Volume 26 No. 2, 1976

the telecommunication journal of Australia

IN THIS ISSUE

26/2

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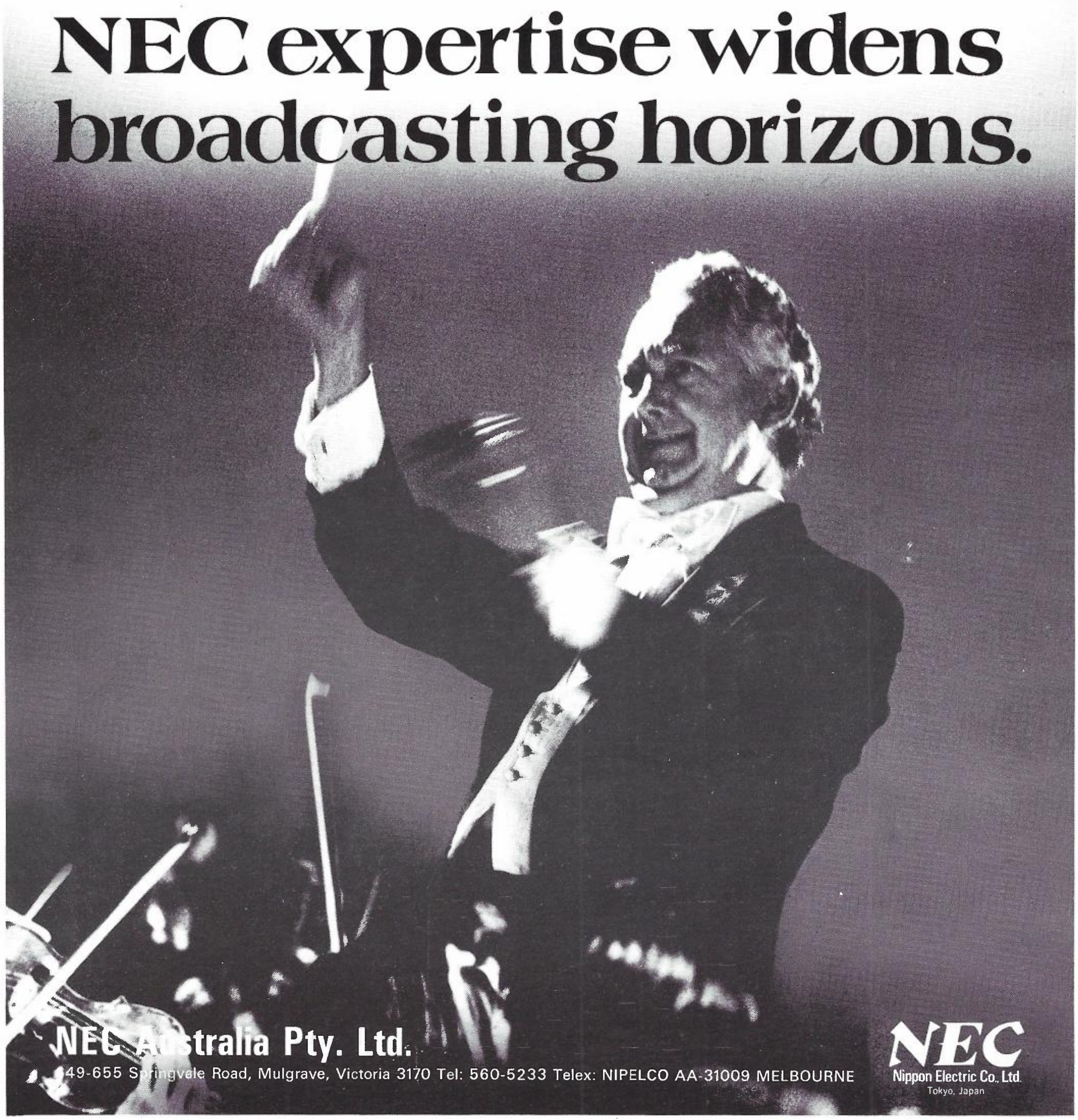

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

VOL. 26. No. 2. 1976

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COVER
ALEXANDER GRAHAM BELL

The Telecommunication Journal of Australia

The Journal is issued three times a year (February, June and October) by the Telecommunication Society of Australia. The object of the Society is to promote the diffusion of knowledge of the telecommunications, broadcasting and television services of Australia by means of lectures, discussions, publication of the Telecommunication Journal of Australia and Australian Telecommunication Research, and by any other means.

The Journal is not an official journal of the Australian Telecommunications Commission. The Commission and the Board of Editors are not responsible for statements made or opinions expressed by authors.

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1876-1976: A Century of Telephony

S. E. WEAL

The early history of the invention of the telephone is well documented in the literature. This article is presented to celebrate the centenary of the invention of the telephone by Alexander Graham Bell and brings together a few of the more interesting facets of the beginnings of telephony, with some reference to the introduction of telephony in Australia.

INTRODUCTION

"Mr. Watson, come here, I want to see you."

When, on the 10th March, 1876, Alexander Graham Bell said the above, thus transmitting the first complete sentence over the telephone, he opened a new sphere in world communications. Although the reaction at the time was one of amazement, it would seem that Bell had no doubts as to the future of his invention for in 1878 he said:

> "It is conceivable that cables of telephone wires could be laid underground, or suspended overhead, communicating by branch wires with private dwellings, country houses, shops, manufactories, etc., uniting them through the main cable with a central office where the wires could be connected as desired, establishing direct communication between any two places in the city. Such a plan as this, though impracticable at the present moment, will, I firmly believe, be the outcome of the introduction of the telephone to the public. Not only so, but I believe, in the future, wires will unite the head offices of the Telephone Company in different cities, and a man in one part of the country may communicate by word of mouth with another in a distant place."

EARLY HISTORY

For several years, the concept of electrical transmission of sound had interested men such as Hooke, Wheatstone, Page, Bourseul and Reis.

These men made several attempts at transmitting sounds over wires. Some of these attempts were successful but all failed to transmit speech. It was

Fig. 1—Bell and Watson on 10th March, 1876.

not until 10 march, 1876, that the successful transmission of speech was achieved by Alexander Graham Bell.

In 1872, Bell began experimenting in what he termed the field of multiple telegraphy. Bell's early experiments involved a series of tuning forks which were used as transmitting forks and receiving forks. Each transmitting fork had a corresponding receiving fork of equal pitch. A single wire connected the transmitting and receiving forks and the manipulation of a series of keys at the transmitting end produced simultaneously a series of musical signals in each of the receiving forks.

Subsequent experiments saw the replacement of the tuning forks by metallic reeds. These in turn were replaced by a single diaphragm. Bell theorised that he could induce an undulating current by attaching the end of one magnetised reed to the centre of a diaphragm and causing the latter to vibrate. It was not until 2 June, 1875, that Bell discovered that this principle actually worked. This led to the construction of an instrument called the "Gallows" Telephone. This instrument employed a membrane diaphragm. Bell had been considering the possibilities of a membrane speaking telephone back in 1874 but he remained quiet about his idea.

> "Fearing that ridicule would be attached to the idea of transmitting vocal sounds telephonically, I said little or nothing of this plan."

Months of experimentation followed the construction of the "Gallows" Telephone which culminated in the preparation of a patent specification which was subsequently lodged on 14 February, 1876. This became U.S. Patent No. 174465 of 7th March, 1876. It is interesting to note that another experimenter, E. Gray, filed a similar patent only one or two hours after Bell on 14th February. After subsequent legal action, it was decided that Bell had achieved the invention first. In all, Bell's patent withstood some 600 lawsuits.

The telephone industry in its infancy struggled because of lack of demand and Bell and his partners, Thomas Sanders and Gardiner Hubbard, struggled from one financial crisis to another. At one point of time, the partnership offered to sell Bell's patent to the Western Union Telegraph Company for the sum of $100,000. This offer was rather short sightedly turned down by the President of Western Union who remarked, "What use could this company make of an electrical toy?" However, Bell and his partners persevered and in July 1877 the Bell Telephone Company was born.

EARLY DEVELOPMENTS

Within a few months the telephone had outgrown its humble beginnings. As early as 1877, there existed a telephone switching device at Boston. On 28th January, 1878 — only 21 months after Bell's invention, the world's first commercial exchange was opened at New Haven, Connecticut. Other cities such as New York and Philadelphia quickly followed the trend and acquired similar equipment. Western Union watched the growth of the telephone network with interest and finally stepped into competition with Bell when they saw their printing telegraph plant being replaced by Bell's telephones. They formed the American Speaking Telephone Company and employed as their technical consultant Thomas Alva Edison.

Bell's telephone used the same instrument as transmitter and receiver which had certain pitfalls. It was inconvenient if only one instrument was installed and, although its performance as a receiver was satisfactory, its performance as a transmitter was poor. Edison solved this problem when he invented his carbon button transmitter. It consisted of a metallic diaphragm which rested against a carbon button and consequently any vibration of the diaphragm resulted in a variation of the current flow with a high degree of fidelity. Edison's principle remains unchanged to this day.

The invention of Edison's transmitter gave Western Union a distinct advantage in that they were able to supply superior telephone equipment. Bell discovered, however, that Emile Berliner had been working on a transmitter and had in fact filed a caveat for a transmitter similar to Edison's 13 days before Edison filed his patent. Bell eventually hired Berliner in exchange for the control of his caveat and his inventions. This led to the Bell Telephone

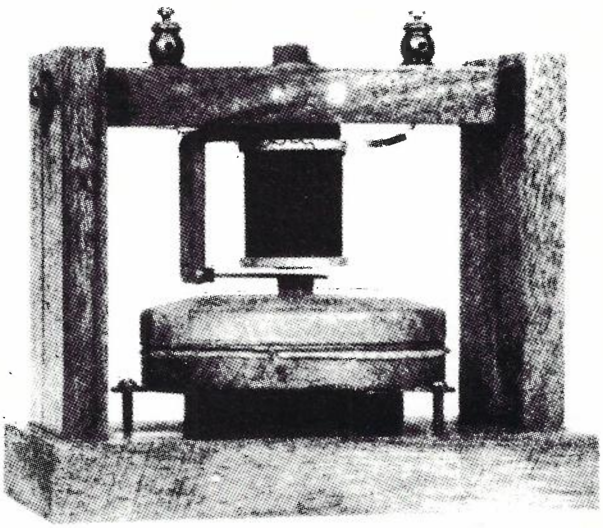


Fig. 2—The Gallows Phone.

Company filing an interference lawsuit against Edison's transmitter which prevented the final issuance of Edison's patent. The result was that the Bell Telephone Company successfully sued Western Union and the American Speaking Telephone Company was absorbed into the American Bell Telephone Company which was formed in April 1880.

Lars Magnus Ericsson of Sweden also became interested in the telephone industry. He not only pursued studies of the transmitter but he set about developing the world's first large scale production of telephone sets . He used his own design of carbon transmitter which was not only smaller but more efficient than others available at the time. Ericsson used a carbon and later a precious-metal film diaphragm. It was Ericsson who, in 1884, invented the handset when he successfully arranged a transmitter and receiver at opposite ends of a 6" piece of broom handle.

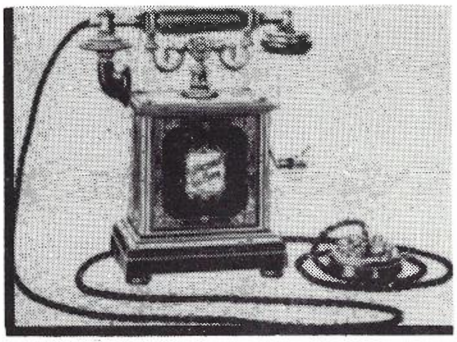
The handset has proven to be one of the major improvements to the telephone instrument. This is best summed up by a letter which was published in "Punch" shortly after the introduction of the handset in Britain and is reproduced here with their kind permission.

> "I have lately become one of those rare and interesting creatures, a Changed Man. You read about them often in novels and advertisements, but you seldom meet them in real life and still seldomer become one. It is, I assure you, an experience worth describing, especially when, as in my case, the change is so emphatically a change for the better.
>
> I do not mean by this that I have just been cured of drink, drugs, stammering, dyspepsia, obesity, inability to play the piano, or any other of the vulgarer vices and misfortunes; in fact, I think that the previous "I" was quite a nice man really and, as men go, happy. Yet somehow I was never what is generally known as successful. My business did not flourish as it should. I was always on the verge of pulling off some big deal, and at the last moment the other fellow always got the better of me. But now, as I have said, I am a Changed Man, and all because a month or so ago I installed in my office an H.C.S.
>
> An H.C.S., or Hand Combination Set, is the technical term for the type of telephone which a benevolent G.P.O. has recently bestowed upon those of us who care to pay a few extra shillings a year. No sooner had I set eyes on one of these instruments in a friend's house than I determined to have one for myself. It was aesthetic considerations that weighed with me most, I admit — I was that sort of man in those days. The sturdy yet elegant contours of its base — oblong, tapering upwards in four restful curves, and then spreading out once more with a generous sweep into a pair of shining black antlers; and, lying horizontally across the antlers, unobtrusive yet ready to serve you at an instant's notice, the handpiece itself, ingeniously shaped for the perfect comfort of your palm, with its two ends drooping gracefully, glossy and black, like the ears of a favourite spaniel; these, I say, were the things that first attracted me. Such a change from the insolent perpendicularity of the ordinary telephone, which stands all day cocking snooks at you with up-tossed head and aggressively-gaping trumpet, like a monstrous caricature of a fossilized and blackened daffodil. . . .
>
> It often happens that if you choose things for purely idealistic and unpractical reasons they turn out to be the best for utilitarian purposes also. (This is a profound and pleasant truth, but it must have been a ghost of the former me that wrote it down, for my present self condemns it as an unbusinesslike digression). Anyway, hardly had the H.C.S. been installed in my office before I embarked upon my adventure of becoming a Changed Man. The explanation of all my previous failures suddenly dawned upon me. The greater part of my business is carried on by telephone, and for years I had been suffering from acute, though undiagnosed, Telephobia; that is, a semi-conscious aversion from telephoning, a feeling of physical discomfort and moral inferiority while doing so. For years, when conducting negotiations, I had leaned forward obsequiously in a conciliatory attitude, one hand uneasily twisted backwards behind my left ear, the other outstretched to grope for pencil and jotting-pad. After several minutes of this I would develop a crick in my neck, an ache in my left wrist, a squint from writing with my eyes two feet to the west of my pen, and a sense of being at a complete disadvantage all round. Small wonder, indeed, that the Other Man won.
>
> What happens now?
>
> "Get me Mr. Hogthorpe of Bunker and Bream's, I say to my secretary, and while she is putting the call through I sit at ease and light a cigar. (I can afford cigars now). In a few seconds — for somehow Hogthorpe does not seem to keep me waiting so long as he used to — there is a discreet buzbuzz. Out goes my left hand — but in a leisurely, gentlemanly fashion, mind you, for the new telephone does not clamour imperiously for attention like the old one: rather, it respectfully invites it, like a well-trained dog who knows his place but would be grateful all the same for a pat on the head. Well, you shall have it, my faithful lop-eared spaniel. I pick up the handpiece. One end of it caresses my ear to a nicety; the other curves gently round and remains suspended at exactly the right distance from my mouth. I cross my legs and lean back in my armchair.
>
> "That you, Hogthorpe?" I say lightly, in my ordinary talking key, for the H.C.S. is so sensitive that there is no need to use the old "telephone voice.'"
>
> "Well, Hogthorpe, I thought you might like to know what my terms are about this Manchester scheme . . . ."
>
> Hogthorpe demurs and argues, pleads and cajoles. I can almost see him leaning anxiously forward, clutching his old-fashioned receiver to his servile ear. As for me, I am adamant. I lean still farther back in my chair, rest my eyes on the tranquil expanses of the ceiling and dictate my own terms. I only wish that Hogthorpe could smell my cigar — but that, no doubt, is a refinement that will come.
>
> "Sorry," I say firmly, "but I'm afraid your people must just take it or leave it."

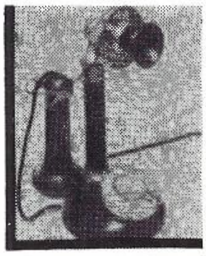
Telephone developments down the decades

Pictured in these pages are some landmark designs in the development of the telephone. Like all technology, the telephone has grown in many small steps through contributions from designers all over the world. Some of those steps are shown here as the telephone developed from an elaborate monster of wood, nickel and brass to the compact efficient instrument we use today.

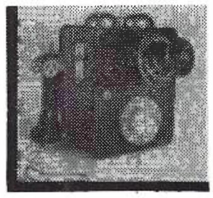
With acknowledgements to Bruce Whitehead Secretary Australian Historic Telephone Society



Beginnings of 20th century utility shows in Ericsson's 1898 magneto table set. It was seldom used in Australia.

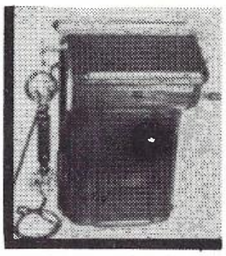


USA can take the credit generally for the perfection of the "candlestick" or "daffodil" telephone. This example is a Stromberg Carlson pedestal telephone of 1915-1920 vintage. The compact base with dial gave rise to the base of the modern phone.

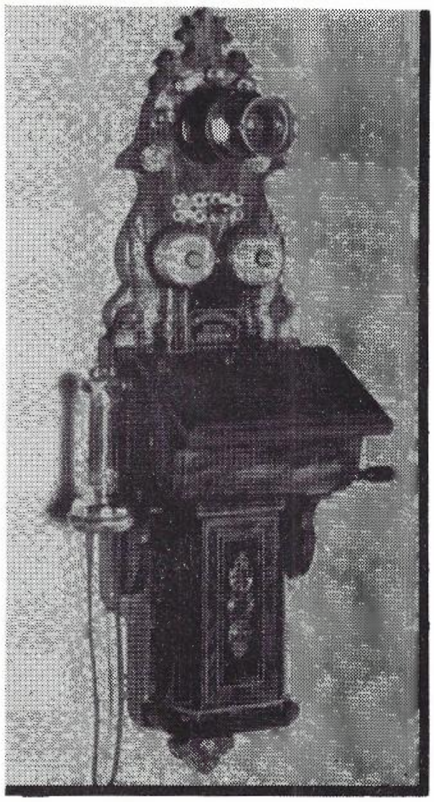


There's usually a wall phone to match each table phone and this instrument matches the Automatic Electric pedestal phone. Both were used in early automatic telephone exchanges in Australia which started with Geelong (Victoria) in 1912.

This American telephone of 1924 illustrates the gradual change in thinking from the candle-stick type of telephone built from 1895 to 1925 to the moulded handset approach.



World War II left Australia without telephone supplies and we rebuilt recovered instruments such as this "tucked" Ericsson. Subscribers regretted the loss of the fancy work but were desperate for a phone. We soon realised we could mass produce telephones.



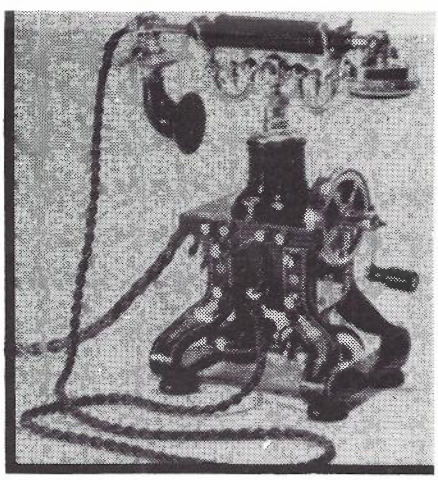
In the beautiful range of L. M. Ericsson wall phones around the 1890's was this Pulpit model. Note the rosette mounting screws. These were not used in public telephones in Australia due to the occasional theft of the plug-in handset! Unfortunately such phones are rare due to preference for the handset model.

L. M. Ericsson (Sweden) really started something with this design in 1932. Many countries followed with their own versions including England and Australia, with our 300 and 400 series. Note unusual dial numbering.

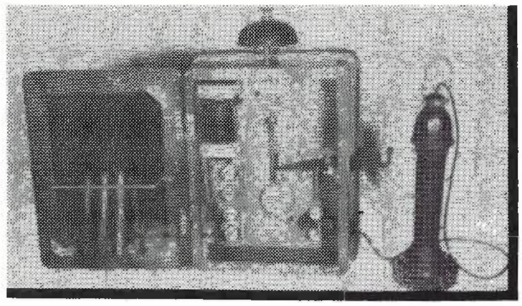
Fig. 3—Telephone Developments

Ericsson placed a box around his open frame model to produce a magneto and later central battery model. Nineteenth century elegance is remembered in perpetuity with the trade mark.

A rather special telephone was this Biscuit Barrel telephone of 1895. Several have turned up in collections around Australia.



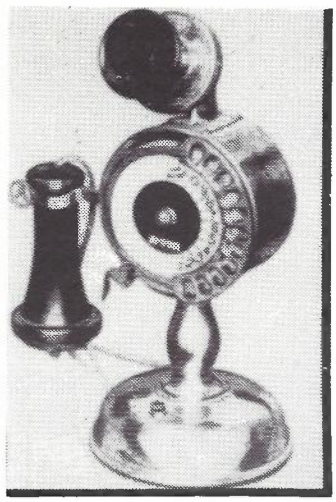
The first truly compact functional and extremely elegant telephone was this L. M. Ericsson (Sweden) 1892 "open frame" or "coffee grinder" table set. Its transmission response and efficiency can be closely compared with the modern telephone, recent tests have shown. The converser gave rise to our modern handset. The model was popular in Australia from its introduction and some units have seen over 80 years of service.



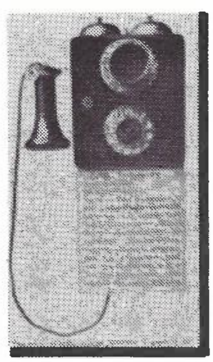
ABOVE: The three carbon rods resting on the sheet metal door of this Gower-Bell Telephone illustrate the principle of the carbon transmitter. Results were quite satisfactory. Phones of this model were popular in Australia in the 1880's.

An Australian expedient was the 237 AW (auto wall) built from recovered pedestal bell sets.

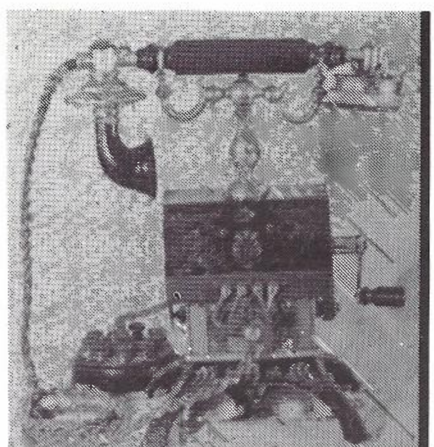
Prior to automatic working, larger cities installed CB (Central Battery) working to eliminate the expensive magneto and dry batteries or lechlanche cells from user's premises. Peel-Conner in Great Britain built this instrument in 1910.



LEFT: The American Automatic Electric Co. (Strowger) built a large wooden wallset and this charming 'desk stand' auto telephone in 1905. An 'O' was dialled between digits to step the group selectors across for hunting and the distant party's bell rung manually with the push key. Up to 12 wires were used per service.



The blurb below this early automatic phone says that it worked without adjustment or repair in Honolulu from 1910 to 1922. In Melbourne a similar phone was recently recovered after 63 years trouble free service.



Western Electric built a large range of table and wall telephones including this table set often referred to as the Eiffel Tower model. The original handset has been replaced by an LM Ericsson handset.

Down the Decades.

"We'll take it," says Hogthorpe at last, beaten, as I knew he would be, by my coolness, my confidence, my complete mastery of the situation — beaten, in fact, by my Hand Combination Set.

"I thank you, Mr. P.M.G. for the invention of the H.C.S. But one thought haunts me: what will happen when Hogthorpe installs one, too?"

THE AUSTRALIAN SCENE

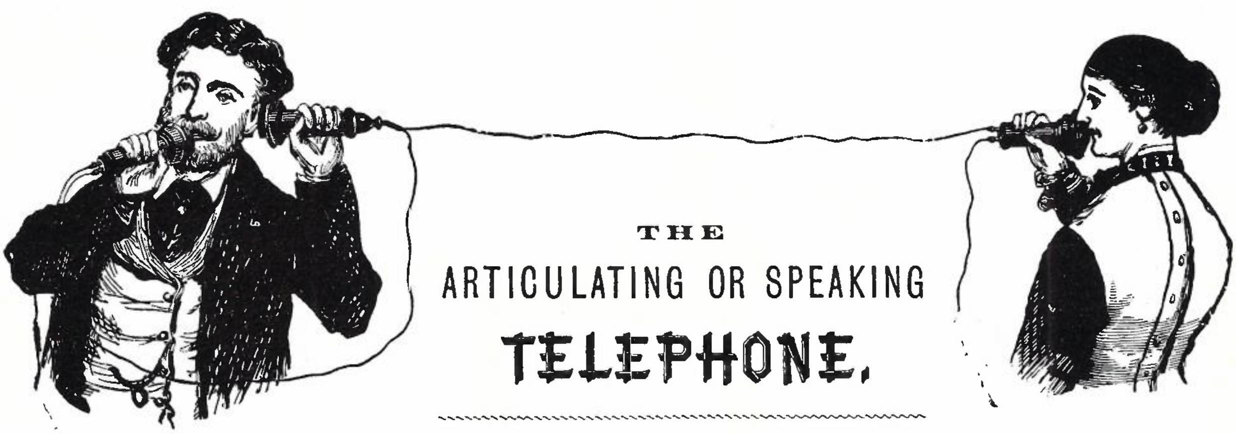
It did not take long for the telephone to develop in Australia with contributions being made by many States. In 1878, telephone instruments developed by Mr. Challon were successfully used in long distance transmission experiments. The calls were made between Melbourne and Ballarat (70 miles) and Port Augusta and Semaphore (240 miles). At the same time, Mr. E. C. Cracknell, Superintendent, Electric Telegraphs, New South Wales, successfully experimented with telephonic communications between West Maitland and Sydney (140 miles).

In February, 1878, what is believed to be Australia's first regular telephone service was installed for Messrs. McLean Bros. and Rigg. The service operated between their Warehouse at 69 Elizabeth Street and their Store at 190 Bourke Street West. This covered a distance of approximately one mile. The instruments used were developed by Mr. J. E. Edwards.

In the November-January, 1877-78, issue of their journal, the Telegraph Electrical Society included an article on the Telephone, part of which is reproduced below. This article provides a description of the type of telephone instrument being used for experiments and its method of functioning.

"In the present journal the Committee present to members the practical results of this wonderful invention as realised in Victoria up to the present time. At the time the last journal was issued, we had merely hearsay and newspaper reports of what had been done with it in America, and were waiting anxiously for accounts of it from England. In the meantime, various members of the society, notably Messrs. Challen, Edwards, Joseph, and Quarry, were endeavouring to manufacture telephones from the descriptions which reached them from time to time in the American and European scientific journals. Their efforts were ultimately successful, and we will in this journal give some newspaper extracts — the correctness of which we vouch for from personal knowledge — of experiments carried on with instruments of these gentlemen's construction.

In order that absent members who may not yet have seen a telephone may exactly understand what sort of instrument it is, a complete description with diagrams is given in the present number of the society's journal. It will be found to be the same in principle as that described in No. 9, page 243. As at present used by the majority of experimentists in Melbourne, it consists of a single electro-magnet,



DURING the past few months **MR. J. E. EDWARDS** has made a great variety of experiments to test the powers of the Telephone. It is found possible to speak with facility through a hundred miles of wire, and persons using them on lines of a few miles long can converse with ease in the same manner as though they were in the same room; even the voice of the person speaking can be recognised at the other end of the line.

In the early part of February a pair of these Instruments was fixed on Messrs. M'LEAN BROS. AND RIGG'S line, which communicates between their Warehouse, 69 Elizabeth street, and their Store, 190 Bourke street west, near Spencer street, about one mile by wire, by which all their business is transmitted, the Telephone having superseded the Wheatstone instruments previously used. The Telephone can be seen in use, and also on sale, there at any time during business hours.

These Instruments are of great practical value. They can be used for any purpose, and in any position, without technical training, wherever communication or conversation is required from a distance, as between the principals and employes in commercial houses—between central and branch banks—in mining operations, between the manager's office and the employes in the mine—in large hotels or mansions—in factories of every description between the manufacturer and his factory, and between the superintendent and his leading men; and, in fact, it may be considered as an ordinary speaking tube, with all the advantages of Telegraphic communication.

The above arrangement needs but a wire between the points of communication, a pair or two pair of Telephones, and two alarm-bells to call attention to either end of the line, though a hundred yards or miles apart.

Further particulars and estimates may be obtained on application to M'LEAN BROS. & RIGG, 69 ELIZABETH ST.; or

J. E. EDWARDS, the Manufacturer, 37 Erskine st., Hotham Hill, Melbourne.

Fig. 4—Early Advertisement for the Telephone which includes a Description of the First Telephone Service Installed in Australia.

Fig. 5—Switchboard of the Melbourne Telephone Exchange, 1886.

about the size of a large cotton-reel, the iron core being attached to a permanent bar-magnet about six inches long; a plate of extremely thin iron, about the size of a five-shilling piece, is fixed close to but not touching the front of the electro-magnet, and the whole is enclosed in a turned wooded case, and resembles, in appearance, a pocket telescope with one joint drawn out. The iron plate is covered with a wooden mouthpiece, which only exposes as much of the iron as could be covered by a threepenny-piece. The line wire is, of course connected to the coil which surrounds the electro-magnet, the other end going either to earth or on to another station. No battery is used, but the telephone is placed close to the mouth of the operator, who utters distinctly and in a deliberate manner whatever he wishes to transmit to the receiving station. The sound of his voice, striking against the exposed part of the iron plate causes it to vibrate in front of the electro-magnet. Of course these vibrations are infinitesimally small, but they are apparently sufficient to produce a current or series of currents through the coil which surrounds the electro-magnet, and these currents, conveyed by the line wire to the electro-magnet at the receiving station, cause an exact reproduction on the iron plate of the telephone at that end, of the vibrations caused by the voice at the sending station. The operator, therefore, at the receiving station places the telephone close to his ear, just as a deaf person would an ear-trumpet, and is enabled to catch, from the vibration of the plate, whatever is being said to him. Of course it is evident that the sound reproduced at the receiving station is of the faintest possible description; the tick of a watch is loud in comparison with what one usually gets through a telephone, and therefore it is not only necessary that everything around should be perfectly quiet, but also that the listening operator should not even allow his mind to be distracted from his work, but must concentrate it on listening alone. The sound comes in a singularly weird-like manner, which is still more impressive when the receiver is conscious that the person speaking to him is many miles away. When one first hears a voice through the telephone, knowing that the speaker is only in another room, perhaps in the same house, one is merely pleased, and has his curiosity satisfied; but when a ghostly "co-o-o-e" is heard, coming from fifty or a hundred miles away, the receiver is almost awe-struck; and it is not only a ghostly cooey, but the minutest miniature of one, as much like a real one as the mere dot on the object-glass of a microscope resembles the whole sheet of the "times", of which it is the faithful representation by photograph.

It is a singular fact that the Australian cooey, the sound of which the simple savages of Australia pitched on to communicate with each other from long distances, is found to be the one which, of all others, travels best over long distances between telephone and telephone. What a jump to make in a few years in this country of ours! Then, some perfectly uncivilised natives cooeying to each other in the forest; now, over the same ground, men of high civilisation uttering the same sound, from city to city, through one of the most wonderful inventions of modern or of any times."

The members of the Society recognised the problem of decreasing speech currents particularly over long-distance transmission. This problem became widely recognised before the turn of the century and it was not solved until 1900 when Michael I. Pupin, Professor in Mathematical Physics at Columbia University, patented his loading coil concept.

On 12 May, 1880, the newly formed Melbourne Telephone Exchange Company Limited opened Australia's first exchange at 367 Collins Street. The Company was founded by Messrs W. H. Masters and T. T. Draper. Sydney and Brisbane quickly followed suit by opening exchanges later on in the same year. By 1887, telephone exchanges had been opened in every State capital in Australia.

AUSTRALIAN MILESTONES

The following is a resume of the significant events that have occurred in Australia.

1878—First trunk telephone call demonstrated in South Australia between Semaphore and Pt. Augusta (240 miles) and between Sydney and West Maitland (140 miles) only two years after Alexander Graham Bell invented the telephone.

1880—First telephone exchanges opened at Brisbane, Sydney and Melbourne two years after world's first.

1902—First interstate trunk line opened from Mt. Gambier (South Australia) to Nelson (Victoria).

1907—Sydney-Melbourne trunk line service in operation and first Central Battery Telephone Exchange opened at Hobart.

1912—First public automatic telephone exchange in in Australia and second in British Empire opened at Geelong, Victoria. 100,000 telephone subscribers in Australia.

1923—Sydney-Brisbane telephone trunk line opened following introduction of thermionic repeaters.

1926—First country automatic exchange opened.

1930—Overseas radio-telephone service started.

1933—Table handset telephones introduced.

1936—Tasmania-mainland telephone service opened over the then longest submarine telephone cable in the world.

1940—500,000 telephone subscribers in Australia.

1945—Inter-capital city operator dialling over trunk lines introduced.

1953—1,000,000 telephone subscribers in Australia.

1956—Subscriber Trunk Dialling (STD) first introduced in Australia between Dandenong and Melbourne and between St. Mary's and Sydney.

1959—First broadband trunk system in Australia, a microwave radio link opened between Melbourne and Bendigo, Victoria.

1962—Broadband network: Sydney - Canberra - Melbourne coaxial cable opened for all telecommunications traffic (first interstate broadband system).

1962—STD introduced between Canberra and Sydney. Australia New Zealand-Fiji links of the Commonwealth Pacific Cable (Compac) opened. Compac is a large capacity submarine coaxial cable.

1963—Australian telephone operators able to dial direct to subscribers in Canada, the USA and Britain.

1965—STD introduced, Melbourne-Sydney: Sydney-Brisbane: Melbourne-Adelaide: Melbourne-Launceston.
The two millionth telephone subscriber service connected and more than 2,800,000 telephones in use.

1967—South East Asia Commonwealth Cable (Seacom) officially opened between Australia and Singapore.

1968—First earth station opened at Moree, N.S.W. by the Overseas Telecommunications Commission for transmission of overseas commercial telecommunications traffic via satellite.

1969—Earth stations opened at Ceduna (S.A.) and Carnarvon (W.A.).

1970—The giant 1,430 mile East-West microwave trunk system was brought into service enabling STD between the eastern and western halves of Australia — and nationwide live TV programme relays.

1973—Work began on the 195.2 metre Telecommunications Tower on Black Mountain, Canberra to provide centralised communications facilities including TV and FM radio broadcasting for the national capital.

1974—New electronic trunk exchange opened in Pitt Street, Sydney, to provide an improved STD service and, ultimately international subscriber trunk dialling (ISD).

1975—World-wide tenders called for a new generation of telephone exchanges to provide improved services such as push-button telephones and abbreviated dialling.

1976—ISD outgoing from Australia commenced.

CONCLUSION

The telephone developed rapidly from its humble beginnings both overseas and in Australia. Through the efforts of men like Challon and Edwards, Australia was well to the fore in the early years of the development of the telephone. In an earlier article, R. M. J. Kerr (Ref. 1) summed up the efforts made in those early years.

> "Readers of this Journal could well take time off to spare a thought for those more leisurely days towards the close of the last century when a few far-sighted pioneers laid down the foundations of the telephone system in this country. Without their vision and efforts, Australia could not hold the position in the communication world which it does today".

ACKNOWLEDGEMENTS

The author would like to express appreciation of the assistance given by Mr. B. Whitehead for the provision of background material.

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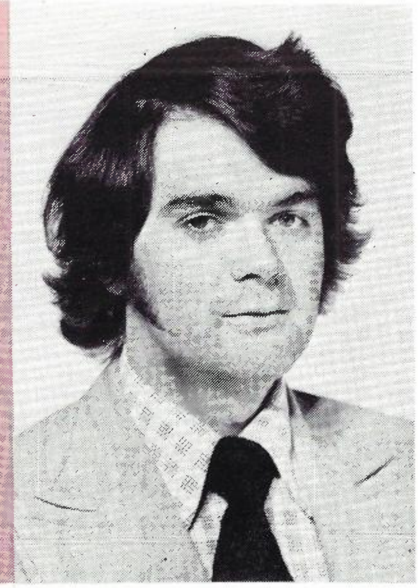

Technical News Item

EVOLUTION OF SOLUTION FOR BEHAVIOUR OF LONG TRANSMISSION LINES

Long lines were used in electrical communications for many years before any clear conception was attained regarding their theoretical behaviour. The first attempt at an analysis of the propagation of electrical energy through a long uniform circuit was made by Sir W. Thompson (Lord Kelvin) in 1855 (Math. Phys. Papers 2, P61, Proc. R.S.). This analysis was concerned with a single-wire conductor having concentric earth return, which was applicable to an undersea cable. Most land-lines in those days were single-wire earth return circuits and Thompson's solution was incomplete because his theory excluded the inductive effect which materially affects the resulting behaviour.

