

# The *Estelco* Bulletin

No. 20

JANUARY, 1950

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## *Editorial*

### THE OVERSEAS MARKET

*We have always endeavoured to meet the requirements of the overseas market with a design and manufacturing technique that, while jealously retaining the high standards of which we are so justifiably proud, is flexible enough to allow considerable modifications to our normal products to ensure satisfactory service under a wide variety of operational and climatic conditions. This demands instant appreciation of new manufacturing methods and of new technical developments, a readiness to apply them to the problems peculiar to overseas telecommunications and a keen recognition of the difference between the essentials of the home market and those of the export market.*

*Present day conditions, coupled with currency restrictions, have compelled certain administrations to consider the introduction of an alternative type of switching equipment and as a result of this a demand for exchange equipment may bring a collateral problem of interworking the step-by-step system with existing exchanges employing an entirely different switching principle. The article on the interworking of step-by-step and rotary exchanges will be of special interest to engineers who are faced with such a problem.*

*We have always played a leading role in the design of "safe" telephone equipment for coal mines, and continued research has been directed to overcome the greater risks in other industries, thus, the production of safe apparatus has been expanded for overseas markets where it is being installed extensively in petroleum and chemical plants, harbours, etc. The article on developments in equipment of this nature will be of interest to all administrations where the risk of explosion or fire would be increased by the use of conventional type telephones.*

*Because of the high cost of physical circuits, increasing use is being made of multi-channel carrier telephone systems and radio links; apparatus supplied by our transmission department for working inter-continental radio links, is described in the article on radio-telephone terminating equipment.*

*In addition to the specialized equipment which has been briefly mentioned, the export of telephones and exchanges continues to increase; the 3700-line automatic exchange for New Plymouth, New Zealand, being a topical example. Exports are of prime importance at the present time and no effort is being spared in our drive to increase overseas trade, a sales drive having repercussions in almost every department of our factories. Research is being intensified to improve designs, reduce production costs, step up output, and to enhance the reputation we have always had for manufacturing goods of the finest class.*

## Microscopy Applied to Production

A matter of vital importance to industry is that the fullest utilization of scientific methods, knowledge, and apparatus be made in the field of production. Many scientific instruments, once used exclusively in laboratories or for academic purposes, are now essential forms

and for the measurement of profile and form, therefore, this article deals with microscopes which are applied to other technical aspects of manufacture.

For most purposes, industrial requirements are covered by three types of instruments. Probably that which best covers the diverse requirements of industry is the micro-photographic apparatus, an excellent example of which is the Vickers metallurgical microscope, illustrated in Fig. 1.

It will be seen that the general construction is very robust, all components being mounted on a heavy, rigid casting. Facilities are provided for different illuminating systems for use with opaque or transparent specimens, while a range of rapidly interchangeable objectives and eyepieces give a wide selection of magnifications, from  $\times 4$  to  $\times 1300$ . The elements of the microscope incorporated in the equipment are inverted, enabling specimens to be positioned

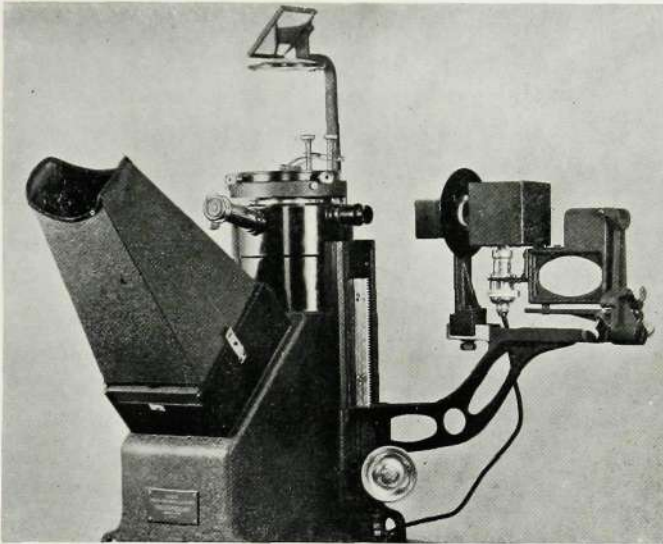


Fig. 1—Vickers Projection Microscope.

of equipment for the development and control of manufacturing processes and are in regular daily use. An outstanding example is the manner in which metallurgical and other microscopes are widely employed in electrical and engineering industries and by suppliers of raw materials. The instruments are consequently being developed in forms which are robust in construction and suitable for daily usage under workshop conditions.

Previous *Bulletin* articles have dealt with instruments which incorporate microscopes for the determination of precise dimensions

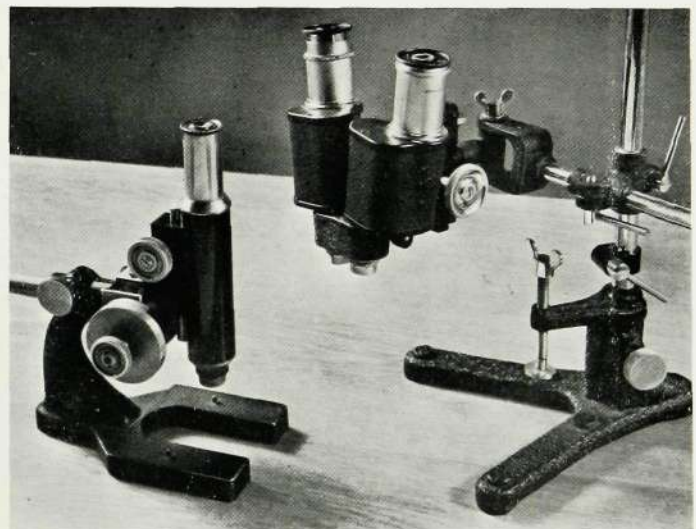


Fig. 2—A Greenough Binocular and Micrometer Microscope.



on the stage without mounting or fixing. The image is projected to the base of the instrument from whence it is reflected up at an angle on to the ground-glass hooded viewing screen used either for photographic or visual working. An additional ocular tube is provided, so that examination can be made by eye, in the conventional manner.

The second group of instruments includes the ordinary types of metallurgical or other microscopes which have the advantage of being portable so that they can be taken to the location where they are required for use and where visual examination only is required.

The third group comprises binocular microscopes which are widely employed for the examination of uneven surfaces where relatively low magnifications are involved (Fig. 2).

There are, of course, instruments such as refractometers, hardness measuring machines, spectrosopes, and many others which include elements of the microscope in their construction.

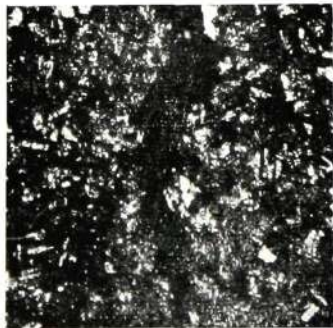
In addition to microscope study connected with research, many hundreds of examinations connected directly with processes and materials in everyday use are conducted by this means at the Company's

works each year and when desirable, photographic records are retained for future reference and comparison.

A small number of examples chosen from our work in this field will illustrate some of the applications of microscopy as applied to production.

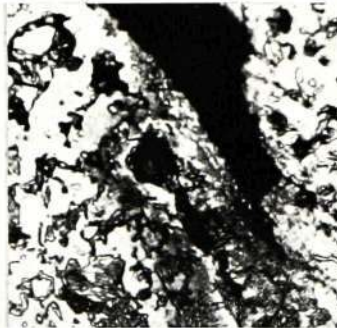
#### EXAMINATION OF MATERIALS.

The composition and quality of metals and other materials are normally checked regularly by means of chemical analysis and mechanical tests. These methods, however, are not completely revealing, therefore, microscopic examination must be used as a supplement in order to determine the distribution of impurities, the grain size and formation, or manufacturing defects such as extrusion and drawing faults. Metallurgy is a precise and extensive branch of science. The various forms or phases in which alloys of similar composition can exist are well defined, and can be readily identified by microscopic examination which reveals not only the characteristics of the alloys but also data on the mechanical state of the metal, specimens of which are polished, etched and stained before study. The methods and chemicals employed vary considerably and are selected to reveal the structures or compounds to be studied.



× 60

Fig. 3—Extrusion Fault in Brass Rod.



× 600

Fig. 4—Rolling Fault in M.S. Sheet.



× 100

Fig. 5—Slag Inclusion in M.S. Sheet.

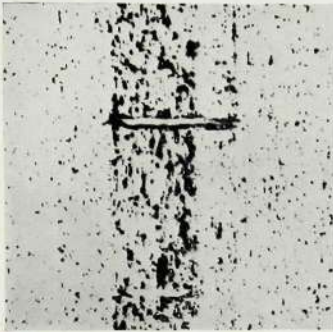


Fig. 6—Sulphur Segregation  
in M.S. Rod, from Sulphur  
Print. ×4

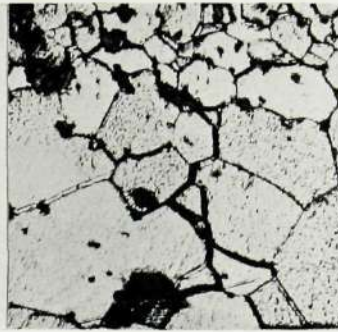


Fig. 7—Carburized Areas in  
Pure Swedish Iron. ×240



Fig. 8—Surface De-carburization  
of Tool Steel. ×100

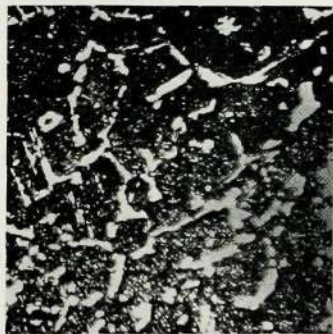
In the production of micrographs there is a wide variation in the techniques employed in the preparation of the specimens and in the final photography. Obviously, when micrographs are used for works reference, the simpler and more rapid methods are employed. On the other hand, when matters arise which are of exceptional importance, it is frequently necessary to aim for very high standards of preparation and photography.

A typical micrograph is reproduced in Fig. 3 which illustrates an extrusion fault in brass rod, however, as a result of the excellent progress achieved by manufacturers of non-ferrous materials, faults of this nature are very rare indeed.

