# THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

VOL. 42 APRIL 1949 PART I

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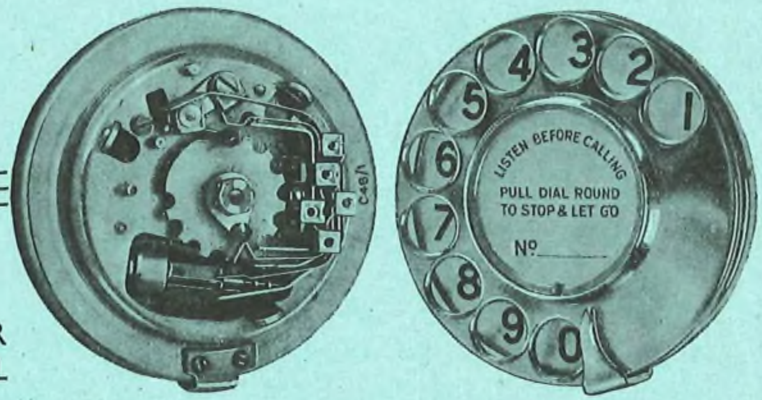


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# THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

Vol. 42 April, 1949 Part 1

## Yeading Central Motor Transport Repair Depot

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**The Post Office has recently opened an extensive repair centre at Yeading, near Greenford, Middlesex, for the overhaul of motor transport vehicles, units and components, on a "factory" basis. This article describes the circumstances that led up to its inception, how it fits into the existing nation-wide scheme of repair for motor transport, its functions, and also details of its layout and equipment.**

*Introduction.*

THE Post Office fleet to-day consists of some 25,750 vehicles and is still rapidly increasing in number. Although a high proportion of these vehicles is of Morris (Morris Motors and Morris Commercial) manufacture, owing to the sudden need in 1946 to obtain vehicles for the Engineering fleet expansion and also because of the inception of the Engineering Department's Road Haulage Scheme[1], the Post Office was forced to take over surplus Service vehicles and in consequence the fleet now contains practically every known make. Amongst the petrol-engined vehicles are such makes as Albion, Austin, Karrier, Leyland, Fordson, Bedford, Bedford-Scammell and Crossley. The oil-engine makes include Maudslay, A.E.C., Leyland, Foden, Albion and Scammell (Gardner engines predominate). In addition to this commercial vehicle fleet there are a considerable number of passenger cars and also a few omnibuses. The number of motor cycles is round about 600. It may be of interest to note that the number of vehicle types listed for costing purposes is 95.

In the Morris Motors range the principal chassis types are the "Z" (used on Engineering Minor and Postal 50 cu. ft. vans—R.A.C. rating 8·05 h.p.) and the "Y" (used on 8-cwt. Engineering and 100 cu. ft. Postal vans—R.A.C. rating 11·98 h.p.). In the Morris Commercial range the chassis used are the "LC" (for Postal 240 cu. ft. and Engineering 1-ton Utility and 1-ton Stores Carrying vehicles—R.A.C. rating 15·9 h.p.), and the "CV" chassis (for 360 cu. ft. Postal and Engineering 30-cwt. Utility and Stores Carrying and Engineering Test vehicles—R.A.C. rating 24·8 h.p.). There are also two other makes which are held in quite large numbers, the Albion (30-cwt. B.118 engined chassis—R.A.C. rating 19·6) and Austin (2-ton chassis with engine of 26·9 h.p.—R.A.C. rating).

*Necessity to Replan Motor Transport Repair Organisation.*

Although to a very great extent overhauls and repaints as well as day-to-day maintenance have been carried out in the great majority of the 350 Regional workshops, a degree of central working had been developed in each Region in the reboring of engines, replating of batteries, overhaul of electrical components and overhaul of Engineering lorries. This work was allocated to certain of the Regional workshops because it was not practicable to supply costly equipment such as boring bars to all of the workshops, while batteries and electrical components were segregated because of the requirements of specialist staff and of special equipment and accommodation. This measure of centralised repair would, but for the war, have been developed to a far greater extent. At the same time another factor made it very necessary to give urgent consideration to the setting up of Central Repair Depots. In 1939, the fleet totalled approximately 17,500 vehicles. To-day, it is almost 50 per cent. greater in number and, consequently, in maintenance requirements. During that period of growth, as a result of the almost total ban on new buildings from 1938 onwards, the additional workshop accommodation provided to meet this growth has been practically negligible. Consequently, all workshops to-day are carrying on under very grave handicaps. Apart from the limitation of workshop space, an increasing number of vehicles have to remain overnight in the open, which results in extra maintenance attention being necessary.

It has therefore become imperative to replan the complete Motor Transport repair structure to avoid a breakdown. The existing workshop buildings are sited mainly in built-up areas on relatively costly sites where their location and size is dictated by the requirements of the operating centre of the user. For Postal vehicles, in order to avoid very heavy off-centre operating costs, they are usually sited as near as possible to the Sorting Office, which is in turn generally sited near the Railway Station, while for the Engineering Department's Section Stocks and Garages, although these are farther out and not necessarily in the centre of towns or cities, they are in the main in built-up areas where no extension is possible. Consequently, as it is impracticable to increase the size of the present workshops the logical solution to give relief is to leave these existing

[1] *P.O.E.E.J.*, Vol. 40, p. 135.

workshops to carry out day-to-day maintenance work and to set up new workshops, not necessarily in the business centres of population, to carry out that work which can most conveniently be divorced from running repairs. The location of these secondary shops is not critical and less expensive sites are suitable. This policy enables the user's day-to-day maintenance requirements to be fully met by staff stationed with the operating fleet and at the same time permits overhaul staff to work without the distraction of attention to faults.

When the overhaul requirements were analysed in greater detail, paying special regard to the distances that some vehicles would have to go and also to the high cost of some of the machine tools and specialised equipment needed, it was realised that it would be desirable to divide the overhaul responsibilities still further. Such work as chassis stripping and repaints, coupled with unit exchanges, could quite well be carried out economically in selected shops in each Region and consideration of the problems of delivery and collection of vehicles and components suggests that the economic radius of operation of these workshops should be in the neighbourhood of 40 to 50 miles. Usually each Region will require two or more of this type of overhaul workshop, giving a total for the country of approximately 20.

Machine tools and specialised equipment for the overhaul and testing of engine and other major components are very costly and this work must be done in bulk to cover the very considerable overhead charges. These factors necessitate the concentration of such repetition work as engine overhauls, including crankshaft regrinding, and unit and component overhauls in a limited number of National Repair Depots planned on factory lines. The organisation now being planned for the country as a whole is :—

*1st-Line Workshops* (*Regional*). Day-to-day maintenance, valeting, decarbonising, top and bottom overhauls, minor accident repairs, preventive maintenance to body and chassis, tuning, brake and clutch adjustments.

*2nd-Line Workshops* (*Regional*). In these workshops complete vehicle strip-down and rebuilds would be performed, utilising reconditioned units and components sent forward from the 3rd line workshop. The operations performed would include engine, gearbox, front and rear axle exchanges, component exchanges, body dismantling, chassis stripping and rebuilding, brake shoe relining, brake drum turning, clutch relining, major accident repairs, body repaints and semi-major body repairs. Each 2nd-line workshop will act as a parent to a group of 1st-line workshops.

*3rd-line Workshops* (*National*). Overhaul on a " factory " basis of engines, gear boxes, front and rear axles, electrical components and accessories received from 1st- and 2nd-line workshops. Engine running-in and dynamometer testing. Reconditioning of batteries. In addition, the 2nd-line workshop functions will be effected in respect of vehicles within a radius of 40 to 50 miles. Further, the staff, accommodation and equipment available render the 3rd-line workshop eminently suitable for building prototype bodies and carrying out test work required for development, time studies, checking advertisers' claims for new equipment and accessories and performing work necessary to assist the Motor Transport Branch purchasing section.

In considering how many 3rd-line workshops would be necessary to cover the country it was decided that initially two Central Repair Depots would be required, one in the South of England and the other in the North, which would permit of covering practically the whole of England and Wales and parts of Scotland until such time as the density of vehicles called for additional 3rd-line workshops. Accommodation has not yet been finally secured for the workshop in the North of England, but after many disappointments suitable premises are under consideration and strenuous efforts are being made to secure them.

For the Central Repair Depot in the South, an opportunity came of taking over suitable premises in a very convenient and economic operating and distributing centre at Yeading, near Greenford, Middlesex.

### The Yeading Central Repair Depot

The premises taken over form a self-contained section of what was, during the 1939-45 war, a Royal Ordnance Filling Factory. The buildings and layout are typical of many similar factories which sprang up in various parts of the country during the war for the manufacture of armaments, and comprise single storey, modern, factory-type buildings of various sizes and heights, administrative office blocks, first aid centre, fire station, etc., the whole being set out with adequate approaches and service roads, and the site of 120 acres bounded by wire fencing. The workshop accommodation consists of one main factory and one smaller adjacent workshop which is eminently suitable for a paint shop—work which is preferably segregated from other workshop processes. In all, some 247,000 sq. ft. of workshop and office floor space is available.

All buildings are steam heated, supplied from a battery of high pressure steam boilers which are fired by mechanical stokers having electrically driven chain grates fed by hoppers. Distribution is by overhead piping suspended on gantries. The heating within the main workshops is by fan unit heaters. It is well known that this type of element gives space heating in winter and improves ventilation in both winter and summer. Another factor that was of considerable help in enabling a substantial amount of machinery to be installed speedily was the presence of electricity supply mains adequate for a very heavy load.

The immediate objective in setting up this Central Repair Depot was to deal primarily with the vehicles of the London and Home Counties Regions but it is the intention, as staff becomes available, to extend unit and component replacement services to the South West, Welsh and Border Counties and Midland Regions, thus linking up with the service area of the Northern Central Repair Depot. Production of reconditioned engines is already sufficient to cover the London and Home Counties fleets and in addition, urgent relief has been given when emergencies have arisen in other parts of the country. This necessitates a minimum output of 60 reconditioned engines per week of the usual Departmental types in addition to a number of types less commonly used. Another objective aimed at in equipping the Depot was that it should be, as far as possible, self-supporting, and not have to rely on outside contractors for specialist repairs such as crankshaft grinding, welding of cylinder blocks, etc. During the recent war it was found impracticable to secure satisfactory services outside for this class of work as the time factor was in most cases extremely unsatisfactory and the charges high, even making allowances for all the circumstances.

Hence the staff of the Depot comprise a great many other grades of craftsmen and tradesmen apart from Motor Mechanic. Included are turners, milling machinists, precision grinders, crankshaft grinders, tool room fitters, production inspection staff, sheet metal workers, specialist welders, automobile electricians, body builders, wood working machinists and coach painters.

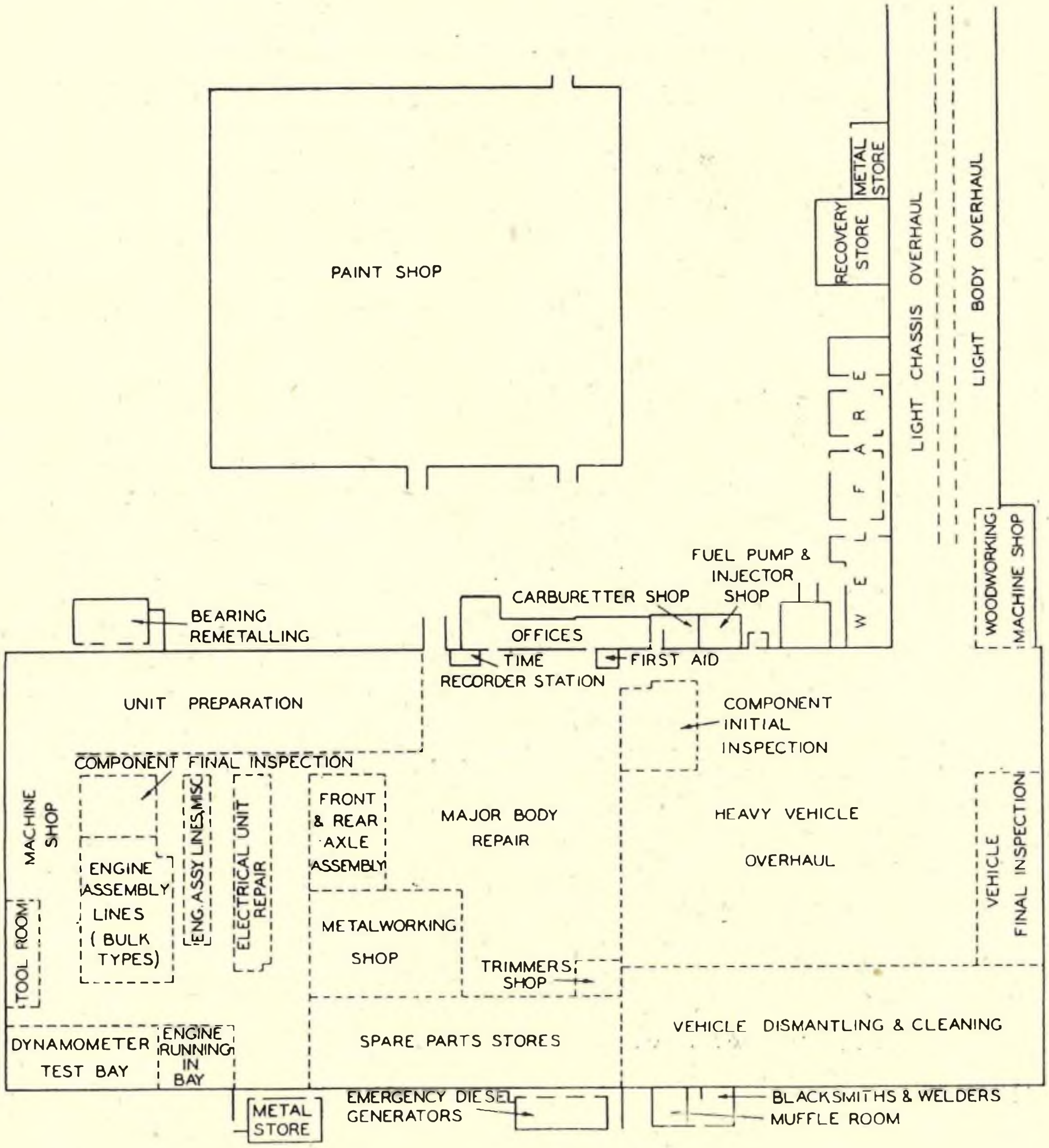



Fig. 1.—Layout of Yeading Repair Depot.

In laying out and organising the work within the Depot (see Fig. 1), a primary objective was to ensure that the work circulated within the building on a flow system in order to reduce time in transit between successive operations. Even allowing for the fact that the buildings were not planned for the purpose and had to be occupied in two stages, this objective has very largely been achieved although some replanning and greater use of mechanical handling devices is regarded as desirable and is in hand.

*Preliminary Treatment of Vehicles.*

The vehicles on arrival have a thorough external wash and are delivered to the stripping bay where the first operation is to remove engine and gear box. Next the body is removed and placed on one side to await inspection before transfer to the body line. The front and rear axles are then removed from the chassis complete with springs and steering, leaving the chassis frame ready for cleaning and reconditioning.

This sequence refers to light and medium vehicles where the individual chassis and body can readily be shifted by electrically driven trolleys. For heavier vehicles, e.g. diesel driven, the vehicles are cleaned in the stripping bay and then the complete vehicle is transferred to the heavy vehicle body shop where the body is raised from the chassis and left suspended on chassis stands. The chassis is next removed to the heavy vehicle chassis line where the engines, gearbox and front and back axles are stripped out and brought back to the stripping bay for further dismantling followed by degreasing. A view of the degreasing bay is shown in Fig. 2.

Fig. 2.—Degreasing Bay.

It should be mentioned that the original components of a heavy vehicle will, after reconditioning, come together again during assembly but in general the smaller vehicles are assembled from a number of reconditioned units irrespective of their origin. This policy is followed also in respect of the actual components of the smaller engines with one exception—the engine block and camshaft are kept together as there is no way of taking up wear in the bearing located in the engine block other than by metallic deposition on the camshaft.

*Degreasing and Cleansing.*—Various methods of degreasing and cleansing are employed. No one method is suitable for the whole range of operations but each of the methods adopted has been selected as being the most suitable and economical for a particular operation.

*Trichlorethylene Vapour.*—Used for heavily grease-laden parts not having a carbon deposit and also for non-ferrous parts which are likely to be attacked by other processes. This method is very successful but it is expensive and somewhat unpleasant to operate.

*Hot Caustic.*—This method is used for hard carbon deposits on cylinder blocks and cylinder heads. It is not suitable for aluminium components. After treatment in the hot caustic tank, parts are rinsed off in a second tank containing hot water.

*High Pressure Steam.*—Useful for removing exterior dirt on larger components such as chassis frames and axles, and when used in conjunction with a suitable cleansing agent can be employed for paint stripping.

*High Pressure Paraffin Wash.*—Used mainly for degreasing ball and roller bearings which are afterwards dried off by an air stream and then immersed in a light oil.

The various components, after degreasing and drying, are blown with compressed air to remove all surface dust; cylinder blocks and cylinder heads are wire-brushed to remove all trace of carbon deposit. All the components then pass in for inspection where they are graded broadly into :—

(1) Parts suitable for further use without treatment.
(2) Parts needing reconditioning.
(3) Parts treated as scrap.

Those parts in category (2) are sent in batches to the various repair sections, and after reconditioning are again inspected and returned to stores where, together with parts in category (1) plus any required new parts, they are made up into kits ready for assembly. The workshop is well equipped both with ordinary machine tools such as milling and drilling machines, lathes, surface grinders, etc., and the specialist machinery which has been developed for the motor industry. In the latter category are such items as crankshaft grinders, cylinder boring machines, in-line bearing boring machines, etc.

*Repair and Reconditioning of Engine Components.*

The primary reason for overhauling an engine is almost invariably wear in the cylinder bores, and engines are selected for overhaul when bore wear is ·010 in. to ·015 in. according to the size of engine. The wear results in a falling off in performance and excessive consumption of lubricating oil; in consequence, the user complains of the engine fuming. A contributory cause of fuming is compression piston ring wear or breakage.

The conditions of service for the Post Office motor vehicle fleet are very severe as compared with those of normal trade or private vehicles. Owing to the frequent starting and stopping necessary and the continual operation at low temperatures, bore wear is heavy. An additional adverse factor in accelerating wear is that to cover day and night services many Postal vehicles are driven by relays of drivers.

*Cylinder Blocks.*—For light vans of capacity 5-8 cwt. 20,000 miles is a reasonable bore life between overhauls, while for vehicles used mainly in towns, it may fall to 15,000 miles. For vans used on rural services where the runs are long and stops fewer, lives up to 25,000 miles are obtained. When the engine is dismantled, primarily on account of bore wear, it is found that other parts of the engine need attention.

On 1-ton vans, the average bore life may be taken to be of the order of 25,000 to 30,000 miles but quite a number are found to last up to 50,000 miles. Bore wear is of the order of ·001 in. in 2,000 miles.

For 30-cwt. to 2-ton vehicles the record of bore wear is considerably better and lives of 70,000 miles are not uncommon, although it may fall to 30,000 miles for vans used exclusively on short runs. A number of blocks passing through the workshop after a life of 30,000 miles showed a bore wear of ·008 in. and the bore wear of this type may be roughly stated as ·001 in. in 4,000 miles.

About 2 per cent. of the cylinder blocks going through the workshop are found to be cracked either as the result of old frost damage or strain in use. The cracked blocks are welded and in this connection it might be mentioned that welding of cast-iron calls for a high degree of skill and knowledge.

The region of greatest wear in a bore is on the thrust side immediately below the top of travel of the top compression ring. Cylinder blocks are reconditioned by boring out to ·020 in., ·030 in. or ·040 in. over standard size depending either on the condition or whether the bore had already been bored out at a previous overhaul. If the bore does not fall within these limits or cannot be cleaned out within the ·040 in. oversize on the smaller engines or ·050 in. to ·060 in. on the larger engines, the bore is machined out to a larger diameter and a liner inserted. The cylinder block is bored to such a diameter that an interference fit is obtained when the liner is driven into position by a hydraulic press. The liner is then bored to size to take standard pistons.

It is interesting to note that in general, cylinder bore wear is about one-third less over the same mileages for blocks fitted with liners as compared with the original blocks.

*Valve Inserts.*—In hot running, high efficiency engines, severe demands are made on the valve gear and valve seatings. When a block is due for rebore it is frequently found that most of the valves are pocketed and in need of reconditioning. This operation is carried out by boring out the seating to take a new cylindrical insert which is pressed home ; a new seating is then ground on the insert to provide line contact. When blocks are found to be cracked round the exhaust valve seats, this trouble can usually be overcome by inserting a new valve seat.

The cylinder block face is also examined and if the irregularities in the surface exceed a permissible tolerance of ·008 in., the block is surface ground to ensure a gas-tight joint.

The final operation on the cylinder block is to remetal the main bearings after which these bearings are line-bored to dimensions determined by the diameter of the corresponding journals of the crankshaft to be fitted to that particular engine.

*Crankshafts.*—Crankshaft journal wear does not take place evenly ; when examined practically all crankshafts are found to have some degree of ovality. In addition, the majority of crankshafts are found to have a certain amount of scoring, probably due to abrasive material which gets in the oil stream. Consequently, it is the practice to regrind all crankshafts passing through the workshop. This work is carried out on a battery of crankshaft grinders, which are very high-grade machines, and the Post Office was fortunate in being able to acquire from Government surplus disposal depots such excellent machines as Landis, Norton and Van Norman, although practically all of them required a certain amount of reconditioning. In addition, jigs had to be made to allow the offset journals to be ground.

Crankshaft grinders (see Fig. 3) are usually worked in pairs, one machine grinding the main journals while a second machine grinds the offset journals. This results in a substantial saving of time as it is not necessary to alter the setting of the machine except at the end of a batch. One machine acquired was designed for what is known as plunge grinding, which process simply explained means employing a grinding

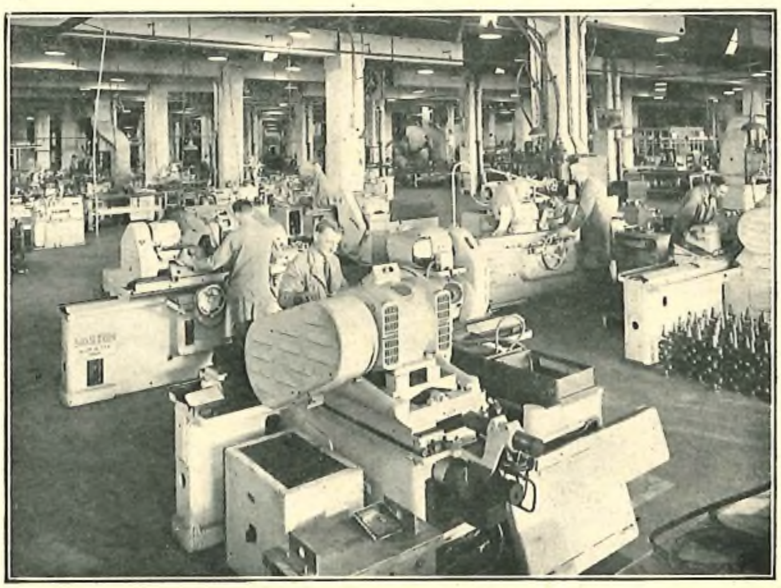


FIG. 3.—CRANKSHAFT GRINDERS.

machine with its face trued up to the exact contour of the bearing journal. The machine automatically takes its cut to a pre-determined depth and then releases and withdraws the wheel carriage in readiness to repeat the process on another journal. The operator, therefore, has only to move the machine to the next grinding position. The other machines in use have been modified to employ a somewhat similar plunge system but on these the operator has to feed the grinding wheel in by hand to a depth indicated by " Zero " position on a Mercer dial type gauge.

The majority of crankshafts are found to clean up at first overhaul to ·005 in. or ·010 in. undersize. At subsequent overhauls regrinding in stages of ·005 in. up to a maximum undersize of ·040 in. for small engines and for the larger crankshafts up to ·060 in. under size is usual. Thus, one crankshaft will last at least five engine overhauls after which a new crankshaft is required. The number of crankshafts breaking in service is very small indeed.

Building up of journals either by electrolytic deposition or by metallisation, i.e. metal sprayed on in a molten condition after the journal face has been roughened has not yet been undertaken, but is under consideration.

*Connecting Rods.*—These are checked for truth and size of bearing aperture and then remetalled. One method is to metal the bearing alloy into the rod itself and the success of this method is probably due to the satisfactory heat transference which results from the intimate contact between the bearing metal and the main material of the connecting rod.

The connecting rod big-ends are bored out to size to suit the crankshaft supplied for a particular engine. The diametrical clearance between the crankshaft journal and the bearing surface is normally ·0015 in. while the permissible end play is of the order of ·005 in. to ·006 in.

*Pistons.*—New pistons complete with rings and gudgeon pins are usually fitted at each overhaul, but a measure of recovery is carried out by turning down to normal size used oversize pistons. This work is carried out on a special machine and at the same time the piston lands are cleaned up to take new piston rings.

*General Machining.*

As mentioned earlier in this article, as well as the specialist machines, a considerable number of general machine tools are used mainly for recovery purposes to take out scoring, indentation or warping. Cylinder head warping occurs either by reason of normal working stresses or by excessive unbalanced bolting down. Where the warping exceeds a permissible tolerance of ·008 in. the cylinder heads are refaced on a vertical milling machine using an inserted tooth cutter. Jigs have been made for each of the standard makes overhauled and this operation can be carried out quite quickly and shows a big saving over contract prices previously paid for this work. Fig. 4 shows a view of part of the general machine shop.

Surface grinders have proved most valuable especially in dealing with hardened parts where ordinary machining is not possible. Truing-up of fly wheel faces, clutch pressure plates, clutch thrusts, etc., also provide ample scope for the use of these machines. Formerly many such items were scrapped because facilities for reconditioning were not available. Similarly, tappet heads and tappets are ground to give a true surface and in all the examples quoted, a large number of items are ground at one operation, special jigs made in the Central Repair Depot being employed. On recovery work of this nature a clear-cut saving is evident.

One of the hardest worked machine tools in the depot is the radial drill. In the process of overhaul it is found that tapped holes in castings are prone to damage either by threads being stripped or by past efforts in the field to remove broken studs. This damage is made good by filling up the hole by welding, or by drilling out to an oversize and inserting a metal blank which in turn has to be drilled and tapped. This operation calls for precision as correct positioning of holes is essential to register with other components.

The lathes in the general machine shop are used for production of a variety of bushes and pins and for the production of some of the simpler parts which are in short supply. It becomes a serious matter when the whole production of a workshop is jeopardised by the absence of essential spares, and the ability to turn out a number of these to bridge the gap is obviously of great value.

Brake drum turning to remove scoring is carried out on a special brake drum turning machine. The friction surface of the brake drum becomes work-hardened and highly polished with deep scoring, and to cut into this surface it is necessary to use tools having cutting tips of tungsten carbide or similar alloy.

Fig. 4.—General Machine Shop.

*Tool Shop.*

As the bulk of engines dealt with are, fortunately, of a limited number of types, repair and reconditioning in batches has been made the standard system. To do this economically calls for production of special jigs and fixtures to make the operation as far as possible approximate to mass production methods. This was visualised right from the inception of the workshop and a very fully-equipped tool room was provided. The equipment includes high-grade lathes, universal miller, shaping machine, cutter grinder, " do-all " metal band saw and a number of smaller precision machine tools as well as a Vickers Hardness machine. The tool room, as is usual, is partitioned off from the main machine shop so that the machine tools provided can be kept for high-grade work only and not for heavy production turning.

*Inspection.*

All components, after reconditioning and before issue on the assembly lines, are subjected to close scrutiny by an independent inspection section. This group is well equipped with comparators, hardness testing machines, spring testing and measuring machines, together with all the necessary micrometers and fixed gauges. A crack detector is used for examination of parts heavily stressed in use, such as crankshafts, steering arms and stub axles.

*Assembly of Engines and Gearboxes.*

The assembly of components into engine and gearbox units is dealt with broadly by two methods.

For light engines which form the bulk of requirements, assembly is on the line system, that is, the complete engine is assembled in stages as it proceeds through various hands on the line. A separate line is in use for each of the main types.

The assembly starts with a complete kit of components necessary to build the engine and this is prepared in advance of requirements by the "Initial Inspection and Make-up Section." The work benches adjacent to the line (see Fig. **5**) are equipped only with such tools as are necessary at each stage of the work and the work is facilitated as far as possible by the use of high-grade ring and socket spanners, torque spanners, and electric nut runners. Specially designed wrenches and fixtures have been provided where necessary to speed up the work.

The heavier engines such as Gardner Diesels are assembled by individual mechanics and do not pass through several hands. The "initial kit" system applies, but these types retain their identity so far as components are concerned and as distinct from the main types where parts are, in general, freely interchanged.

Completed engines all pass through some form of power testing and here again the light types are specially treated by being first run-in in tandem on suitably designed cradles. One engine under its own power drives by means of a connecting shaft a similar engine not under power. After a running-in period of one to two hours according to how the engines behave under test, the driven engine is powered and in turn provides the means of running-in a further engine. A proportion of the light engines are finally tested fully for power and consumption on a Heenan Froude (DPX 2 model) dynamometer, to ensure that the results are consistent with the maker's design and that the repair tolerances, etc., are acceptable and unlikely to cause trouble in service.

The heavier type engines are not given this initial tandem running but are brought up slowly to full power on test benches made by Messrs. Bennett Feregan. These dynamometers (Fig. **6**) absorb the engine power hydraulically and give direct readings of torque. During the course of testing an analysis of exhaust gases is made to determine the suitability of the carburettor settings. A cathode ray oscilloscope is used to provide visual evidence of the efficiency of the whole of the ignition system.

*Carburettors and Diesel Fuel Pumps.*

It will be appreciated that if the best results are to be obtained from an overhauled engine it is important that the carburettor should be subjected to close examination and repair. There is no doubt that this engine component is still very largely a specialist job and the best settings can only be obtained by testing in conjunction with its individual engine. A small shop has been set up apart from the main workshop for carburettor repairs and is equipped with all the necessary small tools and testing equipment proper to this class of work.

A similar workshop has also been set up to deal with diesel fuel pumps and injectors. The requirements of this work are exacting as the atmosphere must be entirely dust free and to this end the work-

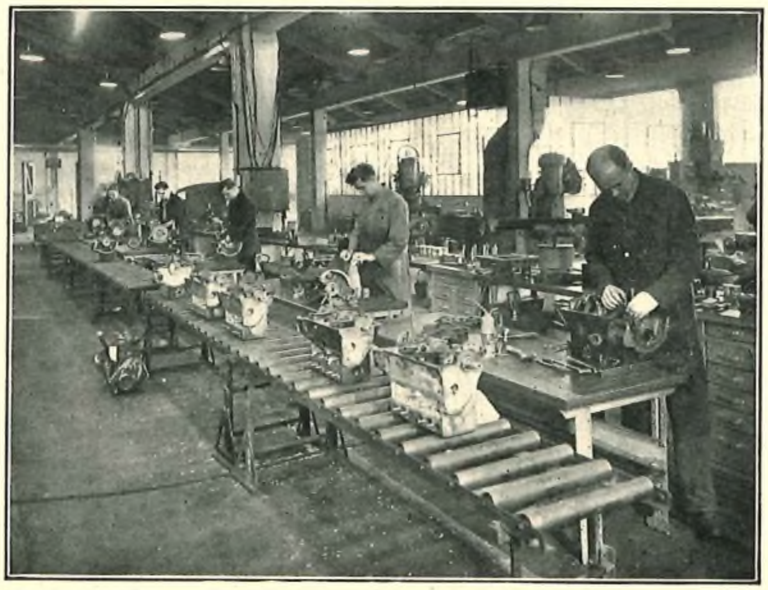


Fig. 5.—Engine Assembly Line.

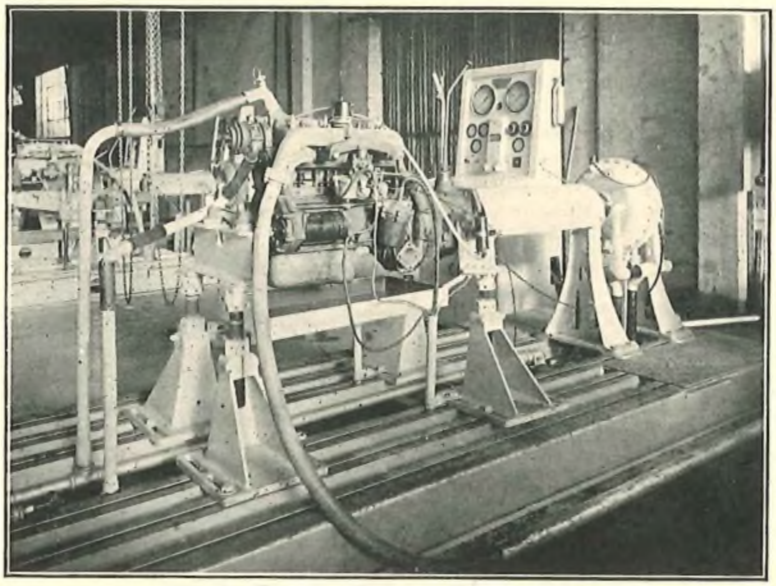


FIG. 6.—BENNETT FEREGAN DYNAMOMETER.

shop is sealed and provided with a small air conditioning plant. Floors and walls have to be given anti-dust treatment. The equipment of this workshop includes a Hartridge test bench which is used for calibrating, phasing and testing of fuel oil pumps, while injectors, after servicing, are tested in a sprayer test cabinet.

Heavy oil engines (diesel) are finding a growing use in the departmental fleet of heavy vehicles and considerable additions of this type have been made by taking over vehicles from the Government Surplus Depots. In recruiting staff for the Yeading workshop particular care was taken to engage a number of men with wide diesel engine experience both as regards the actual fitting work and testing. This precaution has enabled all classes of this type of engine to be dealt with fully and has provided very satisfactory results.

It might be mentioned that diesel-engined stand-by power units were also acquired from Surplus Depots to assist in the event of electricity load shedding and these were overhauled at Yeading and installed both at Yeading and in the Factories Department, Perivale.

*Repair of Electrical Units.*

Electrical units, in common with the general system employed in the workshop, are repaired in batches. As far as possible staff are employed for lengthy periods on the repetitive overhaul of one type of electrical component and thus become very expert in the course of time. A special bench is set up for each piece of equipment to facilitate the layout of tools, testing equipment and spares. The general layout is illustrated in Fig. 7. The aid of the machine shop is enlisted in cleaning up the contact surface of the many types of commutator used in dynamos and starter motors.

The number of items dealt with in the electrical section is fairly high, possibly because electrical equipment in general is not of such robust design as the mechanical parts of a vehicle. Another factor is that this equipment suffers two types of damage, i.e. mechanical and electrical, and electrical faults frequently result from mechanical failures. Examination of the components passing through the workshop for repair shows that they exhibit the following characteristic defects.

*Trafficators* suffer mainly mechanical damage due to the driver or passenger colliding with them while they are in the " indicating " position. This particular type of damage is due to the fact that many of them after a time fail to be self-restoring. It is significant that a leading manufacturer has recently produced a trafficator for commercial vehicles having an articulated arm. One other fault occasionally experienced is that of an electrical burn-out caused by failure of the arm to rise when switched on, due to jamming in the casing.

*Windscreen Wipers.*—These fail mainly as a result of commutator and brush wear with consequent choking by dust, causing bad brush contacts. Failure can also be caused by overloading consequent on continuous running, particularly if the screen becomes dry.

*Instruments.*—Ammeters frequently burn out, generally because of accidental short-circuits.


FIG. 7.—ELECTRICAL COMPONENT REPAIR SECTION.

*Petrol Gauge.*—Failures are usually due to the breakdown of the potentiometer coil in the tank or to puncture of the float.

*Fuel Pumps.*—Breakdown occurs either in diaphragm or contact. Failure of the diaphragm from fatigue throws an overload on the windings and this in turn leads to burning of contacts. The diaphragm life is much influenced by the ambient temperature.

*Regulators.*—The introduction of this item in place of the simpler cut-out mechanism has given an improved performance but results in more repair work because of its comparative complexity. Incorrect wiring after clearance of a fault can result in the burn-out of contacts. Another type of fault occurs if the regulator is adjusted to compensate for high resistance in the external wiring, this leading to overheating with the possibility of subsequent burn-out.

*Dynamos.*—Electrical faults are not often experienced, the primary cause of breakdown being mechanical failure. Wear on pulley-driven armature shafts results if the drive pulley runs eccentrically on the shaft thus setting up undue strain and fatigue. Excessive fan belt tightening has the effect of putting undue pressure on the bearing causing the armature to receive damage by coming into contact with the dynamo stator.

*Starters.*—Some starters exhibit considerable commutator wear, but on examination brush spring pressures are found to be normal and commutation correct. Electrical breakdown follows because of the extreme effort required when starting a cold engine.

*Batteries.*—A well-equipped battery shop is used for conditioning and replating the batteries, and handles all types of battery in use. Complete replatals and the manufacture of such items as connectors are undertaken. Initial charging of the completed battery is by the constant potential method carried out in a suitably designed enclosure. A number of rapid chargers are employed for boosting batteries of vehicles in transit; in these the charging current, which may amount to 90 amps., is controlled by a thermostat placed in the electrolyte and a 120 amp. battery can be fully charged within one hour. The main value of this shop lies not so much in the immediate saving, which is quite considerable, but in the ability to keep the fleet supplied with batteries when trade sources of new batteries have dried up. This has happened on many occasions.

*Bodybuilding Workshop.* (*Fig.* **8**)

In contrast to the mechanical work of reconditioning engines in which a measure of repetition is possible, thus permitting a regular routine to be adhered to, bodywork has proved much more difficult to organise. The wide variety of bodies and the multiplicity of individual jobs to be carried out has called for very considerable detailed planning in order to organise the work properly. For the mass-produced types, the solution is felt to lie in a very much increased use of jigs. For example, when the work was started it was the practice, if a body was distorted, either to select a door which could be fitted to it, or alternatively to modify the door. Operations such as these take a considerable amount of time and it is better, by using jigs, to bring the vehicle body and doors back to standard dimensions. Again, this method allows damaged or rusted parts of the body to be cut out and fresh parts welded in with comparative ease.

The mass-produced pressed steel body is in use on most of the standard cars and light vans produced by the motor industry to-day. It undoubtedly provides a method of construction economical in manpower which is a great asset to the manufacturer. For the maintenance engineer, however, this means a constant battle against corrosion. Vehicles now leaving the manufacturers' works are given coats of aluminium paint in an effort to keep corrosion at bay, and most makers are introducing methods of rust-proofing for both body and chassis.

A further factor is that postal vehicles back in and out of loading bays several times per day, and it is inevitable that they sometimes sustain body damage during such operations.

These factors make it difficult to achieve the desired result of the flow of bodies being equal to the flow of engines, but the position is now improving. For the larger and more expensive vehicles the problem is not so difficult and very satisfactory production has been achieved. The specialist coachwork calls for individual treatment, but as compared with charges for similar operations carried out in the past, and which are still being performed in the country as a whole, the central workshop will undoubtedly show large savings. The inception of the National Road Haulage Scheme would have been well-nigh impossible

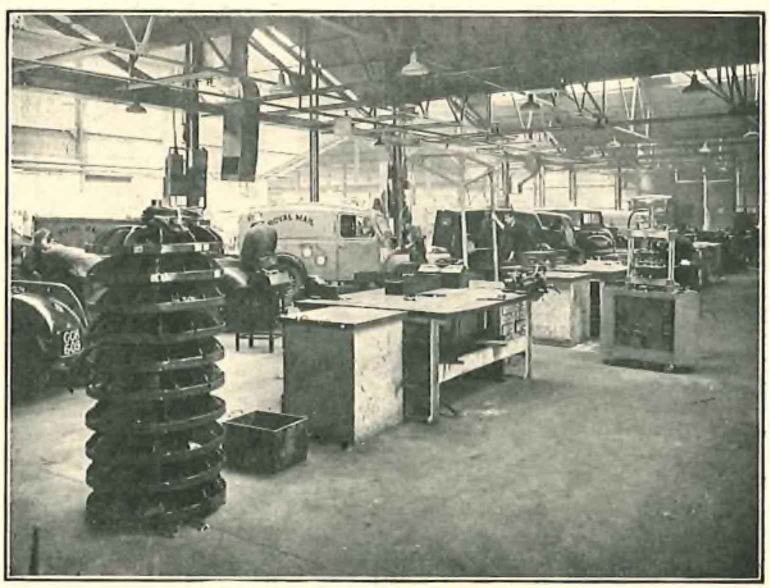


Fig. 8.—Light Van Body Shop.

without the facilities afforded by the Yeading workshop. Already nearly 200 heavy-load carriers, including many 12-ton oil-engined vehicles, have passed through this workshop and frequently the bodies had to be practically rebuilt. Another formidable task was to reduce the width of many heavy vehicles from the Service 8 ft. to the maximum legal width of 7 ft. 6 in. This meant cutting the cab in halves and rebuilding; the body bearers had to be reduced and the sides repositioned.

Other interesting jobs which have passed through the body shop have been the production at short notice of a Mobile Post Office, the conversion of R.A.F. radar trailers to take mobile automatic exchange equipment and the overhaul of a " Jeep " and " Dukw " for Criggion radio station.