Kirchhoff (Pogg. Ann. 100, P193) and Weber (Pogg. Ann. 100, P351, 1857) were the first to include the inductive effect into the analysis of long-line behaviour. Their results, which were developed independently agree in all essential details although both contain assumptions which limit their practical effectiveness. Both investigations assumed that the single-wires were totally isolated from other conductors which is neither practically feasible nor theoretically possible to give the required degree of rigor in the evaluation.

The advent of the telephone into the communications field aroused a more concerted effort towards a better description of the theoretical behaviour of long lines. This is because telephonic communication required a much better transmission circuit than was needed for satisfactory telegraphic communications. Today high speed telegraphic (and equivalently pulse) systems require equal care in designing the transmission path. It will be noted that Maxwell's field theory was not available to either Kirchhoff or Weber but it was known to Heaviside who formulated the inductance concept to a more rigorous and practical fashion. (Phil. Mag. Vol. 1, P53, 1876).

A more detailed investigation of the long line problem was made by Heaviside (El. Papers 2, P119 and P307, 1886-87) which ended a gap of nearly 30 years in the recorded development of the theory. Rigorous treatment of the single-conductor line was made by J. J. Thompson in 1886 (Math. Soc. Proc. 17, P310) and of the concentric cable in 1889 (R.S. Proc. 46, P1). A more complete treatment of the single-conductor line was given by A. Sommerfeld in 1899 (Wied. Ann. d. Phys. 67, P233) and the first successful exact treatment of two infinitely long parallel wires was made by G. Mie in 1900 (Ann. d. Phys. 2, P201).

Heaviside was the only one to consider the nature of the leakage through the insulation as well as the boundary effects for both the transient behaviour and steady state condition of the line (El. Theory, Vol. 1, Art. 54; Vol. 2, Art. 393, 394). Although Heaviside considers primarily only one component wave out of a large total, his work forms the backbone for all subsequent investigations of an engineering nature.

This short account of the historical development of long-line theory does not do justice to those illustrious men of genius, a few only who have been mentioned, whose imagination, perseverence and skill erected the theoretical foundations of electromagnetic engineering, a great monument to the human intellect.

International Subscriber Dialling for Australia

W. R. CRAIG, B.E. (Hons.) and C. W. A. JESSOP, Bsc., M. Eng. Sci.

Telecom Australia has adopted the following policy on the introduction of International Subscriber Dialling (ISD) from Australia:

- *That ISD outwards from Australia should be progressively introduced using Automatic Message Accounting (AMA) as the preferred method of recording the subscribers charges for ISD.*
- *That as an interim measure, ISD outwards from Australia be introduced using the multimetering technique to record subscribers charges, and under these conditions subscribers should be normally barred from access to ISD, unless access is specifically requested.*

This paper describes the background to International Communications between Australia and the rest of the world, and the reasons for Telecom Australia's decision to introduce ISD. It also describes the strategy to be adopted in implementing ISD from Australia, and comments on problems still to be solved in the field of international communications.

INTRODUCTION

Being a geographically isolated country, Australia relies heavily on telecommunications for discourse with the rest of the world in matters of a commercial, political, and social nature. Early overseas communications were by means of the electric telegraph with a major event occurring in 1872, when the completion of the Overland Telegraph connected the southern part of the Continent to the telegraph cable to London.

In 1930 the first commercial radio telephone service connecting London and Australia was established and by 1940, telephone subscribers in Australia could gain access to 93% of the total telephones of the world in more than 50 countries. In that year some three thousand international calls were made. Since then, there has been a continuous rapid growth in the international traffic and by 1975 nearly four million calls were made between Australia and over 200 overseas countries. By 1980 it is estimated that international calls will reach about 15 million per year and it is expected that this figure will exceed 120 million calls per year by the year 2000.

Figure 1 shows the growth of international calls originating in Australia since 1960 and the curve represents an equivalent compound growth rate per annum of about 25%. By way of comparison, the equivalent figure for the growth of national trunk calls is of the order of 12-13%. It is this extremely high growth rate in international calls which provides the basic impetus for the introduction of ISD.

SIGNIFICANT DEVELOPMENTS TOWARDS ISD

The responsibility for handling international traffic to and from Australia is vested in two organisa-

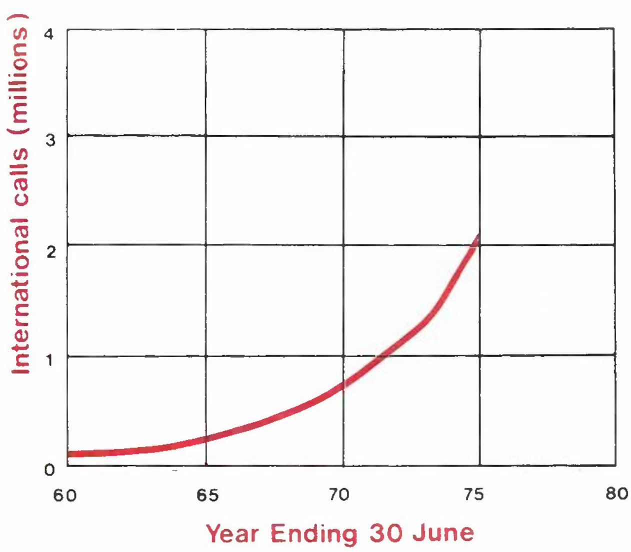

Fig. 1 — International Calls Originating from Australia.

tions who are responsible to the Minister for Post & Telecommunications. Within Australia, Telecom Australia assumes responsibility for the provision and maintenance of facilities to handle international calls from their point of origin to the International Gateway exchanges in Sydney. The International Gateway exchanges and the facilities for handling calls in the international network are the responsibility of the Overseas Telecommunications Commission (Australia), OTC(A). The Gateway exchanges provide the technical interface between Australia's national telephone network and the global communications network.

Looking briefly at the international network, the major facilities for handling traffic to and from Australia are:

- *Submarine Cables*

  COMPAC cable which went into service in 1963 and runs from Sydney to New Zealand then via Fiji and Hawaii to Vancouver where it connects to the Trans-Canada system. This cable provides communication channels from Australia to New Zealand, U.S.A., Canada, U.K., and Europe.

  SEACOM cable, which was commissioned in 1967, and runs from Cairns to Madang, Guam, Hong Kong and Singapore, providing Australia with telephone channels to the countries of the Far East and Papua New Guinea.

- *Satellites*

  Australia has two earth stations located at Moree, N.S.W. (1968) and Ceduna, S.A. (1969) which have access to INTELSAT satellites over the Pacific and Indian Oceans. These satellites currently carry some 66% of Australia's overseas circuits.

International calls originating in Australia are controlled by Telecom Australia operators located at international manual assistance centres at Sydney, Melbourne, Brisbane, Adelaide, Perth and more recently Canberra. For many years these operators switched their calls through a semi-automatic network to special international operators in Sydney who controlled the overseas HF radio circuits. With the establishment of the first automatic Gateway exchange in 1963, the operators were given direct access via the Gateway to overseas circuits. From about 1967 Telecom Australia began establishing a fully automatic trunk switching network employing new switching and signalling systems which would enable subscribers to dial their own trunk calls. These new systems also provided additional facilities required for full international operator working whereby the international operators could establish calls automatically through the national trunk network via the Gateway exchange to overseas countries. The automatisation of the trunk network and the international interface at the Gateway exchanges, were basic steps towards the future possibility of ISD.

NEED AND ADVANTAGES OF ISD.

With the rapid growth in international calls it is clear that large numbers of operators would be required in the future. For example, with a 25% growth rate in calls about 3,300 operators would be needed by 1986 compared to about 300 in 1972. Table 1 shows the estimated operator requirements over the period 1971/72 to 1985/86. The capital costs of providing the equipment, accommodation, etc., plus the annual costs for operators salaries, training, etc., meant that Telecom Australia would be involved in very heavy expenditure if the handling of international calls were to be continued on a manual basis. Furthermore, the indications were that the costs of equipment, salaries, and accommodation would increase considerably in the future and that revenue from increased call growth would not allow a realistic return on the funds employed. It is noteworthy that about 96% of the cost of handling international calls manually is accounted for by operators salaries. An indication of the orders of expenditure involved, is shown in Table 2.

The situation with regard to international traffic is, in fact, reminiscent of the conditions which were encountered in the early 1950's with respect to national trunk traffic. At that time, economic studies indicated the need for the introduction of Subscriber Trunk Dialling (STD). The studies on

TABLE 1 — ESTIMATED GROWTH OF OUTGOING INTERNATIONAL CALLS AND OPERATOR REQUIREMENTS

Year	Outgoing Calls	Positions Required	Operators Required
71/72	1,072,000		
72/73	1,340,000	106	344
73/74	1,675,000	127	412
74/75	2,094,000	151	490
75/76	2,617,000	179	581
76/77	3,271,000	214	695
77/78	4,089,000	254	825
78/79	5,112,000	303	984
79/80	6,390,000	360	1,170
80/81	7,987,000	429	1,394
81/82	9,984,000	511	1,660
82/83	12,480,000	608	1,976
83/84	15,600,000	724	2,353
84/85	19,500,000	862	2,801
85/86	24,374,000	1,026	3,334

TABLE 2 — ESTIMATED COSTS OF A MANUAL INTERNATIONAL TELEPHONE SERVICE.

	Year		
	1973/74	1979/80	1985/86
Number of International Manual Operators	412	1170	3330
Annual Expenditure (Operators and Equipment)	$2.9m	$11.5m	$46.0m
Progressive Total Expenditure	$2.9m	$44.8m	$212.0m

international traffic now show a similar need for subscribers to dial their own international calls. It is noteworthty that overseas countries have encountered, or are now encountering, the same sort of economic problem with international traffic, and the solution is universally accepted as "Introduce ISD".

PROBLEMS IN THE INTRODUCTION OF ISD

The major problem to be resolved before introducing ISD into Australia concerns the method of recording charges for international calls. Three practical methods were considered, namely:

- *Multi-metering.* Charge determination is automatically performed at a central point and multi-metering pulses are repeated back through the network to be registered on the calling subscribers' meter.
- *Automatic Message Accounting (AMA).* Information about the call (for example called number, calling number, duration of the call and date) is recorded at a central location and later printed out on the subscriber's bill. AMA requires the identity of the calling subscriber to be forwarded, by means of signals, through the network to the recording centre and involves the provision of Calling Line Identification (CLI) equipment at the originating subscriber's exchange.
- *Semi-Automatic Message Accounting.* This scheme is similar to AMA above but does not require CLI. The originating subscriber dials the international number but before the call matures, a checking operator is connected across the circuit to ascertain the calling subscriber's number and to transfer this number to message accounting equipment.

Multi-Metering. The multi-metering charge technique, considered as a possibility for the charging of international calls, has the following advantages and disadvantages:

Advantages

- Multi-metering is currently used for the charging of STD calls and hence the national trunk network has the basic facilities required for repeating multi-metering signals.
- The work required for implementing multi-metering ISD is relatively minor (e.g. access barring, trunk register modifications) and hence provides the possibility of introducing ISD at an early date.

Disadvantage

- With multi-metering, ISD call charges are registered on the subscriber's meter and cannot be isolated from normal local and STD call charges. Based on experience gained with STD this factor is unlikely to encourage subscribers to use the ISD service, particularly in view of the high multi-metering rates which are applicable to international calls, thus negating the prime aim of reducing the amount of manual international traffic. The effect of this factor is extremely difficult to quantify and has been the subject of considerable debate.

Automatic Message Accounting

The major advantages and disadvantages of the AMA technique in charging ISD calls are:

Advantages

- The subscriber can be given a detailed record of ISD calls on his bill which should promote usage of the ISD service, and reduce complaints about incorrect charging.
- Information concerning the cost of an ISD call can

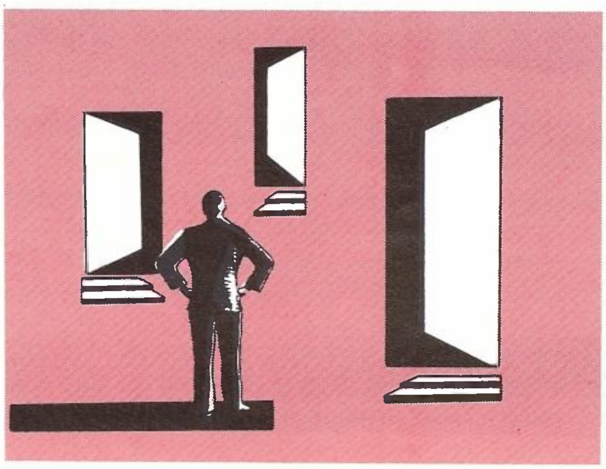

TABLE 3 — ESTIMATED COSTS AND SAVINGS FOR ALTERNATIVE ISD CHARGING METHODS.

		Alternatives		
	Completely Manual	(i) Manual plus Multimetering ISD	(ii) Manual plus Multimetering Followed by AMA/ISD	(iii) Manual plus AMA/ISD
Estimated Costs	$M	$M	$M	$M
— Operators	203	126	85.5	104
— Capital	9	5	29.5	32
— Total	$212M	$131M	$115M	$136M
Estimated Savings compared with completely Manual	—	$ 81M	$ 97M	$ 76M

be made available immediately on completion of the call.

Disadvantages

- AMA requires extensive additions of equipment to the network to provide calling line identification facilities and also necessitates significant changes in the information signalling scheme.
- In view of the large number of equipment changes and additions required, it is expected that AMA could not be introduced into the network until late 1978 at the earliest and hence does not offer any relief of operator requirements until that time.

Semi-Automatic Message Accounting

The major factors in considering the feasibility of employing this method of charging are:

Advantages

- A detailed record of international calls made can be provided for billing purposes.
- CLI is not required and hence the major equipment additions needed for this facility are avoided. Of course, the centralised accounting equipment still has to be established.

Disadvantage

- Checking operators are needed with attendant salary, accommodation, and training costs.

Three basic options emerged as being feasible ways of implementing the ISD charge function.

These were:

- Introduce multi-metering charging as the initial solution and continue this method into the long term.
- Introduce multi-metering initially and follow this with AMA/ISD in the long term.
- Introduce AMA/STD only and accept the penalty of delayed introduction.

Costs studies were performed on these options and results are shown in Table 3. The savings indicated are necessarily related to predicted growth rates, forecast ISD penetration rates, usage of the ISD service, and operator efficiency. These parameters are a function of many factors some of which are extremely difficult to quantify. However, even a pessimistic estimate indicates that very significant savings accrue from the introduction of ISD. Furthermore the second option appears to represent the most desirable solution to the problem of ISD charge determination.

TELECOM AUSTRALIA POLICY ON ISD

Following the economic and technical studies into the need and timing of ISD, Telecom Australia undertook formulation of a policy which would be adopted for the introduction of an ISD service. In summary, this policy is based on the following basic premises:

- ISD is essential in the near future to help meet subscriber demand for international telephone service in an economical manner.
- The adoption of the AMA charging technique is desirable to enable subscribers to be given complete charging information so as to ensure a high level of ISD usage.
- As it would be extremely difficult and costly to meet the demand with a manual service until AMA is widely available in the 1980's, the use of multi-metering in the interim from 1975 is considered unavoidable.
- To avoid criticism of a multi-metering system for ISD which may reflect into the STD system, whilst

multi-metering is used, subscribers should be normally barred from ISD, with access being provided only for those who request it.

From the above basic premises the following policy was formulated and approved on 5 September, 1973:

- That ISD outwards from Australia should be progressively introduced on those routes where adequate operational standards exist subject to agreement between administrations and OTC(A) on rates and their division.
- That automatic message accounting (AMA) is the preferred method of recording the subscribers charges for ISD and should be introduced as early as possible. Current estimated commencement date for AMA is 1978.
- That as an interim measure, ISD outwards from Australia using the multi-metering technique to record subscribers charges should be introduced as soon as possible. The estimated commencement date is 1975.
- That under multi-metering conditions subscribers should be normally barred from access to ISD; access to the ISD service to be given only to those subscribers who specifically apply for it. With AMA, access to ISD would normally be available as the subscribers would then have the protection of the printed record.

As can be seen from the above statements a two stage policy is envisaged covering the short term and the long term. Such a policy allows the earliest possible establishment of ISD on a multi-metering basis, with the main objective being to limit the growth of international manual exchanges, and their associated large annual operating costs.

Subsequently, the policy is directed at providing the service on a more widespread basis, and improving the overall usage of the service, by making available to the subscriber a printed record of the subscriber dialled overseas call.

IMPLEMENTATION OF ISD

In determining the broad implementation plan for introduction of ISD it is necessary to examine those factors which have the greatest influence on achieving the main objective of limiting the growth of international manual exchanges. These are:

Originating Traffic Dispersion. Studies for the international traffic originating in Australia show that approximately 85% of all overseas calls originate from the metropolitan areas of the capital cities (including Canberra). The Sydney metropolitan area alone accounts for about 40% of the calls, with Melbourne metropolitan area the next highest source originating just under 25% of the Australian total. Table 4 shows the percentage of calls originating from capital city metropolitan areas and from the country areas of each State. From this table it can be seen that the capital cities constitute the prime areas for early introduction of ISD facilities.

TABLE 4 — ORIGINATING INTERNATIONAL TRAFFIC DISPERSION.

Source	Percent of Total Effective Calls
Sydney Metro.	42.21
New South Wales Country	3.79
Australian Capital Territory	2.37
Melbourne Metro.	24.14
Victorian Country	1.75
Brisbane Metro.	8.17
Queensland Country	4.35
Adelaide Metro.	4.22
South Australia Country	1.36
Perth Metro.	5.84
West Australia Country	0.90
Hobart Metro.	0.44
Tasmania Country	0.42
	99.96

Percentage of calls from capital city metro. areas (including Canberra)	87.39
Percentage of calls from country areas	12.57
Percentage of calls from Sydney and Melbourne metro. areas	66.35
Percentage of calls from Sydney, Melbourne and Brisbane metro. areas	74.52

Terminating Traffiic Dispersion. Clearly, it would be desirable to provide ISD facilities firstly to those destinations which terminate the higher volumes of traffic outgoing from Australia. Table 5 shows, in descending order of traffic volume, the 12 destination countries which terminate the major streams of Australia's overseas calls. Another factor to be considered in determining those destinations which will be made available to the ISD service is the availability of ISD facilities which enable overseas subscribers to dial direct into Australia. Papua New Guinea, U.K., West Germany, and parts of the U.S.A., and Belgium currently have ISD into Australia and a number of other countries are expected to introduce this service in the near future.

Operational Standards. In deciding which overseas destinations will be "opened" to the ISD service, Telecom Australia has a responsibility to ensure that its customers encounter an acceptable grade of service on their ISD calls. At present, some overseas routes which carry significant volumes of traffic from Australia do not exhibit satisfactory performance levels for a variety of reasons, and performance levels will need to be improved before ISD traffic can be directed to these routes.

Technical Restrictions in the National Network. The implementation of stage 1 of the policy (i.e. multi-metering ISD) requires modification of existing local and trunk exchange equipment. Basically, in local exchanges, these modifications involve the provision of facilities for barring unauthorised access to the international service, the provision of a subscriber classification for those subscribers who request ISD facilities, and the ability to handle the longer number lengths encountered on ISD calls. In trunk exchanges, modifications will also be required to handle the longer number lengths, and to perform the appropriate signalling, translation, and analysis functions.

In order to avoid the significant modifications which would be necessary to establish ISD charging facilities in existing ARM trunk exchanges, it has been decided that multi-metering charge facilities will be provided only at 10C trunk exchanges. Consequently, minor changes are also necessary to outgoing ARM trunk repeaters to enable them to effectively silence the high rate of multi-metering pulses generated from the charge centre.

Clearly, the rate at which ISD can be introduced into the Australian network will depend largely on the availability of resources to carry out the above equipment modifications. Furthermore, in the interests of efficiency it may be desirable to carry out modifications for ISD in a particular exchange at the same time as other modification programmes are being implemented at that exchange. Telecom Australia is currenly examining these aspects in order to establish a detailed National programme for introduction of ISD.

TABLE 5 — TERMINATING INTERNATIONAL TRAFFIC DISPERSION.

Destination Country	Percent of Total Calls
Britain	22.1
New Zealand	21.9
United States	11.4
Papua New Guinea	9.9
Italy	3.3
Hong Kong	3.3
Singapore	3.0
Japan	3.0
Greece	2.4
Fiji	2.3
Canada	2.0
West Germany	1.9
	86.5
Other Countries	13.5

Proposed Broad Implementation Timetable for Multi-Metering ISD

The proposed implementation programme for the introduction of multi-metering ISD envisages four phases.

WHERE, THE INTERNATIONAL ACCESS CODE IS 001
THE CALL DIGIT IS 1
AND THE INTERNATIONAL NUMBER
CONSISTS OF WORLD CODE FOR THE DISTANT
COUNTRY (1, 2, OR 3 DIGITS) FOLLOWED
BY THE NATIONAL SIGNIFICANT NUMBER
OF THE DISTANT SUBSCRIBER.

EXAMPLE:

SUBSCRIBER NO.	AUSTRALIAN SUBSCRIBER DIALS
2483567 IN LONDON	001 + 1 + 44 + 12483567
	UK WORLD CODE + NATIONAL SIGNIFICANT NUMBER (INTERNATIONAL NUMBER)

Fig. 2 — Number Dialling on ISD Calls.

Phase 1. ISD from metropolitan crossbar ARF subscribers commences from Sydney in 2nd quarter of 1976. Extension to other capital cities and expansion to other overseas destinations during 1976.

Phase 2. ISD from country ARF crossbar subscribers commences fom large centres late1976.

Phase 3. ISD from metropolitan step-by-step subscribers commences approximately 1977.

Phase 4. ISD from country ARK crossbar subscribers and country step-by-step subscribers.

These phases are determined mainly by the availability and extent of the work specifications for the modifications required to various equipment types, and by the objective of programming ISD penentration so that the service will be provided first to those subscribers who are most likely to make use of it. It is noteworthy that considerable numbers of subscribers on step-by-step exchanges in the capital cities originate significant volumes of international traffic. In order to provide the ISD service to these high usage step subscribers initially, it is proposed that, where practicable, they would be offered a crossbar number.

General Aspects of ISD Implementation

Numbering. For international subscriber dialling, CCITT recommends a maximum of eleven digits and exceptionally twelve digits (excluding the international prefix). For Australian subscribers, the form of the number to be dialled on ISD calls is shown in Figure 2.

Trunking. The decision that multi-metering ISD charge facilities will be provided only at 10C trunk exchanges constitutes the major restriction on the way in which ISD calls are trunked through the network. This means that all ISD calls must trunk via a 10C exchange and that exising direct routes between main ARM exchanges and the international Gateway exchanges cannot be used to carry ISD traffic. Figure 3 shows the trunking ar-

Fig. 3 — Trunking ISD from Capital Cities.

rangements to be implemented for the introduction of ISD from Australian capital cities. These arrangements conform to CCITT recommendations concerning the maximum number of interexchange links which may be allowed in the international connections.

Multi-metering ISD Charging. Until further IOC exchanges are installed, Sydney 10C exchange will perform charging for all ISD calls originating in New South Wales, A.C.T., the Northern Territory, Queensland and Western Australia, while Melbourne 10C exchange will charge ISD calls from Victoria and Tasmania, and Adelaide 10C exchange will charge ISD calls originating in South Australia. By 1980, 10C exchanges proposed for Brisbane and Perth will provide charging facilities for Queensland and Western Australia, respectively.

Echo-Suppressors. All ISD calls originating in Australia require the insertion of an A end echo-suppressor. Ideally, echo-suppressors should be located at the two-wire/four-wire conversion point. However, in practice a maximum distance of 2,000 km between the location of the two-wire/four-wire conversion point and the echo-suppressor is allowed. With the initial introduction of ISD, existing echo-suppressor pools will be employed as follows:

ISD Calls Originating in	E.S. Inserted at
New South Wales and Northern Territory	Sydney
Australian Capital Territory	Canberra
Queensland	Brisbane
Victoria and Tasmania	Melbourne
South Australia	Adelaide
Western Australia.	Perth

For ISD from those areas (for example North Queensland) which exceed the distance limitation mentioned above, further echo-suppressor pools may need to be established before ISD can be introduced to subscribers in these areas.

ISD IN THE FUTURE

With the commencement of the implementation of AMA/ISD proposed in 1978, subscribers will be able to obtain a detailed record of their calls, and this fact is expected to give considerable impetus to the usage of the ISD service. Current predictions indicate that by 1985, about 8 million calls will be dialled directly representing about 50% ISD. Figure 4 shows the estimated overall growth of outgoing international telephone calls from Australia and the expected growth of the ISD service commencing in 1976 and reaching about 50% penetration by 1985. Expansion of the ISD service throughout the Australian network will, of course, be parallelled by growth in the numbers of international circuits between Australia and overseas.

It is conceivable that our subscribers of the future will expect not only voice communications between their home and overseas, but also visual and data communications.

These, and other problems (some of which are depicted in Figure 5) will need to be solved in the years ahead.

CONCLUSIONS

This article has described the policy adopted by Telecom Australia for the introduction of ISD from Australia, and outlined the reasons for adoption of this policy. The article also provides an outline of the broad implementation policy to be followed in providing ISD for Australian subscribers.

ISD will provide an improved international telephone service for Australian subscribers, allowing them greater flexibility in making international calls. At the same time it will allow Telecom Australia to contain the escalating costs of a fully manually operated international telephone service, and thus provide an economical service to the customer.

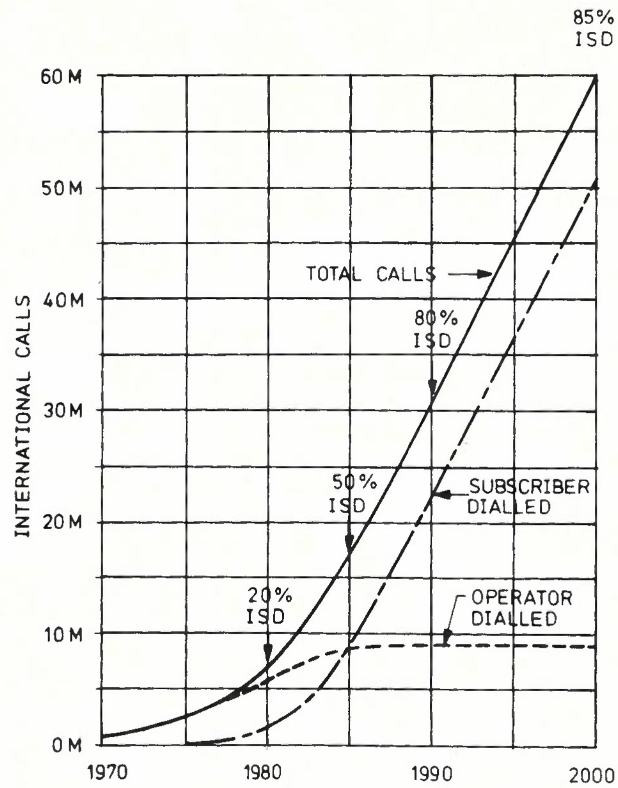

Fig. 4 — Forecast of International Calls Outgoing from Australia.

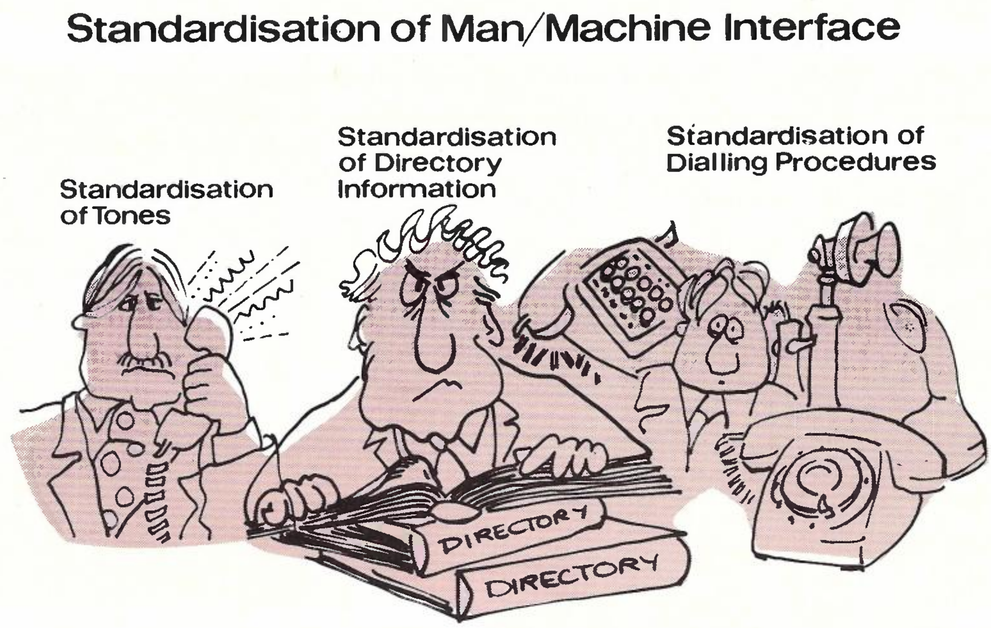

Fig. 5 — International Telephone Communications in the Future.

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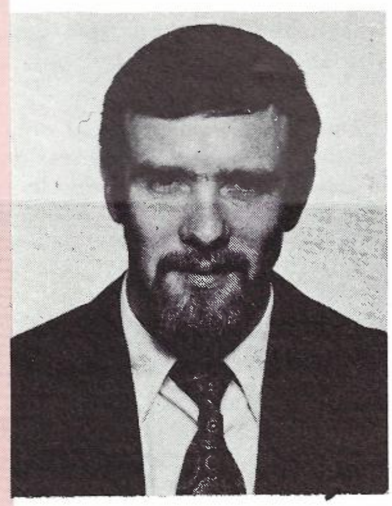

The Development of the Public Telephone in Australia

J. C. COCKREM, A.A.I.M.

Since the take-over of the Company Coin "Red" and "Easi" phones and the recent formation of Telecom Australia, a new approach is being taken with public telephone policy which is expected to substantially improve the commercial and service aspects. This approach has increased interest in the public telephone sphere and this article describes the development of these instruments from the time when the first known types were in service.

INTRODUCTION

The Public Telephone is now a 24-hour service provided by Telecom Australia to enable people who do not rent a service, or who may be away from their homes or offices, to make chargeable private calls or free calls to emergency and certain other services.

Prior to 1930, a 24-hour public telephone service was not possible because there were no automatic public telephones. Up to 1920 service was provided by over-the-counter means, and from then on by CB or magneto instruments from which the traffic was switched by operators, but only during office hours.

Generally, connections were obtained only within the local fee area applicable, but it was possible to make trunk calls from public phones located at post offices by paying the fee at the counter during office hours or to an operator at other times.

CB AND MAGNETO OPERATION

Mechanism Description

The mechanism and coin tin were housed in separately locked compartments in either a rectangular or tubular metal case. The assembly was used as an attachment to a CB or Magneto wall telephone from which the calls were made (See Fig. 1).

The mechanism operated on a "pay-on-answer" mode and did not have a refund facility. Calls were initiated without coins and when the called party was available, the operator asked the user to insert two pennies. These coins, inserted in sequence, passed down a coin chute into the coin tin and in passing, struck a small weighted pendulum which vibrated causing two springs connected in the transmitter circuit of the telephone to make intermittent contact, thus creating a buzzing noise in the line which indicated to the operator the number of coins inserted.

Installation Method

Particular attention was necessary on installation to ensure that the mounting was rigid and that the springs were correctly adjusted so that well aimed blows on the side of the case did not generate false deposit signals.

Coin Tin

The coin tin was rectangular with a hinged lid through which a small projection protruded when the lid was closed. A piece of string was passed through a hole in the projection and knotted. The knot was placed in a depression in the lid and covered with sealing wax into which the imprint of an office stamp was made while the wax was warm. Although it was simple, it was more successful in preventing interference than some of the more recent complicated sealing methods.

AUTOMATIC UNIT FEE OPERATION

2d Telephone Description

After 1930, the increase in the number of manual exchanges being converted to automatic necessitated the design of a local call telephone which did not require operator assistance. A new coin handling mechanism was built to fit the existing rectangular case (See Fig. 2) to which was added a tubular section to house the coin tin. The mechanism was fitted with a switchhook and the components for the telephone circuit were fitted inside the mechanism compartment. A bell receiver was used, the transmitter and dial were fixed in mountings on the mechanism compartment door and the shape of the coin chute and the head design was also changed. (See Figs. 3 and 4).

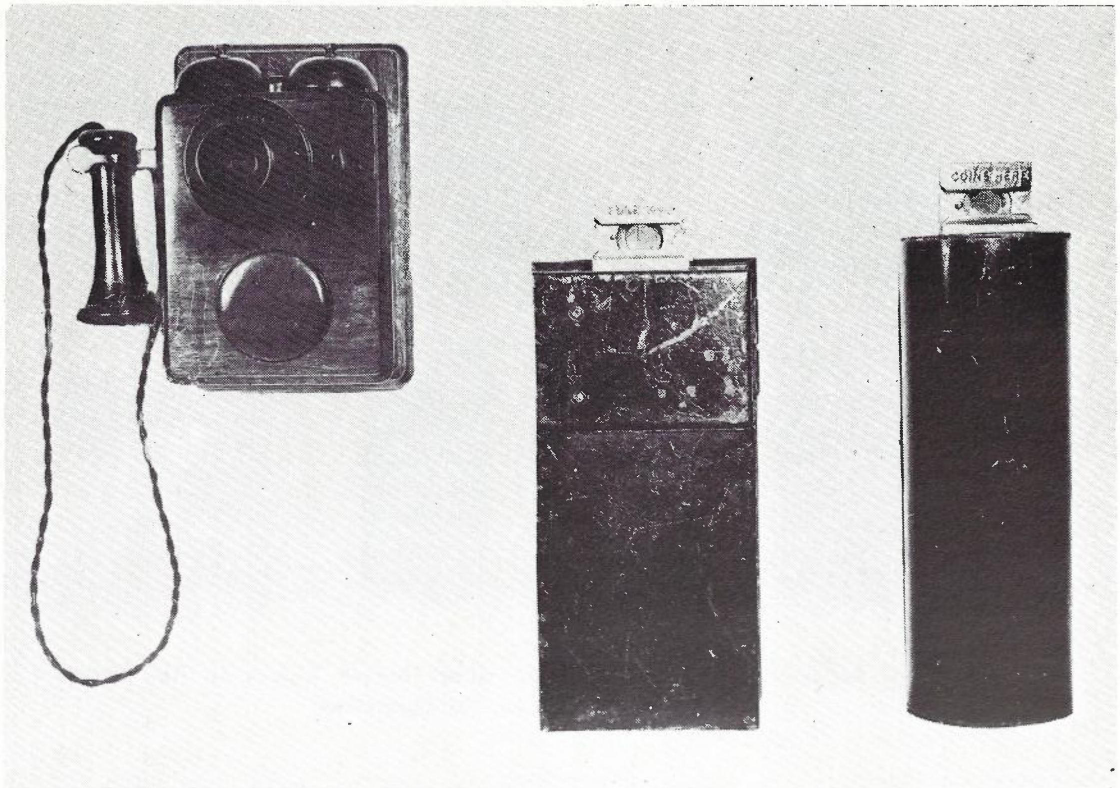

Fig. 1—Early type CB Local Call Telephone and Mechanisms, 2d Operation.