The maintenance of high standards in

the quality of mild steel sheet and rod requires the closest collaboration between supplier and user. In spite of the care taken in manufacture and the subsequent inspection at the steel works, it is not possible to avoid isolated cases of rolling or drawing defects. The supplier relies on the user industry for precise information should any difficulty be experienced due to these faults, and the micrograph forms a ready means of conveying the necessary information, as may be seen in Fig. 4 which shows a rolling fault in mild steel sheet. Micrographs showing respectively, slag inclusion in electrical iron sheet, and sulphur segregation in mild steel rod, are reproduced in Figs. 5 and 6.

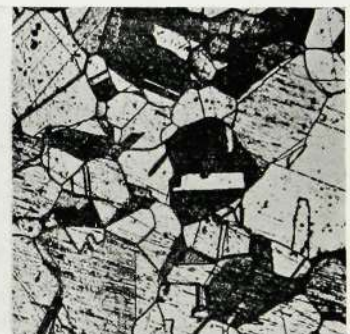
High standards of purity are required in the irons used for magnetic circuits in the



70 Cu : 30 Zn. ×150



62 Cu : 38 Zn. ×150



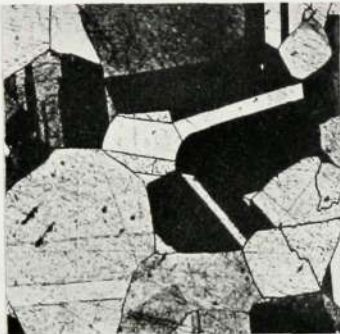
51 Cu : 49 Zn. ×150

Fig. 9—Typical Brass Structures.



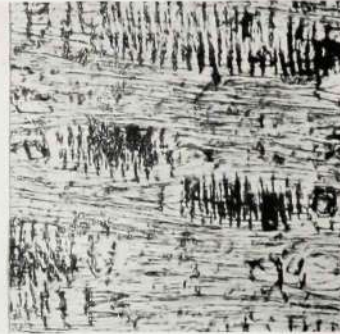
× 60

Fig. 10—Isolated Grain Formation in 57 : 43 Brass.



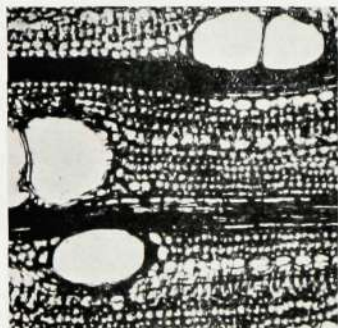
× 60

Fig. 11—Orientated Grain Formation in 70 : 30 Brass.



× 60

Fig. 12—African Mahogany (Tangential Section).



× 60

Fig. 13—African Mahogany (Transverse Section).



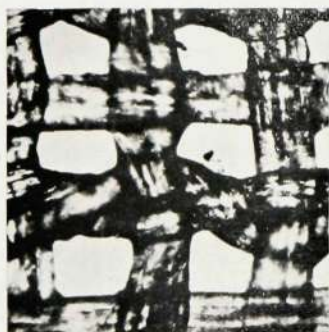
× 60

Fig. 14—Insulating Paper, American Origin.



× 60

Fig. 15—Insulating Paper, Asiatic Origin.



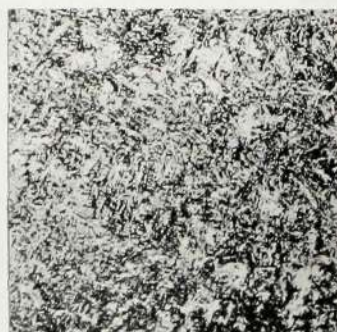
× 100

Fig. 16—Bolt Silk Gauze.



× 200

Fig. 17—Cobalt Magnet Steel, Austenitic, Early Transition Stage.

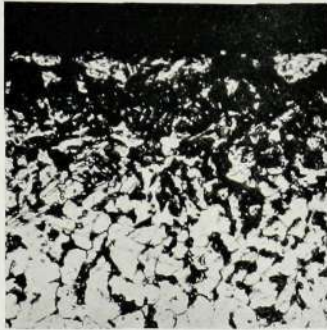


× 200

Fig. 18—Cobalt Magnet Steel, Austenitic, Complete Transition Stage.

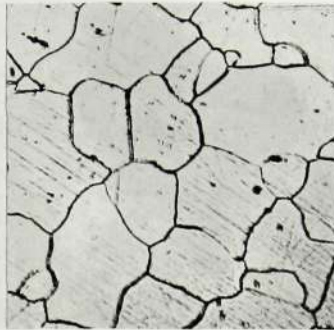
telephone industry ; in particular, it is important that the carbon content should be very low, of the order of  $\cdot 03\%$ , but occasionally, small isolated carburized areas are formed during manufacturing processes

and these are difficult to reveal by chemical analysis. Microscopic examination however, shows this particular fault very readily (Fig. 7) and material of this type must, of course, be rejected or used for purposes



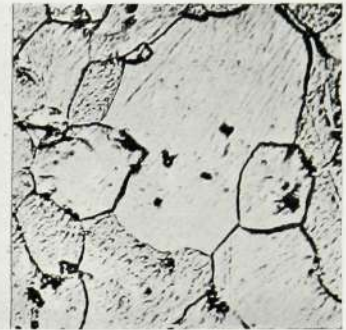
× 80

Fig. 19—Carburization of M.S.



× 200

Fig. 20—Pure Iron, Annealed Condition.



× 200

Fig. 21—Pure Iron Incorrectly Annealed.  
(Note large grain structure).

which are less exacting. Conversely, in the case of carbon steels used for the manufacture of hardened tools, it is essential that the alloy should be quite uniform and free from any decarburization. Fig. 8 illustrates the decarburized edge of a section of tool steel; the material can be used, of course, provided the decarburized surface is machined away before the tool is produced.

The remarkable changes in the microscopic appearance of non-ferrous metals with slightly differing compositions are shown in the next series of illustrations, which are of brasses containing, respectively, 70%, 62%, and 51% copper (Fig. 9). In many cases the microscope will indicate the composition of these metals with sufficient accuracy for identification, so that chemical analysis is not necessary.

Figs. 10 and 11 illustrate the importance of crystal formations in their relation to machining properties, by comparing an isolated grain formation with



× 60

Fig. 22—Cartridge Brass, showing Strain from Extrusion.



× 60

Fig. 23—Cartridge Brass Extruded and Annealed.

an orientated structure of brass of similar composition which has not been processed in the most suitable manner.

The microscope is used to supplement the knowledge and experience of the timber technologists in identifying various types and growths of wood used for the manufacture of caseworks, etc. Very thin sections of the timber are examined from tangential and transverse cuts and comparisons can be made which are of value in selecting, as alternatives, lesser known varieties. Figs. 12 and 13 show the appearance of African Mahogany. (*Khaya Ivorencis Meliaceæ*).

Other materials which are subjected to microscopic examination include textiles, papers, insulating materials, and plastics. Figs.

14 and 15 are micrographs of thin insulating papers of different origin, while Fig. 16 shows clearly the weave formation of a gauze used in the telephone transmitter inset.

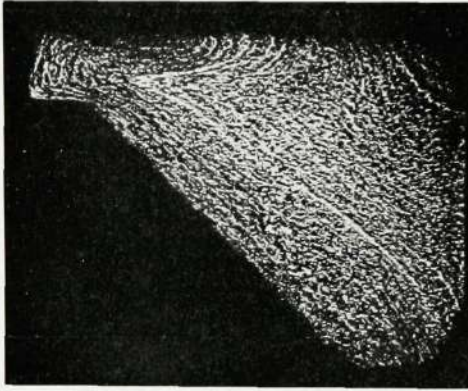


Fig. 24—Metal Flow induced in M.S. Relay Yoke during Cold Heading.

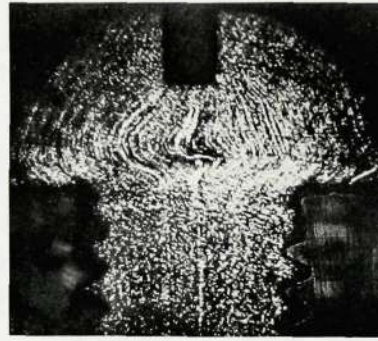


Fig. 25—Metal Flow induced in M.S. Screw during Cold Heading.

maintained by surface hardness measurements, and the depths of the carbon cases are checked by means of the microscope. Fig. 19 shows carburized cases developed in lever key cams.

All iron parts for relays and

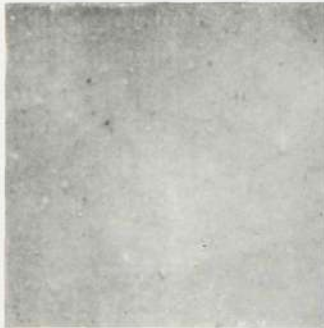
#### STUDY OF HEAT TREATMENT PROCESSES ON MATERIALS.

The structures developed in metals by hardening and annealing processes are clearly recognizable by microscopic examination and the various alloy phases which exist in hardened, tempered and annealed metals are precisely defined and named.

The heat treatment processes used at the Company's works are developed and specified by the process laboratory, the desired results being checked by microscopic study.

Many telephone mechanism parts are case-hardened to controlled depths in accordance with the working conditions and life requirements for the apparatus concerned. Routine process control is

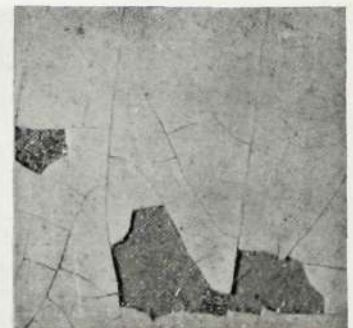
other components of magnetic circuits are carefully annealed to obtain the highest permeability. At the same time it is necessary to control the grain size of the iron to ensure that this does not become too large and adversely affect the mechanical properties of the material which may be reduced. Fig. 20 shows the correct grain size for annealed pure iron, while Fig. 21 shows the much larger grain size which must be avoided. Similarly, in the case of non-ferrous metals such as brass it is essential to control the grain size developed by annealing processes. The large grain, shown in Fig. 22, developed during the early drawing stages in the manufacture of a meter case, is corrected to the smaller desired size shown in Fig. 23



×8  
Fig. 26—Paint Finish, Film Intact.