A further activity of the body shop is the production of prototype bodies prior to bulk manufacture. Previously it has been necessary for this work to be carried out at manufacturers' works—a slow and costly process. A recent example of prototype body building has been the production of the proposed 2-ton utility van designed to supersede the present 30-cwt. vehicle used by main line gangs.[2]

[2]See p. 22.

*Future Trends.*

A very considerable volume of work for the central workshop can be foreseen and now that the workshop is actually in being it will undoubtedly prove a substantial asset to the Post Office. The ability to give relief to any part of the country experiencing difficulty or breakdown is of great value. A further asset is the fact that the headquarters design and maintenance staff come very much more closely into contact with the performance of vehicles and causes of failure on various vehicles.

By studying the work in progress it is quite clear that the future trend of development will be to extend the life between overhauls by adopting such processes as hardening of journals by nitriding or some similar method, greater use of bearing alloys such as lead-bronze, chromium-plated cylinder liners, hardened valve inserts and special alloy valves.

Because of the large number of vehicles in use by the Post Office, fault analysis is of very great value to the manufacturers and in view of the volume of work passing through the central repair depot it is anticipated that characteristic failures will be brought to notice earlier, thus helping materially in the development of the British motor vehicle.

## Book Reviews

" Microwave Transmission Circuits." Volume 9 of the Radiation Laboratory Series, edited by George L. Ragan. McGraw-Hill Publishing Co. 725 pp. 624 ill. 51s. in the U.K.

The contents of this latest volume in the Radiation Laboratory Series conform closely to the title : they are concerned almost entirely with the means for transmitting microwaves from one part of a circuit to another, and not at all with their generation, detection or radiation.

The book starts with a brief clear treatment of conventional transmission line theory which quickly evolves into a general consideration of coaxial lines. This is followed by a theoretical study of waveguides which, although not rigorous, is very instructive and covers some of the lesser known types of waveguide, including a coaxial pair excited in its higher modes. The next section deals at some length with the graphical representation of the way in which current, voltage, etc., vary along a transmission line, and with various impedance charts and their application to transmission line and waveguide problems. Telecommunications engineers generally will find this part of the book very interesting. About a third of the book then covers various aspects of coaxial transmission line and waveguide circuits. To summarise this part of the book briefly is quite impossible ; the subjects treated range from the effect of irregularities, the design of branching circuits, and the behaviour of iris diaphragms in waveguides, to such mundane matters as the corrosion testing of various finishes. But theory and practice are pleasantly mixed, and in spite of the variety of subjects covered, the result is satisfactory, and much of the material is applicable to lower frequencies.

The book finishes with a full, authoritative, discussion of wave filters, with special reference to filters using coaxial line elements, resonant cavities, and irises in waveguides. Such filters will assume great importance in commercial microwave transmission systems and this excellent treatment, the first of its kind to be published, is likely to be studied widely.

The reviewer has only two criticisms : it is a pity that no attention has been paid to the shielding of circuits, i.e. the elimination of crosstalk, a trouble that many engineers run into when they graduate to the higher frequencies ; and the title is far too modest—there is much in this volume that is applicable, and indeed of great value, to workers on frequencies below the microwave part of the spectrum. H. S.

" Radio at Ultra-High Frequencies," Vol. II (1940-1947) Radio Corporation of America, New Jersey. 485pp. 258 ill. Price $2·70, post free.

This is the eighth volume in the R.C.A. Technical Book Series and the second on the general subject of radio at frequencies above 30 Mc/s. To those who are not familiar with these publications, it is necessary to point out that each consists of reprints of articles by R.C.A. engineers which have been published over a certain period of years, in this particular case, 1940-1947. The title is somewhat misleading in the light of the current definition of U.H.F. radio, namely, 300-3,000 Mc/s, since the articles deal with radio at frequencies both above and below this band.

There are twenty-two articles in all, which have been grouped into seven categories ; antennas and transmission lines ; propagation ; reception ; radio relays ; microwaves ; measurements and components ; aids to navigation. The articles have been supplemented by an equal number of summaries of articles.

In as much as the work is restricted to that of R.C.A. engineers the book cannot, nor is it intended to serve as a text book. Nevertheless, it is a handy collection of authoritative articles and the inclusion of a bibliography of over 300 references to articles on U.H.F., which is not restricted to R.C.A. engineers, enhances the usefulness of the book.

In an Appendix are given the summaries of the articles and the summaries which appeared in " Radio at Ultra-high frequencies Volume I," which covered the R.C.A. literature for the years 1930-1939. H. T. M.

# Mechanical Trunk Fee Accounting

K. M. HERON, A.M.I.E.E., and
D. L. BENSON, Grad.I.E.E.

U.D.C. 681.1 : 657 : 654.15

## Part 2.—Trunk Charge Calculator, Sorting and Tabulating Equipment

**A description is given of a Trunk Charge Calculator designed, developed and constructed in the Engineering Department. The Calculator operates in conjunction with the " sensing/punching " machine previously described, accepting basic charge data in the form of electrical signals on marking leads. When the calculation has been made, outgoing signals from the Calculator are converted via electromagnets in the sensing/punching machine to operate punch rods and perforate the Powers-Four card in appropriate columns. The article concludes with references to the mechanical sorting of the punched cards and use of a Tabulator to prepare Trunk Charge statements as furnished to subscribers.**

*The Trunk Charge Calculator.*

THE operating principles of the calculator are shown in schematic form in Fig. **6**. The equipment uses Siemens motor uniselectors[1] for charge calculation and 3,000-type relays for storage and circuit sequences.

A group of sense storage relays, provided on the basis of one per punching position for each of the columns containing data essential to the charge computation, accept signals from the sensing/punching machine referred to in Part 1 of this article. On receipt of this information it is first necessary to derive the basic charge for the call, this value being dependent upon the charge letter, the call duration in minutes, and the period (full or cheap rate) in which the call originated.

Contacts of the duration relays are connected to mark positions in the banks of two motor uniselectors, termed " Charge Switches." The banks and wipers of each of these uniselectors are divided into three sections, dealing with tens of shillings, unit shillings and pence values respectively. Considering a particular contact in the pence section, this represents a co-ordinate position where the ordinate is the call duration in minutes and the abscissa the charge letter for either full or cheap rate periods. Such a co-ordinate position is assigned a pence value determined from the charge tables laid down by the Administration. The equivalent contacts in the shillings and tens of shillings sections of the bank are connected to represent shillings and tens of shillings values respectively as dictated by the charge tables. Thus, emerging from the pence section are twelve leads representing pence values of 0 to 11 pence, each lead being connected to the appropriate bank contacts in the pence section as dictated by the charge tables in use. Similarly, there are 10 commons in the shillings section, representing values of 0 to 9 shillings. In the third section there are four commons equivalent to 0 to 3 tens of shillings.

The relays operated in respect of charge letter and period cause the selection of one of the two charge switches and this uniselector hunts and stops at the position marked by the duration relays. In this position three of the charge switch wipers selected by the charge letter and period relays are marked with an earth signal. Thus, a lead in each of the three sections is marked with a signal, the combination indicating the basic charge of the call. The charge switches can deal with durations of up to 29 minutes, which, for the maximum value charge letter (L-Z) amounts to a basic charge of £1 16s. 3d. Such a charge would be signalled by earth markings on the 3 tens of shillings lead, 6 unit shilling lead and 3 pence lead.

Certain types of call which involve services such as " Personal," " Fixed Time," etc., are subject to a charge additional to the basic charge. In the calculator, summation of the basic charge and additional charge is performed by two motor uniselectors termed " Additional Pence " and " Additional Shillings " switches, respectively. The twelve pence commons emerging from the charge switches are connected to twelve wipers of the Additional Pence switch and the shillings commons from the charge switches are connected to ten wipers on the Additional Shillings switch. Since the highest additional charge is less than ten shillings an addition switch for tens of shillings is not required.

The Additional Pence and Shillings switches run to and stop at positions marked, this movement being coincident with the hunting of the charge switch. The stopping positions for the addition switches are marked from contacts of the charge letter, period and type of call relays via a tag block, which permits the necessary changes to be made should the Administration modify the charge for a particular service. Thus, assuming that the call involves Personal service at the full rate for which an additional charge of 1s. 6d. is made, then the Additional Shillings switch runs to contact 2 (contact 1 is allocated to zero value) and the Additional Pence switch to contact 7. If the pence value derived from the basic charge switch is tenpence, then the signal fed forward will mark wiper 10 on the Additional Pence switch, and the co-ordinate contact (contact 7, arc 10) must represent a pence value of fourpence. The bank contacts are commoned in the manner shown in Fig. **6**, and it will be noted that 23 common points emerge. This is because any pence value (other than eleven pence) resulting from the addition of two separate amounts, may, or may not, be associated with a shilling to be carried, e.g. five pence plus five pence results in a total of tenpence and eleven pence plus eleven pence also results in tenpence, but with a shilling to be carried. Thus, for all values except eleven pence there are two commons, representing like pence amounts, but one indicating that a shilling must be carried in to the next unit. Like commons are connected via separate windings of individual relays, each relay representing pence values of 0 to 10 pence. Similar windings on each relay are commoned

[1] *P.O.E.E.J.*, Vol. 26, p. 248.

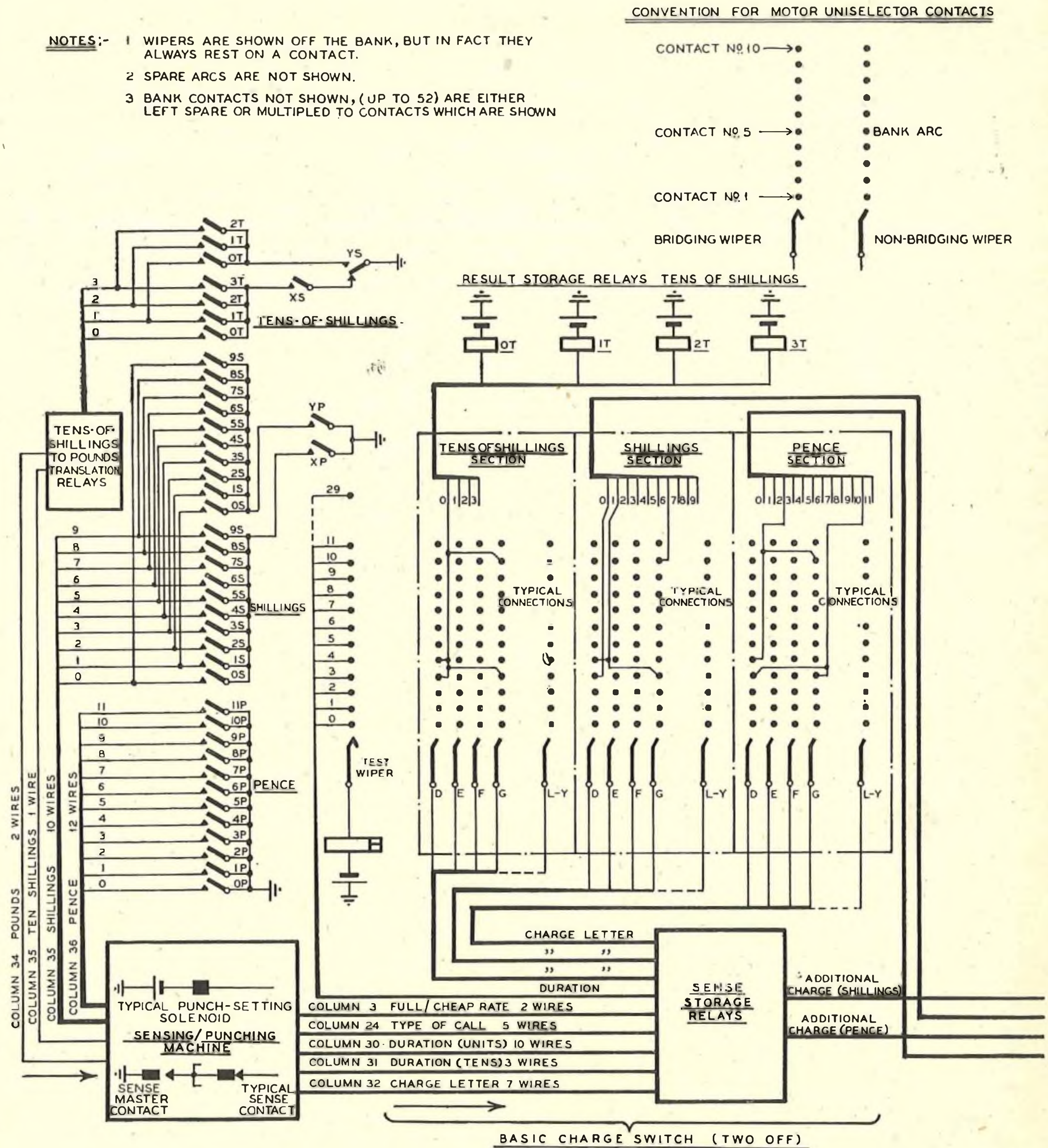
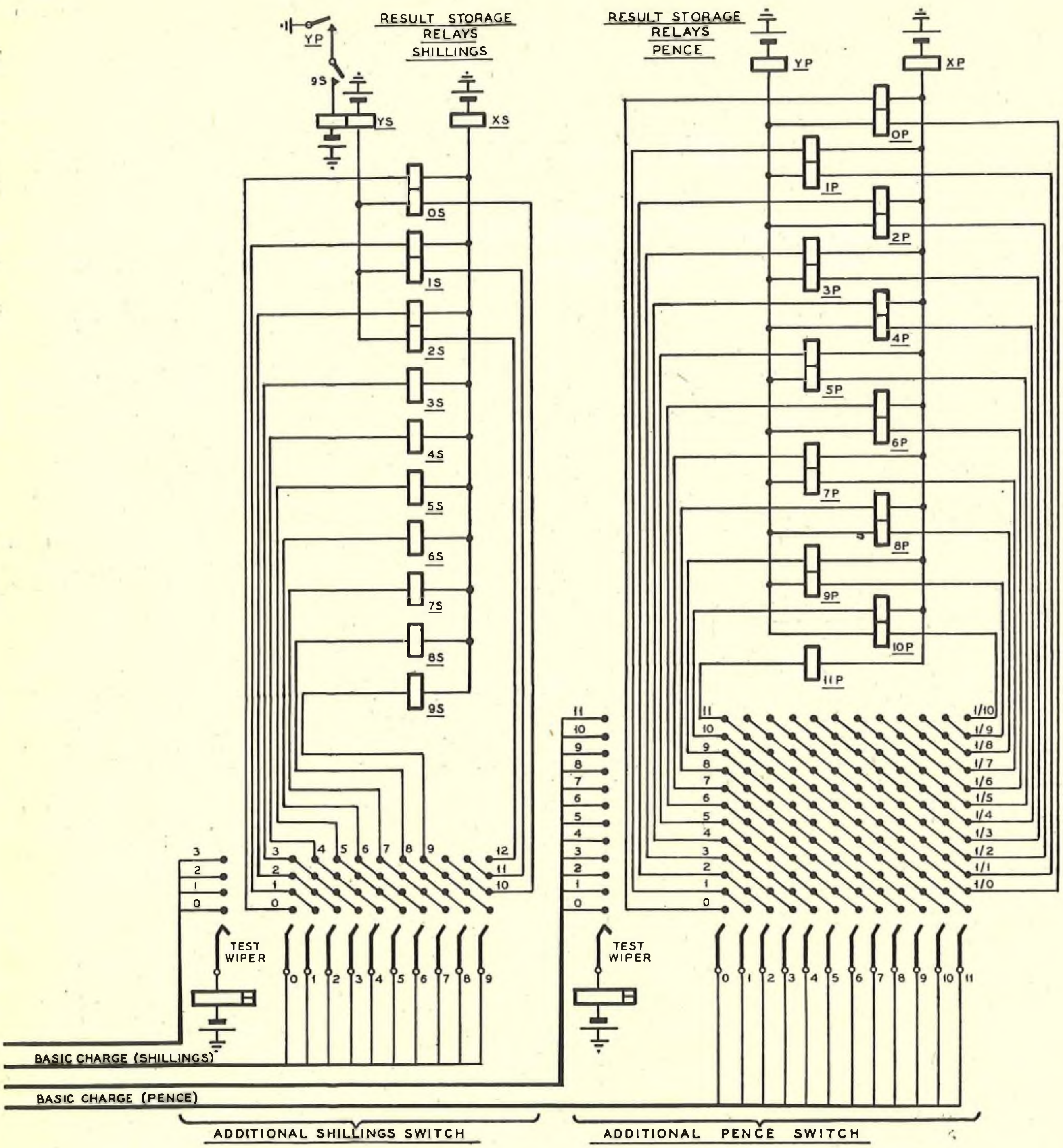



Fig. 6.—Schematic Circuit

together and the two commons are connected via separate relays, XP and YP, which indicate "Carry" or "No Carry" conditions. The "eleven pence" relay requires but one winding connected in series with the "no carry" relay, since no two pence values can produce a sum of 1s. 11d.

The bank wiring of the Additional Shillings switch is similar to that of the Additional Pence switch, excepting that the former uses a radix of 10. Facilities have been provided for a maximum additional charge of 3s. 11d. (at present the highest additional charge is 2s. 5d.) and thus there are only 13 commons emerging




OF THE CALCULATOR.

from the Additional Shillings switch bank. The 13 commons from the bank terminate on a group of storage relays representing shillings values and discrimination in respect of Carry and No Carry (in this case into the tens of shillings) is provided by two common series relays, XS and YS.

The tens of shillings values are marked direct from the charge switch bank to a tens of shillings relay storage group. Associated relays in this group, translate multiples of tens of shillings to the equivalent value in pounds.

During the time of derivation of the basic charge and the summation of basic and additional charges, the punched card from which the data emanated is moved from the sense to the punch position. When the calculation has been completed contacts of the operated pence, shillings and pounds storage relays, connect earth signals to the appropriate marking wires terminating on solenoids in the sensing/punching machine. Thus the appropriate rods are operated and latched, and at the correct period the details are punched into the card.

The results of each calculation, in addition to producing punched information in the card, are signalled to an adding circuit, termed an " Accumulator " which is part of the calculator. The Accumulator uses six motor uniselectors and two P.O.-type uniselectors. The circuit principles, whereby each calculated amount is added to the amounts preceding, are an extension of those used for the additional pence and shillings circuits. The facility is of value in deriving a daily total of revenue for the cards passed by the sending/punching machine. The total is presented in the form of illuminated characters on a stencilled glass plate, the display being fitted on the calculator control panel. The accumulator is capable of dealing with totals up to £5,000 and means are provided for resetting to zero when a total has been recorded.

A further facility (used only in connection with the preparation of statements for call offices or for subscribers who rent a coin box) is available to evaluate the call office fees due in respect of trunk calls originated from such lines. These fees are 2d. or 1½d. for each call made from a call office or subscriber's coin box respectively. A batch of punched cards relating to calls made from a call office or coin box line, after sorting in respect of the calling subscriber's number is fed into the sensing/punching machine. The cards for each number are prefaced by a " Guide " card into which is punched details which include the appropriate call office charge (2d. or 1½d.). The calculator, switched by key operation to the facility termed " Call Office Count," receives a signal from the guide card indicating the call office fee due in respect of each following card. The cards feed through the sensing/punching machine, and each card as it reaches the sense position causes a "card count" signal to be transmitted to the calculator which totals the number of cards in the batch. Certain calls, e.g. phonograms, etc., are allowed from call offices without a call office fee being charged. Cards in respect of these calls are recognised by the sensing/punching machine and the calculator passes them without adding to the count. The product of the fee and the number of cards counted is computed by the calculator and signalled back to the sensing/punching machine, where equivalent punchings are inserted in a "Coin Box Charges" card which terminates the batch. The equipment then restores to normal and automatically repeats the sequence of operations on the next batch of cards.

The calculator, together with the punch and clutch solenoids of the sensing/punching machine, operates from a 50-volt supply.

*Mechanical Sorting.*

In previous processes, the punched cards have been retained in batches, each relating to calls originated from a particular exchange on a certain date. In order to segregate cards into groups, each representing a number of trunk calls made by a particular subscriber over a period of days, or months, a mechanical sorter is employed. This machine (Fig. 7) is equipped with 12 separate receiving magazines, card entry into a magazine being via a mechanical gate. The operation of a gate is made dependent on the existence of a hole punched in a particular position, in any one column selected for the sorting operation. Preliminary sorting is carried out on columns 25 to 29, in which is recorded the number of the calling subscriber.

For reasons associated with subsequent processes it is necessary that each sorted group of trunk cards pertaining to calls made by a particular subscriber, should be preceded by a " Guide " card. These guide cards (previously mentioned in connection with the Call Office Count facility) are prepared in respect of every number on all exchanges in the Area. They are punched to show exchange name and number, type of line, accounting period, etc. Thus all the guide cards relating to an exchange for which trunk cards are to be sorted are placed in the feed magazine and the sorter is set to sort on column 29 (columns 25 to 29 of the guide cards bear calling subscriber's number as do trunk cards). The sorter is power driven and cards feed on to a sense plate, where the position of the perforation in column 29, which relates to the units digit of the number, is determined and the requisite gate to a delivery magazine is opened. The card feeds into the indicated magazine and the gate is closed. This

FIG. 7.—SORTING MACHINE.

process is repeated at the rate of 400 cards per minute, and at the conclusion of the sorting operation, the cards will have been distributed over the ten magazines representing units digits 0 to 9. At the conclusion of this operation when guide cards have been sorted in respect of units digits, the batches of trunk cards are inserted into the feed magazine in date order and are also sorted in respect of column 29, being deposited in the various receiving magazines on top of the guide cards bearing identical units digits. When all cards in respect of the exchange have been sorted in terms of units digits, the batches of cards are removed from the delivery magazines, and returned to the feed magazine in unit digits order. The sorter is reset to sense on column 28 (tens digit) and the process is repeated. Thus, after four sorting operations, sensing on columns 29 to 26, in that order, the trunk cards are in calling number sequence. The cards relating to trunk calls made by an individual subscriber are then in date order and preceded by the subscriber's guide card. There will, of course, be numbers of guide cards without following trunk cards, for subscribers who have not made trunk calls.

*Mechanical Tabulation.*

The final operation in the accounting process is that of extracting the required information from each group of trunk cards, and translating this into readable form on a Trunk Statement, for enclosure with the subscriber's main account. This work is performed by a standard machine known as a " Tabulator " (Fig. **8**).

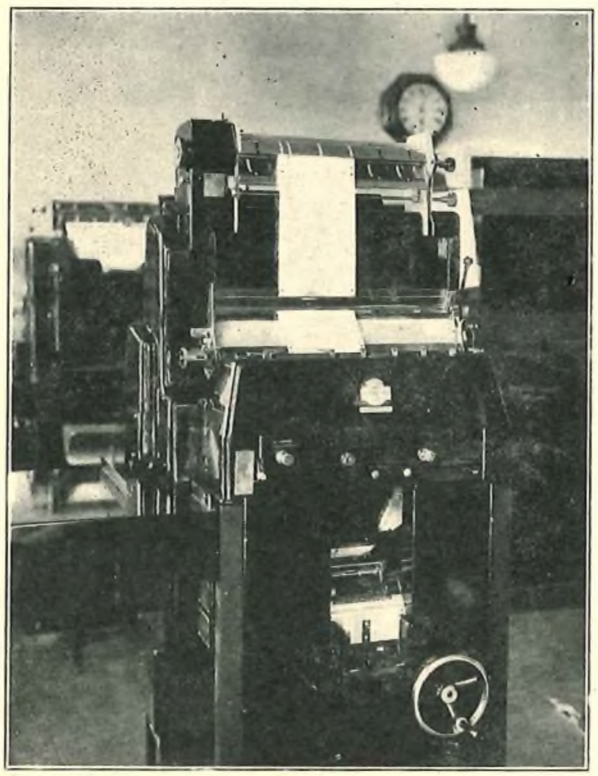


Fig. 8—Tabulator.

The Tabulator can be set to sense cards on a particular column or combination of columns and reproduce information in the form of figures or letters, printed in the required positions on the trunk statement. The machine contains a number of type heads, each equipped with all the characters for either numerical or alphabetical printing according to the requirements of the printed form. Each type head can be raised independently, so that a particular type character required is positioned in front of a type hammer. The type characters, which are spring loaded, slide in guides in the type head, and operation of the type hammer, forces the required type character into contact with a typewriter ribbon, which marks the paper with the character, numeral or symbol intended. The level to which each type head selected for use is raised, is made dependent upon the position of perforation in each particular column of the card which is sensed. The mechanical link between the sense rods which detect the position of perforation in each column, and the type heads, is via a "connection box." Such connection boxes, which are easily removed and replaced, can be constructed to allow any card column (or group of columns) to effect control of any type head.

Thus groups of cards relating to trunk calls made by subscribers, each group preceded by a guide card, are inserted in the feed magazine. The first guide card feeds on to the sense plate and details of the calling exchange and number together with type of line are extracted and the relevant information is printed at the top of the trunk statement. The guide card is followed by the trunk cards and from each of these the date (month and day), called exchange name, type of call and charge are extracted and printed on the statement, a line being allocated to each call. The tabulator also incorporates a mechanical accumulator, which totals the charges of individual calls, and prints this total on the trunk statement. A typical trunk statement prepared on the tabulator is shown in Fig. **9**.

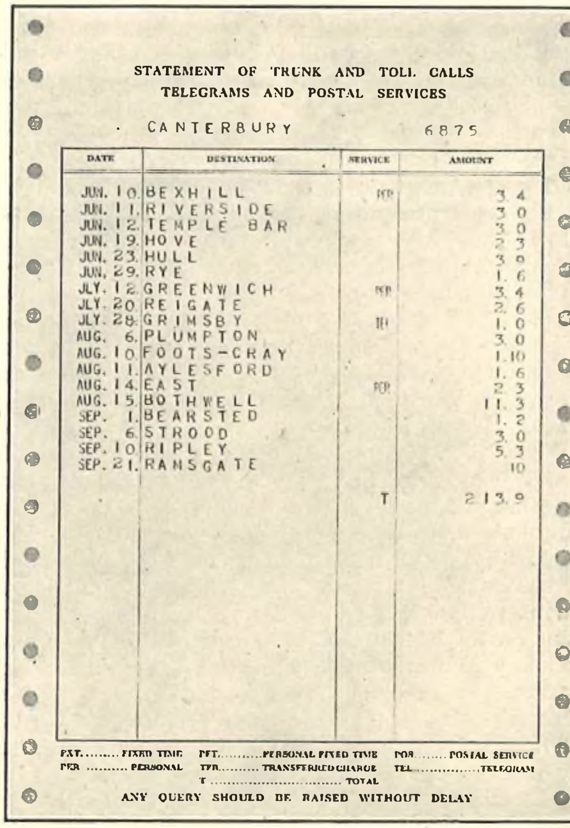
The tabulator produces trunk statements at the rate of 100 card entries per minute, i.e. a trunk statement on which details of 100 separate trunk calls have to be printed, is completed in one minute The statement shown in Fig. **9** was prepared in 12 seconds.

*Conclusions.*

The trial installation at Canterbury consists of 12 Automatic Key Punches, 1 Automatic Verifier, 1 Sensing/Punching machine and associated Trunk Charge Calculator, 4 Sorters and 2 Tabulators. The installation deals with approximately 16,000 trunk cards each day.

Experience in telephone manager's offices is that many queries are raised by subscribers who have forgotten a trunk call by the time that the account is presented. The effect of the new trunk statement in this connection is problematical, but it is hoped that the addition of the called exchange name will assist in reducing subsequent queries by subscribers.

With trunk calls recorded in the form of punched cards these can be used after preparation of trunk statements as a source of statistical data. It is only necessary to pass the cards through the sorter, set to segregate cards on, say, charge letter, or even called



STATEMENT OF TRUNK AND TOLL CALLS
TELEGRAMS AND POSTAL SERVICES

CANTERBURY 6875

| DATE | DESTINATION | SERVICE | AMOUNT |
|---|---|---|---|
| JUN. 10. | BEXHILL | PER | 3. 4 |
| JUN. 11. | RIVERSIDE | | 3. 0 |
| JUN. 12. | TEMPLE BAR | | 3. 0 |
| JUN. 19. | HOVE | | 2. 3 |
| JUN. 23. | HULL | | 3. 0 |
| JUN. 29. | RYE | | 1. 6 |
| JLY. 12. | GREENWICH | PER | 3. 4 |
| JLY. 20. | REIGATE | | 2. 6 |
| JLY. 28. | GRIMSBY | TFR | 1. 0 |
| AUG. 6. | PLUMPTON | | 3. 0 |
| AUG. 10. | FOOTS-CRAY | | 1. 10 |
| AUG. 11. | AYLESFORD | | 1. 6 |
| AUG. 14. | EAST | PER | 2. 3 |
| AUG. 15. | BOTHWELL | | 11. 3 |
| SEP. 1. | BEARSTED | | 1. 2 |
| SEP. 6. | STROOD | | 3. 0 |
| SEP. 10. | RIPLEY | | 5. 3 |
| SEP. 21. | RAMSGATE | | 10 |
| | | T | 2 13. 9 |

FXT.........FIXED TIME PFT..........PERSONAL FIXED TIME POS.......POSTAL SERVICE
PER..........PERSONAL TFR.........TRANSFERRED CHARGE TEL...............TELEGRAM
T.............................TOTAL
ANY QUERY SHOULD BE RAISED WITHOUT DELAY

FIG. 9.—TRUNK STATEMENT.

exchange name, to derive information as to the loading of routes. Other facts such as the average of call duration, day loads, etc., which influence circuit provision, are available as a by-product of the accounting process.

The Engineering Department's main interest in the field trial is with the performance of the Trunk Charge Calculator, in respect of the accuracy of calculations performed and the ability of telephone type equipment to withstand the large number of operations daily. Regarding accuracy, at the time of preparation of this article the Calculator has priced over two million trunk calls involving a total revenue of some £250,000. A 1 per cent. check of the completed cards has failed to disclose any error on the part of the calculator.

Despite the large number of operations performed by the calculator, at present amounting to some 16,000 wiper operations daily by certain of the motor uniselectors, the faults to date have been few.

Maintenance of the calculator equipment is carried out by area staff, and the Powers equipment is serviced by a resident Powers' engineer.

*Acknowledgments.*

The authors would take this opportunity to thank the various members of the Engineer-in-Chief's Circuit Laboratory, who have shared in the development work involved in the production of the Trunk Charge Calculator, besides constructing and testing the equipment. Acknowledgments are due also to Powers Samas Accounting Machines, Ltd., who were always willing to undertake modifications of the sensing/punching machine in order to meet changed requirements, and to colleagues in the Personnel Department (O & M Branch) and the Inland Telecommunications Department who, besides sponsoring the development and subsequent field trial, gave considerable assistance in explaining little-known aspects of trunk call charging and procedure adopted in telephone manager's offices.

## Book Review

"Vacuum Tube Amplifiers." Edited by George E. Valley, Jr., and Henry Wallman, Massachusetts Institute of Technology, Radiation Laboratory Series, Vol. 18. McGraw-Hill Publishing Co., Ltd. 743 pp. 391 ill. 60s.

This book, the 18th of the Massachusetts Institute of Technology Radiation Laboratory Series, is largely the result of work done in America during the war on amplifiers required primarily for radar uses. The first chapter, on linear-circuit analysis and transient response, forms a theoretical introduction to the design of amplifiers for the reproduction of transient signals. This is followed by a chapter on high-fidelity pulse amplifiers and one on amplifiers dealing with pulses of differing amplitudes. Chapters 4-8 deal with the different aspects of wide bandpass amplifiers for pulse-modulated carrier frequencies up to frequencies of 200 Mc/s with bandwidth of 20 Mc/s and 100 db. gain, including the practical aspect of freedom from instability. A chapter on low frequency amplifiers with stabilised gain for computer devices follows in which variations in gain should be less than $\pm 0{\cdot}1$ per cent., whilst the next chapter deals with low frequency selective feedback amplifiers operating as electronic bandpass filters. These are much lighter in weight than LC filters for frequencies of the order of 30 c/s. Direct-coupled amplifiers are next considered and many ingenious devices are described for stabilising them against supply voltage variations. Since radar receive amplifiers are required to operate to the utmost limit of sensitivity the limit of amplification set by thermal and shot noise is dealt with very thoroughly, together with practical methods of obtaining minimum noise circuits and the measurement of the noise figure of an amplifier.

Each chapter is written by an acknowledged expert on the subject and is first treated theoretically and then detailed practical designs are given which include many useful constructional ideas.

It is perhaps unfortunate to communication engineers that the book has been written around radar experience only and does not include some mention of multi-channel pulse modulated amplifiers, particularly from the aspects of crosstalk and harmonic distortion, and does not cover to any appreciable extent wide band amplifiers with a large maximum to minimum frequency ratio and freedom from harmonic distortion.

It will, however, prove of considerable value to all electronic engineers who are interested in amplifier design of any type. L. E. R.

# The New Post Office Standard Uniselector

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U.D.C. 621.395.658

**A new uniselector has been designed and developed for the British Post Office and tests on the prototype show an improved performance over the present standard switch. The heavy-duty version of the new uniselector includes features such as a more efficient magnetic circuit, redesigned wiper assembly and brush feed, and improved drive mechanism. A light-duty switch of similar design, but omitting certain refinements, will be available for use in subscribers' calling equipments.**

*Introduction.*

SINCE the introduction of the Post Office standard uniselector over 15 years ago, only this one type of uniselector has been supplied in any quantity for United Kingdom exchanges.

At present there is only one model of standard uniselector mechanism in two frame sizes (5 levels and under, and over 5 levels) and it has been used for all purposes although with two types of bank, light duty with brass contacts for use in subscribers' calling equipments and heavy duty with nickel silver contacts for all other purposes. Many thousands of standard switches have been installed in this country and abroad and it was decided a few years ago that the experience gained in their manufacture and operation, and in the operation of the preceding proprietary types, was sufficient to permit the production of a new range of standard switches.

It has been found, however, that to obtain the best performance from heavily worked switches it is necessary to incorporate refinements which could not be economically applied to the less frequently used switches. It was decided therefore that two models of switch should be designed, the first (to be known as Post Office Uniselector Type 2) for all purposes except subscribers' calling equipments, and made in two frame sizes (Figs. **1** and **2**) and the second (to be known as Post Office Uniselector Type 3) for subscribers' calling equipments only, made in one frame size for 4 or 5 levels. The original standard uniselector will in future be known as Post Office Uniselector Type 1.

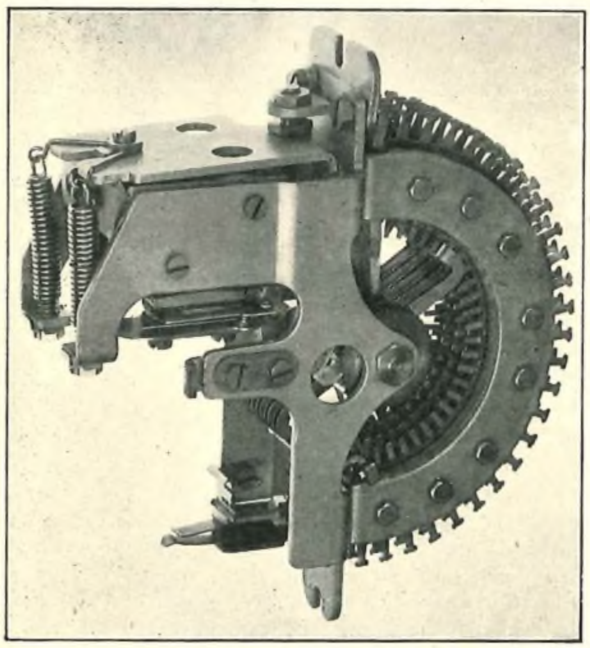


Fig. **1**.—P.O. Uniselector Type 2—5 Level.

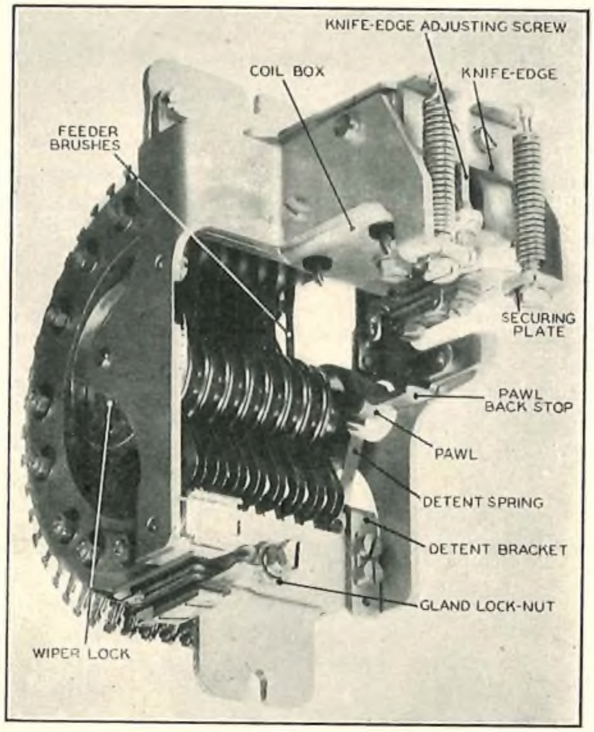



Fig. **2**.—P.O. Uniselector Type 2—8 Level.

The design of the new switches has now been completed and production has commenced, so they will come into service in increasing number in the future.

The new mechanism can be mounted in place of any existing standard mechanism, although owing to the small size of the Type 3 mechanism it will not be possible to mount a Type 1 mechanism in the place of a Type 3, but this, of course, will never be necessary.

## The Type 2 Uniselector

*Development.*

In developing the new heavy duty switch it was essential that it should be interchangeable with the existing item and in the new design this has to a great degree been achieved. The only exception is where switches are mounted on relay set bases where a slight alteration to the mounting brackets is necessary to prevent the switch touching the cover.

It was felt, however, that the requirement of strict interchangeability should not preclude a change to the brush feeds as the present trolley wheel and wire type has not proved entirely satisfactory. At first glance this seems to interfere with interchangeability but this is not so, as it has been decided that when a mechanism is changed a new brush feed will be fitted. The salient features of the switch, as described in the following paragraphs, have been designed to represent the best modern practice. Some points are entirely new, but many of the basic ideas have been derived from the Type 1 switch and its predecessors. The efficiency of the new design cannot be properly judged until large numbers are in service, but laboratory and field tests have given very good results; samples in the laboratory tests have performed over 10 million half-revolutions without major repairs.

*The Magnet and Armature.*

The most noticeable feature of the switch is undoubtedly the new design of magnet and armature. It had been found that the magnet of the Type 1 switch, particularly in the 5-level frame, gave insufficient margin of power with heavy wiper loads, making the adjustments rather critical, so the new switch was designed with a more powerful magnet system.

The coil is wound on a single, large diameter core fixed in a box-shaped yoke, the armature completing the magnetic circuit (Fig. **3**). The coil is large and

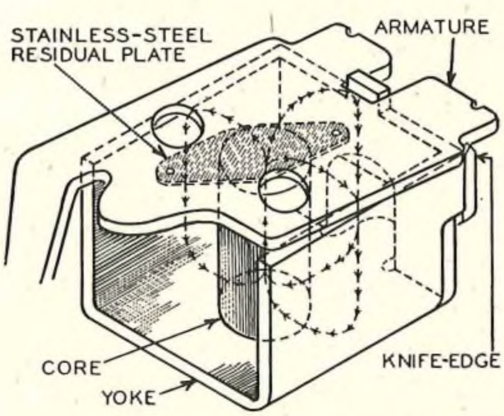



FIG. 3.—MAGNETIC CIRCUIT.

with the efficient magnetic circuit gives ample margins of power under all normal conditions of adjustment and voltage. The same magnet is used for both frame sizes in the interest of standardisation, as on account of the wide load variations with different types of wiper the design is necessarily a compromise.

The wire used in the coil is insulated with high temperature enamel, giving better protection from the development of short-circuited turns under fault conditions and consequently less risk of excessive overheating.

The knife edge armature suspension used successfully in the Type 1 switch has been retained, but there are three essential differences in the armature arrangements:

(*a*) The coil and the pawl are on the same side of the knife edge. This permits the use of a residual plate without any other armature front stop without risk of the armature leaving the knife edge at the end of its stroke. The first models of the Type 2 switch had nickel silver residual plates, but it was found that these fractured under the incessant hammering of the armature. The residual plates are now of "Staybrite" stainless steel, which incidentally is non-magnetic, and these appear unchanged after 250 million armature strokes.

(*b*) Instead of moving the coil assembly in relation to the armature for adjustment purposes, the armature is moved in relation to the coil by adjustment of the knife edge. The coil assembly being fixed makes possible a more efficient magnetic joint between the core and the yoke. This arrangement necessitates a new adjustment technique, as discussed later. For the moment it is sufficient to say that the knife edge is adjusted so that the armature, when operated, lies squarely on the core. This adjustment is not difficult to make as the face of the core is slightly convex (Fig. **4**) and by

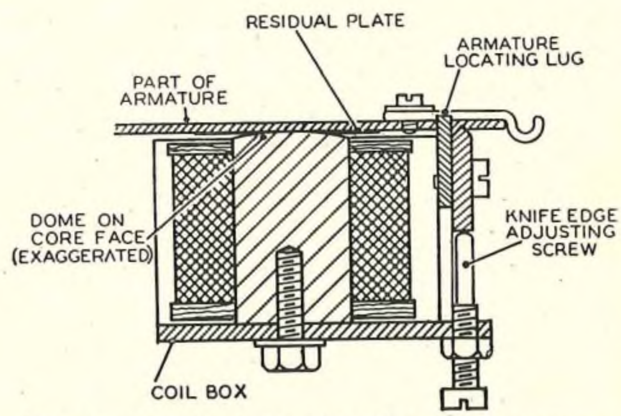



FIG. 4.—CROSS-SECTION OF COIL BOX AND ARMATURE.

holding the switch to the light it can be seen if the armature rests on the apex.

