchanges and repeater stations supplies air to cables at a pressure of 620mbar (9lb/in^2 gauge). This limitation is due to factors such as the strength of joint closures, but sufficient protection is provided to meet most circumstances.

Cable pressurisation equipment – known as equipments, cable-pressurising (ECP) – is provided according to the number and type of cable to be pressurised. Certain common principles apply. Basically, a compressor feeds wet air to a desiccator whose function is to reduce its moisture content to an acceptable level and to regulate the pressure applied to cables. The rate of flow of dry air from the desiccator to each cable is measured by flowmeters and the distribution is made through individual air pipes leading to the cable chamber or trench. A typical ECP is shown in the photograph.

Each cable has an air-block installed at its terminal ends and, in some cases, at loading coil positions. Valves are fitted at most jointing points to allow for pressure readings to be taken when locating air leaks.

Two types pressurisation system have been introduced – the flow system for local main cables interconnecting exchanges and primary cross-connection points (PCPs), and the static system for main network and junction cables. In many stations both systems are used, the compressor being common to both.

Flow system

When our present techniques were conceived it was realised that the task of locating and sealing every air-leak in the old lead-sheathed local exchange network would be uneconomic. So in this system we seal sufficient defects to reduce the air input to an acceptable level and then continuously pump dry air into the cables.

The air-flow is acceptable if it is not more than 0.5 cu ft/hour. Those with inputs of 0.5-1.0 cu ft/hour are reported to the external plant maintenance centre, (EPMC), and kept under observation, while cables with air-flows in excess of 1.0 cu ft/hour are classed as defective and are reported to the EPMC for attention. The majority of cables are protected if a minimum pressure of 200mbar (3lb/in^2 gauge), is maintained at the far end. This, however, leaves only a small margin of reserve when supplying air to a leak, so with new schemes, using polyethylene sheathed cables, we hope to attain higher pressures.

Alarm-type pressure gauges, set to operate when the pressure falls to a pre-determined level are installed in suitable PCPs of each cable. These are extended to the ECP and displayed on the alarm panel when a pressure gauge operates.

Static system

In this system the cable is made air-tight by repairing all sheath defects, then pressurised to 620mbar (9lb/in^2 gauge) throughout its length, following which the air supply is turned off. The maximum permitted fall of pressure varies between 69-138mbar (1-2lb/in^2 gauge) in four weeks depending on the length of the cable. If the drop in pressure is within the limit the cable is topped-up as a matter of routine, but otherwise it is classed as defective and is earmarked for maintenance.

As with flow systems, static pressure systems are also monitored by alarm-type pressure gauges, but in this case the gauges are installed on the ECP. In addition, alarm contactors are installed at intervals along the cable at joints and repeater cases. These are extended back to the ECP on one wire of a looped cable-test pair. In the event of a contactor alarm, a Murray bridge is used to locate the operated contactor by measuring the resistance to the earth applied by the closed contacts.

Compressors

We use various types of continuously running compressors. Compressor 1A is a reciprocating, oil-free, carbon ring type; Compressors 1B and 3 are flood lubricated, rotary vane types and Compressor 1C is a two-stage, oil-free rotary vane type with carbon blades.

We also have a number of reciprocating compressors which are used with an associated air receiver, (Compressor receiver 2). These compressors run intermittently as required to recharge the air receiver which stores moist air prior to desiccation.

Desiccation

Moisture is removed from the air supplied by the compressor by passing it over a disiccant. This is a material which has the property of holding water vapour to its surface by capillary attraction (absorption). The desiccator has two beds of desiccant which come into use alternately. The one which is in service supplies dry air both to the cables and to the second bed to purge it of accumulated moisture. When the second bed is reactivated, a changeover is brought about by pneumatic valves which are electrically controlled by a process timer.