×8  
Fig. 27—Paint Finish, Marked Deterioration.



×8  
Fig. 28—Paint Finish, Final Breakdown.

by suitable heat treatment matched to the amount of thickness reduction during each subsequent drawing operation.

#### DEVELOPMENT OF MACHINE-SHOP OPERATIONS.

When new pressing operations are being developed by tool room engineers for the production of a component, it is frequently necessary to gain information on the direction and form of the metal flow. In particular, any folds or other weaknesses which may result in the development of cracks or undue wear on the tools must be avoided. Parts are therefore examined under the microscope at comparatively low magnifications, as in Fig. 24 which shows the flow of the metal in a telephone relay yoke. This is completely free from folds or flaws and will respond satisfactorily to the subsequent annealing necessary for magnetic irons of this type. Fig. 25 is a section of a cold-headed screw in which the flow is developed to give high strength at the junction of the head and the threaded portion. In a similar way, turning, milling, grinding and other machine-shop operations present many opportunities where the microscope is of direct assistance in the promotion of first-class manufacturing technique. In the case of very small machined parts and machine-shop assemblies, the binocular microscope is an asset for inspection and as an aid to process development.

#### MICROGRAPHIC RECORDS OF CLIMATIC AND LIFE TESTS.

Telephone parts and finishes are required to meet a variety of stringent conditions and it is therefore necessary to assess their performance under life tests and the various

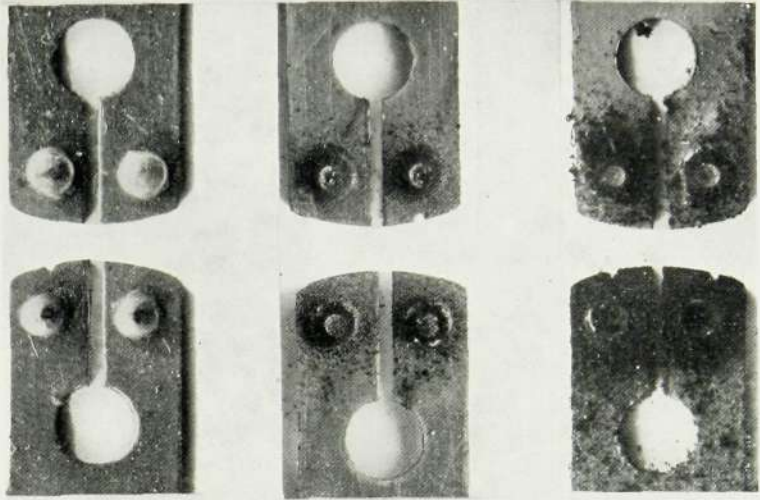


Fig. 29.  
Relay Contacts after  
Operation in Normal  
Atmosphere.

Fig. 30.  
Relay Contacts after  
Operation in  
Paraffin Vapour.

Fig. 31.  
Relay Contacts after  
Operation in  
Phenolic Vapour.

accelerated climatic or corrosive tests. Micrographs provide very useful records of the results and enable comparisons to be made with subsequent tests of a similar nature as, for example, with new materials which are being constantly examined by the Company for use in the production of paints and enamels. Finished panels in wood or metal are subjected to accelerated weathering tests (*Bulletin 18*) and in many cases signs of deterioration which cannot be detected by ordinary visual examination, are revealed by the microscope. By this means continuous improvements in finishing materials and processes are effected and ensure that the best available raw materials are employed. Figs. 26, 27 and 28 show the effect of identical accelerated tests on different finishing materials. Similar records revealing the wear and deformation of electrical contacts, gears, cams, ratchets, etc., after mechanical life tests, are also maintained.

#### SPECIAL INVESTIGATIONS.

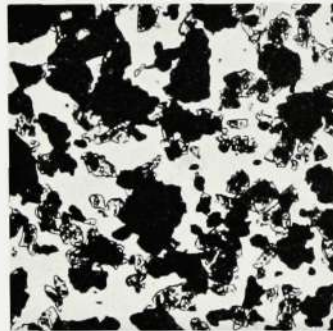
The application of the microscope in special investigations is so extensive that it

is not possible to give a detailed summary, but one or two examples may be given to indicate the type of problem involved. A series of tests were conducted on relay contacts in order to study the effect of contaminated atmospheres present in certain industrial locations where telephone apparatus is used. It was established that carbon deposits are generated when the atmosphere contains

traces of organic vapours such as those of benzine, paraffin, lubricating oils or rubber solvents. Micrographs reproduced in Figs. 29, 30 and 31, clearly show the degree of deposits formed and made it possible to determine the measures to be taken to avoid such deterioration.

Metallic powders are widely used in the telephone industry for the manufacture of dust cores and metallic finishes, also, carbon granules are used for transmitters. Materials for these purposes require special study and the microscope enables the grain size, shape and other characteristics to be determined; for example, Fig. 32 clearly reveals the form of a powder composed of metallic particles mixed with a transparent filler, and also illustrates the application of the microscope to measurement and relative size comparisons, as each constituent of the powder can be measured directly. Similarly, sieves incorporating fine metallic gauze can be easily checked for mesh and regularity of screening aperture.

It is essential that all classes of telephone equipment shall give long and uninterrupted service, therefore, materials and processes employed must be critically examined to ensure that all possible causes of corrosion are eliminated. This applies particularly to coil windings and small and delicate assemblies. Special investigations are therefore conducted with respect to not



× 60

Fig. 32—Powder Comprising Metallic and Non-metallic Particles.



× 22

Fig. 33—Corrosion on Aluminium Caused by Contact with Another Material under Humid Conditions.

only the materials used but also to those which may come into contact with the piece parts, thus, specimens of unprotected metals are placed, under humid conditions, in contact with organic insulating materials, fluxes, solvents, etc. and are examined microscopically after a suitable period to see whether any corrosive influence has been exerted on the metal. Fig. 33 shows the result of one of these tests and illustrates the corrosive spot caused on aluminium by a material which was subsequently rejected as being unsuitable for use.

Mechanical and corrosion resistant tests made to assess the strength of welded or brazed joints are greatly aided by the use of the microscope, which reveals the physical and metallurgical form of the filler with the base metals. Suitable cross-sections are prepared and from these may be judged the degree of penetration and the extent to which the fillet was built up, whilst any undesirable elements, such as slag inclusions or areas of decarburization in the base metal, may be observed.

The typical examples which have been selected, whilst representative of the use of microscopy in production, are chosen from many thousands of cases which have arisen in connection with the Company's manufacturing processes and which are reflected in the very high class of goods supplied to the telephone user.

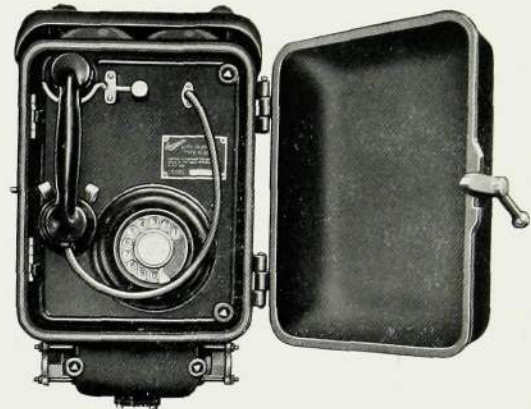
## *Developments in Safe Communication Equipment for Coal Mines, Petroleum Refineries, etc.*

**I**N coal mines and in certain other industrial establishments, particularly chemical and petroleum distillation plants, gases and vapours if ignited may result in a serious explosion, a flame, naked light, hot surface or an electric spark being sufficient. Some of the common industrial gases and vapours with the right proportion of air form combustible mixtures which may be ignited by sparks from even the weak currents used in bell and telephone circuits. There are two methods of safeguarding against this possibility, the first, "flameproofing" (FLP), entails limiting any sparking to a robust chamber with broad joints such that any flame from an explosion of gas inside the chamber is cooled on its passage to the outer atmosphere so that even the most inflammable surrounding mixture cannot be ignited. Special safeguards are very necessary in wiring between each instrument or junction box.

The second method is to make the circuit "intrinsically safe" by limitations on energy and by by-pass and surge reduction devices, so that any spark which may occur is incapable of igniting any mixture of gas or vapour for which the apparatus is certified. No special line precautions are necessary in this case.

Of the two protective systems "intrinsic safety" is obviously preferable; unfortunately its application is limited to low-energy devices such as tele-communication equipment. Its use for bell and telephone circuits in coal mines is compulsory. As knowledge of the spark ignition of gases is

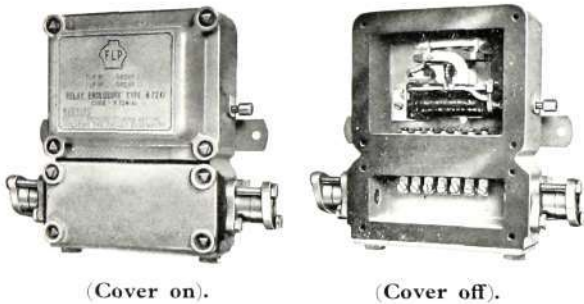
extended by research we may expect to see a widening of the field of application, which is already extending in the petroleum industry.



**Fig. 1—N.1087 Type Flameproof Auto Telephone with Bakelite Micro-telephone.**

It should be noted that the two systems (FLP and intrinsically safe) are entirely separate and distinct, and instruments in either class must not be fitted on installations of the other class unless they are certified for both.

Power devices must of necessity be "flameproof" and the very considerable volume of research thus stimulated has resulted in the classification of a wide range of gases and vapours into four groups. (See British Standard 229). As Group I is methane (firedamp) and Group IV comprises gases for which certain protection cannot be provided, the only two for which certificates for flame-proof signal apparatus are issued are Groups II and III. This covers a large industrial range which, moreover, is still being extended by addenda to B.S. 229.



(Cover on).                      (Cover off).  
**Fig. 2—N.7241 Type Flameproof Enclosure with Mercury Tube Relay.**

The development of safe telecommunication equipment for use in mines is a branch of the industry in which the Company has been interested for many years.