(*c*) The armature weight is very much less than in the Type 1 switch and this reduces wear considerably.

*The Ratchet, Pawl and Detent.*

The pawl is attached to the armature by a steel spring as in the Type 1, 5-level switch. The spring is much more substantial than in the Type 1 switch and, to reduce the stress across the rivet holes, double clamping plates are used at both ends. The clamping plates are slightly chamfered at the one end as shown in Fig. **5**, so that as the pawl moves the spring gradually flexes on the curved surface, taking the load smoothly and without concentrated stresses at any point.

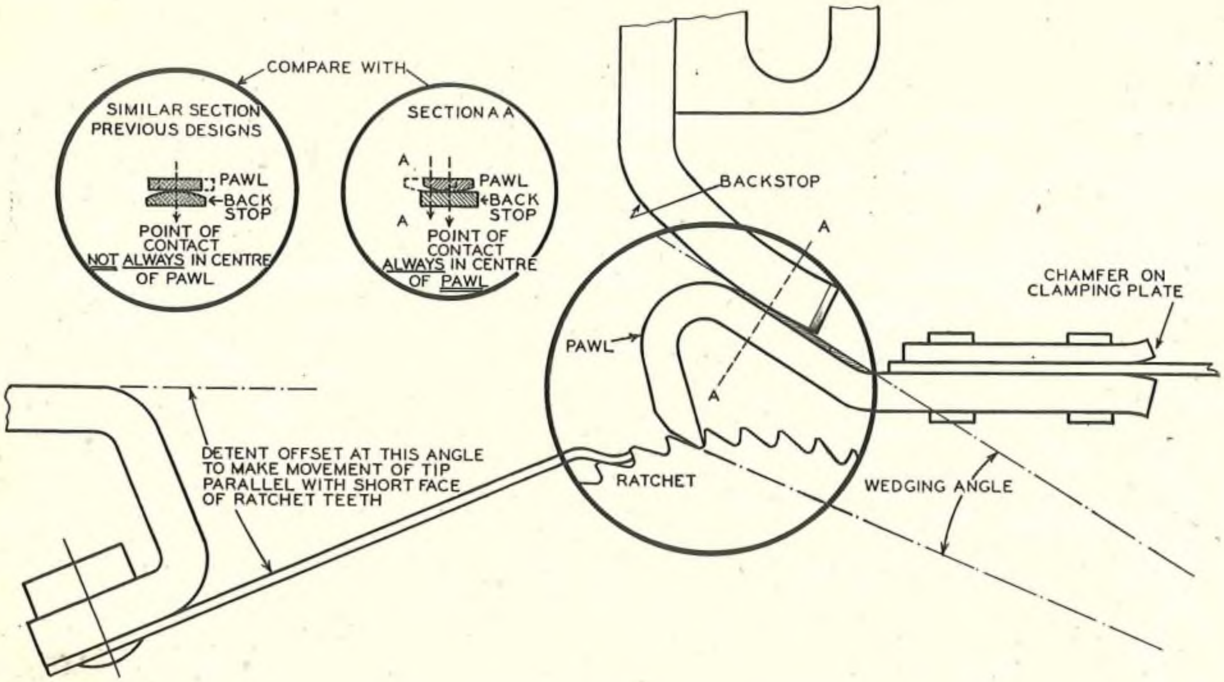



FIG. 5.—MAIN FEATURES OF DRIVING MECHANISM.

The design of the pawl and back stop has an important bearing on the life of the switch. When the armature rests on its back stop the pawl must be lightly wedged between the ratchet wheel and the pawl back stop or there will be backlash in the wipers, but at the same time the pawl must be free to move forward on the next stroke of the armature. By making the surface of the pawl, where it meets the pawl back stop, at a suitable angle to the long face of the ratchet tooth (indicated as " wedging angle " in Fig. **5**) there is no risk of the pawl jamming.

The pawl back stop is slightly curved (Fig. **5**) to ensure that even if it is slightly out of correct alignment it will always make contact near the correct point on the pawl; otherwise excessive stresses may be imposed on the pawl spring. The curvature of the back stop also simplifies adjustment as the first pawl stop fixing screw is very near the centre of the arc, with the result that any slight movement of the stop when tightening the fixing screws will not upset the adjustments. The pawl is slightly cambered across the width of its back (Fig. **5**), so even if it is not central relative to its back stop the thrust of the stop will always be central on the pawl.

As the pawl of the Type 2 switch lies on the front of the ratchet wheel in the position occupied by the detent of the Type 1 switch a different detent had to be used. In the early models of the Type 2 switch a straight flat detent was used. This had two main disadvantages (*a*) it rested on the tips of the ratchet teeth causing wear; and (*b*) the movement of its tip was not radial to the wheel. Thus, as the tips of the ratchet teeth became worn the detent dropped further in and as its movement was not radial it permitted increased back lash. This point is illustrated in Fig. 5. The detent now used is mounted so that it is tangential to the ratchet wheel making the movement of its tip parallel to the short face of the ratchet tooth and its tip is so formed that it rests on the long face of the ratchet tooth reducing wear to a minimum.

*The Wiper Assembly and Feeder Brushes.*

As mentioned earlier, the trolley wheel and wire type of feeder brush arrangement used in the Type 1 switch has not proved entirely satisfactory as wear is rather rapid in some circumstances, and with wear there is a tendency for the brushes to jam in the collector rings. Flat outward-bearing brushes running in parallel sided collector rings are used in the new switch, and as wear causes only a gradual shortening of the brushes and a very slight scoring of the collector rings they remain reliable throughout their useful life. In addition, to give the best possible performance, it has been decided that the wiper assembly and the feeder brushes shall always be changed together. Both the collector rings and the feeder brushes are of nickel silver.

To hold the brush blades together while the mechanism is inserted in the bank a moulded comb tool is provided which clips on to the brushes. (Comb No. 1 for " 5 level and under " switches: No. 2 for 6-8 level: No. 3 for 10 level.)

In the Type 1 switch the wiper position on the bank contact, apart from the necessity for centering the mechanism in the bank, is dependent on the adjustment of the pawl and detent, so that practically the whole of the adjustments have to be made with the mechanism in position. In the Type 2 switch the position of the wiper on the contact is independent of the pawl adjustment and the only adjustments to be made with the mechanism in position are for wiper, feeder brush and armature restoring spring tensions, and wiper alignment and position on the contact.

The parts of the wiper and ratchet wheel assembly are shown in Fig. 6. The wiper assembly consists of the number wheel, collector rings, wipers and insulators clamped together on a stainless steel sleeve. This assembly fits freely on the ratchet hub and is locked to the hub in the correct position relative to the ratchet wheel by the clamping ring shown. This clamp fits on the split extension of the stainless steel sleeve (to be seen in the centre of the number wheel in the illustration) and is kept in place by a small retaining screw. By tightening the locking screw the split end of the wiper assembly sleeve is clamped to the ratchet wheel hub. The wipers have been provided with an additional flare at the tips to permit movement in either direction across the bank contacts during adjustment. The combined wiper and ratchet wheel assembly is free to rotate on a central steel spindle which is screwed into the uniselector frame.

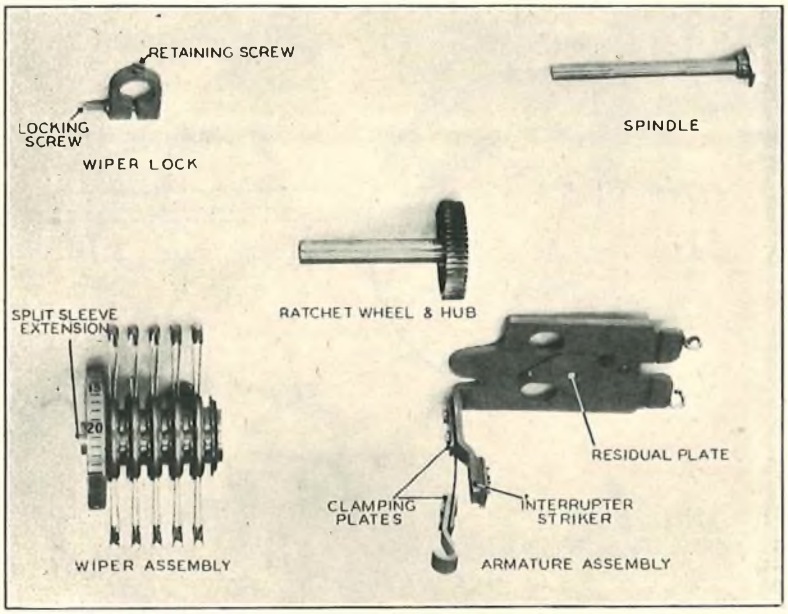



Fig. 6.—Parts of Uniselector Type 2.

*The Interrupter.*

The Type 1 switch has platinum interrupter contacts, and although these give almost complete immunity from faults due to dirty contacts they wear rather rapidly, necessitating frequent re-adjustment. To give long life the Type 2 switch uses tungsten interrupter contacts. Tungsten is a metal of great toughness and extremely high melting point (3,500° C), but it has the disadvantage that under normal atmospheric conditions it develops an oxide coating of high electrical resistance. It is possible by correct design to ensure that this coating is broken down, either mechanically or electrically, and laboratory and field trials of the new switch have given good results. The main factors in design are the contact pressure, the relative movement of the contacts after making, and the spark quench arrangements.

The design of the interrupter can be seen in Fig. 7. The upper, or buffer, spring can move between the two stops, a movement of ·012 in. to ·018 in., and is tensioned against the lower stop with a pressure of 40-60 grams. The lever spring is tensioned against the buffer spring with a tension of 150-250 grams when the buffer spring has been forced back against the upper stop. Thus as the contacts make there is a slight rubbing action between the contacts with a pressure of 40-60 grams while the buffer spring moves between the two stops, followed by a steady pressure of 150-250 grams.

Considering both reliability and long life the best spark quench for tungsten contacts is a capacitor of 1 microfarad in series with a resistor of 10 ohms, or even a capacitor alone. In most of the applications of the Type 2 uniselector it is necessary for the switch both to self-drive on the interrupter and to impulse from a relay contact so the quench used must be suitable for both tungsten and platinum contacts. However, on account of the low contact resistance of platinum there is an excessive discharge current from the capacitor when platinum contacts make across a 1 $\mu$F + 10 ohms quench, causing pitting and welding of the contacts. It was decided, therefore, that the present uniselector quench of 1$\mu$F + 200 ohms must be retained, and it has been found that the mechanical design of the interrupter does in fact give efficient contacting even with this quench.

The interrupter striker (Fig. 6) is a plate of bakelised fabric riveted to the striker arm. The interrupter is mounted on a rocker plate (Fig. 7) so that by manipulating the two hexagon-headed screws seen in Fig. 1 the interrupter can be brought into the position for the best contact opening without upsetting the spring tension adjustment.

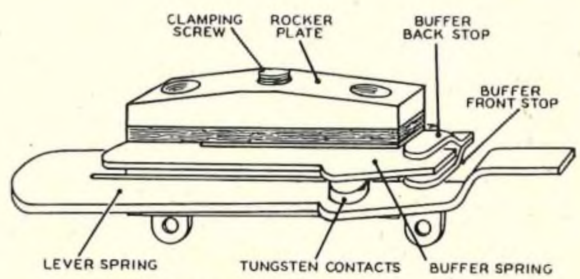



Fig. 7.—Interrupter of Uniselector Type 2.

*Other Details.*

During the development and testing of the switch a number of minor alterations were made to give better performance or easier maintenance and some of these are of general interest.

A locknut has been provided on the mechanism positioning gland (Fig. 2) so that the mechanism can be removed and replaced without re-adjusting the gland.

Securing plates have been fitted to the adjusting screws of the armature restoring springs (Fig. **2**). These prevent movement of the screws due to vibration and yet do not interfere with adjustment.

A large circular hole has been provided in the side of the frame (Fig. **1**) to make the pawl and detent clearly visible when the mechanism is being adjusted out of the bank.

The side members of the frame have been cut away to facilitate the observation of the wipers of adjacent switches when mounted in the rack.

The frame is cut away slightly round the test jack to facilitate withdrawal of the mechanism (Fig. **2**).

*Adjustment.*

To get the best performance from the switch and to make the best use of the various adjustment facilities provided, it is necessary to use a new adjustment technique. The following is a brief outline of the adjustment differences between the Type 1 and the Type 2 switches.

In the Type 1 switch as the wipers are integral with the ratchet wheel the first stage of adjustment is to position the wipers on the bank contacts by centering the mechanism and adjusting the detent. The armature is then positioned to suit the ratchet wheel and the coils to suit the armature.

In the Type 2 switch the position of the wipers is independent of the ratchet wheel so the mechanism can be adjusted out of the bank. The coil is fixed and this used as the reference point for the adjustment of the mechanism. The armature is adjusted to lie square on the core as described earlier, the pawl back stop, armature back stop and detent being adjusted to suit. The mechanism is then inserted in the bank for final adjustment of the wipers, feeder brushes, armature restoring springs and interrupter.

*Stepping Speed.*

As the Type 2 uniselector is required to be interchangeable with the Type 1 it is essential that its stepping speeds, both on self-interruption and on impulse drive, shall be very nearly the same. Full details will not be available until production models from the various manufacturers have been tested, but tests on the prototypes indicate that there is no appreciable difference between the two types ; not only has the new switch substantially the same maximum operate and release times in extremes of adjustment, but the minimum operate and release times are also the same. The minimum times are important because if operation is too quick in light adjustment or if release is too quick in heavy adjustment transient circuit conditions may cause switches to make false additional steps.

## The Type 3 Switch

The Type 3 switch for subscribers' calling equipments is very similar in appearance to the Type 2 and it incorporates many features of the latter, but it is simpler and lighter in construction and a number of the refinements essential in the general purpose switch have been omitted.

The Type 3 switch will be made in one frame size, with 4 or 5 levels, and for 50-volt working only.

*Reduction of Width.*

By employing an alternative form of wiper assembly adjustment, reducing the width of the ratchet wheel, and by avoiding projecting screw heads, it has been possible to reduce the overall width of the Type 3 switch to under $1\frac{3}{4}$ in. This allows 25 switches to be mounted on one shelf in standard 4 ft. 6 in. racks and new racks are being designed which will carry up to 50 per cent. more calling equipments than the present standard. At the same time the new switch can fit in the place of the old, so that when the Type 1 switch is no longer available Type 3 switches can be used as maintenance replacements on existing subscribers' calling equipment racks.

*The Mechanism.*

In general, the mechanism is similar to that of the Type 2 switch the adjustment facilities and technique being the same. As the mechanism will be required to drive only five wipers the coil and armature are smaller, and the coil resistance is 100 ohms as against 75 ohms for 50-volt working in the Type 1 and Type 2 switches.

The interrupter is similar to that fitted on the Type 1 switch, but the bakelised fabric interrupter striker plate is riveted to the striker arm as in the Type 2 switch. The contacts are of platinum.

A simplified arrangement is used to transmit the drive from the ratchet wheel to the wiper assembly. A flat arm is riveted to the ratchet wheel hub at the end remote from the ratchet wheel. A short screw riveted to the outer end of the arm passes through a slot in the number wheel and is secured by a nut. Loosening of the nut permits a relative movement of about $1\frac{1}{2}$ contacts between the ratchet wheel and the wipers. As the arm is riveted on after the ratchet wheel hub has been inserted in the wiper assembly the ratchet wheel hub cannot be separated from the wiper assembly and the whole must be changed when renewal is required.

The wipers, bank contacts and feeder brushes are of nickel silver as in the Type 2 switch, but brass collector rings are used. There is little difference in cost between nickel silver and brass for stamped-out parts, but where turning operations are required brass is easier to machine and is consequently appreciably cheaper.

*Acknowledgments.*

It is desired to record appreciation of the assistance rendered by the staff of the General Electric Co. in preparing this article and providing illustrations and to acknowledge the helpful suggestions and criticisms given by colleagues of the Telephone Branch of the Engineer-in-Chief's Office.

# A New Utility Vehicle

G. H. SLATER

U.D.C. 629.113

**A 2-ton general utility vehicle of an experimental type has been designed by the Post Office and is now on trial in the field. The advantages over earlier types include higher pay-load ; low loading ; more floor and locker space ; adequate pole- and ladder-carrying capacity and an improved standard of comfort for workmen.**

*Introduction.*

TO introduce the subject, perhaps a reference to some of the utility vehicles of the past will best serve to provide a suitable background against which to display what it is hoped will be the advantages of the future version of this type of vehicle.

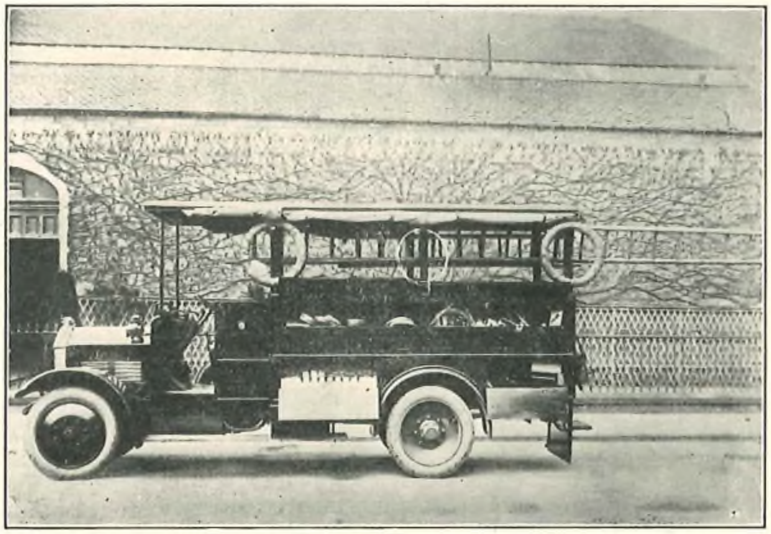


Fig. 1.—Utility Vehicle in 1925.

One of the earliest, if not the earliest, " Utility " is shown in Fig. 1. Here some of the disadvantages of these vehicles of the earlier days of motor transport in the Engineering Department are clearly presented ; the open cab, the open body, the unbalanced suspension of the ladders to avoid obstructing entry to the cab, and the lack of pole-carrying facilities.

At the time this vehicle was introduced (about 1925), it was no doubt the acme of design, and although compared with present-day standards it presents a somewhat severe and angular appearance, it was indeed a great step forward from the alternative of trundling a heavy handcart in the execution of works necessary to the provision and maintenance of an efficient telephone service.

In 1927, the vehicle shown in Fig. 2 was brought into service, the design of which incorporated a closed body with glazed panels, improved ladder-carrying facilities, pole-carrying facilities, wiring drums and an improved locker space.

The Utility as we know it to-day remains little changed from the vehicle shown in Fig. 2, except for minor modifications such as sliding glazed panels, improved locker doors and an attempt, in the form of hooks, clips and a detailed stowing list, to provide a place for everything necessary. These vehicles are of the 30-cwt. class and are officially described as 30-cwt. Utility vehicles. They are most extensively used by gangs employed on Advice Notes and Minor Works and are the standard vehicles for four-man gangs.

Contemporary with the 30-cwt. Utility is the 30-cwt. Stores-carrying vehicle, which is sometimes used as a Utility because of its superior pole-carrying capacity and its suitability for underground cabling works ; during the war years it was used because the standard utility vehicles were not available. The stores-carrying vehicle, as its name implies, is primarily a vehicle for carrying general stores, and when it is used as a Utility, it is usually necessary to provide removable tool-lockers. Recently, in an attempt to alleviate the discomfort occasioned to workmen riding in the body of the vehicle, a draught screen has been provided for fitting under the tilt of the vehicle.

*Necessity for a New Utility Vehicle.*

The present time, therefore, some 23 years after the introduction of the first Utility, finds in regular

Fig. 2.—Utility Vehicle in 1927.

service two standard vehicles, one a utility vehicle which does not meet entirely the present-day requirements, and the other a stores-carrying vehicle which is, at best, a makeshift affair when used as a Utility. This also was the position in 1938, but the intervening war years precluded any investigation of the possibilities of improvements so clearly necessary to keep abreast of the changing conditions and practices. Further, during the immediate post-war years, with all the attendant production difficulties of that period, it was necessary to accept almost any vehicles which could be obtained quickly, to meet the intensive campaign against the arrears of telephone installation works. Thus, the investigation was further delayed until the immediate post-war demand was met and the production position became more stable.

Eventually, an exhaustive investigation was made towards the end of 1946, and it was found that the 30-cwt. Utility vehicle was being used for many purposes for which it was not designed; overloading was occurring more frequently than was desirable, and in many cases 50 per cent. of the locker space was not used even when the vehicle was employed on Advice Note works—for which it was originally intended. In practically all cases, on whatever duty the vehicle was employed, the floor space was found to be occupied by items which could not be stored in the lockers, such as earth plates, stayblocks, bricks, sand, earth from excavations, joint box frames, crowbars, sledge hammers, coils of rope, fire pots, jointers tents, drums of cable, and motor pumps. One vehicle was carrying ten men and hauling a motor winch.

Gangs provided with 30-cwt. Utilities had little criticism to offer when employed on overhead Advice Note work, and gangs provided with 30-cwt. stores-carrying vehicles used as Utilities on similar duties, were generally envious of gangs with 30-cwt. Utilities and complained that the removable lockers were unsuitable, that they occupied too much floor space and afforded inadequate accommodation for tools and stores, and that appreciable discomfort was occasioned to members of the gang when riding in the body of the vehicle.

Gangs employed on underground works, although not enthusiastic about the stores-carrying vehicle used as a Utility, preferred it to the 30-cwt. Utility, with the general complaint that the floor height of the vehicle was too great.

Supervising officers generally agreed that the 30-cwt. Utility lacked floor space in the body of the vehicle, and was of limited use and, therefore, unsuitable for the mixed duties gangs are required to perform.

*Design of New Vehicle.*

On analysing the information gleaned from the investigation, it became clear that to meet the requirements of the mixed duties—anything from joint box building and underground cabling works to Advice Notes—a vehicle was required which combined as far as possible all the advantages of the 30-cwt. Utility without introducing any of the disadvantages; in the main, a vehicle which provided ample floor space and payload, adequate pole- and ladder-carrying facilities, adequate comfort for the gang, a low floor height and sufficient locker space.

Proposals for a new utility vehicle were therefore formulated and the specification provided *inter alia* for a minimum payload of 2 tons, cab accommodation for five persons including the driver, lowest possible floor height even if wheel arches within the body could not be avoided, and, inside the vehicle, open locker space confined to the offside and front end of the body.

An experimental vehicle was decided upon, and its construction was undertaken by the Post Office in the workshops at Yeading, where, under the direction of Motor Transport Branch officers, every detail of the specification was incorporated in the design of the new vehicle described in the following paragraphs and illustrated in Fig. 3.

A 3-ton Karrier Low Loader chassis with small diameter twin rear wheels has been used to provide for a payload of 2 tons, and to give a floor height of approximately 3 ft. A step placed to the offside of the tailboard and a conveniently placed grab handle (see Fig. 4) should prove of considerable advantage to the users and reduce to a minimum the exertions necessary to get in and out of the vehicle; quite an appreciable saving of effort when one considers the number of times a workman may get up into and down from the vehicle during a normal day's work.

The cab of the vehicle as shown in Fig. 5 next calls for comment. Built as an entirely separate unit from the body, this spacious compartment will accommodate in comfort five persons including the driver. A locker beneath one of the seats provides accommodation for the foreman's books and papers, and a

FIG. 3.—THE NEW EXPERIMENTAL VEHICLE.

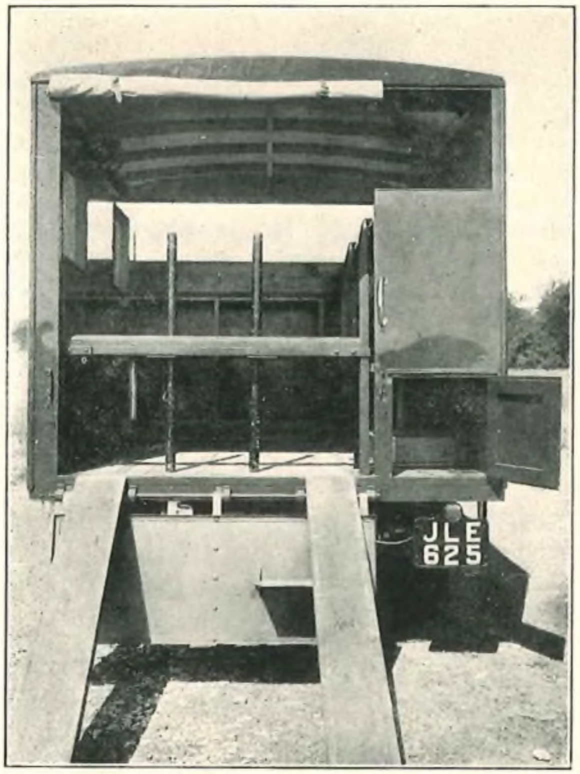



Fig. 4.—Rear View.

folding table, together with a conveniently placed light for use when occasion demands, completes the furnishing and provides adequate office facilities for completing the records a foreman is called upon to make. Mention must be made of the exceptionally clear view afforded by the forward setting of the cab, the adjustable driving seat, and the wide forward-hung doors. The introduction of this cab as standard should, in the author's opinion, remove once and for all those complaints, many of which were quite justified, of the discomfort of riding in the Department's Utility vehicles. Further, the degree of comfort provided for the gang while travelling to and from a work will no doubt be reflected in an enhanced efficiency when on the job, and will repay for the careful consideration expended in devising the cab accommodation.

So far the emphasis has been on the comfort of the workmen, and the impression may have been gained that this was the sole purpose in mind. Important as this may be, however, it is not the only factor to receive attention, and the remainder of the description will show that a balance has been struck in providing a vehicle which will result in an improved overall efficiency in the field.

Mention was made earlier of the limited pole-carrying facilities of the 30-cwt. Utility, and the high loading height of the 30-cwt. stores-carrying vehicles. In the new vehicle both these disadvantages have been overcome in that the bolster arrangement gives a low loading height and provides for the carrying of an adequate load of poles of maximum length 36 ft. and to a total load of 30 cwt. when necessary. The openings at the forward end of the body are fitted with doors which, when opened, lie flat on the top of the cab, and have been arranged in three sections so that only the section required need be opened. The opening of these doors is effected from inside the vehicle.

The ladder rack has been formed on top of the offside lockers inside the vehicle, and has the advantage that an easy lift to the rack is possible, thus avoiding the awkward and high lift to the hooks that occurs with the 30-cwt. Utility. Attached to the front edge of the rack, two straps, arranged to prevent them being left under the ladders as they are placed on the rack, provide a means of securing the ladders in position. The rack is free from loose parts likely to become lost.

The lockers, as previously mentioned, have been arranged along the offside and front end of the body, leaving a clear floor space of approximately 8 ft. 6 in. × 4 ft., when the seat along the nearside of the body is folded back. Anchor rings for securing loads when necessary have been fitted along each side of this clear floor space. The lockers take the form of open bins with a four-inch guard rail and loose partitions for dividing the bins to the requirements of the work whether it be Advice Notes, U.G. cabling or O.H. construction, and within reasonable limits allow for individual preferences in the arrangement of the locker space. The lower shelf of the offside lockers provides accommodation for the long tools such as digging bars and spoons, and a conveniently-placed door in the rear panel of the body gives access to this space. The deep forward lockers will provide ample space for storing coils of rope, wire and similar items.

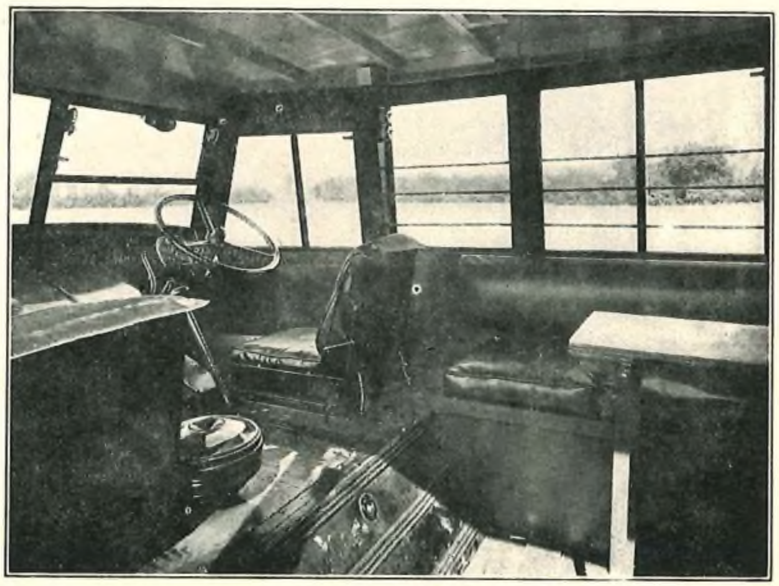


Fig. 5.—The Cab.

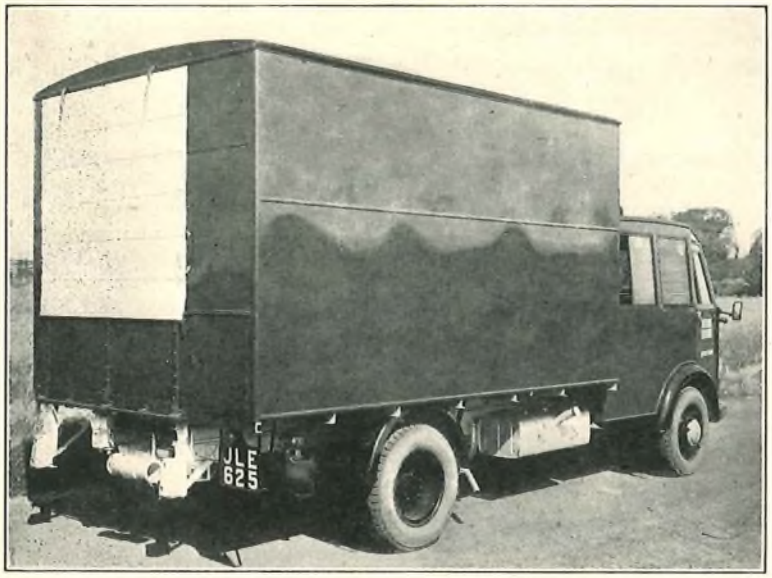


FIG. 6.—VEHICLE CLOSED AND LOCKED.

To facilitate the erection of open wires, arrangements have been made for three spindles to be provided as part of the vehicle equipment. These spindles have been designed to fit into sockets in the floor of the vehicle. Two of the spindles are suitable for carrying wiring drums for 40-lb. bronze and cadmium copper and one for the wiring drum of the drum wheelbarrow so that the heavier gauge conductors may be handled without the need for conveying the barrow. It is not proposed to provide drums as standard equipment of the vehicle because the utility of the vehicle permits of its use on many works where drums are unnecessary, and the requirement can be met by drums already in existence.

For cabling operations a bollard for attachment to the spring-loaded draw bar provides a means of attaching the rope for pulling in cables by means of the vehicle.

The body of the vehicle is made lockfast by means of a steel reinforced canvas sheet (Fig. 6) which covers the rear opening and which is secured in position by a steel bar and padlocks. A small door hinged at the top edge and secured in position with a spring bolt completes the lockfast arrangements at the rear end of the vehicle when ladders are not being carried. When ladders are in position, this door is secured to the underside of the roof, the ladders themselves providing sufficient obstruction to prevent unauthorised access to the interior of the vehicle.

Last, but not least, are the coat hooks for the gang's clothing, the light for illuminating the interior of the body and the provision made for storing the rear pole bolster and skid boards beneath the floor of the vehicle when these items are not in use—a considerable improvement over the old method of stowing them on the floor of the vehicle where they were invariably in the way and often inaccessible without moving part of the load.

*Conclusion.*

In conclusion, it should be mentioned again that this is an experimental vehicle which will be subjected to extensive field trials before its introduction as a standard vehicle is considered. In the meantime, therefore, the existing vehicles must remain the standard.

*Acknowledgment.*

It is desired to record acknowledgments to the officers of the Motor Transport Branch concerned in this development and particularly to Messrs. Wright and Doe for their work in transforming the requirements into a practical form.

## Book Review

" Transmitter Interference." The Incorporated Radio Society of Great Britain. 32 pp. 28 ill. 1s. 3d.

This booklet is one of a series published by the Radio Society of Great Britain and is intended for the radio transmitting enthusiast. Its function is to indicate how an amateur transmitter may cause interference to the reception of sound broadcasting and television transmissions, and to show in an essentially practical manner what steps may be taken to minimise such interference. Its publication is, therefore, extremely topical.

The booklet starts by stressing the need for the amateur to co-operate with and seek the good will of any neighbours to whom he may inadvertently cause interference. Interference to broadcast reception is then discussed in general terms, and mention is made of the principal causes. The succeeding chapters describe numerous suppression devices suitable for use at the transmitter and at the affected receiver ; the appropriate component values are given. The final chapter deals on similar lines with interference to television reception, and the booklet concludes with a useful table giving the values of intermediate frequency employed in many commercial television receivers. The only significant omission is a failure to mention the use of a Faraday screen between the two windings of a tuned R.F. transformer as a method of attenuating harmonics.

A practical publication which should be of use to all users of transmitting apparatus. G. A. C. R. B.

# The Conversion of Carrier Routes from 12- to 24-Circuit Working

F. W. G. DYE, A.M.I.E.E.

U.D.C. 621.395.44 : 621.315.21

**The circuit capacity of most of the 24-pair, 40 lb. P.C.Q. carrier cables in the United Kingdom is to be increased from 288 (12-circuit working) to 576 (24-circuit working). This article describes the methods employed for the conversion of the line plant and the new filter equipment provided at the terminal repeater stations.**

*Introduction.*

IN 1939, experiments were made to determine the suitability of existing 24 pr. 40 lb. P.C.Q. carrier cables for 24- and 36-circuit working. The results indicated that 24 circuits per pair should be possible, employing a frequency spectrum 12-108 kc/s, but that in a number of cases 36-circuit working was not practicable. It was decided to convert most of the existing routes to 24-circuit working but the outbreak of war delayed the commencement of this programme. The necessary planning and design was, however, proceeded with and in 1946 a successful field trial was made on the Liverpool-Manchester route. Specifications were then issued for the conversion of a number of existing routes, the first two, London-Derby and Derby-Manchester, being completed in September, 1948 ; 24-circuit working was in operation between London and Manchester by the end of the year. It is planned to convert most of the remaining routes within the next three years.

The work involved can be divided into two parts :—

(*a*) conversion of line equipment;

(*b*) provision of additional equipment at the terminal repeater stations.

It is proposed to deal with the subject under these two headings.

## Conversion of Line Equipment

The line amplifier used for 24-circuit working is the type adopted for the No. 7 carrier system. When this system was designed, 24-circuit working was envisaged and the amplifier was specified to have, among other characteristics, a gain/frequency response sensibly flat between 12 and 108 kc/s and a maximum gain of $65 \pm 1$ db.[1] The latter requirement, based mainly on the minimum permissible signal level that can be tolerated to ensure a safe signal/noise ratio, determines the maximum spacing allowable between adjacent repeater stations.

This same requirement applied to 12-circuit working (highest line frequency 60 kc/s) and was satisfied provided the distance between repeater stations did not exceed 22 miles. For 24-circuit working, however, the frequency range extends to 108 kc/s and due to the higher cable attenuation at this frequency a shorter repeater section must be adopted. The distances decided upon are 14·0 miles between a H.F.R.D.F. (high frequency repeater distribution frame) station and its adjacent intermediate, and 15·5 miles between all other intermediate stations ; the lower value allows a margin of amplifier gain in hand for maintenance adjustments at the H.F.R.D.F. station. It will be seen, therefore, that the conversion of an existing route involves the re-spacing, where necessary, of the intermediate repeater stations. The procedure adopted depends upon the existing spacing and will fall into one of the following categories :—

(*a*) provide new stations only, retaining all those existing ;

(*b*) provide new stations and cut out some existing ones ;

(*c*) provide new stations and cut out all those existing.

Some typical examples of the above are :

(i) London-Derby ; 4 new stations provided.

(ii) London-Oxford ; 3 new stations to be provided, one existing station to be retained and one cut out.

(iii) Birmingham-Oxford ; 3 new stations to be provided, both existing stations to be cut out.

Although quite a number of existing stations will be retained it will be necessary to change the equipment where this is of the No. 5 or No. 6 type. The line amplifiers in both these systems were designed to work only up to 60 kc/s and therefore have to be replaced by the more modern No. 7 type ; it will be necessary also to change the line equalisers from 12- to 24-circuit type. A converted route will, therefore, usually have completely new equipment throughout.

The conversion of a route presents some interesting problems in view of the fact that the cables and equipment are already in service. The operations (*a*), (*b*) or (*c*), together with the change from old to new equipment at existing stations, are planned to ensure minimum interference to the working 12-circuit groups. Of all the operations required, that of intercepting the main cables and extending them into a new station takes the longest and for this reason is performed at night during a week-end. The procedure adopted is as follows :—

*Interception of Main Cables at a New Station.*

When the cable terminating bays (C.T.B.s) have been installed in the new station, the 24-circuit test tablets thereon are connected to lengths of standard carrier cable, provided between the C.T.B.s and the interception manhole outside the building. In addition, a short length of E.S. and W.C. cable is provided temporarily on each C.T.B. and pair-to-pair connections are made between the Up and Down side test tablets on the equipment side of the line U-links. These " strap " connections are required to maintain continuity until the new amplifying equipment has been brought into use. Prior to the actual inter-

[1] *P.O.E.E.J.*, Vol. 34, p. 105.

ception of the main cables, tap-through tests are made (*a*) at the manhole, between the ends of the new lengths of carrier cable via the " strap " connections on the C.T.B.s and (*b*) between the existing stations on either side of the new one, to ascertain if any A and B or pair-to-pair crosses exist. If such are found, they are corrected before the interception is made. Upon completion of this work the interception can proceed on normal lines. The work is co-ordinated over a speaker-circuit set up on a spare pair between the manhole and the adjacent existing repeater station, at which a battery is applied to each pair in turn. As each pair is identified at the manhole it is cut and the two ends connected to the two new cables into the repeater station, continuity being maintained via the " strap " on the C.T.B. The circuit connections will now be as shown by the thick lines in Fig. **1**.

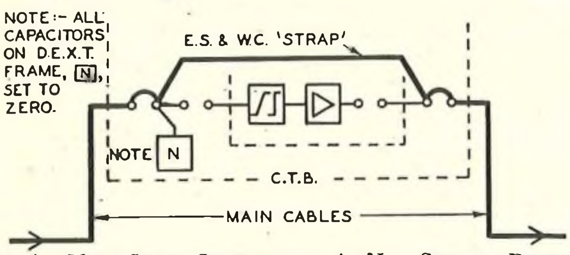



Fig. **1**.—Main Cable Connections At New Station Before Equipment Is Cut In.

*Connections of New Equipment Prior to Conversion.*

The equaliser and amplifier connections have been included in Fig. **1** and it will be seen that the input is disconnected at the second U-link sockets on the C.T.B. and the output at the amplifier U-link sockets, mounted on the amplifier panel. The introduction of the amplifier into circuit is then merely a matter of inserting the two U-links and removing the " strap." The cut-out of an existing station can be performed by a reversal of the operation just described, i.e., the " strap " is connected and the U-links withdrawn, the main cables then being put straight through in the manhole at the earliest opportunity.

*Change of Equipment at Existing Station.*

When completely new equipment is required at an existing station it is either installed in a new position and cabled to new C.T.B.s or the old equipment racks are recovered and the new, installed in their place, cabled to the existing C.T.B.s. The former procedure is adopted when the existing C.T.B.s are of an obsolete pattern and the circuit arrangements are then as in Fig. **2**.

" Strap " connections are provided between the old and new C.T.B.s and the main cables are opened up in the repeater room and connected to the new 24-circuit test tablets. The main cable connections to the old C.T.B.s are then removed and the cable plumbed up.

The introduction of the new equipment involves only the removal of the two straps and two U-links associated with the old equipment and the insertion of the two links proper to the new.

When the new equipment is to be installed in the positions occupied by the old, temporary bays of amplifiers are erected in the repeater room and cabled direct to the C.T.B.s, the equalisers and amplifiers on the temporary equipment being set to the same

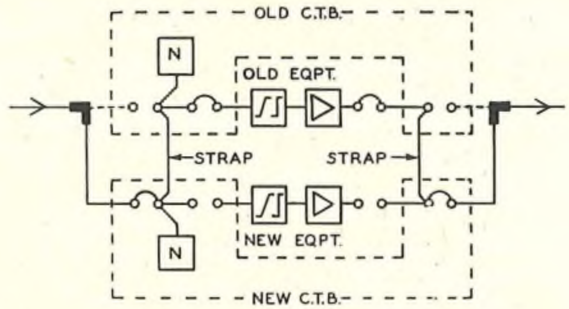



Fig. **2**.—Connections at Existing Station before New Equipment is Cut In.

values as those on the existing. The diversion of the circuits to the temporary equipment is then effected by the completion of the connections at the C.T.B. and the withdrawal of the C.T.B. and amplifier output U-links. The arrangement will then be as in Fig. **3**.