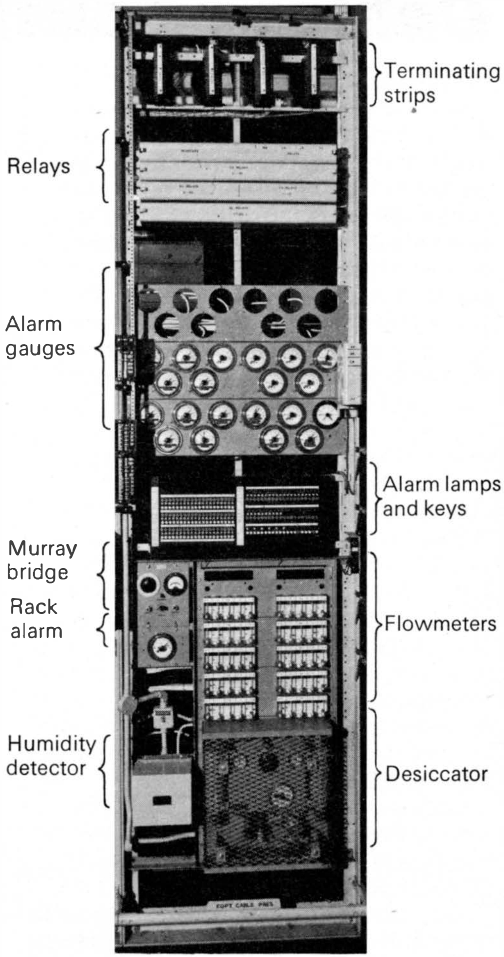
Two types of reactivation are used. Desiccators 1 require an eight hour reactivating cycle which consists of four hours heating and purging followed by four hours of cooling. This type of desiccator will supply 45 standard cubic feet of dry air an hour. Desiccators 2 require a one minute cycle whereby reactivation is achieved by purging only. This type supplies 180 standard cubic feet of dry air an hour.

The output pressure from the desiccator is monitored by an alarm type pressure gauge installed on the ECP. This needs to operate relatively quickly in the event of a compressor failure or a fault in the desiccator involving loss of the air supply. To fulfill this function it is set to operate as close to the supply pressure as possible and not lower than 560mbar (8lb/in² gauge).

Humidity detection

The moisture content of the air supplied from the desiccator is monitored by a humidity detector which switches off the compressor if the moisture content increases above an acceptable level. But occasionally, following installation or maintenance, we need to purge the system of moist air before pumping to the cables. So the detector is fitted with an over-ride switch which allows moist air to be sensed but keeps the compressor running. When the switch is operated, the flowmeters must be turned off and a spare flowmeter opened, since by so doing any moist air produced from the system is vented to atmosphere rather than pumped into the cables. The over-ride switch must be used only for short periods and only for the purpose outlined above.

Cable pressurisation is effective in reducing the number of service affecting faults in the trunk, junction, and local cable networks. It does, however, depend on the efficient operation of equipment such as compressors, desiccators, humidity detectors and alarms. Staff responsible for the maintenance of this equipment play an important role in ensuring its correct operation by the regular performance of the specified routines and by reporting alarm conditions to the EPMC.
Sv5.1.2 (01-432 1310)



Equipment cable pressurizing (ECP)

Datel test centres

by **John McKenna** Sv7.1.2

When PO Datel Services were first introduced in 1967 one test centre dealt with the whole of the country's modems. Since then, the expansion of the service has seen a test centre established in each region with the exception of Northern Ireland who use the Manchester centre.

Datel modem tests entailing on-site visits by PO staff are expensive and should be avoided if possible; so customer-controlled circuitry is included in the design of PO datel modems which allows testing of the modem to be carried out over the public switched telephone network (PSTN) from a centralised point. This is called the datel test centre (DTC). It is equipped with a PO modem of each type in service, a datel tester and other items of equipment such as frequency counters and level measuring sets which are mounted in a Console 3A. Each DTC is responsible for remote data transmission tests as and when needed on all PO modems within its region which have access to the PSTN.

The testing requires the co-operation of the customer. He is asked to disconnect the privately provided data terminal equipment (DTE) from the modem by withdrawing the interface plug from the modem and then to operate its test controls, so enabling testing by the DTC. The output of the modem's demodulator is connected to the input of its modulator and the modem is connected to line in the 2-wire mode. At the DTC, data test signals are transmitted and received so that distortion and element error rate measurements can be made on the datel tester. In the case of a Datel Modem 2, which is a 2-wire full duplex 200 bit/s modem, the DTC can transmit on say, Channel 1 (frequencies 980 and 1180 Hz) and receive on Channel 2 (frequencies 1650 and 1850 Hz). Similar tests can be made on a Modem 1 when it is equipped to operate at 600 bit/s in one direction and 75 bit/s in the other direction, but obviously the tests can only be carried out at the slower signalling rate. When Modems 1 are equipped to operate in both directions of transmission at the same bit rate they cannot be remote tested in the manner previously outlined, but are made to self-oscillate in response to a brief period of signal transmitted by the DTC. The correct functioning of this mode is then checked by observing the reversals so generated by the modem.

