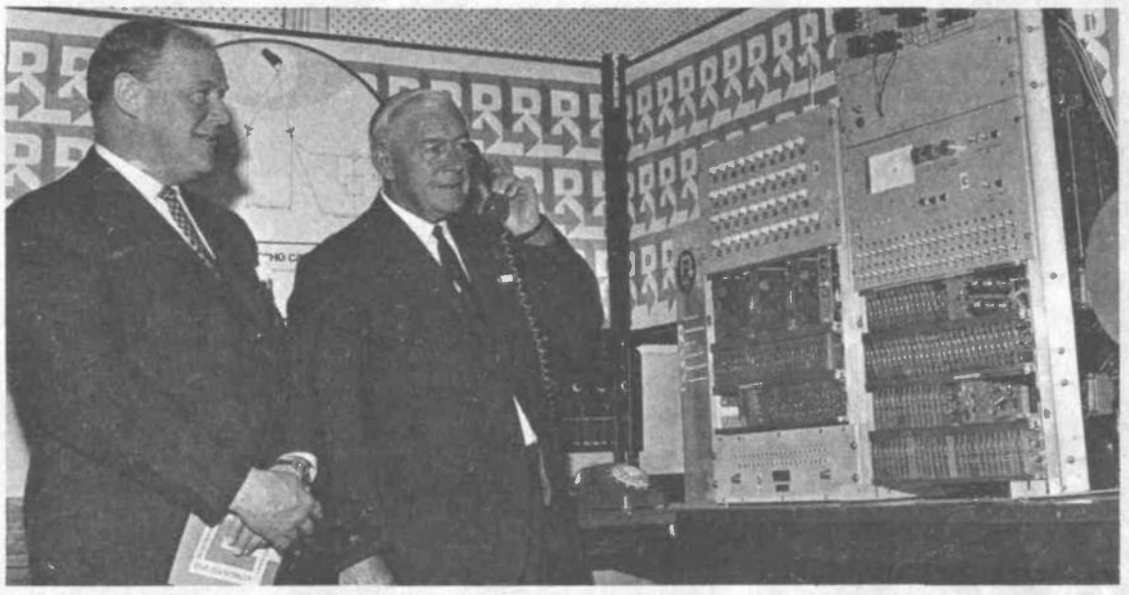
The POST OFFICE Research Report

ISSUED BY THE PUBLIC RELATIONS SECTION, AUSTRALIAN POST OFFICE

RESEARCH LABS WELCOME VISITORS...

In September 1969, thousands of visitors inspected the Australian Post Office Research Laboratories in Melbourne in a week-long series of Open Days held to illustrate the extent and variety of work done by the research teams.



A demonstration phone call by the Postmaster-General, Mr. Alan Hulme, during the Post Office Research Laboratories Open Days program, held the interest of the Lord Mayor of Melbourne, Cr. E. W. Best, who viewed many of the projects presented.

On the first day a V.I.P. group led by the Postmaster-General, Mr. Hulme, and the Lord Mayor of Melbourne, Cr. E. W. Best, were among the first visitors through the laboratories.

They were followed by scores of other conducted tour groups — businessmen, school teachers and students, researchers from other establishments, members of the Press, radio and television, engineers and other professionals and tradesmen interested in the exhibits, as well as members of the public for whom most research, finally, is done.

At the six centres operating in Melbourne, they all saw the vast variety of projects undertaken by the research staffs.

Many were impressed by the high proportion of original research undertaken, at the extent of leadership Australian researchers are showing in many communications fields and at the large number of systems now in use that were devised by Australian researchers.

Among the exhibitions visitors saw were lightning flashes of up to 1.4 million volts being discharged to test lightning's effects on equipment. They could study, too, the remote control camera equipment which records the flashes and their effects in close detail.

There were displays of the new science of fluidics — the use of jets of air, liquid or gas for propulsion or numbering systems. Computer operations were arranged and explained. An Australian innovation for fusing twisted wire joints, tip-welding, was demonstrated.

A large amount of the work shown and demonstrated is being done to help increase the efficiency of long range communications. Efforts to curb 'fading' or loss of quality in microwave radio networks . . . the possible uses of laser beams in communications . . . improvements that will come with satellite links . . . the continuing battle to maintain peak clarity and efficiency in telephone reception — all these were displayed.

There were demonstrations also of standard tests on equipment, temperature and atmosphere tests on clothing and equipment, working demonstrations of the locally invented machine that gives quick, efficient tests of electronic circuits, as well as the making of printed electronic circuits from an idea conceived through all the processes to that finally constructed.

Workings of coaxial cables, the Australian-invented PETRA machine that gives a record of STD telephone calls, instruments that measure light, color, speech, metal strengths were among the hundreds of exhibits shown.

This paper gives in more detail just some of the work of the Research Laboratories. Much more — a book at least — would be necessary to give a full coverage of all the details of what is now a major industry in Australia's largest single enterprise: the Post Office.

The Laser Beam is destined to be the answer for the high capacity transmission media needed for the ever-growing communications traffic of the future.

TOMORROW: LASER BEAMS

For the coming step into more efficient mass communication methods, Post Office researchers are experimenting with modulation studies into Laser and other beam techniques. Modulation is the process wherein the subscriber's voice changes the electrical characteristics of a single band of frequencies, or "channels".

Just as microwave systems developed as an extension of broad band radio, Lasers are believed to be a future extension in communications transmission.

A single beam could be used to carry 250,000 telephone channels. And the system, as well, could be a carrier for television programs, computer data and, when it arrives, the telephony service of the future: videophone.

Coherent light

Current trends in coherent light communications favor guided rather than free space Laser transmission. In this system the beam would be enclosed in a fibre optic cable which would be run underground with the beam in it and transmitted on a non-direct route.

In experiments in 1967-68, studies were made with a 12-channel system using an incoherent infrared light beam as a carrier across the city of Melbourne. These were aimed to discover to what extent light beam communications' efficiency could be diminished by natural urban hazards. It was found that smog, dust, smoke, heavy rain and fog interfered seriously with the transmissions. Anything that crosses the beam optically will, naturally, interfere with reception. In an outback environment, dust storms and even flying birds crossing the beam's path in the atmosphere would be disadvantageous.

Underground carriers

Since there is wide agreement that the most successful operations with Lasers must be as underground carriers of communications, American and British research teams are already working on cable links for these underground services. In Australia, Post Office teams are concentrating their studies on terminal posts and on modulation and demodulation of the beams.

In all countries, as the density of communications traffic increases, the need for higher capacity transmission media is becoming more evident.

Higher frequencies

As more radio frequency bands are brought into use, the trend is towards using higher frequency carriers. Lasers provide a communication carrier with a frequency of 10^{14} cycles per second, But the possible uses of the Laser's enormous band-width potential are limited so far by the problems of its guided propagation and the lack of complete techniques on modulation and demodulation.

In the Melbourne tests with incoherent light beams — similar tests were done also in Sydney — both analogue and digitally encoded voice signals were transmitted on the optical carrier.

Reliability

Although the range and transmission rates achieved with an incoherent optical link are much less than those expected with Lasers, the results showed a free space transmission reliability of 9.8%.

They also indicated that pulse coding was the superior modulation technique.

These studies were done specifically to study free space transmission of beam communications in an urban environment.

They confirmed that for long range transmission, guided propagation of the beams will give the best, most reliable results.

TESTING ELECTRONIC CIRCUITS

This machine was specially designed and built by Post Office research engineers to enable them to make faster, efficient tests of electronic circuits before they are put into practical use.

Today's modern circuits, transistorised and wafer-thin or only slightly larger than a pinhead, present something of a problem for engineers wishing to know their accuracy of design under work conditions before they are actually employed.

In the past, special testing equipment had to be set up for each particular circuit or module. Or the tests simply had to be done under practical operational conditions.

This was in many ways inefficient. There was always the recurring expense of setting up testing equipment, plus the time factor involved in investigating and, if necessary, debugging a complex system if this had to be done.

To overcome this, the engineers produced their own Circuit Tester to handle this work speedily before the circuits were put into use.

Its test control unit has 25 lines, each with selected functions, which pass through a field of terminal posts where discrete components may be added to simulate serial and parallel loads. The lines are connected to a range of sockets wired in parallel to take integrated circuits, printed circuit cards, relays and external cable connections.

In essence, the component operation of the circuit is duplicated in the tester by means of shorting pins which are inserted into the lines according to the pattern of the circuit. It is then this exact duplication of the circuit that is tested for operational efficiency.

There is also a major accessory, which is a 30 by 60 point program matrix board. Twenty-five of the 30 lines are connected to the Electronic Circuit Tester, leaving five available for other functions. The 60 lines are connected to a range of connectors and shorting pins are inserted in the cross-points of the board to inter-connect these sockets and select lines to be connected to the Electronic Circuit Tester as appropriate.

Indicative of its speed, the machine can test simple circuits at the rate of 50 an hour, contributing worthwhile savings in time and expense to Post Office operations in this expanding field of circuit operations.

This Electronic Circuit Tester greatly reduces the workload traditionally involved in circuit testing.

FIGHTING AN ENEMY UNDERGROUND . . .

Each year the Post Office suffers heavy losses as a result of 'enemy attacks' on its equipment — by Nature's predatory attackers.

Termites, rats, mice and rabbits are the leaders in these assaults. And they receive strong back-up support from a wider variety of animals, insects and birds.

Buried cables are the main targets for all these and the war against the attackers is now being stepped up considerably with the most modern weapons from the Research Laboratories' armory.

For more than 50 years, as long as cables of any kind have been buried in the ground, damage by animals and insects has occurred. And this has always resulted in small yet quite significent percentages of cable faults and service breakdowns.

Until 1957, all these cables were sheathed in lead and most damage was done by termites. But there were also isolated incidents of rats and other gnawing animals being responsible.

Polythene sheath

Then came polythene sheathing, which brought considerable technical and economic advantages but resulted in a greater number of attacks since this softer sheathing material was more easily penetrated by insects and animals.

Faults caused by these attacks occur in all parts of Australia, but more frequently in tropical and sub-tropical regions — and some areas in the cooler Southern States are also seriously affected. North of the Tropic of Capricorn, where the giant termite Mastotermes operates, steel tape armored cable has had to be used widely, as plastic sheathed cables, until quite recently, were considered totally unsuitable.

Termite and ant attacks result in not only the cable sheathing but also conductor insulation being penetrated, allowing water to enter the cable and cause an electrical fault. Depending on the species of attackers, individual holes in sheathing have ranged from 1 square inch to 0.02 in. in diameter. And the extent of the damage can vary from a few inches in length to hundreds of feet of the one cable.

Not known

It is still not known just why ants and termites attack these cables. Materials such as lead and polythene have no material food value for them. It can only be assumed that the cables are chewed to see if more palatable material lies underneath. Or it is possible that the cable is simply an obstacle in the foraging path of attackers.

Termites have posed a constant threat to underground cable sheath covering. A new nylon coated polythene sheath cable (left) has proved particularly resistant to insect and rodent attack.

Post Office Research Laboratories have been working for many years studying ways of protecting plastic cable from attack. Test plots of earth have been established in areas where termites abound and sample cable lengths have been buried in these, attached to or encased in termite-susceptible timber pegs for up to five years.

This has been done to invite rapid attack. And samples recovered at intervals have indicated the degree of resistance of different types of sheathing material. In these researches, the CSIRO Division of Entomology has also been helpful in providing answers to major questions based on the laboratory exposure of samples to certain species of termites.

Counter-measures

Earlier counter-measures, based on overseas experiments, included incorporating insecticides into cable sheathing when it was made. But it was discovered that additives like these would ideally have to act as a repellant before an attack was begun on the material. Naturally, poisoning by ingestion is far less effective if a large number of insects involved in a typical attack, each taking at least one bite, are allowed to cause considerable damage before the insecticide can take its poisoning effect.

Materials used in these experiments with additives included lead naphthenate, pentachlorophenol, Dieldrin, Aldrin and Gammexane. But they produced varying results. Even at the maximum concentration possible on technological and economical grounds, none of them provided the level of immunity required.

As new insecticides are constantly being developed, this method has still not been ruled out entirely.

Special sheathing

But interest in more recent years has centred on developing a special sheathing to resist automatically insect attacks. To be most effective, studies showed, it must have not merely hardness but also resilience and, at the same time, a super-smooth surface to make it harder for small attackers to pierce.

Among the many different materials experimented with were high density polythene, polypropylene, nylon and acetal. It was finally discovered that the best result came by using a thin jacket of nylon — 0.03 in. — over the normal polythene sheath. This was found to provide complete protection during many years of exposure, even in the worst termite regions.

This type of cabling is now being used in all Australian field installations. Meanwhile, further experiments are being done into treating also the soil used to surround the cable when it is laid in the ground.

Soil treatment

In Western Australia it has been standard practice for several years to treat this soil with insect and rodent repellants and insecticides. Statistics indicate that this method is achieving its aim. Further tests are being done to see if this method will also give lifetime protection in all soils and in the highest rainfall areas. Controlled experiments with different soils, different soil treatment and various concentrations are now going on.

Other studies are being made into such things as stray current corrosion and various means of protection to counter it. In this field the Post Office is working in conjunction with the Victorian Railways.

INSTRUMENTS MADE, REPAIRED, SERVICED

A service as complex and as widespread as the Australian Post Office naturally must use an incredible array of instruments of all types, both electrical and mechanical.

It operates with more than 200 different types of recorders. There are also more than 1000 different types of indicating instruments, including multimeters, pressure gauges and many others of a special nature.

All repairing and servicing of these instruments has always been done by the instrument making section of the Post Office Research Laboratories. To do this the Post Office laboratories employ a group of qualified instrument makers and apprentices who are responsible for maintaining instruments of the electro-

As well, this staff group provides other instrument making facilities as required by other research laboratory staffs at the Post Office.