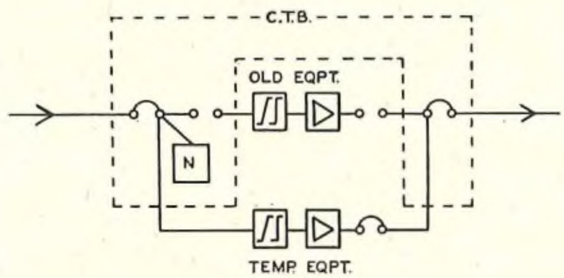



Fig. **3**.—Existing Equipment Replaced by Temporary Equipment.

The old equipment can now be recovered and the new installed in its place. The restoration of the circuits to work via the new equipment is then only a matter of restoring the U-links and removing the C.T.B. connections to the temporary equipment.

*Conversion Procedure.*

Where a new station is to be cut in between two existing ones that are to be retained, the operation can be performed as soon as the arrangements shown in Fig. **1** for the new station and Fig. **2** or **3** for the existing stations have been completed, the cut-in and change to new equipment being made simultaneously, pair by pair.

Where existing stations are to be cut out the operation must be made simultaneously with the cut-in of the adjacent new station(s). Where all existing stations are to be cut out and replaced by new ones, the necessary operations at all stations must be performed simultaneously together with the change to new equipment at the receiving terminal (H.F.R.D.F.) station. In some cases the route will consist of more than one H.F.R.D.F. section and the simultaneous operations can then, if more convenient, be confined to each of these sections, at different times.

Before any of the foregoing operations can be performed it is necessary to adjust the new equalisers and amplifiers to the required settings and for this purpose a spare pair is made available in both cables. The equipment proper to this pair is then connected and preliminary line-up measurements made. When the best settings have been decided, all the 24 equipments on the one cable at any one station are adjusted to the same value. When this preliminary work has been completed at all stations the actual conversion can take place and the procedure for a typical conversion is illustrated in Fig. **4**. Each cable is dealt with in turn, Fig. **4** showing the Go cable from A to E.

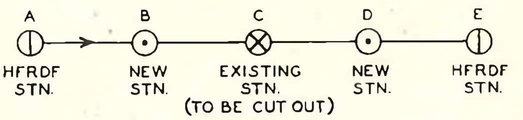



FIG. **4**.—CONVERSION OF ROUTE FROM 2 TO 3 REPEATER SECTIONS.

A loudspeaking telephone (referred to later) capable of transmitting as well as receiving is provided at all five stations, connected to a phantom or double-phantom circuit throughout the route. All stations are therefore in communication with each other on this speaker circuit, the operations being controlled preferably from the centre one.

The first pair to be dealt with is the spare, previously referred to. Its equipment is connected at stations B and D, cut out at C and changed at E, by the means already detailed. Frequency measurements are now made to check for equalisation and gain. A variable-frequency oscillator is connected to the pair at the outgoing C.T.B. of station A, " through " levels are measured at the outgoing C.T.B. at stations B and D and a terminated level at the Receive amplifier output at station E. As the readings are taken, at each station in turn, they are called over the speaker circuit and recorded at the controlling station. The spare pair having been proved satisfactory it is now used to make good the working carrier group from each of the other cable pairs in turn, by means of patch-cords, on the C.T.B. at station A and the amplifier output U-links at station E. Assuming pair 1 is the spare, the first working pair, No. 2 say, can now be dealt with. The controlling station requests " patch 2 " and stations A and E then perform this operation simultaneously. Station A now connects 40 kc/s tone to pair 2 at the C.T.B. and station E measures a terminated level at the output sockets of the *old* equipment, recording the result and also reporting back to the controlling station. Control now request all stations to " convert," and each one then performs the necessary operations. Stations B and D measure a " through " output level and station E a terminated level on the new equipment (the 40 kc/s tone from station A still being applied), the presence of these readings indicating completion of the conversion of pair 2. The values obtained are reported back to " control " who records them. Station E now adjusts the new Receive amplifier gain potentiometer to provide the same output that was measured on the old equipment. This will ensure that the group overall, when pair 2 is restored to traffic, will be the same as it was prior to conversion. Control now requests " restore 2, patch 3 " ; stations A and E then restore pair 2 to traffic and patch the working group from pair 3 to the spare pair. Pair 3 can then be converted and the foregoing operations repeated for all 24 pairs. The Return cable is then dealt with, the same procedure being adopted except that the operations detailed for stations A and E are interchanged.

It may, perhaps, be thought that the foregoing is a somewhat lengthy operation and in some respects elaborate. In actual fact the reverse is the case. A route of the type described can be converted, both Go and Return, in two hours, the only interruption to working groups occurring during patching to and from the spare pair. These interruptions are of such short duration that no serious trouble is caused to speech channels. They may, however, affect voice frequency telegraph circuits and for this reason any such circuits are switched to their " reserve " during the conversion period.

The need to complete as quickly as possible the conversion of all 24 pairs in the one cable is important, as a degradation of cross-talk can occur during the whole period. This is due to the difference in level between pairs that have been converted and those still remaining to be dealt with. At station B the outgoing power on the converted pairs will be at the standard channel test-level of +5 db., whereas the level on unconverted pairs, at the same point in the cable, could be in the worst case approximately −35 db. (assuming 15 miles between station A and B and a cable attenuation of 2·7 db./mile at 60 kc/s). Similar conditions will exist at stations C and D and it was thought, in the early planning stages, that such conditions could be so serious as to necessitate the complete shut-down of a route during the conversion period. In practice, however, it has been found to date that, whilst an increase in cross-talk does occur, it is not sufficient to cause circuits to be reported out of order.

*Loudspeaking Telephone.*

The biggest factor contributing to speed of operation during the conversion is undoubtedly the use of the loudspeaking telephone previously referred to. This instrument consists of a two-stage mains-driven valve amplifier and associated moving coil loudspeaker. A two-way key is provided which, in its normal position, connects the input of the unit to line and the output of the last stage to the loudspeaker. In the operated (non-locking) position, the key interchanges the connections of the line and loudspeaker which now becomes a moving coil microphone working via the two-stage amplifier to line. It has been found possible to operate six of these instruments, connected to a double-phantom circuit, over a distance of approximately 50 miles. On the London-Derby route, a total of eleven were used, and although direct communication between the two terminal stations was not possible, both could speak to the central station who was thus able to relay messages in either direction.

*Cable Rebalancing.*

A further factor contributing to cross-talk degradation arises during a route conversion in that the cut-in of a new station (or cut-out of an existing one) will destroy the distant-end cross-talk (D.E.X.T.) balancing conditions that existed on the cable over the original repeater sections. This unbalanced condition will, of course, persist until the cables have been rebalanced over each of the new repeater section lengths and the condensers on the new D.E.X.T. frames adjusted. This rebalancing is carried out as soon as possible after the completion of the route conversion and can be effected with the working groups in traffic, using test frequencies outside the carrier frequency range.

*Phantom and Double-Phantom Circuits.*

The patching of cable pairs one at a time at a C.T.B. automatically destroys the in-quad arrangement of the phantom and double-phantom circuits. Working phantom or double-phantom circuits would therefore be subjected to much longer interruptions than the carrier groups and for this reason any such circuits are diverted, when possible, to a different route during the whole of the conversion period. Following completion of the conversion they are reconnected, Amplifiers No. 35 being brought into use at the new stations.

*High-Frequency Line-up.*

Following completion of the conversion of both cables, attenuation/frequency measurements are made on all pairs, over the complete H.F.R.D.F. section. The spare pair is again used to make good each working group in turn, by patching at the two H.F.R.D.F. stations as already described. At the sending end, the station carrier test-trolley is used (the oscillator being previously checked for accuracy) and all 24 frequencies are sent, i.e. 14·7 to 106·7 kc/s in 4 kc/s steps, each frequency being adjusted to an output power of 1 mW. As each frequency is applied, " through " output levels are measured at every intermediate station where they are recorded for future reference and also reported over the speaker circuit for recording at the control station. The terminal receiving station adjusts the Receive amplifier gain control to obtain " zero " and records the setting as well as reporting back to the control station. It will be seen that each station will be in possession of the results for its own equipment, whilst the control station will have this information for all stations on the route. By this means it is possible for the control station to check, as the line-up proceeds, that the results obtained at the intermediate stations are within the allowable tolerances of the equalisers and amplifiers. It will no doubt be appreciated that the results obtained at any one station depend not only upon the performance of the equipment at that station but also upon that of the equipment at all the preceding stations.

As mentioned previously, it has been found possible to use identical equaliser and amplifier settings at any one station for all 24 equipments in the one cable, an obviously desirable condition from a maintenance point of view. Slight variations of level will occur between pairs due to differences in equaliser and amplifier characteristics. Some idea of these variations (or " spreads ") can be gained from Fig. 5, which shows the results of the H.F. line-up obtained over the London-Leicester H.F.R.D.F. section of the London-Derby route. The length of this section is 104 miles, with a total of 11 repeater stations.

*Line Residual Equalisers.*

The total " spread " is caused by the addition of smaller " spreads " of identical shape introduced by each of the 10 repeater station sections. With the relatively simple type of equaliser employed these

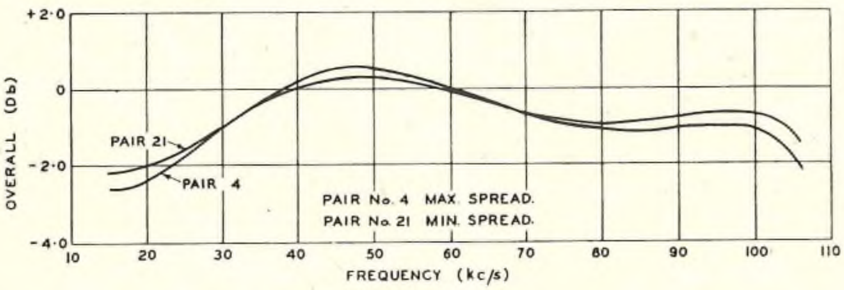



FIG. 5.—MAXIMUM AND MINIMUM VARIATIONS OF LEVEL WITH FREQUENCY ON LONDON-LEICESTER SECTION OF LONDON-DERBY NO. 2 CABLE.

individual " spreads " cannot be reduced and the total " spread " obtained on any particular route is therefore directly proportional to the number of repeater sections concerned. It has been found on the number of routes so far converted that slight variations in overall " spread," both with regard to shape and magnitude, occur, depending upon the different manufacture of cable and equipment. In general, however, the results shown in Fig. 5 are typical for the length concerned. From a maintenance standpoint such line characteristics are undesirable as they complicate faulting and necessitate different gain settings on the channel amplifiers associated with the terminal equipments. In extreme cases, distortion of the frequency-response of individual channels could result. It is intended, therefore, to provide additional equalisers installed at selected H.F.R.D.F. stations, at approximately 100-mile intervals on a route, to reduce the line spread to, at most, 1 db. Sufficient data have already been obtained and the design of these residual equalisers is in hand.

*Temperature Effects.*

The increase in line frequencies from 60 kc/s to 108 kc/s will cause the attenuation/temperature effects of the cable pairs to become more apparent. The change of cable attenuation with temperature is, of course, already experienced in 12-circuit working and is compensated, when necessary, by adjustment of the gain of the Receive amplifiers at group control and sub-control stations. These gain adjustments will affect all frequencies by the same amount, but unfortunately the change in cable attenuation with temperature varies with frequency and the gain adjustments can afford only a compromise solution.

With 24-circuit working, however, more accurate adjustments will be necessary on the long-distance circuits, in that the non-uniform change will be more pronounced over the wider frequency spectrum. This may be seen from Fig. 6, which gives the average

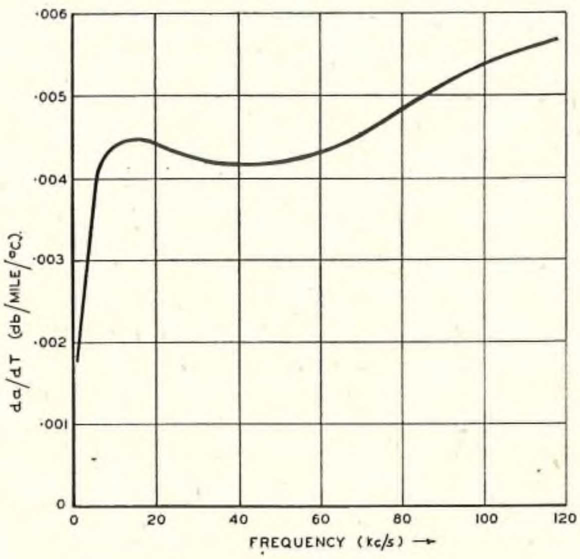



Fig. 6.—Cable P.C.Q. Carrier 12-Quad 40-lb. Side Circuit. Variation of Attenuation (*a*) with Temperature (T) (db./mile/°C) v. Frequency.

attenuation : temperature/frequency characteristic obtained from tests on a number of samples of carrier cable of different manufacture. In addition to these sample measurements, field tests have been made of a number of long-distance circuits set up for the purpose, these circuits including the necessary equalisers and amplifiers. These tests have now been made during a complete temperature cycle and the results agree closely with the sample tests. Sufficient data are now available for the design of a variable temperature equaliser and the matter is in hand. They will probably be installed at the same stations selected for the residual equalisers.

## Terminal Equipment

The 24 circuits per cable pair are provided in two 12-circuit groups, Group 1 in the frequency range 12-60 kc/s (nominal) and Group 2 in the range 60-108 kc/s (nominal). The two groups are derived from standard Nos. 5, 6 or 7 carrier terminal equipment with the addition, in some cases, of group-modulating equipment. It is necessary to combine the two groups at the transmitting end of the circuit and separate them at the receiving end, and the filters and associated amplifiers required for this purpose represent the only new type of equipment required at the terminal stations. This new equipment is known as 24-Circuit, Filter and Amplifying Equipment; a block schematic diagram of the circuit arrangements at one of the terminal stations together with the Post Office designations, and channel test-levels, etc., is shown in Fig. 7.

Similar equipment is provided at the other terminal station and when both are connected to a Go and Return cable pair the complete arrangement comprises a "24-circuit link" between the two stations concerned.

*24-Circuit Filters.*—A total of 10 (+ 1 spare) transmit and receive filter panels can be accommodated on a standard 10 ft. 6 in. bay, i.e. sufficient for ten 24-circuit links. Each filter consists of a coil and condenser section together with a crystal section, the crystals being of the "wired" type. In addition, filter equalisers and attenuators are provided.

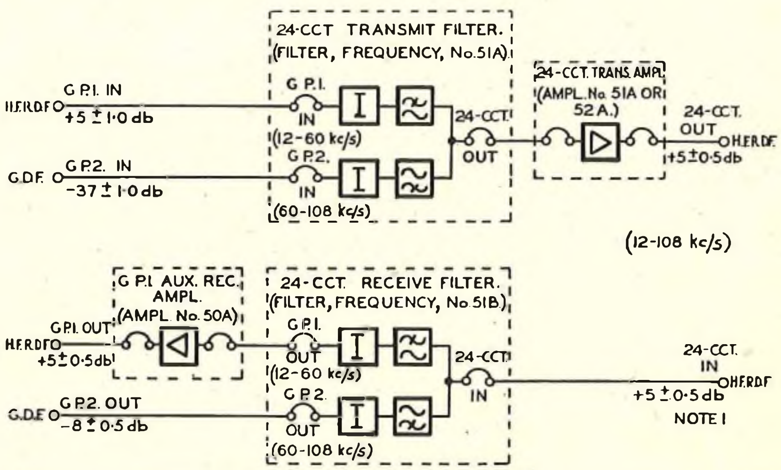
*24-Circuit Transmit Amplifiers.*—These are standard No. 7 type line amplifiers having the performance already detailed. For association with 24-circuit filters, the amplifier gain is fixed at 59±0·5 db. 10 (+ 1 spare) amplifiers are accommodated on a 10 ft. 6 in. bay.

*Group 1 Auxiliary Receive Amplifiers.*—Usually these amplifiers will consist of reconditioned No. 5 type, recovered from converted routes. Their performance is adequate as they have only to amplify frequencies in the 12-60 kc/s range. As for the transmit amplifiers, the gain is adjusted to 59±0·5 db. and 10 (+ 1 spare) can be accommodated on a 10 ft. 6 in. bay.

The bays are installed side-by-side in the repeater station, a suite of three thus catering for ten 24-circuit links. When necessary, each of the bays can be supplied half-equipped.

*Electrical Performance of 24-Circuit Filters and Associated Amplifiers.*

*Group 1 Transmit Path.*—Measured at the H.F.R.D.F., from "GP1 IN" to "24-circuit OUT,"




*Note* 1 : The limits of ± 0·5 db. will not apply on long distance circuits until Line Residual Equalisers have been provided.
*Note* 2.—All levels refer to the appropriate group reference frequencies, with correct adjustments, viz., 36 kc/s for Group 1 ; 84 kc/s for Group 2.

Fig. 7.—24-Circuit Filter and Amplifying Equipment.

the insertion loss at 36 kc/s must be 0±0·5 db. with a frequency-distortion spread not exceeding 0·5 db. over the range 12-59·7 kc/s. The 36 kc/s insertion loss must be exceeded by at least 20 db. at 60 kc/s and by at least 40 db. at all frequencies from 60·3 to 108 kc/s.

*Group 2 Transmit Path.*—Measured from "GP2 IN" on the G.D.F. to "24-circuit OUT" on the H.F.R.D.F., the insertion gain at 84 kc/s must be 42±0·5 db. with a frequency-distortion spread not exceeding 0·5 db. over the range 60·3-108 kc/s. The 84 kc/s insertion gain must be reduced by at least 20 db. at 60 kc/s and by at least 40 db. at all frequencies from 12 to 59·7 kc/s.

*Group 1 Receive Path.*—The performance must be as for the GP1 transmit path, the measurement being made from " 24-cct. IN " to " GP1 OUT."

*Group 2 Receive Path.* — Measured from " 24-cct. IN " on the H.F.R.D.F. to " GP2 OUT " on the G.D.F. the insertion loss at 84 kc/s must be 13±0·5 db. The frequency-distortion spread and the discrimination must be as quoted for the Group 2 transmit path. In addition to the above, each filter is provided with attenuators adjustable in steps of 1 db. to permit the insertion loss to be varied ± 2 db. Independent adjustment of any of the four transmission paths can thus be made to compensate, if necessary, for any extensive H.F. line spreads. It is unlikely this facility will be required, except on very long routes prior to the introduction of line residual equalisers.

*Utilisation of 24-Circuit Links.*—It will be seen from Fig. 7 that standard H.F.R.D.F. and G.D.F. conditions are provided. The interconnection of a 24-circuit link with a 12-circuit or coaxial system is thus made possible in addition to normal point-to-point working. The simplest case in the latter category is shown in Fig. 8.

No. 5 or 6 type terminal equipment is used for Group 1 and No. 7 type for Group 2. In the latter case the group modulating equipment, normally used with No. 7 terminal equipment for 12-circuit working, can be omitted. This is obviously the ideal arrangement and will be adopted whenever the equipment position permits at both terminal stations concerned.

If, however, only No. 5 or 6 equipment is available, it will be necessary to use group modulating equipment in the Group 2 path to effect the frequency translation from 12-60 kc/s to 60-108 kc/s. Similarly,

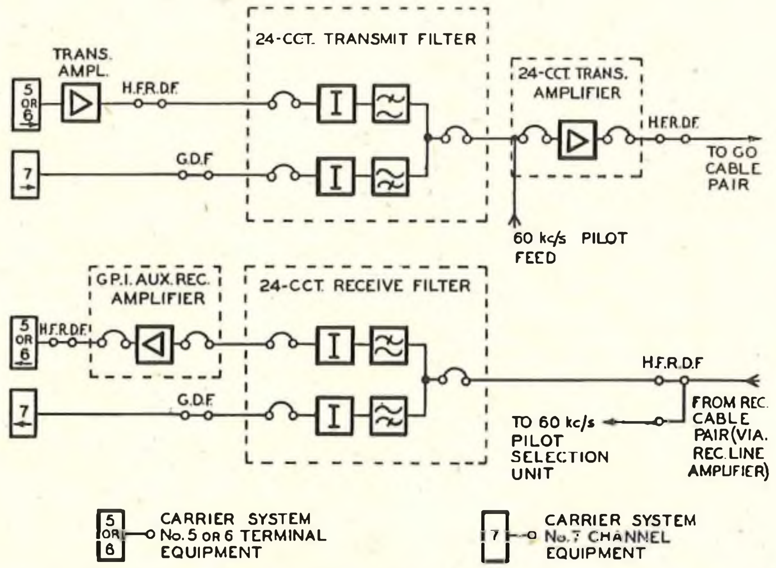



Fig. 8.—Utilisation of Carrier System No. 5 or 6 Terminal Equipment for Group 1, and No. 7 Channel Equipment for Group 2.

group modulating equipment must be used for the Group 1 path if only No. 7 equipment is available. Other combinations are possible including a " break-

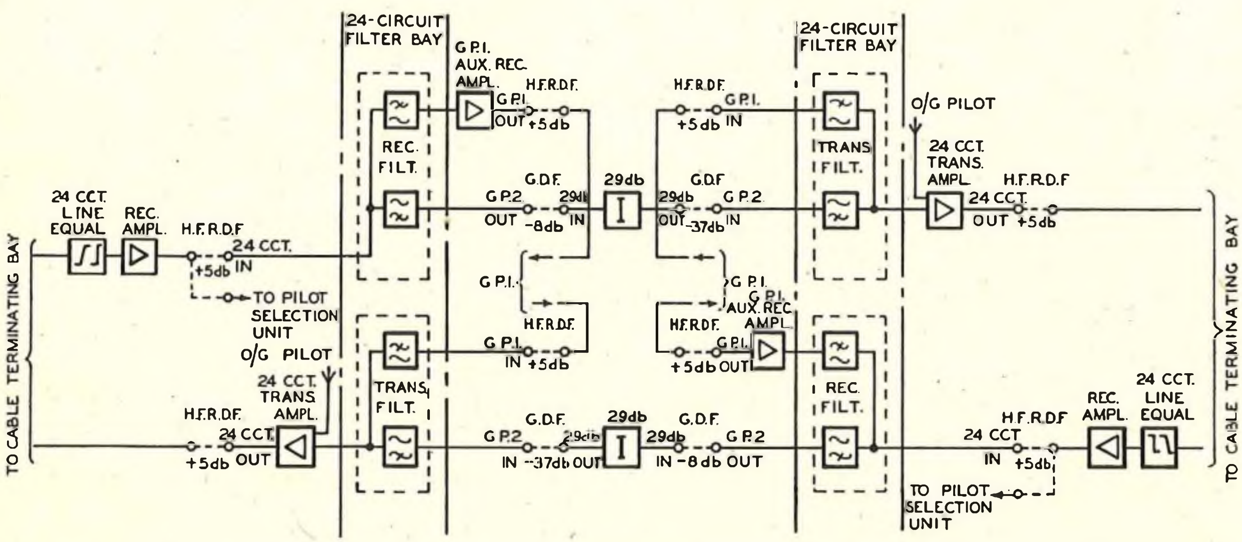


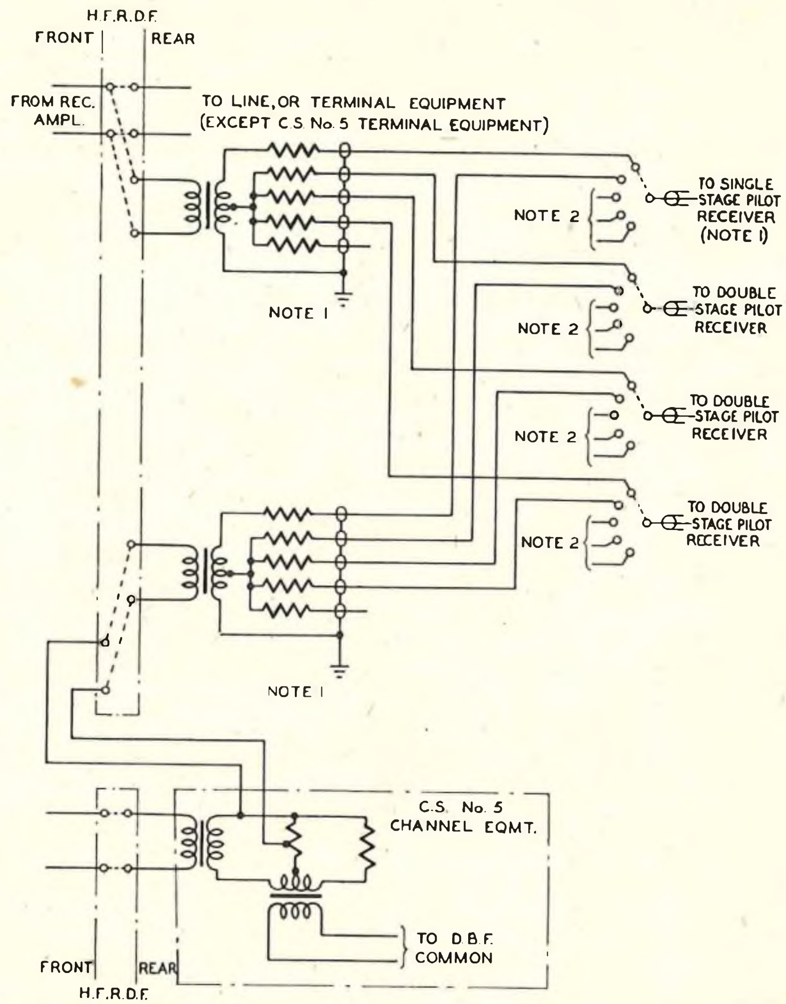

Fig. 9.—Group 1 Made Available and Group 2 Connected Through.

out " facility whereby Group 1 can be made available and Group 2 connected through. This condition is shown in Fig. **9**. Similarly, Group 2 could be made available, intercepted at the G.D.F., and Group 1 connected through at the H.F.R.D.F.

29 *db. Pads.*—In order to maintain standard G.D.F. test levels, it is sometimes necessary to use 29 db. pads as in Fig. **9** in the Group 2 path. The pads are mounted on the G.D.F. and are jumpered in as required.[2]

60 *kc/s Pilot Distribution.*—Due to the need for separation between the Group 1 and Group 2 frequencies between the limits 59·7 and 60·3 kc/s, a frequency of 60 kc/s will be suppressed by at least 20 db. in the 24-circuit filters and the transmission of a synchronising pilot via this equipment is, therefore, impracticable. The use of pilots on 24-circuit links is nevertheless required and it has become necessary to introduce a new system as follows :—

At the transmitting end of the link the pilot is injected at the 24-circuit transmit amplifier. At the receiving end the pilot is " picked off " the pair concerned by a parallel connection at the H.F.R.D.F. (see Figs. **8** and **9**). The tee connection is taken to the input of a Pilot Selection Unit, mounted on a Miscellaneous Apparatus Bay adjacent to the H.F.R.D.F. The unit has a high input-impedance, introducing a tapping loss no greater than 0·5 db. The basic circuit arrangement is shown in Fig. **10**.




*Note* 1.—Depending upon the output connections, each transformer unit caters for either one single-stage pilot receiver and three double-stage pilot receivers, or four double-stage pilot receivers.
*Note* 2.—The outputs from five transformers are connected to the banks of four switches.

Fig. **10**.—Basic Circuit Arrangements of Pilot Selection Unit.

The carrier frequency generating equipment can thus be synchronised at the receiving station and a 60 kc/s supply generated at this station can be extended, if necessary, by injection into the transmit amplifier of another link or a 12-circuit group.

*Conclusion.*

The doubling of circuit capacity on converted routes will be obtained at relatively small cost and (apart from the 24-circuit filters) without the use of new types of terminal equipment. An improvement in overall reliability should result consequent upon the replacement of the old Nos. 5 and 6 line amplifiers by the more modern No. 7 type. In this connection it should be mentioned that the " vibration testing " technique is applied to all new equipment prior to its being brought into use and it is confidently expected that the fault incidence on 24-circuit links will compare very favourably with the performance experienced in the past on 12-circuit lines.


*Acknowledgments.*

This article describes the present stage of the planning and development work carried out by past and present members of the Main Lines Branch of the Engineer-in-Chief's Office, and acknowledgments are due to them and to the General Electric Co. and Standard Telephones & Cables, who designed and produced the equipment to Post Office specifications.


[2] *P.O.E.E.J.*, Vol. 40, p. 113.

# The London-Birmingham Television Cable

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## Part 2.—Cable Design, Construction and Test Results

U.D.C. 621.315.212 : 621.397.5

**In this concluding part of the article details are given of the experimental work on the design and manufacture of the cable, the production of factory lengths, and the jointing technique employed in completing repeater sections. Test results on typical sections are given which show that the electrical requirements referred to in Part I have been met with satisfactory margins.**

### Early Experimental Work

As soon as the principal requirements of the large television tubes were established consideration was given to the mechanical features involved in a practical cable design. To meet the impedance uniformity limits a high degree of precision is required in the dimensions of both the inner and outer copper conductors and also in regulating the quantity of solid dielectric per unit length of tube. In factory lengths it is desirable to hold the external diameter of the inner conductor to within less than 0·001 in. and the effective internal diameter of the outer conductor to within 0·0025 in. of the average values. At the top frequency for which the cable has been designed, skin effect limits the useful thickness of the inner and outer conductors to a few mils.; it is therefore desirable to economise material by making the conductors in the form of thin cylindrical tubes. The quantity of solid dielectric must also be reduced to a minimum on account of cost and to reduce dielectric loss.

Operating against the electrical requirements, however, is the fact that the tubes must be able to withstand factory handling involving reeling on to drums of a size suitable for the subsequent operations of cabling, lead covering and protection. The completed cable must also be capable of withstanding the handling encountered during installation.

*Inner Conductor.*

Experience with the standard 0·375 in. coaxial cable employing the interlocking tooth type of outer conductor indicated that for the large tubes a centre conductor constructed along similar lines could be expected to provide a high degree of uniformity of diameter and to be flexible enough to meet the manufacturing and installation conditions. To keep the seam closed some external binding or clamping is necessary, but it is undesirable to provide a continuous binding of insulation over the inner tube since this would introduce an undesirable amount of dielectric in the most intense portion of the electric field. This problem has been solved by using clamping discs which form part of the insulating spacers in the tube.

To provide a smooth inner conductor, the interlocking teeth project inside the tube, which has, therefore, a smooth cylindrical external surface with a single longitudinal seam at the abutting edges.

*Dielectric.*

Of the many known dielectrics only two are generally available having low permittivity and loss at the frequencies involved. These are polystyrene and polythene. Polystyrene, unless used in thin films or threads, tends to be less flexible than polythene and for this reason polythene is preferred. Its permittivity is 2·3 and its power factor 0·0004.

In the early experiments consideration was given to the extrusion of a continuous tube of polythene to provide support for the outer conductor. However, the difficulty of controlling concentricity and external diameter to tolerable limits ruled out this method. The final solution adopted is to use the injection moulding technique to produce short thin-walled cylinders of polythene having a disc with central hole to support the centre conductor and a spigot at one end, the spigot making joint with the next cylindrical spool in the cable. These spools are slit radially to enable them to be placed in position on the inner conductor. They can be made with a high dimensional accuracy and the method of insulation has the advantage of allowing the conductor spacing to be controlled to very close tolerances during manufacture. The spools used have a centre-to-centre spacing of the discs of 1·56 in., a wall thickness of 0·080 in. and an external diameter of 0·940 in.

*Outer Conductor.*

Electrically the outer conductor also should be a smooth thin-walled cylinder. The internal diameter necessary to meet the attenuation requirements is 0·975 in. and a thin-walled tube of this diameter will buckle and crack when subjected to frequent bends such as occur during subsequent manufacturing operations. The conventional methods of making a flexible hollow tube are to produce a tube from spirally wound tapes or to form transverse corrugations in the wall of the tube. The use of spiral tapes introduces a spiral component into the current passing along the cable and it is considered preferable to corrugate a tape and form it into a tube with a single longitudinal seam, although this involves some additional attenuation introduced by the corrugations. However, by controlling the degree of corrugation the increase in attenuation is limited and can be allowed for in the design.

In the first experimental cables the corrugated outer conductor tape was supported on the spool insulators, but impedance variations along the completed tubes showed that changes in the effective diameter of the outer conductor were excessive. It was therefore decided to make the outer tube self-supporting. This has been achieved by off-setting the corrugation at both edges of the tape so that when formed into a tube the two opposing edges of the tape are prevented from over-riding. In this way the diameter of the outer conductor tube is dependent only on the width of the tape from which it is formed, and can be controlled to very close limits.

*Binding.*

After the outer conductor tube is formed it is necessary to hold the abutting edges together by binding the tube ; the binding must also provide mechanical strength and add to the crosstalk attenuation between the tube and other tubes and pairs in the cable. The requirements are met by providing a binding of four steel tapes each 5 mils thick, the first pair of tapes being applied with right-hand lay and the second pair with left-hand lay. In this way, in addition to meeting the above requirements, torsional rigidity is imparted to the tube, which enables it to withstand subsequent handling.

To retain the steel tape binding under the appropriate tension when the tubes are cut for testing and jointing purposes and to insulate the outer conductor for testing, a binding of adhesive insulating tape is applied directly over the steel tapes and a final lapping of numbered paper is provided for identification.

## Final Cable Design

The above description outlines the main channel of development which led to the final cable design, although many subsidiary lines were explored before various alternatives were discarded. The final design of the large tubes is therefore as follows :—

*Centre Conductor :* Hollow tube constructed of 0·010 in. thick copper tape with internally interlocking teeth.
External diameter of tube : 0·250 in.

*Dielectric :* Polythene spools having an effective length of 1·55 in. and an external diameter of 0·940 in.

*Outer Conductor :* Transversely corrugated tube formed from 0·010 in. thick copper tape with offset corrugation on the edges.
Effective internal diameter: 0·975 in.

*Binding :* Two 0·005 in. steel tapes breaking joint with right-hand lay.
Two 0·005 in. steel tapes breaking joint with left-hand lay.
One adhesive insulating tape.
One numbered paper tape.
External diameter : 1·080 in.

Fig. 3 shows two views of the large tubes. In the upper view the abutting edges of the outer conductor are visible and in the lower one the tube is turned round to show the radial slit in the polythene spool.

The 0·375 in. tubes and balanced pairs in the cable conform to existing practice and call for no comment. The lay-up of the complete cable has already been described in Part 1, following a discussion of the factors determining the diameter of the large tubes. Fig. 4 shows specimens of the cable as laid. (In the specimens the protective covering of bitumen and hessian with which the cable is served overall has been removed.)

*Joints.*

In arriving at a design of joint for connecting together factory lengths of cable during installation on the cable route, the following principal requirements have to be met :—

1. The joint must not cause appreciable reflections of the energy transmitted through it in the frequency spectrum 1 to 26 Mc/s.
2. A water barrier must be provided in accordance with Post Office practice for all air-spaced telephone cables.
3. The joint must be so constructed that during assembly, and when, if the occasion should arise, the joint is opened, there should be no risk of damaging the dielectric structure of the cores or of the joint itself by melting of the polythene insulators as a result of the soldering operations on the conductors.

For the first requirement it was found that a symmetrical disposition of the components on either side of a solid polythene disc, forming with two rubber rings the required water barrier, could be so proportioned that although elemental portions differed in characteristic impedance from the cores and there-

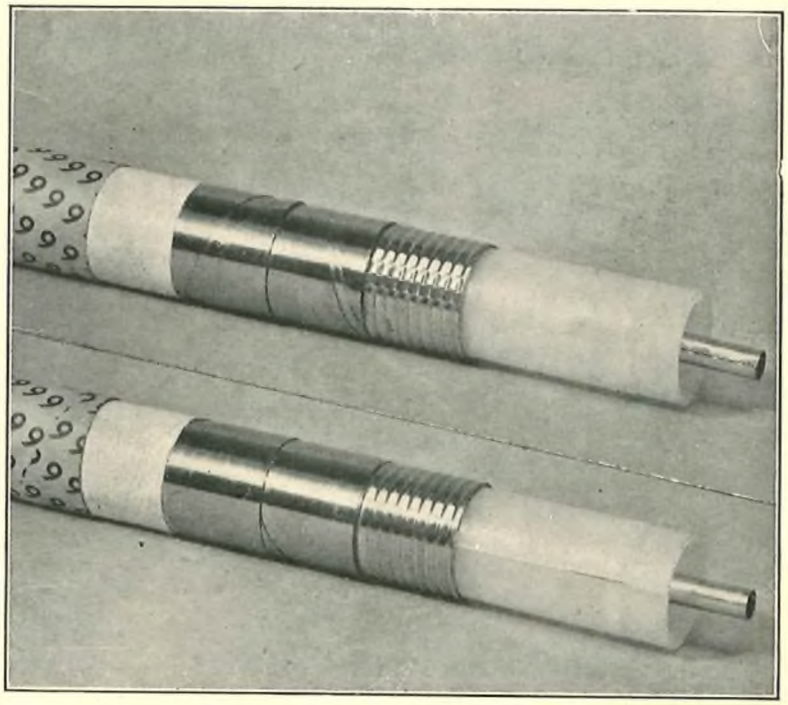


Fig. 3.—Views of 0·085 Inch Tubes.

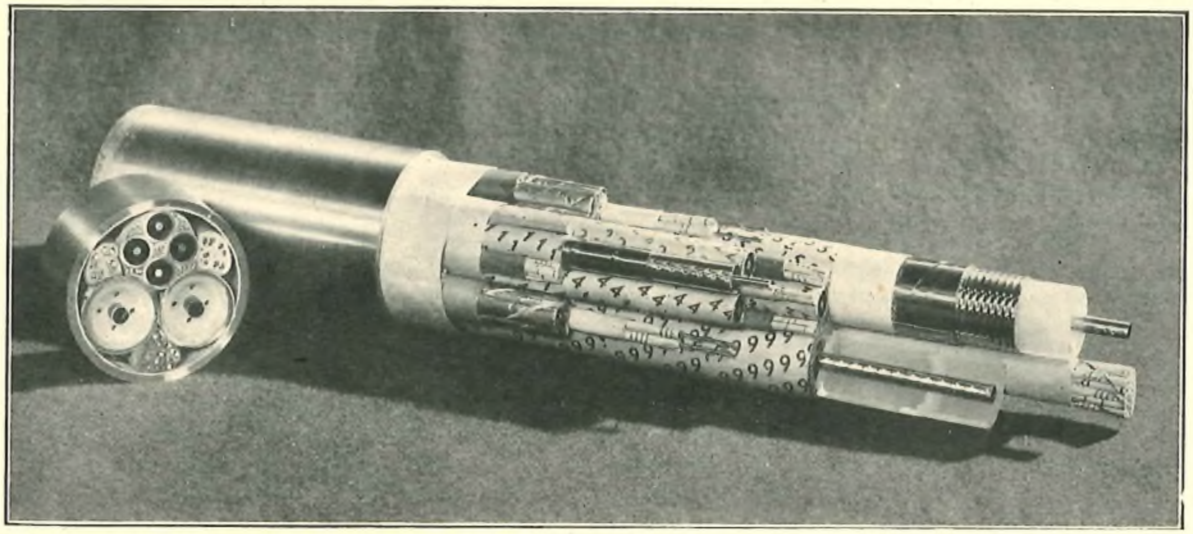


Fig. 4.—Lay-up of Composite Cable.

fore caused reflections of the transmitted wave, the vector resultant of all the reflections occurring in the joint was sensibly zero over the whole frequency spectrum up to 26 Mc/s or more. Two views of the joint finally adopted are shown in Fig. **5**; the joint is described below :—

A simple procedure has been evolved for cutting the ends of the two cores to be jointed so that the distances to the first polythene discs on either side of the joint are the same, and are between 0·5 and 1·0 times one polythene spacer length. The centre tubes of the core are connected together by means of a copper rod inserted into the open ends and soldered. Over this rod the split polythene spacer with central disc, previously mentioned, is tied firmly into position over a small rubber ring. During the soldering operations required to fix a steel collar and copper ring to each outer conductor the polythene spacers are temporarily removed from the core end for a sufficient distance to avoid any distortion of spacers due to excessive heating. After replacing these spacers the joint between the two outer conductors is made by means of a cylindrically formed thin copper plate which is seam-soldered at either end and along the longitudinal seam. Since this soldering operation does not involve heating large masses of metal there is no melting of the polythene spacers inside the sleeve. To improve the engagement between the inner surface of the outer copper sleeve and the rubber ring encircling the outside of the split polythene joint spacer, a tight binding of copper wire extending for approximately 1 in. is applied to the centre of the sleeve and soldered into position. To complete the screening of the joint and to render its mechanical strength independent of the outer copper sleeve, a steel sleeve with locking rings is screwed to steel collars previously soldered to the steel tapes and outer conductors of the cores. The joint, which is finally wrapped in empire cloth, is

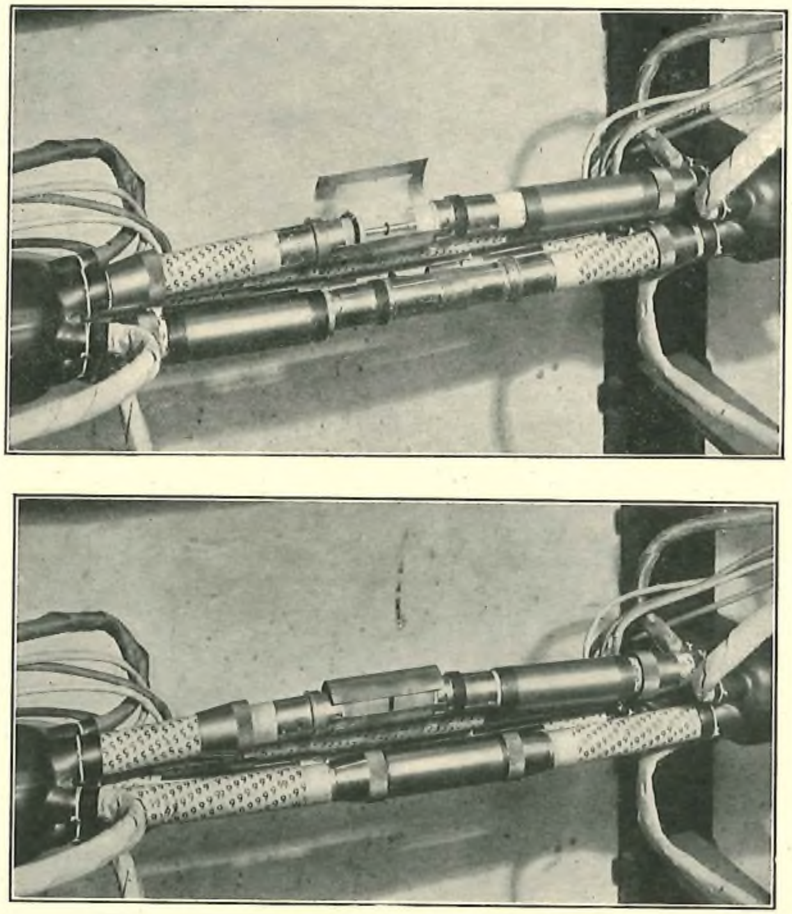


Fig. 5.—Construction of Joints in 0·975 Inch Tubes.

approximately 7 in. long and 1½ in. diameter. In the complete cable joint there are two of these joints for the 0·975 in. tubes, four smaller joints for the 0·375 in. tubes and the usual joints in the unscreened and screened pairs, the overall dimensions being 30 in. long by 4 in. diameter. To prevent passage of water along the interstices between the various coaxial tubes and the pairs in the main joint a pair of multi-outlet plastic sleeves are fitted tightly over all the components where they leave the lead sheath of the cable inside the outer lead sleeve of the joint.