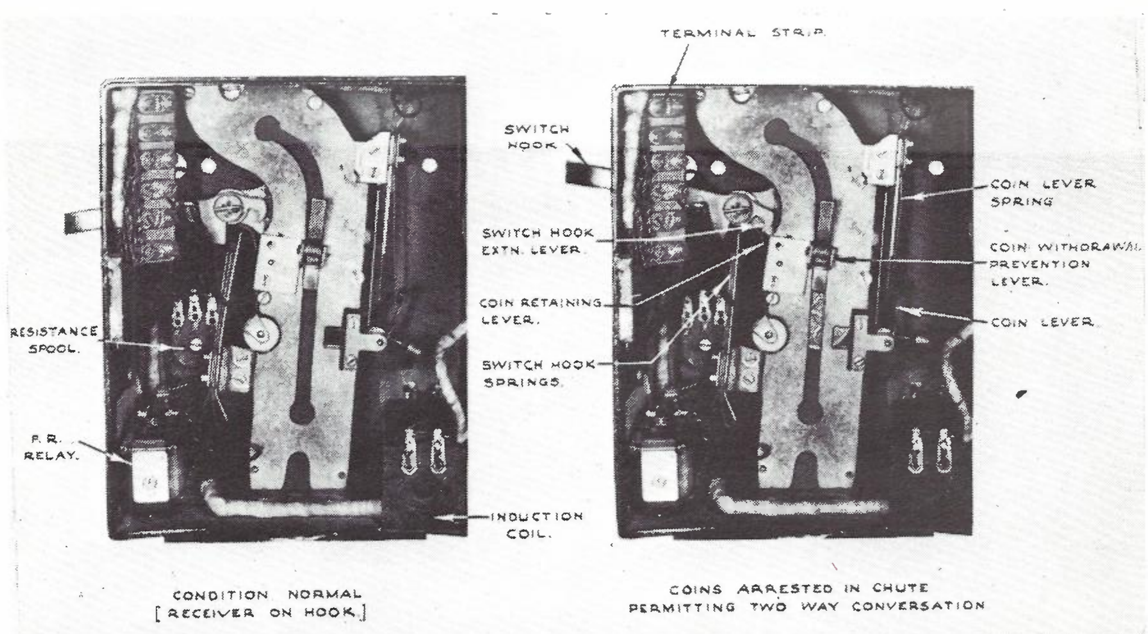

Fig. 2—Early type Automatic Unit Fee Mechanism, 2d Operation.

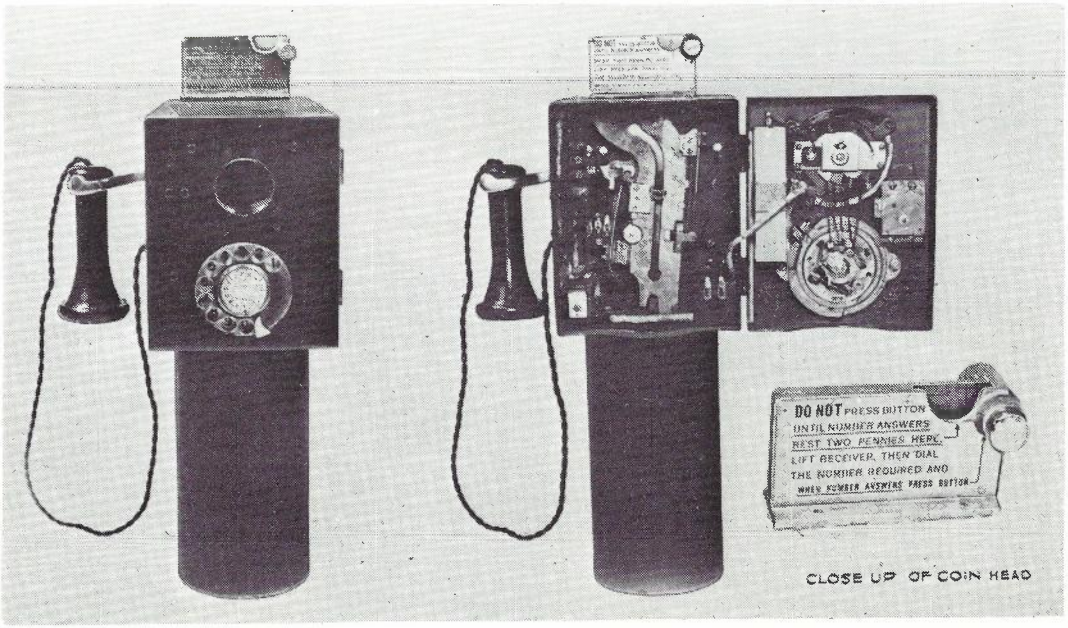

Fig. 3—Early Automatic Unit Fee Telephone, Short Breech type with Bell Receiver and Fixed Transmitter, 2d Operation.

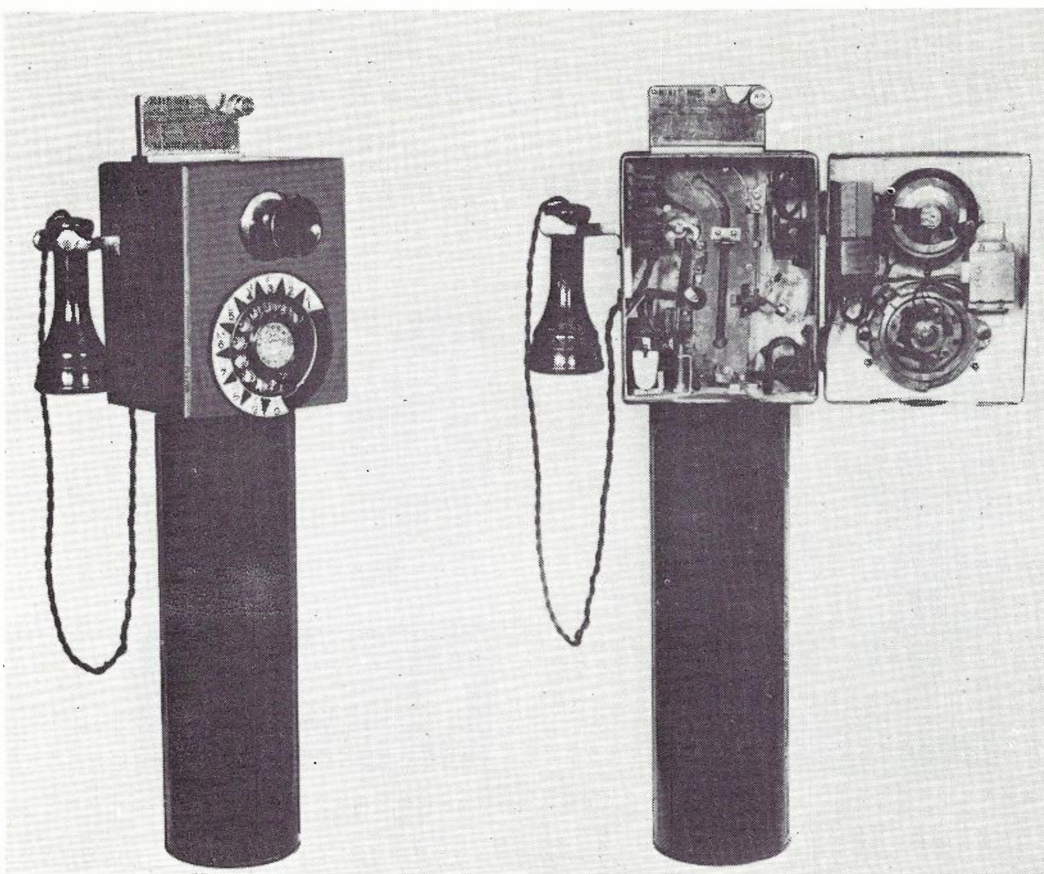

Fig. 4—Early Automatic Unit Fee Telephone, Long Breech type with improved Bell Receiver and Fixed Transmitter, 2d Operation.

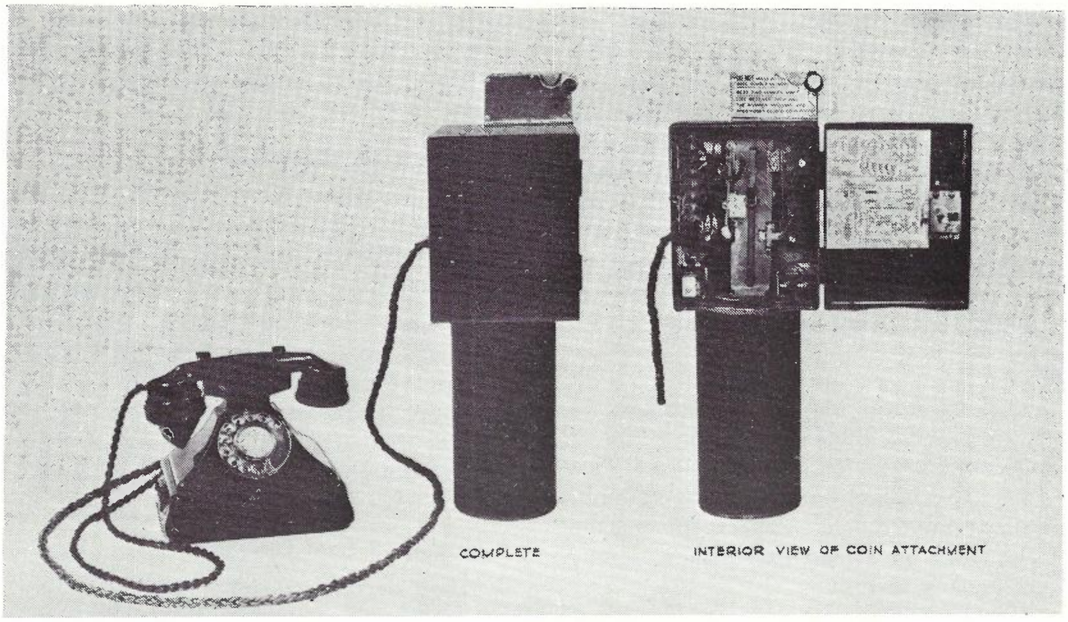

Fig. 5—Early Automatic Unit Fee Mechanism with 162 Series Table Telephone, 2d Operation.

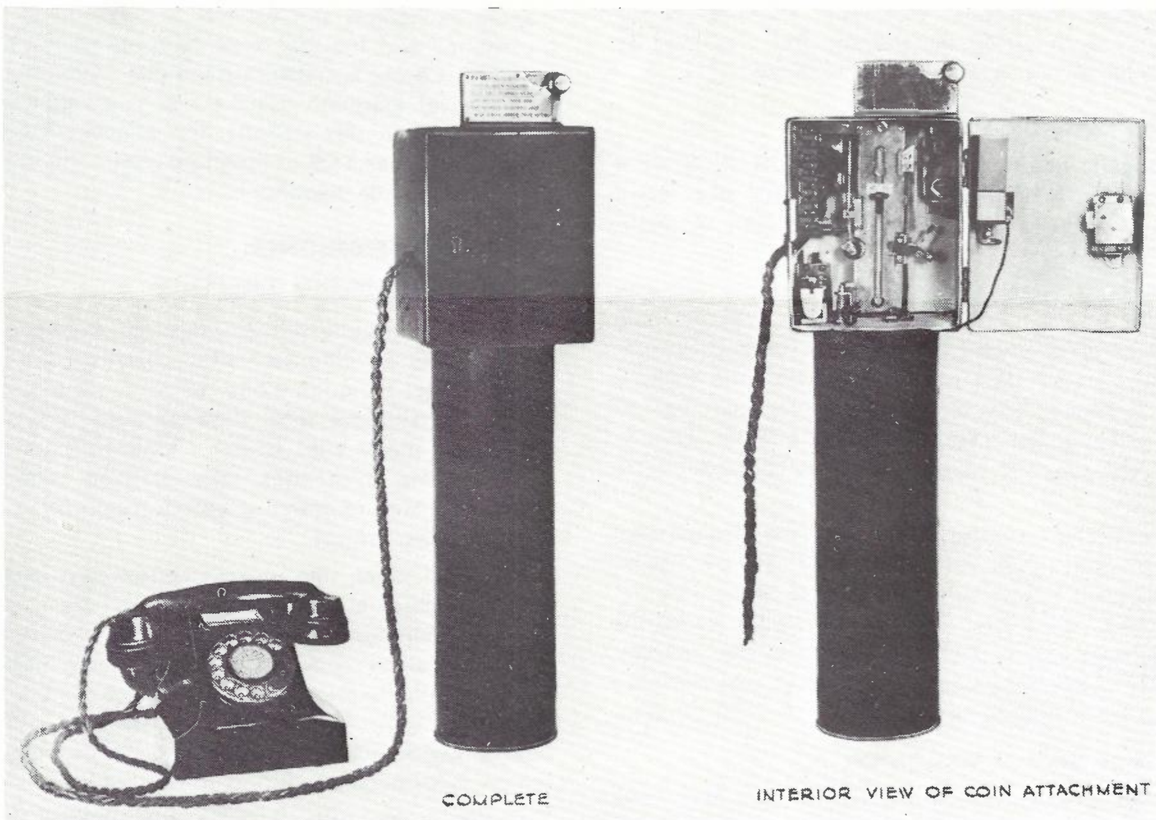

Fig. 6—Early Automatic Unit Fee Mechanism with 300 Series Table Telephone, 2d Operation.

When a line potential reversal was received on "called subscriber answer", a polarised relay operated preventing conversation until the user inserted two pennies. These ran half-way down the coinway where they were held by a roller and spring which operated to short circuit the relay, allowing conversation to proceed. When the receiver was restored, the switchhook mechanically released the roller which allowed the pennies to pass into the coin tin. This public telephone was called the "Fixed Tariff Unit Fee Wall Type".

Other Types

In addition to the fixed transmitter and bell receiver types, some were fitted with either a 162 or 300 type Table Telephone for pay-station use. (See Figs. 5 and 6). The operation of these telephones was similar to the bell receiver type except that the coin roller was held by a magnet which was only energised during line reversal.

Automatic 4d Operation

In 1955, a new unit fee mechanism was introduced which allowed for a change in tariff from 2d to 3d or 4d operation and these were fitted into two types of telephone termed the "Variable Tariff, Unit Fee PT's". The first type had a bell receiver and fixed transmitter fitted in similar manner to its predecessor, the Fixed Tariff type, and the second type was installed in pay stations and was used as an attachment to a standard telephone.

4d Mechanism Description

The coin head was slotted to hold 2, 3 or 4 pennies and a button at the end of this slot, when pressed, allowed the coins to run down in sequence. (See Fig. 7).

The coins passed straight through the coinway into the tin, but in so doing each successive coin triggered a pawl which acted on a toothed escapement. As each coin passed the pawl, the escapement dropped one tooth. The correct number of coins caused the escapement to operate springs which changed the circuitry to allow conversation to proceed.

In the fixed transmitter type, the escapement was reset, in readiness for the next call, by a lever on the switchhook which operated when the receiver was hung up. In the pay station type, the escapement was reset by a magnet in the mechanism which operated when the handset was replaced on the table telephone.

Telephone Handset Introduction

About 1962, when the bell receivers and fixed transmitters were in short supply, a third type was introduced. By redesigning the switchhook to take a telephone handset, and altering the circuit to one using an anti-side tone induction coil, the transmission efficiency was improved and the number of faults, due to carbon packing in the fixed transmitter type, was reduced.

Automatic 6d Operation

In 1964, when the unit fee tariff for private subscribers was increased, it was decided to raise the public telephone unit fee tariff to sixpence.

The variable tariff types were modified to become single coin instruments accepting sixpence. This was done by reducing the number of teeth on the escapement to one and reducing the size of the coin chute and coin head to control the smaller diameter coin. In place of the coin head release button, was a recess in which the coin was placed prior to deposit.

Automatic 5 Cent Operation

When decimal currency was introduced in 1967, no modifications were necessary because a 5 cent coin is the same size as a sixpence. With the introduction of silver coin operation, the circuit of the pay station telephone was altered slightly to accommodate an 800 Series telephone (See Fig. 8).

CB and Magneto Adaption

As the unit fee tariff increased in areas where manual exchanges still existed, the automatic fixed transmitter and handset type telephones were adapted for CB use by replacing the dial with a dummy dial and for magneto use the dial was replaced by a generator. In pay-stations, the attachments were fitted with either a CB or magneto telephone in place of the automatic telephone.

MULTI-COIN TELEPHONES

Two Button Multi-Coin Telephones

About the middle thirties, Telecom Australia adopted a BPO development which had the ability to accept three denominations of coin; penny, sixpence and shilling; thus allowing local and trunk calls to be made with operator assistance from CB and Magneto exchanges and allowing automatic local calls and operator assisted trunk calls from Automatic exchanges.

For local calls, the user inserted two pennies which latched a weighted balance arm and on answer, operation of an "A" button deposited the coins and allow conversation to proceed. On ineffective calls the money was refunded by operation of button "B". This operation also triggered a buzzer which acted as a warning to operators of button mis-operation during trunk line calls.

During trunk calls audible identifying signals were forwarded to the operator; a tone from a spiral gong when one penny was inserted, tone from a

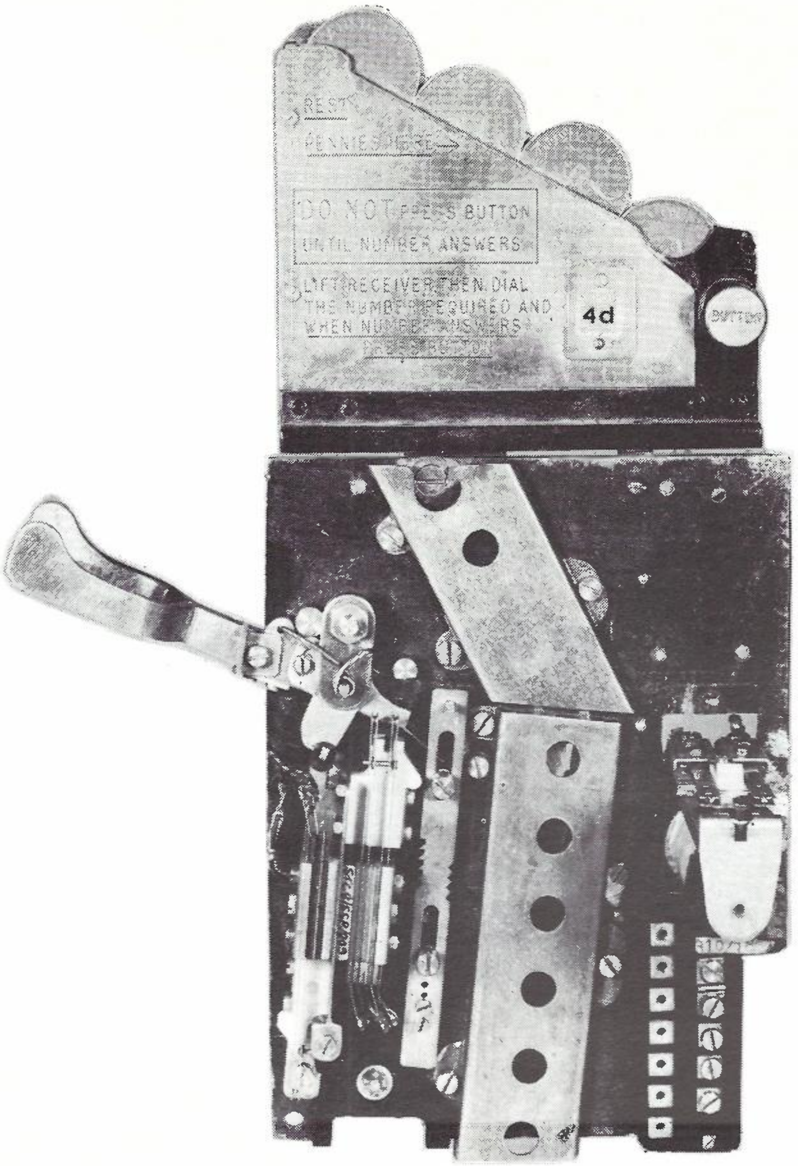

Fig. 7—Original Variable Tariff Unit Fee Mechanism, 4d Operation.

bell being struck once when a sixpence was inserted and tones from the bell being struck twice when a shilling was inserted. When the operator was satisfied with correct coin insertion, the user was asked to press button "A" to allow deposit of the coins and allow conversation to proceed.

Prior to 1964, the unit fee change from 2d to 3d and then to 4d, was accommodated by moving the weight of the balance arm to a position where it would latch with the required number of coins. During the 4d era, an additional latch was fitted to the back of the mechanism to allow the use of a sixpence for local calls for any user who was not carrying 4 pennies.

When the change of unit fee to 6d took place in 1964, it was not possible to adjust the balance arm to operate with six pennies and the mechanism was redesigned to operate with a sixpence for local calls. The penny runway was redesigned to accept a 2 shilling piece in lieu of pennies and the 1 shilling runway was retained. To ensure correct operation with the lightweight sixpence, the balance arm was redesigned to latch with a magnet and restoration was achieved by a special arc fitted to the coin quadrant which was activated during "A" button operation.

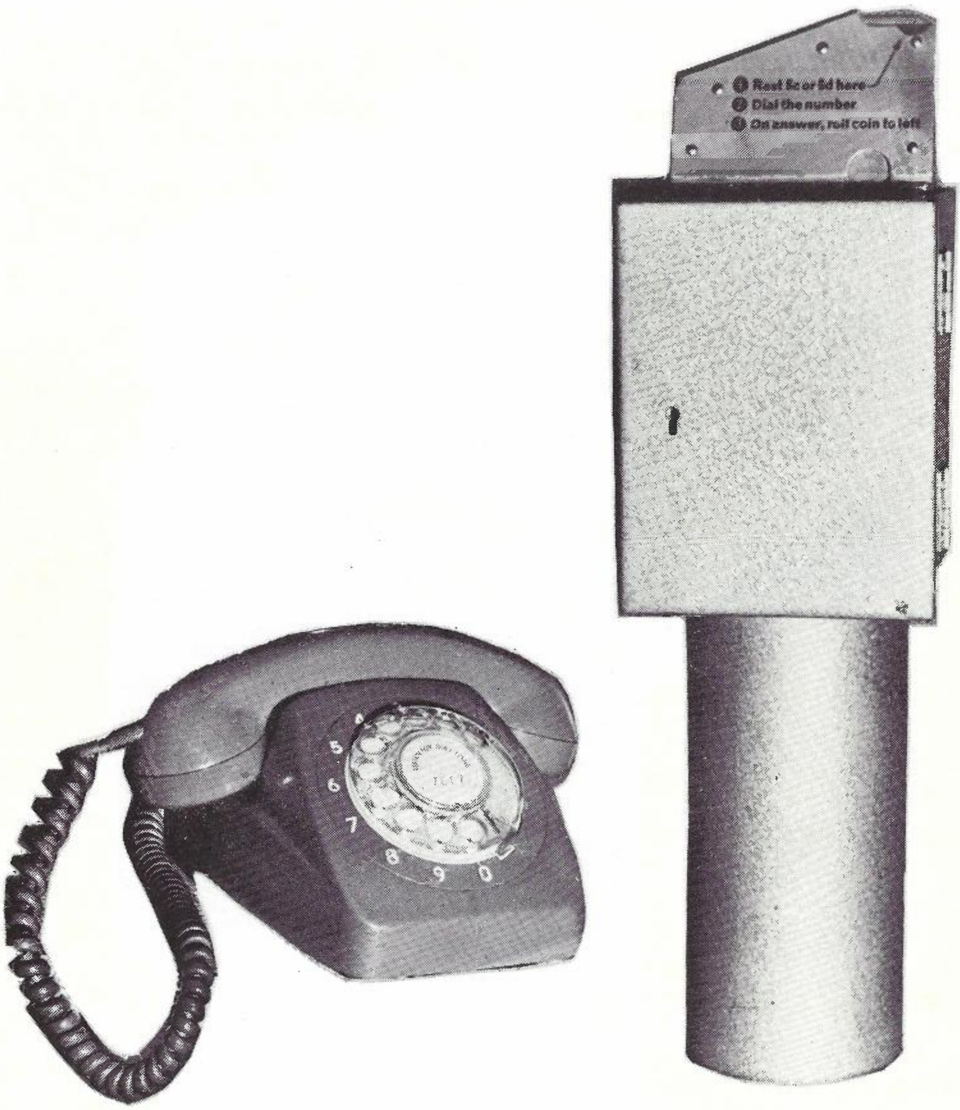

Fig. 8—Unit Fee Mechanism with 800 Series Telephone, 5 Cent Operation.

This 2-button multi-coin telephone was the standard trunk line instrument until introduction of the Coin Telephone No. 1 in 1966 and, with several modifications, such as the 10 cent conversion, is still in use. (See Fig. 9).

One-Button Multi-Coin Telephone; Coin Telephone No. 1

The Coin Telephone No. 1 was manufactured by Associated Automations in Britain and has similar facilities to the 2-Button Multi-Coin telephone, but uses electronically generated tones for identifying coin insertion to the operator. It has only one button which is for depositing the coins during operator-assisted calls and has an Australian modification which acts as a deterrent to calls without coins to service numbers such as "Time", "Weather" and "Sport". This deterrent is an oscillator which, when no coins are inserted, comes into circuit during line reversal to mask reception. To overcome the need for a second button to obtain coin refund, the circuit is arranged so that refund is obtained when the user replaces the handset.

Fig. 9—2-Button Multi-Coin Telephone, Local and Trunk Calling.

Fig. 10—Coin Telephone No. 1, 1-Button Multi-Coin, Local and Trunk Calling.

Vandalism Deterrents

On the introduction of "Silver Coin" operation and the Coin Telephone No. 1, the theft from and damage to public telephones increased to such an extent that special attention was given to re-inforcing the covers of the 2-Button Multi-Coin instrument and providing complete new cases for the Coin Telephone No. 1 and Variable Tariff public telephones (See Figs. 11A and 11B).

STD OPERATION

With the introduction of STD working, the need for a public telephone capable of making this type of call became imperative and a number of instruments, of overseas design, were examined to see if they would meet Telecom Australia requirements.

Two-Button Multi-Coin Type

In the interim, some 2-button multi-coin instruments were modified to accept only 20 cent coins. They were enamelled orange for distinguishing purposes and in conjunction with an exchange relay set, allowed 20 cents worth of STD calling. A limited number of these instruments were installed in holiday areas and some are still in use (See Fig. 12).

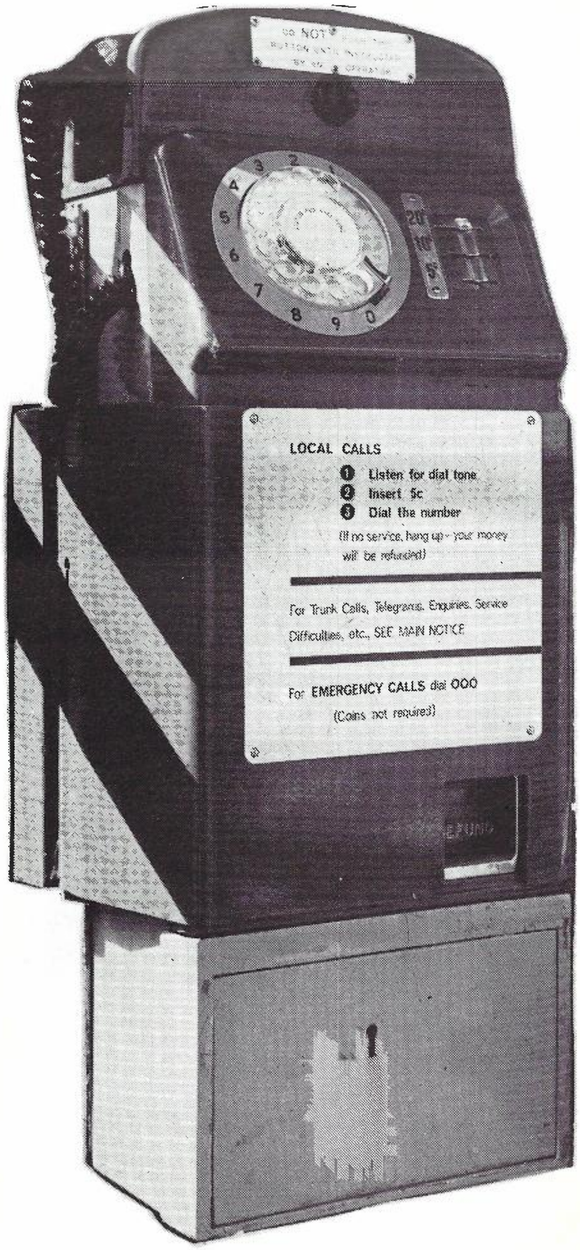

Fig. 11A—Coin Telephone No. 1, Vandal Proofed.

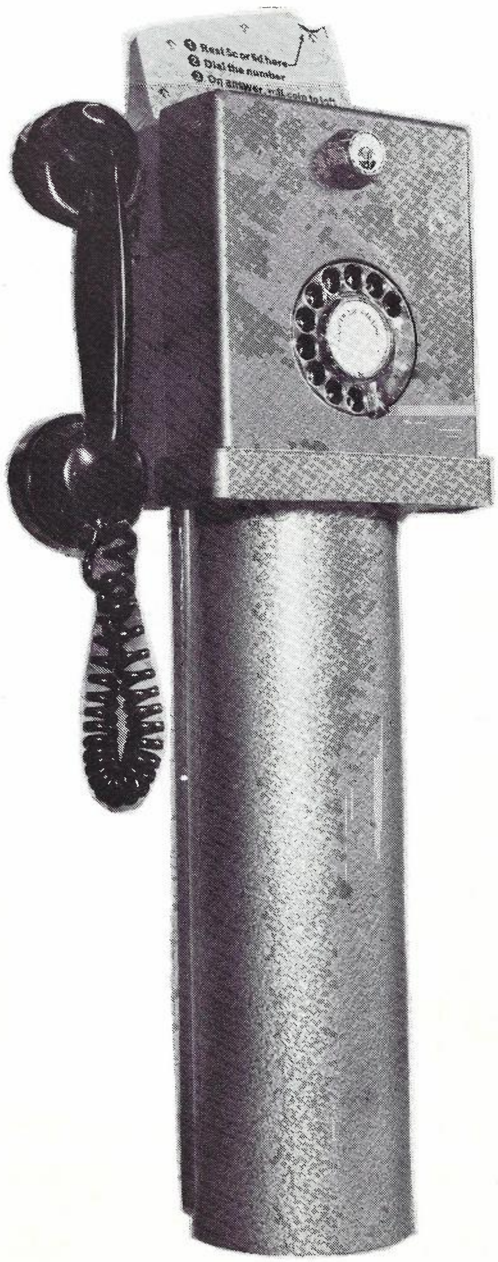

Fig. 11B—Unit Fee Telephone, NSW Workshops Production.

Coin Telephone No. 3

In 1971, an STD multi-purpose instrument, manufactured by the Anritsu Company of Japan and modified for local conditions, was introduced into Australia. (See Fig. 13.)

These telephones, named Coin Telephone No. 3, gave satisfactory operation during the initial field trial and further purchases have since been made. The additional units have improved circuitry and are fitted with a special Coin Telephone, 800 Series handset.

The instrument provides for Local Calls, STD Calls, Operator-assisted Calls and Emergency Calls, the latter can be made without coins during both normal and power fail conditions. The tones for the operator-assisted calls are similar to those of the Coin Telephone No. 1, that is, they are electrically generated on coin insertion.

For both Local and STD calling, the coins are collected by meter pulses obtained from a special relay set in the exchange and the power required for operation of the collect magnets, relays and semi-conductor circuitry is obtained from a continuous mains supply via a step-down transformer usually mounted in the cabinet's light fitting.

A warning light in the face of the instrument glows steadily when the last coin is collected on STD calls and this light begins flashing during the last paid charge period. On later versions the addition of an aural warning tone is being considered.

If an STD call terminates with coins still remaining in suspense, they are automatically refunded when the user replaces the handset on the switch-hook.

The collection of coins for operator assisted calls is similar to the Coin Telephone No. 1, that is, the operator requests the user to press the collect button when she is satisfied the correct amount of coins have been inserted. For later versions of the telephone consideration is being given to making this button functional only during operator-assisted calls, i.e., on any other type of call, the button is out of circuit which prevents coin collection should the button be operated inadvertently.

Should an attempt be made to make a chargeable call without the use of coins, the call is cut off on receipt of the first meter pulse from the exchange relay base. This has been done to eliminate free access to service calls such as "Time", "Weather" or "Sport" and as a protection should the instrument ever be offered as a leased service.

COMPANY COIN TELEPHONES, RED PHONES AND EASIPHONES

In 1963, the first of the Company Coin Telephones was introduced to the public. The Red Phones were then owned by the Victa Telecommunications Company (later VTC) and the Easiphones by Elliott Automation (Pty.) Ltd. who leased them as public telephones to various organisations such as Clubs, Hotels and Shop-keepers for a period of approximately 12 years. Because they were not available for 24 hours a day, they could not be called true public telephones but they offered valuable unit fee service as well as having some facilities, such as the pre-payment mode, which assisted in the assessment and development of Telecom Australia coin telephones.

The Victa Red Commercial and Domestic models and the Easiphone differ from the Telecom public telephones in that coins must be inserted before dialling can commence and are therefore true PRE-PAYMENT telephones.

Company Coin Take-over

In December 1974, Telecom Australia took over all of these telephones from the two private companies and these consisted of approximately 20,000 Red Phones and 2,000 Easiphones, the vast majority of which are leased services and this increased the number of Telecom coin telephones to almost 60,000 Units.

Fig. 12—2-Button "Orange" Multi Coin Telephone for 20 Cents of STD Calling.

Fig. 13—Coin Telephone No. 3, Multi-Purpose STD, Local and Trunk Calling.

Red Phones

There were three types of Red Phones on take-over, all manufactured by the Tamura Company of Japan. They consisted of the large Commercial model (2 types, one suitable for connection only to Step-by-Step and Reg-LM exchanges, the other for connection to both these exchange types and, by change of strapping, to ARK and Reg-LP exchanges). The third type was the smaller Domestic model, suitable only for connection to Step-by-Step and Reg-LM exchanges. (See Figs. 14A and 14B).

Easiphone

The Easiphone is a British development of the 2-button multi-coin telephone. They were initially designed for connection to Step-by-Step and Reg-LM exchanges but by simple means could be modified for ARK and Reg-LP exchange connection and can be easily recognized by their vivid green and yellow colouring. (See Fig. 15.)

Red and Easi Phones, General

A feature of these pre-payment coin telephones is inbuilt circuitry which renders them self-barring to STD and undesired levels; by use of a key they can be transformed into a standard telephone with access to STD and other levels if desired by the Lessee.

Unlike Telecom Australia public and leased telephones, which at that time operated on a local call charge of 5 cents, the majority of Red Phones and Easiphones required a 5 and 2 cent coin for their operation and although originally intended for use as leased services, a small number of the Red Phone Commercial models were installed as Public Telephones in some protected areas.

In July, 1975, a program was launched to convert all Coin Telephones to 10 cent operation. The Red Phones were the first to be converted followed by the original Telecom installations such as the 2 Button Multi-Coin, the CT1, the Variable Tariff Unit Fee, the Multi-Purpose Coin Telephone (CT3) and finally the Easiphones which are confined to New South Wales and Victoria.

POST OR PREPAYMENT MODES

Dialling is possible without coin insertion on the 2-Button Multi-Coin, the Coin Telephone No. 1 and the Coin Telephone No. 3 but they are generally used in the PRE-PAYMENT MODE. The Variable Tariff telephones differ from the ex-Company and all other coin telephones in that the coin should be inserted after the called party has answered and therefore they can be termed POST-PAYMENT telephones; a feature which often confuses the user.

Pre-Payment Unit Fee Telephone

Following a survey conducted in 1967-68 which showed that all country public telephones should be capable of making trunk calls as well as local calls, there was then some demand, in metropolitan areas, for instruments suitable only for making local calls. Because of this, and because it is desirable to have public telephones operate with a similar payment mode, a new pre-payment local call telephone was developed at that time to replace the only post-payment type, which was then, the variable tariff unit fee public telephone modified for single coin operation. The new telephone was named Coin Telephone No. 2.

Since the take-over of the Company Coin Telephones and the success of the Multi-purpose Coin Telephone No. 3, further development of the Coin Telephone No. 2 has not been pursued and their production and installation is confined to Victoria.

Fig. 14A—52 AUX Red Phone, Commercial Model.

Fig. 14B—674 AU Red Phone, Domestic Model.

The Coin Telephone No. 2 uses a modified vending machine mechanism for coin acceptance and is housed in a steel case designed to prevent all known methods of vandal attack. A special feature of the refund chute is a reinforced glass panel designed to give an indication of blockage and thus inhibit deliberate "stuffing" of the refund chute. (See Fig. 16.)

CONCLUSION

The future of public telephones is difficult to forecast accurately. It is well known that they often contain enough cash to reward determined efforts to steal from them and, in addition, ingenious individuals discover methods of manipulation which enables them to make free calls. The development of deterrents to prevent this type of call has been a challenge since their inception and this, no doubt, will continue and so it can be anticipated that improvements to case security and new deterrents for free calls will be necessary, as miscreants develop new tactics.