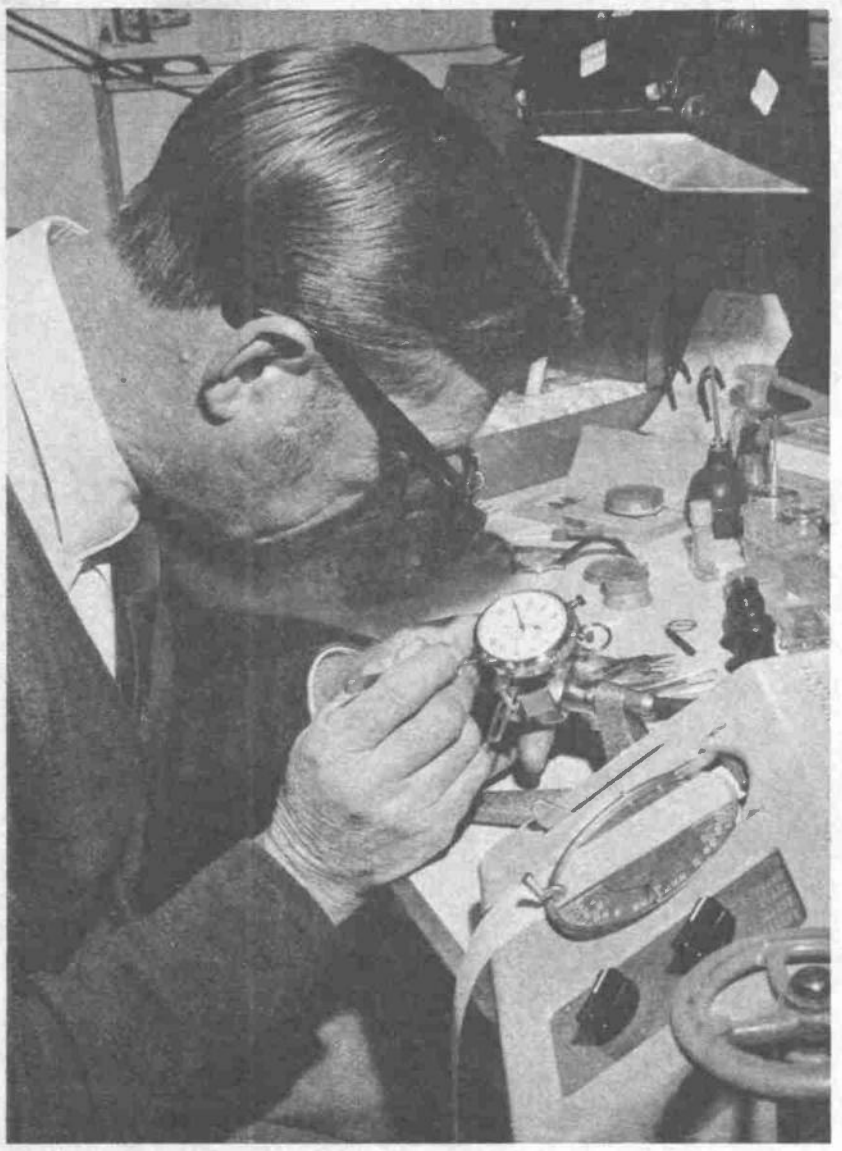
Work like this entails a microscopically fine degree of accuracy. One section might be working on a coil winder, which layer winds through 2000 turns a moving coil of enamelled copper wire of 50 gauge — or 0.001 of an inch in diameter.

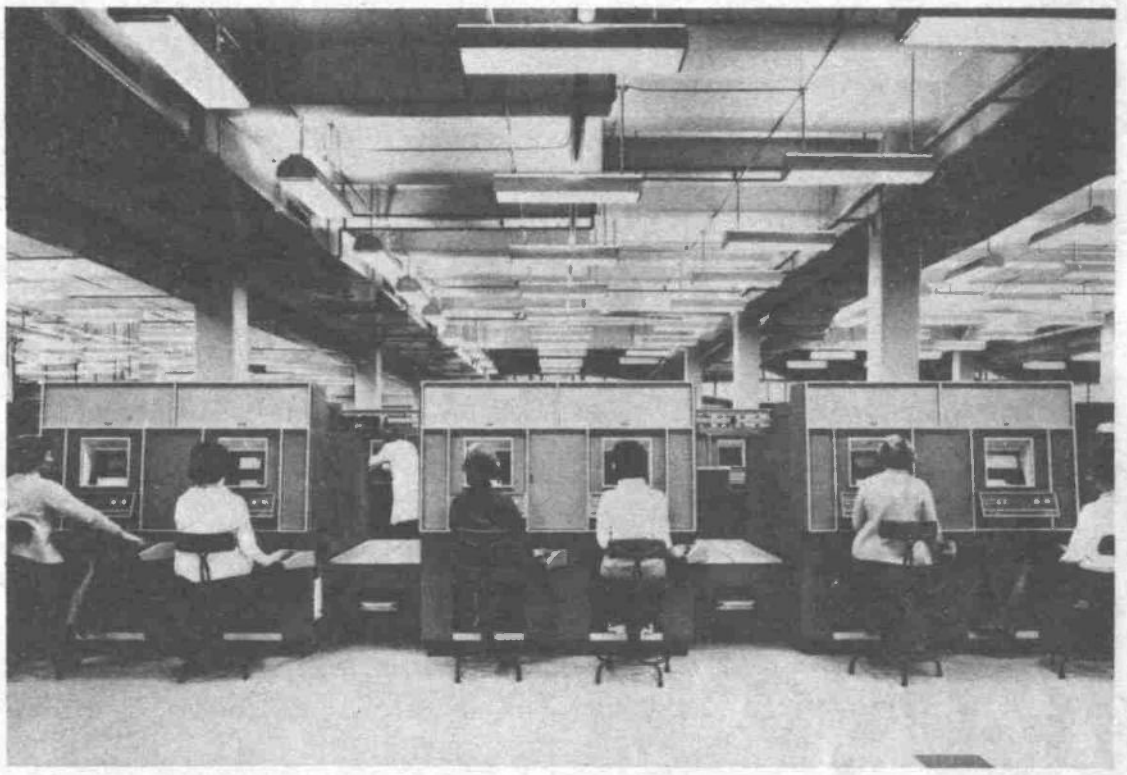
Clocks and gauges, recording and checking instruments of all types and all sizes flow into on flat or curved surfaces and permanently magnetising equipment parts are other aspects of its work. It also builds prototype models for research by other departments and parts for repairing laboratory equipment.

As the Australian Government will shortly introduce the metric system nationally, this section currently has the job of ensuring that when the Post Office purchases new equipment it conforms to metric standards or is capable of easy

In many ways like these, today especially this section of the Research Laboratories at Exhibition St., in Melbourne, is a vital nerve centre of the Post Office's research operations.

The instrument making section of the Laboratories carries out repairs on both electrical and mechanical equipment covering a very broad range of services and apparatus.





Operators at coding machines in the modern Sydney Mail Exchange in Redfern, N.S.W.

MAIL HANDLING: A MAJOR POST OFFICE OPERATION

Handling of the mails remains one of the Post Office's principal operations. And it is becoming an increasingly bigger, more complex job as mail volume grows each year.

This year the Australian Post Office will handle almost 3000 million items of mail, an increase of 40 per cent on the volume handled a decade ago.

Prime responsibility for providing and operating all types of mail handling machinery lies with the Post Office's Postal Services Division. Technical maintenance is done by the Engineering Works Division. But there are many occasions when the facilities and technical experience of the Research Laboratories are usefully applied to particular problems of design or operation.

Lab. responsibilities

In September 1967 a Mail Handling group was established in the Research Laboratories. It has two main responsibilities —

- to provide close liaison between other divisions involved in mail handling and the groups in the Research Laboratories which could assist with particular problems in this field, and
- to make special investigations of mail handling problems.

Into category one comes such work as the chemical and physical analysis of coding tapes used in mail sorting, of paint finishes and constructional materials; the testing of switch contacts; advice on encapsulation techniques and patent protection.

Category two covers such work as the analysis of the stresses in mechanisms, the design of modifications to equipment, performance testing of prototype units, electrical and electronic circuits design and allied matters.

Work with luminescent tape coding of letters, which falls within the first category of duties, has been important in developing automatic sorting of letters at the new Sydney Mail Exchange.

Luminescent dots

After facing and stamp cancelling, the backs of the letter envelopes have a pattern of luminescent dots punched on to them. This dot pattern contains coded information which enables the sorting machinery to identify the intended destination of the letters.

As the letters pass through the decoding station the patterns are first illuminated with ultra-violet light — and then passed under the fibre optic light guides which transmit light from the dots to photomultiplier tubes. A pattern of pulses from these tubes causes the appropriate sorting channels to open.

Luminescent material is punched on to the envelopes from a mylar-based tape which is coated with activated zinc sulphide. All this equipment was developed by the staffs in the Post Office Research Laboratories as most suitable for Australian requirements.

At the mail exchange, a sorter reads the address on the envelope and punches the postcode — say it is 3468 — on a machine which, with a heated punch, impresses code marks in dots one-eighth of an inch in size on to the reverse side of the envelope.

It remains always invisible to the human eye. Its passage in front of the photomultiplier tubes which 'read' the code-marks and then send it to be correctly sorted takes only 50 milliseconds for each letter. This, of course, is far speedier than if the sorting were done completely by hand. It also attains a higher degree of accuracy.

Torque-limiting

Last year the Research Laboratories conducted endurance tests with a new torque-limiting clutch which was also designed at the Laboratories' Mail Handling group to replace a unit which had proved to be unsatisfactory in machines purchased for the Sydney Mail Exchange.

These tests formed part of the operations within the second category of the group's work.

At the input end of each letter coding or decoding machine at the Sydney Mail Exchange there is a letter storage tray into which letters are intermittently fed forward by so-called 'stacker arms'. These arms are drawn forward by a roller chain drive.

Undue resistance to movement of a stacker arm could lead to fracture of the arm or other damage to the machine, unless some provision is made for limiting the driving force.

When in service the clutch is installed in the drive train to the chain. It is designed to transmit power until the torque exceeds 45-50 inch lb. Beyond this value the clutch slips in order to prevent equipment damage, in the event of accidental overloading.

Under working conditions the clutch should be required to slip only rarely. Its duty cycle — the ratio of slipping time to non-slipping time — should also be small.

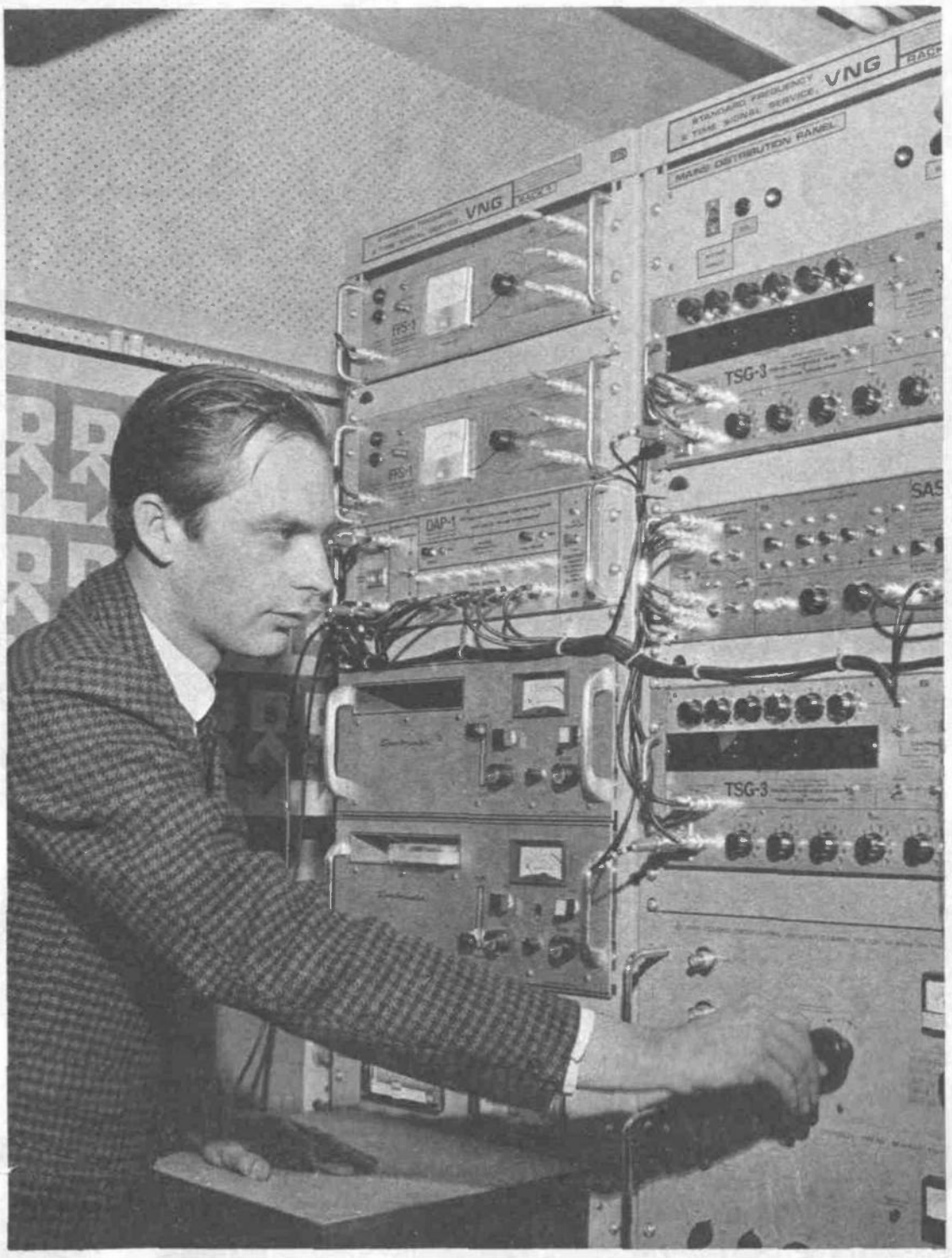
Life of clutch

Laboratory tests subjected the clutch to relatively arduous conditions. It was made to execute a duty cycle of 50 per cent on / 50 per cent off, with a cycle duration of two minutes. This was to achieve the aim of determining the life of the clutch under such testing.

It was felt that if the clutch survived the test without significant change in slipping torque for a month or two, this should guarantee long trouble-free service life.

To make the tests, the clutch was mounted on a dead shaft. A cycle-timer switch operated a driving motor which made the clutch slip in the pattern devised by the testers. At regular intervals the slipping torque was measured by disconnecting the roller chain and applying a special C-spanner and torque wrench to the sprocket.