*Experimental Cable.*

When the preliminary development work had resulted in the production of a number of drum lengths, it was decided to manufacture and joint together in the factory a substantial length of cable to allow the repeater section characteristics of the large tubes to be determined ; in particular to check the effect of the joints on impedance uniformity. This would also enable measurements of attenuation, impedance uniformity and crosstalk to be made, which could not be measured accurately on individual lengths. Upon the completion of this work the measurements, which were made on 2·3 miles of cable, comprising 33 drum lengths, showed that the attenuation and crosstalk were satisfactory, but that the variation of impedance of the large tubes was rather more than had been expected. A detailed examination of the test results on individual drum lengths and a comparison with the tests on the 33 lengths in tandem showed that the dimensional accuracy of the outer tube was insufficient to meet the high degree of uniformity required. The construction of the large tubes was then altered somewhat, as indicated previously, the principal changes being the use of a self-supporting outer conductor, the shortening of the spacing spools, and improvements in the outer binding.

A mile of cable of the modified design was manufactured, jointed in the factory and tested, and the results obtained showed that the requisite uniformity of characteristic impedance had been achieved. Manufacture of a full repeater section of cable was therefore put in hand. Meanwhile the mile of cable was installed on the London-Birmingham route and retested. The results after installation showed virtually no change from the factory results, thus indicating that the cable had the necessary degree of stability to withstand handling during installation.

The repeater section was manufactured and installed on the London-Birmingham route between Gladstone and Cunningham repeater stations. This repeater section was then completely tested and satisfied all requirements.

*Details of Cable Route.*

A line diagram of the main and tail cable routes is shown in Fig. 6. The cable from Alexandra Palace to Birmingham has the lay-up already illustrated in Figs. 2 and 4, but between Birmingham and the transmitter at Sutton Coldfield the four 0·375 in. tubes and associated balanced pairs are omitted, because one-way television, only, need be catered for on this part of the route. The places at which the three-mile repeaters will be located, and the power feeding points, are shown in the line diagram.

*Cable Terminations.*

The method adopted for terminating the cable, as arranged at an intermediate station, is shown in Fig. 7. The cable uprising against the wall is separated into short lengths of individual lead-sheathed coaxial

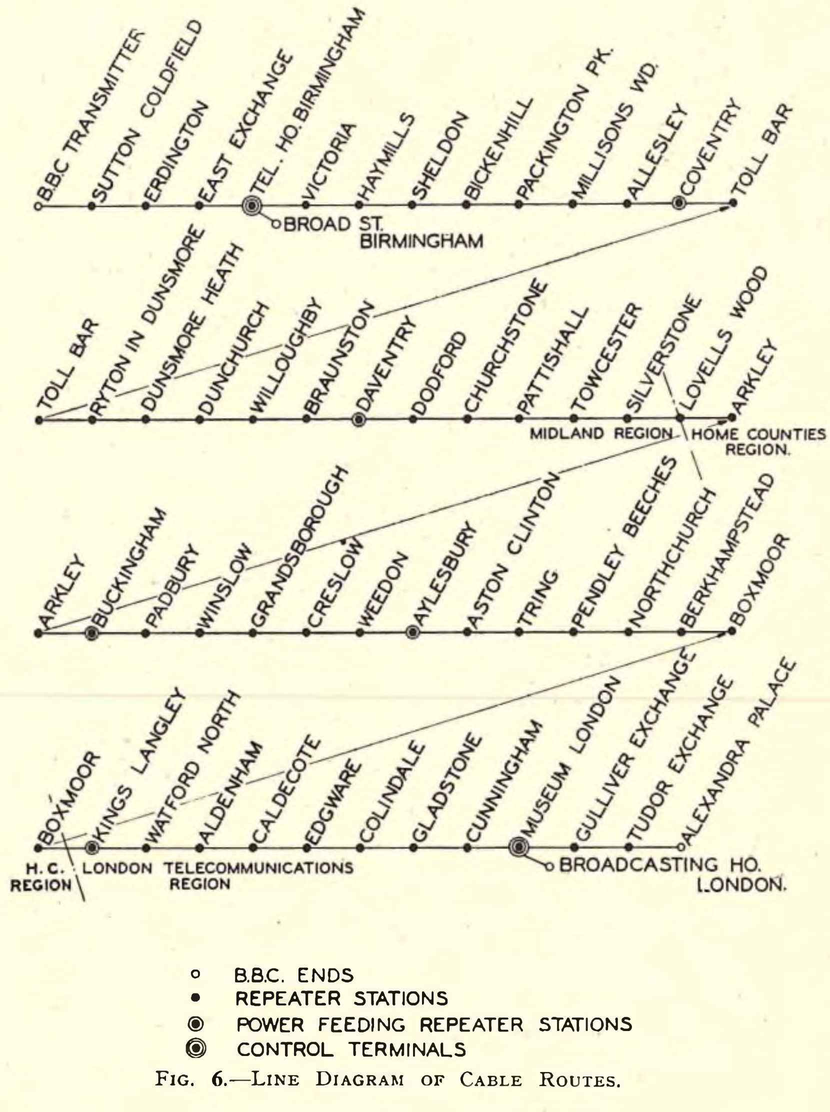



Fig. 6.—Line Diagram of Cable Routes.

Fig. 7.—Cable Terminations.

tube and groups of balanced pairs at the plug joint. The coaxial tubes are carried over racking to the point where they finish in sealing ends designed to provide an airtight termination to which flexible cable can be connected through a plug and socket without introducing an impedance irregularity. Each sealing end provides an earth for the outer conductor which can be removed for testing purposes.

It will be seen that in this particular station all the coaxial tubes terminate in sealing ends in this way, and that the balanced pairs also are terminated in test tablets, shown on the right-hand side of the picture. But sealing ends for the 0·375 in. tubes and test tablets for the balanced pairs are provided only at the 6- and 24-mile repeater stations, and at intermediate points permanent through connections are provided inside plumbed joints.

## Test Results.

Although the cable has not yet been completely installed it is possible to give some results that are typical of the sections already tested :—

*Characteristic Impedance.* Fig. **8** shows the way in which the resistive component of the input impedance of a 0·975 in. tube varies with frequency at one end of a three-mile repeater section, when the other end is terminated in 75 ohms. The sum of the six largest differences of impedance corresponding to this curve is 22·1 ohms, compared with the specification figure of 26·5 ohms.

In Fig. **9** a copy is shown of the complex echo pattern observed on a cathode ray oscilloscope at the sending end of a three-mile section, when a 0·1 micro-second D.C. pulse is applied. This type of test is very useful for locating irregularities and diagnosing them. The break-through of the sent pulse, and an echo from the far-end terminating impedance, appear at the beginning and end of the time scale respectively and it will be seen that the biggest echo returned from within the section is 60 db. below the sent pulse and arises 740 yd. from the sending end. The pair of echoes of opposite sign, arising 1,900 and 2,050 yd. from the sending end, suggest that on one drum length the characteristic impedance of the tube tested is slightly lower than that of adjacent lengths. Since an echo near the sending end 60 db. below the level of the sent pulse, corresponds to a change of impedance of the order of 0·15 ohm it will be seen that the response shown in Fig. **9** indicates a very high degree of impedance uniformity.

On all repeater section ends so far tested the mean characteristic impedance around 20 Mc/s lies between 74·8 and 75·2 ohms, which should be compared with the specification limits of 74 and 76 ohms.

*Attenuation.* There is considerable difficulty, having made accurate measurements of cable attenuation, in correcting them to a reference temperature, because of the difficulty of determining the temperature of the cable, which can vary along its length. However, it appears from precise measurements on a section of the cable that at 15°C the attenuation of the 0·975 in. tubes conforms to the law :—

$$A = 1{\cdot}55\sqrt{f} + 0{\cdot}011\, f \quad \text{db./mile},$$

where f is the frequency in megacycles per second. The maximum departure from the attenuation law as specified in Part 1 of this article occurs at 1 Mc/s and amounts to $-0{\cdot}65$ per cent. The change of

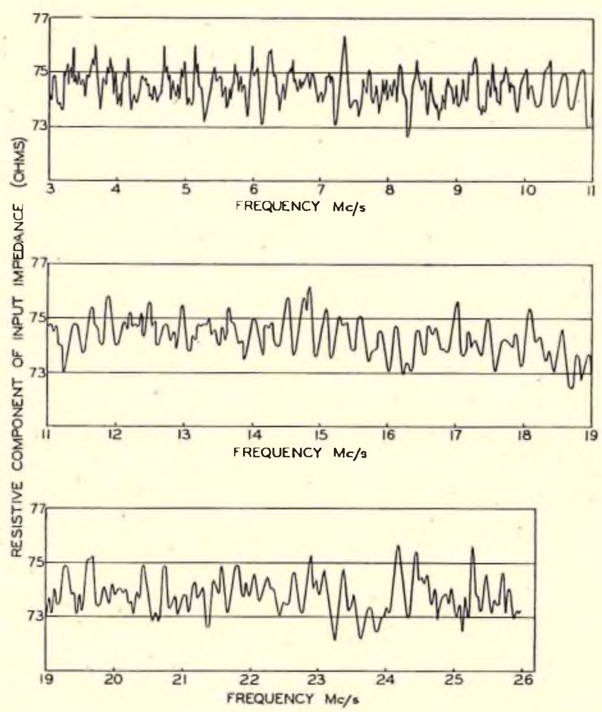
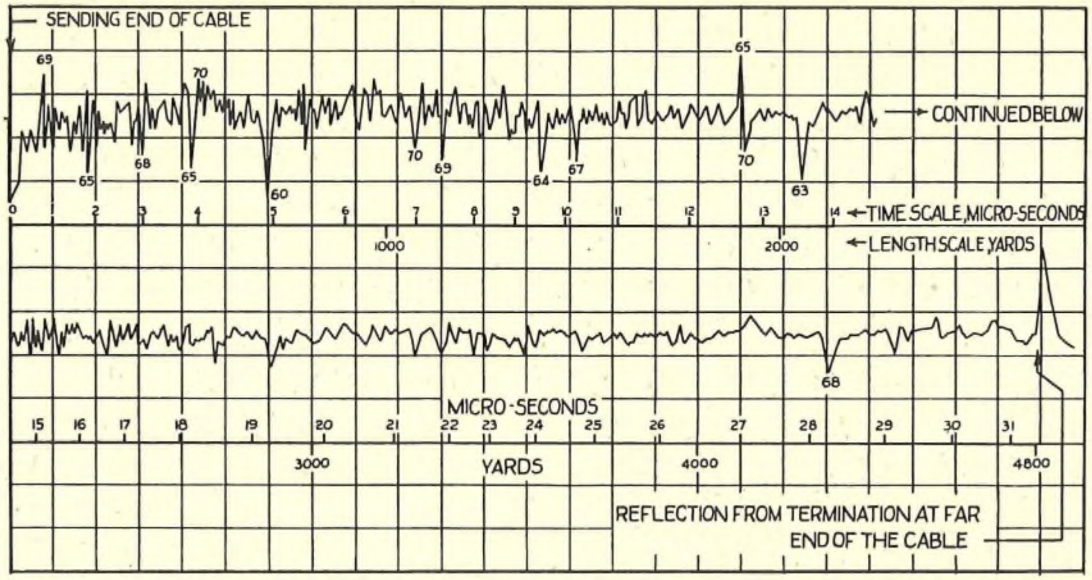



Fig. 8.—Variation of Resistive Component of Input Impedance with Frequency for 3-Mile Length of 0·975 Inch Tube.




*Note.*—Figures appended to principal reflections give their magnitude expressed in decibels below incident pulse level.

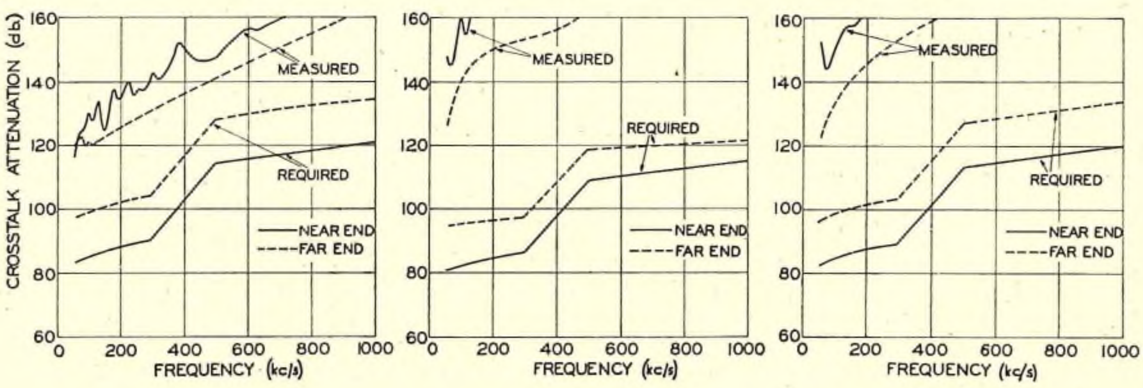
FIG. 9.—PULSE TEST ON 2·73 MILE SECTION OF 0·975 INCH TUBE. APPROX. RECTANGULAR D.C. PULSE OF 0·1 MICRO-SECONDS WIDTH.

attenuation that occurs when the cable is drawn into the duct appears to be less than 0·3 per cent.

*Crosstalk.* Typical crosstalk attenuation results are shown in Fig. 10 with the minimum requirements indicated for comparison. It will be seen that on far-end crosstalk between 0·375 in. tubes there is a margin of at least 10 db. and that in all other cases the requirements are satisfied with much greater margins.


*Acknowledgments.*

The authors have much pleasure in acknowledging their indebtedness to their colleagues in the Post Office and in Standard Telephones & Cables, Ltd., who have been associated with them in various aspects of this work, in particular to Messrs. E. C. H. Seaman and E. Baguley who have also assisted them in the preparation of this article.


Between 0·375 in. Tubes. Between 0·975 in. Tubes. Between One 0·375 in. and One 0·975 in. Tube.

FIG. 10.—CROSSTALK ATTENUATIONS FOR 6-MILE SECTIONS.

# Unification of Screw Threads

F. C. CARTER, B.Sc.(Eng.), M.I.E.E.

U.D.C. 621.882.1.082 : 061.3

**International discussion on the basic design of screw threads has been taking place since 1873 with a view to "Standardisation" or "Unification." In this article, the author gives an historical survey of the question, leading up to the recent Anglo-American-Canadian Declaration of Accord on a Unified Thread System for nuts, bolts, etc., between $\frac{1}{4}$ in. and 6 in. diameter. In conclusion, the existing thread differences for sizes below $\frac{1}{4}$ in. are explained in relation to forthcoming discussions on standardisation of this range.**

*Introduction.*

MANY readers will, no doubt, have noticed references recently, both in the popular and technical presses, to "Unification" or "Standardisation" of Screw Threads, and may have wondered as to the reasons for these references.

It is a fact that for some time past certain Anglo-American-Canadian discussions have been taking place on the question of the basic design of screw threads, and, although it will be some years before the results of these discussions become apparent, it is probable that, eventually, they will affect the users of all but the smallest nuts and bolts.

This article has been written, therefore, to give a brief historical background to the problem and a résumé of the results of the recent negotiations.

*Historial Survey.*

The shape of the screw thread which has been in common use in Great Britain for very many years is that known as the Whitworth thread. It is named after Sir Joseph Whitworth, who was responsible for its standardisation in 1841.

The fundamental point of standardisation is the V angle of the thread at 55°, but other important points are the number of threads per inch (T.P.I.) and the shape of the root and crest of the screw, these being such that one-sixth of the sharp V is truncated at the top and bottom, the roots and crests being rounded equally by circular arcs.

To appreciate Whitworth's work in its proper perspective it must be realised that this original standardisation was achieved at a time when engineers were concerned, primarily, with heavy engineering problems, e.g., steam engines and railway bridges, and when the principal material available was wrought iron; also, the highly developed and specialised light engineering industries of modern times and, particularly, the radio, telephone, automobile and scientific instrument industries did not exist.

The standard proposed by Whitworth was chosen not by scientific comparison, but by averaging the dimensions of threads then in common use. Nevertheless, his proposals appear to have been quite acceptable to Continental engineers and some measure of the credit due to Whitworth is the fact that his standards have remained unaltered for over 100 years—probably a unique achievement in engineering history.

The Whitworth threads continued in fairly general use until about the time of the American Civil War, when relations between Britain and America became strained and the "Sellers" thread was introduced in America.

The principal difference between the Whitworth and the Sellers thread is that the latter has a V angle of 60°, and the root and crest of the thread are made flat instead of being rounded. Although there is no marked difference in the strength of this thread, it is claimed to be easier to produce and measure and so offers certain advantages in production. The number of T.P.I. is, with one or two exceptions, unchanged. The comparative shapes of these threads are shown in Fig. 1.

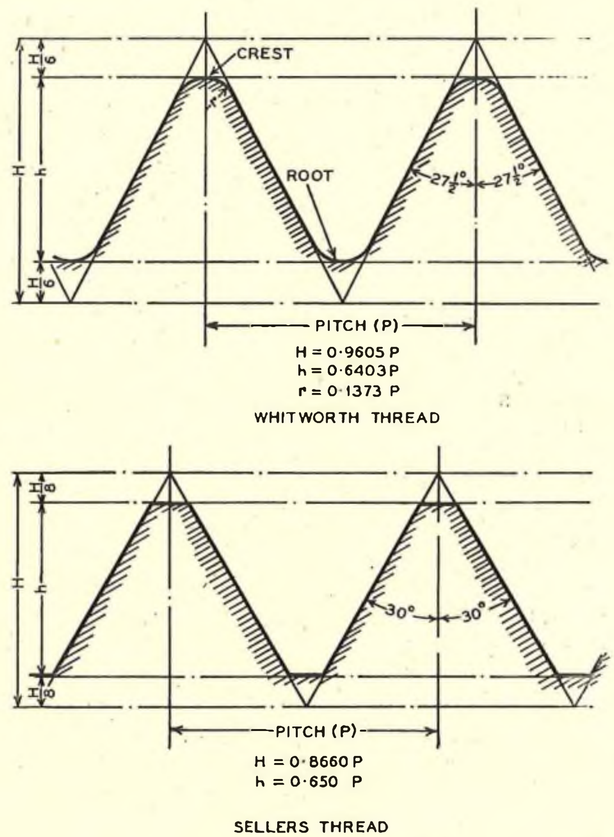



FIG. 1.—COMPARATIVE SHAPES OF WHITWORTH AND SELLERS THREADS.

After the Franco-Prussian war in 1871, Germany adopted the metric system of measurement and metric threads soon followed, and in Europe became a competitor to the Whitworth thread which was based upon the inch system of measurement. There were, however, certain differences preventing interchangeability between some of the French and German metric threads, and other differences between the French and Swiss threads.

Various International Screw Thread Congresses were held between 1873 and 1898 in endeavours to reach standardisation, and eventually a thread known as the International Metric Thread was agreed upon at Zurich in 1898.

The basic metric thread is identical with the Sellers basic form, but the pitches being on a metric basis are different. The standard tolerances allow for these sharp flats to be rounded within certain limits to allow for the tool wear during manufacture.

The Zurich agreement applied only to screw threads for basic diameters between 6 mm. (0·236 in.) and 80 mm. (3·15 in.). Above and below these diameters some differences between the French, German and Swiss national standards continued. It is of interest to note that in 1943 the British Standards Institution published a specification for International Metric threads in order that the essential information might be readily available to British engineers who had to manufacture this thread, but there was no suggestion of changing general British screw thread practice.

Although the use of these three different threads may have caused a certain amount of irritation and inconvenience, screw-cutting machinery was not highly automatised and alternative threads could be produced with no very great additional effort, although difficulties were bound to occur in repairs and maintenance.

After America entered the first World War the disadvantages of the use of the different threads became more apparent, and in 1917 Dr. H. S. Rowell proposed to the Screw Thread Committee of the British Engineering Standards Association that, for both Britain and America, the V thread angle should be $57\frac{1}{2}°$. At that time the errors in screw thread angles were often as great as $2\frac{1}{2}°$, so that the proposal was not unreasonable.

No very definite progress appears to have been made with this suggestion until the U.S. Congress appointed a Screw Thread Commission in July, 1918, but the subsequent early termination of the war appears to have weakened the common urge for standardisation and the matter did not proceed beyond the discussion stage.

In 1926, Sir Richard Glazebrook led a mission to America to suggest the common use of a compromise thread of $57\frac{1}{2}°$, but interest in such a compromise had lapsed, trade was flourishing and the suggestion appears to have had no great appeal. The proposals were, therefore, dropped.

*Later Developments.*

The matter remained in this state until a comparatively advanced stage in the second World War, when Great Britain and America again found themselves striving to produce armaments for their combined forces at the maximum possible rate.

With the advent of the modern engineering industries, and the closer limits generally employed in manufacture and the great increase in the mechanisation of the Armed Forces, much of the flexibility of interchange between different threads disappeared and it became difficult to avoid each country having to manufacture threads to the other's standards. In the field, interchange of spares was restricted and the stocking of spares became a major problem.

In 1943, a British mission visited New York to discuss thread problems with America and Canada ; in August 1944, a joint U.S.-Canadian Screw Thread Mission visited Great Britain to discuss the whole problem and a further three-country conference was held in Ottawa in 1945.

The compromise proposal of $57\frac{1}{2}°$ was again examined, and various experimental programmes instituted to compare the different forms of threads. The $57\frac{1}{2}°$ proposal now, however, appears to have been much less popular with all parties since, with the much closer tolerance limits in general use, its adoption would have incurred a very large amount of retooling by all parties concerned and general opinion now appears to have favoured the joint use of the 60° thread, presumably on account of the preponderating North American production.

*Anglo-American-Canadian Conference,* 1948.

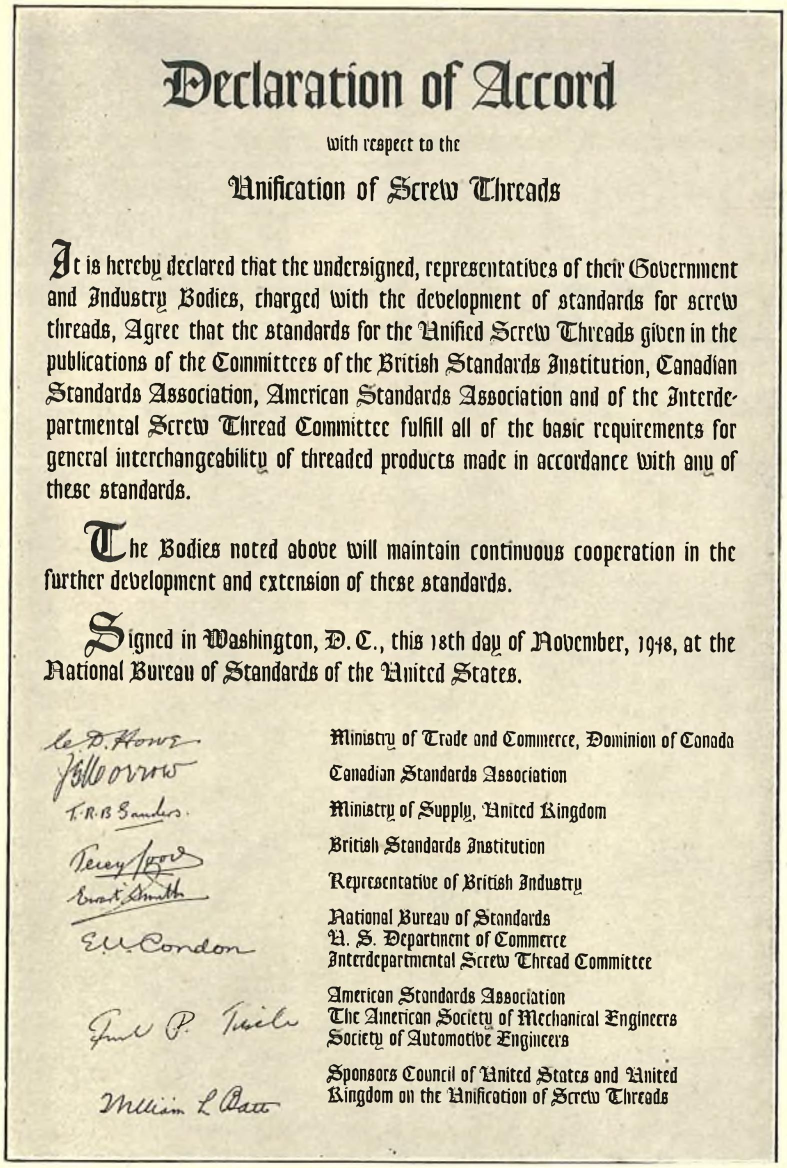
Although no final agreement had been reached before the termination of hostilities, this time the negotiations were not allowed to lapse, but were actively continued into the post-war period.

These discussions culminated in a final conference, held in Washington on November 18, 1948, at which agreement was reached between America, Canada and Great Britain on a common series of screw threads. A photographic reproduction of the declaration is shown in Fig. 2.

This agreement covers the thread form, a series of diameters for nuts, bolts and fastening threads from $\frac{1}{4}$ in. to 6 in. diameter and manufacturing tolerances. The form of thread is one having a 60° angle. The bolt thread will have a rounded root with the alternatives of a rounded crest in Great Britain and a flat crest in North America. The main series includes two series of threads, a "fine" and a "coarse," and special design threads are also included.

The parties to the Agreement also agreed to acceptance of the following principles and procedures.

1. That the thread system will be known as the "Unified."
2. That they will use identical designations for identical threads.
3. That they will indicate specifically and in detail in their own individual published standards those dimensions, tolerances and other data which are mutually agreed as coming within the Unified System.
4. That Service Departments of the participating countries agree to use the Unified System as far as is practicable for all new equipments and stores designed to their order specifically to meet Service needs.
5. That subject to the above, the B.S.I. would authorise the immediate issue of a Provisional Standard Specification with the new Unified (60°) thread, although this involves a major change in British engineering practice.
6. That the importance of agreeing acceptable unified standards below $\frac{1}{4}$ in. diameter was recognised and it is agreed that further discussions shall take place between the three countries at an early date in the United Kingdom.



# Declaration of Accord

with respect to the

## Unification of Screw Threads

It is hereby declared that the undersigned, representatives of their Government and Industry Bodies, charged with the development of standards for screw threads, Agree that the standards for the Unified Screw Threads given in the publications of the Committees of the British Standards Institution, Canadian Standards Association, American Standards Association and of the Interdepartmental Screw Thread Committee fulfill all of the basic requirements for general interchangeability of threaded products made in accordance with any of these standards.

The Bodies noted above will maintain continuous cooperation in the further development and extension of these standards.

Signed in Washington, D. C., this 18th day of November, 1948, at the National Bureau of Standards of the United States.

Ministry of Trade and Commerce, Dominion of Canada

Canadian Standards Association

Ministry of Supply, United Kingdom

British Standards Institution

Representative of British Industry

National Bureau of Standards
U. S. Department of Commerce
Interdepartmental Screw Thread Committee

American Standards Association
The American Society of Mechanical Engineers
Society of Automotive Engineers

Sponsors Council of United States and United Kingdom on the Unification of Screw Threads

Fig. 2.—Declaration of Accord by America, Canada and Great Britain.

*Provisional B.S. Specification for Unified Thread.*

This agreement will be implemented in Great Britain by the British Standards Institution issuing early in 1949 a provisional British Standard Specification for the Unified Thread. This specification will be prepared by the Mechanical Engineering Standards Committee of the B.S.I., but the work has been endorsed by the Automobile, Aircraft, Cinematograph, Electrical Engineering, Petroleum and Scientific Instrument Industries Standards Committees.

After this provisional specification has been available for general consideration and comment, including that from the Commonwealth and Dominions, it will be reviewed by the B.S.I. probably at the end of 1949, with the object of its confirmation as a Standard Specification.

The natural development of this thread unification, namely an agreement on the general dimensions of bolts, nuts and screws is now being very actively pursued.

It will, of course, be fully realised that the issue, even of such a formal Standard Specification, does not imply that there must be any immediate and large scale changeover by British Industry to the new thread series, or that they will be immediately available to the public.

The first and most important step in this change is the fact that the new Standard will have equal standing with the existing standards, i.e., the Whitworth series, and that the Design Engineer will have the option of calling for them as and when he desires. The second important point is, of course, the availability of the threads and this will depend upon the demands that are made for them. In this connection the undertakings already given by the representatives of the Service Departments must not be overlooked.

The use of the new thread for other industrial purposes is entirely optional. It is understood, however, that there is a substantial production of American type threads in this country already which, if not precisely within the Unified limits, are in practice interchangeable with them; this production may well be stimulated by demands from overseas.

*B.A. Threads.*

The telecommunications, radio and lighter side of the electrical industry are concerned, primarily of course, with the B.A. range of threads below $\frac{1}{4}$ in. and they have not been greatly concerned with the results of the above negotiations. Since, however, these industries are probably the principal users and producers of B.A. threads they will be extremely interested in the results of the proposed conferences on the sizes below $\frac{1}{4}$ in. It may not be inappropriate at this stage, therefore, to review both the origin of the B.A. series and to mention briefly the standards which are at present current in America and Canada in this range.

The standard sizes and dimensions of the B.A. series were first proposed for standardisation by the British Association in 1894. In fact, the series derived its name from that association. In 1903, the British Standards Institution (then the Engineering Standards Committee) was approached to take over this work and issue the information as a standard specification. This specification was issued in 1905. It is of interest to note that the B.A. series is based upon the metric system of measurements, the pitch being arranged in a geometrical series.

The V angle of the thread is $47\frac{1}{2}°$ and the root and crest are rounded in a similar manner to the Whitworth. Manufacturing tolerances were not included originally in these standards, but in 1919 they were agreed for the range 0 to 15 B.A. The smallest threads 16 to 25 B.A., which are probably mostly used by the clock and watchmaking industries, still remain untoleranced. The external dimensions of B.A. nuts and bolt heads were standardised by the B.S.I. in 1911.

The Standard Threads which are at present current in U.S. and Canada in the range below $\frac{1}{4}$ in. are of the same basic form as the Sellers. The series includes a range of 12 diameters between 0·216 in. and 0·073 in. and each diameter has a " fine " and a " coarse " thread.

It is understood, however, that in order to minimise the total number of thread sizes to be produced in any one factory, certain manufacturers have concentrated on the production of a range of threads selected from both series. It is not very clear at present, however, exactly how far this practice is uniform or is represented in the published standards.

The sizes of these threads and of the corresponding B.A. range is shown in Table 1 and illustrated graphically in Fig. **3**.

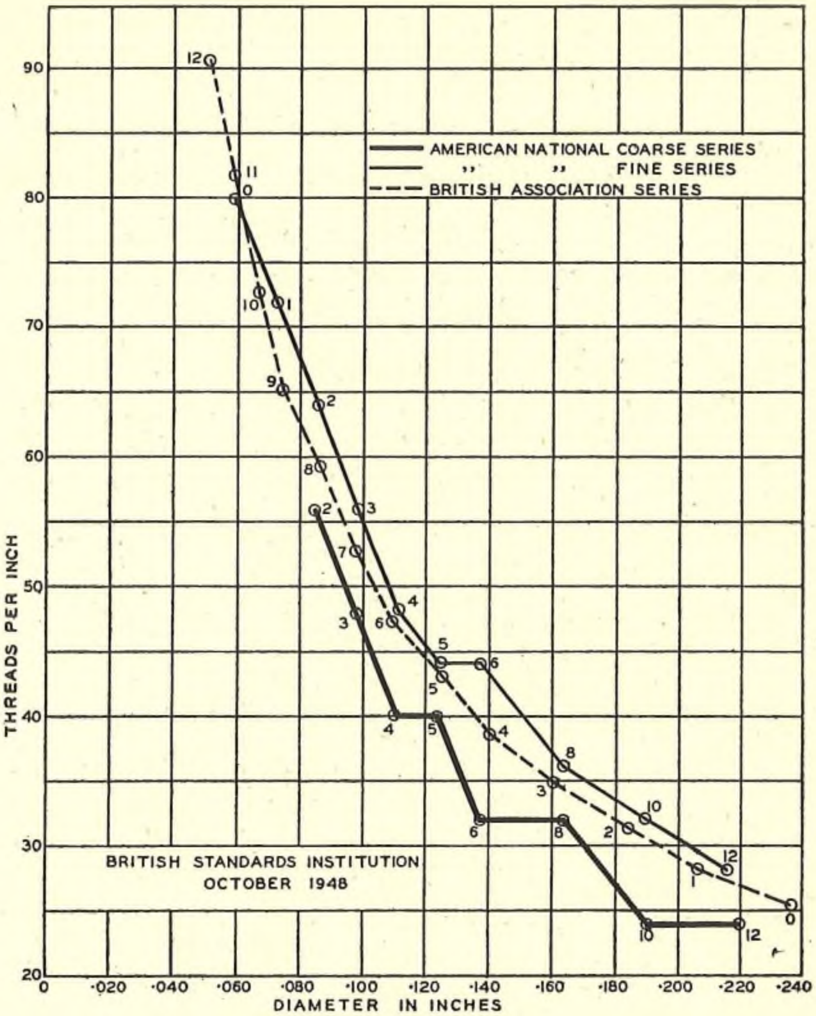



FIG. **3**.—COMPARISON BETWEEN BRITISH AND AMERICAN STANDARD SIZES FOR THEADS IN THE RANGE BELOW $\frac{1}{4}$ INCH.

TABLE 1

| B.A. SERIES | | | | AMERICAN NATIONAL SERIES | | | |
|---|---|---|---|---|---|---|---|
| No. | Diameter mm. | Diameter Inch | T.P.I. (approx.) | No. | Diameter (inch) | T.P.I. Fine | T.P.I. Coarse |
| 0 | 6·0 | ·236 | 25·4 | 12 | ·216 | 28 | 24 |
| 1 | 5·3 | ·209 | 28·2 | 10 | ·190 | 32 | 24 |
| 2 | 4·7 | ·185 | 31·3 | 8 | ·164 | 36 | 32 |
| 3 | 4·1 | ·161 | 34·8 | 6 | ·138 | 40 | 32 |
| 4 | 3·6 | ·142 | 38·5 | 5 | ·125 | 44 | 40 |
| 5 | 3·2 | ·126 | 43·9 | 4 | ·112 | 48 | 40 |
| 6 | 2·8 | ·110 | 47·9 | 3 | ·099 | 56 | 48 |
| 7 | 2·5 | ·098 | 52·9 | 2 | ·086 | 64 | 56 |
| 8 | 2·2 | ·087 | 59·1 | 1 | ·073 | 72 | 64 |
| 9 | 1·9 | ·075 | 65·1 | 0 | ·060 | 80 | — |
| 10 | 1·7 | ·067 | 72·6 | | | | |
| 11 | 1·5 | ·059 | 81·9 | | | | |
| 12 | 1·3 | ·051 | 90·7 | | | | |

It will doubtless be appreciated that one very real difficulty in handling nuts and bolts below $\frac{1}{4}$ in. diameter having different screw threads is the fact that owing to their small size it is physically impossible to mark them with any satisfactory distinguishing marking.

*Conclusion.*

Complete details of the thread sizes and manufacturing tolerances for the Unified Thread Series[1] have not been included in this article as they are of rather limited interest to telecommunication engineers; they will be published by the B.S.I. early this year.

The author would like to acknowledge his indebtedness to the British Standards Institution and to the editor of *Engineering* for making available much of the material used in this article.

[1] A comprehensive summary of the basic dimensions of the series is given in *Engineering*, Vol. 167, No. 4430, of January 21st, 1949.

# A Phase Meter for the Frequency Band 100 kc/s - 20 Mc/s

W. T. DUERDOTH, B.Sc., A.M.I.E.E.

U.D.C. 621.317.772.029.54/.58 : 621.395.645.37

**A phase meter covering the band 100 kc/s to 20 Mc/s is described which is primarily intended for the measurement of the phase change round the feedback loops of amplifiers. An accuracy generally better than ± 3° is possible provided that the loop gain or loss is not greater than 40 db.**

*Introduction.*

THE estimation of the stability margin of a feedback amplifier requires a knowledge of the attenuation and phase shift of the four-terminal path created by breaking the feedback loop. The frequency range over which this information is necessary depends upon the amount of feedback employed and the width of the working frequency band. With multichannel amplifiers working up to 1 Mc/s, measurements up to about 20 Mc/s become necessary and measurements at sub-audio frequencies, although not so essential, are desirable for audio frequency amplifiers.

With amplifiers having a single feedback loop it is not necessary to determine the magnitude of the loop characteristic with great accuracy, ± 1·0 db. being ample, but the accuracy requirements for the phase measurements will depend upon the phase margin of the amplifier. Where the phase change exceeds 150° an accuracy of ± 5° is desirable, but if less than 150° a reduced accuracy is sufficient. With multipath amplifiers, where the addition of two or more paths is concerned, greater accuracy is necessary. It is not possible to give any figures rigidly, but ± 0·5 db. and ± 3° are desirable ; these can be relaxed when the phase margin is great.

The sense of the angle is of importance, particularly for small phase margins. This is not given directly by this apparatus, but when used to plot a Nyquist diagram[1] the succession of points together with the amplitude characteristic leaves no ambiguity.

The apparatus has a high input impedance so that it can be connected to an amplifier without changing its loop characteristic. It has also been designed to operate with low input levels to avoid non-linear distortion in the amplifier.

*Principle and Method of Operation.*

A block schematic diagram of the apparatus is shown in Fig. 1, where it will be seen that the voltages whose phase is to be compared can be picked up by the two probe amplifiers. The outputs of these probe amplifiers, after further amplification, are combined in a three-winding transformer and the resulting voltage is measured by a selective frequency changer working with a constant output frequency of 40 kc/s.

The phase relation between two voltages of equal magnitude can be easily deduced from the magnitude of their sum (this is illustrated in Fig. 2). However,

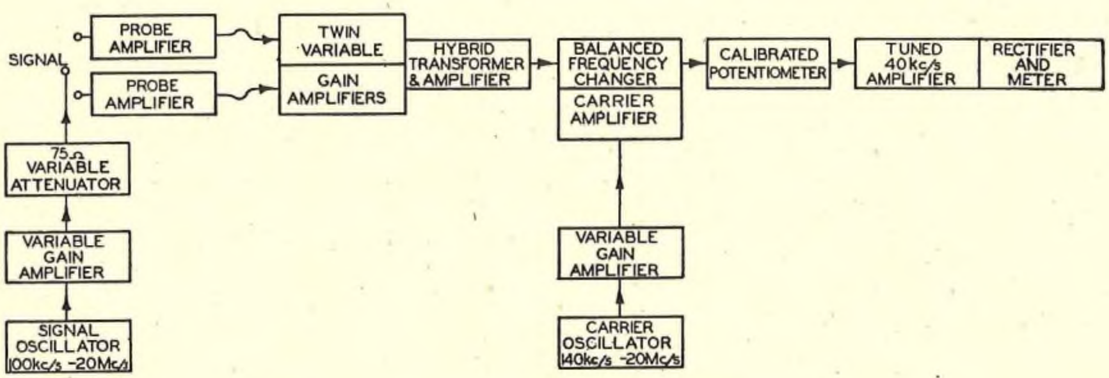



FIG. 1.—BLOCK SCHEMATIC DIAGRAM OF PHASE METER.