Laboratory investigations were being conducted as long ago as 1914 and led finally to the development of relays and bells which were informally approved in 1917, i.e. three years before the Home Office introduced official recognition of "safe" equipment. This pioneering spirit has been maintained ever since and justifiable pride is taken in the fact that in almost every case the first official certificate of safety for any new apparatus has been granted to the Company.

The expansion in the chemical and petroleum industries in recent years, the export drive and research work on gases have stimulated developments some of which are briefly described.

#### FLAMEPROOF EQUIPMENT.

##### *Auto and C.B. Telephones.*

In order to extend their useful range, the design of auto and C.B. telephones, types N.1087 (Fig. 1) and N.1470 respectively, has been modified and the telephones re-certified to cover their use in Group III gases in addition to Group II. These instruments are now also certified for interconnection by means of "Pyrotenax" (a solid drawn, mineral-insulated, copper-sheathed cable) in addition to the armoured

cable and seamless steel conduit previously approved. A further improvement is the replacement of the built-up metal handset by a modern moulded micro-telephone.

##### *Relay or Key Enclosure.*

A completely new addition to the range of FLP apparatus is a flameproof enclosure, type N.7241, (Fig. 2) designed to accommodate a relay and rectifier operating on telephone ringing current at approximately 50v. 16 $\frac{2}{3}$  c/s and controlling mains operated devices such as Klaxons, lamps, etc. The relay may be of normal non-locking type or can be made to self-lock and be released by a plunger provided on the side of the chamber. Heavy currents are controlled by a mercury tube switch; smaller currents by a conventional spring-set fitted with tungsten contacts. The maximum rating is 350 watts at 250 volts, which is ample for relaying any signal.

The same enclosure is also certified to take a normal telephone relay or a telephone type push key and the terminal chamber can be supplied to accommodate any one of the approved types of wiring; i.e. seamless conduit, steel wire armoured and Pyrotenax cables. The enclosure is certified for use in Group II gases for the relays and for both Groups I and for II keys.



**Fig. 3—N.2121.Z Magneto Table Telephone for use Under Cover on the Mine Surface.**



## INTRINSICALLY SAFE EQUIPMENT.

### *Magneto Table and Wall Telephones.*

In order to keep mining instruments up-to-date and in line with the latest developments in telecommunications, certification has recently been obtained for a new table telephone, type N.2121Z, shown in Figs. 3 and 4. This instrument, intended solely for surface use under cover, now replaces the previous office desk set N.2120Z and its separate bell set N.3100Z. The new instrument incorporates the bell, latest alnico generator and all other components in one housing. The moulded casework is of the same pleasing design as the latest British Post Office type telephone. In order to provide an easier and smoother turning action the generator drive has been placed on the right-hand side, instead of on the front as in the previous model. Telephone N.2121Z is certified intrinsically safe for use in petroleum vapours as well as methane. The complementary magneto wall telephone for surface use is the type N.2518, which is generally similar to the type N.2504 which it supersedes. It also replaces the N.2202

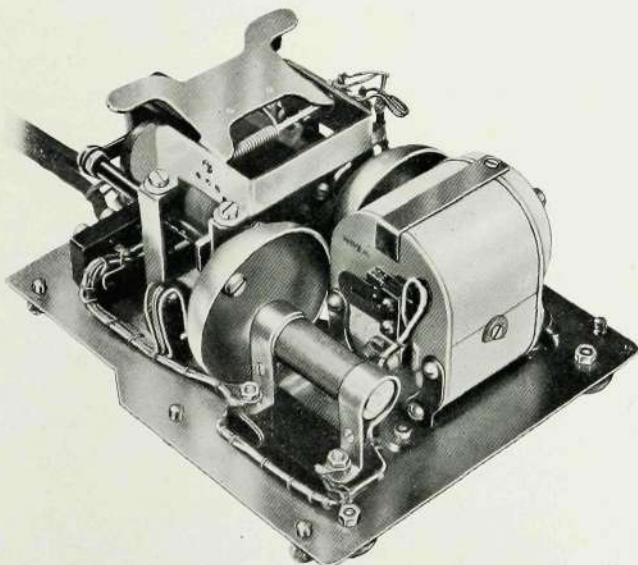


Fig. 4—Enlarged Interior View of Telephone in Fig. 3.

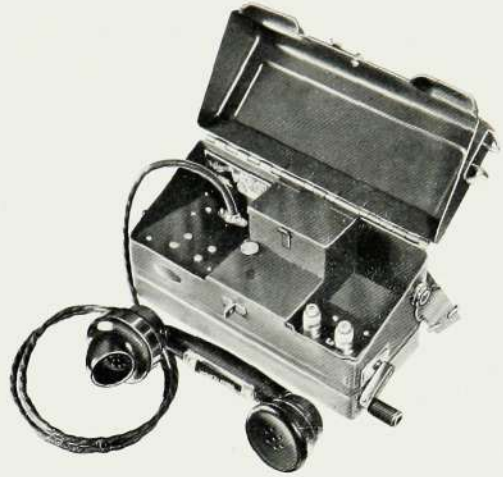


Fig. 5—N.1846 Portable Magneto Telephone for Mines.

wall telephone which did not incorporate a battery compartment.

### *Portable Magneto Telephone.*

The range of intrinsically safe instruments has been further extended by a portable magneto telephone type N.1846. The design, which is very robust and compact, is based upon the wartime development of a lightweight instrument for the Services and is notable for the high grade of speech transmission it provides. It is intended principally as a linesman's or electrician's telephone, but in an emergency it would provide a temporary station where a standard instrument was not immediately available. Type N.1846 portable telephone is certified for use in both methane and petroleum vapours and is illustrated in Fig. 5.

### *Magneto Switchboards.*

Pyramid type and ordinary cordless boards have been re-certified in order to incorporate under one certificate various improvements and additions which have been introduced since the original certificate was granted in 1933.



Fig. 6—N.555 Type Magneto Cordless Switchboard.

The opportunity was taken still further to modernize the equipment and also to simplify operation of the boards by using the calling indicators for supervision. A modern moulded bakelite hand micro-



Fig. 7—N.3111 Iron Cased Loud Ringing, Magneto Extension Bell.

telephone and the latest alnico generator have also been fitted. A 10-line board, type N.555, with three connecting circuits, is shown in Fig. 6.

#### Magneto Extension Bell.

In certain circumstances a bell is required in a different location from that of the telephone instrument. For this purpose a loud-ringing magneto bell has been developed, type N.3111 (Fig. 7). This bell, suitable for underground and outdoor use, can be wired in parallel with the bell in the instrument, or may actually replace it, the instrument bell being disconnected.

#### Mains Signalling Bell.

Type N.3111C. bell is similar to the above magneto bell, but is intended for operation on a system energized via a certified intrinsically safe signalling transformer as defined in B.S. 1259. The bell coils are suitably proportioned to the voltage and frequency and the original  $16\frac{2}{3}$  c/s movement has been re-designed with a lightweight stem and hammer to respond to the 50 c/s standard mains frequency. It has been certified for use in methane and petroleum vapours.

#### Mine Rescue Telephone (Fig. 8).

The only modification to this equipment, which was described in *Bulletin No. 14*, January 1939, is in the signalling apparatus and arises from a request by the Mines

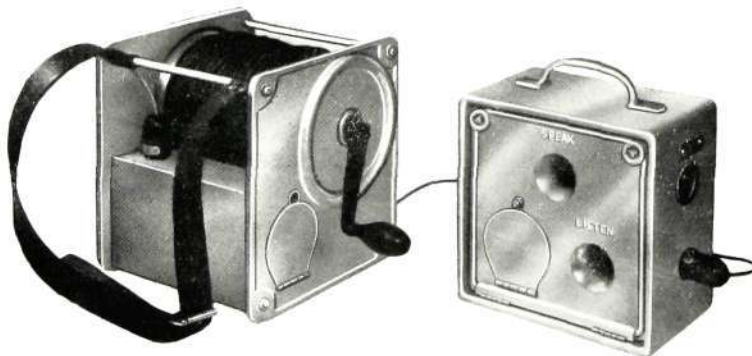


Fig. 8—Mines Rescue Telephone.

Rescue Superintendents for a buzzer which would remain in stable adjustment for a longer period of service than was given by the original type, consequently a new design based on wartime experience with field telephones has been developed. This buzzer has a double-acting, double polarized, twin contact vibrating reed and is found to be extremely stable. It is almost entirely unaffected by mechanical shocks and vibration.

The safety devices, consisting of spark quench and battery reversal rectifiers and voltage limiting resistors, have been suitably proportioned to the new design.



## *Radio-telephone Terminating Equipment*

**L**ONG-DISTANCE telephone channels frequently use beamed short-wave radio for some sections of the link and always do so for a long-distance trans-oceanic channel, such as London to New York.

In a private installation it is usual for the microphone to be placed at the transmitting station and the person speaking very often controls the transmitter and receiver throughout the conversation.

The initiation of an inter-continental call over the normal public telephone system is obviously less direct. The British Post Office route all such calls through an International exchange in London.

When a subscriber in Great Britain makes an inter-continental call, the trunk operator at the local zone centre passes it on to the International exchange, from which it is again passed forward, this time to the radio transmitter and thence, by short-wave link, to the distant receiver, where it proceeds through the conventional telephone system to the corresponding operator at the distant exchange, who extends the call to its ultimate destination.

It is probable that any such call will traverse several diverse telecommunication systems, each with its appropriate control, but the radio link requires special provision for its control. Owing to changing atmospheric conditions and the diurnal variation of the Heaviside layer, it is not possible to transmit to one destination always at the same frequency, except at uneconomically high power and low frequency. Thus a permanent link is impracticable and to maintain optimum

efficiency the state of the channels has to be under constant supervision.

In lining up a radio link, problems similar to those met in lining up a long-distance trunk line circuit have to be overcome. For example, if the overall circuit gain, transmit-receive, is greater than the overall loss, then the circuit is unstable and will "sing". The equipment must therefore provide against this risk and also maintain the input signal level into the transmitter sensibly constant, either by hand or automatic control, so that the transmitter may be adjusted to this level and then left unattended.

It will be seen that for each radio channel special monitoring and control equipment is needed. The radio telephone terminating (RTT) equipment described here, designed and developed by the Research and Radio branches of the British Post Office has recently been made by the Company.