Only by making thorough sample tests like this can equipment of all kinds used in the vital processes of mail handling be kept at peak optimum operating efficiency.



Australia now has its own Standard Frequency and Time Signals Service accurate up to 0.0001 of a second. The equipment is contained in two racks each checking the other for accuracy.

GETTING THE RIGHT TIME... EXACTLY

"What's the right time?" — a question often asked, but one rarely answered with complete accuracy.

Ordinary clocks and watches, no matter how accurate for general purposes, cannot be expected to stay right on time all the time. Variations in temperature and atmospheric and weather conditions can throw even the best regulated instrument slightly off its regular beat in its process of measuring time.

Keeping a check on the exact time, under closely controlled scientific conditions, and transmitting completely exact time readings and signals are yet more tasks assigned to the Australian Post Office.

Signals transmitted have been sent since September 1964 from the Post Office's Time Signal Service short-wave station VNG situated at Lyndhurst, in Victoria. Recently new master clocks and master control equipment regulating the entire system were installed by the Post Office Research Laboratories personnel at Radio Lyndhurst.

This equipment took two years to be built by Post Office engineers and technicians and was completed in June 1969. It cost slightly less than $47,000 to build. If similar equipment for this work had been purchased from outside manufacturers the cost could have been more than $300,000.

At every moment of every day and night the equipment gives readings of the time accurate to within one ten-thousandth of a second. It is actually two systems that function side by side but act independently, each maintaining a check on the other. If the slightest difference in a time assessment occurs between them, an alarm sounds and the necessary adjustment can be made to the one which becomes inaccurate by however small a margin.

Accuracy vital

Accuracy is, of course, vitally important especially when the signals are used in such things as astronomical surveys, by seismic and geophysical exploration teams and by observatories and academic groups as well as private industries and Government departments in all parts of the country.

Overseas organisations operate similar services and their results are available in Australia. But hitches can occur with them. Due to the lengths of the transmission paths overseas signals must travel, there can be marginal delays in receiving their signals, reception is not always possible for all of them and there can be propagation fadings as well as delays.

Confusion can also arise from reception of more than one service on the same carrier frequency. In any case, it was felt that Australia should initiate its own time broadcasting service, with the Post Office the most suitable service to build and maintain it.

Previously VNG time signals were transmitted by a simple time code. But after conferences and correspondence with users, it was decided last year that a slightly more complex time code would provide a more accurate service to the user.

Seconds of time passing are signalled by tone bursts for each one. Time coding is performed by varying the tone bursts that mark each second, the various lengths being 50 milliseconds, 5 milliseconds and 0 milliseconds.

No tone burst

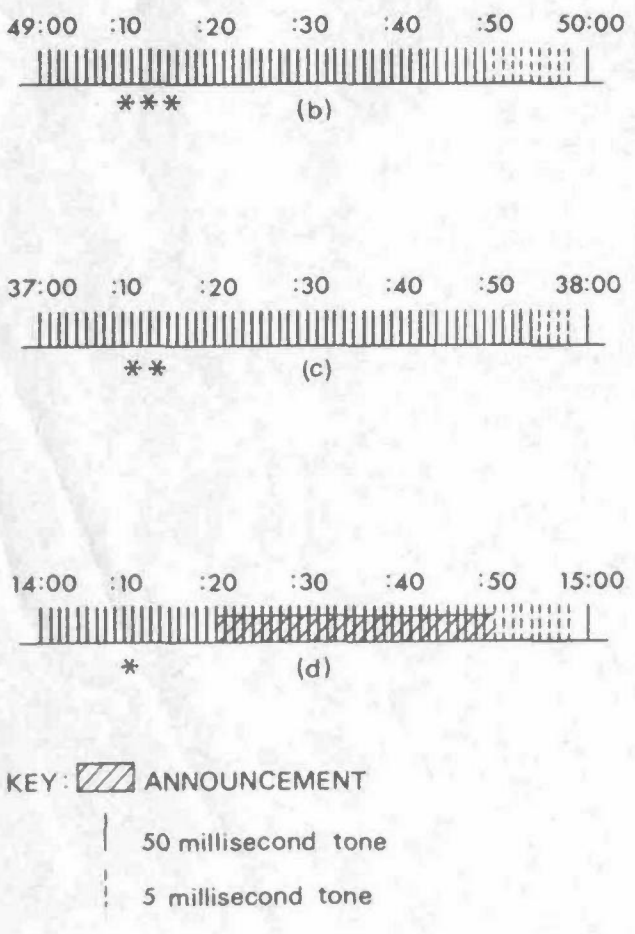
There is no tone burst to mark the end of the 59th second interval in each minute. This gap in sound then becomes its own silent signal that the minute is about to elapse and the first tone burst after the silence marks the start of the new minute.

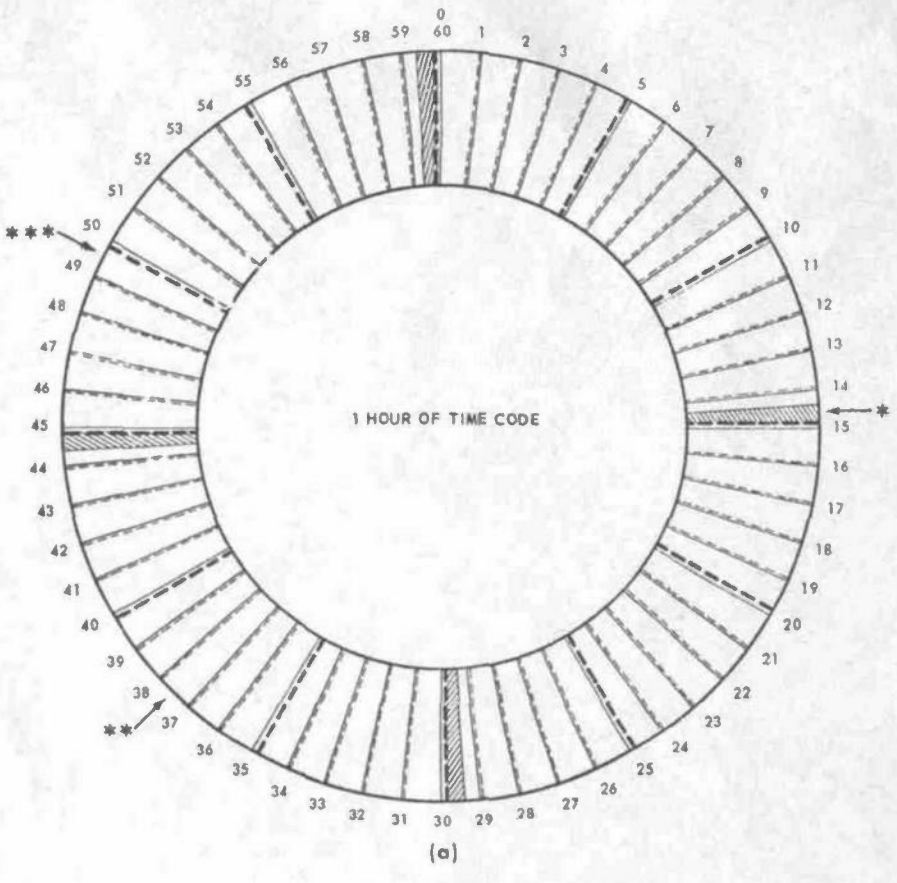
These signals are sent from the VNG transmitter at Lyndhurst, which is 20 miles from the 59 Lt. Collins St. laboratories in Melbourne, where the Australian Post Office master clocks operate. To ensure accuracy between the two points, three separate control and measurement methods are used every day by landline and radio links between them. If any variation should occur, it can be corrected immediately.

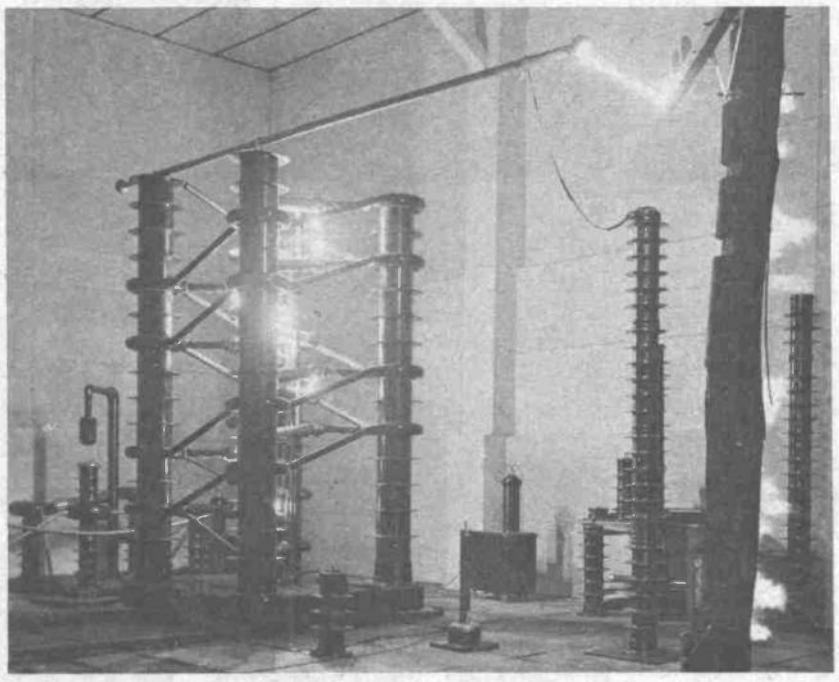
It is anticipated that this new VNG service will operate without any modification of form for many years. It is possible that extensions might be added to the service: one could be the inclusion of a LF transmission to provide groundwave coverage for most of Australia.

Another possible addition could be the installation of transmitters in major cities for the precise dissemination of time and frequency information in areas with the highest population and industrial densities.

Clock face representation of the time coding, with various minutes of the coding asterisked and shown in expanded form in (b), (c) and (d).







Man-made lightning is produced by this Impulse Generator discharging 1.4 million volts at the A.P.O.'s North Carlton laboratories.

THEY MAKE LIGHTNING THEN CONTROL IT

Lightning, one of Nature's most hazardous natural phenomena, is very much a fact of life with many Post Office operations.

Sudden high voltage attacks can damage equipment, throw communications into havoc, disrupt the orderly flow of essential Post Office services. They may also kill people unless proper understanding of high voltage power is developed and safeguards taken against it or to control it.

Man cannot yet harness lightning as he can water. But he can probe it, establish protection against its damaging forces and, to help him achieve all this, has learned how he can recreate it so that its destructive powers may be minimised.

At two different research sites in Melbourne, Post Office researchers study its powers and ways of control.

At the North Carlton laboratories, the centre piece of this research is an Impulse Generator capable of discharging 1.4 million volts. It is used for research into what can happen when high voltages strike telegraph poles or equipment connected to aerial or even underground cables.

This damage might not always come from lightning. High voltage damage can also result from induction in cables caused by large earth currents, or even the normal operations of trains, trams or large motors.

So that equipment may be designed and tested to see how it functions under these assaults, researchers have constructed apparatus to simulate high voltage attacks. With this, equipment can be tested before it is installed or, if failures occur during operations, probable reasons can be studied.

Impulse generator

This is done with an impulse generator, an eight-stage voltage multiplier designed on the 'Marx' principle. It consists of eight capacitors charged in a parallel circuit configuration and then discharged as a series connected circuit by means of spark gaps. These spark gaps may be seen as open circuits until firing occurs, when they become short circuits.

To do this, power is taken from the regular 230 volt mains and increased to a peak of 100,000 volts a.c. by means of a transformer. This is then rectified and doubled by means of a conventional capacitor-input half-wave doubler circuit, which can deliver 175,000 volts d.c. of selected polarity to the main multiplier unit.

When all eight capacitors are charged to this voltage in parallel and then discharged in series, the result is a total charging of 1.4 million volts (175,000 X 8), which is the maximum that this equipment can achieve.

If the spark-gap separation is reduced, the firing may be made at any predetermined voltage. Each capacitor has a capacity of 0.125 microfarad and when charged to 175,000 volts makes a total maximum energy of 16,000 joule.

Actual lightning strikes usually have a power between 50 million and 300 million volts. But the Post Office researchers' equipment provides sufficient power to perform the tests necessary for their purpose.

Tests at the laboratories show the splintering that takes place when a telegraph pole is struck by lightning. By spraying one side of the test pole with water — even lightly from a domestic gun spray — it is possible to concentrate the high voltage attack down that side. Then it is possible to examine the extent of damage to the pole.

Other tests

Other tests are made of such Post Office equipment as rubber insulating mats that are used by staff and which could be subjected to high voltage hazards. Faulty equipment could endanger the life of Post Office staff, so insulating equipment is checked regularly under voltages far higher than any staff member would ever be likely to encounter.

Other studies concentrate on testing and, if necessary, designing the most effective types of lightning conductors and arrestors for all types of buildings and equipment. Commercial equipment is subjected to the tests and if no suitable proprietary equipment is available for a Post Office requirement the Engineering Staff of the Laboratory Equipment Division designs and constructs its own instrumentation.

Lightning strikes

An Automatic Photography System to study lightning strikes is an example of some apparatus specially designed and built for a specific purpose. It was set up to provide detailed information on the energy content of lightning strikes in Australia — the peak amplitude as well as the 'wave shape' or rise and fall times of strikes.

A six-month trial was first conducted at Mt. Gravatt, in Brisbane, before the equipment was installed at Mt. Canobolas, near Orange, N.S.W. Here, when a number of lightning strikes occurred, photographs were taken of them as they hit the 546-ft. ABC TV tower. This point was chosen because it is 4810 ft. above sea level and the ABC tower, except for a smaller nearby commercial TV tower, is the highest point for several miles around.

To detect the lightning current, a wide band, high current — 50,000 amps maximum — transformer was placed in series with the main earth strap connecting the tower to its earthing system in the ground. Because there is an earth strap on each of the tower's four legs, the total lightning current is approximately four times the measured current. When a strike occurs on the tower, the amplitude is recorded and camera equipment is automatically triggered to film the wave shape which is displayed on an oscilloscope.