A large amount of information on public telephone working has been obtained by several specialized groups and this is being studied and used to form the basis of an improved Sales, Installation and Maintenance system. It would be desirable to have only one type of Public Telephone for all purposes and this is being seriously considered for the future which, of course, would take some considerable time before implementation because of the many types that require phasing out of service.

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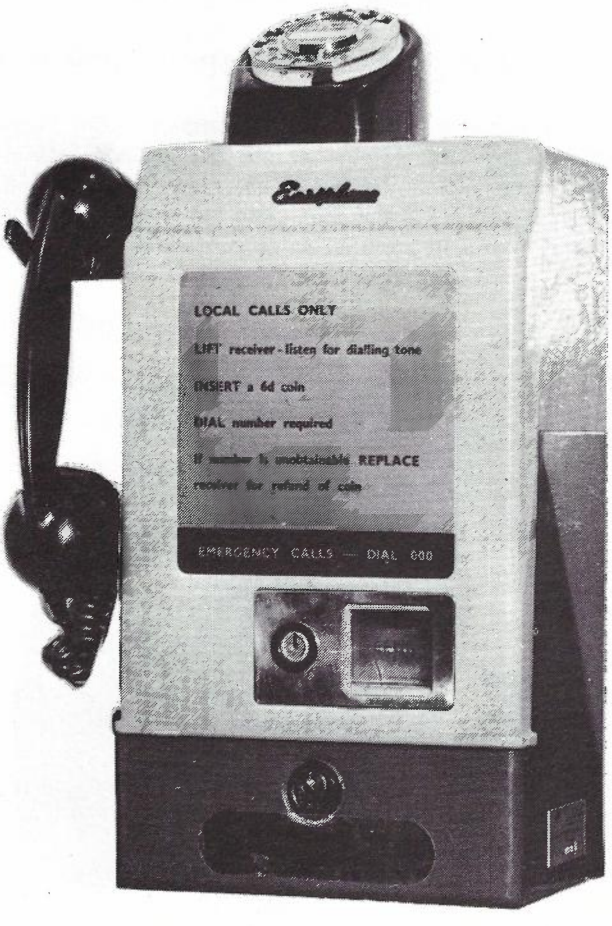
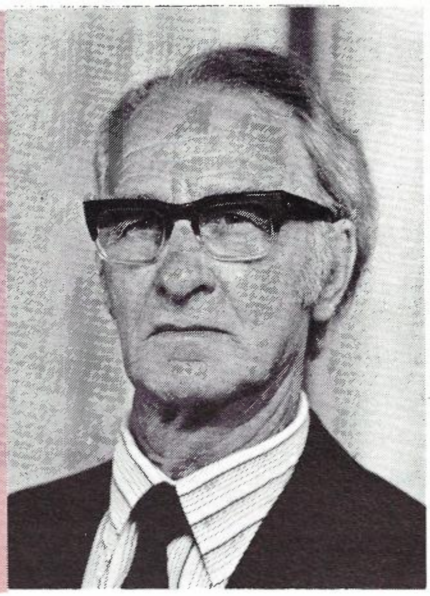


Fig. 15—Easiphone Coin Telephone.

Fig. 16—Coin Telephone No. 2, Local Call, Victorian Workshops Production.

J. C. COCKREM joined the staff of the Melbourne Postal Workshops as Technicians Assistant in 1939 after serving 5 years in the Victorian Railways. After 5½ years service in the AIF as a Signals NCO, he returned to the workshops and qualified as Senior Technician after completing the first Adult Technician-in-Training course from 1947 to 1950. From 1953 to 1960 he was Senior Technician, Long Line and Auto Equipment at the Ringwood Telephone Exchange. While serving as Telephone Inspector in Metro Service Central from 1960 to 1966 he became interested in Public Telephones and has retained his interest since transferring to Headquarters, where he is at present STO 3, Team Leader of the Telephone Subscribers Services Section, Network Performance and Operations Branch.



Teletraffic Congress to be held in Australia

Telecom Australia and the Australian Telecommunications Development Association are jointly sponsoring the Eighth International Teletraffic Congress which will be held in Melbourne from 10 to 17 November 1976.

The first International Teletraffic Congress was organised by Professor Arne Jensen, at that time of the Copenhagen Telephone Company, and held in Copenhagen in 1955. The success of this initial meeting assured the continuance of the Congress, and since that time, it has been held every three years. Later Congresses have been held at The Hague, Paris, London, New York, Munich, and Stockholm.

Since its inception, the Teletraffic Congress has fulfilled a role which is in many ways complementary to that of Working Party XIII/2 (Traffic Engineering) of the International Telegraph and Telephone Consultative Committee (CCITT). A close liaison has always existed between the two bodies, but in recent years the link has been formalised and the Teletraffic Congress is now recognised as an international organisation taking part in the work of the CCITT.

As in previous cases, the Melbourne Congress will deal with the application of the theory of probability to telecommunication research, engineering and administration. Within this general framework, the fields to be covered include single and multi-stage switching networks, local and trunk networks, common control systems, manual service systems, new simulation techniques, computional procedures traffic measurements, traffic engineering aspects of subscriber behaviour and reliability, planning and forecasting, dimensioning and service criteria, data network, and traffic problems in developing countries.

Past Congresses have attracted delegates from administrations, manufacturing companies and universities and the 8th I.T.C. will maintain this blend. The number of prospective delegates is about 300 of whom more than 230 are from overseas countries, and 150 papers will be presented during the 6 day technical programme.

Arrangements for the Congress, which will be held at the Southern Cross Hotel, Melbourne, are in the hands of a National Organising Committee whose membership includes representatives of Telecom Australia, ATDA and universities. The committee is chaired by Mr. I. A. Newstead of Telecom Headquarters.

Obituary – Mr. E. Sawkins

It is with deep regret that the Society records the passing away recently of Mr. E. Sawkins, OBE, a former Deputy Director General of the Australian Post Office. Mr Sawkins had a most distinguished career which commenced as Cadet Engineer in Sydney in 1928. His early experience included duties with exchange customer equipment maintenance and installation.

In 1945, he was selected to lead the first group of Engineers to specialise on the planning of telephone networks, and in 1950 he was appointed Supervising Engineer, Telephone Planning. Mr Sawkins made a number of notable contributions to those pioneering days of planning, and developed the first comprehensive plan to cover the development of the Sydney automatic network for a period of 20 years. He also developed a postwar rehabilitation plan for telecommunications services in New South Wales, a completely new phonogram system, and a street lighting control system for air raid precaution purposes. In September 1955, he was appointed Assistant Director, Engineering, New South Wales, and served as State Director for a short period.

In 1956, Mr Sawkins transferred to Central Office, where he was appointed Engineer-in-Chief. He formulated plans for the future development of the Engineering Division at Central Office, including the establishment of a separate major planning group.

Many important developments in national telecommunications took place under his leadership. The X-bar switching system was adopted, national plans were adopted for switching, numbering and call charging to pave the way for the introduction of STD, and the basic elements of the broad band transmission network were established.

In June 1964, Mr Sawkins was appointed Deputy Director General, the position he occupied until ill health forced his retirement in 1975.

As Australia's representative at the International Telecommunications Union meetings, Mr Sawkins displayed great interest in international telecommunications, making beneficial contributions to the Union. Upon his retirement in April 1975, the Secretary General of the ITU in a recorded greeting to Mr Sawkins said 'Your services over many years on the ITU Administrative Council, your important contributions to the future of the Union and your very useful work as Chairman of Committee Seven of the Plenipotentiary Conference will be remembered with gratitude.'

Another major interest was that of conservation. His interest was evident before the issue was generally recognised publicly. This was illustrated during the laying of the Melbourne to Sydney coaxial cable as he maintained an active interest in ensuring that re-instatement work was carried out, and that no individual was unduly handicapped by the laying of the cable.

The Telecommunications Society records its gratitude for the significant contributions Mr Sawkins made to the Society's work. He wrote six articles for the Journal, ranging from topics such as "Treatment of Concrete Floors in New Exchange Buildings" to "Worldwide Automatic Telephone Networks." He was Sub-Editor of the Journal from 1947-1954, and was the first Sub-Editor appointed outside Headquarters. He was Chairman of the Council of Control during 1962/63.

For his great contribution to the development of telecommunications engineering in Australia, Mr Sawkins was awarded the OBE in 1966. He was very well respected among all staff associated with him throughout his career.

Problems of Growth in Sydney's Telephone Cable Tunnels

K. T. ANDREW

The Sydney telephone tunnel network, built mostly around the year 1900, has served the city well for many years but is now becoming grossly inadequate, at least in certain sections. The congestion, which now limits its usefulness, complicates relief measures, which are difficult and expensive. Also the establishment of new major and hence heavily cabled exchanges, which must be linked with the existing tunnel system poses special problems at the intersection of the old and new systems.

This article surveys those problems and proposed solutions.

INTRODUCTION

The inner city area of Sydney has a network of underground telephone cable tunnels totalling about 16 km in length, encompassnig an area of about 4.8 km by 3.5 km (see Fig. 1), and while this network includes a few short sections which have been constructed in relatively recent times (see February, 1948 issue of this journal "New Tunnel for Telephone Cables — Pitt and Dalley Sts., Sydney"), by far the greater part of the network was constructed around the turn of the century actually between 1892 and 1901, mostly by the day labour resources of the Post Office or the Department of Public Works.

These tunnels are mostly of arched construction, commonly 1.8m (6'0") or 1.7m (5'6") high by 1.4m (4'6") wide, built of bricks said to have been brought to Sydney as ballast in the wheat and wool clippers of that time. They were apparently commonly built with only an earth floor, which usually housed a drain, the latter often being also a sewer, the two functions being combined in some of the older elements of Sydney's drainage system. The earth floors were later sealed with a layer of concrete. The average cost of the original 9.84 miles of construction was, according to old records £2/15/10½ per foot. This compares with the cost of current (March '76) extensions to the tunnel system of $1500 per foot (by cut and cover methods).

These tunnels have served Sydney well in the intervening period and, with the exception of a portion of the main Pitt Street tunnel in the Central Business District and certain other key intersections which are becoming very congested, are likely to continue doing so for many years, and they may be regarded as a monument to the foresightedness of our Engineering forbears.

There have been, however, two main areas of concern with these tunnels as Sydney grows. They both have to do with intersections; one has to do with original intersections and is due to a feature of the original design, the other concerns new intersections, generally associated with the establishment of new exchanges.

ORIGINAL INTERSECTIONS

All intersections in the original tunnel system were constructed in the one horizontal plane without any increase in tunnel height or width, so that cables traversing one tunnel tended to block the path of both cables and personnel from the intersecting tunnel. This may have been seen as only a minor inconvenience with the small number of cables envisaged at the time of construction, but it has assumed the proportions of a major problem in recent years in some of the more heavily cabled sections, such that personnel access has been virtually cut off and the accommodation and installation of cables rendered a hazardous and unworkmanlike affair; see Figs. 2 to 3, which show examples of two single level tunnel intersections.

Fig. 2 depicts the condition of the intersection of the main Pitt St. tunnel with the Liverpool St. tunnel in 1959, and many more maximum size cables have been added since that time. Fig. 3 is a recent picture of the intersection of the York St. and Barrack St. tunnels, a fast growing intersection on routes between York and other city and near city exchanges.

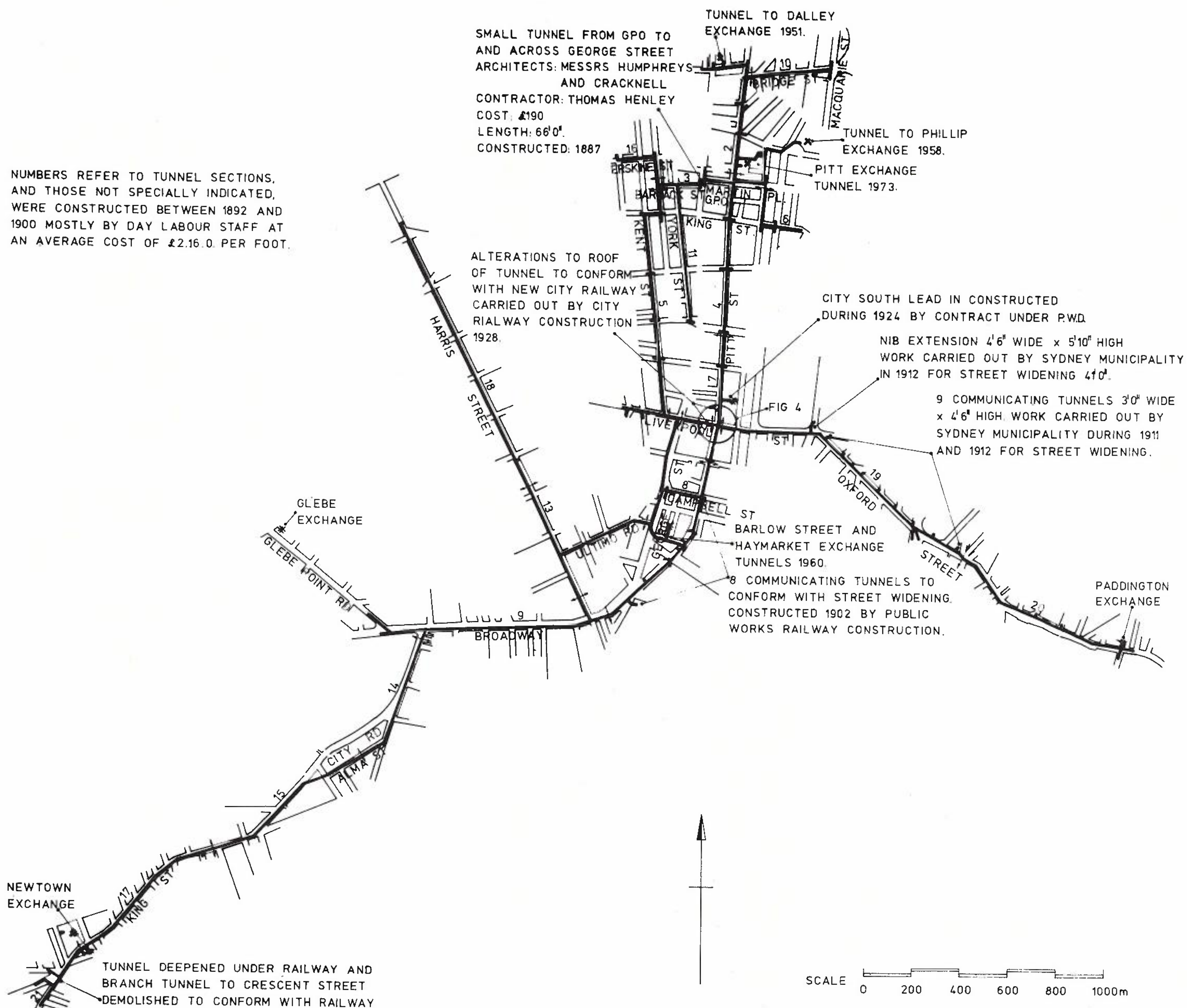


Fig. 1—Sydney Telephone Tunnel Network.

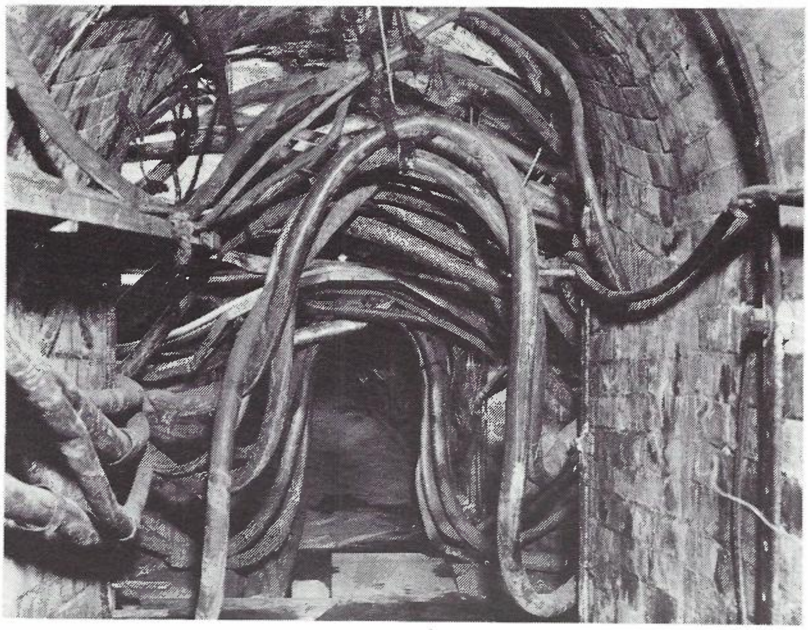


Fig. 2—Intersection, Pitt St. and Liverpool St. Tunnels (Before Reconstruction).

From time to time over the years minor ameliorating steps were taken at the worst intersections, consisting chiefly of the provision of small underpass chases in the floors of tunnels at the intersections but these were, at best, palliatives and in turn became problems as the number of cables grew. Examples of these can be seen in the bottom left foreground of Figs. 2 and 3.

Over the past several years a steady programme has been undertaken of rebuilding the worst of these congested intersections in order to provide unimpeded paths through them for cables and personnel. By the time congestion has dictated the need for reconstruction, the operation is lengthy and involved, often difficult and usually quite expensive. Both the intersections depicted above have now been reconstructed and the solution in respect of the Pitt and Liverpool Sts. intersection (Fig. 2) is seen as having established the principles to be adopted in such intersections and the details of this case may, therefore, be of interest.

In re-designing such an intersection, apart from drainage, lighting and ventilation, the following needs must be met:

(a) A path for every cable, existing and proposed, which will provide—

- Adequate support in the form of runway or bearers;
- At least minimum recommended bending radii, where cables have to traverse curves;

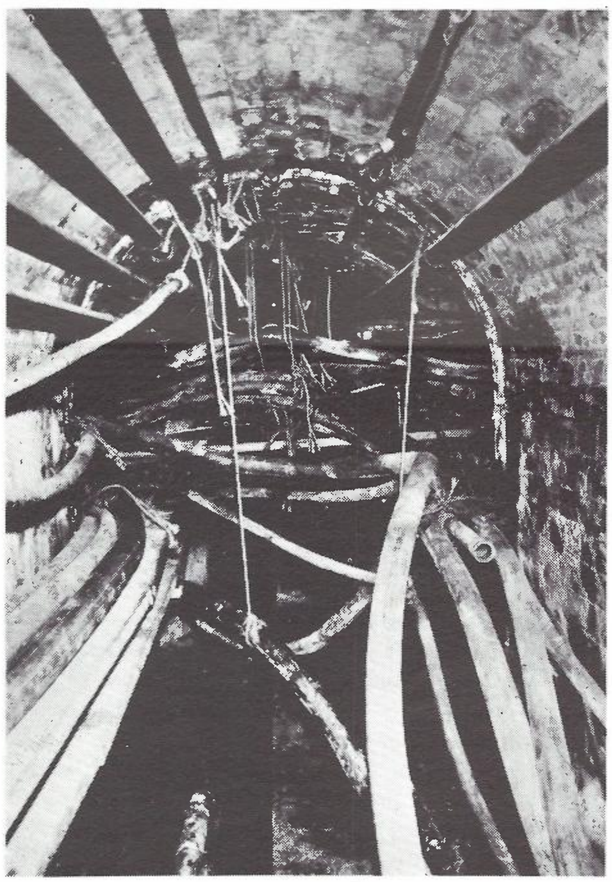


Fig. 3—Intersection, York St. and Barrack St. Tunnels.

- Accessibility for cable hauling operations;
- Protection from possibility of mechanical damage, where necessary;
- Accessibility for repair, should this become necessary.

(b) Unimpeded passage for personnel in all directions involving—
- Head-height clearance (2 m);
- Properly designed access in any direction through the intersection;
- Safety devices for ladders, hatchways, etc.;
- Adequate lighting.

(c) Fixtures to facilitate cable hauling, where necessary.

(d) Adequate access from surface level.

As a general rule, the above specifications require at least a two-level under/over-pass arrangement, with corner radii of 1.2m minimum and some form of guarded hatchway and ladder to give personnel access between different levels.

Fig. 5 gives details of the method adopted in the reconstruction of the intersection depicted in Fig. 2 and Fig. 4 (locality sketch), while Fig. 6 is a recent photograph of the reconstructed intersection, now some years after completion. The work was carried out by a Departmental Primary Works conduit party with pneumatic tools from within the existing tunnel, access for all purposes and egress for spoil being provided by an existing manhole enlarged for the purpose, located some 13 m from the intersection, see locality sketch in Fig. 4.

As will be seen from Fig. 5, the main feature of the method adopted was to excavate alternate sections of about 1.6 m length of the Liverpool Street tunnel to final depth, underpin the walls of these sections, then excavate the remaining sections, followed by underpinning of those sections of wall. The new floor was then poured and the walls finished by plastering of joints, etc. As the excavated material was a soft rock, no problems were anticipated in having the walls of the first series of excavation stand up; no special supports were provided and no troubles were encountered.

As may be expected from the location in a busy city intersection, and outside a busy department store, the operation which extended over some 6 months (including the Christmas period during which it was necessary to close the job down), caused interruption and congestion to vehicular and pedestrian traffic and required considerable liaison with other public utilities, including the diversion of a large sewer at a cost of approximately £4,700 in the currency of the day.

The reconstructed intersection has now been in

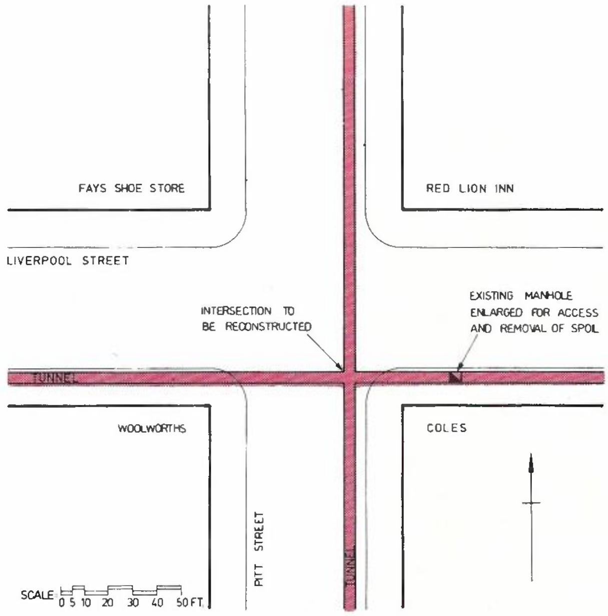


Fig. 4—Locality Sketch, Intersection of Pitt St. and Liverpool St. Tunnels.

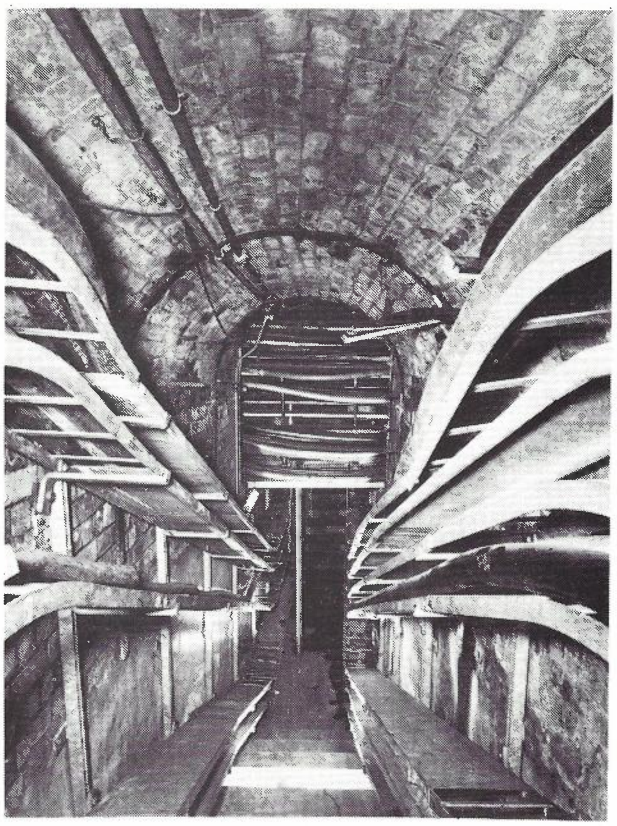


Fig. 6—Intersection and Underpass, Pitt St. and Liverpool St. Tunnels (After Reconstruction).

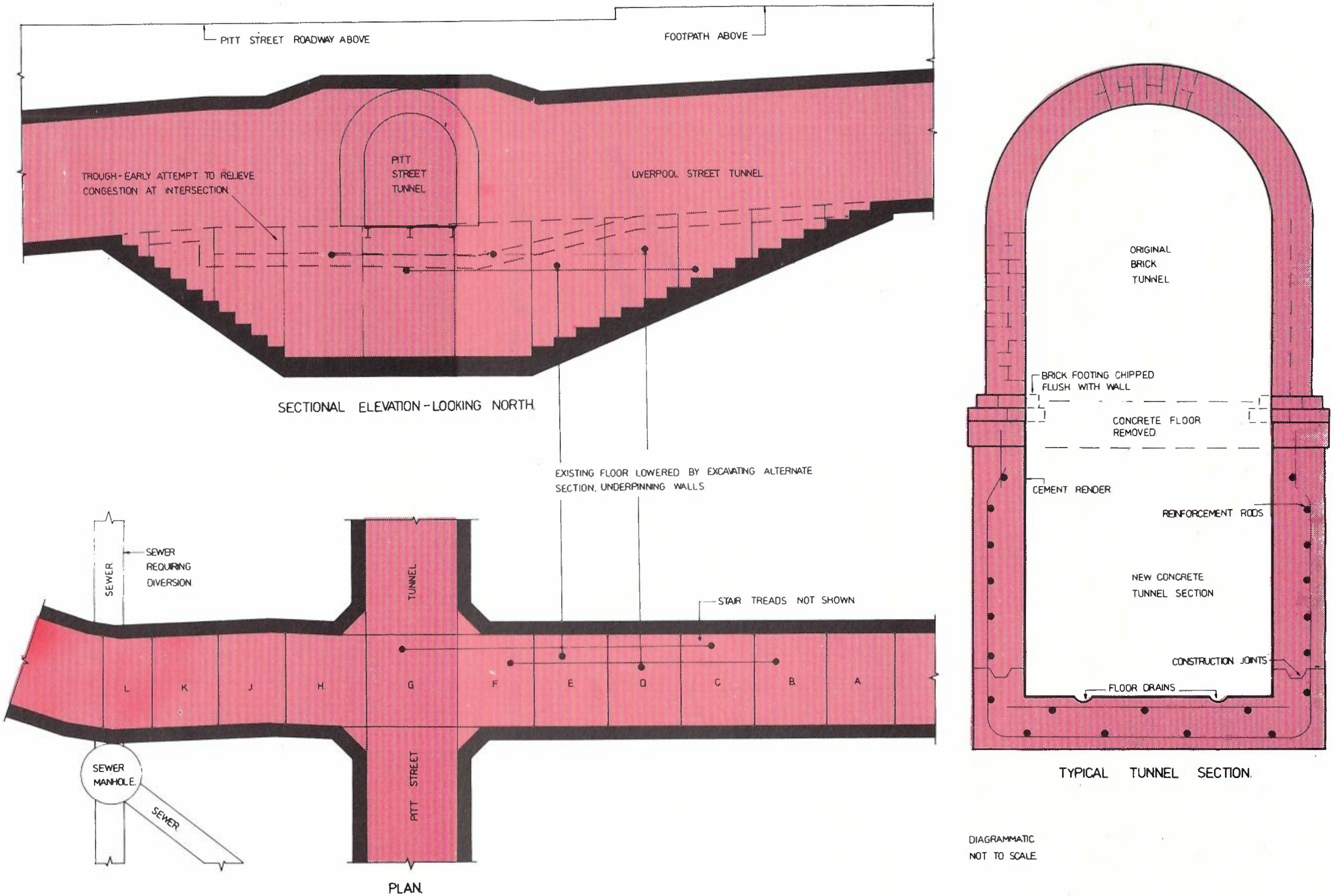


Fig. 5—Underpass, Intersection—Pitt St. and Liverpool St. Tunnels (Method of Construction).

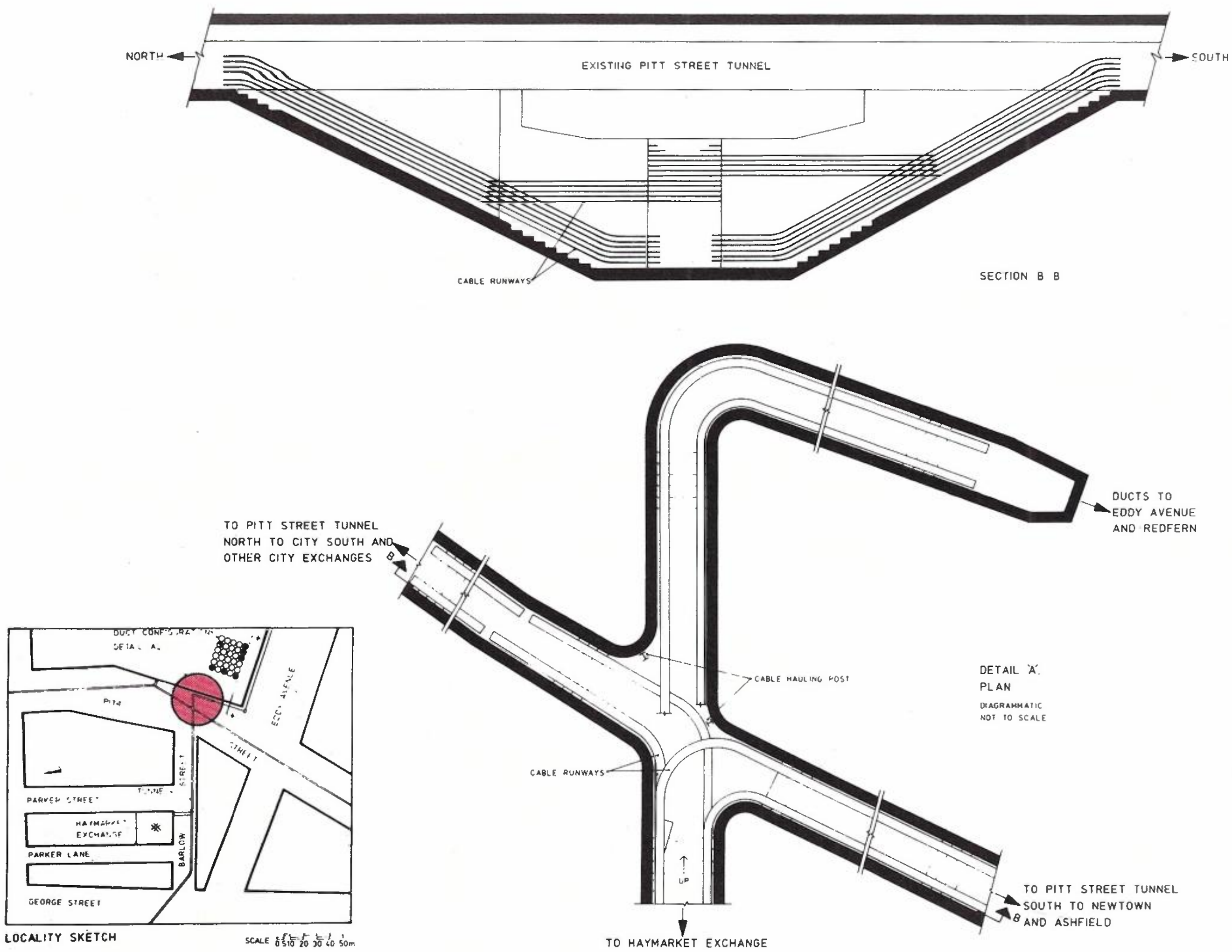


Fig. 7—Intersection, Pitt St. Tunnel and Haymarket Exchange Break-off (General Arrangement).

use for some years and, as shown in Fig. 6, has proved the design by the manner in which it has facilitated the installation of numerous additional cables whilst still maintaining order, accessibility and unimpeded access through and between tunnels for personnel.

NEW INTERSECTIONS

The term "new" may be liberally interpreted in this context to mean, substantially, other than original, and the "new" intersection which has set the pattern for succeeding years and is likely to continue into the future was, in fact, constructed some 14 years ago in connection with the establishment of the first Haymarket Exchange.

In this case the problem was how to provide for the introduction of an ultimate of 156 cables from the Haymarket Exchange into the existing tunnel network, of which some 60 were to be injected into the Pitt Street tunnel, the main backbone tunnel of the network. The many examples of the inadequacies of the single-level intersection generated a determination to develop a design which would give an assurance of meeting the ultimate requirements in an orderly manner.

The concept finally adopted should be credited to Mr. R. J. Kanaley, at that time Supervising Engineer, Primary Works, in Sydney and now retired. It consisted of constructing a new tunnel along Barlow Street from the new exchange so as to approach the Pitt Street tunnel at right angles, but at a lower level. The connection between the Barlow and Pitt Street tunnels was made by two short ascending tunnel sections in the line of the Pitt St.

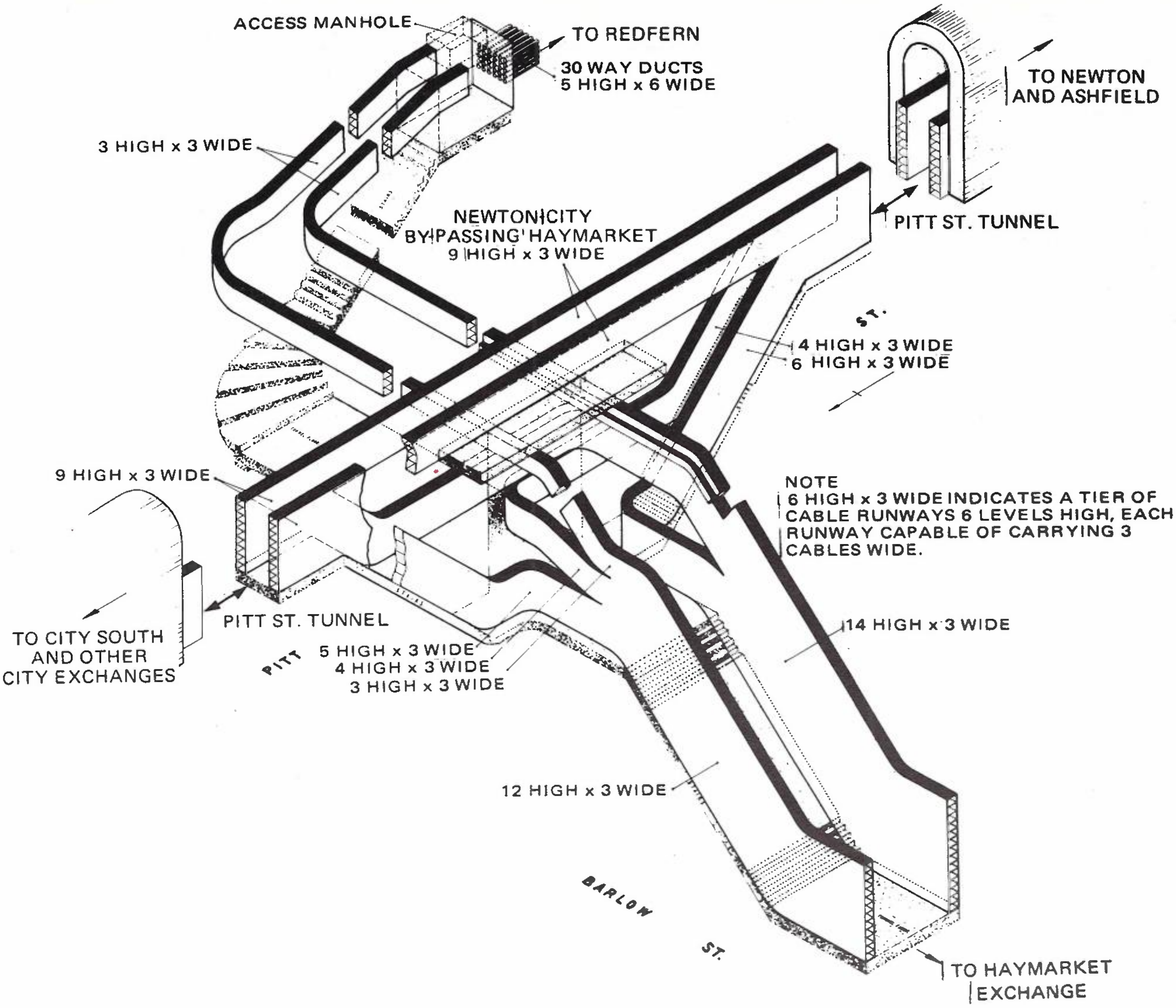


Fig. 8—Intersection, Pitt St. Tunnel and Haymarket Exchange Break-off, Cable Runway Complex.

tunnel, one for each direction, which broke, from below, into the floor of the existing Pitt Street tunnel, a portion of which was maintained intact between the break-in points. The top racks in the existing Pitt Street tunnel were dedicated to "through" cables, the lower racks to cables dropping and diverting to the new exchange. To permit cables from both sides of the Pitt Street tunnel to turn westward into the Barlow Street tunnel and thence into the Haymarket Exchange without cutting off personnel movement, a very high ceiling was provided in the intersection underneath the Pitt Street tunnel, thereby also providing a track for 18 cables (ultimately) to pass at high level, through the complex to another route (Eddy Avenue) out of Haymarket.