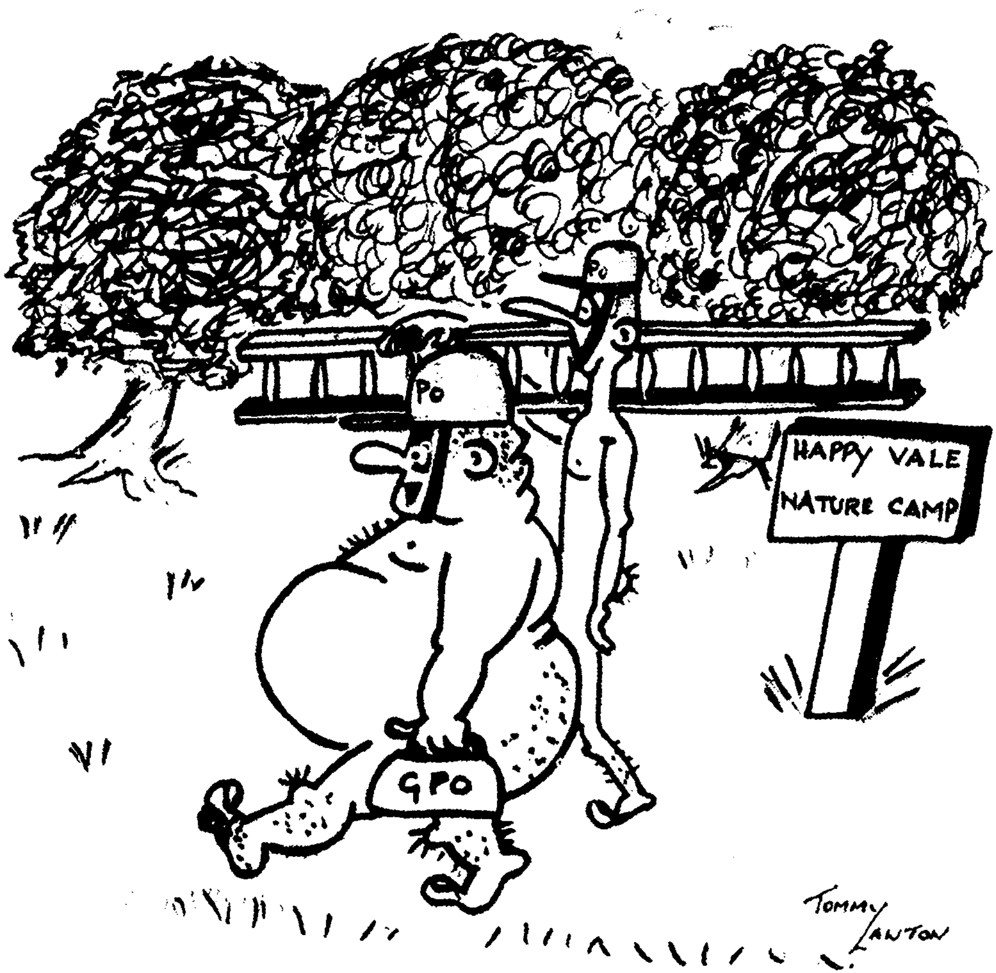
These test facilities are relatively simple arrangements and do not test all aspects of the modem's operation. Their effectiveness varies according to the type of modem and the facilities it provides. Generally however, these simple test facilities find out if the modem is modulating and demodulating, but

Seated at a Console No. 3A is Bill Moore of SETR headquarters.

do not always indicate how well it is performing these functions. Despite this shortcoming, remote testing has proved a satisfactory first approach to diagnosing modem faults since most faults are found in this way. When a satisfactory test follows a reported fault there is ample justification to ask the customer to try his service again. If the customer's repeat tests confirm that a fault still exists, it is then necessary to send a field maintenance officer so that more comprehensive tests may be carried out either in conjunction with the DTC or on an end-to-end basis.

The DTC holds the fault and information records for all the modems it needs to test. Although its staff do not actually clear modem faults themselves, they play a large role in their clearance by arranging for a field maintenance officer to visit customers premises whenever a modem fault or service difficulty is suspected and by offering advice and guidance to this officer. DTCs also liaise with each other when it is necessary to arrange end-to-end data transmission tests on circuits which extend beyond regional boundaries.

Sv7.1.2 (01-432 9162)



"Him and his ruddy 'rules is rules'!!"

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