### GENERAL DESCRIPTION.

The equipment is built in the form of a 10' 6" x 1' 7" bay, and power supplies are derived from 3-phase 50 c.p.s. mains. The 6v heater supplies provided by two transformers on the alarm panel, are fed through lead-sheathed cable laid in a special screening channel running down the centre of the rack so that hum pick-up from the heater supply is reduced to a minimum. Each main heater feed is fused and appropriate alarm equipment for heater failure is fitted.

The 300v d.c. h.t. supplies are obtained from a 3-phase metal rectifier power pack, and individual fuses and panel alarms for h.t. failure are provided. The h.t. is

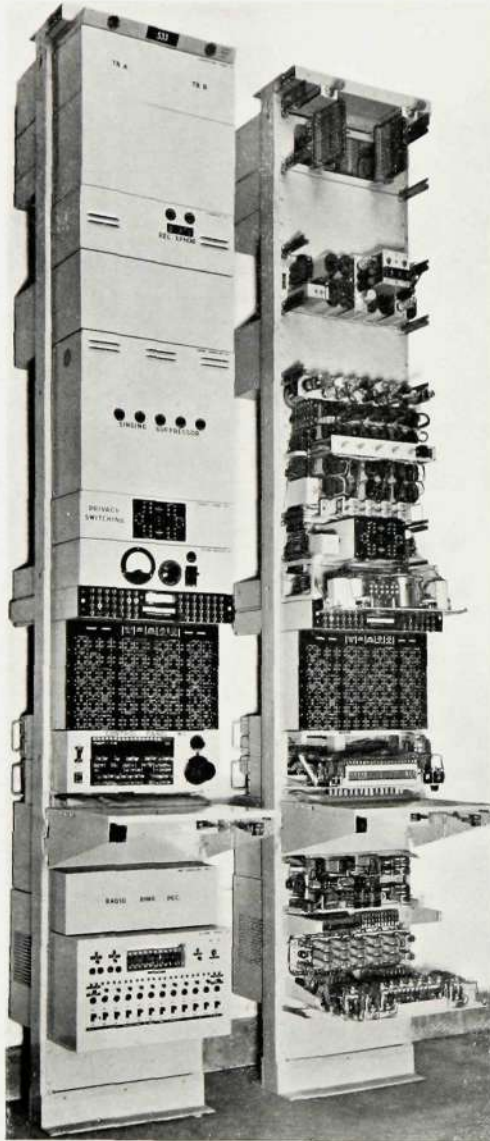


Fig. 1—R.T.T. Equipment Bay, Front View with and without covers.

switched to each panel individually and provision is also made for monitoring the h.t. voltage.

The 50v d.c. supply for the alarm relays is obtained from a separate metal rectifier power pack and in the case of complete failure of the mains supply, a 50v battery connected to the bus bars at the top of the bay operates the necessary alarm.

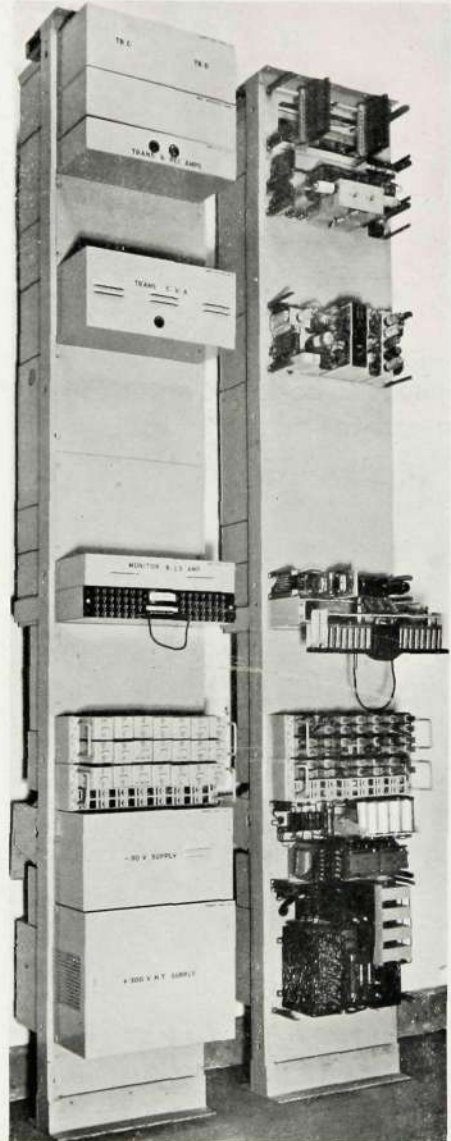


Fig. 2—R.T.T. Equipment Bay, Rear View with and without covers.

All panels supplied with h.t. are fitted with isolating links so that the h.t. supply is automatically disconnected when the cover is removed.

A feature of the design is the care which has been taken to ensure that all panel-mounted equipment is accessible for maintenance. This has been achieved, as can be seen in Figs. 1 and 2, by the use of

hinged front panels, sliding panels and easily removable mounting platforms. Many of the resistors and condensers have been incorporated in transformer pots, so allowing most of the panel wiring to be run in local cableforms.

give a visual indication of the signal level at any specific point in either the "transmit" or "receive" path, or, when used with the "U" link test tablet, at any desired point in the system, as the links can be used to bridge or break the lines at all

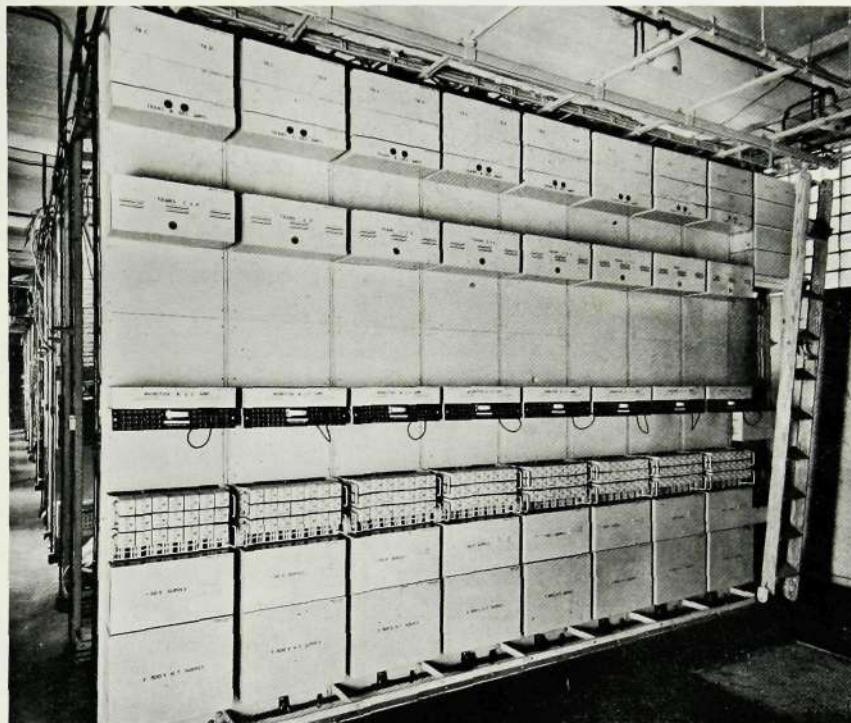


Fig. 3—R.T.T. Equipment on Site (Rear View).

To enable valve operating conditions to be checked independently, meter panels are provided on both the front and rear of the bay. Either meter can be connected, by means of its jack field, across a close-tolerance resistor which is connected in the cathode or anode circuit of each valve, the resistor being so proportioned that the voltage drop across it is read as the particular anode current; in addition, the lining-up control currents and voltages are measured on these meters.

On each bay a volume indicator is fitted and serves several purposes; it is used to

useful points in either path. Thus by using an external oscillator and the volume indicator, full performance tests may readily be made on any panel on the bay.

For ease of operation, the control keys and switches for all panels, with the exception of the volume indicator, are mounted on a separate control panel on which the line supervisory lamps and keys and the transmit manual gain control are also placed. The operator's table, fitted beneath the control panel (Fig. 1) is equipped with jacks for plugging in a micro-telephone and a morse key and can be folded down or entirely

removed when not in use. Thus each channel can be monitored at the bay by a technical operator, who has full facilities for speaking over the radio link and to the International exchange, as well as for fault location.

On B.P.O. installations this local control facility is not always used ; instead a group of channels is remotely controlled from a special monitoring position. Because of this, amplifiers are incorporated in each bay to raise the level of the line signal to a value suitable for operating either a telephone or a loudspeaker at the remote monitoring position.

the radio terminal equipment. As the circuit from the exchange may be either 2-wire or 4-wire, provision is made for the terminal equipment operator to select either condition by a simple key operation.

Referring to the block schematic shown in Fig. 4, if 2-wire working is used the call passes via a hybrid transformer to the main transmit path, through either the transmit constant volume amplifier (trans. CVA) or a variable attenuator and flat gain amplifier, to the compressor, if one is used, and thence through static relay No. 3 and its associated compensating amplifier. At this point the signal may be taken out of the

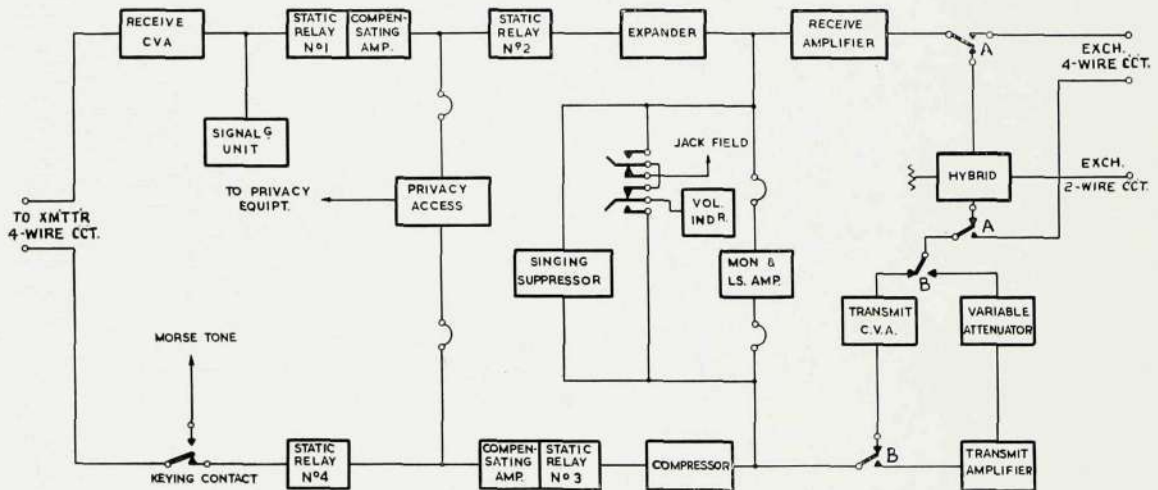


Fig. 4—Block Schematic of Radio Telephone Terminating Equipment.