To be able to record a strike at any time, the camera system is lightproofed, the camera shutter open and the equipment energised 24 hours, every day of the week. This requires the scale lamps of the oscilloscope to remain off except when they become pulsed to light the graticule for each strike. Exposure time for any strike, i.e. the pulse to when the camera shutter closes, is controlled by an electronic delay circuit.

After each strike, the Robot Camera advances the film one frame and the shutter opens ready for the next strike.

Film record

During the exposure time the oscilloscope and therefore the film recorded the various components of the strike. These can vary, depending on the site and the severity of the storm. But generally the wave shape shows a 10-90% rise in 5-20 microseconds, while the number of components comprising a strike is typically within the range of 2 to 6, with a period of 10-100 milliseconds between each.

Peak current is usually between 6,000 and 30,000 amperes through each leg of the tower, making a total yield of 24,000-120,000 amperes total in each strike.

In practice the exposure time was set at 1 second and the oscilloscope time base 200 microseconds full scale, allowing for a recording of up to 10 components for a strike. Every three days the equipment at Mt. Canobolas was tested mainly to prevent the film from fogging, and a log sheet was compiled to show counter readings as well as storm details.

Like the simulated lightning flashes generated at North Carlton, this was research unique in the country.

NOT ALWAYS AS STRONG AS STEEL

At Mt. Gambier, S.A., a 500-ft. television mast collapsed during erection when the steel guy ropes to support it were being tensioned.

It was a drastic demonstration to Post Office research engineers of a little-known factor that can occur in heavy stress steel equipment. A factor known as Strain Age Embrittlement.

This is a change that can occur in the properties of steel with time after it has been cold worked or strained. Different steelmaking conditions can have marked influences on the susceptibility of steel to strain ageing. Rimmed (high combined oxygen content) and semi-killed steels are the most frequently affected. Fully-killed steels have a low combined oxygen content.

In structural steels, which are generally semi-killed, strain ageing is manifested by a serious loss in ductility. This comes as a result of the ductile to brittle transition temperature being moved to higher temperatures.

Strain ageing occurs most commonly in mild steel which has been severely cold worked by punching, shearing or bending and is then galvanised. But it may also occur in cold worked regions which are in heat affected zones during working.

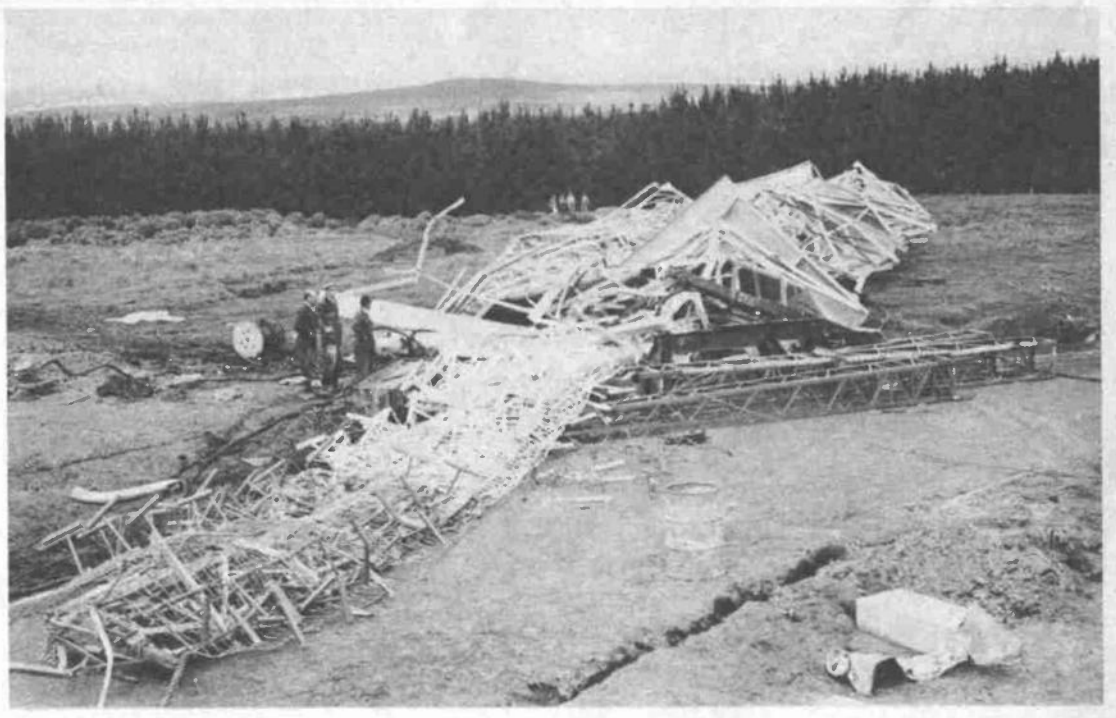
In the Mt. Gambier collapse, four factors were discovered to have been in combination to bring about the failure:

- strain age embrittlement occurred at the end of a sheared and galvanised steel anchor,
- a rolling seam in the anchor steel acted as a stress concentrator,
- incorrect geometry was applied for the pin hole placement, and
- the steel had poor notch ductility.

From this most practical example Post Office researchers discovered ways to prevent a repetition of a mishap like this. Principally, these were that heavily cold worked areas should not be exposed to high tensile stresses and, whenever these are unavoidable, the cold worked areas should be removed by machining, hot bending to 850°C. or heating after bending to 850°C.

In an era of stronger yet always lighter weight steels being used increasingly in major constructions, research into many of the newly discovered properties — and some hazards — in these steels has to be a continuing process.

Strain Age Embrittlement overcame this 500-foot television mast under construction at Mt. Gambier, S.A.



INTO THE NEW WORLD OF SATELLITES

Research is going on continually to expand and to improve Australia's telephone networks.

It is expected that by 1975 STD facilities will be available to 66 per cent of the nation's telephone subscribers. But for this to be achieved there are many problems of routing to be solved and several present difficulties with reception quality that will have to be overcome.

By 1975 it is possible that a satellite will have been launched into permanent orbit over Australia to sustain the most effective flow of telephone links to remote areas as well as carry international telephone calls. Already the ATS-1 American satellite now in orbit has been used for successful experiments along these lines.

For several years the Post Office has been working towards achieving a completely automatic telephone system in Australia. One major difficulty has been to provide this service to the large number of subscribers in country areas who have erected their own single wire earth return lines. These give performances of varying quality when connected to the old magneto-type exchanges, but they are quite unsuitable for automatic services.

'Metallic circuits'

Physical lines — 'metallic circuits'—must be properly constructed, with two conductors adequately insulated from each other and from the ground. An alternative means of line provision is the radio telephone system, but until satellite communications are introduced there are still some subscribers who are too far from an exchange to be served by either a physical line or a radio system.

Present conventional radio telephone systems replace telephone lines between subscribers and their exchanges and offer excellent performance. But under favorable propagation conditions their operating ranges are limited to 40 or 50 miles. Economically they have been attractive only as alternatives to very long lines.

But the Post Office's Radio Systems Division is at present attempting to develop a cheap and reliable radio telephone system which will be more economical than the system has been in the past. Present systems use analogue frequency modulation of the carrier and transmitter powers ranging from one to 25 watts. But the system now being explored by the Post Office would code analogue signals into digital systems for transmission. Theoretically, only one-tenth of the transmitter output power required by the present methods would be required for this new system. Significant reductions in initial and operating costs are therefore expected.

Major advantage

A major advantage of a satellite system is that it could be used by earth control stations located anywhere at all in the area covered by the satellite's antenna. These stations would automatically assign channels to users as required, also enabling connections to be made between conventional telephone subscribers and those in the satellite network.

Careful studies now show that digital modulation on single channel carriers is the most suitable modulation method for this system when it is introduced.

Experiments using a satellite to show how closely the satellite channels can be spaced in frequency and how to give vital information on the transmitter powers required by the system are in progress.

Meanwhile, the technology of present telephone communications is undergoing interesting and important phases of development, characterised by very rapid changes in both the technical and philosophical aspects of telephone systems.

Far-reaching developments in the semiconductor industry provided the initial momentum for these changes. Progress was further accentuated by the application to communications of techniques developed for the computer industry.

A new system known as Integrated Switching and Transmission (IST) is at present undergoing a thorough study by Post Office researchers to determine its effectiveness and applicability in the Australian telephone network in the hope that it will give highest optimum effectiveness to telephone services.

Essentially, any telephone network has the fundamental task of enabling any subscriber to be connected to any other subscriber in such a way that they may speak to each other. This task becomes quite formidable when tens and even hundreds of thousands of subscribers seek connections simultaneously.

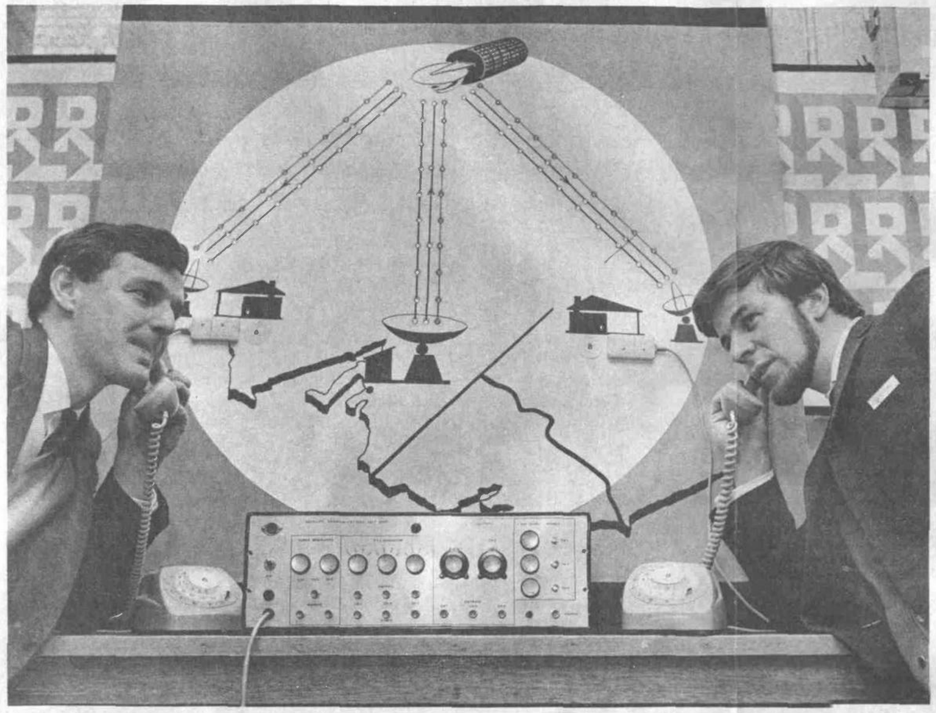
Equipment which controls the 'setting up' of a call through an exchange is in active use only during the relatively short time necessary to establish a path between the two subscribers. It is therefore reasonable and economic to provide control equipment which may be shared by many subscribers.

Common control

This leads to the concept of a common control type of telephone exchange. In the latest exchange designs, the common control function is performed by a processor whose behaviour is determined by a program stored in its memory, much as computers operate by storing programs in their memory banks.

This control technique, called stored program control (SPC) provides the high degree of flexibility required by large, modern telephone exchanges.

A modern concept in telephone communication is that of digital modulation of speech. Pulse code modulation (PCM) transmission systems carry speech in digital form as a series of pulses, and the different speech channels of a PCM system are separated in time (time division multiplexed, TDM). The Post Office is looking to a further utilization of this technique by use of the completely electronic IST system, in which digitally modulated transmission systems are interconnected using digital switching techniques.



This Satellite Communications Test Unit simulates person-to-person telephone conversations across the Australian continent.

TAKING ECHOES FROM PHONE CONVERSATIONS

Everyone knows the echo effect that exists in varying degrees in all telephone conversations. Usually it is a purely background sensation and not troublesome to the speakers. But there are times when it can become acute and, in fact, sometimes makes complete comprehension of the telephone conversation impossible.

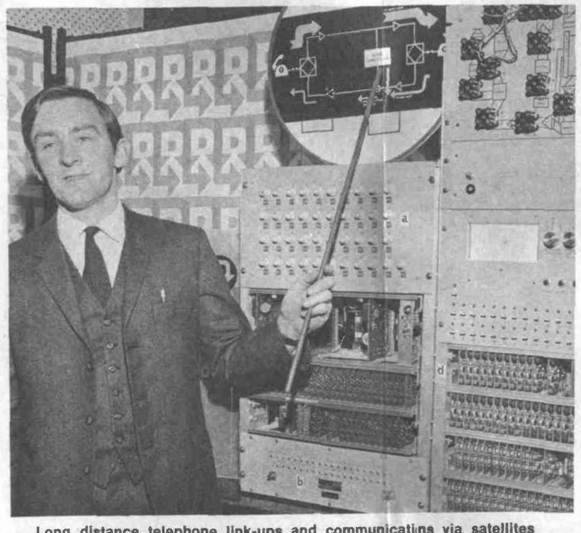
One phase of Post Office research at present is to evolve equipment to take this echo effect completely away from the telephone service. This project, aimed at entirely clear reception on telephones, has been given some urgency with the advent of communication satellites and the rapid growth of international telephone traffic.

There is already in existence a standard echo suppressor which can be used if the echo effect becomes serious. But its use impedes the natural flow of conversation and cross-conversation since it allows conversation to flow in only one direction at a time. It operates simply by detecting in which direction the speech is flowing and suppressing the flow of speech from the other direction.

In the present project the aim is still to allow two-way conversation all the time. This means finding a method of echo-cancellation to function on both speech circuits independently. In initial research work, this is being done by generating a special noise signal equal in magnitude but directed against the unwanted echo — and then adding this signal to the outgoing path of the conversation.

This has already been done by using a transversal filter as a response simulator with the ability to sense echo and use a correlation technique to diminish it. Eventually it is intended to introduce also a control strategy so that the speech signal becomes its own sensing signal, able to cancel continuously its own echoing effects. A level detector would operate the control process, cutting it off when the echo magnitude falls below nuisance point.

Already laboratory work has achieved a degree of cancellation which renders the echo still perceptible but unobjectionable. This work is still proceeding and, when completed, should bring considerable benefits to all telephone systems.

