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THG

The work of the PTO

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My manager on exchange construction at Faraday had called me up to his office to tell me that I was moving on to "precision test." It would mean working outside with cable gangs who could be a rough bunch, and it could be dirty work, I liked the idea of being a PTO because I was getting a bit bored with the day-to-day bain of construction work; running and terminating cables. I will let Angus Cargill from Kirkcaldy in Scotland tell you what the attraction was:

"The other part of underground was the main cables, the big important cables, that's where I really wanted to be, that looked like where the technology was. We had a guy called a PTO (Precision Test Officer). He had a big wagon which was quite a strange thing, it was like a high-top van, like a small bus.he had all his testers in the back of the van. Big wooden boxes with big brass knobs, it was old fashioned technology all sparkling brass. " Quotation by courtesy of BT Heritage.

London Precision Cable Test Fault location on trunk and junction cables used high precision instruments to locate the fault by measuring the change in electrical characteristics bought about by the fault. Water getting into the cable in very small quantities is the cause of faults because it worsens the insulation between the wires in the cable. The water creates electrical leakage paths between wires in the cable or by making paths between the pairs and earth. The effect of this is to make pairs unserviceable or to degrade their performance by introducing loss or crosstalk. The cables radiating from Faraday carried large amounts of public and private traffic and TV and Radio broadcasts, making their serviceability important.
London Precision Cable Test had its own test room and its own fleet of vans. I enjoyed the work and working in a team of the same three people. Some faults were dealt with from the office; others required a trip out in the van. We could often locate a fault to within the nearest foot (300 mm), a feat that often amazed the "jointers" sent to fix the cable.

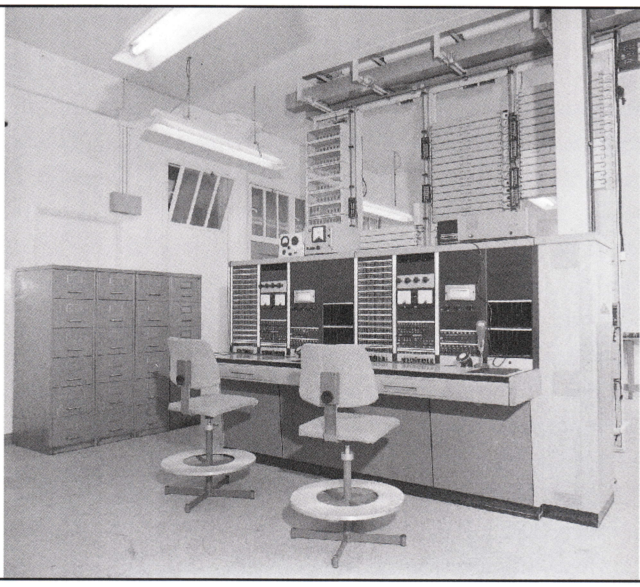

Figure 1 The London Precision Cable Test office in Godliman house © Photograph courtesy of BT Heritage. The test desk was adaption of the standard design. Its main differences were the jack fields in verticals 1 and 5 for the links to Faraday MDFs, a decade resistance box in verticals 2 and 6 (above the two meters) and in positions, 3 and 7 there is a galvanometer. There are pigeonholes in verticals 4 and 8 for record cards. On the top, there is a PYE "Westminster" VHF radio to contact each of the vans in our fleet; the aerial was on the Post Office (BT) tower. The cabinets contained a plan for each cable that showed the layout of the cable so you could see the stations it served and the allocation of pairs to stations. In addition, each cable had a pocket book that gave the street address of each joint and the length of cable between joints.

I had not moved far for the new job because our test room was just across the road from Faraday in Godliman House, on the corner of Godliman Street and Knightrider Street. Our office contained a test room complete with a two-position test desk and a small area with some easy chairs, personal lockers and somewhere to make tea. The TOA had a desk there and the AEE an office upstairs; not that we saw much of the AEE during the day and never at nights and weekends. We never saw the TOA at nights or the weekends. Most of the vans were garaged in the underground car park of Atlantic House, a civil service building next door to Holborn Viaduct (now replaced by a modern building); the van used by the rota team was kept in the yard of Wren House International Exchange.

Figure 2 Side view of the PTOs van.© Photograph courtesy of BT Heritage.

Figure 3 View inside the PTOs van. © Photograph courtesy of BT Heritage.