In Fig. 3 may be seen a suite of bays in position on site. It will be noticed that where equipment is not initially required, blank panels are provided to preserve a neat, uniform appearance and to prevent the ingress of dust to apparatus directly behind.

#### CIRCUIT OPERATION.

##### General

A call originated by a home subscriber is routed via the International exchange and appears on the "transmit" path of

system and passed via a privacy access panel to the privacy (scrambling) equipment for secrecy purposes ; this equipment may take one of two forms, providing either for simple band inversion of the signal, or, for full secrecy, comprehensive multi-section scrambling.

After scrambling, the signal is returned to the main transmit path and passes via a further static relay to the output line which conveys it to the radio station. This line is normally expected to be 4-wire working.



From Fig. 5 it will be seen that the static relays and associated amplifiers are actually components of the singing suppressor panel, the functions of which will be described in detail later.

If the signal-to-noise ratio is poor, a considerable improvement can be effected by the use of a compressor and expander. As, however, they are unnecessary where the ratio is good, they are not provided as

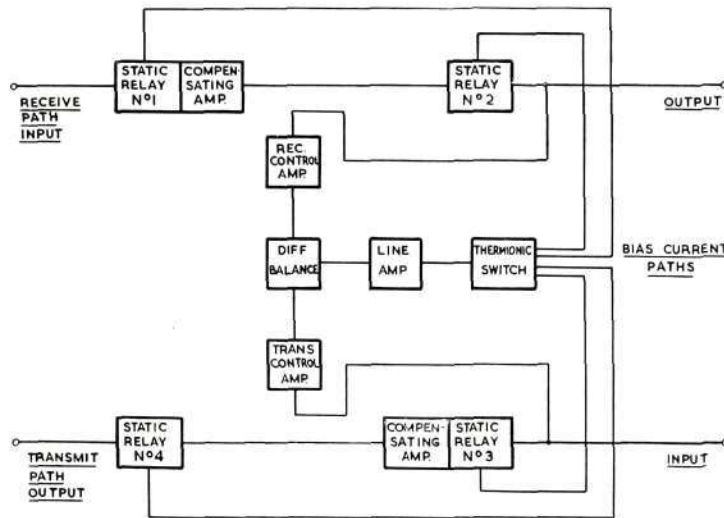


Fig. 5—Block Schematic of Singing Suppressor Equipment.

As will be seen from Fig. 4, alternative signal paths are provided at the input of the transmit path, one via the trans. CVA and the other via a manually controlled 40db attenuator, variable in steps of 2db. Manual control is necessary for any very high quality transmission, such as for music, as the CVA would tend to flatten the level of all signals and so degrade the general quality. In any case, under extremely bad radio conditions manual control is preferable to fully automatic working.

An incoming call from the radio station is received over the 4-wire land line and appears first at the receive constant volume amplifier. The amplified signal goes via a static relay and its compensating amplifier, then, if scrambled, to the unscrambling equipment and on through the second static relay and the main receive amplifier to the exchange line.

an integral part of the standard equipment, but provision is made to switch in such units if necessary ; sometimes an improvement can be achieved without loss of intelligibility by using an expander only.

Signalling into the radio circuit is by 500/20 c.p.s., or alternatively, 1000/20 c.p.s. ringing tone. This is normally controlled by the International exchange operator and conversion to 17 c.p.s. is left to his discretion. Occasionally, however, it may be desirable to convert to 17 c.p.s. at the terminal, or to give visual indication of ringing incoming over the radio link, and for this purpose a signalling unit "radio ring receiver" is incorporated.

The volume indicator and the monitoring and loudspeaking amplifiers seen in Fig. 4, are normally of high input impedance and so cause little loss when bridged across the line. The volume indicator input can

be switched to give 600 ohms impedance and thus provide correct termination for panel testing.

Referred to a level of  $-20$  db at 1500 c.p.s., under the worst conditions of test, the transmit path overall frequency characteristic is :—

200—6000 c.p.s.  $\pm 1$  db

70— 200 c.p.s.  $\pm 2$  db

Similarly, the receive path overall frequency characteristic is :—

200—6000 c.p.s.  $\pm 1$  db.

100— 200 c.p.s.  $\pm 2$  db. (Zero level = 1 mW in 600 ohms).

Crosstalk, noise and hum are kept very low throughout. The maximum working output level at which overload does not occur is  $+8$  db.

### The Singing Suppressor Panel.

If, owing to excessive crosstalk or to a leak over the hybrid transformer, the overall gain on any closed transmission circuit exceeds the loop loss, "singing" will result. In long land-line circuits echo suppressors fulfil the dual purpose of eliminating echo and preventing singing. On a radio link the most convenient point at which circuit stability can be ensured is in the audio equipment, therefore a singing suppressor panel has been included in the R.T.T equipment.

The singing suppressor is a device so controlled by the signal voltages as to close or open the transmit or the receive path, according to which is required, by means of an increase or decrease in the impedance of the appropriate speech path. This is achieved by the static relays, each of which consists of a suitable rectifier network biased to offer either high or low impedance to speech as required. As there is a slight loss in the low impedance direction, a

compensating amplifier is included in each speech path to restore the loss in the suppressor circuit. A pair of static relays gives a change in insertion loss from the open to the closed condition of from 2.5 db to approximately 90 db. Under normal operating conditions the bias on the relays is so arranged that the receive path is open and the transmit path closed, but on the appearance of a signal in the latter, the bias is reversed so that the transmit path is opened and the receive path closed.

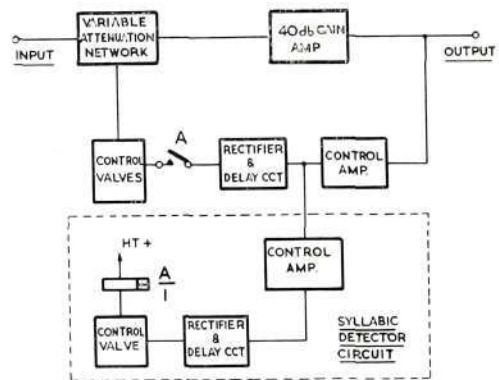


Fig. 6—Block Schematic of Transmit C.V.A. Equipment.

To prevent the constant switching of the static relays during slight breaks in the signal, as for example between words in a conversation, delay devices are introduced to allow a pre-determined time interval to elapse after the cessation of the transmit signal, before the relays switch over.

The main control circuit consists of an amplifier, the controlled output of which is rectified and fed into a thermionic switch known as a trigger. This consists of two valves, the combined anode currents of which are used to bias the rectifiers in each static relay, all the relays being wired in series with the anodes of the trigger valves. When a signal appears in the transmit path it is amplified by the transmit control amplifier, filtered by a 700-2000 c.p.s.



band-pass filter and then passed into a single stage push-pull amplifier whose gain is adjustable to allow variation in the sensitivity. The resulting signal is passed into a voltage limiting amplifier, rectified, and the d.c. voltage so obtained is used to control the operation of the trigger circuit.

As will be seen from the block schematic of the singing suppressor, Fig. 5, "receive" speech, under certain circumstances, will appear in the transmit path, therefore, it is necessary to ensure that the transmit path is not opened when a signal is present in the receive path. This is achieved by tapping off the receive signal output, feeding it into a control amplifier and then into a differential balance arrangement where it effectively prevents any signal from the transmit path operating the thermionic switch. Simultaneously the anode currents in the control amplifier stage of the trans. CVA (Figs. 4 and 6) are suppressed.

Suitable controls, operated from the main control panel, are provided for varying the sensitivity of the transmit and receive switching circuits, and for holding open all static relays simultaneously, thus allowing the R.T.T. equipment to be worked in tandem (in effect as a repeater) with other similar equipment, as for instance on a two-country inter-connection.

#### *The Transmit Constant Volume Amplifier.*

The transmit constant volume amplifier (Fig. 6) consists of a linear amplifier preceded by a variable attenuation network whose characteristic is controlled by a d.c. bias derived from the output of the amplifier. The effect of this arrangement is to vary the apparent gain of the amplifier in such a way that the output is constant and almost independent of the input signal. The main amplifier has linear character-

istics, a nominal gain set at 40db, and a normal output of zero level (1 mW) which may be increased by 20db before overloading occurs. The controlling network is composed of a selenium bridge rectifier circuit so biased, that with no input signal there is negligible attenuation.

The voltage from the main amplifier is tapped off, amplified again, passed through a rectifier and delay circuit, then via relay contact A to two valves whose anode currents are used to control the variable attenuation network. The operation of the A relay is controlled by the "syllabic detector circuit" consisting principally of rectifier and delay networks having time constants such that the relay is released by incoming ordinary speech signals but not by a continuous steady signal. The controlling voltages fed to the variable attenuation network are therefore derived solely from speech signals and are independent of noise, etc. The efficacy of this arrangement is improved by weighting the frequency response to the amplifier in the syllabic detector circuit.

It is possible to arrange that if a leak should occur from the receive path to the transmit path, the gain of the trans. CVA can be made insensitive to such a signal by taking the signal from the receive control amplifier of the singing suppressor and using it to make the syllabic detector circuit inoperative.

The foregoing description shows the type of equipment necessary to give adequate control over a radio link which connects two ordinary telephone systems in widely separated areas, and also gives details of the essential measures which have to be taken to enable a large proportion of the control of the whole circuit to be achieved in the audio circuit, compared with control in the radio circuit.