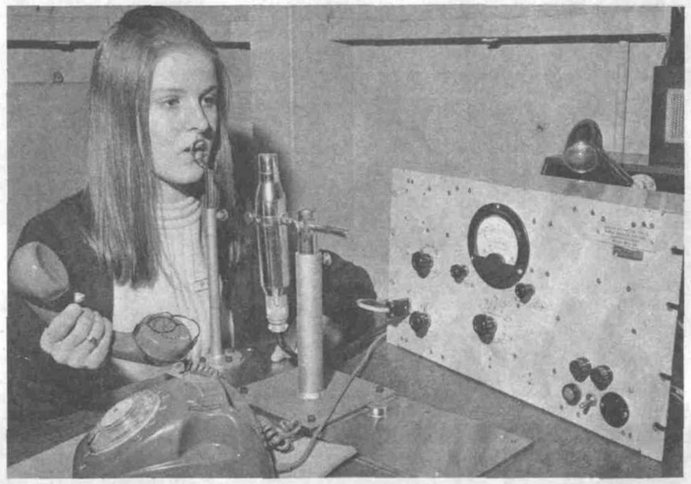


Long distance telephone link-ups and communications via satellites frequently have serious echo distortion. This demonstrator is describing recent A.P.O. research into the development of n echo canceller to reduce echo to an acceptable level.

COMMUNICATIONS... AIMING AT BETTER TELEPHONE RECEPTION

Efforts towards improving the quality of telephone speech reception are never-ending.

Peak transmission performance of a telephone connection is reached when the speech communication between two interconnected subscribers attains maximum clarity, as well as most effective volume.



Achieving this means scientific study of the components necessary to bring these things about. This is done by —

- Articulation tests, in which the ability of the telephone circuit to transmit intelligible words or sentences is determined through personal operations of trained teams of speakers and listeners,
- Loudness comparison tests against a specified reference speech transmission circuit, again using trained teams, and
- Soliciting opinions on the quality of the transmission over the circuit in terms of excellent, good, fair, poor, etc., from a large number of people conversing in pairs over the test telephone circuit.

Loudness of received speech has been found to be the most important factor in subscriber satisfaction. At present the standard method of rating telephone circuits is by means of a loudness comparison against a reference transmission circuit.

The International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) has defined the performance of a reference transmission system known as NOSFER, which can be constructed from a high quality microphone and head receiver, together with appropriate amplifiers and equalisers. This transmission system is used as a standard of loudness (or volume) efficiency against which telephone circuits can be rated in terms of volume reference equivalents.

Under carefully specified test conditions, the speaking distances to both the telephone and reference system microphone are maintained by the use of guard rings. Speaking level is also fixed and selected test phrases are used, such as "Joe took father's shoe bench out".

In comparison tests, the listening member of the team hears alternatively the two circuits and adjusts an attenuator in one circuit until both signals sound equally loud.

Most of the effort spent in the transmission rating of telephone circuits is directed at the local circuit where this subjective measuring, involving speakers and listeners under standardised room conditions, is necessary for consistent results.

In other tests clarity of reception is also measured and adjustments made in equipment where necessary.

Other Post Office research entails study into telephone subscribers' speech characteristics so that equipment designed should always be the most efficient. A Speech Level Meter, developed by Australian Post Office engineers, can provide statistical information on the average power levels of speech signals, their level distribution and their activity factor — or the fraction of time speech is present.

This equipment, which is not yet in full use, takes its recordings four times a second. Its findings are fed into a computer which processes the required information on speech signals.

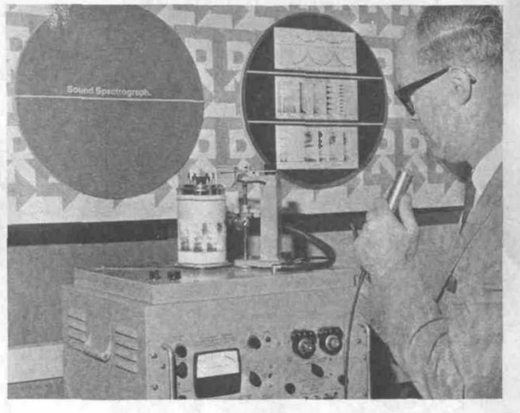
Tests are also going on into the use of a Sound Spectrograph, an incredible machine best described as an audio frequency spectrum analyser which can produce graphic recordings of any type of complex sound wave, such as speech, with components in the frequency range of 5 to 16,000 Hz.

It is fitted with a high quality microphone and a recording disc for taking sound or speech samples. This machine gives what has been neatly described as a 'voice fingerprint', in other words a thorough and graphic account on paper of voice strengths and accent variations.

Importantly, it is considered capable of identifying phone pests — people who use the anonymity of the telephone to pester others — through the accuracy of its speech analysis.

The clarity and articulation of telephone conversations are tested under controlled laboratory conditions.

Reasonable loudness of telephone conversations is one of the most important factors in giving satisfaction to telephone users.



The sound spectrograph produces graphic recordings of sound waves and can give accurate diagrams of speech analysis.

KEEPING UP STANDARDS OF POST OFFICE EQUIPMENT

In the Post Office, as in any major organisation, it is essential that equipment being dealt with in mass numbers be rigidly maintained at required set standards.

During mass production of equipment, there can often be variations in manufacturers' output. Once the goods are distributed on the market or to the public, these variations would soon become apparent. They could harm the reputation of the Post Office which must always aim for consistency of quality in its goods and equipment.

To protect against this happening, regular checks are made of all equipment used by the public. A good example of these checkings can be studied in the way telephones are regularly tested, as they come from the manufacturer, for the consistency of their color.

Telephone colors

Once the Post Office decides on a set of colors for telephones, manufacturers submit samples and then, when approval is given and contracts let, begin mass producing and supplying the telephone sets. But before color tests are begun and then continued at intervals during the years of output, required standards of testing are first established.

First, a standard set of the exact colors is established and then all subsequent products are compared against this set. But for completely accurate readings and the detection of any variation, even slight, in color, it is essential that the product be compared against the original colors under light of exactly the same intensity and spectral composition.

Daylight can vary sharply from artificial light. It is essential for the characteristics of the viewing light to be completely standardised so that matches made on one occasion can be compared accurately with those on another.

An international organisation concerned with light and color measurement, the Commission Internationale de l'Eclairage (C.I.E.), has specified a number of standard illuminants for various purposes. Two of these, for example, are lighting that will simulate clear overhead daylight and another that gives horizon daylight. Colored telephone mouldings are sampled in these lights regularly as they come from the factories.

Munsell cards

Munsell standard color cards are used for obtaining visual color matches. A necessary condition of visual matching, of course, is that all operators must be tested and found to have no color vision defects.

These cards have a central square of colored material which the object under test should match. There are also surrounding squares of closely similar color. If the object differs from the color of the central square, it is not acceptable if it is also different from any of the surrounding ones, which are the maximum permitted limits in the major color attributes.

They must also match under different lighting, because two surfaces which match under one type of lighting might not also match under another. This phenomenon is called metamerism.

An instrument called a colormeter is also used to compare the diffusely reflected light from the surface being measured with the light from a standard white, freshly painted magnesium oxide surface. Separate readings are made for three colors of incident light, the illuminants being produced by passing the light from an incandescent lamp of carefully regulated color temperature through an appropriate C.I.E. standard filter.

A photo-electric cell is used to determine the intensity of the reflected light.

For each surface, three readings are obtained which, because the C.I.E. filters have been carefully chosen for the purpose, can be used accurately to specify the color by numerical values. This instrument can be operated by a color-blind person as well as one with normal vision.

In these ways, any drift away from carefully controlled color standards is scientifically detected and measured.

Stress areas

Other similarly scientific tests are continually being made to determine the stresses and the special stress areas in materials which take mechanical loads in Post Office equipment.

Plastic and metal parts in telephone dialling systems, for instance, are regularly tested for acute stress points, using a source of polarised white light shining from behind while the mechanism is viewed from the front through a polarised light analyser.

This analyser does not transmit light which is polarised in the same plane as the light emitted by the source. So, if any rotation of the plane of polarisation occurs between the source and the analyser the area in which this occurs in the equipment being tested will transmit some light and the stress distribution becomes apparent.

It is known that some mechanical stress causes rotation of the plane of polarisation and so the brighter a given area of equipment appears the greater the stress at that point.

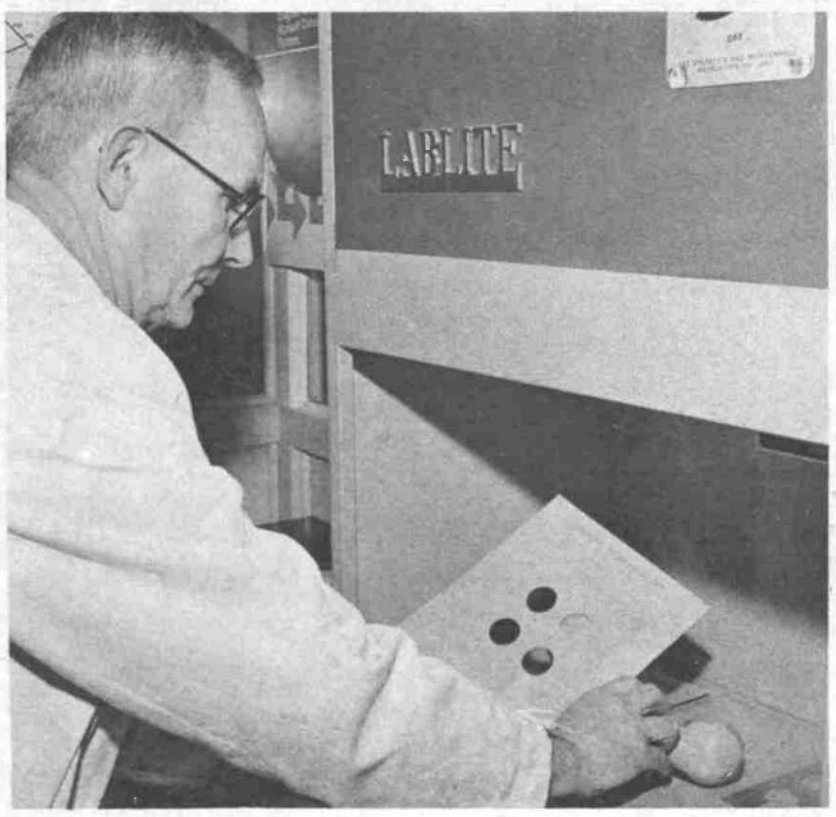
Photometry tests

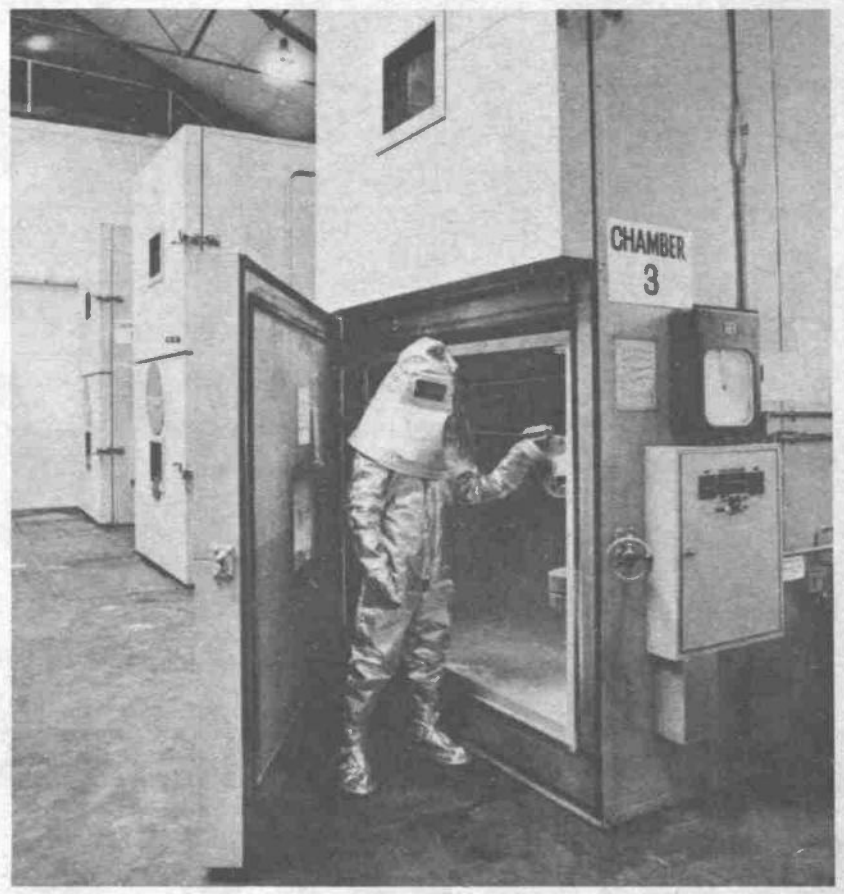
In the same laboratory, photometry tests are made on lamps as they arrive from the manufacturer. This is done with a photometric integrating sphere and photometric integrating cubes, with the lamps tested on racks at different voltages. Optimum brightness and life characteristics of the different brands of lamps are discovered in this way.

In the photometric integrating sphere and cubes, measurements are made of the brightness of the bulbs through as much as possible of the light being made to fall on a photo-electric cell. Then the voltage output of the photo-electric cell gives an accurate indication of the brightness of the lamp, since the sphere or cube has been previously calibrated with special standard lamps.

By methods like these, all equipment supplied to the Post Office is thoroughly checked and regularly tested to ensure maximum standards of quality and efficiency.

In order to maintain uniform standards of color and quality in the A.P.O.'s mass-produced equipment, this technician is checking color consistency in telephone receivers.





Environmental Chamber No. 3 tests equipment, clothing, etc., at temperatures as low as–40°C. Special protective clothing must be worn by operators.

All in One Laboratory

TESTS FROM SNOW TO THE TROPICS

Australian weather conditions vary widely: from humid, tropic heat in North Queensland to chill snow temperatures in Tasmania and searing dry heat with intense cold changes on the Nullarbor.

Since Post Office equipment must often withstand a variety of these environmental weather conditions, a series of special test chambers has been established at the North Carlton laboratories and operates under the Environmental Physics Division of the Post Office Laboratories.