An idea of the general arrangement may be gained from Figs. 7 and 8 while Fig. 9 is a recent photograph of the complex.

The depth of construction required by the proposed intersection virtually dictated tunnelling methods, as distinct from "cut and cover", and test bores indicated that it would be advantageous to go deeper still in order to reach rock giving better tunnelling conditions. In the event, this geological information proved to be unrepresentative of the general nature of the ground and a good deal of

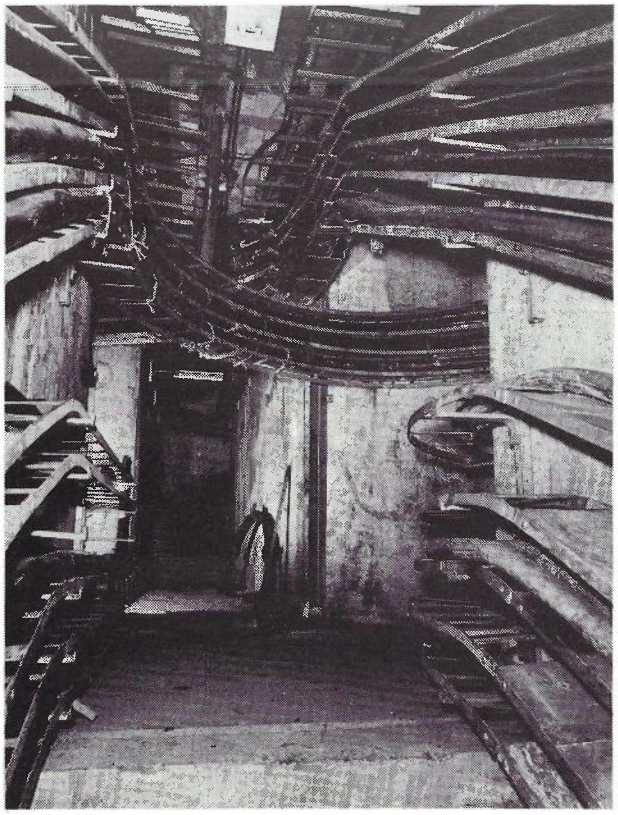


Fig. 9—Intersection, Pitt St. Tunnel and Haymarket Exchanges Break-off (General View from Tunnel Leading to Haymarket Exchange).

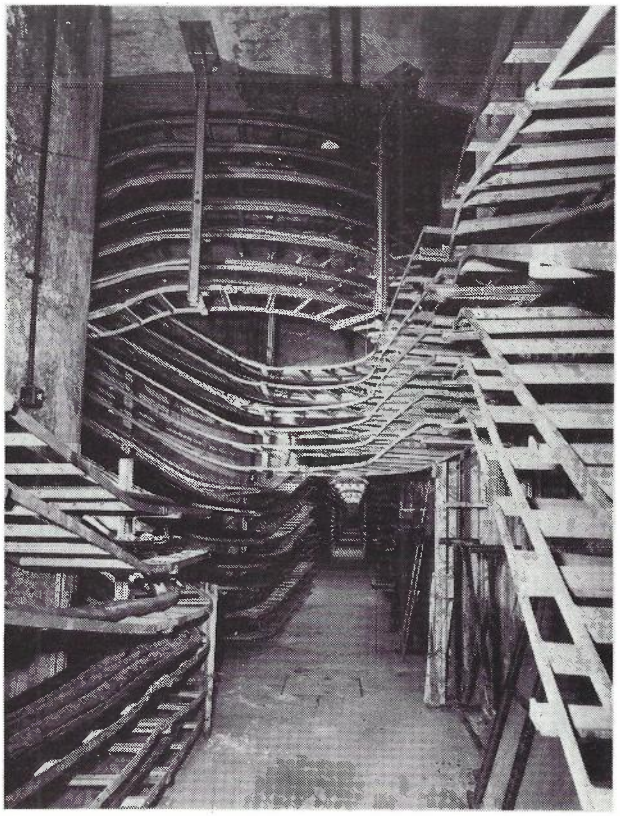


Fig. 10—Haymarket Exchange Cable Entry. (Steps to Cable Chamber Ascend to Left of Picture; Tunnel in Background Leads to Breakoff from Pitt St. Tunnel—see Fig. 9.)

trouble was experienced with loose and soft rock and with water from the fissures therein, but this is the reason for the otherwise unnecessary depth of the Barlow Street section of the tunnel, and the entry to the Exchange Cable Chamber.

The same functional design principles were applied to the intersection of the new Barlow Street tunnel, provided at the same time, with the actual entry to the Haymarket Exchange. Although only a nominal single "level" intersection was constructed, it was of such a height as to provide the space for planned distribution of racks for 150 cables in four basic directions, plus the unimpeded passage of personnel, see Fig. 10. The great height of a large proportion of the cable racks dictated the necessity for the use of a working platform for cable hauling staff, and a quantity of dismantable scaffolding is stored in the intersection for that purpose, as may be seen against the right hand wall in Fig. 10. This feature is now seen as a weakness in this design, experience showing that it is safer and more efficient to so arrange the design to include permanent platforms.

The functional design for all the tunnel construction associated with the Haymarket Exchange was carried out by Departmental Engineering and Drafting staff; the structural design and construction was, in this case—because of its magnitude—carried out by the Commonwealth Department of Works (now Australian Department of Housing and Construction).

CONCLUSION

Although the three instances dealt with in this article were designed and constructed several years ago, they are of current significance in that they established principles and applied them on a scale which can fairly claim to have pioneered the necessity to "think big" in the area of underground cable accommodation. This is an area where adequate provision for the future means very expensive construction but "skimping" will establish a monument of inefficiency and set the stage for appalling tangles of cables in the future.

The success of the designs detailed herein and the now (after a relatively few years) demonstrable justification for such large "holes in the ground", supports a continuing programme of similar major, though increasingly complex and varied underground chamber and tunnel construction. It is hoped to present details of the other examples of these in future issues of this journal.

Mr. K. T. ANDREW joined the Postmaster General's Department in Sydney N.S.W. in 1936 as a Junior-Mechanic-in-Training and after 2 years service in that position, spent 2½ years as Clerk Third Division, and 9 years as Draftsman and Sectional Draftsman in the Sydney Drawing Office.

Having completed the Diploma in Radio Engineering at the Sydney Technical College in 1947, he transferred to the position of Engineer in 1949.

After experience in the Telephone Planning, Equipment Installation and Metropolitan District Works Section in Sydney, he transferred to the Primary Works Section in 1954 and has been engaged on the installation of major underground plant since that date.

He now occupies the position of Asst. Superintending Engineer, Programme and Resources Co-ordination (External Plant) Construction Branch, Engineering Department, of the newly constituted Australian Telecommunication Commission, in N.S.W.

He is a Member of the Institution of Engineers, Australia.

International Computer Seminar

Some of the world's most experienced and qualified practitioners of data communications will be the leading speakers at a seminar entitled "Data Communication Technology and Practice" being organised by the International Federation of Information Processing (IFIP) and the Australian Computer Society (ACS) in Sydney on August 24, 25, 26 this year.

The ACS feel that this seminar offers a unique opportunity for the professional development of its members in this most important area of computer technology. It will be some years before the IFIP Committee meets again in Australia and consequently this will be a big opportunity to allow members to participate in a seminar with so much international experience represented.

The programme will consist of:

Day 1 Policies and future trends

Common carrier policies, outline of current status of communications network development, future needs and trends in Australia and overseas, international data communications.

Day 2 Networks in practice

Practical experiences drawn from a number of countries data communications standards, local issues relating to equipment selection, operations and the centralisation/decentralisation debate with specific reference to commerce and industry.

Day 3 Operational probems and Application workshops

Terminal environment issues including a discussion of industrial problems and design factors affecting the specification of a terminal and the systems specification.

Persons interested can obtain further details of the conference by contacting the NSW Executive Secretary Graham Neale, at P.O. Box N250, Grosvenor Street, Sydney, 2000. (Phone 02 276399). Students will be registered for half the above amounts.

Coaxial Cable, Spare Drum Quality — Some Impedance Considerations

W. J. STRAIN, B.E.

Spare drums quality cable is used for replacement purposes such as cable faults and deviations in working coaxial cables. Despite its high quality, it may introduce comparatively high impedance mis-matches. This article examines the extent and effect of these possible mis-matches on the transmission performance of the cable. The findings are confirmed by the results of a fairly large sample of tube/repeater sections.

INTRODUCTION

The concept behind the use of Spare Drum Quality (SDQ) coaxial cable is that the "close specifications" on the manufacture of such cable will permit its use for replacement purposes, cable faults and deviations, without causing any degradation to the transmission performance of the working cable (Ref. 1). However, it is possible that the jointing of SDQ cable into a working cable could introduce significantly larger mis-matches than those normally encountered in a properly designed cable route. It will be shown that such mis-matches will not prejudice the Transmission Acceptance Limits for a coaxial cable repeater section.

The specifications for SDQ cable are:
End Impedance 75.05 ohm ± 0.1 ohm
Echo Attenuation > 60dB

where End Impedance is a measure of the input impedance of the cable with the far end of the cable terminated in a network which closely matches the end impedance of the tube at a frequency of 2.5 Mhz;

and Echo Attenuation is a measure of the reflections (of signal energy) caused by impedance irregularities in the tube, i.e., echo attenuation =

$$20 \log_{10} \frac{\text{Sending end amplitude of trans. pulse}}{\text{peak amplitude of reflected signed}}$$

These terms, and their measurement, are covered in full detail in the various references (Ref. 1, 2 and 3). Incidentally, the nominal impedance of factory drums lengths is quoted at 0.05 ohm higher than that of installed cable (75 ohm) to allow for the cable drawing in process which causes elongation of the tube with resultant contraction in tube diameter and reduction of end impedance.

DRUM SCHEDULING

The normal drum scheduling on a coaxial cable route is on the basis of a maximum impedance mis-match of 0.20 ohm between successive drums lengths which corresponds to a reflection of 57.5 dB return loss. However, the specifications for factory lengths constituting a repeater section allow a tolerance of ± 0.30 for 90% of all tube measurements (of end impedance) and up to ± 0.50 ohm for 100%. In general, such wide deviations in cable impedance, from the nominal 75 ohm, would occur some distance from the repeaters as the impedance tolerances at repeaters are restricted to 75± 0.15 ohm for all tubes.

Figure 1 shows, in part, the drum allocation sheet for the City South-Gore Hill T85 8 tube coaxial cable. It will be seen that the impedance of tube 4 drops to a value of 74.55 ohms, that is —0.45 ohms below the nominal value, at the end of drum length No. 11 corresponding to a distance of 1736m from City South and 3766 from the first 12MHz repeater. The impedance of this drum length is only just within the maximum tolerance of ±0.5 ohms. However, it took an examination of over 2000 tube/repeater sections to find a cable of such wide variation in end impedance.

It might be noted that due to the introduction of colour TV transmission in this cable, additional repeaters for 21MHz video equipment have been installed. The above impedance irregularity is now within 742m of this new repeater site.

DRUM Nº	C774	C703	C757	C747	C708	C755	C758	C713	C734	C733	C767	C736	C749	C694	C696	C740	C744	C727	C724	C715	C702	C729	C752	C731
LENGTH (m)	70.4	163.7	214.8	109.7	217.6	206.6	216.7	213.9	74	135.3	89.6	83.2	100.5	120.7	102.4	102.4	85	221.2	129.8	113.3	158.2	216.7	232.2	224.9
ROTATION Nº	1	2	3	4	5	6	7	8	9	10	11	12	13a	13b	14	15	16	17	18	19	20	21	22	23

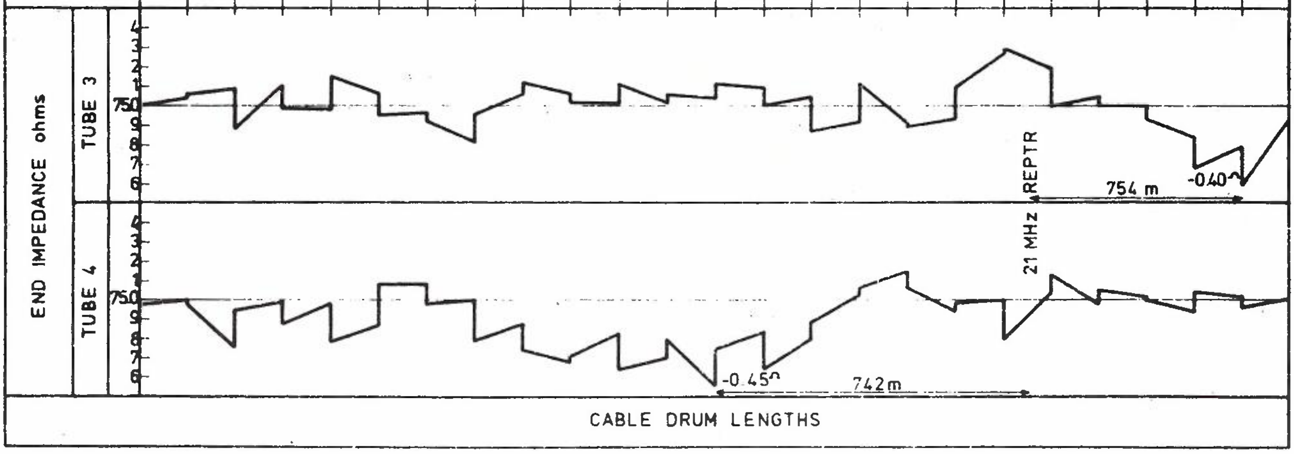


Fig. 1 — Coaxial Cable Drum Allocation Sheet for T85 City Sth-Gore Hill (in part).

WORST MIS-MATCH

The worst mis-match that could be introduced by jointing SDQ cable into a working cable could then be as high as 0.6 ohms where the tolerances of the working cable and SDQ cable are at a maximum and of opposite sign.

e.g., working cable: 74.5 ohms (—0.5 ohm)
SDQ cable: 75.1 ohms (+0.1 ohm)

This is a much higher level of mis-match than that laid down for normal drum allocation (0.2 ohm).

However, depending on the location of a possible mis-match of 0.6 ohm, it can be shown that it would not normally cause any significant reduction in the transmission performance of the cable and that the cable would still meet the Transmission Acceptance Limits.

TRANSMISSION ACCEPTANCE LIMITS

The transmission acceptance limits for impedance irregularities in coaxial cable are as follows:

Worst Reflection — Echo Attenuation without correction (WUC) — 54 dB.

Worst Reflection — Echo Attenuation with correction (WC) — 48 dB.

RMS of 3 worst corrected reflections (3WC) — 51 dB.

Each of these limits may individually be reduced by 2 dB in a given repeater section providing other repeater sections in the cable are much better than specifications and that only one of the above TAL's are affected. (Ref. 2).

EFFECT OF WORST MIS-MATCH

The effect of the worst possible mis-match of 0.6 ohms on the Transmission Acceptance Limits is shown in the following treatment.

Worst Un-corrected (WUC)

A mis-match of 0.6 ohm represents a reflection of:

48 dB if located right at a repeater.
52 dB if located 3 μ secs (430m) from repeater.
54 dB if located 4.5 μ secs (640m) from repeater.

These reflection measurements are carried out with a Pulse Echo Test set (PET). In a WUC measurement, no allowance is made for the attenuation of the pulse as it travels down the tube. The PET set is calibrated so that distance to the reflection is shown in time taken (μ secs) for the pulse to reach the reflection; then as pulse travels at about 144m/μ secs, the distance to the reflection can be accurately calculated and, from established Pulse Attenuation vs length characteristics, the extent of Pulse Attenuation can also be calculated.

So a reflection of 0.6 ohms mis-match some 640m from a repeater would meet the WUC specification of 54 dB. Relaxing these limits by 2.0 down to 52 dB would allow the mis-match to be within 430m of a repeater.

However, it is most unlikely that the use of SDQ cable close to a repeater could cause a mis-match as large as 0.6 ohms as the drum allocations are normally arranged such that drum lengths with wide tolerances are placed well away from the repeaters, preferably in the centre of the repeater section and the tolerance for end impedance at repeaters is restricted to 75 ohms ± 0.15 ohms. The sample of over 2000 tube/repeater sections, referred to in "Drum Scheduling", indicated that the largest impedance variations were:

0.35 ohms at 430m from a repeater
0.45 ohms at 640m from a repeater

and both of these mis-matches represent reflections of 56.5 dB. Furthermore, these results occurred in only one of the cables covered in the sample; cable T85 previously referred to in the section on "Drum Scheduling" was one of the earliest cables laid in NSW (1961). All of the other cables in the sample were to much closer tolerances, the largest impedance variation being 0.25 ohms at a distance of 640m from a repeater.

On the basis of this sample then, the use of SDQ cable for faults and cable deviations could not prejudice the WUC Transmission Acceptance Limit of 54 dB irrespective of its location in the repeater section.

Worst Corrected (WC)

A mis-match of 0.6 ohms represents a WC reflection of 48 dB irrespective of its location in the repeater section.

The reason for this statement is, of course, that irrespective of the location of the mis-match, the pulse attenuation to that location is allowed for in making the measurement.

For example, if the distance to the mis-match is 4.5 μ secs, corresponding to a pulse attenuation of 6.0 dB, the gain of the Receive Amplifier in the PET set would be increased by 6.0 dB to effectively bring the mis-match right up to the PET set.

So again, the use of SDQ cable in any part of a repeater section will not degrade the WC Transmission Acceptance Limit of 48 dB.

RMS of 3 Worst Corrected

The effect of a mis-match of 0.6 ohms on this specification can best be gauged by assessing the magnitude of the other two reflections, after making allowance for a reflection of the order of 0.6 ohms.

The limit value of 51 dB corresponds to 0.28% reflection of the line pulse.

Figure 2 — Return Loss, Mis-match and Reflection Factor Nomogram provides a quick method for determining any two of these three parameters from a knowledge of only one parameter.

e.g., 0.15 ohms mis-match corresponds to 60 dB Return Loss and 0.15 ohms mis-match corresponds to 0.1% Reflection factor.

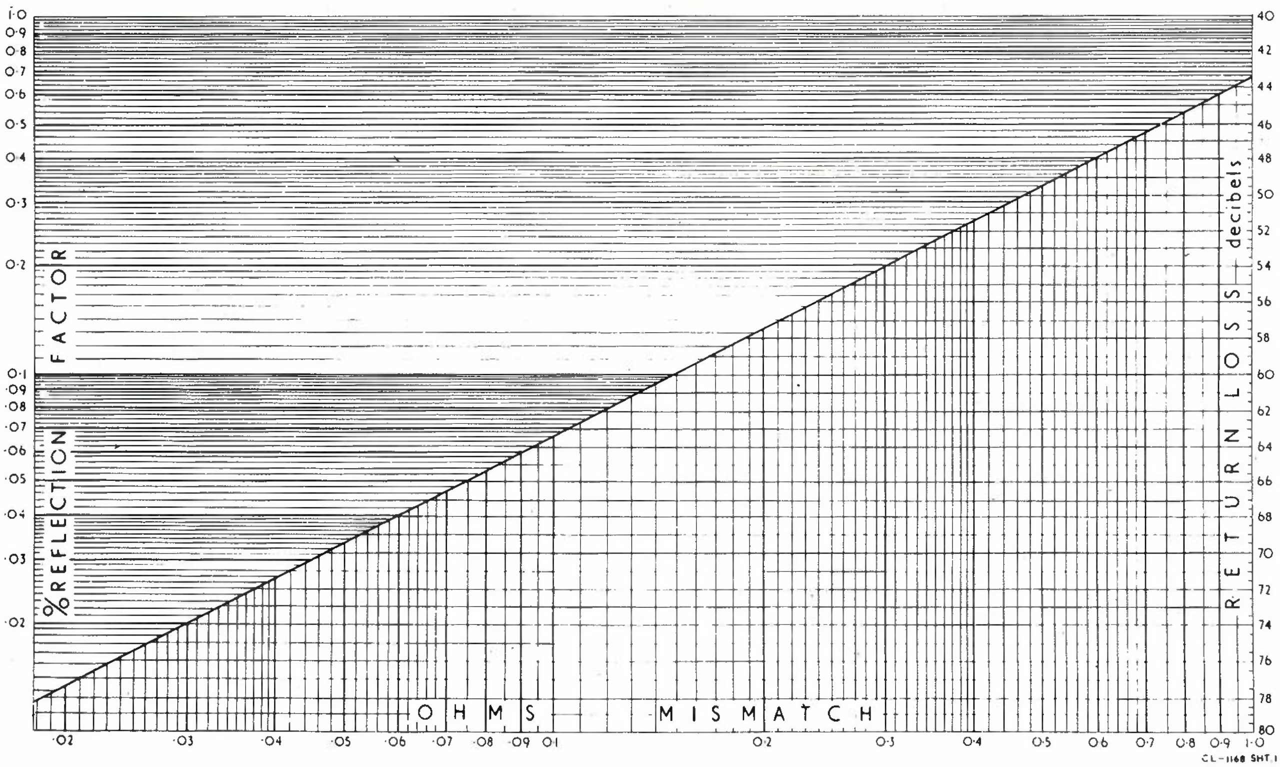


Fig. 2 — Return Loss Mis-match and Reflection Factor (extracted from E.I.—Lines, Cables T2431).

The RMS of the 3 WC reflections is calculated as shown below, the individual echo attenuation, in dB's, being converted to % reflection factors

$RFz = \sqrt{[(RFa)^2 + (RFb)^2 + (RFc)^2]/2}$

let RFz = 0.28 % (A reflection factor of 0.28 % corresponds to a return loss of 51 dB, the limiting value for the RMS of the 3 WC) then $(RFa)^2 + (RFb)^2 + (RFc)^2 = 3 \times 0.28^2$

$= 0.2352$

Let RFa = 0.4 % (0.6 ohms mis-match) and assume RFb = RFc then $RFb = RFc = \sqrt{0.2352 - (RFa)^2/2}$

$= 0.195\%$

and from Figure 2, this corresponds to a reflection of 54.2 dB, on a mis-match of 0.295 ohms.

The limit value of the RMS of 3WC will then permit, in addition to a large 0.6 ohm mis-match, two fairly large mis-matches of the order of 0.295 ohm.

The sample of tube/repeater sections indicated that the two largest reflections that could be encountered as components of the RMS of 3WC were 0.31 ohm and 0.245 ohm. The RMS of these two reflections plus a reflection from a 0.6 ohm mis-match gives a value of 0.277 % reflection factor corresponding to 51.2 dB for the RMS of 3WC..

This final test again confirms that SDQ cable will not degrade the Transmission Acceptance Limits.

One last point here, if the limit value for the RMS of 3WC were to be relaxed by 2.0 dB, ie, reduced down to 49 dB, what would be the magnitude of the two largest reflections that could then be tolerated?

CONCLUSION

The objective of this article has been to demonstrate that the use of SDQ cable for fault or deviation purposes in a working coaxial cable, although possibly introducing a mis-match as large as 0.6 ohm, will not degrade the transmission performance of the cable irrespective of the distance between the repeater and the cutover joint of the SDQ cable.

A sample of over 2,000 tube/repeater sections confirms that the Transmission Acceptance Limits would also be met without any relaxation of these limits.

One final point; the author is not recommending the whole-sale use of SDQ cable for deviations as this would be extremely wasteful of a very expensive commodity — SDQ cable. The usual practise, of course, for any planned deviations is to order coaxial cable to match the end impedances of the working cable at either side of the proposed deviation. The local state Transmission Measurement Sections maintain records of all drum allocation sheets and can supply this information on request.

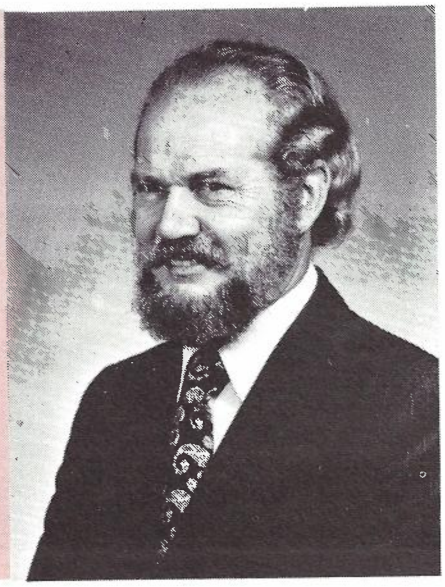
It is essential that stocks of SDQ coaxial cable be conserved for fault restoration and urgent cable deviations.

REFERENCES

1. Engineering Instruction — Lines Cables A3902 — Cable Design and Impedance Considerations.
2. Engineering Instructions Lines Cables T2431 — Coaxial Cable Transmission Acceptance Tests.
3. Information Bulletin No. 40; External Plant — Acceptance Testing of Coaxial Cables.

W. J. STRAIN joined the P.M.G.'s Department in 1946 as a Technician-in-Training and, after working as Technician and Clerk in the Engineering Division, commenced as a Trainee Engineer in 1957. On graduating from the University of N.S.W. with the Degree of Bachelor of Engineering in 1961, he worked as an Engineer in Lines Planning, Transmission Planning and Internal Plant Planning. In 1969 he was appointed Divisional Engineer, Transmission Measurements and is currently acting in the position of Supervising Engineer, Line Practices and Protection Section.

He is a committee member and lecture organiser of the N.S.W. Division of the Society and a member of the Institute of Engineers, Australia.



The East-West Microwave Radio Relay System – A South Australian Operational Report (Part 2)

D. R. WATSON, B.E. and L. J. WILLIAMS, B. TECH.

The East-West Microwave Radio Relay System was, at the time, the largest broadband project ever to be undertaken by the Australian Post Office. It completed the first broadband link between Perth and the rest of Australia. Special design concepts, outlined in a description of the new system given in issue 1, Volume 21 of the Journal (February 1971), were used to overcome problems peculiar to the situation.

This first part of the South Australian report reviewed traffic performance and reliability aspects of the system in the light of these concepts and changes found necessary to them under operational conditions. The second part describes the maintenance philosophy adopted in South Australia, the staff organisation, and also the modifications found necessary to optimise equipment performance and maintenance costs.

MAINTENANCE PHILOSOPHY

During the design stages of the project, it was decided that maintenance would be carried out, as far as possible, by unit replacement. Faulty units were to be returned to a central base for overhaul and subsequent re-alignment.

As a result, no spare components are held at repeater sites. Instead, a complete set of spare units, or modules, is available at the Base Repair Centre (BRC). The appropriate unit for replacement is determined by analysis of the supervisory system which displays the state of the equipment at the remote repeater sites.

This original maintenance philosophy placed emphasis on the need for the safe transport of units between the BRC and the distant sites. As road transport is involved in almost all unit movements, early design efforts were directed towards the development of a special transit case to meet these needs.

It is also envisaged two distinct points of continuous control for the system.

One of these was the Maintenance Control Centre (MCC) located at Kongwirra (Ceduna) which was responsible for the day to day co-ordination of fault clearance, operational switching and the regular bearer performance measurements. Located alongside was the BRC referred to above.

The other point, which was to oversight and support the first, was that of Radio Line Section Control (RLSC). This, in South Australia, was vested with the State radio terminal at Mt. Bonython.

The commencement of operation of the route (Pt. Pirie to Kongwirra) in December, 1969, however, produced a considerable number of problems rather more difficult than anticipated. As a result, there was an extreme load on staff at the MCC and it was recognised that the RLSC was not suitably placed to meet the demands made on it for assistance.

The whole situation was sufficiently serious by mid 1972 to justify creation of a professional Engineer's position for full time work on the East-West route.

Early efforts were directed toward the solution of problems in the equipment associated with the generation of spurious signals and poor reliability of units. In conjunction with this work, re-alignment of the bearers between Pt. Pirie and Eucla was also carried out and some improvement in bearer performance was achieved.

Following the experience gained on the route, the original maintenance philosophy has been modified. Although the two levels of control have been retained, much more emphasis has been placed on the maintenance control group at Kongwirra for the oversight of bearer performance and re-alignment. This has been aided by the introduction of a local Computer Orientated Fault and Maintenance History (COFAMH) which contains the history of unit replacements and the bearer performance information since the last re-alignment of the bearers.

Replacements of Units

The three most numerous and most essential units associated with each bearer are the transmitters, receivers and phase modulators. These are each capable of operation at one fixed frequency only and consequently spare units must be provided for each frequency in use. A total of 14 different frequencies are needed in the South Australian section of the route, since the transmitters in alternate repeaters on any one bearer use the same frequencies.

Two complete sets of spare units are provided in South Australia (phase modulators for eight frequencies are provided as these are only used in conjunction with the Telephony No. 1 and protection bi-directional bearers). These units are held at Kongwirra, which is the maintenance control centre for the South Australian section of the route.

Units are conveyed to and from the BRC by technical staff using conventional station sedans. Carrying cases are manufactured from a hard fibrous material ('globite') and lined with a layer of 2.5 cm of foam rubber to provide adequate insulation against shock and vibration. The units are further protected by a 7 cm layer of foam rubber covering the floor of the station sedans. The type of case now in use has overcome the objections of weight and bulk encountered with other proposals, and has provided quite adequate protection.

A full range of case sizes and shapes has been provided to cater for all equipment which needs to be transported to the field.

Staffing

Staff at Kongwirra are responsible for all unit repair and re-alignment as well as unit replacement and bearer re-alignment as required.

The present staff provision is one Senior Telecommunications Technical Officer Grade 3 (STTO 3), one Senior Telecommunications Technical Officer Grade 1 (STTO 1), seven Telecommunications Technical Officers Grade 1 (TTO 1), four Technicians and one Linesman. At Ceduna are located a Senior Motor Mechanic, a Motor Mechanic plus a Senior Electrical Fitter and Mechanic. These staff are responsible for the maintenance of power plant and motor vehicles

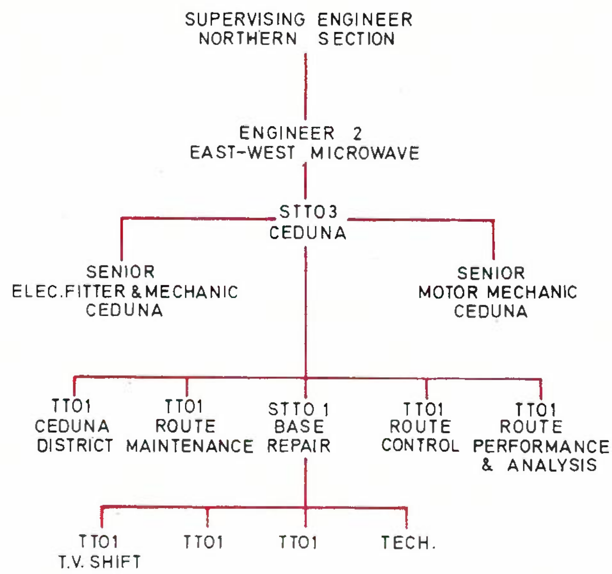


Fig. 9 — Ceduna (Kongwirra) Staffing.

associated with the route. Fig. 9 shows the operational and line control responsibilities for the South Australian section of the route.

The BRC located at the Kongwirra terminal requires an STTO 1, two TTO 1's and a Technician from the above staff. All faulty units returned from the field are repaired and/or re-aligned and tested before being returned to the base maintenance store. A wide range of test equipment is provided, including an environmental test chamber which enables temperature cycling of units from 0°C to 70°C. This is essential to test equipment units over the range actually encountered in service, the equipment being specified to operate unimpaired within a temperature range from 0°C to 50°C.

Staff Training and Utilisation

The staffing of such a remote station as Ceduna, which is approximately 800 km from Adelaide, always presents difficulties, and it has been necessary to obtain technical staff from whatever sources are available, irrespective of whether they have had a strong microwave radio background or not. Consequently a comprehensive staff training programme must be kept up at Ceduna.

Staff training takes three forms:

- Formal lectures presented by more experienced staff members;
- Practical training in the Base Repair Centre;
- Practical field training on bearer line-up.

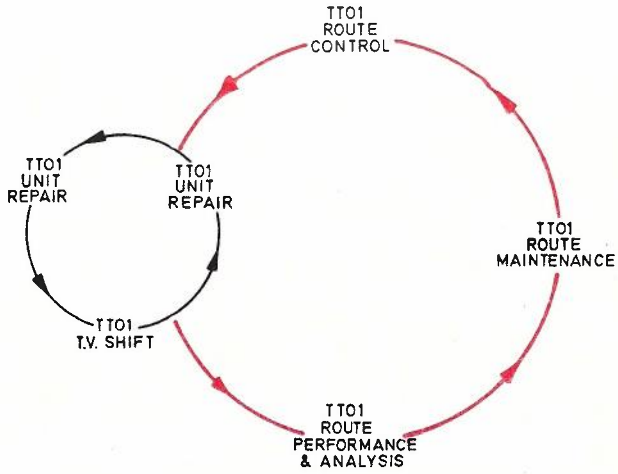


Fig. 10 — Kongwirra Staff Rotation Roster.

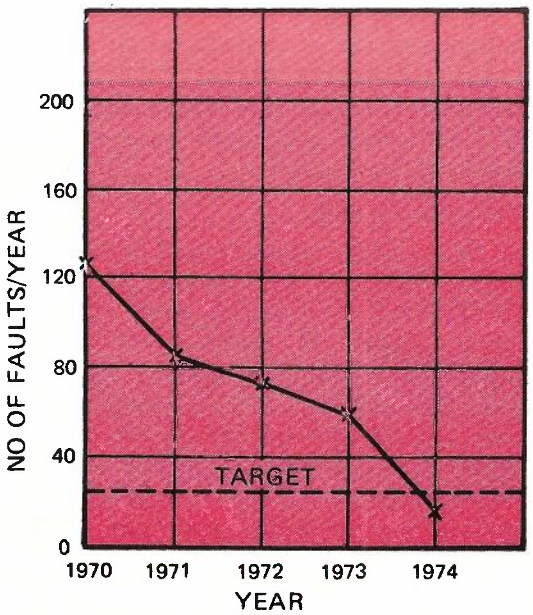


Fig. 11 — Unit Failure Rate.

Fig. 10 shows the rotation roster employed at Kongwirra. Staff normally spend three months in each cell with the exception of the BRC staff, (TTO 1's), who rotate within the cell spending two weeks on unit repair and one week on the TV shift during the six month (total) stay in the BRC.

The position of TTO 1, Route Performance and Analysis has been introduced at Kongwirra within the past eighteen months. The duties of the position are to analyse the daily log from the Route Control Position, the monthly unit meter readings, computer printout and bearer performance figures to obtain trends in equipment performance to enable the efficient utilization of staff and other resources. For example, the replacement of a unit, which extrapolated meter readings indicate would bring up an alarm condition within several months, would be carried out on the next scheduled maintenance visit to save the expense of a special trip to the site concerned, a trip which could necessitate a 1,000 km journey involving two staff members. In the same manner, bearer performance figures are analysed and have resulted in the detection of degraded units and the replacement of these before bearer failure and possible loss of traffic has occurred.

RADIO EQUIPMENT

It could be anticipated that the major source of faults would be the more complex units associated with the bearers, that is, transmitters, receivers and phase modulators. These also happen to be the most numerous. In the South Australian section at the time of writing there were 147 operational transmitters, which are easily the most complex of the units associated with the radio bearers.

In original design considerations, a failure rate for all units, including supervisory equipment, of 0.56 faults per bearer repeater per year was postulated. This figure was derived from component information available at the time and includes degradation as well as total failure of units.

An analysis of faults occuring during the years 1970/1974, for the Port Pirie-Kongwirra section, is given in Table 3 and Fig. 11.

TABLE 3

	1970	1971	1972	1973	1974
Transmitters	58	21	13	12	3
Receivers	24	35	19	15	1
Carrier Reinsert Unit	7	2	20	17	1
Phase Modulator	2	6	9	7	4
Power Units	2	—	4	—	4
Supervisory System	29	18	12	8	11
TOTAL	122	82	77	59	24
Target	27 faults/year, first in bearers only.				