The photograph shows the van in standard GPO green livery. Ours had a yellow roof and a flashing beacon on top that allowed us onto airports and military sites where there were aircraft. Inside the bench seat folded away as did the worktable. One of our tasks was to maintain the radar cables at Heathrow and the motorway telephones on the M1. Originally intended as a "planners" vehicle we used the worktable to set up test equipment for roadside tests.

Shift Work

We operated 24/7. The rota paid a daily allowance, and we got overtime for working on Sundays and Bank Holidays. The rota ran over five weeks and consisted of

- Five consecutive 12-hour nights based in the office.
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- A Saturday and Sunday 12-hour day based in the office.
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- Rest days followed the nights and long days.
- The rest of the rota was four and a half normal days. During this part of the rota, we worked out of the office. Overtime normally made up the half day to a full day.
- Over the five-week period, the hours averaged out to a normal working week.

Each team consisted of two TO's and one T2A. One team worked the nights, another the days and the third were on their rest day. Other TOs worked a normal working week. In addition there was a spare man who did equipment maintenance and cleaning, a TOA and an AEE.

Night work

The nights could be difficult because there was little to do unless there was a fault to deal with. The worst part of the night shift came at three in the morning, I always felt cold and hungry, and often did my two shift mates. However, we had the van and you could always find food from the pubs and all-night cafes around London's markets and the "print" in Fleet Street.

Being one of the poles and holes brigade

It was fortunate for me that with my poor head for heights I never had to climb a pole. However, I saw plenty of underground plant. Everyone loves looking down a manhole. Taking off the cover and putting up the guard soon drew someone to look down at what you were doing down there. If the manhole was in the road, you put out cones and signs so you could work safely. In central London, where traffic was heavy, the police would not let you open the manhole during the rush hour or even during the day. That was OK of course, for it meant working overtime to repair the fault.

Some jointing chambers and their chimney were clean some were not. Most were wet from water seeping in from the surrounding ground. The water source could also be leaking from mains (not a problem) or from sewers (quite a problem). Sewerage was unpleasant to the nose but carried the risk of illness and explosive or asphyxiating gas.

Bad gas could also come in from natural sources and there was one new danger of the 1970s; gas from leaking gas mains.

Certainly the "jointers" could be a rough bunch in their manners and language, and craftier than a waggon load of monkeys. They inhabited a world that could be dirty and dangerous, and they were outside in all weathers. They had a healthy disrespect for any "management" and did not like people who put on "airs and graces." They had liking for vulgar and graveyard humour. As long as you did your job right, pulled your weight, and did nothing dangerous they were friendly. They were devoted to what they did and rightly proud of their technical skills.

Gas leaks

On the change over from gas created from coal to North Sea (natural) gas, leaking gas mains became a problem. The old coal gas contained a lot of moisture that kept the joints in the old cast iron gas pipes gas tight. North Sea gas contained no moisture causing the joints to dry out and leak gas into the surrounding soil, from where it found its way into our ducts and chambers. Later steel and plastic pipes did not give this problem because they used welded or compression joints.

Testing for explosive gas

The first job was to open the manhole cover a small amount and lower in the hose of the explosive gas tester.

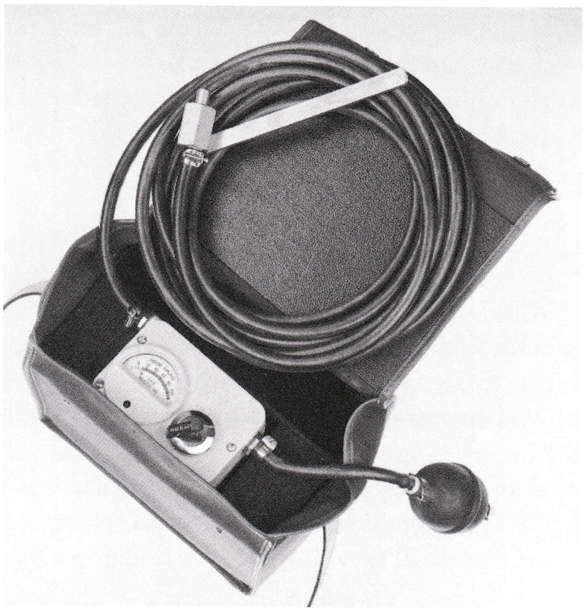

Figure 4 Indicator Gas No.5. © Photograph courtesy of BT Heritage The hose had a metal end with a hanging metal strip attached to it. The strip disturbs the surface of any water in the chamber to stop you from immersing the end of the hose. It also acted as a sounder so that you knew when it was at the floor of the chamber. You had to know where the end of the hose was to avoid drawing dirt or water into the detector and damaging the gas-detecting element. The bulb had a one-way valve in it to let out air but not let it in. The valve ensures that the only air drawn in from the hose reaches the detector element. By squeezing the bulb flat and watching how it re-inflated, you could tell if the one-way valve was working properly and that the hose was not blocked or leaking. To set up the detector you used the small silver knob to set a zero reading on the dial. To test for explosive gas you squeezed the rubber bulb a number of times to draw air through the detector. The meter reads the gas to air percentage. The instrument contained dry cells to power it.