Here all kinds of Post Office equipment are tested, often under accelerated conditions so that results may be observed more quickly. Cables, telephones, connectors, plastic equipment and even the clothing worn by Post Office staffs are given environmental tests to determine their ability to withstand extremes and variants of temperature and atmosphere that they will face in the field.

Aluminium that might be used for new telephone boxes is first, here, subjected to extremes of heat and cold, humidity and dryness. Some telephone subscribers in the tropics have complained that their particular atmosphere causes premature corrosion and breakdown in some of the metal parts of their telephone equipment. To find out if this is so — or whether some other factor is responsible — the particular parts are subjected to intensive tests in the laboratories' weather chambers and carefully examined during tests lasting several months.

Here, too, are tested even different kinds of floor polishes used in Post Office premises. And the brushes and mops used to spread them. Materials and equipment are tested to see if their color fades under strong light. Plastic cabling is exposed to extremes of heat and cold to see how efficiently it withstands them.

Atmospheric extremes

These environmental tests are made in six specially designed and constructed chambers. In the first one, damp heat tests are done in temperatures kept constantly between 53 and 57 degrees centigrade with humidity at least 95%. This simulates the damp heat conditions that equipment faces in the tropics.

Chamber number two operates at temperatures between minus 11 and 93 degrees Centigrade, with humidity ranging from 11% to 100%. This provides tests for the endurance qualities of materials used out of doors in extremes of atmospheric conditions — for instance, wooden laminate used in telephone boxes.

In the third chamber temperatures can be dropped to minus 40 degrees Centigrade. Here large banks of lamps, heaters, batteries, engines and generators are test-subjected to prolonged operations under conditions in which they never reach their optimum operating temperatures. Protective clothing for Post Office employees is also tested in this chamber and in the fourth, where the temperature is set at 90 degrees Centigrade with 20% relative humidity.

In chamber number five, a Weather-ometer simulates the effects of sunlight and periodical rain in temperatures that give a full range of environmental weather factors. Water sprays provide rain as required in set volumes and cycles. Temperatures are taken as high as 100 degrees Centigrade while tests are made on such things as painted and plastic goods used in Post Office work.

Chamber six operates as a constant temperature enclosure at 70 degrees Centigrade to test such things as the long term effect of air pressure on cable sheaths in this environment.

DO IT BY COMPUTER

A computer service has been established to help Post Office research.

At the Computer Centre in the Flinders Lane Laboratories, a C.D.A. 160-A digital computer allows quick access to information and data under review. It helps in the untangling of engineering and scientific problems, makes tests of algorithms and programs which are to be run later on larger computers and serves as a control for other hardware during experiments.

In 1963 the centre began with a central processor and paper tape peripheral equipment. Soon afterwards, a printer and magnetic tape units were added. In 1968 an auxiliary memory unit was also purchased.

Now, as well as the central processor, surrounding it are two memory banks, an auxiliary memory unit with two additional banks, a paper tape reader and punch, a peripheral controller and two magnetic tape units, a line printer and a digital plotter.

Each memory bank contains 4096 12-bit words with a cycle time of 6.4 microseconds. Air conditioning controls the centre's temperature and humidity.

Staffing the Computer Centre are two programmers, a computer operator, two paper tape punch operators and a clerical assistant. The programming staff assists users with their programs, writes general purpose library programs and develops and maintains software.

When a program is received it is recorded in a register and then sent to the computer room. After the program has been run, the output is checked by a programmer. Any minor errors that are easily located are corrected and the program re-run.

Because the centre operates usually in a scientific or engineering environment, much of the programming effort is towards developing short-lived programs. A large percentage of the computer time is therefore used for program testing. Some recent programs included simulation of a PABX and the effect of a filter on a specific wave form. A program which approximated a function by a sum of Laguerre functions was also tested on the computer before later running on a larger machine.

A comprehensive library of standard programs has now been established. It contains programs to perform statistical analyses, mathematical manipulations — such as the solution of equations and complex arithmetic — and general utility programs.

Experiments have also been conducted in using the computer to control a model telephone exchange. A program in the computer analysed the digits as they were dialled, then directed the switching equipment to connect the call. Subroutines were available to connect the ring tone, determine when the called party answered, detect excessive dialling and do other functions.

In other work the computer has been used as a link in a computer-to-computer hook-up. This link was made through the ATS-1 satellite, which is used for applied technology experiments.

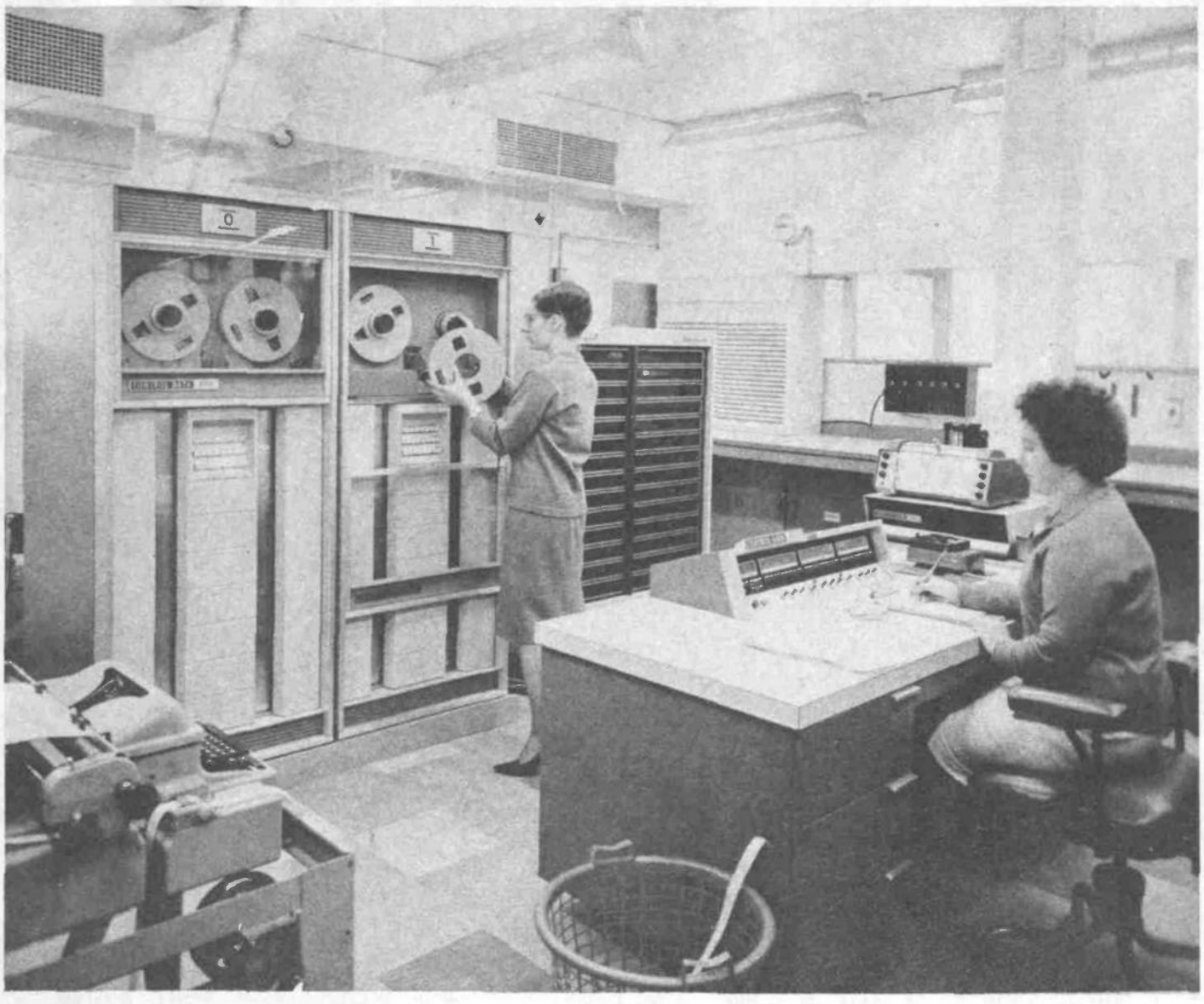
America's National Aeronautics and Space Administration (NASA) was a co-sponsor of the experiment and it was done with the assistance of Control Data (Aust.) Pty. Ltd., who supplied the 'distant' computer which was in their building in St. Kilda Rd., Melbourne.

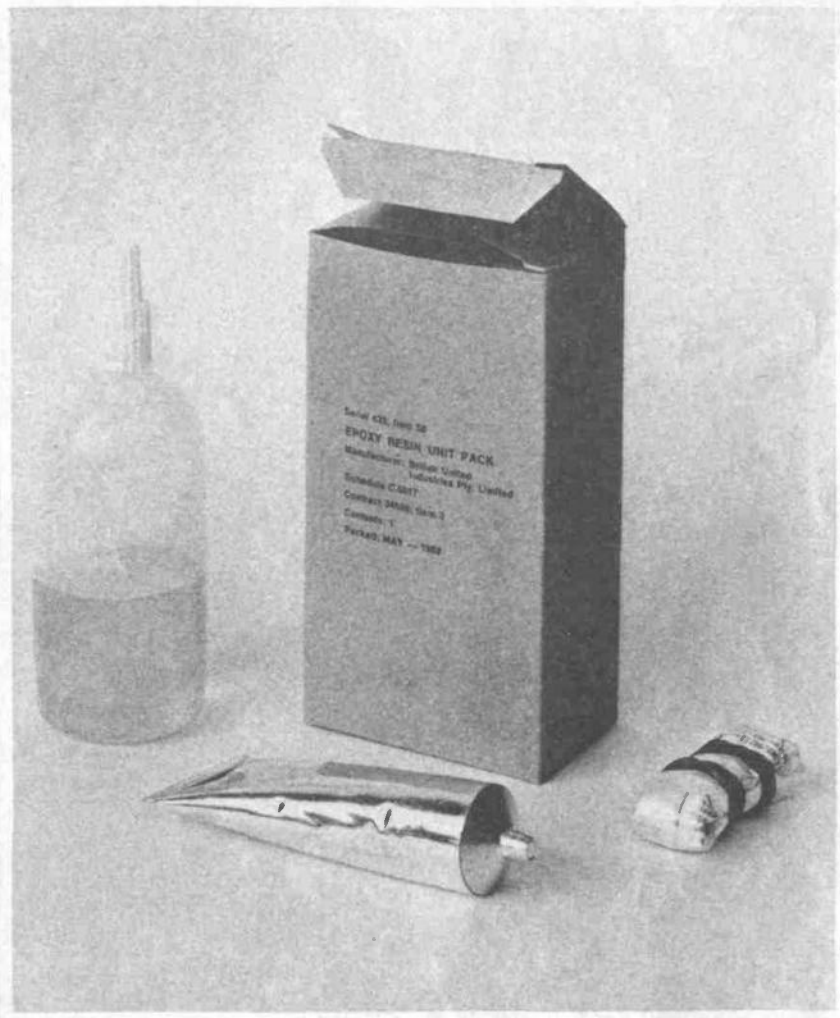
In this experiment, one computer was able to interrogate its partner automatically and ask it to do specified tasks. Subroutines allowed the computers to transfer data which was either stored on magnetic tape or printed on the line printer and to subdivide the data into blocks and transmit a test pattern to determine errors which were deliberately introduced during the transmission.

A transmission path of 50,000 miles was established through the satellite.

Speed of transmission was 1200 bits a second.

Through its Computer Centre, the Post Office is keeping up with one of the latest developments in technology. Recent experiments only start to suggest the computer's speed and efficiency.





More than one million easy-to-use Epoxy resin field packs are used annually in Australia, greatly simplifying cable jointing operations.

Epoxy resin pack design

Epoxy resin — one of the newer type thermosetting plastics which cure to hard, irreversible material — plays an important and widespread role in Post Office engineering operations.

Often they must be used in on-the-spot emergencies, although frequently in routine operations it is simpler and more economical to take the resin to the scene of where it is required rather than take the equipment needing resin to the workshop or laboratory for application.

To meet both types of demand, Post Office researchers devised their own original Epoxy Resin Unit Pack which enables the resin to be applied quickly and simply by field staff in the course of their work away from the workshop.

Epoxy resins are favored over all other types of casting resins because they combine a unique blending of special properties. These include low viscosity, low shrinkage, high adhesive strength, good mechanical and electrical endurance and good chemical resistance.

Epoxy resins are therefore ideal for use in cable terminal strips, as gas dams in cable and pothead chambers, as non-skid surface coatings for pit-lid and manhole covers, to waterproof joints in underground plastic sheathed cables — as well as many other tasks.

But most epoxy resin is used in the making of joints in plastic sheathed cables which were introduced by the Post Office in 1956. For easiest use of the resin, a pack was designed to provide a non-contact method of mixing and dispensing pre-measured quantities of resin in the field.

After first donning gloves provided, the operator injects the required amount of resin into a small plastic bottle, kneads the resin in the bottle by hand and then pours the mixed compound into the mould where it is required.

Each year almost one million of these packs are used by Post Office field staff in cable jointing operations alone. The packs cost about $500,000 annually, but their use has resulted in considerable savings.

A PROBLEM SOLVED: BY TIP-WELDING

Post Office research engineers recently evolved a new and more effective method of fusing the tips of twisted joints in copper and aluminium conductors.

IT IS KNOWN AS TIP WELDING.

Large telecommunications systems relying on physical interconnection of their component parts require a very large number of joints. In Australia's continually expanding system, millions of these joints must be made annually, some times in remote areas and under difficult outdoor conditions.

For reliably high standard yet low maintenance service, these joints must have low stable resistance. And this must not be degraded by the environment in which they are used, because they must have a life expectancy at least as long as the equipment interconnected by them. It is also desirable that the cost of each joint be as low as possible, that they be made with simple and inexpensive tools and with a minimum of time, effort and operator's skill.

Over the years several methods have been used to make these joints: stripping the conductors of insulation and then merely twisting them together, twisting and soldering, using various types of connector, or resistance arc welding.

But tip-welding, as now introduced by the Post Office, is an improved version of arc welding of the conductors' tips because it does not depend on electrical resistance at the junction between the workpiece and an electrode to initiate the welding process.