It can be seen from this Table that the failure rate over this period has dropped from 4.5 times that predicted to 0.9 times, a value which is slightly superior to the postulated figure.

It will also be seen that the number of faults occurring on transmitters has fallen from a failure rate of 120% to 4% of the working units. (Original bearers only considered). The majority of transmitter failures has been due to a drop in output power, sufficient to bring up a 'Transmitter Fail' alarm, (i.e. a 3 dB drop in output power). In a number of cases during the early history of the route, units were also rejected due to the production of high level spurious oscillations. In the main, both these types of faults were caused by variations of the tuning adjustments due to aging of components.

The tuning of these units is a complex and time-consuming operation due to the number of interdependent adjustments available, the average time required for a relatively experienced operator being three days. Staff who have had considerable experience on the units can, however, carry out the re-alignment procedure in two days.

A number of modifications have been introduced to the alignment procedures since 1970. These include 'sweeping' the signal source during alignment and, in the case of certain assemblies, a reduction of approximately 1 dB in output power, to gain stability in the performance of the unit.

Experience has indicated that thorough temperature cycling is mandatory if reliable operation of the varactor-multiplier oscillators is to be achieved.

It has been found that once a transmitter has been thoroughly tested in the BRC, the probability of failure due to the types of faults described is extremely low. Subsequent failures, in the majority of cases, have been due to component failure for which no set pattern has emerged.

The maintenance concept on this radio system was based on the assumption that the supervisory system would indicate the faulty unit. However, in the case of spurious oscillations the supervisory system does not necessarily indicate a fault. The application of techniques developed with experience, and the knowledge of the likely causes enables maintenance staff, aided by the use of a spectrum analyser, to predict with reasonable accuracy which unit will be required, thus reducing the number of units needed to be carried along the route under these conditions. The actual location of the source of spurious signals is still a time-consuming exercise, but because of the new alignment techniques their occurrence on the original bearers is now very rare. Fault records show that there has been only one detected case of major spurious signal generation on the four original bearers in the two years to July 1975.

As mentioned earlier in this article, one of the causes of excessive intermodulation noise has been the premature loss of gain of the Tunnel Diode Amplifier. This has been traced to a variation in value of R6 (shown in Fig. 12), which forms portion of the bias circuit. The original supply of resistors has now been exhausted; later supplies have not exhibited the same instability characteristics.

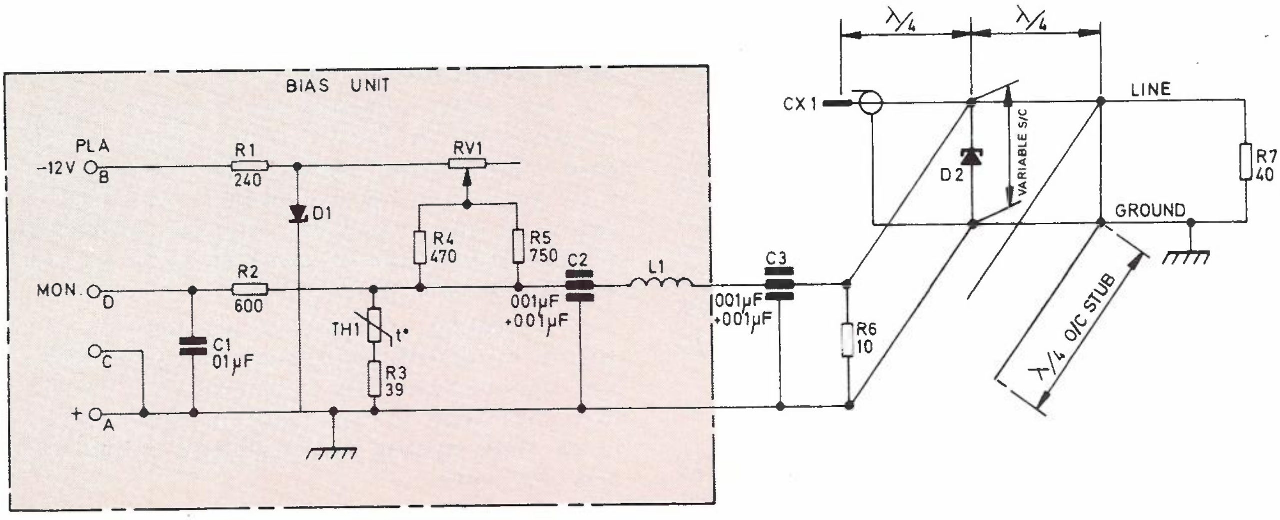


Fig. 12 — TDA Circuit.

During the first several years of operation, a considerable number of transmitter units were rejected due to spurious signals being generated within the multiplier unit accompanied by instability in output power. This occurred despite the temperature cycling described earlier. The problem has been largely overcome by a sweep method of alignment of the multiplier. This method allows the response of the multiplier unit, one megahertz either side of the normal centre frequency to be examined. Fig 13 (a) shows the typical response of a unit which was adjusted prior to the introduction of the sweep method. Obviously in this case, any detuning brought about by aging of components or temperature variations could result in a sudden drop in output power from the multiplier unit. Fig. 13 (b) shows a typical response with discontinuity at a frequency Fs. This circuit would be very prone to generation of spurious signals. Fig. 13 (c) shows the response which is desired, that is from a unit which has a stable power output and is also free of spurious signals, with all normal variations in temperature and component reactance.

Another major source of spurious signals was the oscillator multiplier section of the receiver. As a result of joint efforts by Telecom Australia staff and the Contractor, this problem was solved by the addition of resistor R3 and alteration of type of capacitor used for C6. This is shown in Fig. 14. The sweep method of alignment is also applied to these units and has resulted in a stable unit which no longer presents any major source of trouble.

The source of intermodulation noise is not confined to the active elements within the system. One notable source of this problem was found to be the waveguide filters. Mounting methods used and the construction of the filters, resulted in the end sections of the filters cracking as they were subjected to the extremes of climatic condition experienced on the route. Modification of the mounting method and the development of repair and readjustment techniques by Telecom Australia staff have largely overcome the problems in this area. An exercise to check and readjust the return loss characteristics of all filters on the route has also helped to reduce intermodulation noise.

Emergency Equipment

The provision of spare units at Kongwirra has been designed to cater for normal operational needs and does not cater for the emergency situation, e.g. the destruction of a repeater site by occurrences such as earthquake, light aircraft accident or vandalism. To meet this situation, transportable repeaters and power supplies have been provided in both South Australia and Western Australia. These units are fully equipped with all necessary units to restore the first two bi-directional bearers installed on the system and are suitable for long term operation. Used in conjunction with the aluminium quick-erect tower mentioned later, the equipment provides facilities to replace any repeater or demodulation station on the route. A recent field trial of this equipment is shown in Fig. 15.

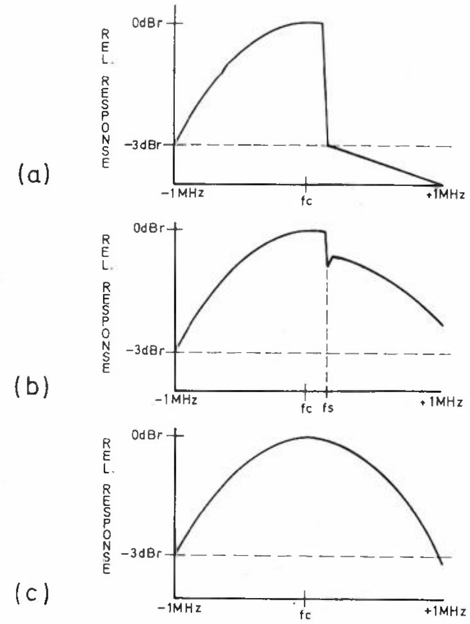


Fig. 13—Transmitter Oscillator Adjustment Curves.

Bearer Performance

In mid 1972, a decision was made to re-align the bearers in the South Australian section of the route. This decision resulted from the degraded noise performance of the bearers, the high incidence of bearer switching and the undesirable rising baseband response exhibited by the bearers, and already defined in Fig. 7.

In conjunction with this line-up exercise, procedures for achieving improved unit group delay, amplitude response, and transmitter output power were introduced. These procedures were applied to all units repaired and re-aligned in the BRC after that time.

Since the maintenance concept for the route was completely new, the line-up procedure differed from that used on other existing radio relay systems. The procedure adopted was as follows:

- An experienced TTO 1 from the BRC proceeded along the route and checked all units 'in-station' to ensure that they met the limits laid down by the Maintenance Engineer. Units failing to meet these requirements were rejected and returned to the BRC for complete overhaul and re-alignment;
- At the completion of the 'in-station' testing phase, a line-up team proceeded along the route, equalising on a repeater hop basis. The parameters which were closely watched for this alignment were group delay and limiting amplitude response.

  The 'hop' equaliser was adjusted to give the following conditions:
- Group delay—maximum variation: 1 nanosecond (nS) over a 10 MHz bandwidth, rising to 5 nS over an 18 MHz bandwidth, centred about 70 MHz;
- Limiting amplitude response—maximum variation: 0.1 dB over an 18 MHz bandwidth and symmetrical about a centre frequency of 70 MHz.

At the completion of the 'hop' alignment, group delay, baseband frequency response and white noise performance were checked from the terminal to the repeater site under test. This allowed a progressive check on the bearer performance.

The resulting improvement in the overall performance of the bearers is illustrated in Table 4.

Experience gained since the re-alignment of bearers commenced has resulted in the modification of the alignment procedure used for the Receiver IF amplfiiers. This new procedure has resulted in improved performance of the units, and has had the effect of stabilising the baseband level variations which occur with varying RF input level and reduced the loss in level of the 8.5 MHz pilot.

Overall System Performance

Performance of traffic circuits derived over the system is continually monitored in Adelaide and Perth. The measurements taken relate to the performance of the overall broadband bearer derived between these two centres.

Table 5 provides a summary of the overall

TABLE 4 — TOTAL AND BASIC NOISE pWOp

Mod. 1 — Demod. 1 Combination	At Commissioning		Immediately Prior Lineup		Immediately After Lineup		Two Years After Lineup	
Normal Level	Total	Basic	Total	Basic	Total	Basic	Total	Basic
Slot 1, 70 kHz	87	69	180	120	110	87	110	80
Slot 2, 1248 kHz	775	123	2600	150	490	174	450	190
Slot 3, 2438 kHz	436	123	3000	160	436	174	280	150

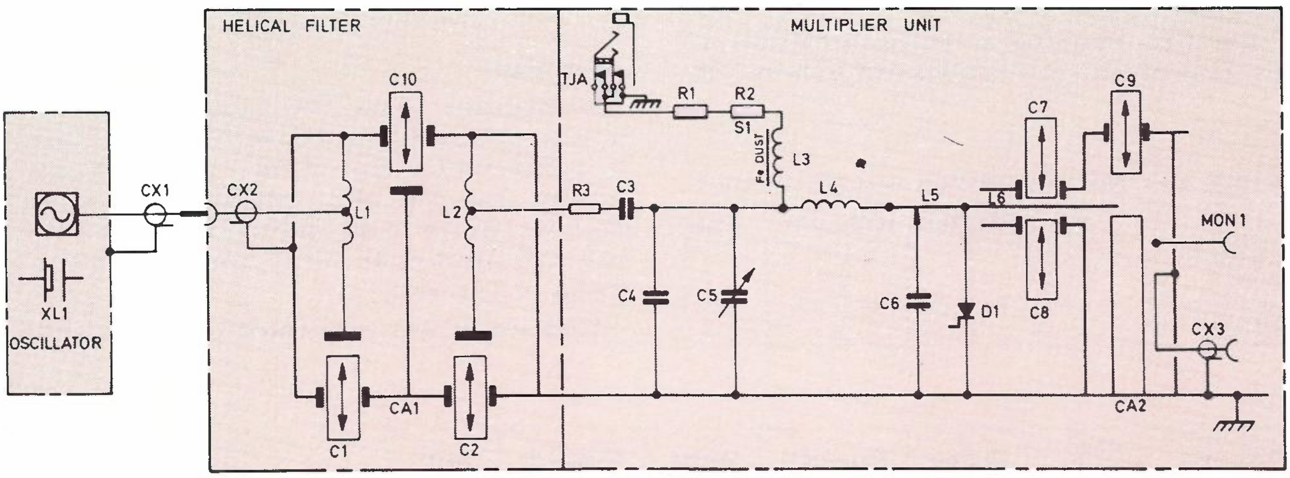


Fig. 14 — Receiver Oscillator Circuit.

TABLE 5

	No. Interruptions/ 1000 Km Per Month	Unplanned Route Outage Time (Total)	Unplanned Outage Time Pt. Pirie-Northam	% Time Noise Above 4 pWOp Objective
1973				
October	40	0 mins	0 mins	2.8%
November	50	45 ,,	0 ,,	3.1%
December	39	0 ,,	0 ,,	2.3%
1974				
January	40	40 ,,	3 ,,	4.4%
February	67	5 ,,	5 ,,	0.9%
March	53	60 ,,	0 ,,	1.3%
April	34	11 ,,	5 ,,	0.28%
May	53	6 ,,	4 ,,	6.03%
June	48	1 ,,	0 ,,	3.6%
July	24	1 ,,	0 ,,	5.8%

Note: Bursts counted as one interruption.

traffic circuit performance in terms of interruptions per 1,000 km/month, unplanned outage time and percentage time the noise is above the stated objective for the period October 1973 to July 1974.

POWER SUPPLIES

Wind Generators

The operation of the wind generators has been less than satisfactory. Whilst a useful contribution, amounting to approximately 40% of the total power requirements at most sites has been made, the reliability is poor and operating costs high, in comparison with the diesel generators. Maintenance costs have been analysed and average $800 per machine/year, compared with the diesel maintenance costs of $400 per machine/year. The cost per kilowatt supplied by the wind generators is approximately one and a half times the cost of power supplied by the diesel installation.

The total proportion of power contributed by the wind generators is slightly less than the percentage contribution postulated during the design stage and will, of course, decrease as the number of bearers installed increases.

During the early stages of operation of the route, a number of wind generators suffered mechanical damage to the turntable assembly. Examination of the failed units revealed that fracture had occurred to the base casting. The cause of this was traced to an armature unbalance which produced severe vibration under no load conditions. The problem has now been eliminated, however the wind generators still represent a heavy maintenance load and whilst no one area can be singled out, Table 6 indicates that most faults are mechanical in origin. Note that the increase in the number of units changed during 1973 and 1974 reflects, not an increased failure rate of the units, but on efforts made to clear outstanding faults due to the change in organisation during 1972.

TABLE 6 — WIND GENERATOR FAULTS; 1970-1974

	1970	1971	1972	1973	1974	Total
Number of Wind Generators Changed	9	7	5	8	11	40

Fault Area	Prop. Assembly	Gearbox	Turn-Table	Brakes	Electrical	Total
Number of Failures	6	12	10	8	4	40

Diesel Plant

As discussed above, the operating cost per kilowatt delivered power from the diesel plant is approximately 66% of the cost of power obtained from the wind generators. The diesel plant has proven to be very reliable, with little additional maintenance effort other than normal service requirements.

Some trouble was experienced with diesel plant in the period shortly after commissioning. These problems were mainly associated with non-return valves in the oil make up tank, cracked fuel pump diaphragms, broken fuel lift pump linkages, starter motor solenoids and the three start-timers. These problems have been cured by modification of the components involved. The fault incidence on diesel plant has now dropped to a level which reflects the high standard of maintenance being performed by power plant staff.

The installation of a second diesel plant at most sites has now been carried out. As a result of this action the wind generators will be gradually phased out of service, which will result in an overall reduction in the operating costs on the route and an increase in the reliability of the overall power plant installation.

Batteries

The operation of the batteries in South Australia has, in general, been very good. While a number of individual cells have been replaced due to low specific gravity, examination of these cells by the Telepower Section has revealed that generally they have recovered their full capacity if specially treated. The batteries have been installed since mid 1968 and in the majority of sites are expected to last until early 1976 before major battery replacement will be required.

Test discharges carried out during 1974 at three sites selected at random, revealed that the batteries are delivering up to 150% of their rated capacity. Replacement of banks at several sites has recently been undertaken and the cells recovered from these locations have been tested and graded and are being used for replacement purposes.

In the light of experience gained to date, the following maintenance philosophy is being followed:

- Batteries are 'boost' charged on a regular basis, (each six to nine months) unless individual cell specific gravities differ by more than 30 points, in which case a 'boost' charge is carried out to determine whether the cell will recover;
- Cell replacement, when necessary, is carried out using cells of a similar age and condition (instead of new cells), as those in the bank. Experience has shown that a new cell will generally fail within two years of installation due to its lower initial capacity;
- Low 'mud' spaced cells should not be used under charge/discharge conditions as failure within three years can be expected due to sediment build up;
- To cater for the additional load created by future bearers and to provide a greater safety margin in the event of diesel failure, battery capacity at non-mains operated sites will be increased to 2,000 ampere-hours when bank replacement becomes necessary at these sites.

ANTENNA SYSTEM

Maintenance and Emergencies

Problems associated with the maintenance of the antenna system of a major radio relay route divide into two main classes:

- Those which are spasmodic or non-recurring and are generally caused by storms, vandals or freak accidents;
- Continuous activities such as corrosion and gas leaks.

In the first category, actual break-downs of widely varying magnitude may be caused by:

- Violent storms, which may distort or dislodge an antenna from its set position. Flying objects carried by strong winds are usually the agents in these cases;
- Vandalism or sabotage damage as small as a bullet hole through a reflector or as extensive as demolition of the entire tower structure;
- An aircraft crash, earth tremor or other shock effect might shift or completely collapse a tower and antenna system.

For all these types of situations, a 'flying-squad' of skilled radio linemen is available in Adelaide at short notice to carry out a range of repairs from re-alignment of a displaced antenna or replacement of a ruptured waveguide to the re-building of the whole tower structure. An emergency rig consisting of a portable aluminium quick-erect mast capable of rising to 65 metres; 150 metres of 2 GHz coaxial cable; two four meter parabolic reflectors plus an assortment of supporting hardware is also held in Adelaide. When tested in conjunction with the trailer mounted radio equipment on a full scale simulated break-down situation in May 1975, the Refuge Rocks repeater station was replaced with this equipment within three days of advice that the station had been completely demolished.

The second category of antenna system problems, whilst somewhat less dramatic, has meant a far greater work load to maintenance staff to date. Probably, the most time consuming and frustrating maintenance exercise of all is the location of small gas leaks in a system using continuous run helical wave guide. Gas pressure is supplied by means of portable gas cylinders

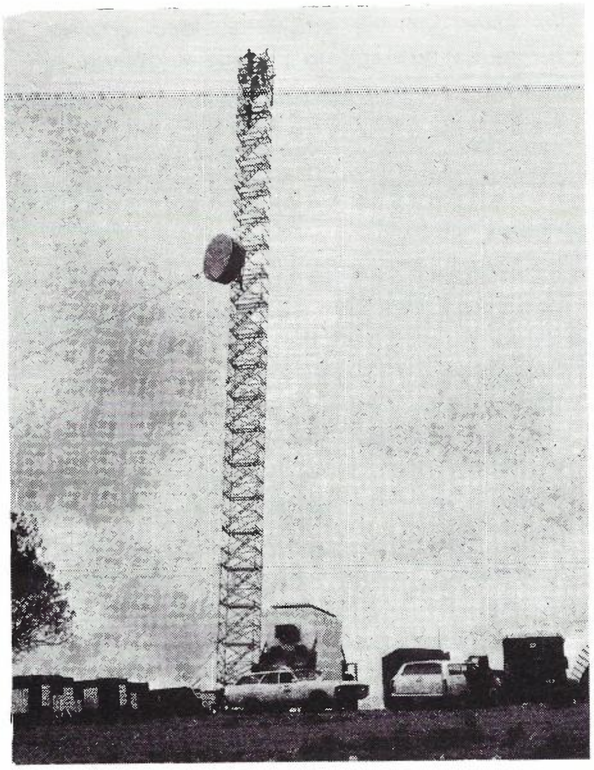


Fig. 15 — Emergency Rig.

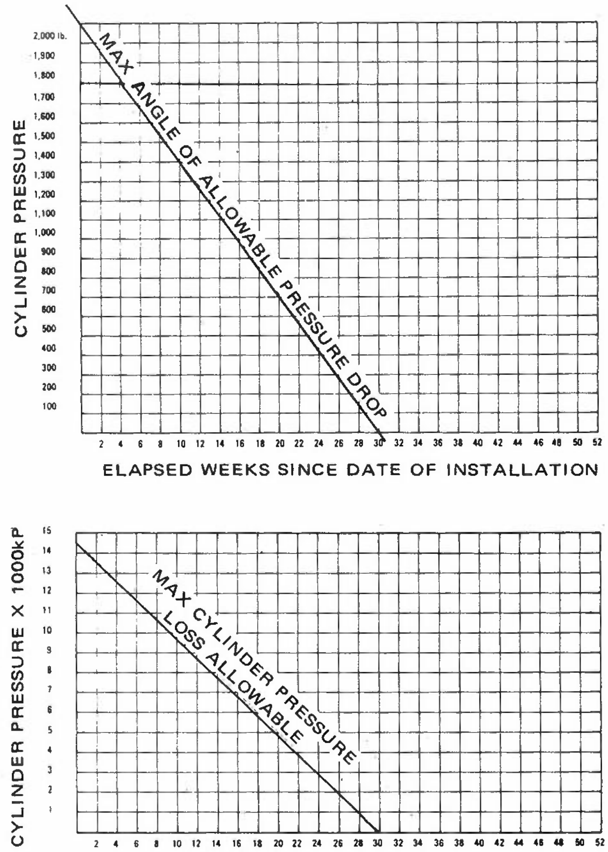


Fig. 16 — Gas Pressure Control Graphs.

which may be replaced periodically. Theoretically, this should only be occasional after an infrequent leak which allowed significant amounts of gas to escape before it was detected and repaired.

In practice, however, there have been persistent leaks of varying severity at one site or another ever since commissioning. Some of these have proved exceedingly difficult to locate and have necessitated regular cylinder replacement and consequent high transportation costs.

In an endeavour to minimise the effects of these persistent leaks and to reduce maintenance costs, plans are currently being formulated for the installation of battery or mains operated pressurization equipment.

Regular supervision of the gas pressure is of course a standard maintenance procedure, but special monitoring of leaking systems to guard against cylinder exhaustion at the same time as organising replacement cylinders without the need for special trips to the sites has been needed as well. Fig. 16 shows the type of control graph which is being kept to assess leak potential and cylinder replacement cycles.

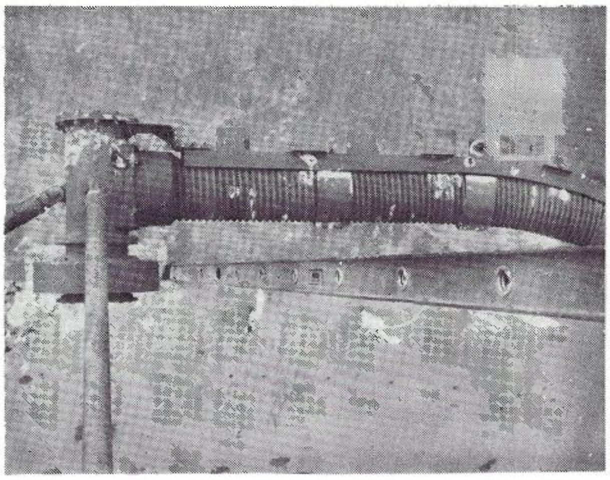
Ultimate location of a fine gas leak may take many months and needs a combination of fine calm weather, patience, persistence and a good deal of experience on the part of the radio fault man. At sites well chosen for their exposure to steady atmospheric mixing winds, the location of tiny air leaks even with the assistance of Freon gas methods can be very tedious.

The ever present salt laden winds produce a very hostile environment for the many stainless steel and aluminium contacts and corrosion has been a continuous threat. This was amply illustrated in the first twelve months of operation by the antenna feed arm corrosion problem.

Feed Arm Corrosion

Rapidly increasing numbers of untraceable gas leaks in the feeder gas pressure systems at repeater sites between Ceduna and Eucla in the first few months of operation, led to a full scale examination of the entire antenna system at all sites.

Feed arms at sites between Ceduna and Eucla were found to have suffered electrolytic corrosion under the stainless steel clamps which held the



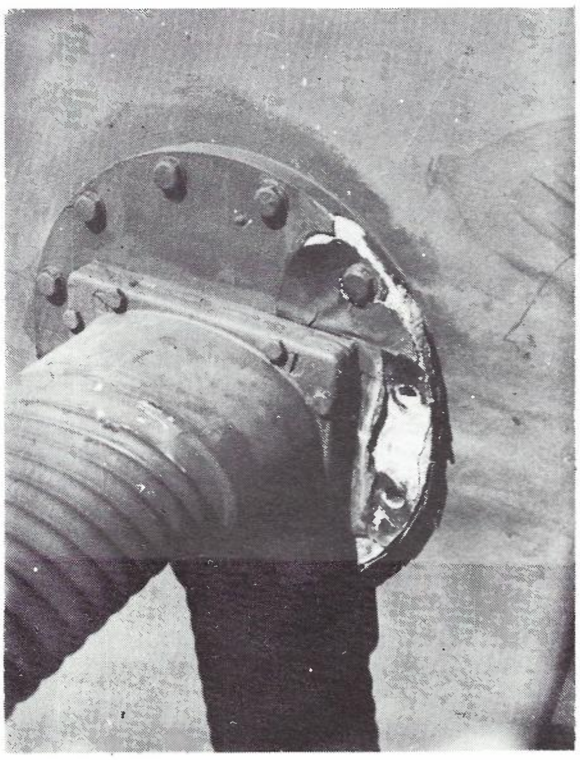


Fig. 17 — (a) Antenna Feed Arm.
(b) Corrosion of Antenna Feed Arm Attachment.

corrugated aluminium feed arm to its supporting member. At least one hole right through the feed arm had occurred at ten of the twelve sites and in some cases, several holes existed in close proximity. It was observed also that the aluminium mounting plates which secured the feed arms to the reflectors were suffering in a similar way around the stainless steel bolts. (See Fig. 17).

In the initial stages of this investigation, because of the generally held belief that stainless steel and aluminium were compatible metals with a low risk of electrolytic corrosion we were misled by the presence of considerable quantities of bird droppings scattered at various points on the feed arm, illuminator and reflector. As it became obvious, however, that there were many corroded feed arms where there was little evidence of bird droppings, the examination was widened in scope and it was soon apparent that the dominant factor was saline deposit resulting from salt bearing winds off the Southern Ocean.

The sites between Ceduna and Eucla are particularly exposed to the prevailing strong southerly winds where the rugged coast line with its high salt spray potential makes the environment very conducive to rapid electrolytic corrosion between aluminium and stainless steel. The same problem has been reported from similar situations in other parts of the world, particularly by power distribution authorities using steel cased aluminium high tension lines.

A much lower level of wind born salt deposition occurs east of Ceduna and although there was still ample evidence of bird droppings, corrosion under the clamps at these sites was either very small or non existant.

The solution developed by the Andrews Corporation is illustrated in Fig 18. A suitable epoxy resin was used to seal the holes and pits in the feed arms prior to the application of a thin aluminium foil. Wrappings of a suitable waterproof sealing tape and nylon sheet to separate the aluminium and stainless steel clamp, completed the job.

A special rig to enable repair men safely to enter and work within the reflector was developed jointly by Telecom Australia and Andrews' staff and the work proceeded carefully hop by hop as a combined exercise.

Although no further trouble has been experienced to this date, recent extensions to the route, requiring the installation of the second antenna system has seen the introduction of a self supporting feed arm, thus eliminating any possibility of the above problem occurring in the new equipment.

TOWERS, BUILDINGS AND ROADS

Towers

It would be expected that the close proximity to the sea and exposure to the salt laden southerly

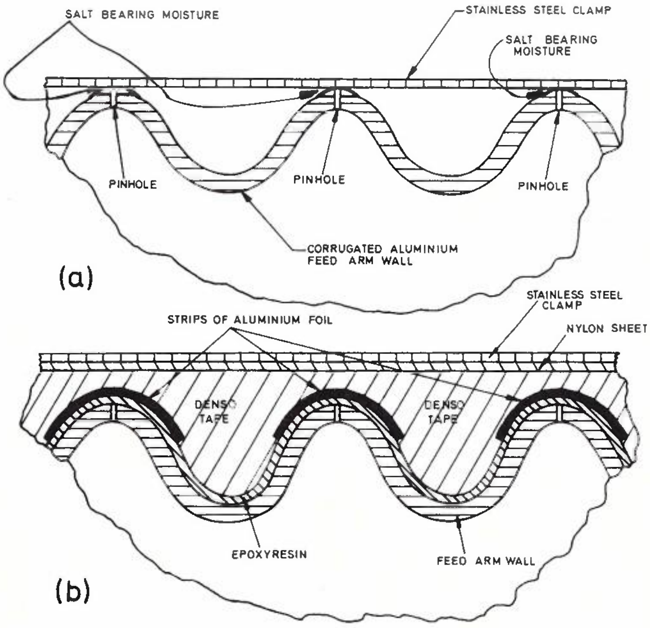


Fig. 18 — (a) Antenna Feed Arm Corrosion.
(b) Antenna Feed Arm Corrosion Repairs.

winds in the Ceduna to Eucla section of the route would result in significant corrosion problems on the towers. However, despite the salt encrustation on some of these towers, there have been only minor cases of corrosion.

Towers are regularly inspected by members of the Radio Communication line staff who carry out minor maintenance and corrective action as required on these inspections.

Buildings

The buildings have been found to be subject to corrosion in certain sections of the route. This has been traced to a combination of two factors:

- Salt laden moist air;
- A design fault which allowed the contact of the aluminium insulation foil and the galvanised iron cladding. This, in the presence of the moist salty air allowed an electrolysis action to take place and has resulted in severe corrosion of shelter panels at several sites. In all other aspects, the buildings have provided a suitable environment for equipment although are rather noisy for staff present on site when the diesel plant is in operation.

Access Roads

Access roads are necessary to all sites and because of the remote locality, prove costly to maintain. The longest of these roads is 16 km. Although the amount of traffic carried is light by normal standards, they require regular attention to maintain a reasonable surface. Contracts for grading these roads are let periodically and total cost is currently seen at some $10,000 per annum.

CONCLUSION

The traditional Telecom Australia approach of installing standardised plant capable of operating within proven widely understood procedures was not used in this project A good deal of capital expenditure was saved thereby, but a larger and much more comprehensive operating programme has been necessary because of it. Much has been learnt about our own operating potential and our limitations during the extensive investigation and modification work. Several transmission shortcomings which would not have come under criticism for some years in other systems have been much better identified by reason of these investigations, and the end results will have wider implications than simply the resolution of the East-West traffic difficulties.

The approach to the ongoing design of power supplies, radio paths system supervision, and operating procedures for other subsequent major projects was strongly influenced by our East-West experience. It was clear, for instance, that the decision to set up a full maintenance control centre at a remote regional locality such as Ceduna was the correct one.

It was already accepted that standardised equipment could be maintained from either city or rural based maintenance centres. We now know under what circumstances unstandard equipment can be successfully operated from a rural based maintenance centre. Perhaps the most important single conclusion which might be arrived at is that comprehensive supervisory facilities, preferably supported by integrated automatic data processors should certainly be an integral part of our broadband network.

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The Telecom Australia Financial Plan

B. L. KENNEDY, M.I.E. AUSTRALIA

This article outlines the means used in Telecom Australia to set down its overall financial objectives for a fiscal period, viz: The Financial Plan. It also indicates how the plan establishes the level of the Engineering Capital Works Programme, the tool used by Telecom Australia to programme engineering projects and to set short-term physical targets.

INTRODUCTION

With increasing emphasis being placed in recent years on ensuring that the marketing, operational and constructional activities of what is now Telecom Australia are in accordance with sound business principles, it is not surprising that a document has evolved that substantially rationalises this objective.

This document, which is called "The Financial Plan", brings together various plans and programmes of Telecom Australia with the view to ensuring that their interdependent financial effects integrate in the optimum way and so result in the best composite business strategy. Along with other plans, such as the Marketing Plan, it will serve as input to and interact with an ultimate overall Telecommunications Corporate Plan.

The following article looks at aspects of the Financial Plan from the view of an engineer and is not intended to cover all components of the plan, nor to be a financial treatise as might be produced by an accountant. Rather, its aim is to serve as an introduction to the plan and to indicate how it relates to the much better known tool within Telecom Australia, the Engineering Capital Works Programme.

THE FUNDS STATEMENT

A major component of the Financial Plan is the Funds Statement, which is a cash flow document expressed in commercial accounting terms formulated to give anticipated earnings, borrowings and expenditure for a financial year. Simply, it indicates the anticipated source of funds for Telecom Australia and how it is expected that they will be spent during the year.

A financial Plan funds statement is similar to that indicated in Figure 1 and brief explanations of the main items are given below. It should be noted that this statement is used for example only. It was taken from the 1974/75 Financial Plan and since Vesting Day (1.7.75) different constraints have been operating. These are referred to later.

Earnings

This item is not a cash flow item, i.e. it is not the actual cash received during a year. Rather, it is intended to cover money to be earned during the year.

i.e. Earnings = Total Billings + Net Accrued Earnings.

Where Net Accrued Earnings = Charges incurred by subscribers (or others), but not yet billed, minus those incurred in previous year but collected in year, minus rentals in advance.

Borrowings

Borrowings is capital normally provided by way of Department of Treasury advances and is subject to interest. The Telecommunications Act 1975, Section 72(1) also provides for the borrowing of moneys from sources other than the Department of Treasury subject to the approval of the Treasurer. However, as the Act requires Telecom Australia to finance at least 50% of capital expenditure from internal sources, the allowable level of Borrowings is limited (see Financial Constraints).

Direct Expenses

This item covers expenses of a non-capital nature and is calculated in similar fashion to Earnings, i.e. it is not a cash flow item. As used in a funds state-

ITEM	$ MILLIONS
Earnings	1054.5
Borrowings	398.9
TOTAL	1453.4
Direct Expenses	502.2
Fixed Asset Expenditure	
— E.C.P.	375.6
— Motor Vehicles	10.8
— Other Plant and Equipment	6.3
— Land and Buildings	50.8
— Administration and Overhead	135.5
Total Fixed Asset Expenditure	579.0
Long Service Leave — Cash	8.4
Increase in Stores	—
Increase in Working Capital	15.1
Superannuation	92.7
Interest	190.6
Price Increases	65.4
TOTAL APPLICATIONS	1453.4

Fig. 1—A Financial Plan Funds Statement.

ment, it is a combination of some expenses which are a direct charge to areas of responsibility and of others which are charged through internal accounting systems (costed expenditures); plant maintenance costs and the non-capital, or expense proportions, of Engineering Overhead and Engineering Administration are examples of the latter and approach some 50% of the item. The total item is substantial in that it exceeds one-third of total funds applications.

Engineering Construction Programme (E.C.P.)

The E.C.P. is the major capital expenditure item in the Financial Plan and the main source of the Engineering Capital Works Programme. (This aspect is covered in more detail later in the article.)

The item includes capital expenditure on
- Telecommunications Plant.
- Engineering Movable Plant (including Mech. Aids, Trailers and Caravans).
- Engineering Technical Assets (Headquarters).

Motor Vehicles

This covers all capital charges for motor vehicles.

Other Plant and Equipment

The item includes capital expenditure relating to
- Workshops Fixed Plant
- Furniture and Fittings
- Office Machines and Aids
- Stores Handling Equipment.

Land and Buildings

All capital expenditure on land and buildings is included in this item.

Administration and Overheads

This includes the capital expenditure component only of
- Engineering Overhead (including Administration)
- Supply Branch Administration
- Management Services (Finance, Personnel, etc.)
- Buildings Administration.

It might be noted that Engineering Overhead is more than 80% of this item.

Long Service Leave

This is the cash amount which needs to be paid during the year for long service leave.

Increases in Stores

This item provides for any change in the level of stores holdings during the year, both in Main Store and Engineers Stores. The "nil" amount shown in the example indicates that no change in stores holdings was expected. If it was intended to reduce stores holdings during a year, then the figure would be negative and so have the effect of reducing proposed capital expenditure in the Financial Plan.

Increase in Working Capital

As indicated above, the assessments of Earnings and Direct Expenses are not cash flow calculations, but are estimates of the true earnings and expenditures by Telecom Australia irrespective of whether income or payments are actually effected during the year, or not. Therefore, in order to convert the Financial Plan to a cash flow statement, it is necessary to introduce the item "Increase in Working Capital" where:

Increase in Working Capital = Increase in Current Assets minus Increase in Current Liabilities

and

Current Assets = Cash on hand and/or income already earned but not yet received as cash payment

and

Current Liabilities = Charges collected in advance and/or debits incurred but not yet paid in cash.