If the gas detector showed flammable gas, the method of getting rid of it is to ventilate the chamber and duct with a fan, after removing adjacent covers to aid the airflow. Placed above ground and well away from the chamber the fan used a large diameter house to get the air into the chamber. The fans were usually electric or propane gas driven.

Testing for asphyxiating gas

If the test with gas detector proved OK, you could then fully remove the cover and lower in the miner's lamp to detect asphyxiating gas.

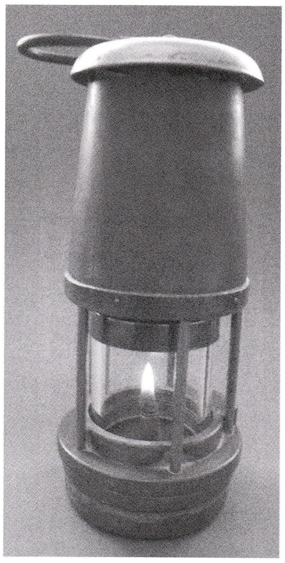

Figure 5 Lamp Safety © The Author

In mining, the miners' lamp has a dual purpose, to detect explosive as well asphyxiating gas. The GPOs **Lamp Safety** was mainly for detecting asphyxiating gas

At the base, the lamp had a small oil reservoir filled with felt to absorb the oil and prevent spills if the lamp was overturned. The wick showed behind the glass window. The top section contained two layers of fine metal mesh that prevented the flame from igniting any explosive gas present in the jointing chamber. The top sections outer cover protected the mesh from damage. The top had vents to give an air supply to the lamp.

The wick gave a small light that extinguished in the presence of asphyxiating gas. You lowered the lamp into the chamber then withdrew it; if the wick still burned, it was OK to enter the chamber.

Bailing out If the safety lamp showed asphyxiating gas, the method of getting rid of it was to "bail" it out of the chamber. This involved a pantomime of lowering a bucket on a rope into the jointing chamber, withdrawing it, stepping aside and emptying what appeared to be an empty bucket. The bucket actually contained the heavier than air gas. If people saw you doing this, they would give sideways glances. The rumour was that someone even phoned up head office and complained about the time wasting antics of public servants. After getting negative results from both tests, the next job was to pump out the water. All that done you could then climb down the steps in the chimney and the ladder to the floor. There was usually a rustling noise as the rats ran away up the duct.

Cable Testing
Our work fell into two types, electrical tests and air pressure tests.

Electrical The Wheatstone bridge formed the basis for most tests we did. For each test, the PTO made up the bridge circuit from its component parts. Each van carried a set of variable resistors, batteries and galvanometers to make the bridge circuit. These are the *"big wooden boxes with big brass knobs"* that Angus talks about. In all of the tests, the faulty cable formed one arm of the bridge circuit.

Basic Wheatstone bridge

Figure 5 Shows the four arms of the Wheatstone bridge circuit

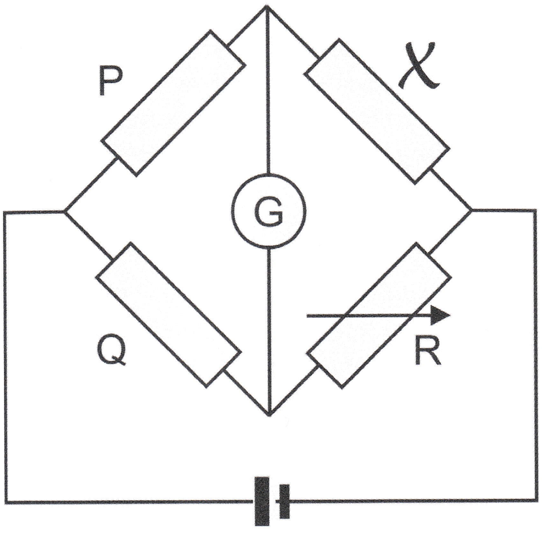

Figure 5 Basig Wheatstone bridge circuit © The Author.