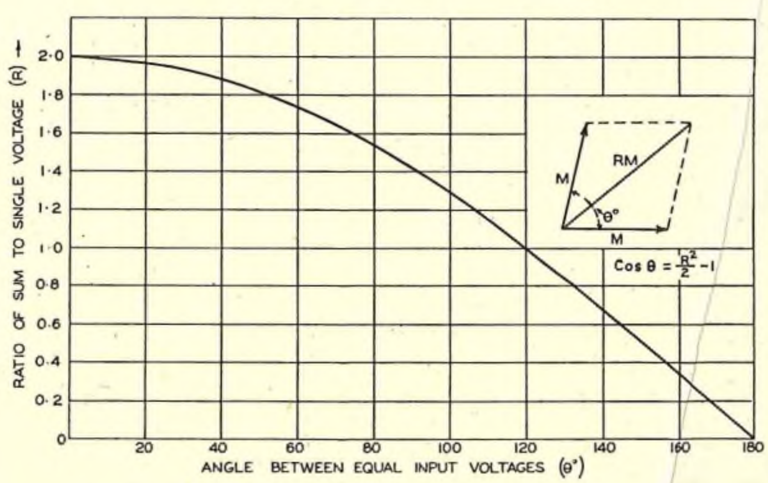



FIG. 2.—RATIO OF MAGNITUDE OF SUM OF TWO EQUAL VOLTAGES AT ANGLE θ°, TO MAGNITUDE OF A SINGLE VOLTAGE.

[1] Nyquist, H., Regeneration Theory, *B.S.T.J.*, January, 1932.

it is necessary to compare the phase of voltages whose magnitude ratio may be 40 db. This has been achieved by employing variable gain amplifiers before the comparison circuit. These amplifiers are the " twin " amplifiers shown in the block schematic diagram and have been so called since their phase changes must be similar to within 1° although their gains be adjusted to differ by some 40 db. The design of these amplifiers was the major problem which had to be solved before this apparatus could be built.

The outputs of the twin amplifiers are combined by the three-winding transformer which is of simple design since its transmission characteristic is not of primary importance, although a high degree of balance between two of the windings is essential. The third winding is connected via a buffer amplifier to the balanced frequency changer. The 40 kc/s output from the frequency changer is applied via a potentiometer to a tuned amplifier and detector.

The apparatus is used to determine the phase relation between two voltages in the following manner. The circuit under test is supplied with a frequency from the signal oscillator, and the probe amplifiers are connected to the required points on the circuit. The modulating frequency is then adjusted to give the 40 kc/s output (its level must be within certain limits indicated by a meter associated with the frequency changer), and infinite loss is introduced into one of the twin amplifiers by earthing a grid; the gain of the other is adjusted so that unity deflection is obtained on the detector meter. After adjusting the other amplifier similarly, the two voltages, now equal in magnitude, are applied together and the potentiometer, previously set to 120°, is adjusted until the meter reading approaches, but is not greater than, unity. The setting of the potentiometer indicates the angle to the nearest 10°, the units being deducted from the meter deflection by means of a calibration chart.

The selection of 120° for the potentiometer setting during adjustment is necessary since 120° is the phase relation between two equal voltages which produce no change in magnitude when combined. (See Fig. **2**.)

*Design of Variable Gain " Twin " Amplifiers.*

These amplifiers (see Fig. **3**) are required to equate the magnitudes of the two voltages to be compared without altering their phase relation. The phase change through the amplifier is of little importance provided that, at all working frequencies and gain settings, it is identical for both amplifiers. The major problem associated with these amplifiers is, therefore, to change their gain by a maximum of about 40 db. without a change of phase in excess of the permissible error.

Both amplifiers are made as similar as possible by using identical layouts and wiring. A 12 db. change in gain is obtained from V1 and three 6 db. steps from V2, the changes being made by Yaxley switches.

Stage V4 is separated from the previous variable stage by a buffer valve V3 and continuous variation in gain is obtained by changing the D.C. bias on V4 by short-circuiting a portion of the decoupled cathode resistor. With this circuit a continuous change of 10 db. produces no measurable change in phase. The switch S3 is employed to earth the grid of V4 to introduce infinite loss in one amplifier while the gain of the other is adjusted.

At the higher frequencies of the working range, an appreciable part of the anode loads is due to the shunt capacitance when the load resistance is high, and to the series inductance of the decoupling loop when the resistance is low. Thus, simple changes of resistance will cause changes of phase angle of the load, but this can be avoided if the anode circuit is similar to that of Fig. **4** and the values of L and C are changed when R is changed so that $L/CR^2$ is a constant. Fig. **4** also shows the frequency responses

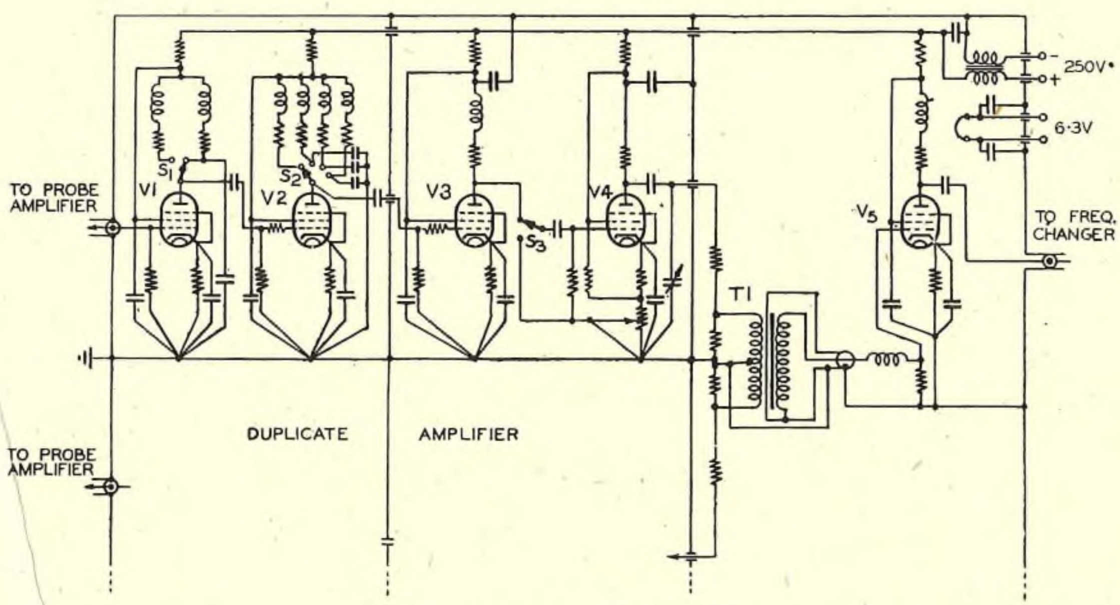



Fig. 3.—" Twin " Amplifiers Circuit.

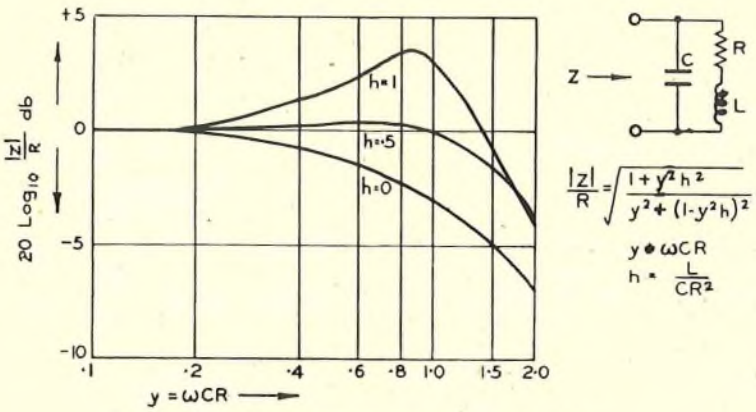



FIG. 4.—ANODE LOAD INCLUDING REACTANCES.

obtained with various values of $h = L/CR^2$. A value of $h = 0{\cdot}5$ which gives a frequency characteristic of $\pm$ 0·4 db. up to $\omega CR = 1{\cdot}2$ (corresponding to 20 Mc/s) has been employed for the anode loads of V1 and V2. The circuit reactances have been minimised by using valves CV 138 and decoupling loops of small area, but parasitic reactances still limit the maximum change of gain possible without additional phase change to 18 db. per stage.

The outputs of stage V4 of both amplifiers are connected to a three-winding transformer T1, the output from which is amplified by V5. This last stage is common to both amplifiers and is designed to provide a flat gain characteristic to the input of the frequency changer.

It will be observed from Fig. 2 that the phase sensitivity of the apparatus is a maximum when the phase angle between the input voltages is 180° and falls as the angle approaches zero. Two transformers are therefore provided, one with windings aiding and the other with the windings opposing, so that the more sensitive condition can always be used.

The twin amplifiers have gain/frequency characteristics which are flat to $\pm$ 3·5 db. and the reactive components of the anode loads have been adjusted so that the frequency characteristics of their gain differences on any setting are within $\pm$ 0·2 db.

The layout of the amplifier is of considerable importance, the apparatus being enclosed in a " coaxial " copper box while screens separate the two amplifiers, the transformer and the output stage, thus reducing crosstalk to a negligible level.

*High Impedance Probe Amplifiers.*

Small probe amplifiers with high input impedances are necessary to enable short connections to be made to the feedback loop of an amplifier and thus avoid modifying its characteristics.

The outputs from the probe amplifiers are connected to the twin amplifiers by 10-ft. lengths of flexible coaxial cable. These leads are terminated by their characteristic resistances( 75 Ω) at the twin amplifiers and constitute the output loads for the probe amplifiers. The probe amplifiers have some 15 db. of feedback which increases the input impedance. The grid leak of the input stage is 2 M Ω so that a range of external capacitance potentiometers may be used without phase change when input capacitances below that of the probe amplifier (10 $\mu\mu$F) are required.

The amplifiers are enclosed in " coaxial structures " and the coaxial leads are terminated in plugs to fit the twin amplifiers. The phase change through the leads is considerable and their lengths must be equal to within 1 inch. It is also important to ensure that the coaxial plugs and sockets are fully engaged or errors up to 2° will occur at the higher frequencies.

The voltage gain/frequency characteristics of the amplifiers are matched by means of inductors in the cathodes of the input valves to within $\pm$ 0·2 db.

*Frequency Changer.*

The frequency changer (see Fig. 5) consists of a pair of triode-hexodes (ECH35) balanced to suppress the carrier frequency in the output. The triode portions of the valves are not employed, the anodes being

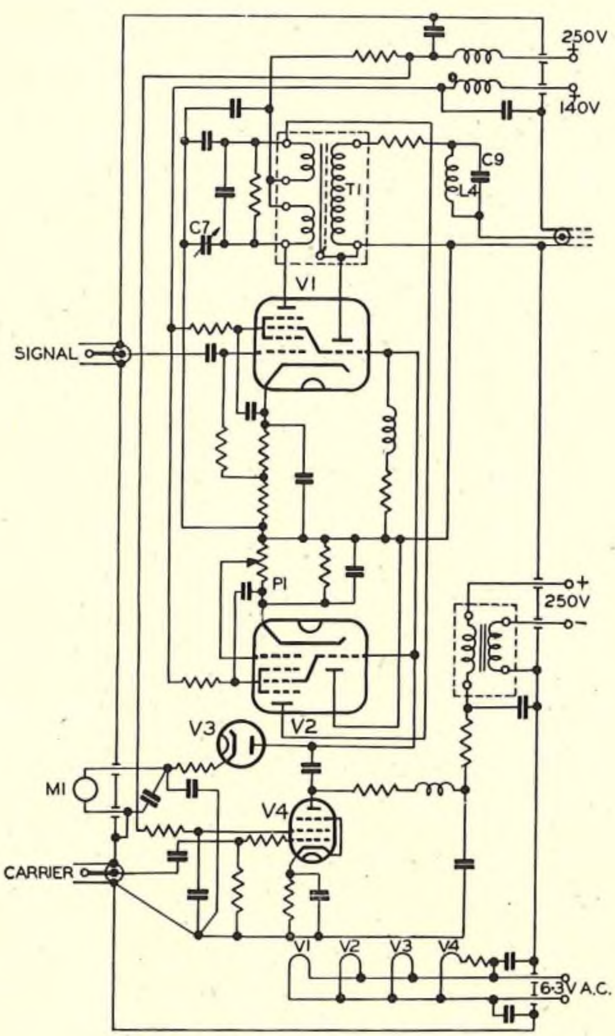



FIG. 5.—FREQUENCY CHANGER CIRCUIT.

earthed and the carrier applied to the oscillator grids. The hexode anodes are connected to an output transformer T1 from which no carrier output will appear provided that both the transformer and the valve gains are adequately balanced. The mutual conductance of V2 is adjusted by means of P1 and the balance of the transformer by C7 ; these adjustments enable the carrier to be sufficiently suppressed to avoid interference in the tuned amplifier.

The signal input is applied to the signal grid of V1 only and appears together with modulation products at the output of T1. With a signal of 100 kc/s a carrier of 140 kc/s is employed and outputs of 240, 100 and 40 kc/s obtained. The selectivity of the tuned amplifier is sufficient to prevent the 240 kc/s tone from producing a deflection on the output meter, but additional suppression is required for the 100 kc/s and is provided by the circuit L4 and C9 tuned to 100 kc/s.

Since carrier inputs ranging from 2-10 volts are required it is necessary to connect the grids of the frequency changer to a high impedance point of the carrier amplifier. The last stage (V4) of this amplifier is therefore included on the same panel as the frequency changer. After amplification the carrier voltage is measured by a half-wave rectifier V3 on a meter M1 and adjustments of the voltage may be used to modify the gain of the frequency changer.

The phase meter is mounted on a 5 ft. 6 in. bay and includes signal and carrier sources, 40 kc/s tuned amplifier, detector circuit and power unit. These components of the equipment are of orthodox design and do not warrant special description.

*Performance Tests.*

The equipment has been designed and adjusted so that the critical paths consisting of the probe and twin amplifiers have amplitude/frequency responses which are similar to within $\pm$ 0·3 db. This accuracy has been achieved by careful adjustments and by making measurements accurate to 0·1 db. over the whole frequency range. These measurements are only possible if testing apparatus is used which makes a continuous coaxial structure with the equipment under test. All the adjustments of the equipment had the similarity of amplitude responses as their goal. This is justified since similar amplitude responses result in similar phase responses provided that certain types of networks are avoided and the amplitude responses are similar over a much wider frequency band. Measurements above 20 Mc/s, however, were not attempted and indeed do not appear necessary since direct checks on phase measurements made by the equipment indicate that the required accuracy had been achieved.

The phase accuracy of the equipment was checked by the following methods :

(1) The two probe amplifiers were connected to the same source. This should result in zero output when both amplifiers are effective. This check was made at a number of frequencies within the range and with all combinations of gain settings.

(2) The phase relation between unequal voltages was measured. The voltages were obtained by small resistance pads with compensation for parasitic reactances so that the unequal voltages were, as far as possible, in phase unison.

(3) The phase change through a coaxial cable with little attenuation was measured and successive checks made with progressively shorter lengths.

(4) The phase change through networks having a calculated attenuation and phase change were measured.

In each case all possible combinations of gain settings of the twin amplifiers were used and an accuracy generally better than $\pm$ 3° obtained. The maximum errors occurred at 20 Mc/s when using gain settings which are not required in practice.

*Use of the Equipment.*

The equipment was built to measure the feedback loops of amplifiers and has been successfully used for this purpose. In particular, it has made possible the development of amplifiers having more than one feedback path. The stability of such amplifiers often depends on the combined voltage obtained from the paths and the estimation of this voltage necessitates accurate measurements of the attenuation and phase change of the individual paths so that the vector sum can be obtained.

A further use of the equipment is to measure the stability margin of amplifiers. Hitherto, this has only been possible by elaborate laboratory apparatus and has been restricted to the first few models of an amplifier, but this equipment makes possible an acceptance test, to be made on all new amplifiers, which will enable those with too small a stability margin to be rejected.

The equipment can obviously be employed for other phase measurements not associated with amplifiers.

*Acknowledgment.*

Acknowledgment is due to Mr. J. Garlick, who organised much of the construction work associated with the equipment and undertook the very tedious precision measurements required to line up the equipment.

# Nomenclature of Frequencies

C. F. BOOTH, O.B.E., M.I.E.E

U.D.C. 621.3.029 : 001.4

**The present designation of the frequency bands employed in telecommunications is based on the use of terms which originally were intended to be of a descriptive character, but which, in recent years, due to the extension of techniques in the higher range of frequency, have become meaningless strings of adjectives, and this has led to much confusion. An alternative classification based on the logarithm of the geometric mean of the frequency band is examined and it is shown that the system is free from ambiguity, and is capable of unlimited extension even to frequencies as far as those corresponding to penetrating radiation.**

*Introduction.*

THE rapid upward extension of the frequencies used for radio communication has emphasised the limitations of the nomenclature at present employed for the sub-division of the frequency spectrum. Whereas the technical problems arising from the application of these frequencies have, in the main, been successfully tackled, the problem of frequency classification has not yet been satisfactorily solved. This position is unhappy since the use of an unsound, and consequently vague, nomenclature acts as a handicap to the dissemination of technical knowledge.

Until about fifteen years ago it was usual to classify the spectrum employed for radio communication, approximately 15 kilocycles per second (kc/s) to 100 megacycles per second (Mc/s) at that time, in terms of wavelength rather than frequency, and to speak of long, medium, short and ultra-short waves. Somewhat later a corresponding frequency classification was introduced, namely, " low," " medium," " high " and " very high frequencies " respectively. During the past fifteen years the highest frequency employed by the radio engineer has increased from about 100 to more than 30,000 Mc/s. Although a satisfactory metric sub-division of wavelength was proposed and applied, the use of superlatives for classification was extended to name the corresponding frequency bands—*ad nauseam*—as the upper frequency limit was increased. This procedure has led to the use of the terms " very," " ultra," " super " and " extremely high frequencies," with consequent ambiguity. It is the purpose of this article to outline the present classification and its limitations and to describe an alternative nomenclature which avoids the difficulties of the existing system.

*Present Nomenclature.*

The present nomenclature, which is based on the recommendation[1] of the IVth C.C.I.R. meeting held at Bucharest in 1937, was approved by the International Radio Conference held at Atlantic City in 1947. However, the Bucharest recommendations were used by many during the 10 years which elapsed before they could be given international approval. The nomenclature[2] accepted at Atlantic City is in accordance with Table 1.

TABLE 1.
PRESENT NOMENCLATURE.

| Frequency Sub-division | Frequency Range* | Metric Sub-division |
|---|---|---|
| VLF (Very Low Frequency) | Below 30 kc/s | Myriametric Waves |
| LF (Low Frequency) | 30 to 300 kc/s | Kilometric Waves |
| MF (Medium Frequency) | 300 to 3,000 kc/s | Hectometric Waves |
| HF (High Frequency) | 3,000 to 30,000 kc/s | Decametric Waves |
| VHF (Very High Frequency) | 30,000 kc/s to 300 Mc/s | Metric Waves |
| UHF (Ultra High Frequency) | 300 to 3,000 Mc/s | Decimetric Waves |
| SHF (Super High Frequency) | 3,000 to 30,000 Mc/s | Centimetric Waves |
| EHF (Extremely High Frequency) | 30,000 to 300,000 Mc/s | Millimetric Waves |

* Frequencies shall be expressed in kilocycles per second (kc/s) at and below 30,000 kilocycles per second, and in megacycles per second (Mc/s) above this frequency.

The frequency terms quoted in the table are almost identical with the Glossary of Terms[3] published by the British Standards Institution ; the differences are that in the Glossary the term " Super-frequency " replaces " Super High Frequency " in the table, and the E.H.F. (Extremely High Frequency) range is omitted from the glossary. It will be seen from the table that the range up to 300,000 Mc/s is covered by eight frequency bands in decade steps, the corresponding wave bands being designated according to the metric system.

Although this nomenclature has been recommended —substantially in its present form—since 1937, it has not been adopted consistently by technical writers as may be judged from the following short selection from recent publications :—

(*a*) Ultra High Frequency for frequencies above 50 Mc/s.
(*b*) Ultra High Frequency for 25 to 120 Mc/s.
(*c*) Ultra High Frequency for 30 to 1,000 Mc/s.
(*d*) Very High Frequency for frequencies above 100 Mc/s.
(*e*) Very High Frequency for frequencies above 700 Mc/s.
(*f*) Extra High Frequency for frequencies above 30 Mc/s.
(*g*) Hyper Frequency for 1,000 to 10,000 Mc/s.
(*h*) Very Short Waves for wavelengths below 1 metre.
(*i*) Microwaves for wavelengths 0·1 to 10 cms.
(*j*) Ultra and Extreme Short Waves for wavelengths 0·01 to 50 metres.

The wave band classification is a sound one and should not be subject to ambiguity, but this cannot be said of the frequency classification. Perhaps the primary fault of this frequency classification is the choice of phrases already in common use to designate precise frequency bands. The reader can never be certain whether an author is using a phrase in its vague general sense or in its precise restricted sense.

[1] IVth Reunion, Bucharest, 1937, Tome II, page 244, Avis No. 85. " Classification of Radio Electric Waves."

[2] Atlantic City, Radio Regulations, Section III, para. 85. § 10.

[3] " Glossary of Terms used in Telecommunication, British Standard 204 : 1943."

Thus, a writer may reasonably refer to loudspeaker performance at high frequencies and mean by this term 5 to 15 kc/s and not 3,000 to 30,000 kc/s, or he might comment that cavity resonators are unduly bulky at low frequencies and intend to refer to frequencies of a few hundred megacycles per second and not the band 30 to 300 kc/s for which his comment would also be true, but, for most readers, superfluous. Again, the allocation of adjectives is apparently arbitrary and few would agree on the order of the relative magnitude of the terms " very," " ultra," " super," " extremely," so that the reader must rely on unaided memory to name the bands. Although the table stops at 300,000 Mc/s it is desirable to include frequencies up to at least 3,000,000 Mc/s, since the Radio Regulations of Atlantic City define Hertzian[4] waves as " Electromagnetic waves of frequencies between 10 kc/s and 3,000,000 Mc/s." In order to include the additional frequency range 300,000 to 3,000,000 Mc/s it would be necessary to introduce a term such as " Extremely Ultra." This clearly demonstrates the limitations and unsoundness of the classification, since further extension increases the existing ambiguity. Finally, the classification is inelegant and unnecessarily so.

*The Alternative Proposal.*

As far back as May, 1942, B. C. Fleming-Williams proposed[5] to end the existing confusion in frequency band nomenclature by dividing the frequency range into decade bands, each designated in terms of the common logarithm of its lower frequency expressed in cycles per second. Frequencies given by $x\,.10^N$ where $1 < x < 10$ and N is an integer would be regarded as in band N.

Such a system requires little mental effort and is capable of extension as higher frequencies are exploited. Its main disadvantage is that the frequency bands so defined do not correspond with those of Table 1 which are based on a metric wavelength decade, and which are familiar to many.

The possible application of the principle originally enumerated by Fleming-Williams has, however, been considered recently by several people. As a result, a frequency classification with the advantages of the principle, but based on the frequency bands of Table 1, has been suggested. This is achieved by designating the frequency bands corresponding to those of Table 1 by the logarithm of the approximate geometric mean of the frequency limits (the geometric mean is the square root of the product), always expressed in cycles per second. Thus, the band 3,000 to 30,000 kc/s has an approximate geometric mean of 10,000 kc/s or $10^7$ c/s and would be designated Band 7. Similarly, the geometric mean (in c/s) of the band 30 to 300 c/s is approximately $10^2$ c/s so it is Band 2. The simple rules for conversion from Band Number to frequency range and vice versa are given below—

*Conversion from Band Number to Frequency Range.* The lower and upper frequencies of the band in c/s are given by $0{\cdot}3 \times 10^N$ and $3 \times 10^N$, respectively, where " N " is the Band Number.

[4] Atlantic City, Radio Regulations, Chapter 1, Article 1 (5).
[5] Letter to the Editor of the *Wireless Engineer.*

*Conversion from Frequency Range to Band Number.* For any frequency given by $x\,.\,10^N$ c/s, where $0{\cdot}3 < x < 3{\cdot}0$, the Band Number is N.

The proposed Band Numbers, and the corresponding frequency and wavelength ranges are set out in Table 2 and in Fig. **1**.

TABLE 2.
POSSIBLE ALTERNATIVE CLASSIFICATION.

| Frequency Sub-division | Frequency Range | Wavelength Range | Wavelength Sub-division |
|---|---|---|---|
| Band 1 | 3 to 30 c/s | — | — |
| Band 2 | 30 to 300 c/s | — | — |
| Band 3 | 300 to 3,000 c/s | — | — |
| Band 4 | 3,000 c/s to 30 kc/s | 100 to 10 kilometres | Myriametric Waves |
| Band 5 | 30 to 300 kc/s | 10 to 1 kilometres | Kilometric Waves |
| Band 6 | 300 to 3,000 kc/s | 1,000 to 100 metres | Hectometric Waves |
| Band 7 | 3,000 to 30,000 kc/s | 100 to 10 metres | Decametric Waves |
| Band 8 | 30,000 kc/s to 300 Mc/s | 10 to 1 metres | Metric Waves |
| Band 9 | 300 to 3,000 Mc/s | 100 to 10 centimetres | Decimetric Waves |
| Band 10 | 3,000 to 30,000 Mc/s | 10 to 1 centimetres | Centimetric Waves |
| Band 11 | 30,000 to 300,000 Mc/s | 10 to 1 millimetres | Millimetric Waves |
| Band 12 | 300,000 to 3,000,000 Mc/s | 1 to 0·1 millimetres | |
| Band 13 | $3 \times 10^6$ to $3 \times 10^7$ Mc/s | 0·1 to 0·01 millimetres | |
| Band 14 | $3 \times 10^7$ to $3 \times 10^8$ Mc/s | 0·01 to 0·001 millimetres (10 to 1 microns*) | |
| Band 15 | $3 \times 10^8$ to $3 \times 10^9$ Mc/s | 0·001 to 0·0001 millimetres (10,000 to 1,000 Angstrom Units †) | |

* 1,000 microns = 1 millimetre.

† 10,000 Angstrom units = 1 micron, and the visible spectrum extends from 3,600 to 7,700 Ansgtrom units.

The frequency spectrum 3 c/s to 3,000,000 Mc/s is classified by 12 bands in decade steps. The wave band classification is in accordance with that of Table 1. It will be noted from the table and figure that by extending the Band Number up to 15 it is possible to include infra-red and visible light waves. The frequency classification could, of course, be extended indefinitely.

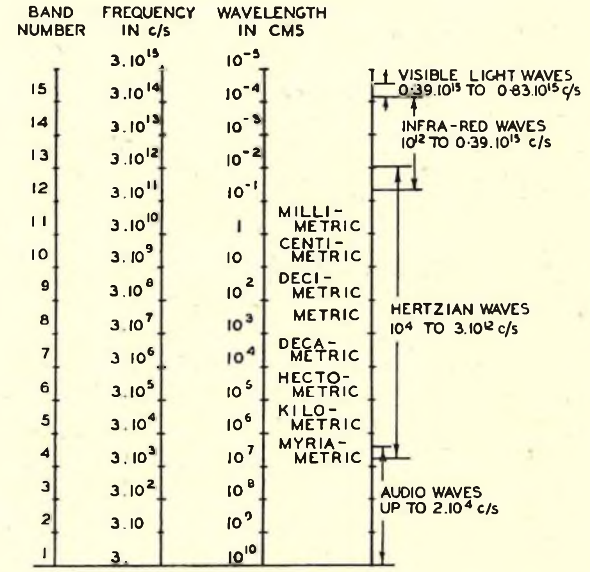



FIG. **1**.—FREQUENCY AND WAVELENGTH RANGES CORRESPONDING TO PROPOSED BAND NUMBERS.

*Conclusions.*

The frequency classification proposed is precise, simple to use and capable of unlimited extension. All that is necessary for the Band Number to appear explicitly in the statement of any frequency is to express the frequency in cycles/second, by a number between 0·3 and 3·0, times the appropriate integral power of ten.

It is considered to have many advantages over the existing systems, and, in the opinion of the writer, the possibility of its introduction as a replacement of the present nomenclature merits serious consideration.

Arrangements are already in hand to use this nomenclature in P.O. Engineering Department Reports.

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# The Institution of Post Office Electrical Engineers

## Annual Awards, Junior Section Papers

SESSION, 1947/48

The Judging Committee has selected the following from the papers submitted by the Local Centre Committees, and awards of £3 3s. and Institution certificates have been made accordingly.

K. D. Jackson, Southampton Centre. " Amateur Radio Transmitting."

D. S. C. Buchan and G. Booth, Aberdeen Centre. " London-Peterhead-Oslo."

D. O'R. Macnamara, London Centre. " Frequency Modulation."

R. F. Howard, London Centre. " Impulsing."

*G. H. Rouse, London Centre. " The New Standard Uniselector—Some Mechanical Developments."

*M. B. Moore, London Centre. " The 2,000 Type Selector."

* *Award shared.*

The Council is indebted to Messrs. W. E. Hudson, E. W. Anderson and I. H. Wallis for kindly undertaking the adjudication of the papers submitted for consideration.

J. READING,
Secretary.

## London Centre

The date of the final Meeting of the current Session previously announced as Tuesday, May 3rd, has been changed to Tuesday, May 10th. The Meeting will be preceded by the Annual General Meeting of the Institution commencing at 5 p.m.

## Additions to Library

Recent additions to the Library include the following :—

1772 *Principles of Radar.* Members of the staff of the Radar School Massachusetts Institute of Technology (American).

Originally prepared for use in the war training courses in principles and applications of radar to American Armed Forces at the Institute. The book begins with a brief description of the components and functions of radar systems and continues with detailed discussion of typical system components. Expositions of circuits and devices provide an unusual combination of technically thorough and accurate treatments with minimum dependence on mathematics. Emphasis in the treatment of circuits is upon quantitative analysis directly from tube characteristics and physical principles. Comprehensively covers timing circuits ; indicators ; receivers ; magnetrons ; modulators ; triode transmitters ; radio frequency lines ; radar antennas and propagations ; wave guides and cavity resonators ; transmit-receive devices ; synchros and servomechanisms.

1773 *What is Atomic Physics ?* K. Mendelssohn (British 1946).

Deals with discoveries rather than with inventions ; it is concerned with the " whys " of atomic energy rather than with the " hows". Its aim is to give, with a minimum of technicalities, a broad survey of the field of atomic physics and to familiarise the reader with the fundamental discoveries which ultimately led to the release of atomic energy. The book explains why the atomic nucleus is a potential source of energy and why this energy is so much greater than that which can be drawn from the combustion of coal or the explosion of T.N.T. The essential difference between the physical laws which govern the world of everyday experience and those which determine the structure of the atom is discussed at length. Nuclear fission and the controlled release of atomic energy are dealt with and a separate chapter is devoted to atomic energy production in the sun and stars. Unnecessarily technical words have been avoided throughout the text.

1774 *Electrical Illumination.* J. O. Kraehenbuehl (American 1947).

Deals with principles underlying the specification and design of electrical lighting for commercial and industrial buildings. No attempt made to treat every type of installation and equipment, but only the important fundamentals that govern lighting practice. A special effort has been made to eliminate complicated mathematical developments. The treatment covers objective and subjective specification of illumination ; colour and shadow ; distribution curves and point-by-point method of determining illumination ; electrical incandescent and gaseous vapour light sources ; light control ; general illumination design ; luminous architectural elements; floodlighting; novelty lighting; maintenance and economics ; automatic control ; and wiring.

1777 *Telephone Manufacturers of India Ltd. Report on the proposed conversion of the Calcutta Telephone Network to Automatic Working.*

Vol. III. Exchange Specifications.

1778 *Practical Optics.* B. K. Johnson (British 1947).

Optical technique and fundamental optical principles concisely explained in practical form, particular attention being given to the practical applications of optical principles in the four main types of instruments—telescopes, microscopes, photographic lenses, and projection apparatus. A section on optical glass helps towards a fuller appreciation of the art and skill required in producing high quality optical work. Sufficient theory is given to enable the experimental illustrations to be carried out intelligently. Although closely related to the principle of optics, the design of lens systems is not dealt with in this book.

(*Continued on page* 60)

# Notes and Comments

### Roll of Honour

The Board of Editors deeply regrets to have to record the death of the following member of the Engineering Department :—

| | | | |
|---|---|---|---|
| Reading Telephone Area | Smith, R. A. M. | Technician | Lieut., Fleet Air Arm, R.N. |

### Recent Awards

The Board of Editors has learnt with great pleasure of the honours recently conferred upon the following members of the Engineering Department :—

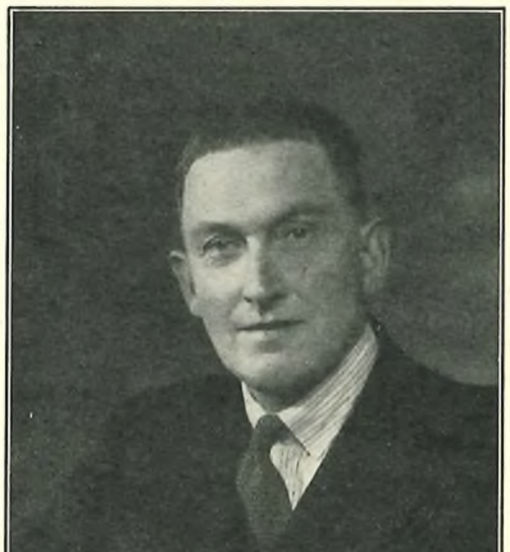
| | | | | |
|---|---|---|---|---|
| Bradford Telephone Area | Hall, G. K., O.B.E. | Engineer | Lieut.-Col., Royal Signals | American Bronze Star |
| London Telecomms. Region | Clark, H. W. | Technician | Lieutenant, Royal Signals | Mentioned in Despatches |

### New Year Honours

The Board of Editors offers congratulations to the following members of the Engineering Department honoured by H.M. The King in the New Year Honours List :—

| | | | |
|---|---|---|---|
| Belfast Telephone Area | Oliver, W. | Inspector | British Empire Medal |
| Cardiff Telephone Area | Marks, J. S. | Inspector | British Empire Medal |
| Engineering Department | Buxton, R. S. | Asst. Foreman Photoprinter | British Empire Medal |
| Engineering Department | Gill, A. J. | Engineer-in-Chief | Knight Bachelor |
| Engineering Department | Sheppard, Miss A. M. | Executive Officer | Member of the Order of the British Empire |
| North-Eastern Region | Allies, H. J., M.M. | Engineer | Member of the Order of the British Empire |
| Welsh and Border Counties Region | Morgan, J. | Chief Regional Engineer | Officer of the Order of the British Empire |

### Sir Archibald J. Gill, B.Sc.(Eng.), M.I.E.E., F.I.R.E.



The knighthood conferred upon the Engineer-in-Chief, Mr. A. J. Gill, in the New Year Honours List, has caused gratification to the whole of the Engineering staff of the Post Office.

Sir Archibald's career in the Engineering Department, commencing in 1913, has been marked throughout by his widespread popularity, originality and enterprise, and his promotion to Engineer-in-Chief on the retirement of Sir Stanley Angwin was warmly welcomed in all quarters.

We feel that the honour bestowed upon him is of double significance ; it is a fitting tribute to one whose many and varied activities have done much to increase the prestige enjoyed by the Department, and at the same time it gives recognition to the services rendered by the Department as a whole under his able leadership.

Sir Archibald's many friends and associates in the telecommunications sphere will undoubtedly wish to join with us in offering him sincere congratulations on his latest distinction.

### Post Office Honours

We were pleased to note that the New Year Honours List included the names of Mr. G. T. Anstey, Comptroller and Accountant General (Companion of the Order of the Bath) and Mr. D. Mackenzie, M.M., Deputy Regional Director, North Eastern Region (Commander of the Order of the British Empire).

### Mr. T. F. Lee, O.B.E.

With the retirement of Mr. T. F. Lee, on 31st December, 1948, his service as Secretary to the main equipment contractors' committees, spreading over the last 20 years, comes to an end. Mr. Lee was awarded an O.B.E. in 1947, in recognition of the splendid services rendered by him during this lengthy period, and in wishing him an enjoyable retirement we would express appreciation of the ability he displayed in maintaining good relations between the Post Office and its principal suppliers of telecommunications equipment.

The vacancy caused by Mr. Lee's retirement has been filled by the appointment of Mr. D. S. Hunter.

## Retirement of Mr. H. G. S. Peck, B.Sc.(Eng.), M.I.E.E.

The retirement of Mr. H. G. S. Peck closes the official career of one of the most able of the engineering officers transferred from the National Telephone Co.

He joined the company's staff in 1901, and acquired extensive experience in exchange construction and subscribers' apparatus fitting and maintenance. Retained by the Company to assist in connection with the Arbitration Court proceedings, he came to the Post Office in 1913 as Chief Inspector and, in 1914, being successful in the Limited Competition, was appointed Assistant Engineer. Some years later he obtained the B.Sc.(Eng.)Lond. degree with 1st Cl. Hons.

Peck served in 1916/19 in the R.F.C. and R.A.F., and returned to the London District, where he remained until 1922, in which year he was transferred to the Telephone Section, E.-in-C.'s office. There, he

was concerned particularly with the design and installation of large P.B.X.'s, the wiring of buildings, and the conversion of the London and Birmingham Areas from manual to automatic.

In 1930, Peck went to the Centre Section L.E.D. as Sectional Engineer and, later, was for two years in charge of the London Technical Section, which he left in 1935, on promotion to Asst. Suptg. Engineer, N. Wales. He was appointed Staff Engineer, Equipment Branch, in 1939, and, in the war years that followed, his notable contribution to the successful work of the Precedence Panel for Line Telecommunication Equipment, and other related bodies, constitutes, perhaps, his crowning achievement. Throughout those years he was also Chief A.R.P. Officer in the Engineering Department. From 1946 to his retirement Peck was in charge of the Organisation and Efficiency Branch.

His many friends regret the departure of a good colleague whose advice, often sought, was so freely given, and wish him good health and much happiness in his retirement. P. J. R.

## Mr. L. F. Scantlebury, A.C.G.I., D.I.C., A.M.I.E.E.

Congratulations to Mr. L. F. Scantlebury, Assistant Staff Engineer, on his promotion to Staff Engineer, " O " Branch, in succession to Mr. H. G. S. Peck.

Mr. Scantlebury entered H.M. Dockyard, Devonport, as electrical fitter apprentice in 1922, and completed this sound introduction to an engineering career by gaining a Whitworth Scholarship in 1926. Following a three years' Electrical Engineering Course at the City and Guilds Engineering College, London, he gained the Diploma of the City and Guilds Institute.

He entered the Post Office as Probationary Assistant Engineer in 1930, and after the first of the 3 months' training courses which were introduced for this grade, completed his field training in what was then the office of the Superintending Engineer, South Western District. In 1931, he was appointed Assistant Engineer, Bournemouth Section.

In 1937, Mr. Scantlebury left the warm, sunny climate of the south for the bracing air of " Auld Reekie " and promotion to Executive Engineer on efficiency duties in Scotland. He performed these duties with his characteristic enthusiasm and initiative, and on the outbreak of war in 1939 he replaced the peace-time aspects of these activities by liaison duties between the Post Office and Headquarters, Scottish Command.

In 1943, he was promoted Assistant Staff Engineer in " O " Branch, Engineering Department, and was engaged in the difficult and complex work of the Engineering Reorganisation. His sound knowledge, ability to work quickly at high pressure, and also his sense of humour, helped him through that difficult period. These same qualities will ensure his success, and the Engineering Department will gain by his promotion to Staff Engineer.

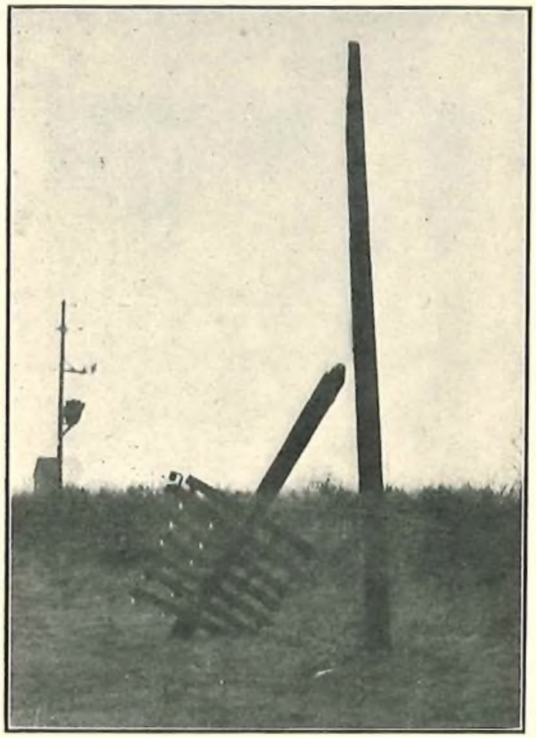
He is very interested in music and possesses a fine singing voice. When in Edinburgh he was in the Edinburgh Choral Union, and is at present a member of the Goldsmiths Choral Union. H. A. A.