The item represents the net value of current assets less current liabilities, compared with the corresponding figure for the previous year. In the example, current assets are indicated to become greater relative to current liabilities and, as this means that there is a cash penalty, i.e. that less cash is available, then this is a charge against the Financial Plan. Conversely, if working capital was to reduce compared with the previous year, the amount against this item would be negative and so reduce expenditure on the Financial Plan.

Superannuation

This is a charge against the Financial Plan to cover the amount of money which must be passed to the Government each year to cover, on an actuarial basis, Telecom Australia's future liability for superannuation. It may be regarded as an annual charge paid into a fund that will cover all future superannuation payments by the Government.

Interest

As mentioned above, one of the sources of funds is Borrowings. As in proper business practice, it is necessary to pay interest on money borrowed and this interest increases each year as additional borrowings are made. Funds advanced from the Department of Treasury are in the form of individual loans with long-term maturity dates, with each loan subject to a constant rate of interest throughout the period of the loan. This interest rate is normally equal to the long-term bond interest rate applying at the start of the loan. As each loan matures it is converted to a new loan and the then current interest rate applied.

Price Increases

Financial Plan expenditure levels are generally set at fixed prices relative to the commencement of the first year of the plan. Consequently, there must be provision in the plan to cover any escalation of prices.

As general comment on the funds statement of Figure 1, it will be noted that the funds to be applied during the year were to amount to $1453.4M. To be viable, funds would need to be available to meet such costs and, as indicated, these were anticipated in the form of $1054.5M from Earnings and $398.9M from Borrowings.

THE TRADING ACCOUNT

The efficiency of a business tends to be judged on its trading result, i.e. whether it makes a profit or loss. Although this should not be the only criterion in assessing the performance of a body such as Telecom Australia, the trading result is of major importance, if only because it is an internal source of finance and so controls the amount of funds available for capital expenditure. This aspect is treated in more detail later in this article under Financial Constraints.

Figure 2 indicates the anticipated trading result from the Figure 1 funds statement. Comments regarding the items are as follows.

Earnings

This is the same item as included in the funds statement of Figure 1.

Direct Expenses

In the funds statement of Figure 1, the Direct Expenses item did not include allowance for price increases, this being provided as part of the Price Increases item in that statement. Allowance has been made in Figure 2 for the price increases associated with Direct Expenses in order that the amount shown is a realistic forecast of such charges.

ITEM	$ MILLIONS
Earnings	1054.5
Expenses	
— Direct Expenses (incl. Price Increase)	526.4
— Depreciation	186.0
— Superannuation	59.4
— Long Service Leave Liability	16.6
— Interest	174.3
TOTAL EXPENSES	962.7
PROFIT—EARNINGS—EXPENSES	91.8

Fig. 2—A Financial Plan Trading Account.

Depreciation

An expense incurred by any business undertaking in terms of its trading result is the liability it incurs each year by reason of its plant ageing and approaching the point in time when it must be replaced. This is expressed as depreciation which represents the amount of money that should be put aside each year to enable the replacement of plant as it falls due.

It might be noted that depreciation is regarded as an internal source of funds (see Financial Constraints) on the basis that such funds are best invested in the expansion of the assets of Telecom Australia rather than externally in another business.

Superannuation

The component of superannuation charged to Expenses is only that attributable to non-capital labour. Funds used on fixed asset expenditure are offset by the value of the fixed asset provided. Consequently, in considering expenses in a Profit and Loss Account, one does not include that component of superannuation or of long service leave liability (see item below) associated with staff employed on fixed asset provision.

Long Service Leave Liability

This is the expense incurred by reason of the long service leave liability associated with non-capital labour.

Interest

Of the total interest bill incurred during a year, a component is not charged to Expenses in the Trading Account, viz: the interest on funds applied to E.C.P. major works and buildings constructions in progress at the end of the financial year. Because such assets are not yet revenue producing, i.e. they do not contribute to Earnings in the Trading Account until they are completed, the interest associated with the money already spent is not considered a legitimate charge to Trading Account expenses.

It is interesting to note that the profit of $91.8M foreshadowed in the Financial Plan as exampled would have given a return on net assets (about $3900M) of approximately 2.3%. The reader will appreciate, no doubt, that business in the private sector would normally look for annual rates of return appreciably in excess of this figure.

The actual 1974/75 trading result was a profit of $95.1M steming from earnings of $1068.6M and expenses of $973.5M (compared to the Financial Plan figures of $1054.5M and $962.7M respectively.

FINANCIAL CONSTRAINTS

Telecom Australia has financial obligations as defined by the Telecommunications Act 1975, Section 73 and these necessarily control the structure of the Financial Plan. In particular, Section 73(1)(b) requires Telecom Australia to finance not less than 50% of its capital expenditure from internal sources, i.e. trading result plus depreciation plus long service leave provisions.

Figure 3 illustrates a method of testing a proposed Financial Plan to see if it conforms to this financial constraint. It uses the figures of the same Financial Plan as exampled in Figures 1 and 2, and it is interesting to note that, although such a plan proposed a capital expenditure of $684.9M, the funds to be generated from internal sources amounted to $286M, i.e. only 42%; and it follows that Borrowings were to amount to 58%. Of course when the 1974/75 Financial Plan was being fashioned, the business of maintaining and developing the national telecommunications network was the responsibility of the now-defunct Australian Post Office which was not subject to the provisions of the 1975 Act. The 1975/76 Financial Plan which is bound by the Act provides for 53% of capital expenditure to emanate from internal sources.

There are other financial constraints laid down in the Telecommunications Act 1975, but rather than itemise them here, the reader is referred to the Act if further information is desired. Suffice to say that, in the broad, these constraints simply expound good business practice.

In referring to the Act, the reader is also recommended to Section 11 which deals with the question of tariffs, and to Section 12 which provides for reimbursement of moneys to Telecom Australia by the Government in the event of the Minister agreeing to proposed expenditure in the Financial Plan, but not approving the increases in rentals and/or charges seen as necessary to support such expenditure. The reimbursement would then, in effect, be a source of funds which would serve as compensation for the reduction in Earnings due to the lower tariffs.

THE FINANCIAL PLANNING CYCLE

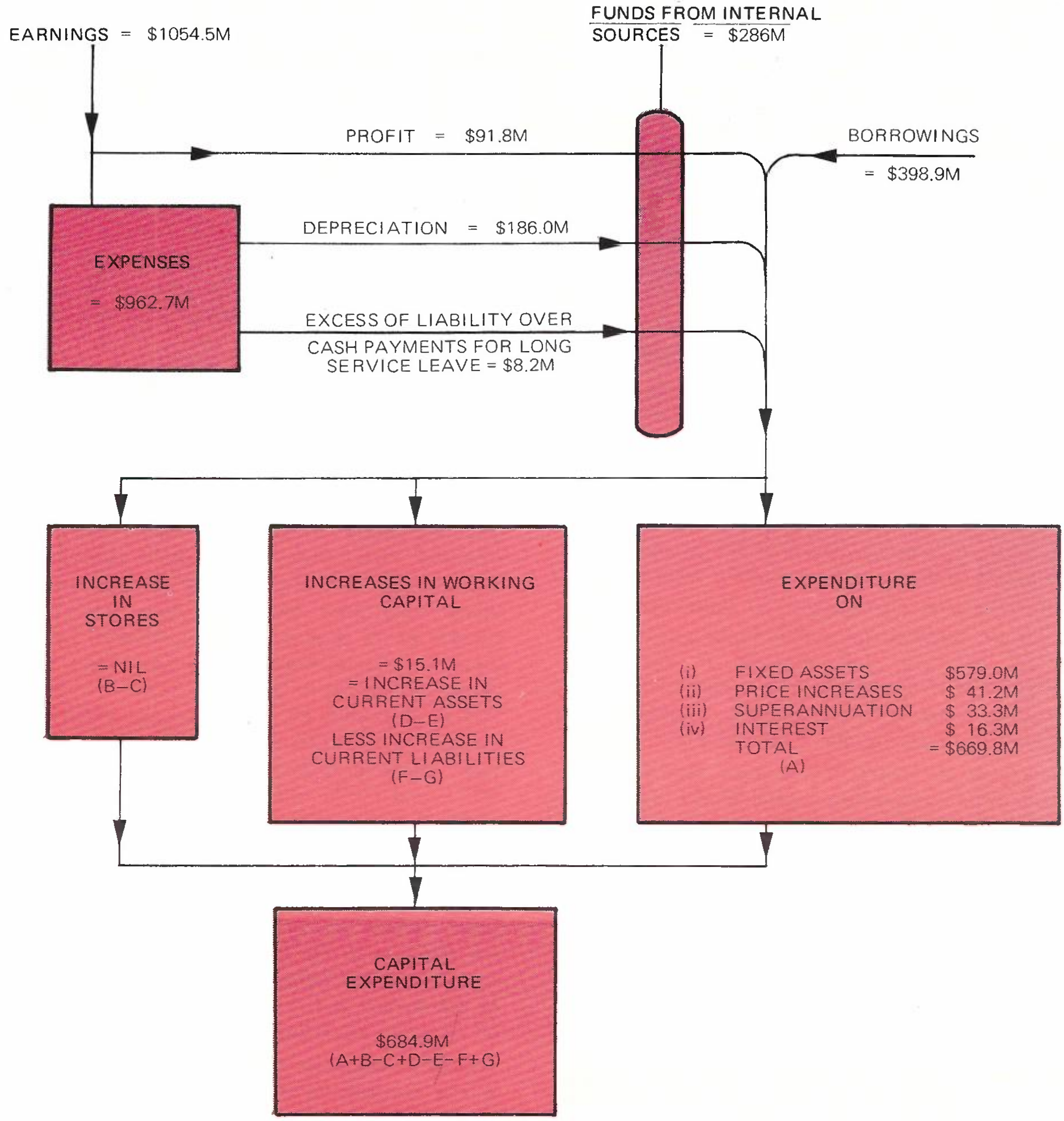
The Financial Plan can be thought of as a bridge between the planning and programming processes. It is the integration of many plans, some of which look to immediate requirements and others to long-term objectives, with financial constraints determining the levels to which such plans can be implemented at any point in time.

Because of this, the plan is not one which is determined in one simple operation. Rather, it is the result of many iterations, culminating in the best overall balance between the needs of the existing network, short-term subscriber and network demands and long-term network objectives.

The Financial Plan covers a three year period and its formulation is a continuing process with substantial effort involved in resolving the question of the level of tariffs. The latter may be considered as the inchpin of the plan as, on the one hand, they control the earnings of Telecom Australia and, on the other, they are an influence on subscriber and network demands and, so, on capital expenditure requirements. This interaction, therefore, requires fine balance of the Financial Plan if the result is to prove viable.

The process of establishing capital expenditure levels is a lengthy and detailed one and consists of reviewing previously proposed programme levels in the light of actual network growth and forecast demand. The latter is updated on the basis of determined tariffs and an anlysis of the national economic situation.

Telecom Australia is also committed, of course, to maintaining the existing network to satisfactory standards and this is a basic and appreciable need for funds in the Financial Plan. Action, therefore, takes place each year to establish the level of maintenance operations to be adopted and this action



NOTE: THE TELECOMMUNICATIONS ACT 1975, SECTION 73 (1) (b) REQUIRES FUNDS FROM INTERNAL SOURCES TO BE NOT LESS THAN ½ (A+B–C+D–E–F+G). IT WILL BE NOTED THAT IN THIS EXAMPLE THE REQUIREMENT IS NOT MET. (SEE FINANCIAL CONSTRAINTS SECTION FOR EXPLANATION)

Fig. 3—Flow Chart for Checking Financial Plan With Regard to Requirements of the Telecommunications Act 1975, Section 75(1)(b).

extends over a timetable compatible with that of the Financial Plan cycle.

It is important to re-emphasise here that the Financial Plan levels of capital and plant maintenance expenditures are not determined in isolation. The whole process is iterative with the final balance conforming to overall financial and manpower constraints.

The plan is updated each year and extended by one year. The cycle then continues with external communication between Headquarters and the Minister and internally between Headquarters and the States, the object being to establish the firm basis of the next year's operations.

ENGINEERING CAPITAL WORKS PROGRAMME

The tool used within Telecom Australia to itemise the engineering projects to be undertaken and also to set down short-term physical targets is the Engineering Capital Works Programme. The level of this programme is established by the Financial Plan, but, because the programme is fashioned to best meet engineering responsibility accounting requirements, it does not flow directly from the plan.

The following information has been included in this article because the author feels it could assist Telecom Australia staff engaged in Works Programme and financial planning activities to better appreciate how the Engineering Capital Works Programme relates to the Financial Plan.

Reference to Figure 4 will show that the major source of the Engineering Capital Works Programme in the Financial Plan is the Engineering Construction Programme (E.C.P.) item. To this is added the costs involved in handling material in engineering stores and in purchasing Workshops fixed plant, the former being portion of the costs included under the Administration and Overheads item in the Financial Plan and the latter being portion of the Other Plant and Equipment item.

The Financial Plan naturally covers a complete fiscal year. In terms of labour, it, therefore, accounts for the total number of working days in the year 1st July to the following 30th June, inclusive. However, because labour accounting in the Engineering Capital Works Programme is normally restricted, for convenience, to 26 pay periods of 10 working days each, there is need, as a rule, to make an adjustment in translating from the Financial Plan to the Engineering Capital Works Programme. This adjustment is termed "Labour Accruals" and is an amount equivalent to "x" days' labour costs where

"x" = the number of working days from the last pay period in june of the year preceding the financial year to 30th June of that year
less
the number of working days from the last pay period in June of the financial year to 30th June of the financial year.

If "x" is negative (as is normally the case) it simply means that the Engineering Capital Works Programme needs to cover "x" days less than the Financial Plan, and so "x" days' labour is subtracted from the plan. If "x" is positive (which occurs only once every 11 years when 27 pay periods of 10 days need to be covered by the Engineering Capital Works Programme) then "x" days' labour cost needs to be added to the Financial Plan. This is illustrated by the following which looks at the period 1975/76 to 1982/83:

Year	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83
"x"	—2	—1	—1	0	—1	—1	+9	—1

The level of Labour Accruals can also be affected when Award variations occur and result in an expense to the Financial Plan in one year, but when actual payments are not made until the following year. Under these circumstances additional funds are required in the Engineering Capital Works Programme in the following year for the backpayment of the Award and it is necessary to adjust the level of Accruals accordingly in that year.

Finally, because the total Engineering Capital Works Programme needs to include those capital works requested by the Australian Broadcasting Control Board (A.B.C.B.) to expand the national broadcasting and television networks, an amount is required to be added to the above to provide for such works. It is important to note that such funds are not part of the Financial Plan, but are allocated separately by the Department of Treasury to enable the Commission to carry out the work for the A.B.C.B.

The figures used in Figure 4 to illustrate the process are those that were appropriate at one stage to the N.S.W. 1975/76 Engineering Capital Works Programme.

ITEM	$ MILLIONS
E.C.P. (Directly from Financial Plan)	131.500
Plus Technicians Stores Operating Costs (TSPH)	0.440
Plus Lines Stores Operating Costs (LSPH)	2.410
Plus Workshops Machinery and Plant (MWP)	0.330
Less Labour Accruals (2 days at $0.250M per day)	0.500
ENGINEERING PROJECT PROGRAMME	134.180
Plus Broadcasting and Television Capital Works	1.477
ENGINEERING CAPITAL WORKS PROGRAMME	135.657

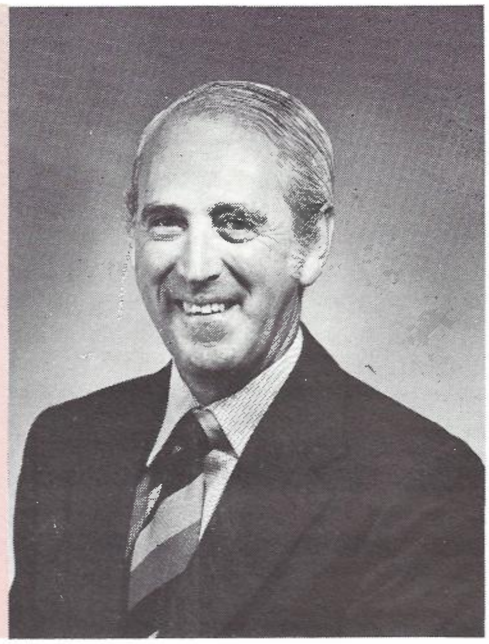
Fig 4—Derivation of Engineering Capital Works Programme Level from Financial Plan.

ACKNOWLEDGMENTS

This article would not be complete without acknowledging the help given by others in its production. In particular, the author wishes to thank Mr. I. Bradley, Class 3 Engineer, Fundamental Planning, N.S.W., both for assistance in producing an earlier information circular from which extracts have been taken and also for his criticism of the article itself. Similar thanks are extended to Mr. D. A. Brooke, Executive Engineer, Headquarters, whose criticisms of the article when in draft form have also aided markedly in its presentation.

The author also felt it wise before publication to have the article perused by a financial expert to ensure that its content, intended mainly for engineers and written from an engineer's viewpoint, did not lead to inaccuracies in financial terms. Mr. L. Mitchell, Telecom Australia's Chief Manager, Finance and Accounting Department, N.S.W., was kind enough to arrange for Mr. J. Gibson, a Chief Finance Officer in his Department, to perform this task and thanks are extended to these two gentlemen for their help in this regard.

BEN KENNEDY joined the A.P.O. in Sydney in 1945 as a Cadet Engineer and, after qualifying in 1949, started his career as an Engineer in Metropolitan District Works. In 1954, following some five years engaged in District Works activities, including two years in Canberra Country District, he transferred to the N.S.W. Planning and Programming Branch. Since that date he has occupied a number of positions in the Branch, being mostly concerned with the transmission and line network. For the past two years he has been Supervising Engineer in the Fundamental Planning Section where he has been intimately involved in the overall co-ordination of the State Engineering Capital Works Programme.



Technical News Item

INTERNATIONAL SUBSCRIBER DIALLING COMMENCES.

ISD service from Australia commenced on 1st April, 1976. The service was available through 70 exchanges in Sydney, 7 exchanges in Melbourne and one exchange in Perth on this date and is being progressively extended to all ARF crossbar exchanges in the mainland metropolitan networks, with later extension to other areas. Initial destination countries available were Austria, Canada, Denmark, Fiji, West Germany, Greece, Hong Kong, Israel, Japan, Singapore, Switzerland, United Kingdom and United States of America. Other countries will be available after the necessary arrangements have been finalised between the Overseas Telecommunications Commission (Australia) and the distant administering authorities.

As described in the article in this issue of the Journal, Telecom Australia is providing an interim ISD service using multi-metering charging which will be followed by the introduction of the preferred method of charging, Automatic Message Accounting, when network modifications have been completed. The interim service introduced on 1st April provides "Customer Choice" access. Subscribers on exchanges equipped to provide the service are normally barred to the service and are only given access if they elect to accept ISD.

Sydney and Perth calls are being charged at Pitt 10C exchange in Sydney and Melbourne calls at Lonsdale 10C exchange in Melbourne.

Earth System Design

T. S. CODY, B.Tech., Grad. I.E. Aust. and D. R. CARR, B.Tech., Grad. I.R.E.E.

Due to a lack of predictability in the methods used by Telecom Australia for designing earth systems, it was thought desirable to investigate the original work done by L. E. Whitehead of the Du Page Laboratories, and to evaluate this work using Telecom Australia methods and materials.

Instead of designing a separate network for every value of earth resistivity measured, the resistivity values up to 400 ohm metres were split into six ranges and, using an upper limit of five ohms, networks were designed for each range. These networks were installed and tested and the results evaluated against design expectations.

INTRODUCTION

While working on the design of minor trunk cable and coaxial cable installations in various parts of South Australia, the subject of earth system design kept arising. Available literature was very general and it became very difficult to find a reliable method for predicting the final resistance of an installed earth system.

Eventually an article by L. E. Whitehead of the Du Page Laboratories (Ref. 1) appeared to provide a reliable method for predicting an earth bed's final resistance. This method was then used as a basis for designing earth systems with a high degree of certainty of achieving the desired value of resistance.

The most significant point raised by the work undertaken was that both the area covered by the earth system and the length of the electrode in contact with the ground were very important; that is, for a given area no matter how much wire or how many stakes were installed in the area, the resistance of the earth system would not fall below a minimum value. This minimum value was a function of the resistivity of the ground.

SOIL RESISTANCE

There are several factors which affect the resistance of an installed earth system. These include the soil resistance which is the most significant, electrode resistance and contact resistance.

The soil resistance (Ref. 2) is the resistance of the volume of soil surrounding the electrode. For a rod, practically all the resistance is contained within a hemisphere having a radius of 1.5 times the length of the buried rod. It can be seen that an earth system which causes the current to spread through a large volume of earth will have a resistance lower than one in which the current density is high. Since most soils and rocks are poor conductors, it is essential to keep the current density as low as possible. It is the linear extension of the electrode that is of importance, not its shape.

Where it is not possible to achieve the required earth mat resistance with one or more rods, a trench earth will usually be more satisfactory. The resistance of trench earths is lower because they bring into play a large volume of earth. The size of the wire is not important provided its resistance is not too high.

EARTH RESISTANCE CALCULATION

When an earth system is installed, its resistance to ground is determined by the area covered by the system, the length of buried conductor and the soil resistivity. From the initial research by Whitehead the following relationship allows the earth resistance of an earth system to be calculated before installation:

$$R = \frac{\rho}{4r} + \frac{\rho}{L} \qquad \text{.................................(1)}$$

Where R = resistance of electrode system to earth in ohms,

ρ = soil resistivity in ohm metres,

r = radius of circle equal to grid area in metres,

L = length of electrode in metres.

Therefore, if the soil resistivity is measured it is possible to calculate the resistance of any desired earth system.

The first term, $\rho/4r$, accounts for the effect of the area covered by the earth system and the soil resistivity. As the resistance of the system is normally specified it indicates that for a given resistivity value the area of the system is important.

The second term, ρ/L, takes into account the length of conductors in the system.

For an earth system, the value of resistivity is fixed by the site position and so to achieve a specified resistance the length of conductors is important.

Other factors must be considered when designing earth systems. For example, the soil moisture content may affect the resistance of the earth system and allowance should be made for variation in this factor. For any system, equation (1) will allow the earth bed resistance to be found. The nomograph in Fig. 2, however, simplifies the procedure. Instead of converting the area of the system to the equivalent radius of a circle, the length and width verticals of the nomograph combine to give $1/4r$ which is represented by a third vertical line. The nomograph gives the $\rho/4r$ and ρ/L terms which must then be summed to give the total resistance.

DESIGNING AN EARTH SYSTEM USING THE NOMOGRAPH

Faced with the problem of installing an earth system, the following variables will have to be determined:

- Soil resistivity;
- Required earth resistance.

It is essential that the soil resistivity be measured at the depth at which the earthing system is to be installed. If this is not done and the system is installed at a shallower depth where the resistivity is usually higher, the total resistance of the system will be higher than predicted. This is particularly important where a long length of ploughed wire is used. To design an earth system using relationship (1) decide on approximate values for the component parts. An iterative process using three or four different values may be necessary before a suitable separation is achieved between each part of the equation. Each pair of values must be calculated and the area of the system and the length of wire checked for practicality in relation to where the earth system is to be installed.

Example:

Let ρ = 100 ohm metres,

$$\frac{\rho}{4r} = 3.5 \text{ ohms and } \frac{\rho}{L} = 1.5 \text{ ohms}$$

i.e. Resistance R = 5 ohms

Then on the nomograph in Fig. 2 draws a line from $\rho/4r = 3.5$ ohms to $\rho = 100$ ohm metres . The intersect on the $1/4r$ scale represents an area which could be made up of any combination of length and width which passes through this point, eg 15.0m × 11.0m or 55.0m × 3.0m. Taking the 55.0m × 3.0m case, the length of wire buried in the ground would be 113m. (See Fig. 1). This is made up of parallel lengths of wire. Using the 113m point on the 'Length' vertical of Fig. 2 and joining it to the point $\rho = 100$ ohm metres gives a value on the ρ/L vertical of 1 ohm.

The total resistance R = 3.5 + 1 = 4.5 ohms. This is slightly better than the specified value and is due to the particular layout selected. The system designed is shown in Fig. 1.

PRACTICAL EARTH SYSTEMS

On long distance cable installation projects earth systems will be required at various points along the route. Each earth system will have to be individually designed. as described in the Example, to allow for the variation in soil resistivity which will occur over such long distances. In this way nearly every system installed will differ in some way or other. To overcome this problem and to introduce some similarity between earth systems in areas of similar soil resistivity, six basic earth systems have been designed. If the scale in Fig. 2 is divided into six approximately equal lengths the following ranges are achieved:

Type 1	Resistivity	0 - 10	ohm metres
Type 2	,,	11 - 20	,, ,,
Type 3	,,	21 - 40	,, ,,
Type 4	,,	41 - 100	,, ,,
Type 5	,,	101 - 200	,, ,,
Type 6	,,	201 - 400	,, ,,

The upper limit of each range is then used to calculate the structure of the earth systems. A 5 ohm or less earth resistance is considered satisfactory by Telecom Australia for external plant protec-

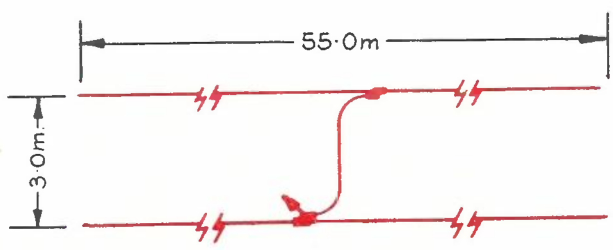


Fig. 1 — Earth System Calculated in the Example.

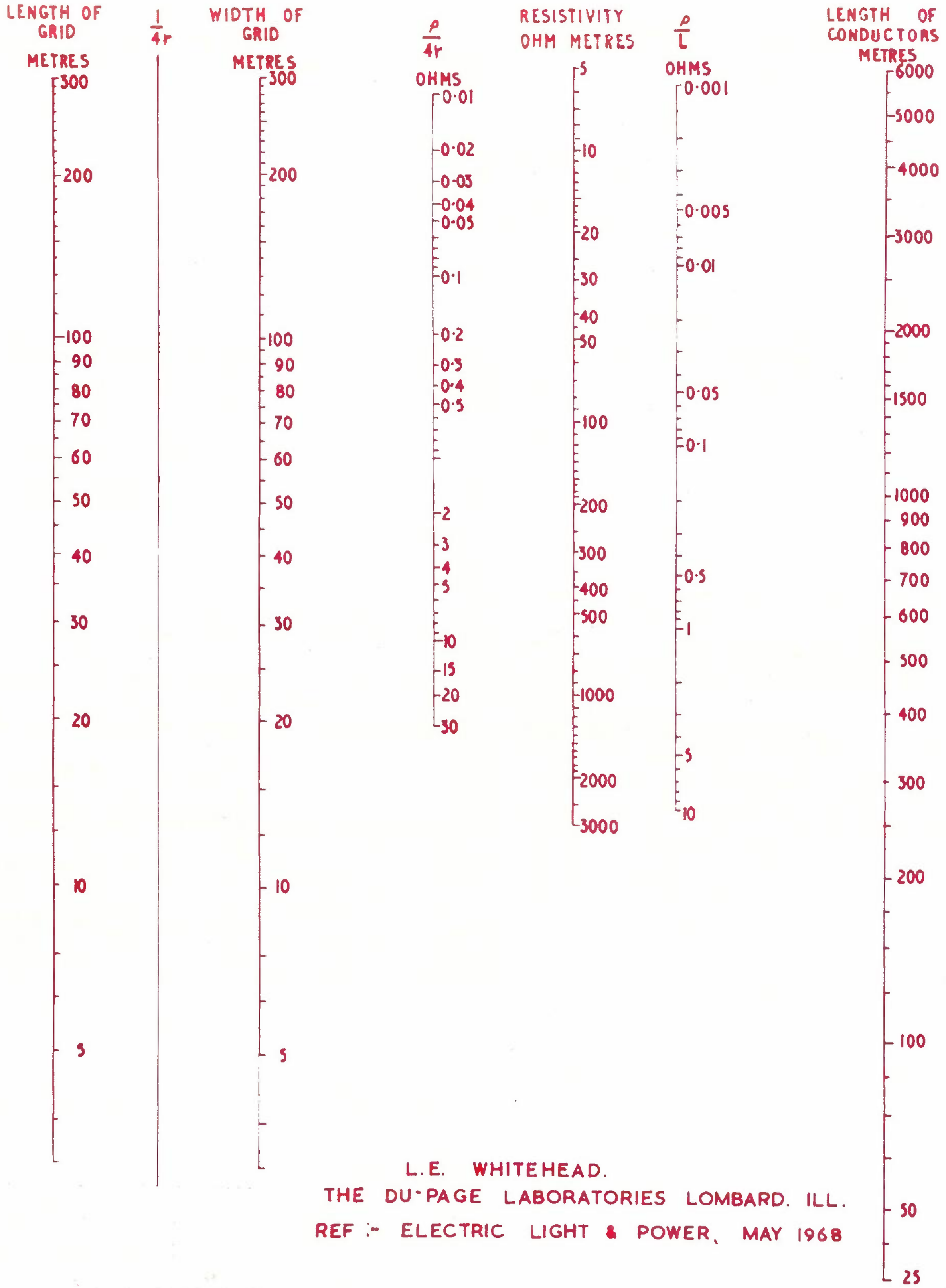
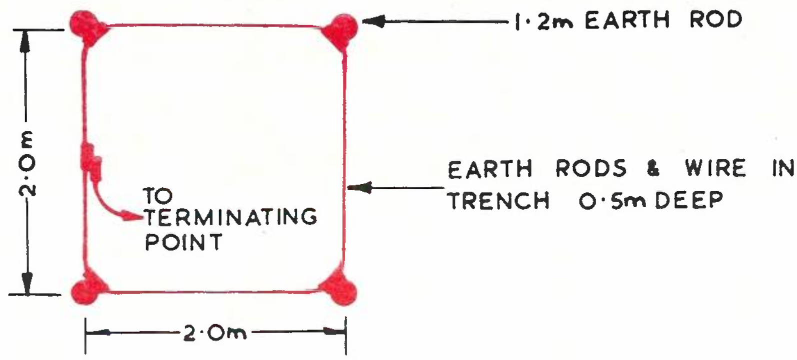
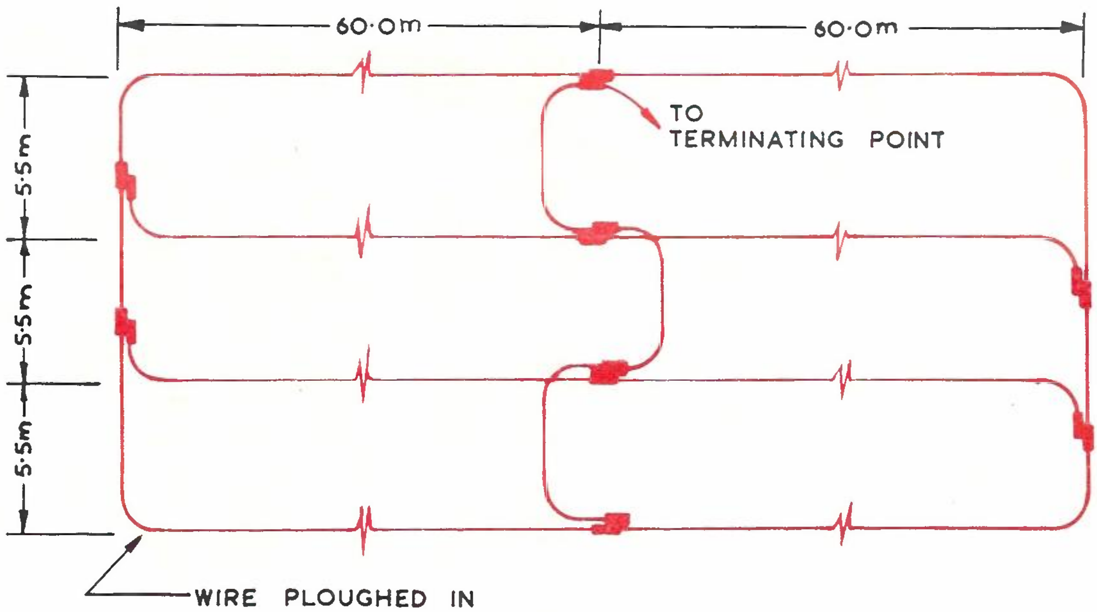


Fig. 2 — Nomograph for Earth Bed Resistance.



TYPE 1.
RANGE 0–10 OHM METRES TO PROVIDE 5 OHM UPPER LIMIT EARTH RESISTANCE.



TYPE 6.
RANGE 201–400 OHM METRES TO PROVIDE 5 OHM UPPER LIMIT EARTH RESISTANCE.

Fig. 3 — Earth System Types 1 and 6.

tion and the systems have been designed to achieve this value. The layouts selected are not the only ones available, but by limiting the available alternatives, design effort is minimized and some degree of standardisation can be maintained.

Initially, all systems were designed to include a number of earth rods. However, field trials showed that the rods were only needed in the Type 1 and Type 2 systems. In the larger systems the length of earth rod was insignificant when compared with the length of buried wire. It was found that the improvement due to the use of the rods did not warrant their use when a few extra metres of wire could be installed at a much cheaper cost. The type 1 and type 6 earth systems have been illustrated in Fig. 3.

INSTALLATION OF EARTH SYSTEMS

When installing an earth system the soil resistivity at the site must be measured. The value obtained will normally fall into one of the six categories listed above and using this information the required earth system type can then be nominated. If the soil resistivity is above 400 ohm metres it will be necessary to design an earth system using the nomograph. Similarly, the nomograph must be used if an earth resistance of less than 5 ohms is required.

All earth systems have been designed to be installed at a depth of 0.5 metre or greater. For the Type 1 and Type 2 systems, trenches should be dug 0.5 metre deep and of the required length and spacing. The earth rods are then driven in at the base of the trench and connected together using earth wire. The trenches are then reinstated.

The larger systems Type 3 to Type 6 are designed to be installed by trenching or ploughing in earth wire and a trench is required across the system at one point to allow interconnection of the laterals with the feed to the point where the earth is required, e.g. a manhole. After the system is interconnected the trench or rip line must be reinstated.

Although it is desirable to install earth systems which correspond to those designed, in practice it will often occur that such systems are impossible to achieve. There are two important factors to remember, namely that the area covered by the system and the length of buried wire (including earth rods if applicable) control the total earth resistance. Provided the area and length of buried wire are not changed, variations in layout will not affect the resistance. Should it be necessary to reduce the overall width of the system then compensation should be made by the addition of additional length.

To reduce the effects of variations in the soil moisture content on the final resistance, the systems are designed to be installed at a depth of 0.5m or deeper. On one particular Telecom Australia installation measurements were made in wet weather with the ground very damp. Even so, substantially high resistivity figures (236 ohm metres) at one metre electrode spacing were obtained.

TEST RESULTS

Initial Test Results

Following the development of this method 24 earth systems were installed in areas with soil resistivities ranging from less than 10 ohm metres to above 250 ohm metres. In most cases the resistance of the installed system was five ohms or less.

It will be noted from the results listed in Table 1 that in a number of instances the earth system type does not correspond to the type which should be predicted by the resistivity value. It was found during the earth resistivity measurements that there was a large change in resistivity e.g. 256 to 75.3 ohm metres, with a change in electrode spacing from one metre to two metres. A compromise was made in the system type and in all but one occasion the compromise produced a satisfactory result. In the one that did not, additional wire had to be added to the systems.

Follow Up Test Results

After twelve months, the earth systems on one installation were retested in the winter and following summer. The results are listed in Table 2.

TABLE 1: INITIAL TEST RESULTS ON INSTALLED EARTH SYSTEMS

Soil Resistivity (Ohm Metres)	System Type	Earth Resistance (Ohms)
2.1	1	0.7
4.4	1	1.3
7.4	2	1.4 Note 1
7.5	2	1.9 Note 1
8.4	1	1.2
8.4	1	3.0
9.9	1	2.5
21.0	4	1.5 Note 1
22.6	3	3.5
23.6	3	4.6
31.4	2	1.9 Note 1
33.3	3	6.1 Note 2
34.6	3	3.3
44.0	4	1.0
46.5	4	3.5
60.3	4	5.0
60.5	4	4.1
61.5	4	3.4 Note 1
75.3	5	3.3 Note 1
79.0	4	4.5 Note 1
89.0	5	3.2 Note 1
95.5	5	6.0 Note 2
122.0	5	3.1

Note: 1. Due to a large change in resistivity with pin spacing, the system installed was a compromise.
2. The system was modified by adding more buried wire to reduce the earth resistance to below 5 ohms.