X is the unknown resistor the others are known.

If the ratio of the two resistors P/Q is equal to the ratio of resistors X/R, then the voltage across the galvanometer G is zero because no current flows in it, and the bridge is at balance.

At the beginning of the test the galvanometer is shunted by a resistor (not shown in the figure) to prevent damage to the sensitive galvanometer, as null is reached the shunt is removed

P and Q are set to a ratio of 1:1 or 1:10 and so on. Adjusting R to give a null on the galvanometer, gives X multiplied by the ratio of P/Q.

The unknown resistor X is worked out from the following formula.

$$P/Q = x/R$$

$$x = P/Q \times R$$

Varley test
This is the most commonly used test. The test procedure depends on the severity of the fault and means making two or three tests.

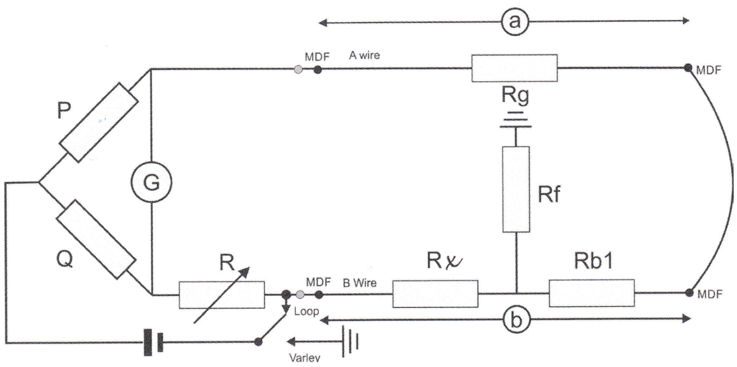

Figure 6 Varley test © The Author.
The good wire (Rg or a) may not have the same resistance as the faulty wire b. The good wire need not be in the same layer or in the same cable. The resistance Rb1 is not worked out but Rx and Rb1 are the resistance of wire b. Rf is the insulation resistance to earth. The Varley test also locates faults where one wire is in contact with another.

Two tests
The first test-finds the resistance of "a" and "b" (the loop resistance). The second test-finds the resistance to the fault Rx. The results "a," "b," and Rx are put into a formula to find the resistance to the fault. Two tests are OK if the resistance to earth is

high, a situation that occurs early on in the life of a fault.

P/Q= (a+b-Rx)/(R +Rx)

If P and Q are equal then R+Rx=a+b-Rx

Rearranging the formula

2Rx=a+b-R

Rx=(a+b-R)/2

Rx=(Loop-Varley)/2

Rx is proportional of the distance from the termination to the fault. All that you do next is to find the resistance of the wire in Ohms per mile and work out the distance.

Three tests

- Do three tests if the resistance to earth is low indicating that the fault is deteriorating and affecting the whole of the cable. You cannot get a good wire in the same layer. Using a good wire in a different layer, results in a different resistance to the faulty wire.
- No good wires are available in the faulty cable resulting in the use of another cable for the good wire. The good wire will have a different resistance because its size or length is different to the faulty wire.

The tests are:

- The first test-finds the resistance of a good wire "a."
- The second test-finds the resistance of faulty wire "b."
- The third finds the resistance to the fault Rx.
- The results "a," "b," and Rx are put into a formula to find the resistance to the fault.

To make most tests the PTO would be at one end of the faulty section of cable, but would need access to the other end of the faulty section. If some of the pairs in the faulty cable were all right, you used these for access to far end. Taking public traffic pairs out of service was all right as long as you asked and got the junctions busied. It was never acceptable to take private circuit or preferential service pairs (marked in red on the MDF). Otherwise, you used spare pairs in other cables that ran between the near and far end. Other factors to take into account were:

- The resistance of test leads between the tester and the cable head (MDF).
- The resistance of the access to the far end.

Air pressure in cables

Water, even in small amounts is death to an external cable. The insulation between the wires soon deteriorates in the presence of water to prevent this problem the GPO put all its cables under air pressure. A flow meter and pressure gauge monitor the cable at each exchange or repeater station.

If the sheath develops a fault, the air leaks out. The pressure monitored by the gauge falls and raises an alarm. Turning on the flow meter allows more air into the cable raising the pressure in the cable. The air leaking out prevents water getting in. Monitoring the flow of air and the pressure will tell if the fault is worsening.