# Regional Notes

## North-Eastern Region

SNOW STORM, 30/31st DECEMBER, 1948

On the evening of the 30th December, 1948, a snow storm swept through a portion of the North-East Region and continued until midnight of the following day. The fall of snow was heavy at times and, with freezing conditions prevailing, overhead wires were soon covered with frozen snow. The peculiar feature about the storm was that it occurred in a 15 to 20 miles belt at a south-west to north-east line across the southern part of the Region, affecting a portion of the Sheffield, Lincoln and York Areas. No damage was suffered by areas immediately north and south of the belt. The danger to traffic was such that the B.B.C. broadcast in their News Bulletin, on both Home and Light Programmes on 30th December, 1948, warning road users to proceed with caution on account of broken poles and wires.



Typical Damage Caused by Snow Storm.

Twenty-two exchanges were isolated as a result of the storm. Within four days, communication was restored to all but four; these were restored within a further two days. Approximately one third of all subscribers' lines in the affected area were faulty and damage was particularly severe in the Worksop and Chesterfield Maintenance Control Areas. The percentages of faulty subscribers were 51 and 63 respectively. The peak period for outstanding faults occurred five days after the commencement of the storm when almost 10,000 subscribers' and 148 junction circuits were still out of service. From this date the number was reduced daily, although for a few days round about 10th January, 1949, strong winds prevented as quick a reduction as was desired, even though additional staff had been drafted into the area.

Many overhead routes suffered serious damage in that wires were down for comparatively long distances, as will be gathered from the fact that approximately 70 miles of I.R. interruption cable were erected to effect temporary repairs. Apart from this, 255 broken poles will have to be replaced, over 2,000 miles of wires renewed and 207,000 spans of wire regulated, as well as stays erected, and so on. The photograph shows a typical instance of damage.

Finally, it must be added that the Supplies Department responded to the full in meeting quickly urgent demands for stores. Expeditious delivery was accomplished by their fleet of lorries, thus enabling circuits to be restored quickly when, otherwise, serious delay would have occurred. J. A.

EXCHANGE CONVERSIONS IN WHARFEDALE

An interesting sequence of exchange conversions and changes of traffic routings is approaching completion in Wharfedale.

Lothersdale, a U.A.X. No. 5 on the eastern side of the Pennines, on its recent conversion to U.A.X. No. 12, ceased to be dependent on Crosshills manual exchange and was parented on Bradford until Crosshills could be converted to automatic working.

Crosshills was opened as an automatic exchange on 25th January, 1949. The 45-year-old magneto exchange was replaced by U.A.X. No. 14 equipment in a D type building which was completed in 1939 but was used during the war for the storage of emergency equipment. The new equipment has an initial capacity of 600 lines and was installed by Ericsson Telephones, Ltd.; it comprises 6 A units, 2 B units, 13 C units and 1 D unit. The Crosshills subscribers have direct access to Keighley N.D. exchange, Skipton (magneto) exchange, Cowling U.A.X. 12, Steeton U.A.X. 7 and Lothersdale U.A.X. 12 on first selector levels 4 to 8. Level 0 calls are routed to Bradford auto manual board and level 9 calls to the Bradford auto equipment, thus giving access to service levels and to Bradford's satellites.

Besides the 408 Crosshills subscribers' lines, 61 junctions were successfully cut over. The transfer of the junctions was complicated by the following operations which took place simultaneously so as to avoid a succession of instructions to the affected subscribers and to coincide with the issue of the new directory :—

1. Lothersdale U.A.X. No. 12 and Cowling U.A.X. No. 12 became dependent on Crosshills and lost their direct parent routes to Bradford. This involved level changes on the selectors at the U.A.X.s.
2. Steeton U.A.X. 7 had its parent route transferred from Keighley to Bradford.
3. Cullingworth, which was formerly a satellite on Keighley, was converted to non-director working with remote manual board at Bradford. This involved level changes at Keighley and Cullingworth and the modification of D.S.R.s at Cullingworth to work as digit-absorbing first selectors.

The final step in the present sequence of operations will be the removal of the auto manual board from Keighley. Further developments such as the replacement of the magneto exchange at Skipton and the full operation of Skipton as an auto manual switching centre must be deferred until a new building at Skipton can be provided.

## Midland Region

STORM DAMAGE

Extensive damage was caused by a fall of snow (4-5 inches) on 30th December, 1948. The storm was unusual, inasmuch as the snow fell for only a few hours and had nearly disappeared two days later. There was hardly any wind and the worst damage to plant occurred in sheltered localities. The damage was limited to a belt, approximately 20 miles wide, stretching across the middle of the Stoke-on-Trent Telephone Area and the northern part of the Nottingham Telephone Area, in a south-west to north-east direction.

The snow was of a moist, clinging nature, which adhered to the overhead wires, forming cylinders of ice along their entire lengths, and the weight on the wires was such that where the poles held, the wires were badly stretched. In many cases the poles were broken or badly deflected. Some idea of the extent of the damage can be gained from the following details.

4,000 miles of wire required renewing.
Regulation of wires was required at 160,000 points.
2,220 poles required re-setting and 140 were broken.
1,080 stays required renewal.

Interruption to service was caused to nearly 12,000 subscribers and 400 trunks and junctions ; 31 exchanges were isolated. Delay in restoration in many cases was due to the necessity of having both to re-set the poles and re-stay before the wires could be re-erected.

This widespread collapse of plant naturally caused some anxious moments. In Mansfield three stays snapped and allowed a 60 ft. pole, supporting an overhead trunk route, to lean towards a railway viaduct, thus allowing the wires to sag until they were in danger of fouling passing trains. The photograph shows efforts

*Photo: " Mansfield Advertiser "*

CLEARING SNOW FROM WIRES ACROSS RAILWAY VIADUCT AT MANSFIELD.

being made to clear the wires of snow in order to reduce the sag and so allow the trains to pass with safety. In another instance the head of a trunk pole snapped and fell into the roof of a cinema while a performance was in progress—fortunately no one was hurt.

Assistance was given by the remaining four Areas of this Region (i.e. Birmingham, Leicester, Coventry and Peterborough) and also the North-Eastern Region by the loan of gangs.

The finding of accommodation for the visiting gangs was greatly assisted by facilities offered at the following places:

Miners' hostels in the Nottingham and Stoke-on-Trent Telephone Areas.

The Engineer-in-Chief's Central Training School at Stone.

A Ministry of Supply hostel not far from the Central Training School.

In all these establishments the general welfare and hospitality were greatly appreciated by the visitors and contributed to a marked extent to the speedy restoration of service.

## Scottish Region

### PEEL CONNER TELEPHONE SYSTEM. QUARTER CENTURY OF SERVICE

On 15th March, 1924, Dundee experienced a changeover from the " ancient " to the " modern." Prior to this, the telephone service in Dundee had laboured under the obsolete and unpopular " call wire " system which is believed to have been the last of its kind in Great Britain.

The Dundee and Broughty Ferry automatic telephone plant was a North Electric system of American design, manufactured and installed by the Peel Conner works of the General Electric Company. Most of the equipment and spare parts were obtainable only from the U.S.A. and in post-war years the normal source of supply was closed altogether. However, the Factories Department came to the rescue and have done valuable work in making all spare parts required. The only item which is unobtainable is a complete selector, but the lack of this has now been overcome by the provision of 2000-type selectors which are working satisfactorily alongside the old, even though the voltage is only 46. The exchange opened with a multiple of 3,500, which has now grown to 4,500.

The maintenance of the equipment has been " hereditary," details of adjustment having been handed down to staff trained in Dundee Central, the practice being to retain a man in the exchange who had been " brought up " as a youth in it. Standard adjustments do not meet the case and, although the Strowger step-by-step principle applies to the system, the switches bear no resemblance to our familiar P.O. pattern. The two-motion selector wipers rotate horizontally before carrying out selection on the vertical motion, and this in itself involves a radical difference in the design of banks and mechanisms.

In 1945 a maintenance drive was made, this time enlisting the aid of the Factories Department for supplies. Since then the service given by the exchange has exceeded all expectations. Great credit is due to the staff who maintain it, as strict routining is necessary to keep the equipment working at its best, and the system has a few inherent faults which only experienced staff can deal with.

It will be some years yet before Dundee and Broughty Ferry will have new exchanges and there is no doubt whatever of the old " North Electric " keeping up its grand tradition until that time comes.

The " Old Exchange " will never die, it will only fade away.

A. N. B. D.

## Welsh and Border Counties Region

### RE-DRUMMING LENGTH OF CABLE WEIGHING 17 TONS

In 1942 the Submarine Section decided to leave at Pembroke Dock a drum with 1,013 yards of 138/20 + 4/40 sc. subaqueous cable weighing 17 tons, as emergency standby for two similar lengths across the Haven.

Several months ago it was found that the wooden drum had deteriorated and arrangements for re-drumming the cable were put in hand. After an extensive search for a suitable drum, jacks and spindles, a Pluto drum of 10 ft. height and 6 ft. 7 in. overall width was delivered, and a 4½ in. diameter 8 ft. spindle and jacks placed on order. Meanwhile, local search had discovered at ship-breaking yards propeller shafts and steel pipes with which it was possible to commence the job. The old drum had a 6 in. hole through which it was possible to put a shaft which would obviously carry the load. For the new drum with its 5¼ in. hole, the strongest items which could be found were a 3¼ in. diameter propeller shaft and a 4½ in. diameter ¼ in. thick steel pipe. Calculation of the maximum stress at minimum attainable span worked out at 15 tons per sq. in. if both spindles stuck together and 22 tons per sq. in. if the 3¼ in. shaft had to take the full burden. On the assumption that the breaking strain for the latter was about 40 tons per sq. in. it was decided to take the risk.

To carry out the operation structures were built up to a height of 5 ft. 6 in. at both sides of each drum by using railway sleepers pagoda fashion and half-portions of engine bearings were bolted in position to carry the spindle. A forty-year-old steam crane of impressive dimensions, with a lift of over 50 ft., was hired for lifting and winding the drums. After a few trial methods it was found that a rope wound several times around the old drum and hoisted by the sling of this crane proved most satisfactory. The cable was fed on to the new drum by hand.

Re-drumming Cable at Pembroke Dock.

Unfortunately, one cheek of the old drum was in a rotten condition and gradually broke up. Complete collapse occurred when some 400 yards of the cable had been re-drummed.

After some further experimental work, it was decided to attempt lifting one side of the old drum, the remaining cheek of which was now flat on the ground. The idea was to pass a sling through the axle of the drum, fasten it around three sleepers stood on edge, and attempt a hoist of the crane. It was feared that the remaining cheek of the drum, also in a poor condition, would break but, if the operation proved successful, the drum could be revolved on the sling by the ball joint of the crane. The attempt succeeded and, with the help of a second but smaller crane to lift the old drum, and using the 50 ft. hoist of the other crane on the new drum, operations proceeded more rapidly than ever.

It had been observed, however, that the spindles in the new drum were revolving with it, and the outer one, instead of being squashed by the cheek of the drum on to the inner, was being cut by the steel outer plates. The spindles were, therefore, moved so that one cut went to the outside of one of the bearings and the other cut inside the barrel and some steel wedges were driven between the tube and shaft. With the help of some oil the drum then revolved easily on a stationary spindle, although after the job was over it was found that the outer tube had broken inside the barrel so that the full bending moment was being taken by the propeller shaft which fortunately proved strong enough. During this final stage of the operations some 600 yards of cable were re-drummed in approximately five hours, compared with over twice this time taken for the first 400 yards. A gang of some 20 men was employed on the work and most of the time this number was fully engaged.

As an 8-ton drum of cable is regarded as an abnormal weight, it can well be imagined that this job provided some new experiences of the habits of heavy weights and some dangers which were well overcome by the men carrying out the work. N. C. de J.

## WEST WALES PRODUCTION EXHIBITION

Swansea was selected as the first of six towns to stage a production exhibition. The main theme of this was to demonstrate to the public how ancillary industries depended on the basic industries for greater production. It was decided, therefore, that the Post Office stand should show the use made of various materials such as copper, iron, steel, timber, etc., and how greater production of these would lead to more telephone services being provided. The complete make-up of a telephone system from subscriber to exchange was demonstrated, other motives being to show how much more was involved than a pair of wires to the house from the pole outside, and how much the Post Office is restricted by export demands.

The stand, 25 ft. × 10 ft., is shown in the photograph.


Post Office Stand—Swansea Production Exhibition.

It was designed around a U.A.X. 12A and C Unit, two working teleprinter tables and the layout of telephone line from subscriber to the U.A.X.

The first problem was one of finding some form of power for the U.A.X. 12. Here fortune favoured in that the hall in which the exhibition was to be held was later to be taken over by the Telephone Manager as offices and garage. In view of this, it was decided to provide pairs to the hall in advance of requirements and use a battery feed from the Swansea auto exchange, which is a 60 V. system, thus allowing a margin for voltage drop from exchange to U.A.X. unit. This arrangement, with a 250 $\mu$F capacitor across the power feed, turned out to be admirable.

The auto units were available from local stores and, although new, the usual run of faults was experienced, as expected, and duly cleared. Four telephones were wired to the unit so that the public could actually see the switches working. These proved to be an enormous attraction, over 2,500 calls being registered during the seven days. One of the telephones was connected via a $\frac{3+4}{12}$ switchboard to open wires from a 10 ft. ring-type D.P. through a pillar, cabinet, cable joint in a dummy joint box, and thence to the U.A.X. This certainly enabled the public to see the amount of work involved in providing new telephone lines and satisfied many people who were on the waiting list.

The teleprinters were two tape machines joined together and working duplex. The covers were left off and the public were encouraged to send souvenir telegrams. The two teleprinter operators sent and made up over 4,000 telegrams during the exhibition.

Two telephones were joined up via voice frequency changers 6A, with a loudspeaker connected across the line, so that the action of "scrambling" could be demonstrated. Other exhibits included the auto demonstration set with its transparent telephone, various 2,000-type switches, amplifier No. 32 panel, a No. 3 ringer panel, cable samples and telephones of various types, and two telephones connected to TIM, over which 2,200 calls were made.

The exhibition turned out to be a great success and, to the 80,000 people who attended, the Post Office stand was apparently the most popular. M. G. T.

## South-Western Region

### EXPERIMENTAL KIOSK TRAILER GLOUCESTER AREA

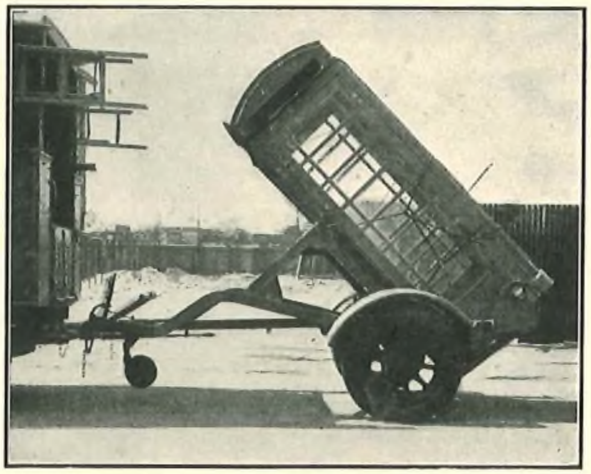
The economics of kiosk erection have for some time been under consideration in the Gloucester Area, especially regarding the continuous employment of all men in a construction party and the saving of ineffective time.

The erection and painting of kiosks, in quantity, at a depot and the conveyance of the complete item to site has always appeared to be expedient. A departmental crane lorry was first tried, but this proved to be uneconomical owing to the fact that two vehicles were nearly always required. The matter was discussed at an Engineers' Meeting and the idea of a kiosk trailer on the sack truck principle was mooted ; it was decided to make further investigation into the possibility of such a device. The chassis of an old trailer tool cart was suggested as the basis of design, with the idea that, with careful regard to weight distribution, a kiosk could be handled by a four-man gang and towed behind a standard utility vehicle. In co-operation with the local R.M.T.O. staff and the drawing office, a design was prepared and the work was carried out by the mechanics' staff with the help of a local welding company. The details of conversion were as follows :

The wheel base was increased by cutting the axle shaft and inserting an extra section, the whole axle being strengthened by welding a rib of steel to the underside. The wheel springs were strengthened with additional leaves. The centre girder complete with tow-bar was left in place and on each side a steel channel section was welded to form the shape of a "U" with the limbs of the "U" at the rear and the centre part at the towing end. The cradle for holding the kiosk was then fitted between the "U" and so bent that the kiosk rested at an angle of approximately 50° with the horizontal, with its centre of gravity slightly forward of the centre line of the wheels. Two jockey wheels with castor action were fitted to the side channel members at the tow-bar ends. On each side at the rear end of the trailer a steel trunnion projects, allowing cable drum jacks to be used for loading and unloading, but these are only necessary where less than four men are employed.

The kiosk is erected on two wood battens to allow the loading platform of the trailer to be slid under the kiosk. The trailer is then tilted by hand, and the kiosk roped down to the bearers on the trailer. The bearers are covered with leather to protect the kiosk paint. The trailer, complete with kiosk, can then be wheeled to the lorry and connected up.

When unloading, the trailer is tilted by hand until the point of balance is reached with the base of the kiosk about 18 in. from the ground. The cable drum jack may then be used, if required, to lower the kiosk to the ground.



LOADED KIOSK TRAILER IN TOWING POSITION.

Up to the time of writing the trailer has been used on about a dozen jobs and has given satisfactory service. It is anticipated that with further experience an average saving of ten man-hours per kiosk will be effected.

R. S. C.

### OPENING OF WESTBOURNE C.B. EXCHANGE

Originally it was intended to provide a new building in the Westbourne area of Bournemouth and instal a non-director automatic exchange as the first step in the Bournemouth auto scheme. Building restrictions and the reduction in capital expenditure caused this scheme to be postponed. Overloading at Bournemouth exchange became serious, and it was decided to provide a "prefabricated" type of building at Westbourne and instal a manual exchange to cater for subscribers transferred from Bournemouth.

The new exchange, which is a C.B. No. 1, 40 V. type, was planned and installed by the Department. All installation work was carried out by the Bournemouth Area construction staff, and cable runways and equipment racking were made on site. The switchboard consists of 18 positions—8 jack-ended B, and 8 A positions—equipped with a multiple for 3,000 lines and 2,800 calling equipments. On 4th December, 1948, at 1.45 p.m., 2,100 subscribers were transferred from Bournemouth to Westbourne and new routes of junctions set up to Bournemouth, Boscombe, Parkstone, Poole, Canford Cliffs and Winton.

An extensive development scheme involving three route miles of duct and four and a half miles of cable was undertaken. 3,800 pairs are available from the new M.D.F. to D.P.s, 3,400 of which terminate on 13 cabinets. Earlier it had been the intention to provide a large number of pillars, but the scheme had to be deferred due to the delay in the delivery of the assemblies. Prior to the transfer all junctions were routed in local cable, and after transfer a block of 200 pairs was cleared in a junction cable and the junctions changed over. A 25/100 and a 28/40 Bournemouth-Parkstone cable were taken in and out of Westbourne to cater for the routing of the miscellaneous circuits.

All subscribers' lines to be transferred were terminated at Westbourne, 800 of these being routed back to Bournemouth via a change-over frame fitted at the end of the new M.D.F. and the rest of the lines " teed " at the 10 cabinets. All lines were disconnected by " wedges, locking " at the new M.D.F. The transfer was effected by disconnecting the 800 lines at the change-over frame and simultaneously cutting the tees at the 10 cabinets, the latter operation being co-ordinated by the use of a control switchboard with speaker circuits to each cabinet. When the report " All cabinet tees cut away " was received, the locking wedges were withdrawn at the new M.D.F. and the subscribers connected to the new exchange. The whole transfer operation being completed without a hitch in 3½ minutes. Immediately after the transfer a staff at Bournemouth exchange proceeded to remove the Bournemouth M.D.F. fuses of the transferred lines, these fuses having previously been marked with black paint.

The method of teeing at the cabinets, although unusual, resulted in a great saving in cable costs, and provided careful control of the " cutting away " operation is maintained and the staff are well rehearsed, it may be recommended for exchange transfers where the conditions are suitable.

The whole of the transfer operations were carried out smoothly and efficiently, and the new exchange reflects great credit on the local staff for their high standard of workmanship. D. E. W.

## A MOBILE CRANE

A one- to two-ton mobile pneumatic crane was brought into use in a city in the South-Western Region on 1st November, 1948, for the purpose of reducing the amount of time and effort required in handling heavy stores, poles, cable drums, telephone kiosks, U.A.X. units, emergency charging sets, etc.

The machine is a four-wheeled model with front-wheel drive and rear-wheel steering in order to provide maximum wheel grip when a load is being carried, and a small turning circle. Power is derived from a standard Ford 10 h.p. engine and gearbox, and is transmitted by chain and reduction gear to a heavy duty front axle. Three forward speeds and a reverse gear are provided, and the machine has a maximum road speed of 9 m.p.h.

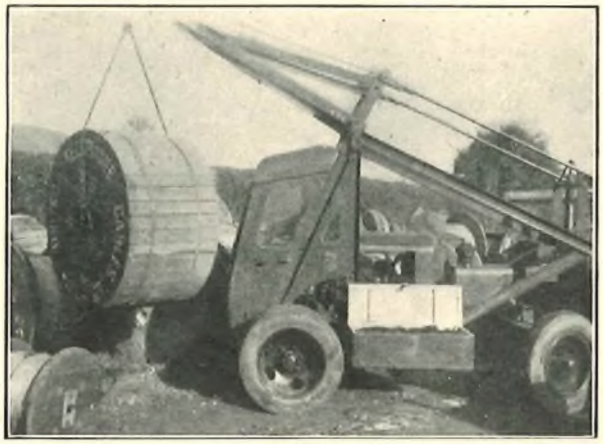
A small compressor unit is permanently coupled to the engine and this maintains a working pressure of 120 lb. per sq. in. in two air receivers fitted over the counterweights at the rear of the crane. Between the air receivers is fitted the pneumatic ram or lift unit, which operates the jib through a simple valve arrangement under the driver's control. Three hooks ingeniously spaced along the jib are provided to deal with loads up to one ton, 30 cwt., and two tons, respectively. There are no ropes or pulley wheels on the crane. There is no danger in overloading because if this is attempted the air pressure is insufficient to raise the load.

The crane is not complicated to handle and drive, and has been found to be an economical item to run and maintain. Special care is needed to ensure safe attachment of the load because, unlike the usual type of crane, if the load becomes suddenly detached the jib does not remain stationary but travels upwards with a force nearly equal to that provided by the load which has been suddenly released. Hand signals to the driver are necessary. Shouting directions is no use because he cannot hear them above the noise of the engine.

The chief merits claimed for the machine, which are borne out in practice, are as follows :—

1. Complicated controls, gears, cables and expensive wearing parts are eliminated.
2. One small lever operates all movements of the jib, and the speed of lifting or lowering is infinitely variable up to a maximum.
3. Low maintenance costs and low fuel consumption.
4. Full load can be carried with the jib in any position including maximum outreach.
5. Head room required with the jib down is 10 ft.

Heavy stores are handled at any of the seven different depots located in the city and, in addition, the machine has been used for such operations as the erection of



Mobile Crane Handling Heavy Stores in a Depot.

heavy poles, the lowering and recovery of decayed poles, and for the placing of kiosks, which have been assembled and painted in a central depot on site. A most important item is that it is now possible economically to erect and paint the kiosks at a central depot under cover, thus providing useful work for war disabled and light-duty men.

Mobile Crane in Use for Placing Kiosk.

A careful record has been kept of the estimated saving in man hours day-by-day as a result of using the machine, and during a period of 13 weeks this saving was approximately 3,600 man hours. A further advantage is the amount of sick absence saved as a result of freedom from accidents due to physical strain in man-handling heavy items of plant. H. T.

DAMAGE TO SWINDON (B) REPEATER STATION BY FIRE

At 8.45 p.m. on 10th February, 1949, a series of "999" calls revealed the fact that Swindon (B) repeater station was on fire. The fire brigade were soon on the scene, followed shortly by local engineering staff. Clearly, however, the fire had got too big a hold before it had been noticed and the whole of the transmission equipment and an 8-channel V.F.T. system were completely destroyed, putting out of service 439 circuits (331 trunks and junctions, 8 telegraphs and 100 private wires). The H.T. and L.T. batteries were damaged and the rectifiers and power cubicle were severely burned. The diesel engine standby set was actually running when the Fire Brigade arrived, apparently having been brought into operation by fire damage to power cables. This set does not appear to be severely damaged although the heat may have impaired the insulation of the motor and generator windings.

The building which was a temporary one, with a steel framework clad with asbestos sheeting and lined with plaster board, was severely damaged as can be seen from the photograph. The effect of the heat on the asbestos caused it to fracture and fly in small pieces in all directions for distances up to 30 yards. The plaster board lining had burned and covered the floor with a black charred mess in the apparatus room, which was obviously the seat of the fire. The roof trusses over the apparatus racks were badly twisted. The apparatus racks present a sorry spectacle and show that the heat generated must have been very intense. The seven main cables entered the building via a cable trench and were led up the wall on which the multiple joints were made. All that remained of this cabling work was a few bunches of copper strands hanging forlornly from racking above.

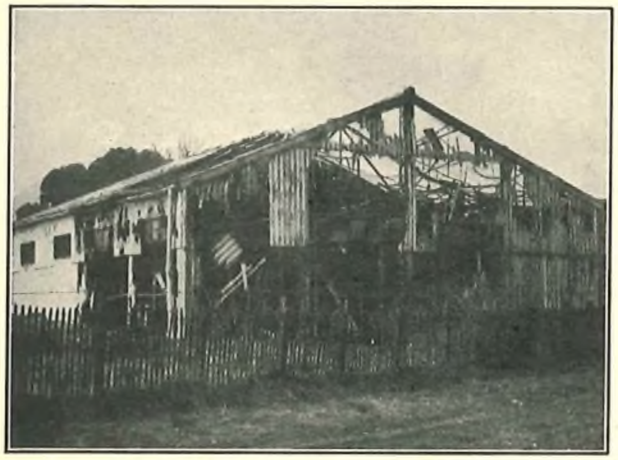


*Photo: "Swindon Evening Advertiser."*

SWINDON (B) REPEATER STATION AFTER THE FIRE.

The first step taken after the fire was to break down the duct line outside the station in order to cut off the wet ends of the cables and to create an interception point. An empty M.A.X. van was taken to the site and parked against this point. This van was then equipped with a distribution frame and the main cables were terminated on it by means of E.S. and W. tails.

Arrangements were made to obtain three mobile repeater stations and 10 additional emergency repeater bays. When these arrived they were parked side by side in the adjacent field and E.S. and W. cables were run between the tag blocks fitted in them and the distribution frame in the van.

The electric power supply which had been cut off was re-established and connected to all vans to provide light and to serve the mains-operated repeater equipment. It was also extended to the welfare accommodation which was in a separate building and was undamaged. This was invaluable during restoration operations both for welfare purposes and as an office for the staff on circuit record work. To guard against power failures a mobile 6·5 kVA petrol engine generator set has been installed on the site.

Restoration of 40 circuits was made within 24 hours, partly by rerouting, but mainly as a result of having jointed the Marlborough-Swindon cable straight through outside the damaged station by 7.0 a.m. the next morning, i.e. only 10 hours after the fire had been detected. The main restoration had to await the bringing into service of the mobile stations and the termination of the cables in the van. All work proceeded continuously for 24 hours a day and within 7 days just over 50 per cent. of the public circuits and private wires had been restored. Complete restoration was achieved in 11-12 days. The loss of the Bristol-Swindon 8-channel V.F.T. system was partly made good within 24 hours by the bringing into use of a spare 4-channel system at Marlborough repeater station, which allowed the setting up of a Bristol-Marlborough system with physical extensions to Swindon. This is in process of being replaced by an 8-channel system.

Praise is due to the supervising officers and workmen concerned for the spirit and energy which they displayed in tackling this unusual and urgent job and which resulted in such speedy restoration of service.

D. E. B.

## Home Counties Region

CABLE BURN-OUT FOLLOWED BY GAS EXPLOSION

On a recent occasion a prompt alarm was received from Hunton satellite exchange shortly after midnight and at 1.20 a.m. it was proved that the Hunton-Maidstone junction cable, a 30/10 + 35/40, was faulty, with all conductors full earth. Half an hour later a loud explosion was heard in the vicinity of College Road, and it was reported that a JRF 9 footway box at the junction of College Road and Tovil Road was damaged, the frame and covers being destroyed. The jointers arrived at 3.0 a.m. and found dense clouds of smoke coming from a JRF 4 box on the opposite side of College Road, and smoke was also coming from adjacent footway boxes. Heat was very noticeable at either end of this section of track and both boxes contained considerable quantities of soot, apparently blown there by the explosion; altogether, four buckets of soot were taken from the boxes and ducts.

The fault in the junction cable was located approximately halfway along the 23-yard section crossing the road and when the ground was opened the surrounding soil was found to be unbearably hot. At the point of excavation a derelict gas main was discovered.

Further excavation exposed a 460V. D.C. E.L. cable, and the burnt-out conductor could easily be traced along the cable for about 25 yards. When the P.O. cable was pulled out it was found to be completely burnt away for approximately four yards, only the bare conductors remaining and these were severed at one point. Only one section of the 4 in. S.A. duct was broken, apparently shattered by the force of the explosion. Fortunately there were no personal injuries.

J. D. N.
E. R. K.

# Staff Changes

## Promotions

| Name | Region | Date |
|---|---|---|
| *A.S.E. to Staff Engr.* | | |
| Scantlebury, L. F. | E.-in-C.O. | 1.2.49 |
| *Area Engr. to A.S.E.* | | |
| Leckenby, A. J. | L.T. Reg. to E.-in-C.O. | 24.11.48 |
| *Area Engr. to T.M.* | | |
| Smith, S. J. | Scot. to Peterborough | 3.10.48 |
| Sims, A. E. | Taunton | 1.1.49 |
| *Area Engr. to Asst. T.M.* | | |
| Turner, C. | L.T. Reg. | 11.1.48 |
| Knight, N. V. | Mid. Reg. to L.T. Reg. | 13.10.48 |
| Stanbury, H. C. O. | Mid. Reg. to L.T. Reg. | 3.10.48 |
| Bucknall, F. R. B. | Glasgow | 1.12.48 |
| *Area Engr. to Principal* | | |
| Harnden, A. B. | L.T. Reg. to Personnel Dept. | 23.2.49 |
| *Area Engr. to Sen. Exec. Off.* | | |
| Weaver, C. W. | S.W. Reg. to Personnel Dept. | 8.11.48 |
| *Engr. to Exec. Engr.* | | |
| Knee, H. | S.W. Reg. | 17.11.48 |
| Lovegrove, L. W. | H. C. Reg. to E.-in-C.O. | 1.12.48 |
| Loosemore, E. S. | S. W. Reg. to Mid. Reg. | 12.12.48 |
| Harris, R. J. | E.-in-C.O. | 1.1.49 |
| Hamilton, D. F. | Scot. to L.T. Reg. | 5.1.49 |
| Blight, A. | L.T. Reg. | 5.12.48 |
| Peddle, H. W. | Mid. Reg. | 17.11.48 |
| Porter, W. F. | L.T. Reg. to Scot. | 9.1.49 |
| *Prob. Engr. to Asst. Princ.* | | |
| Isaac, A. J. | E.-in-C.O. to Min. of Works | 21.2.49 |
| *Prob. Engr. to Engr.* | | |
| Harris, D. J. | E.-in.C.O. | 24.2.49 |
| Cohen, J. H. L. | E.-in.C.O. | 3.3.49 |
| Faulkner, A. H. | E.-in-C.O. | 3.3.49 |
| Marsh, S. B. | E.-in-C.O. | 24.2.49 |
| Walker, N. | E.-in-C.O. | 19.2.49 |
| Horton, G. P. | E.-in-C.O. | 19.2.49 |
| Martin, F. N. | E.-in-C.O. | 19.2.49 |
| Siems, C. V. | E.-in-C.O. to L.T. Reg. | 5.12.48 |
| Gillard, C. H. | S.W. Reg. | 1.1.49 |
| Rowe, J. F. | S.W. Reg. | 12.12.48 |
| Bell, R. J. B. | Scot. | 22.11.48 |
| Lockwood, C. R. | H.C. Reg. | 1.12.48 |
| Baxter, E. C. | L.T. Reg. to E.-in-C.O. | 24.11.48 |
| Wooding, W. J. | L.T. Reg. | 22.11.48 |
| Buckoke, S. | L.T. Reg. | 22.11.48 |
| Janks, F. A. E. | H.C. Reg. | 31.12.48 |
| Heyburn, L. G. | H.C. Reg. | 16.1.49 |
| Pearce, H. S. | L.T. Reg. | 26.1.49 |
| Harrison, H. W. | H.C. Reg. | 31.12.48 |
| *Technician to Asst. Engr.* | | |
| Eva, F. J. H. | E.-in-C.O. | 29.9.47 |
| Lanfear, J. S. | E.-in-C.O. | 16.1.49 |
| *D'sman. Cl. II to D'sman. Cl. I* | | |
| Williamson, F. | E.-in-C.O. | 1.1.49 |
| Turner, C. | E.-in-C.O. | 16.1.49 |
| Goodfellow, J. B. | E.-in-C.O. | 17.9.48 |
| Watson, S. W. | E.-in-C.O. | 1.2.49 |
| Dale, R. A. | E.-in-C.O. | 23.1.49 |
| Culverwell, W. L. | E.-in-C.O. to W.B.C. Reg. | 6.1.49 |
| Cridland, J. F. S. | E.-in-C.O. to L.T. Reg. | 31.1.49 |

## Transfers

| Name | Region | Date |
|---|---|---|
| *Exec. Engr.* | | |
| Trott, L. J. | E.-in-C.O. to S. W. Reg. | 1.1.49 |
| Warren, F. | E.-in-C.O. to N.W. Reg. | 7.3.49 |
| *Engr.* | | |
| Richardson, A. E. | E.-in-C.O. to Admiralty | 21.12.48 |
| *Asst. Engr.* | | |
| Hart, G. B. G. | E.-in-C.O. to N.E. Reg. | 1.12.48 |
| Mitchell, A. | E.-in-C.O. to Min. of Civil Aviation | 8.6.48 |
| Whiddett, S. D. | E.-in-C.O. to Min. of Civil Aviation | 23.11.48 |
| *Asst. Engr.—continued* | | |
| Baird, D. W. G. | E.-in-C.O. to Scot. | 27.12.48 |
| Knight, L. C. | E.-in-C.O. to Min. of Supply | 10.1.49 |
| Whiteoak, H. J. G. | E.-in-C.O. to Board of Trade | 1.2.49 |
| Light, R. W. | E.-in-C.O. to Min. of Supply | 25.1.49 |
| Horner, H. T. | Mid. Reg. to N.E. Reg. | 15.1.49 |
| *M.T.O. II.* | | |
| Chapman, E. | E.-in-C.O. to N.W. Reg. | 1.1.49 |

## Retirements

| Name | Region | Date |
|---|---|---|
| *Staff Engr.* | | |
| Peck, H. G. S. | E.-in-C.O. | 31.1.49 |
| *Asst. Staff Engr.* | | |
| Timmis, A. C. | E.-in-C.O. | 26.1.49 |
| Martin, J. A. S. | E.-in-C.O. | 23.2.49 |
| *Area Engr.* | | |
| McLean, H. | N.E. Reg. | 31.12.48 |
| Durkin, T. | N.W. Reg. | 31.12.48 |
| *Reg. M.T.O.* | | |
| Withers, C. A. | N.W. Reg. | 31.12.48 |
| *Engr.* | | |
| Read, A. | H.C. Reg. | 11.12.48 |
| Fotheringhame, S. D. | Scot. | 31.12.48 |
| Taylor, S. A. | L.T. Reg. | 1.1.49 |
| Henderson, W. G. | N.I. Reg. | 31.12.48 |
| Last, S. G. | H.C. Reg. | 15.1.49 |
| Tootell, T. E. | N.E. Reg. | 31.1.49 |
| Towle, E. H. N. | N.E. Reg. | 31.1.49 |
| Baxter, F. J. | Mid. Reg. | 9.2.49 |
| Grierson, A. | N.E. Reg. | 8.2.49 |
| Baldey, C. | L.T. Reg. | 28.2.49 |
| Tiley, A. E. | W.B.C.Reg. | 28.2.49 |
| Goodchild, R. F. | E.-in-C.O. | 2.2.49 |

**Retirements**—*continued*

| Name | Region | Date |
|---|---|---|
| *Asst. Engr.* | | |
| Burdge, W. E. | E.-in-C.O. (Resigned) | 15.12.48 |
| Brinkley, J. R. | E.-in-C.O. (Resigned) | 15.1.49 |
| Rockall, A. G. | E.-in-C.O. | 26.1.49 |
| Wyness, A. W. | E.-in-C.O. (Resigned) | 6.2.49 |
| Pugh, S. M. | E.-in-C.O. (Resigned) | 28.2.49 |
| Tolhurst, S. | E.-in-C.O. | 28.2.49 |
| Hemming, M. H. | Mid. Reg. | 31.12.48 |
| Mills, J. W. | Mid. Reg. | 31.12.48 |
| Sutton, C. J. | W.B.C. Reg. | 14.12.48 |
| *Inspr.* | | |
| Hardy, R. H. | L.T. Reg. | 31.12.48 |
| Seller, W. G. | L.T. Reg. | 31.12.48 |
| Powell, G. W. | L.T. Reg. | 31.12.48 |
| Tubbs, C. F. | L.T. Reg. | 31.12.48 |
| Sharples, W. | N. W. Reg. | 31.12.48 |
| Vian, F. | L.T. Reg. | 31.12.48 |
| Brayley, J. W. | W.B.C. Reg. | 4.10.48 |
| Dixon, A. S. | W.B.C. Reg. | 31.12.48 |
| Sellars, W. | L.T. Reg. | 10.2.49 |
| McCrossan, A. | N.I. Reg. | 9.3.49 |
| Fruish, J. | Scot. | 31.12.48 |

**Deaths**

| Name | Region | Date |
|---|---|---|
| *Engr.* | | |
| Jones, E. T. | L.T. Reg. | 30.11.48 |
| *Proby. Engr.* | | |
| Groves, D. K. | E.-in-C.O. | 25.10.48 |
| *Asst. Engr.* | | |
| Rae, S. C. | Scot. | 10.8.48 |
| *Asst. Engr.—continued* | | |
| Frowde, E. H. | N.W. Reg. | 22.9.48 |
| Moorehouse, J. H. | N.W. Reg. | 6.12.48 |
| *Inspr.* | | |
| Law, W. | N.E. Reg. | 27.11.48 |
| *D'sman. Cl. I* | | |
| Potter, W. | N.W. Reg. | 3.2.49 |

## CLERICAL GRADES

**Transfers**

| Name | Region | Date |
|---|---|---|
| *H. Exec. Off.* | | |
| Knightsbridge, H. T. | E.-in-C.O. to Min. of Supply | 21.12.48 |
| Dummer, J. F. | E.-in-C.O. to Min. of Supply | 21.12.48 |
| Buxton, A. D. | E.-in-C.O. to Min. of Supply | 21.12.48 |
| Aspden, S. C. | E.-in-C.O. to Min. of Supply | 21.12.48 |
| Johnson, P. B. | E.-in.C.O. to Min. of Works | 16.8.48 |
| *Exec. Off.* | | |
| Edmonds, R. W. | E.-in-C.O. to Min. of Works | 16.8.48 |
| Griffiths, C. | E.-in-C.O. to Min. of Works | 16.8.48 |
| Fyffe, H. G. (Miss) | E.-in-C.O. to Min. of Food | 16.8.48 |
| Hawers, W. A. | E.-in-C.O. to Min. of Food | 16.8.48 |
| *Exec. Off.—continued* | | |
| Watt, G. R. M. | E.-in-C.O. to Min. of Fuel and Power | 22.11.48 |
| John, B. | E.-in-C.O. to Min. of Works | 22.11.48 |
| Feterman, D. | E.-in-C.O. to Min. of Fuel and Power | 22.11.48 |
| Edney, A. J. | E.-in-C.O. to War Damage Com. | 11.10.48 |
| Nelson, H. W. | E.-in-C.O. to War Damage Com. | 11.10.48 |
| Wilson, P. A. V. | E.-in-C.O. to Min. of Supply | 21.12.48 |
| Ellis, A. E. (Miss) | E.-in-C.O. to Min. of Supply | 21.12.48 |

**Retirement**

| Name | Region | Date |
|---|---|---|
| *Exec. Off.* | | |
| Chappell, W. R. | E.-in-C.O. | 27.2.49 |

## Additions to Library

(*Continued from page* 49)

1780 *The Advanced Theory of Statistics, Vol. II.* Kendall (British 1946).
An important contribution to the literature of statistical theory. Deals with estimation ; theory of statistical tests including the analysis of variance and multivariate analysis ; regression analysis and completes the account of statistical relationship begun in Vol. I. Also includes an introductory account of the reaction of theoretical considerations on the design of statistical inquiries ; analysis of time-series.

1781 *A First Year Engineering Drawing.* A. C. Parkinson (British 1946).
A course in elementary engineering drawing for students taking the first year National Certificate Course in mechanical and electrical engineering, as well as for those working through the usual Junior Technical School and matriculation syllabuses. The book contains numerous diagrams and pictorial examples, while numerous exercises, selected from recent examination papers, follow each section throughout the text.