## Inter-working Between Step-by-Step and Rotary Systems

THE New Zealand Posts and Telegraphs Department has embarked upon a long-term programme of development for the Wellington, Auckland, and other areas and is specifying step-by-step equipment for all new exchanges.

Some existing automatic exchanges are of the rotary type, therefore the problem arises of inter-working between the two systems which have little similarity in their switching principles.

The Company has been given contracts for the manufacture of several of the new exchanges and has produced inter-working equipment acceptable to the Department.

In the step-by-step system the equipment is controlled directly from the dial of the calling subscriber, the impulse trains progressively setting the switches to select, on a decimal basis, the wanted subscriber.

The rotary system, in contrast, does not use the decimal principle of selection and must therefore translate the decimal numbers dialled by the subscriber into the

corresponding trains required for the control of the selecting mechanisms.

The translation is carried out by a register which then controls the positioning of the selecting mechanisms on a revertive principle, that is, for each step taken by them an impulse is sent back to the register. By comparison between the translated dialled impulses and the impulses received from the mechanisms, the register is advised when the desired selection is completed and the drive can be disconnected.

The fundamental differences in switching methods are shown in Figs. 1 and 2.

The inter-working equipment employs step-by-step apparatus throughout and is of two types; one for converting the switching technique of the step-by-step system into that of the rotary system and known as S.R. equipment; the other, known as R.S. equipment, for converting rotary to step-by-step.

### S. R. EQUIPMENT.

Fig. 3 illustrates the trunking arrangement in a step-by-step exchange, where level 6 of the first selectors is used for outgoing calls to a rotary exchange.

Each outgoing junction is equipped with an S.R. relay set which, when seized, starts a uniselector-type hunter switch searching for an idle S.R. register,

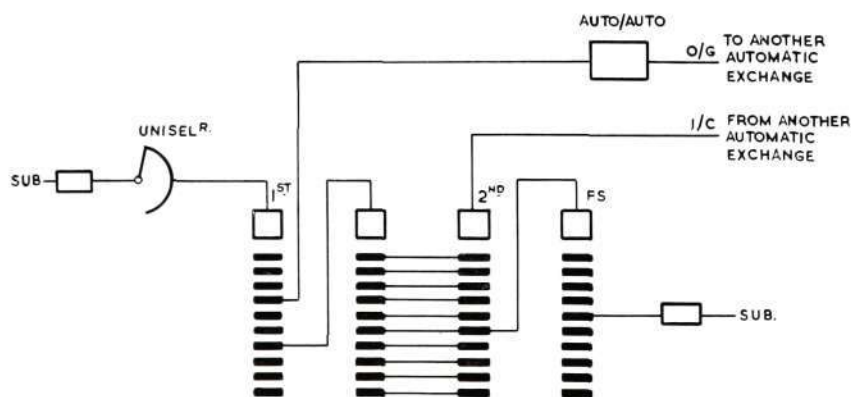


Fig. 1—Step-by-Step System Switching Arrangements.

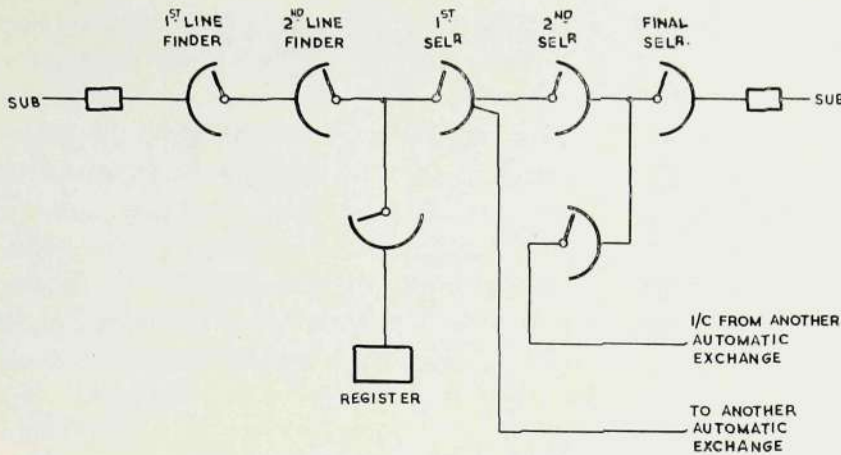


Fig. 2—Rotary System Switching Arrangements.

into two groups, the relay sets on the early choices having access to one group and the relay sets with pre-selection to the other; hence, pre-selection takes place only during the busy periods when the traffic overflows to the second group.

An idle register having been associated with the relay set, the following impulse trains are stored

The seizure of the relay set and the finding of an idle register must take place during the pause between dialling trains, otherwise the next digit of the dialled number will be lost. As the search for the register is a switching operation additional to that normally covered by the inter-train pause in a step-by-step system, the time required to find a free register is reduced to a minimum by recourse to pre-selection. This will ensure that the register hunter is always in contact with a free register, but in order to avoid unnecessary wear of this switch, which is continually moving to maintain contact with an idle register, the scheme is used only where essential, and this occurs when the greater portion of the inter-train pause has been taken up by the search for the relay set. Thus, pre-selection is restricted to those relay sets serving the junctions connected to the late choices of the first selector multiple, and the registers are divided

and translated into the rotary equivalents by the register.

As soon as the first digit is translated, the register sends a signal over the junction to start the equipment at the rotary exchange and then "counts out" the received reverteive impulses against the translation for the first digit. The remaining digits are dealt with in turn and, after the last, the register releases for further services and the junction is connected through to the calling subscriber by the relay set, which remains in circuit to maintain a holding and supervisory link between the two systems.

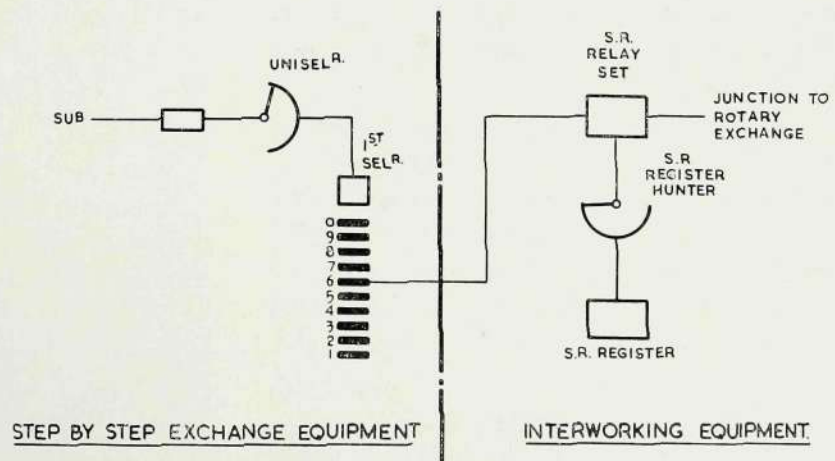


Fig. 3—Step-by-Step to Rotary Trunking.

Should fault conditions be met whilst the register is controlling the rotary equipment an alarm is given, the junction is held and the register releases.

**R. S. EQUIPMENT.**

To suit local conditions the R.S. equipment is fitted in the rotary exchange, but with certain circuit modifications the equipment could be installed in the step-by-step exchange.

control principle permits the rotary register to be restrained until an idle R.S. register is found. With the connection of the latter its uniselectors are controlled by the rotary register, which receives back revertive impulses as the uniselectors step, until it has "counted out" all the switching trains corresponding to the wanted subscriber's number. Until the last train has been received the R.S. register cannot proceed

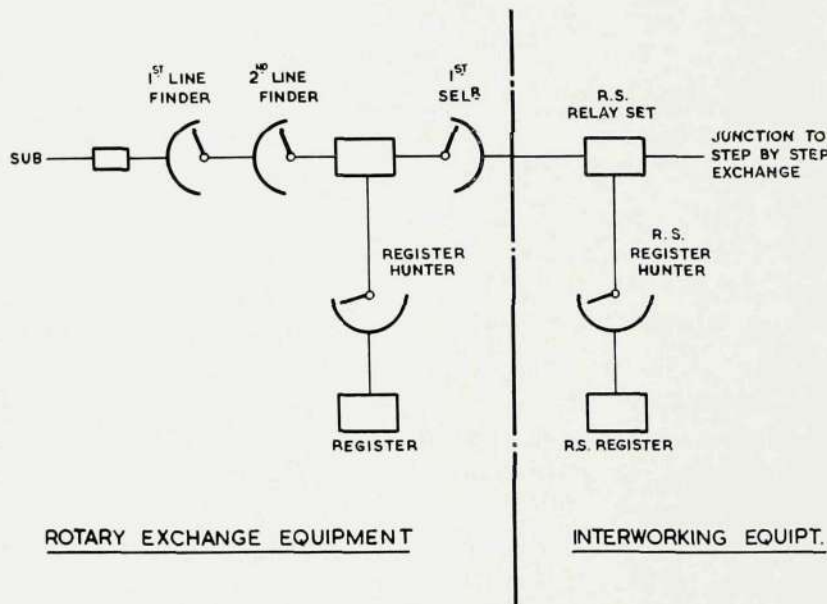


Fig. 4—Rotary to Step-by-Step Trunking.

Typical switching conditions set up in a rotary exchange when an outgoing call is made to a step-by-step exchange are shown in Fig. 4.

The first and second line finders connect the calling subscriber to a rotary register which receives the dialled digits, translates them into the corresponding control trains and routes the call through the switching equipment to an outgoing junction, where an interworking R.S. relay set is seized and its associated register hunter starts to search for an idle R.S. register.

The searching time of the R.S. hunter presents no difficulty, because the revertive

in the setting up of the call because the principle of rotary switching is such that each train is, in itself, only partially selective, final selection being decided by the following train.

With the receipt of the final train, translation takes place and the R.S. register transmits, to the step-by-step exchange, impulses which are the decimal equivalent of the rotary trains. On completion of impulsing, the R.S. register releases and the junction is switched through to the subscriber on the rotary exchange, the relay set providing a link between the two systems.



## *New Plymouth Exchange, New Zealand*

**N**EW Plymouth is one of a number of automatic exchange equipments being supplied by the Company for the New Zealand Posts and Telegraphs Department. It is of interest not so much because of its size but because it incorporates a number of facilities and circuits which are not provided in British Post Office exchanges.