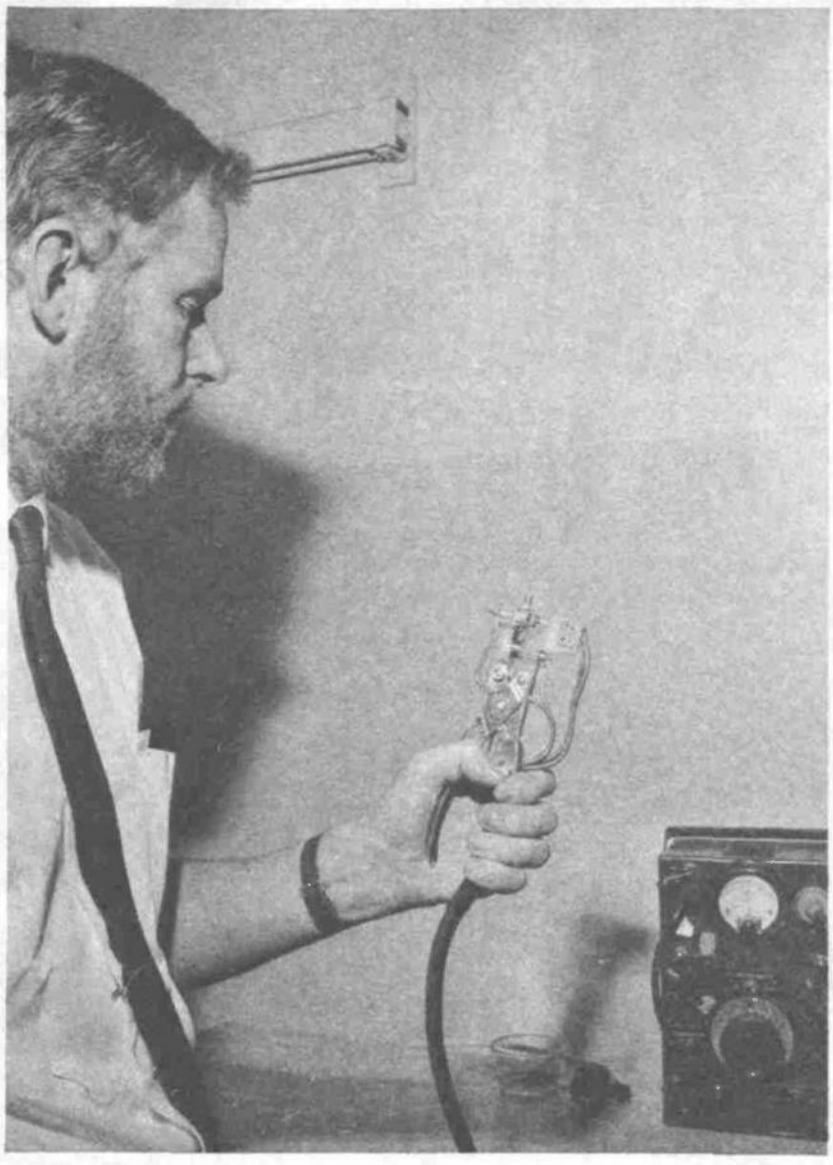
It simply involves placing the already twisted conductor into a specially designed tool which is held in the operator's hand and looks rather like an elaborate pair of hand pliers. It is connected to a 36 volt battery which provides power for the split second welding operation.

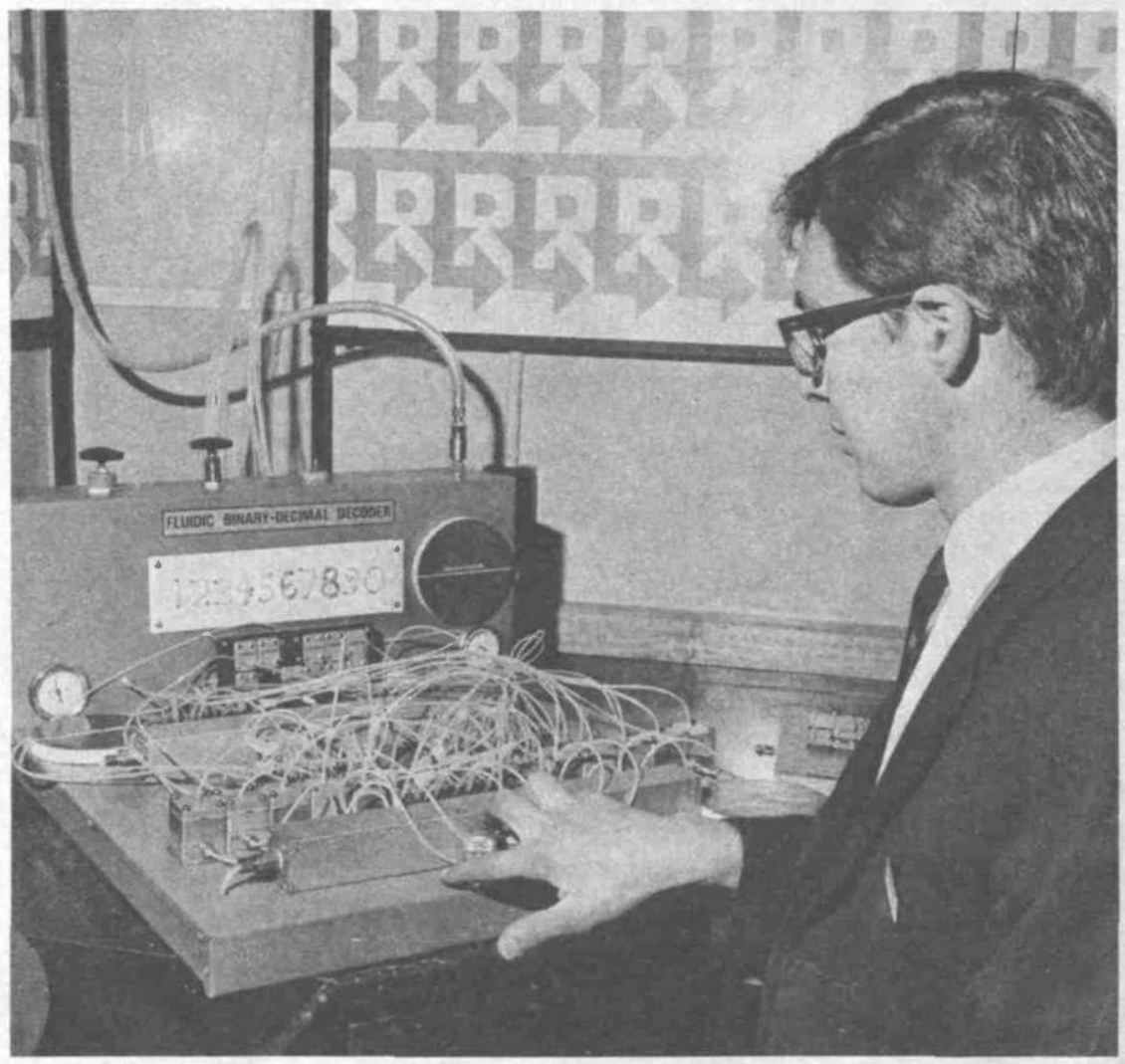
In the tool, the conductor is held automatically a set distance from a metallic electrode. Now the end of the conductor becomes the second electrode and the gap between the two is bridged by a short duration high voltage discharge, triggered by a switch on the tool. This discharge is then maintained by a low voltage, low impedence source — from the battery — until the conductors melt, becoming welded together.

Hundreds of conductors tip-welded in this way have been subjected to intense and accelerated aging tests. And in every case the resistance of the joints, before and after testing, was lower than the resistance of an equal length of conductor. Advantages of tip-welding like this are that no great skill is required of operators . . . higher quality, more uniform welds are achieved . . . greater speed of operation . . . no visual inspection of the weld is necessary . . . less energy is consumed . . . less later maintenance is required.

This is only one of many break-through adaptations of new ideas that have been initiated by Australian Post Office research engineers.

An operator demonstrates the new tip-welding device which will shortly be used in Australia's fast growing telecommunications systems.





The potential of fluidics has hardly been realized — just one example is a Fluidic Binary-Decimal Decoder.

FLUIDICS: NEW AND SO FASCINATING

Fluidics is the technology of using small jets of air, liquid or gas at low pressure as a highly efficient way to propel light items or goods, to operate a digital enumerating system or to control more powerful systems.

It can be channels of forced air being used to carry mail items during the sorting process. Or tiny streams of colored liquid in transparent tubes that form a digital system that gives reference calculations according to the placement of the liquid in the system of digits.

Studies into the possibilities of fluidics represent a comparatively new research field. In 1959 its industrial potential was first recognised, when engineers at the Harry Diamond Laboratories, in Washington, D.C., published details of work they had been doing with it in wall attachment devices and the turbulence amplifier.

Post Office researchers are currently investigating two methods with fluidics: currents of air and the force flow of colored liquids.

Directed flows of air currents are being studied as perhaps a new way of propelling mail instead of by conveyors. This is being studied as being perhaps most helpful as a logical system for checking and correctly re-directing items of mail that have been missorted.

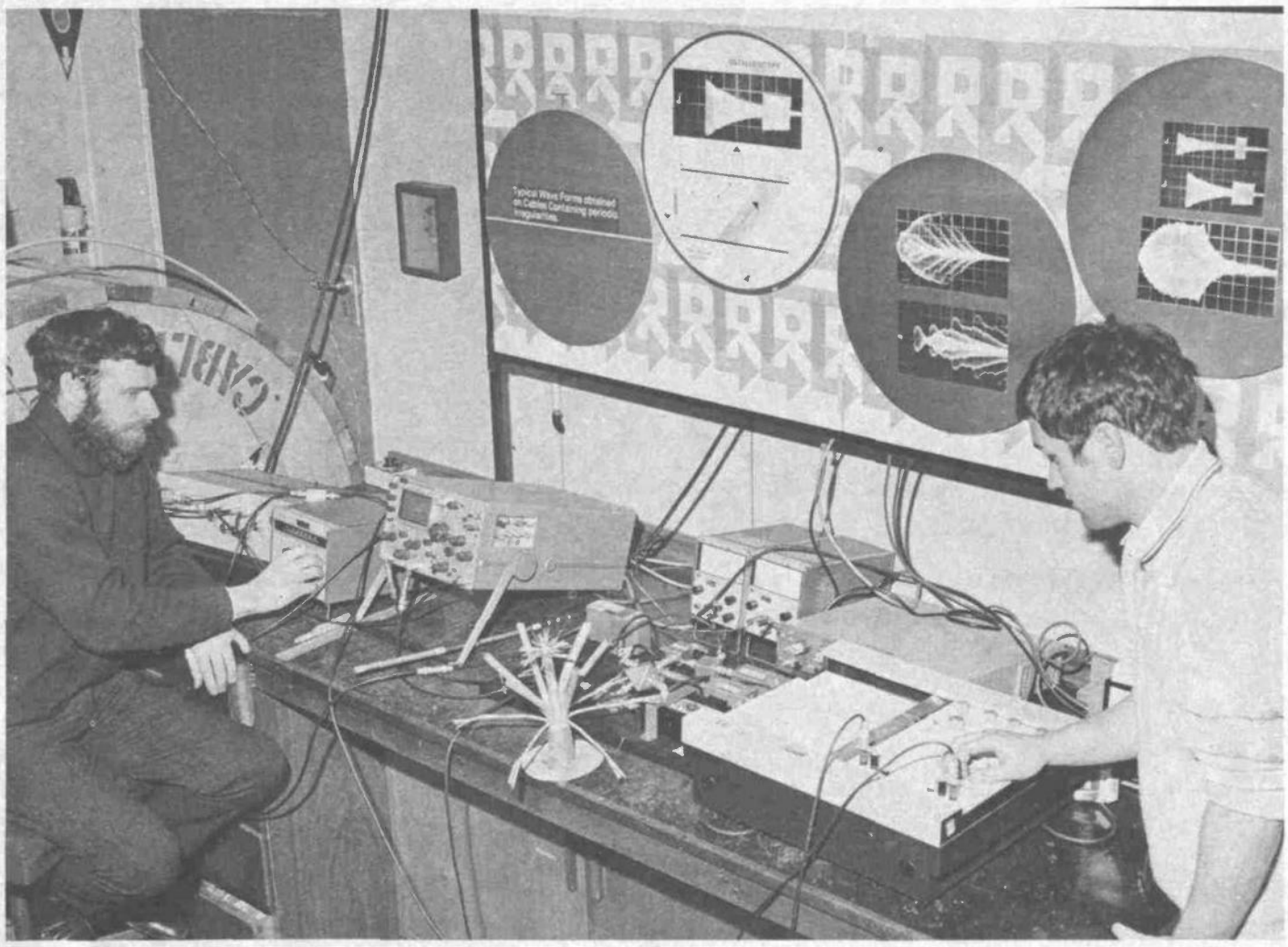
Swift currents of air, properly aimed and channelled along closed passages through which mail goes, could one day be used to re-direct mail items quickly and efficiently with minimum personal supervision.

In the past 10 years, digital circuit design has reached a stage where devices performing all digital functions have been built. In a typical case, into a system of transparent linked numerals is placed a sufficient quantity of colored liquid. As required for whatever job is at hand, the liquid can be forced to flow into the necessary numerals to provide an efficient method of counting or numeral checking. Again, it could be used to provide tallies of mail items, vehicles, mail loads or whatever has to be counted.

Systems like these are especially valuable when used in an environment involving explosives because they are entirely safe. Fluidics is becoming increasingly competitive with electronic devices and fluid-operated devices incorporating spool valves are now used to perform similar functions.

Among the many virtues of fluidics, it is a system that can operate at extremely high temperatures, is tolerant of any atmosphere and is unaffected by nuclear radiation, heavy vibration or shock. It also has the benefits of being small with no moving parts, can be supplied from any fluid source, need no electrical power and is not affected by radio or electrical interference.

Researchers are confident that the next decade will see vast expansions in this so-simple yet so-little explored area of modern science. Answers to many problems depend on a fuller understanding of the flow and adhesive properties of the elements dealt with and the utilization of the most efficient methods for the work required.



Coaxial cables are tested by the Post Office Laboratories, to minimize the possibility of imperfection or poor quality before being laid underground.