TABLE 2: COMPARISON OF INITIAL AND LATER MEASUREMENTS

Initial Measurements			Later Measurements			
			Winter (Wet)		Summer (Dry)	
Resistivity	Type	Earth Resistance	Resistivity	Earth Resistance	Resistivity	Earth Resistance
4.4	1	1.3	5.0	1.3	2.5	1.3
7.4	2	2.5	6.9	1.3	7.8	1.3
7.5	2	1.9	6.9	1.5	4.2	1.6
8.4	1	1.2	6.3	1.3	9.0	3.5
21.0	4	1.5	6.3	0.8	11.0	0.9
33.0	3	6.1	29.0	2.3	47.0	3.0
46.5	4	3.5	20.0	3.4	23.0	3.2
60.5	4	4.1	56.0	2.5	62.0	3.3
61.5	4	3.4	46.5	2.1	54.0	4.0
75.0	5	3.3	22.0	2.1	60.0	9.0
89.0	5	3.2	24.0	1.2	22.0	2.8
95.0	5	6	32.0	2.1	5.7	1.5
122.0	5	3.1	59.0	1.5	40.0	2.5

Note: Resistivity in 'Ohm Metres'; Earth resistance in 'Ohms'.

Of the thirteen sites tested, only one earth resistance exceeded the 5 ohm upper limit. The soil resistivity variation which occurred at this site over the period of the tests was only relatively small and should not have been responsible for the rather large variation in the earth resistance. Since the variation in the earth resistance occurred between tests taken in wet and dry periods it indicates that the soil mosture content, in this particular location, is an important factor in determining the earth resistance.

ANALYSIS OF RESULTS

In considering the implications of the results obtained it must be realised that the information available at this stage covers only a small number of cases, but the results fully bear out the original work of the Du Page Laboratories.

Of the 24 earth systems installed, 22 met or bettered the desired upper limit of 5 ohms. The maximum value obtained was 6.1 ohms in 33.3 ohm metre soil with another at 6.0 ohms in 95 ohm metre soil. Using this small sample the probability of obtaining 5 ohms or better is 91%. However, as the sample size is increased as more systems are installed and experience is gained in the use of the method described, the probability of obtaining 5 ohms or better should increase still further.

Subsequent tests on installed systems after a prolonged dry season have indicated a high degree of stability (92%) on the initial value.

CONCLUSION

Tests so far conducted indicate that the method discussed here for designing earth systems gives reliable and predictable results. The design procedure has been simplified by creating six categories of soil resistivity measurements and designing a standard earth system for each. While there are a few practical restrictions to be observed, the method involved generally allows a large degree of flexibility in designing earth systems to meet particular cases.

Subsequent testing of the method devised has shown a high degree of stability indicating the merit of the method.

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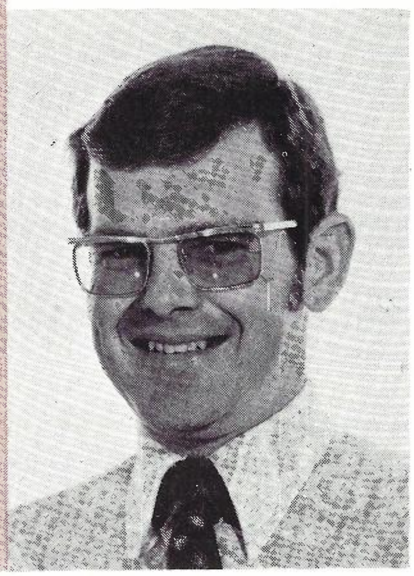
1. Whitehead, L. E.: 'Nomograph Helps Find Resistance of Grounding Electrodes'; Electric Light and Power, May 1968, pp 120-121.
2. Boyce, C. F.: 'Open Wire Carrier Telephone Transmission'; pp. 198-199.

T. S. CODY joined the APO in 1960 as a Technician-in-Training. In 1968 he became a Trainee Engineer and graduated from the University of Adelaide with a Bachelor of Technology degree in electronic engineering in 1971. His first appointment as an Engineer Class 1 was in Building Engineering Services where he spent two years. In 1973 he transferred to the Primary Works Section as project engineer on the Ceduna to Cobar coaxial cable project. He has been involved in the planning and installation of the larger country area trunk cables as well as with a coaxial cable project.

D. R. CARR joined the APO as a Technician-in-Training. In 1971 he was selected as a Cadet Engineer and graduated from the University of Adelaide with a Bachelor of Technology degree in electronic engineering in 1974. His first appointment as an Engineer Class 1 was in Primary Works where he was involved in work on cable installation projects. After approximately 15 months he was transferred to the Services Branch where he has been involved in many aspects of support services work.



ERRATA

VOL. 25, No. 2.

In the article entitled "Underwater Cable Locator", the Conclusion omits reference to John Mitchell, Telecommunications Technical Officer Grade I, who also made a significant contribution to the development of the detector. The Conclusion should read as follows:

CONCLUSION:

This detector has been developed over a number of years by Messrs. Fred Goddard, Testing Officer, and Greg Jackson, Engineer Class 1 from Sutherland Operations, in conjunction with Graham Johns, STTO1 and John Mitchell, TTO1 from Transmission Measurement Studies and Design Section, Sydney.

In its present state this detector would appear more than adequate to locate any cables above or below water that the Department has laid.

VOL. 26, No. 1.

In the article entitled "Colour Conversion of National Television Transmitting Stations", the photographs foı Figs. 7 and 8 should be transposed. The figure references and captions are correct, and in accordance with the text of the article.

Ultrasonic Cleaning

J. J. ANDREWS, B.E. (Elec.), M.I.E. Aust.

An outline of the principles of ultrasonic cleaning as applied to telecommunication equipment is given, with illustrations of the application in the Brisbane Engineering Workshops.

INTRODUCTION

Ultrasonic cleaning systems are in use in most of the Engineering Workshops of Telecom Australia. An example of the use which has been made of the equipment was described previously (Ref. 1). This article gives an outline of the principles involved and describes the system in use in Brisbane Workshops.

CLEANING

The cleaning of intricate mechanisms has always been a difficult and time consuming exercise, as those technical staff who recall the now past days of regular bi-motional switch overhaul will readily agree. Although the philosophy of dismantling, examining and reassembling bi-motional switches on a regular routine basis has been superseded, there are still many mechanical and electromechanical mechanisms in the telecommunications network which require cleaning and refurbishing before they can be restored to satisfactory service.

The cleaning process requires the removal of soluble films and particular soils from the surface to be cleaned, normally by immersing the article in a suitable fluid. If the fluid or the article is agitated then the process is usually much more efficient, as the soil is removed by both the mechanical "washing" action and, if the soil is soluble, by presenting unsaturated fluid at the soiled surface.

THE ULTRASONIC PROCESS

A particularly effective method of agitating the fluid is to use ultrasonic energy. The parts to be cleaned are immersed in a suitable solvent contained in a cleaning tank. Ultrasonic energy derived from an oscillator and suitably amplified is transmitted into the tank by transducers attached to the tank bottom. The transducer surface is vibrated with sufficient amplitude to cause cavitation in the cleaning fluid. This causes the rapid formation and collapse of vapour bubbles within the fluid and is equivalent to a scrubbing action on the surface of the article. This action is effective even in small voids and crevices which would be difficult or impossible to clean by other methods.

Most ultrasonic cleaners work in the frequency range of 20-40 kHz. These relatively low frequencies are favoured because the lower the frequency, the larger are the cavities and the greater the scrubbing action produced on the collapse of the bubbles. Frequencies significantly below 20 kHz approach the human audibility range, with the result that the environment may become excessively noisy, particularly in view of the high power input to the transducers.

In the Brisbane installations two lead zirconate piezoelectric transducers each of 500 watts capacity are fitted to each tank, and operate at a nominal frequency of 23 kHz. Some sub-harmonic vibration is evident (apparently at about 11-12 kHz) and the "hiss" produced by the units had objectionable effects on nearby staff, requiring them to be installed in a separate enclosure.

Choice of Solvent

The cavitation effect is produced in different liquids with varying efficiency (e.g., in water, a power input of approximately 0.6 W per sq. cm. is required to initiate cavitation at 25 kHz). In addition to the requirement that the solvent be suitable for use ultrasonically, it must also be compatible with the equipment being cleaned. The ideal solvent is

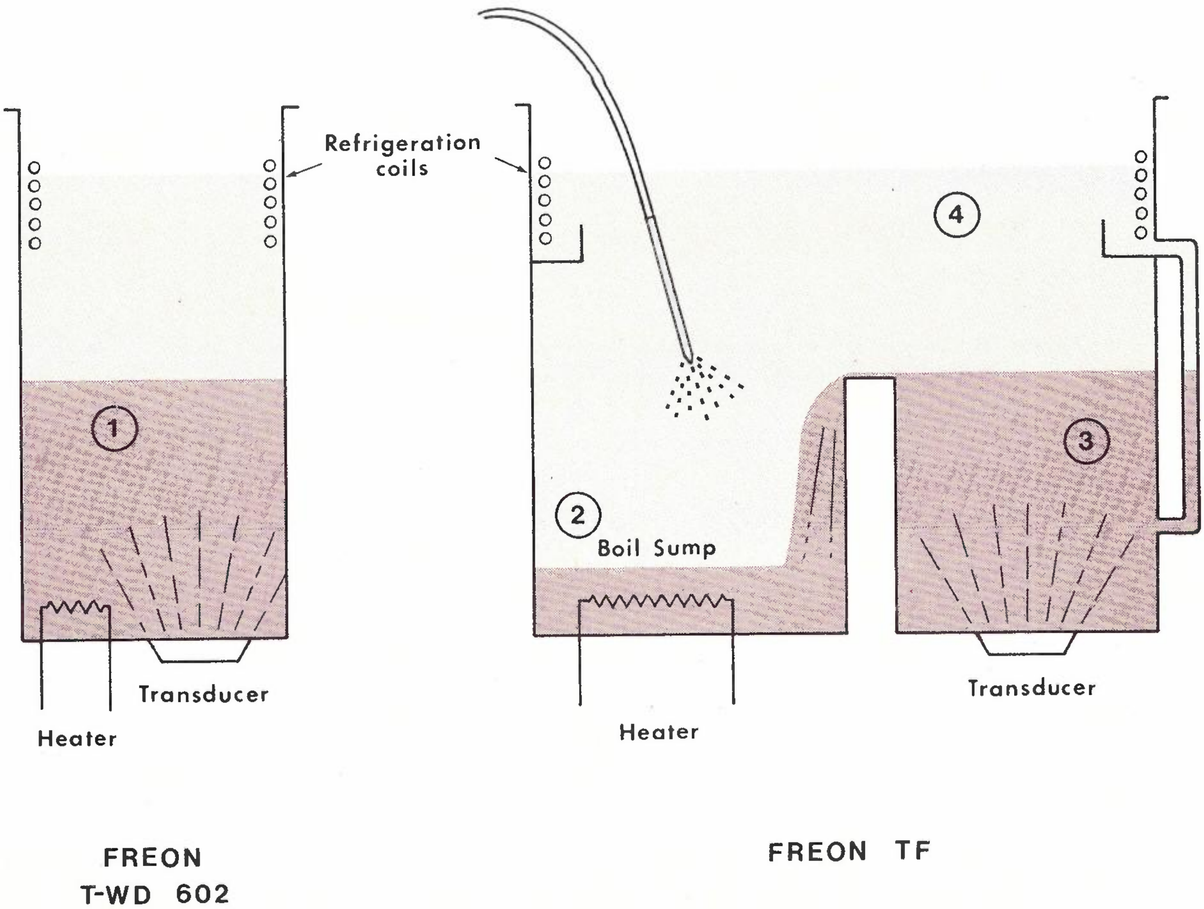


Fig. 1 — Principle of Ultrasonic Cleaner.

one which will remove soils and soluble films without in any way affecting the integrity of the item. At the same time it should be non-flammable, non-toxic and not be unpleasant to use.

Although water is an excellent medium for ultrasonic purposes, since its cavitation effect is powerful and there is a minimum dissipation of energy, and it fulfills many of the other requirements, water solutions have a number of disadvantages. The chief of these, of course, is the absolute incompatibility of water and most electrical and electronic components. Nevertheless water based solutions can be used in some instances and in Brisbane Workshops water-detergent solutions (with small quantities of ammonia) are used for cleaning some non-electrical components and assemblies.

Solvents suitable for degreasing and cleaning include halogenated hydrocarbons (e.g., carbon tetrachloride, trichloroetheylne, perchloroetheylne, methelyne chloride and trichlorotrifluoroethane), acetone, various alcohols and white spirit. All can be used with ultrasonic equipment with varying degrees of efficiency. The latter three (acetone, alcohol and white spirit) are readily flammable and thus undesirable except for special applications. All of the halogenated hydrocarbons have low surface tensions which give them the ability to penetrate into small crevices. Cavitation cleaning can then occur in otherwise inaccessible places. They also drain readily, resulting in little or no residues. All have low specific and latent heats, so minimum energy input is required for distillation and their vapours (which are several times heavier than air) are readily contained in open vessels. They are also non-flammable.

Some of the halogenated hydrocarbons are quite toxic in certain circumstances (e.g. carbon tetrachloride) and others (e.g. trichloroethelyne) are deleterious to some plastics. The solvent chosen for use in most plants in the Workshops is trichlorotrifluoroethane (C Cl2F-C ClF2) more usually known by its trade names of "Arklone" or "Freon". This is the same material as the commonly used refrigerant of the same name. For the sake of brevity, the registered Du Pont trade name "Freon" will be used to refer to this chemical in this article.

Freon is a clear, dense (SG 1.56), colourless liquid with a boiling point of 46°C. It has very good ability to remove or flush away soils and surface films, but will not affect in any significant way most of the materials (plastics and metals) used in the construction of telecommunication equipment. It has somewhat higher cavitation energy requirements than water, but not significantly so. In addition it is practically non-toxic although like most of the other halogenated hydrocarbons it can be broken down into dangerous components by passing through a flame (e.g. a lighted cigarette). Smoking is therefore prohibited in the immediate area.

It will displace water, being heavier, and articles containing traces of water can be "dried" reasonably effectively, the water floating on the surface of the Freon to be separated out later.

In addition to pure Freon ("Freon TF") a proprietary solvent known as "Freon T-WD 602" is used in a preliminary cleaning phase to remove harsher soils. It is a water-in-oil emulsion system which has the advantage over pure Freon of being able to dissolve both water soluble and oil soluble soils. The addition of a small quantity of ammonium hydroxide enhances its cleaning properties greatly, especially when heated. No evidence of stress corrosion cracking initiated by the ammonia has been found in brass parts after many years of use in another Workshop.

THE BRISBANE INSTALLATION

The installation in Brisbane (Fig. 1) consists of two 1 kW units, each of approximately 60 litres capacity in the ultrasonic tank, plus a smaller unit of about 20 litres capacity. The larger units were designed to be capable of accepting the largest crossbar relay sets at present in use.

Method of Use

The item to be cleaned is first immersed in the Freon T-WD 602 tank (1) and ultrasonically cleaned for two to three minutes. The refrigeration coils above the solvent are necessary to contain the vapour in the vessel and prevent loss of Freon by evaporation. The solvent in this tank is heated to approximately 38°C. The liquid rapidly becomes quite filthy and is filtered and decanted at regular intervals. Articles emerging from this tank are still coated in soils, but the prime purpose of this stage is to loosen the soils ready for the next step.

The item is then transferred to the boil sump (2) of the next unit, and rinsed thoroughly with the spray lance using distilled Freon. It is then immersed in the second ultrasonic sump (3) which contains pure clean Freon distilled from the boil sump. Liquid continually overflows from this sump into the boil sump, thus maintaining its cleanliness. Again the treatment time is approximately three minutes.

The article is then raised slowly through the vapour phase (4) for final cleaning, and to allow any excess liquid Freon to drain back into the tank.

Practical Points

As mentioned earlier it was necessary to enclose the units in a special room to reduce the high frequency noise output and also to minimise the flow of air (and hence loss of Freon) across the equipment. This resulted in the temperature in the room rising to unacceptable levels during summer (up to 8°C above ambient). It was then necessary to remove the refrigeration units to outside the enclosure. Temperatures are now satisfactory. One or two leaks occurred due to weld failures in the tank which were very difficult to detect as the Freon evaporated without trace and did not form a pool.

There is insufficient work load to keep the units operating full time and to conserve Freon (which is quite expensive, at over $1.00 per litre) the units are drained during that part of the week when not in use. The T-WD 602 when hopelessly contaminated is distilled and the pure Freon recovered for use in the second unit.

Uses

The units are used on a regular basis to clean dials and dial parts, public telephone mechanisms, intercom key units and relay sets. Bi-motional switches have been cleaned, but one problem is that certain types of buffer blocks used in 3000 type relays tend to shatter unless the ultrasonic energy input is reduced. This appears to be due to voids and flow patterns in the injection mouldings used in the original manufacture. No other ceramic or plastic parts have been damaged, with the exception that some A.B.S. parts have crazed. Another hazard in cleaning bi-motional switches in this way is that every trace of lubricant is removed. It is essential that before the switches are returned to service every moving part be adequately lubricated, including those parts not touched in a normal lubrication programme.

Following the Brisbane floods in January 1974 several thousand relay sets were cleaned. The cleaning was quite successful (after excess mud had been removed by hosing with water) but the hope that the process would displace water and contaminants from the relay coils was unfounded.

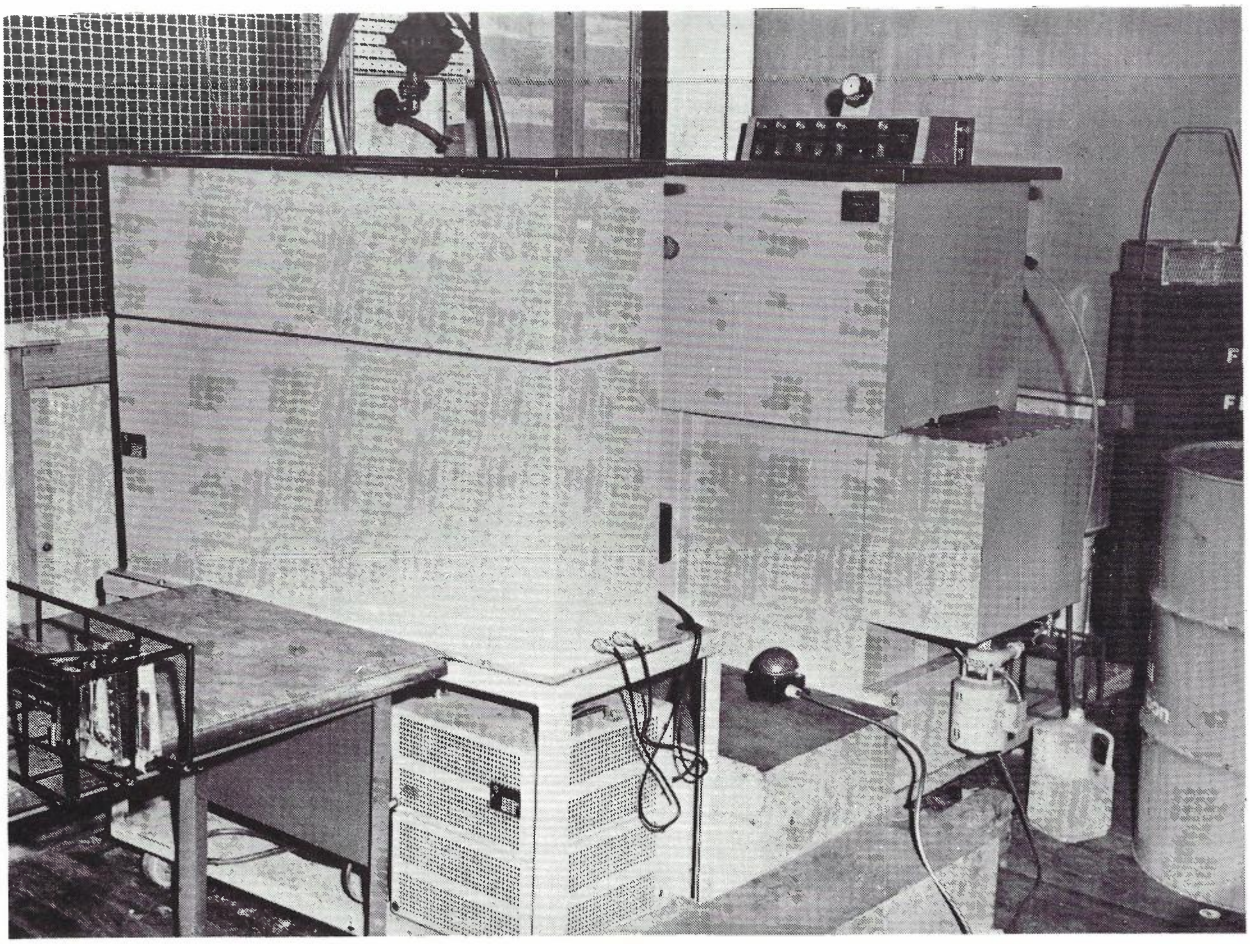


Fig. 2 — The Brisbane Installation.

Almost all relay coils were found to go open circuit due to electrolytic corrosion after battery had been applied for a week or so.

The literature recommends the process for cleaning and flux removal of printed circuit board assemblies, but there are reservations about the effects on components with fine bonded leads such as transistors and integrated circuits. To date little work has been done in this area.

The effectiveness of the system was shown recently when some Siemens 16 switches, installed in 1928, were cleaned. Bank wiring, which had been a dirty brown-black for many decades emerged with the colour coding clearly visible, to the great surprise of those who had not realised it was colour coded at all.

CONCLUSION

The ultrasonic cleaning process is ideal for cleaning the intricate and sometimes delicate electro-mechanical equipment in use in many parts of the network. As this equipment ages and is required to be kept in service it is anticipated that the demand for the service will increase and the process will become an indispensable part of network maintenance.

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1. Telegen, Vol. 8, No. 2, June, 1975.

JOHN ANDREWS joined the Australian Post Office as a Cadet Engineer in 1956. After graduating from the University of Queensland as a Bachelor of Electrical Engineering he spent until 1966 in Metropolitan Service and Exchance Installation Sections. From 1966 to 1968 he was seconded to the Department of Posts and Telegraphs, Papua-New Guinea as Engineer in charge of equipment maintenance and later of equipment installation. After his return to Australia he was transferred to Brisbane Workshops. After several years as Engineer (Trades), he was appointed as Supervising Engineer, Brisbane Workshops in 1972.

Technical News Item

ULTRA-SONIC WELDING AND TRANSMITTER INSET PRODUCTION

A new production technique developed in the Melbourne Postal Workshops for the manufacture of transmitter insets has recently been accepted by the Australian Telecommunications Commission. This process uses ultra-sonic welding to attach the front electrode cup to the diaphragm of the inset. Previously, this has been achieved by the unreliable and comparatively expensive method of rivetting.

The equipment used for the ultra-sonic welding process consists of a high frequency generator (22 kHz) with output power up to 600 watts, and controls for the clamping load and weld time. The welding head (see fig. 1) consists of an upper sonatrode and lower anvil, between which the metal to be welded is hydraulically clamped. The transducer, a laminated nickel stack which expands and contracts when excited by the high frequency alternating current from the generator, is attached to the upper sonatrode by a coupling bar. The frequency used must be close to the resonant frequency of the welding array for efficient operation.

To make the weld, the diaphragm and cup are positioned together on the anvil, which is shaped to fit the diaphragm. The upper sonatrode lowers inside the cup and the ultra-sonic power is applied for a preset time. This produces shear vibration between the cup and diaphragm which are in intimate contact. The vibration abrades the oxide film, exposing the oxide-free metal, which readily forms a metallurgical bond.

The resulting weld produces a more reliable transmitter inset, as the bond between the cup and electrode is mechanically superior to the rivetting process. Additionally, the oxide-free bond between the cup and diaphragm gives a much lower contact resistance, resulting in better performance of the inset.

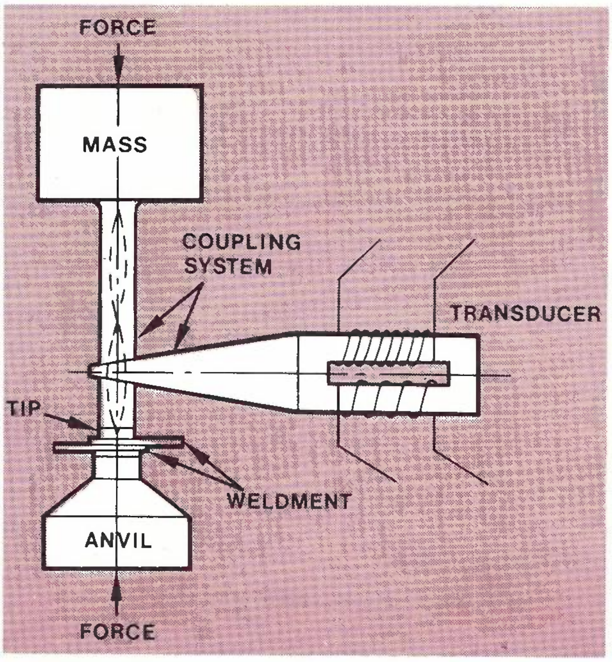


Fig. 1

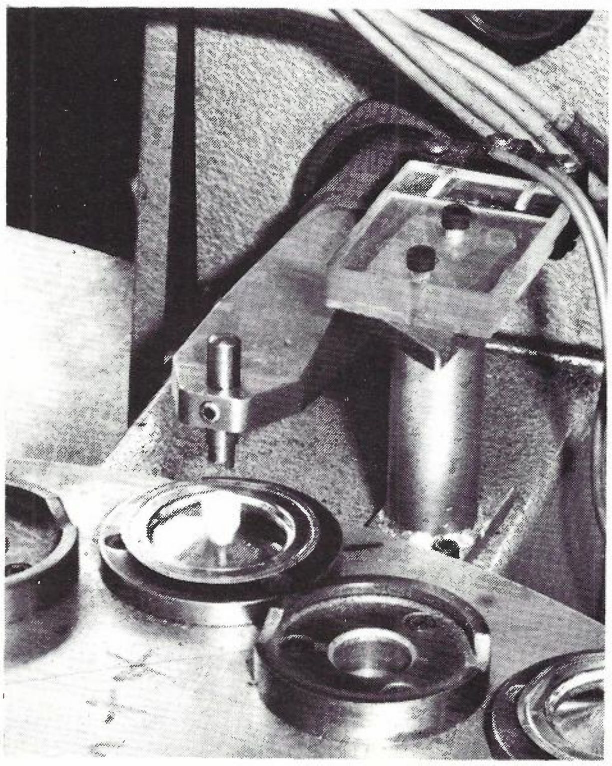
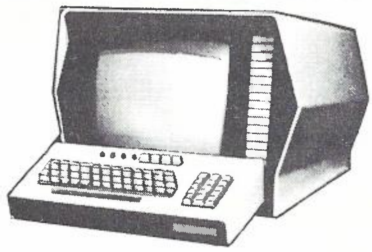
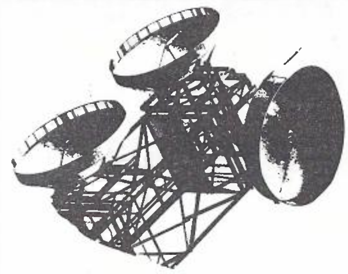


Fig. 2

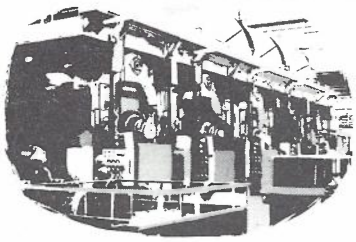
DEDICATED REAL-TIME SYSTEMS



COMMERCIAL ON-LINE SYSTEMS



DATA COMMUNICATIONS



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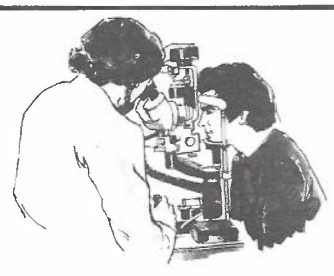

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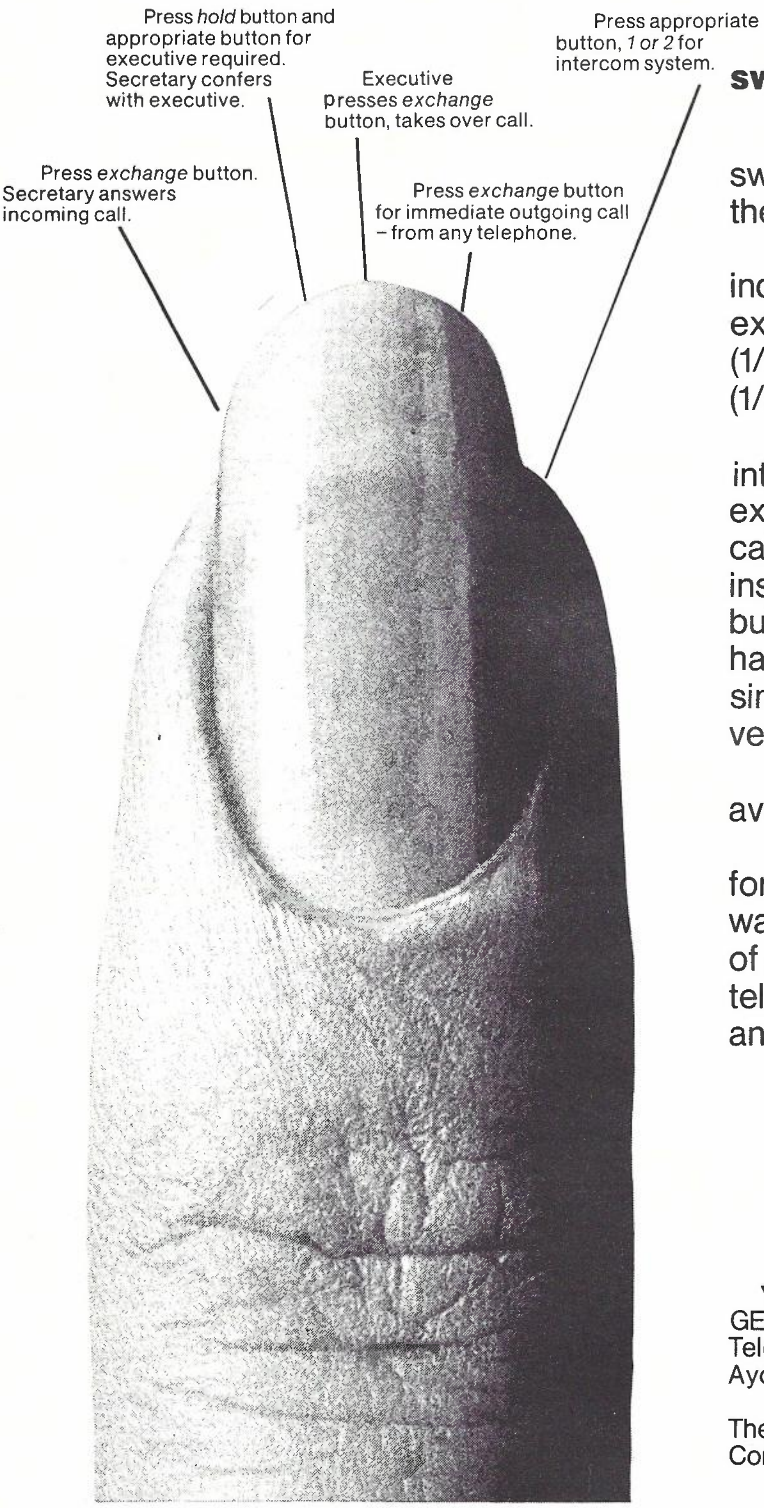

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From GTE.

The Telecommunications Journal of Australia

ABSTRACTS: Vol. 26, No. 2.

ANDREW, K. T.: 'Problems of Growth in Sydney's Telephone Cable Tunnels'; Telecomm. Journal of Aust., Vol. 26, No. 2, page 129.

The Sydney telephone tunnel network, built mostly around the year 1900, has served the city well for many years but is now becoming grossly inadequate, at least in certain sections. The congestion, which now limits its usefulness, complicates relief measures, which are difficult and expensive. Also the establishment of new major and hence heavily cabled exchanges which must be linked with the existing tunnel system, poses special problems at the intersection of the old and new systems. This article surveys those problems and proposed solutions.

ANDREWS, J. J.: 'Ultrasonic Cleaning'; Telecomm. Journal of Aust., Vol. 26, No. 2, page 167.

An outline of the principles of ultrasonic cleaning as applied to telecommunication equipment is given, with illustrations of the application in the Brisbane Engineering Workshops.

COCKREM, J. C.: 'The Development of the Public Telephone in Australia'; Telecomm. Journal of Aust., Vol. 26, No. 2, page 114.

Since the take-over of the Company Coin "Red" and "Easi" phones and the recent formation of Telecom Australia, a new approach is being taken with public telephone policy which is expected to substantially improve the commercial and service aspects. This approach has increased interest in the public telephone sphere and this article describes the development of these instruments from the time when the first known types were in service.

CODY, T. S. and CARR, D. R.: 'Earth System Design'; Telecomm. Journal of Aust., Vol. 26, No. 2, page 160.

Due to a lack of predictability in the methods used by Telecom Australia for designing earth systems, it was thought desirable to investigate the original work done by L. E. Whitehead of the Du Page Laboratories, and to evaluate this work using Telecom Australia methods and materials.

Instead of designing a separate network for every value of earth resistivity measured, the resistivity values up to 400 ohm metres were split into six ranges and, using an upper limit of five ohms, networks were designed for each range. These networks were installed and tested and the results evaluated against design expectations.

CRAIG, W. R. and JESSOP, C. W. A.: 'International Subscriber Dialling for Australia'; Telecomm. Journal of Aust., Vol. 26, No. 2, page 105.

Telecom Australia has adopted the following policy on the introduction of International Subscriber Dialling (ISD) from Australia:

- That ISD outwards from Australia should be progressively introduced using Automatic Message Accounting (AMA) as the preferred method of recording the subscribers charges for ISD.
- That as an interim measure, ISD outwards from Australia be introduced using the multimetering technique to record subscribers charges, and under these conditions subscribers should be normally barred from access to ISD, unless access is specifically requested.

This paper describes the background to International Communications between Australia and the rest of the world, and the reasons for Telecom Australia's decision to introduce ISD. It also describes the strategy to be adopted in implementing ISD from Australia, and comments on problems still to be solved in the field of international communications.

KENNEDY, B. L.: 'The Telecom Australia Financial Plan'; Telecomm. Journal of Aust., Vol. 26, No. 2, page 153.

This article outlines the means used in Telecom Australia to set down its overall financial objectives for a fiscal period, viz: The Financial Plan. It also indicates how the plan establishes the level of the Engineering Capital Works Programme, the tool used by Telecom Australia to programme engineering projects and to set short-term physical targets.

STRAIN, W. J.: 'Coaxial Cable, Spare Drum Quality —Some Impedance Considerations'; Telecomm. Journal of Aust., Vol. 26, No. 2, page 138.

Spare drums quality cable is used for replacement purposes such as cable faults and deviations in working coaxial cables. Despite its high quality, it may introduce comparatively high impedance mis-matches. This article examines the extent and effect of these possible mis-matches on the transmission performance of the cable. The findings are confirmed by the results of a fairly large sample of tube/repeater sections.

WATSON, D. R. and WILLIAMS, L. J.: 'The East-West Microwave Radio Relay System—A South Australian Operational Report (Part 2)'; Telecomm. Journal of Aust., Vol. 26, No. 2, page 142.

This first part of the South Australian report reviewed traffic performance and reliability aspects of the system in the light of these concepts and changes found necessary to them under operational conditions. The second part describes the maintenance philosophy adopted in South Australia, the staff organisation, and also the modifications found necessary to optimise equipment performance and maintenance costs.

WEAL, S. E.: '1876–1976: A Century of Telephony'; Telecomm. Journal of Aust., Vol. 26, No. 2, page 95.

The early history of the invention of the telephone is well documented in the literature. This article is presented to celebrate the centenary of the invention of the telephone by Alexander Graham Bell and brings together a few of the more interesting facets of the beginnings of telephony, with some reference to the introduction of telephony in Australia.

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