The equipment was intended to be accommodated in a new two-storey structure designed especially for the exchange but because of the present building difficulties this was not completed and the exchange is housed in part of a building leased from the City Council.

Equipment is provided for a total of 3700 lines, including P.B.X., two-party

and rural lines, together with a 9-position toll switchboard comprising three 3-position, 7-panel sections terminating 70 toll lines.

The exchange design is based on ultimates of 5000 subscribers lines, and 160 toll lines on 24 switchboard positions, but already extension of the automatic plant up to 5000 lines is contemplated.

Switching equipment is of the British Post Office type 2000 but circuit and cabling arrangements, such as those now described, differ from standard practice.

Discriminating ringing on a two-party line is obtained by giving the line two numbers in the final selector multiple and, by a reversal on the connection, transmitting the ringing over one leg for one number and the other leg for the other; the subscribers' bells are then connected between earth and one leg of the line associated with the numbers on the final selector multiple.

To permit two-party subscribers to call each other, five revertive call and ring back relay sets are provided, which, when reached by dialling a particular number, return the two ringing conditions alternately to the line. Thus, to call the associated subscriber on a party line, this number is dialled and the receiver replaced. Both subscribers are rung so that the cessation of ringing is an indication to the calling subscriber that the other party on the line has answered.

The rural lines must provide for a maximum of ten subscribers on a line of considerable length with a high loop resistance and, to allow these exacting conditions to be met, each line has a terminating

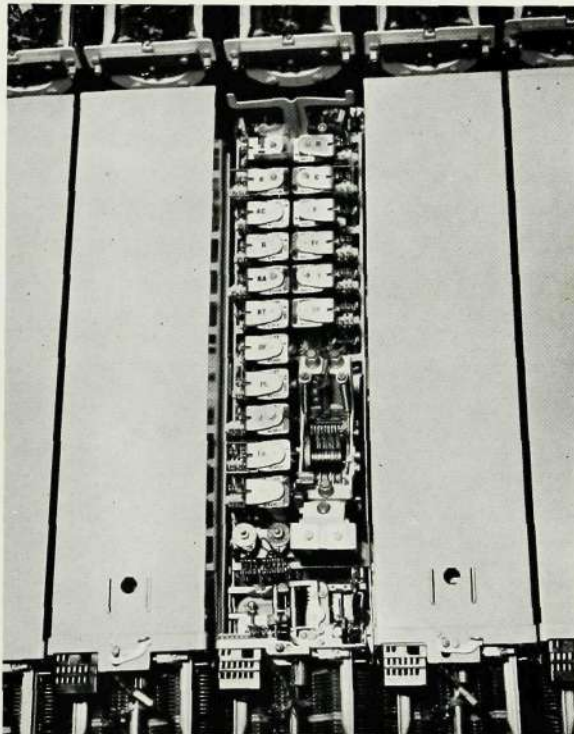


Fig. 1—Rural Trunk Offering Final Selectors.



Fig. 2—Toll Switchboard and Supervisor's Desk.

relay set which couples the line to the exchange equipment through a repeating coil.

Calls within the rural line group are made by code ringing from the subscribers' hand generators, the circuit of the relay set being such that the loop conditions do not affect the exchange equipment.

To allow the subscribers to make calls outside the rural line, the automatic dials are connected simplex to earth, this condition bringing the exchange equipment into use and allowing the rural subscriber to call any other number on the exchange.

Code ringing is employed for calls from the exchange to rural subscribers, each one in the group having a different code. The appropriate signal is given, via contacts of a rotary line switch fitted in each rural final selector (Fig. 1), when the last digit of the required number is dialled.

The toll board (Fig. 2) employs straightforward cord circuits using sleeve dialling, with timing facilities available on all circuits.

The associated relays are fitted on the miscellaneous apparatus rack, the toll board accommodating only the position and miscellaneous circuits.

The switchboard multiples are arranged so that either free line or visual engaged signalling may be employed on particular groups of lines by appropriate strapping on the lamp relay rack terminal blocks.

Through the toll switching train, operators can toll offer to busy subscribers and are advised by a toll busy tone should the subscriber be already engaged on a toll call.

At night all calls, including those associated with miscellaneous services such as information, changed numbers and "emergency", as well as fault alarm signals, can be concentrated, by key operation, on one toll position, thus allowing the supervisor's and test desks to be unstaffed.

A telegraph bureau is associated with the exchange for the verbal passing of telegrams and in order to increase operational speed facilities are given whereby direct access, by dialling, can be gained to a number of toll lines, thus no assistance is required from the toll board operators.

The test desk is of interest because no cords are used, all operations being key controlled. A "test and plugging up" circuit is provided permitting any type of line to be extended to the desk for testing and supervision, calls for the line being

signalled at the desk so that the caller may be advised. For dial testing a circuit is fitted so that accurate readings of impulse speed, count and weight are shown on the test desk voltmeter which is specially calibrated for these measurements. A view of the test desk, with some of the selector and routiner racks in the background, is shown in Fig. 3.



Fig. 3—Test Desk and Auto Equipment Racks during Installation.

The method of protecting selector banks from dust and damage by means of hook-on metal shields can be clearly seen.

Hospital or "emergency" circuits are provided so that service can be maintained, with the assistance of a toll board operator, on lines that are partially faulty. Ordinary and two-party lines can be switched to appear as C.B. extensions on the toll board should fault conditions occur which affect dialling, and rural lines can be operated as magneto lines should difficulties arise with the code ringing.

Departures from British Post Office standard practice have been made in respect of several equipment items; for example, unselector racks accommodate 6 shelves of 50 switches and associated 600-type relays, whereas the standard rack has 10 shelves of 20 switches. The increased capacity is

obtained by using a narrow unselector mechanism on the standard bank. The shelf multiple is split into two groups each of 25 switches arranged in the manner shown in Fig. 4. Final selector racks have four, five or six shelves depending upon the combination of final selector types equipped. On each multiple provision is made to fit five or more switches equipped with the trunk offering facility, these switches being used also as last choice outlets for normal traffic. All final selectors, except those for the rural lines, are of the 200-outlet type.

In the interests of cable economy the decentralized I.D.F. scheme is used whereby the subscribers' lines are cabled from the M.D.F. direct to connection strips at the rear of the final selector racks where are also terminated cables from the adjacent unselector racks, thus the final selector racks virtually become line I.D.F.'s on

which cross-connections are made by terminal strappings and jumpers.

Where possible, miscellaneous circuits, which are normally cross-connected at the I.D.F. have been designed to keep jumpering requirements to a minimum, but where jumpering is necessary provision has been made on connection strips at the M.D.F.

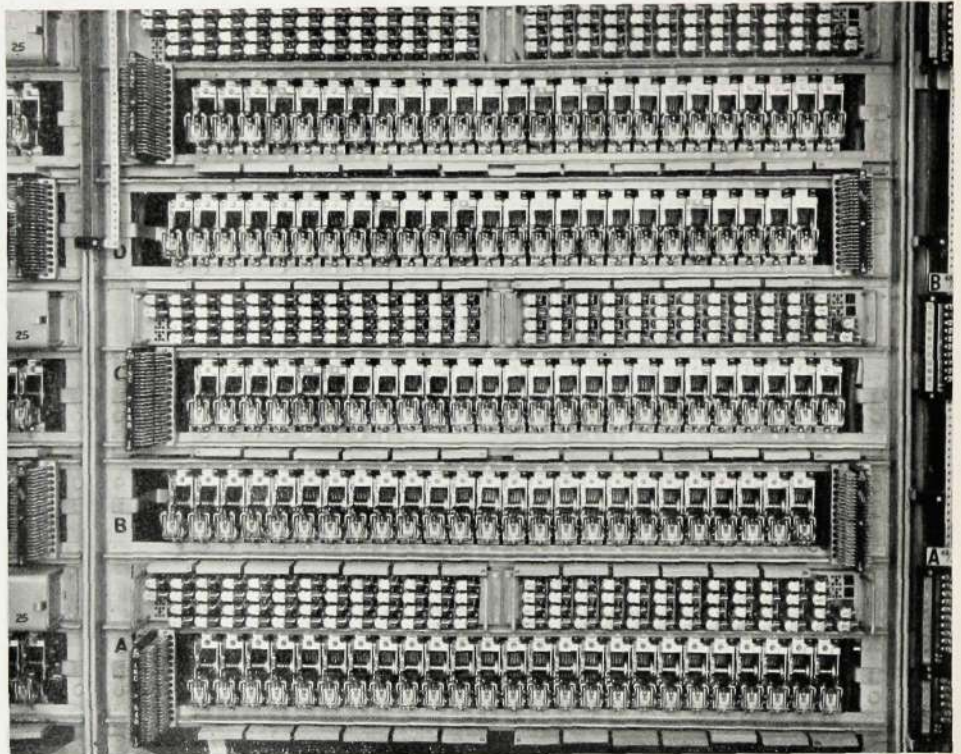


Fig. 4—Part View of Uniselector Rack showing arrangement of Line Circuit Apparatus.

T.D.F. facilities are provided only where necessary, direct cabling between switch racks being used where full availability will still be possible in the ultimate stages.

Initially, two bays of M.A.R. and four of R.S.R. are provided, these accommodating the equipment for special facilities and conversion relay sets for the toll board cord circuits.

No fuse panel rack is necessary, the miscellaneous fuses being fitted on the A.E.R. and toll board fuses on the M.A.R.

In accordance with the New Zealand Posts and Telegraphs Department specification, no subscribers' metering equipment is provided but the exchange circuits have the facility incorporated so that meters may be added later, if desired.

British Post Office standard finishes are considered quite suitable for the New Zealand climate and are used throughout the exchange. It is not so many years ago that certain items of equipment destined for use in countries or districts where standard finishes are suitable, had to be given tropical finishes to protect them during transportation across the equatorial belt, however, with experience gained in recent years, particularly during the war, packing for transport has reached such a high standard of efficiency that additional protection in the form of special finishes is no longer necessary.

Installation of the exchange, by the Department, is well advanced and it is pleasing to be able to state that the Company has been notified that the finish of the equipment is eminently satisfactory.