ALL CLEAR ON THE CO-AX

Coaxial cables, buried underground and linking major population centres, are playing an increasingly important role in Australia's communications. They carry not only television programs, the job they are most publicised for doing, but also a large proportion of interstate and trunk telephone calls as well as computer data for firms.

These cables, themselves intricate pieces of engineering, straddle the continent for thousands of miles and must undergo continuous testing to ensure that the television programs they carry come through clearly, that telephone voice levels remain constant and that the data flowing through them arrives accurately and without interruption. Ensuring all this means the maintenance of acutely constant standards of equipment in their complex construction. A variable in, say, copper content from different suppliers could result in distortion, or even interruption of the even, regular flow of the work they do.

Making tests to find any irregularity or flaw in a cable once it is laid underground can, naturally, be an involved and highly expensive task. To circumvent that having to be done, the Post Office now makes its own meticulous checks of cables while they are still on the drum delivered by the suppliers. By doing this, research engineers ensure that the quality is always perfect and that no hitch or breakdown is likely to occur after the cable is laid underground.

Even microscopically small irregularities in the complex cable can result in a cumulative reaction of disturbance in the cable's transmission performance. In the past two decades, considerable effort has gone into perfecting techniques to test production lengths of cables by two different procedures.

One is the transient or pulse method, where a backscatter of short pulses is observed on an oscilloscope. The other involves measuring the input of the voltage standing wave ratio of a length of cable by what is known as the Carrier Wave technique. Generally speaking, the combination of these two methods has given satisfactory test procedures for systems using most of the high frequencies that are carried in the cables.

But as the upper frequency of transmission is increased, there is the possibility of small systematic or periodic irregularities causing disturbance to transmission performance in certain resonant frequency bands. At some very high frequencies, the simple echo test might not be sufficiently sensitive when systematic irregularities are of the same order of magnitude as small defects distributed at random.

To meet this possibility, Post Office engineers now use both methods in conjunction, at the same time closely observing the backscatter of long Carrier Wave burst signals. Irregularities will cause part of the signal to be scattered back towards the transmitter.

Generating a burst signal requires only a gated amplifier in addition to a Carrier Wave generator and a variable pulse source. In this way short lengths of cable can be tested, sections small enough be held in the hand or the large lengths that are supplied by the manufacturer wound around a circular drum.

In addition, sections of the contents are individually sealed in epoxy packs and, as well, a dessicant is added to ensure finally that any moisture coming into the casing is quickly dried up.

In these ways every precaution is taken to isolate the equipment from exterior interferences that could cause damage or corrosion that would lead to faults and possible breakdowns.

Since these repeaters and the cable links they boost are established above ground, however, they do not encounter the difficulties that engineers have been having with the temperature differences affecting similar below-ground equipment.

This transistorised 12-channel repeater, one of many on the Adelaide-Darwin route, has given five years of trouble-free service and is opened for routine checks and inspection.

A Question of Repeaters

Long distance cable communications depend not only on the abilities of the cable links, but also on the efficiency and durability of the repeaters which are spaced out at regular distances along long distance routes as regular boosters of the power carried in the cables.

Some repeaters, as on the long above-ground link between Adelaide and Darwin and Darwin and North West Cape, are mounted on poles along the route. Others, as in the case of the main coaxial cable routes, are buried in underground manholes.

A problem cropped up in 1969 with the repeaters on the Perth-Carnarvon coaxial link. These repeaters were not showing a sufficiently similar rate of change of temperature with time to the buried cable to which they are attached.

This lack of similarity is undesirable because the amplification of the repeater and the attenuation of the cable are each functions of temperature. Systems like these can operate over quite a large range of absolute temperature and a considerable difference between the cable temperature and the repeater temperature can be tolerated, but this difference must not change by more than 1.6K and greater changes were noted on the Perth-Carnarvon link.

It was believed that the fitting of insulation to the underside of the manhole ceiling and the steel lid might reduce the rate of diurnal temperature increase and decrease — and also cause the manhole temperature environment to follow the cable temperature more closely. To discover the effectiveness of insulation like this, one of two manholes 30 kilometres north of Perth was fitted with a 75 mm thick layer of polystyrene foam under the ceiling and lid. The other manhole was left uninsulated.

The repeater housings connected to the cable were left in their normal positions on a platform 630 mm above floor level. But for trial purposes an additional repeater, identical in construction, was placed on the floor of each manhole.

Temperature sensors placed at various points inside the manhole and in the soil beside and above the cable were established to give temperature readings over long periods on a 12-channel recorder. It is believed, too, that types of soil and the physical setting have certain effects on the thermal behavior of the manholes. These aspects are also under current investigation.

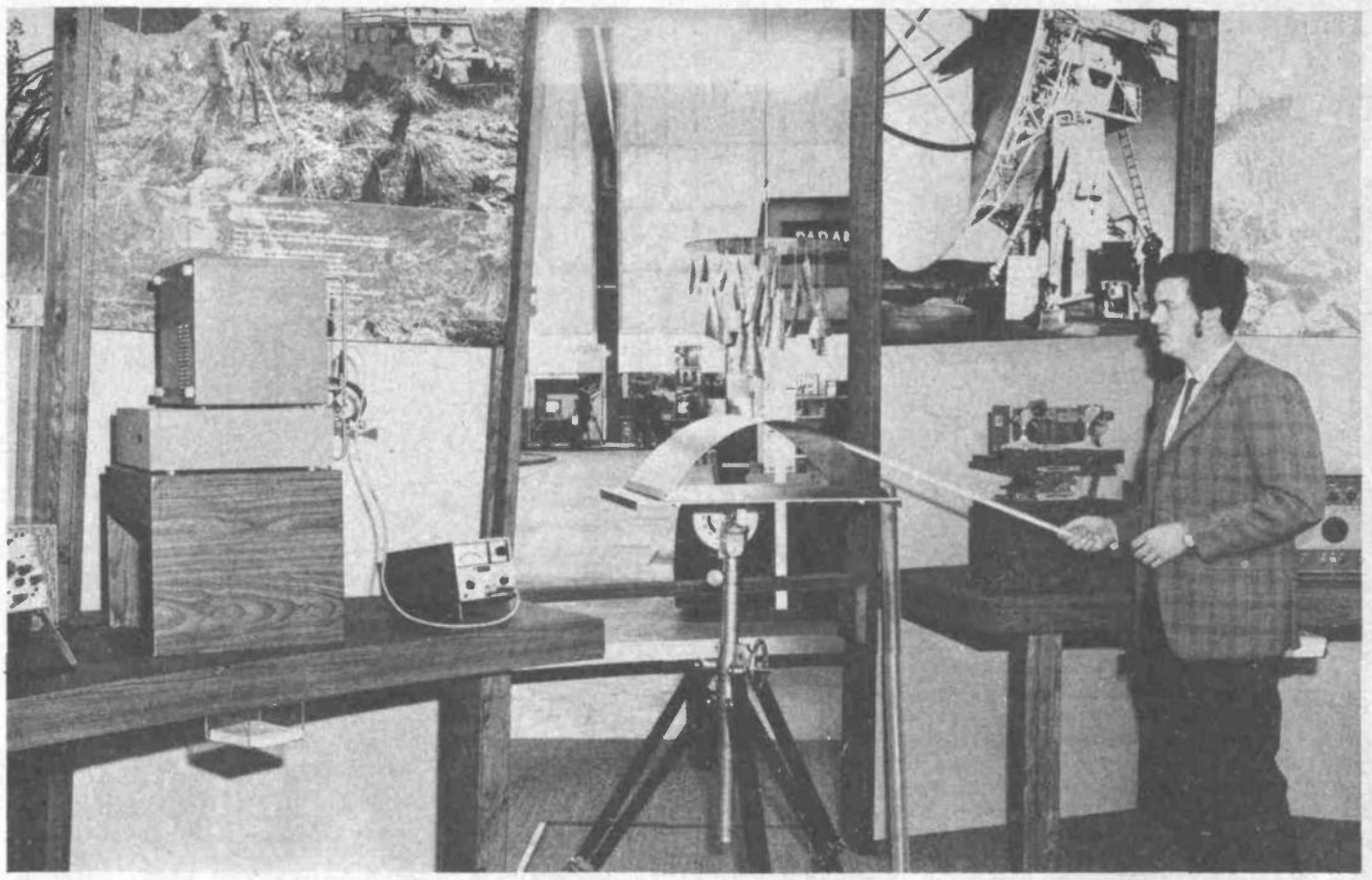
But no problems like that have occurred with the 12-channel repeaters mounted on poles above ground on routes like the Adelaide-Darwin one. These repeaters were designed and built by Post Office Research Laboratories staffs, with Australian conditions specifically in mind.

Special durability is demanded of them since they must be exposed for periods of five years or longer to all the variations in temperature, atmosphere and weather that occur along these lonely routes.

They are mounted in protective shaded boxes which give exterior protection from direct sunlight, rain and dust storms. Since any moisture could corrode their contents, the repeater casings, made of an aluminium alloy, are gas pressurised before sealing.

KEEPING RADIO COMMUNICATION PATHS CLEAR

Increasingly the Post Office is using broadband microwave radio systems to carry heavy telephone traffic as well as television programs over long distances throughout Australia. These systems are continually taking over from overhead wiring and underground coaxial cabling to carry this traffic.



An A.P.O. Researcher demonstrating the effect of obstructions in the radio path between two horn antennas.

Before new long distance links are established, experimental equipment is installed to make initial tests and predict the type of reception that can be expected.

One of the major considerations revolves around the variation in reception known as 'fading'. This is a diminution in the quality and strength of messages carried, even to the end extent of a complete cut-out in reception.

Now, as a result of intense research into advance predicting, studies of the type of terrain to be covered and the atmospheric conditions that will be encountered, are always made before new links are established.

Basic problems

By 1920 mathematical physicists had solved the basic problems of calculating the strength of signals received from a radio transmitter over most types of path and equipment locations. But these researches covered basics only. They did not encompass the vast range of signal variations which occur from time to time in the many given situations that arise in practical application.

Variations occur on all optical radio wave paths, even seemingly quite clear ones in the relatively short range of 20 to 100 miles. System manufacturers now offer equipment capable of giving satisfactory performance that is sufficient to combat reasonable amounts of normal fading. And because of this, operational fading is now rare where equipment operates in temperate zone conditions and over terrain of not more than reasonable roughness for reasonable distances of, say, 35 miles.

But in Australia radio communications are often necessary over longer distances and often over terrain of unusual configuration. Other factors that must be studied include paths over areas of water, repeater points differing widely in height and areas subject to unusual weather conditions. These could be wide temperature variations as well as consistent extremes of heat, cold, humidity or dryness. Fading can be caused by all of these things — even to the meteorological structure of the lower atmosphere: heavy cloud formations, intense rain or thick fog.

To provide a firm basis for engineering assessment and design able to withstand circumstances and hazards such as these, the fade performance must be studied minutely and defined statistically by field measurement.

Field measurement

At present, 'narrow band' equipment is used for most field measurements, defining only the single-frequency performance of the path. But for paths carrying a system of 600 to 960 telephone channels or a television relay, these measurements normally give adequate definition of path performance. As telephone channel capacities rise to 1800 and even 2700 in each radio system, however, there is an increasing risk that many fade conditions will cause marked signal distortion.

Work is at present being directed towards 'broadband' measurement techniques which will provide definition both of amplitude variations of the received signal and of transient variations during fading.

Among the improvements in techniques being studied is the use of digital — magnetic tape — recording on site, which offers direct computer processing of field records and the provision of low power-drain radio equipment of increased reliability. These units are being developed in the Radio Equipment Division of the Post Office Research Laboratories.

By the advance study of the physical paths in a region and the meteorological systems likely to apply, it is possible to predict which paths will have a high risk of serious fading — and where the risk is greatest, as well as why. Indeed, most paths chosen for tests have revealed problems requiring remedial measures.

East-West system

On the East-West microwave system from the Eastern States to Western Australia, for instance, the Ivy Tanks area in South Australia was assessed, from regional factors alone, as offering considerable propagation hazards. Median signal levels at times were so depressed, i.e. low in value, that they would have been a serious embarrassment to the intended system. After a study by the Propagation Research Division, in which this propagation problem was related to the meteorological and physical characteristics of the area, the system was rerouted nearer the coast. Later measurements confirmed the anticipated benefits of this move.

Townsville-Mt. Isa

Similarly, when advance studies were made of the Townsville-Mt. Isa microwave link in Queensland, adverse propagation conditions were predicted in the Julia Creek area because of topographical factors and regional meteorological records. Serious depressions of the median signal level were observed on the test path and an investigation was begun to define possible remedies.

Propagation-measuring equipment is required to operate unattended and in remote locations along the proposed routes of these radio links. It must have considerable stability and reliability in performance so that it can yield an accurate record of propagation variations on the path — also a record not contaminated by equipment malfunctions.

Earlier types of microwave-link equipment did not in themselves offer adequate level stability for use in such precision measurements. To achieve reasonable accuracy in microwave propagation investigations, it was necessary for the Post Office laboratories to develop special measuring equipment. As well as giving general improvements in performance, this equipment includes features and ancillary units which facilitate the overall calibration of transmitter and receiver installations so that absolute values of path attenuation may be determined.

One development was an all-valve piece of equipment which requires a 230 volt supply and relies on thermostatic control of the ambient temperature within its case to maintain level and frequency stability. Another more modern unit again is a solid state, low power-drain item of equipment which is crystal controlled and designed to operate over a wide range of temperatures without local ambient control.

Test paths

Measurements on test paths are usually conducted for periods of 15 months to enable seasonal trends and the 'worst months' to be defined. Statistics derived from the recordings are then used by the Post Office Central Office Radio Section in the design of the final microwave system.

Normal fixed antenna-height recordings are taken continuously of field-strength versus time. Separate receivers are used to record, on a multiple channel recorder, field strength levels for different fixed antenna heights and different frequencies.

It is necessary to check the records carefully so that the causes of fading or variations may be traced and then eliminated. But not all fade causes have been traced back to regularly recognisable phenomena. Some fading, for instance, has been found to be due to a slight water leakage into feeders. And one case was even discovered to have been caused by ladybirds multiplying in a waveguide.

Experimental Antenna Tower on the East-West Microwave Route.