The pressure used at 9 pounds per square inch (620 millibars or 0.6 atmospheres) was small enough not to damage the cable sheath and closures but is sufficient to protect a cable from the about 20 feet (6 metres) of water.

To allow testing each sheath closure (joint) had a bicycle type valve fitted to it. To locate a fault you take pressure readings with a mercury manometer at each joint and plot the readings on a graph with distance on the horizontal axis and pressure on the vertical. The slope of the resulting line indicated the position of the fault.

Air pressure in repeater cases

Repeater cases for co-axial systems and Pulse Code Modulation are pressurised and have an alarm fitted. The case did not connect with the air in the cable.

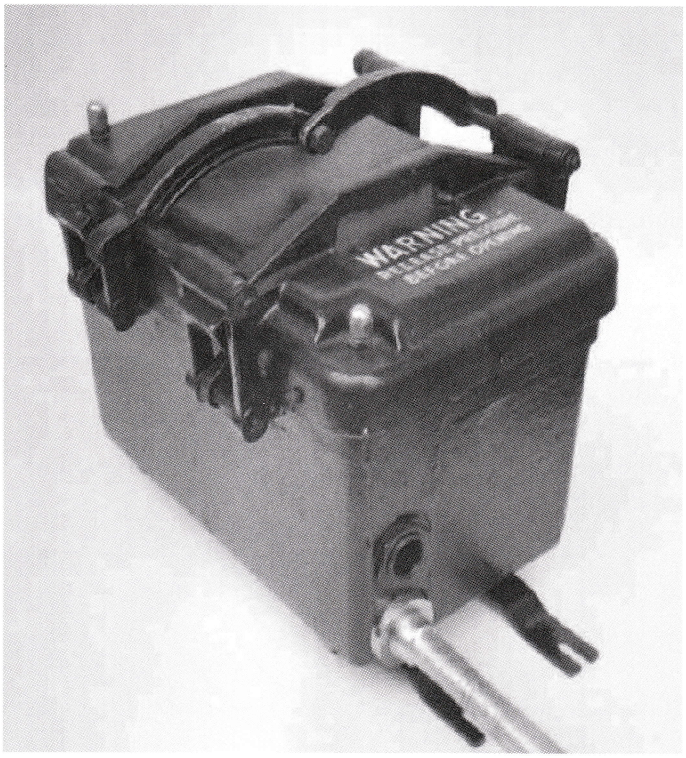

Figure 8 Case Repeater Equipment © Photograph courtesy BT Heritage

The repeater case consisted of a box with a lid. A rubber seal around the edge sealed the case from dirt and water getting in and the pressurised air getting out. A cam and leaver system applied an even pressure to the seal and held the lid in place. The cable tails entered the box through a gland sealed with "O" rings.

To de-pressurise and pressurise the case there are two bicycle type (Schrader) valves.

The case must be de-pressurised before releasing the cam or the lid would fly upwards under force of the air pressure. It was re-pressurised from a foot pump because using an air bottle could over pressurise it.

With no faults developing in the case's lid or cable-entry seals, its pressure remained stable.

I finally left Faraday when an Executive Engineer I worked with told me that a colleague of his in THQ had a vacancy for two TO's and had selected me and another T2A on Precision Test. Both of us got a promotion out of it and as it turned out a fast track into Management as Assistant Executive Engineers. Doing much the same sort of work but ranged over the whole of the UK we found the faults that others had difficulty locating. We also field trialled new test equipment and methods, such as pulse echo location.

Acronym decoder

Acronym	Meaning
AEE.	Assistant Executive Engineer (1st level of Management)
Chimney	The shaft that leads from the surface to the jointing chamber.
EE	Executive Engineer (2nd level of Management).
GPO	General Post Office. In this article I've used this antique term to mean Post Office Telecommunications and its successors British Telecommunications and BT.
Jointing Chamber	The space underground that houses the joints in the cable; loading pots are located here too. Jointing chambers were spaced approximately every 10th of a mile.
PTO Precision Testing	Officer. A Technical Officer who does precision testing work, locating faults on cables.
THQ	Telecommunications Headquarters. The GPO was managed on a geographical basis with Telephone Areas (about 60) in ten Regions with one Head Quarters. Each operational function was repeated at Area, Region and HQ. Areas did the day-to-day work, Regions and HQ concentrated on strategy and development. Faraday was in City Area in the London Region. It had been an area in its own right (called Long Distance Area).
TO	Technical Officer (skilled technical grade).
TOA A	Technical Officer who earns and Allowance by doing supervisory duties.