1782 *Clowes & Colemans Quantitative Chemical Analysis.* Ed. Julius Grant (British 1944).
An intermediate text book paying special regard to the requirements of senior students, giving a reliable cross-section not only of the standard methods of analytical chemistry, but also of the modern trends of the subject. Covers general processes, simple gravimetric determinations, volumetric analysis, miscellaneous methods of analysis, applied quantitative analysis, general organic analysis, gas analysis, with reference tables of useful constants.

1783 *The Microscope.* J. H. Wredden (British 1947).
Theory and applications. Designed to explain simply the optical principles, the construction and components of this highly complex instrument, including its correct operation. The development of the present-day microscope is dealt with and details are also given regarding the selection of specific types of microscopes and their applications including photomicrography.

1784 *Principles of Technical Electricity.* M. Nelkon (British 1946).
A lucid exposition of the fundamentals of electricity catering particularly for first year radio and electrical engineering students. The usual topics are covered and A.C. circuit theory, valves and the cathode-ray oscillograph are introduced.

1785 *The Story of the Telephone.* J, H, Robertson (British 1947).
A history of the telecommunications industry of Britain.

1786 *The Vector Operator j.* F. C. Gill (British 1946).
This book explains simply yet fully how the method may readily be applied to the solution of electrical problems. By working systematically through the numerous examples given, any student having no previous knowledge of the system will be in a position to use it with skill and confidence.

1787 *Testing and Inspection of Engineering Materials.* Davis, Troxell and Wiskocil (American 1941).
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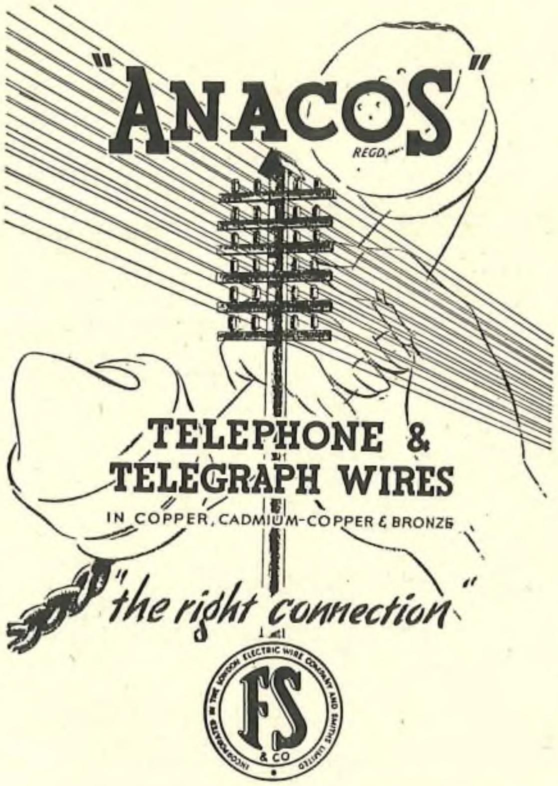


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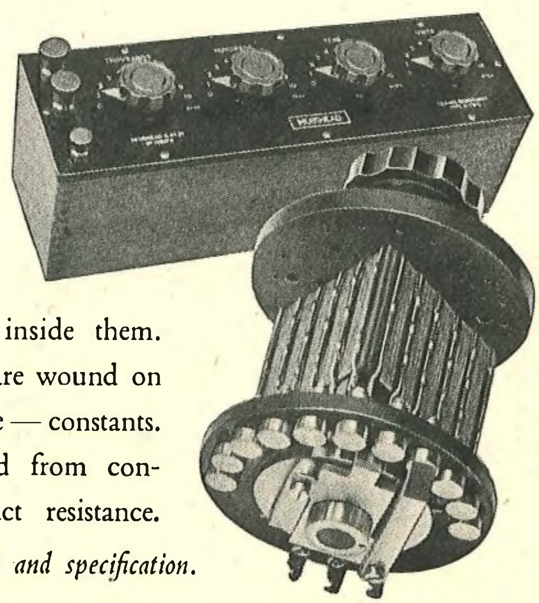

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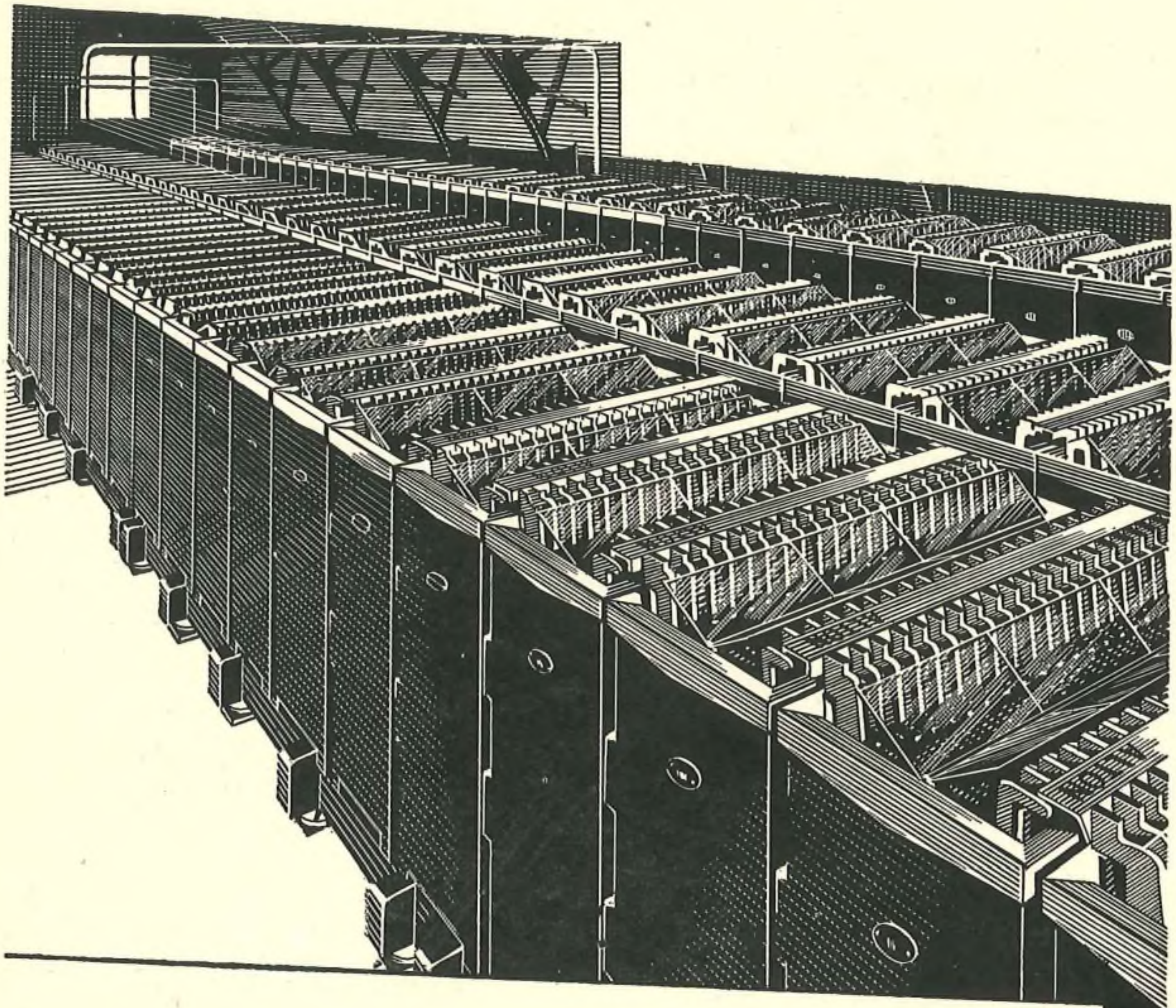

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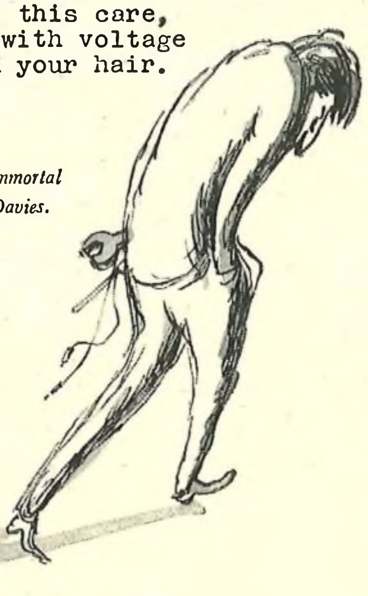

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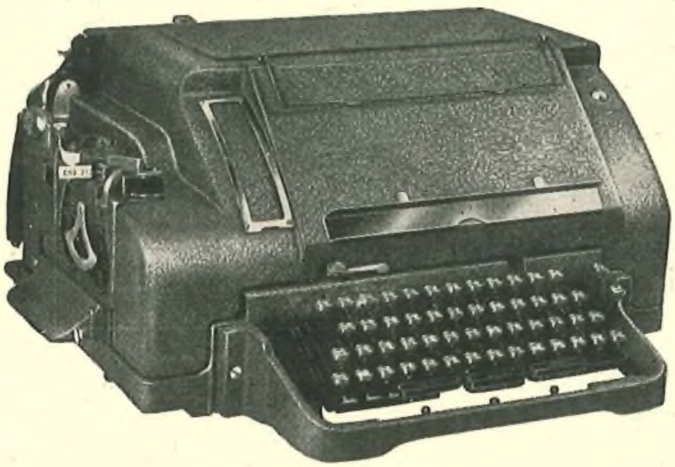

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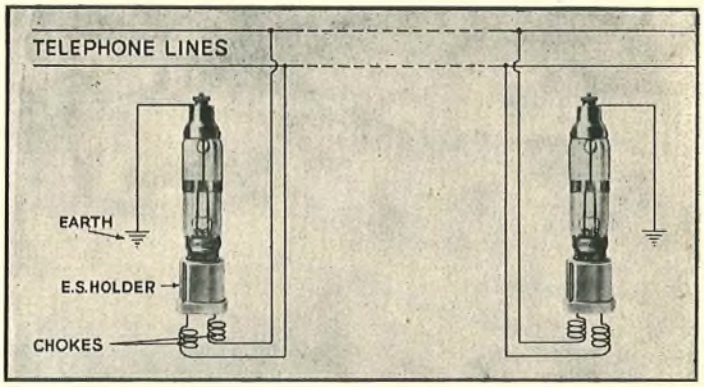


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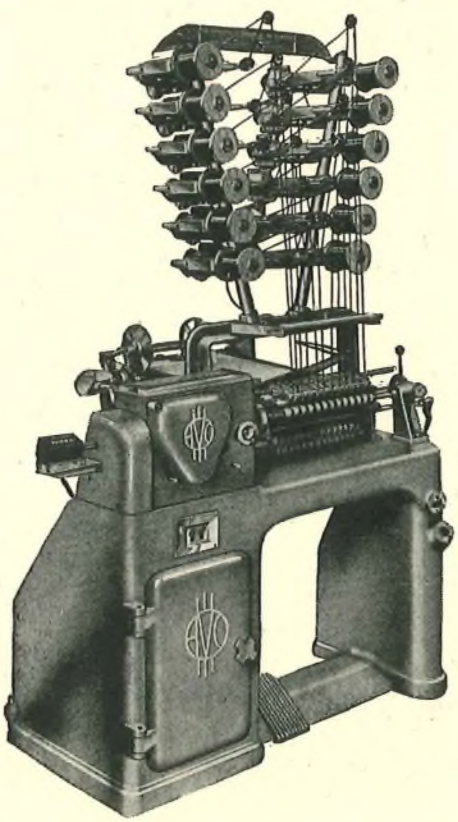

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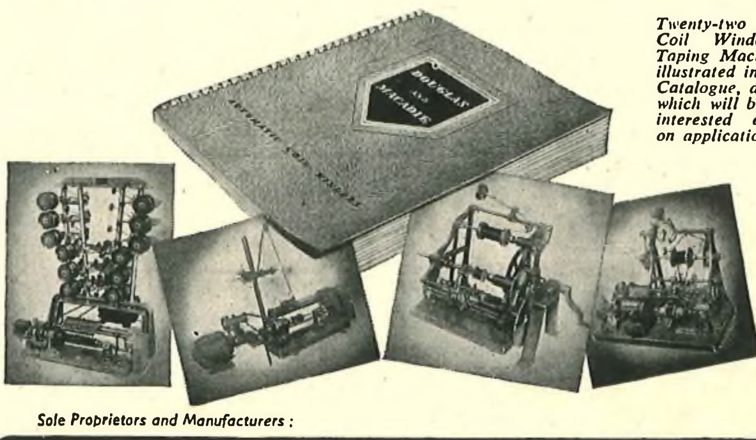

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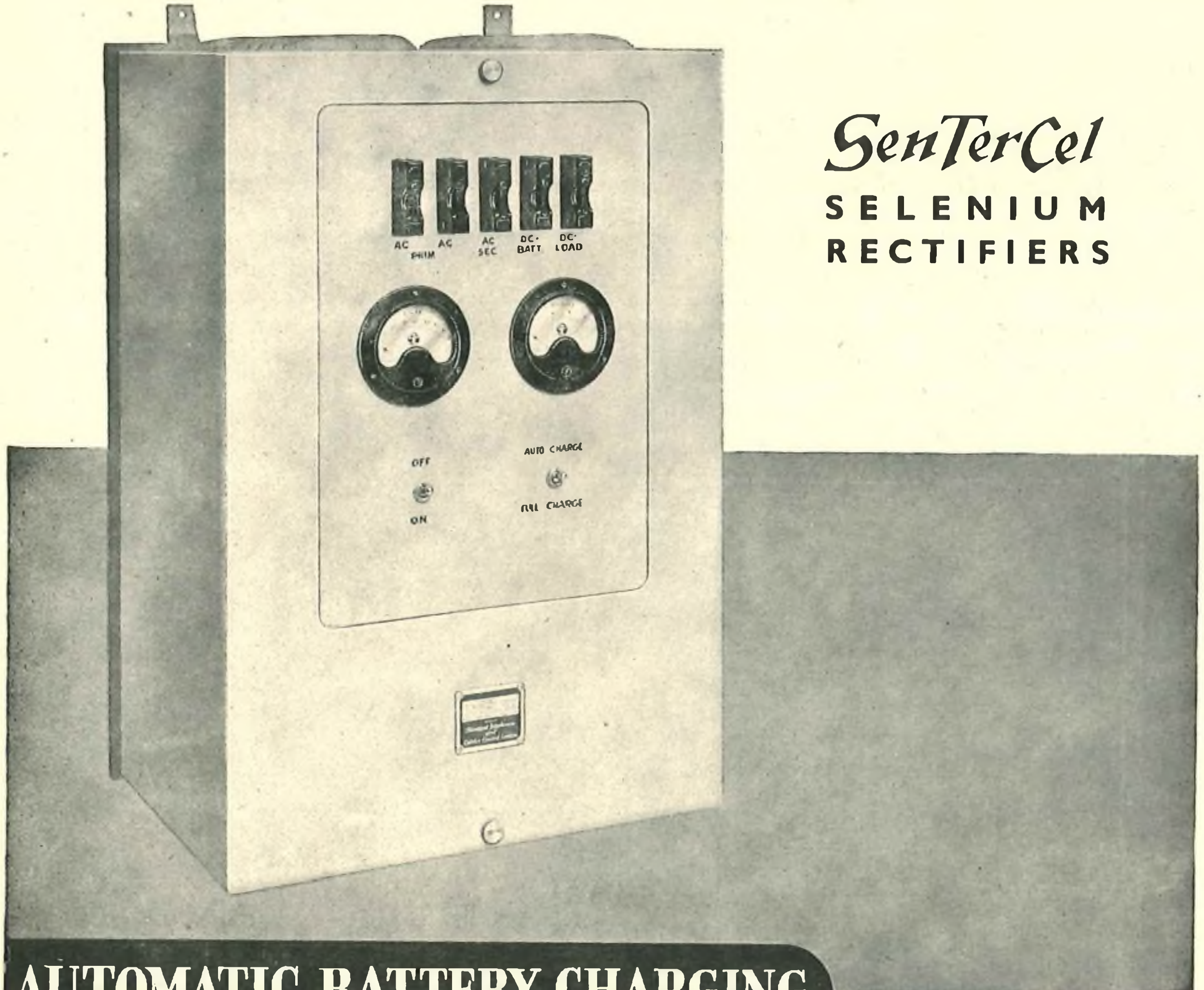


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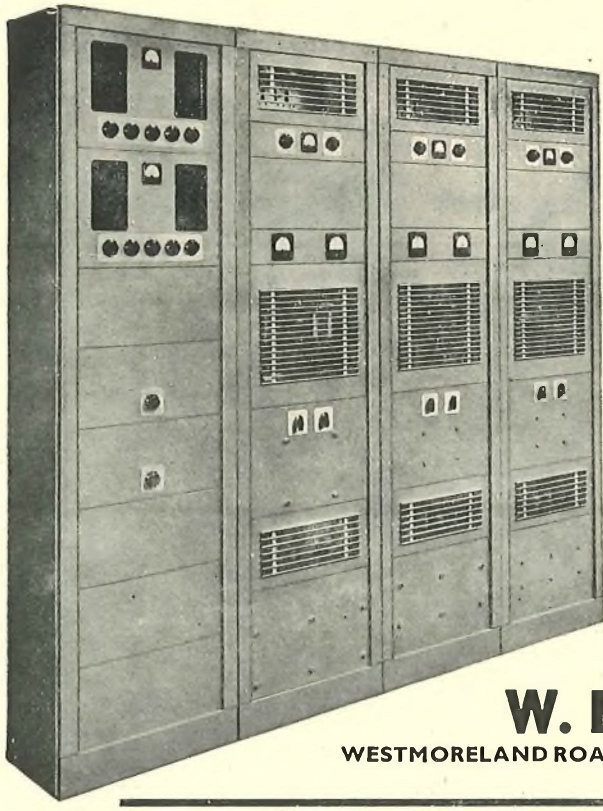

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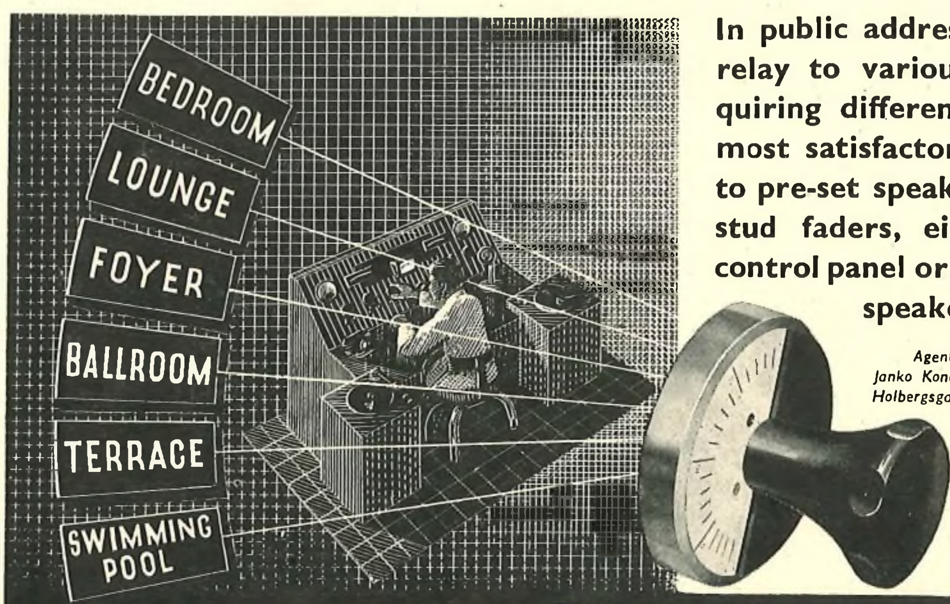


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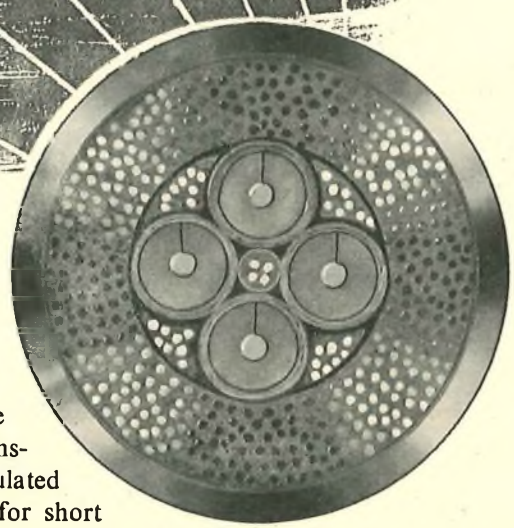

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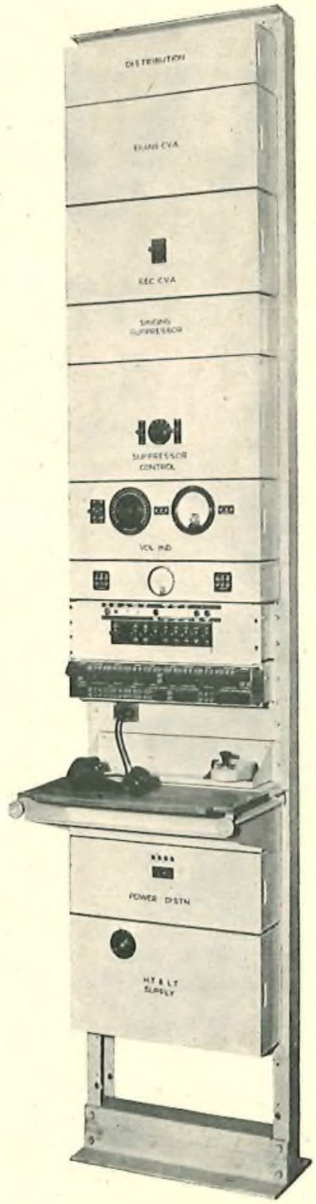

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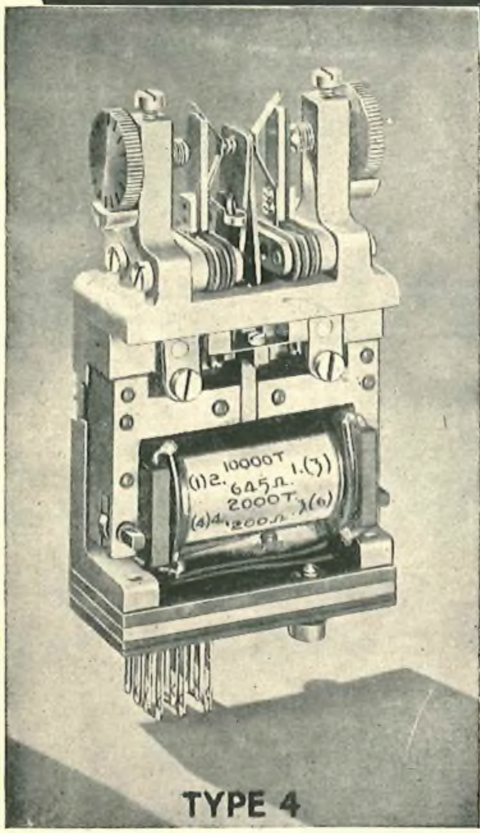


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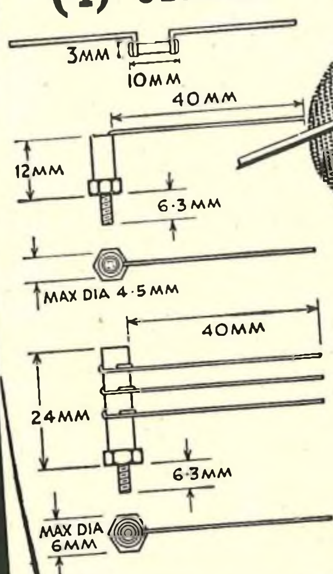


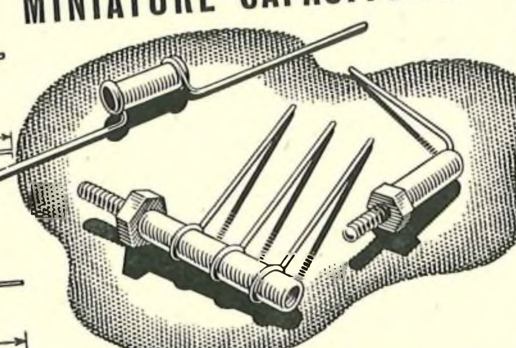

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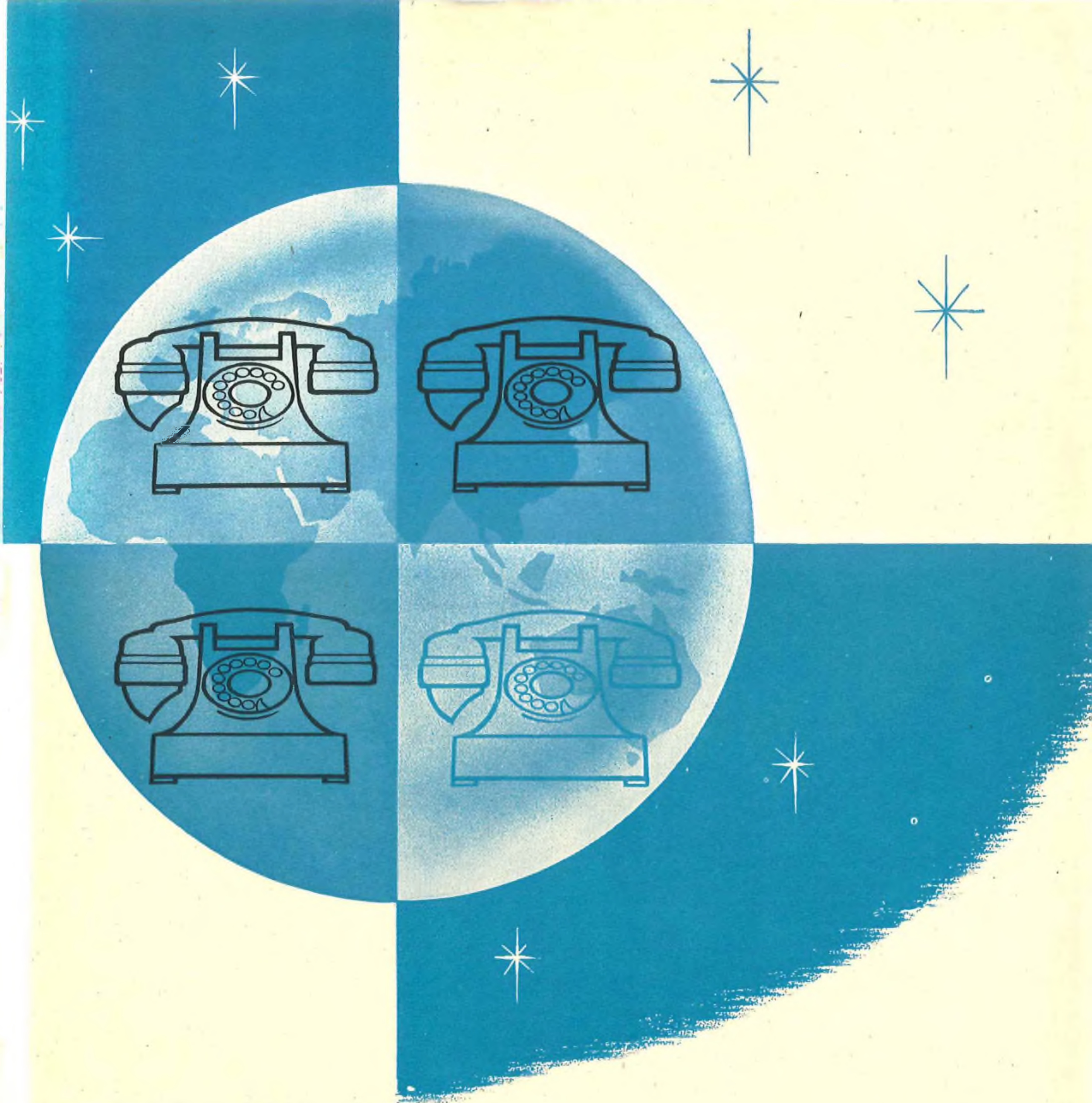


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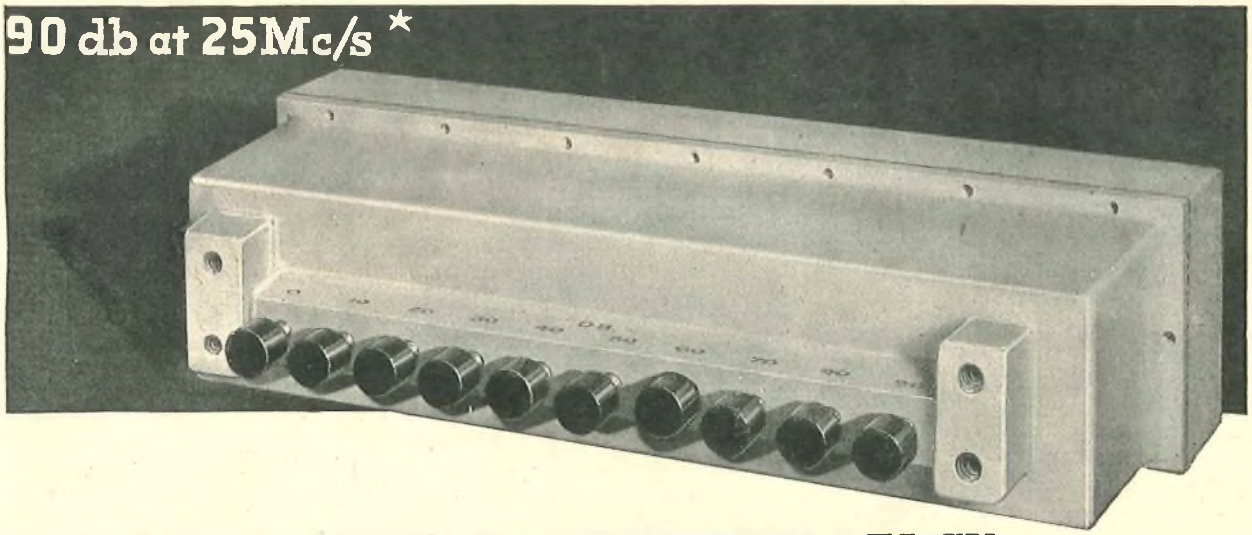


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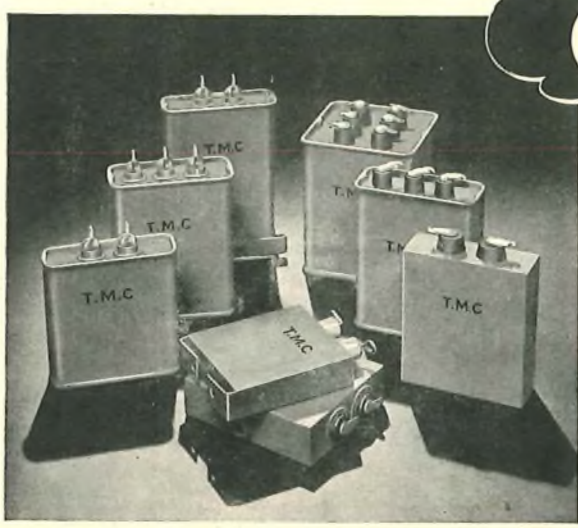


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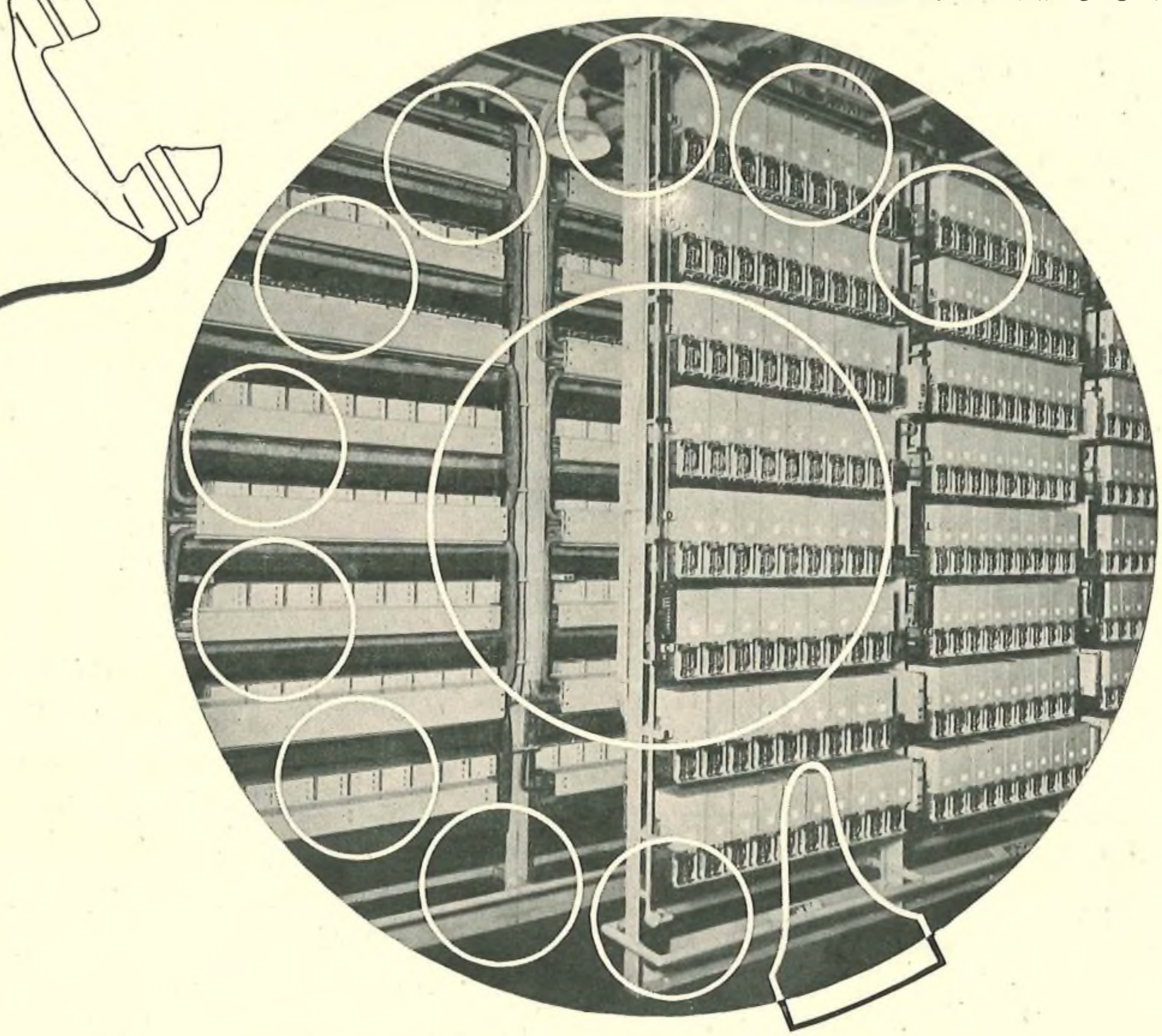

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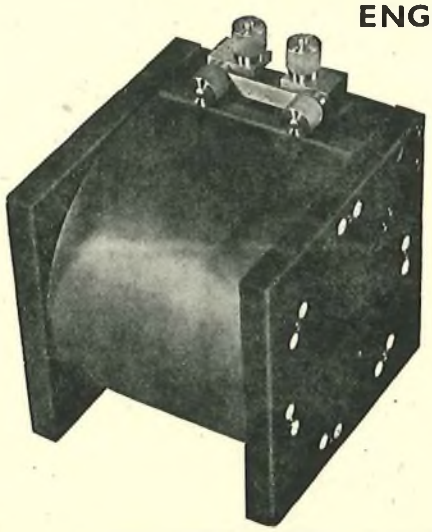

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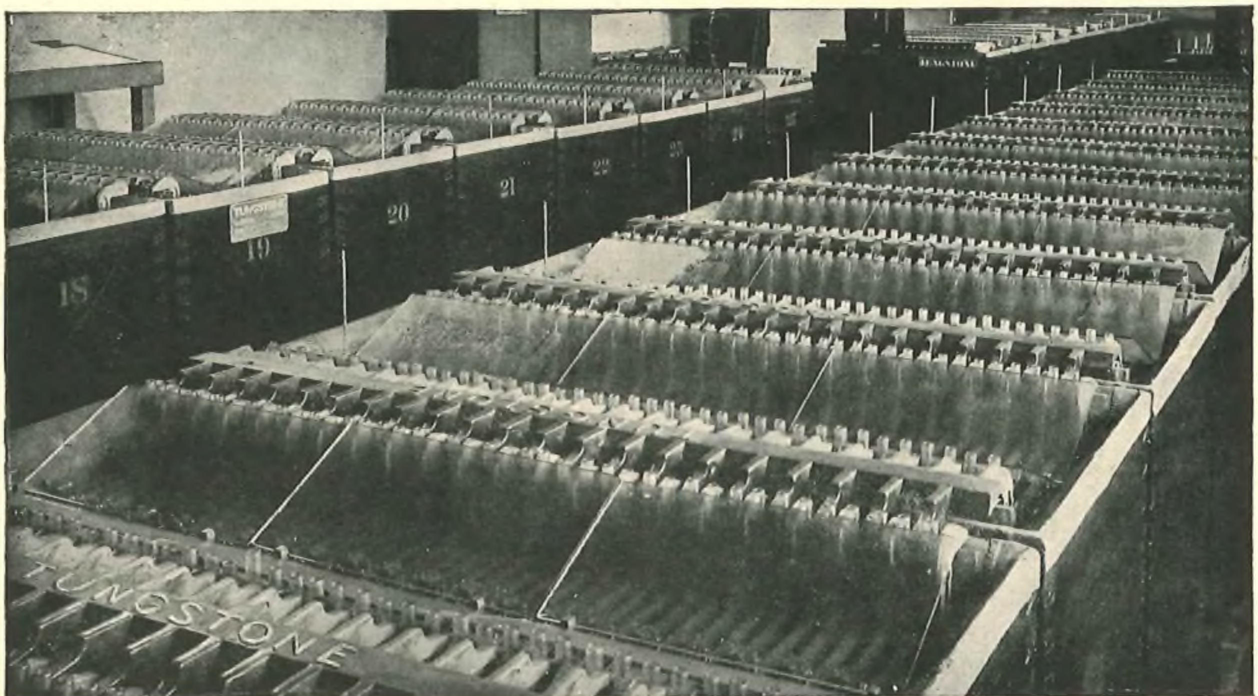


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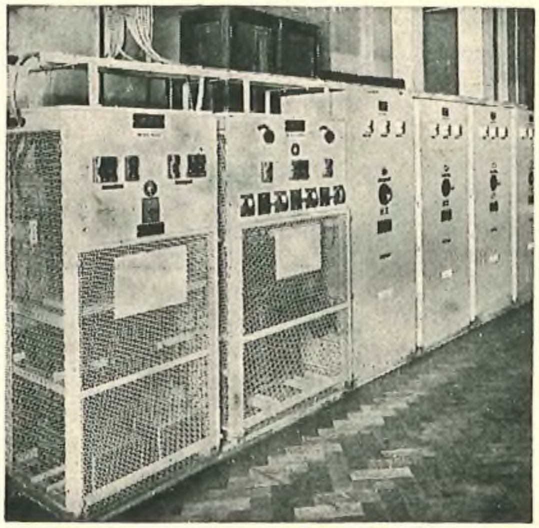

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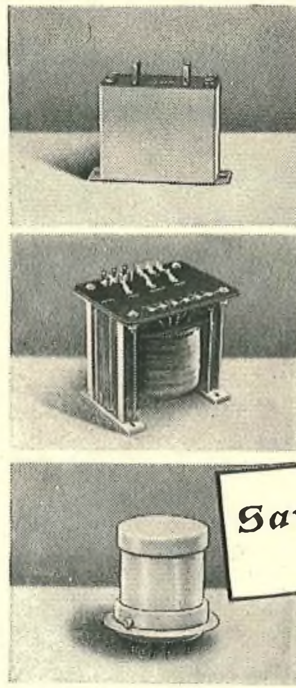

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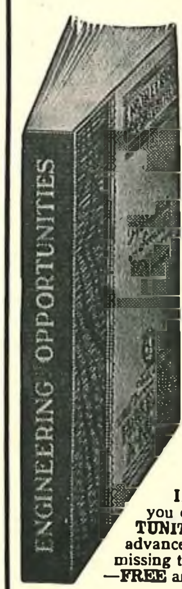


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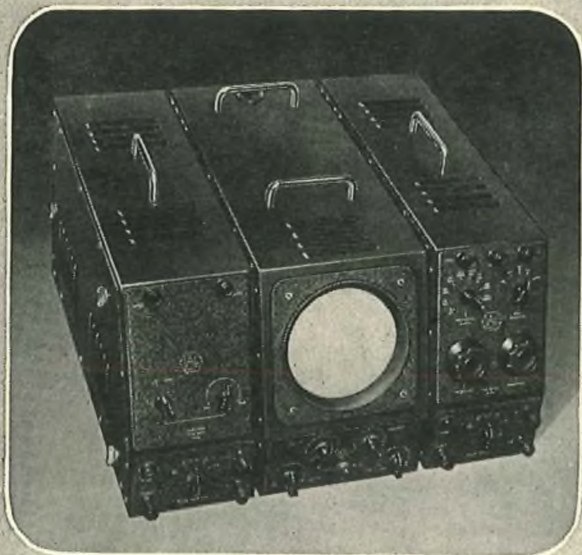

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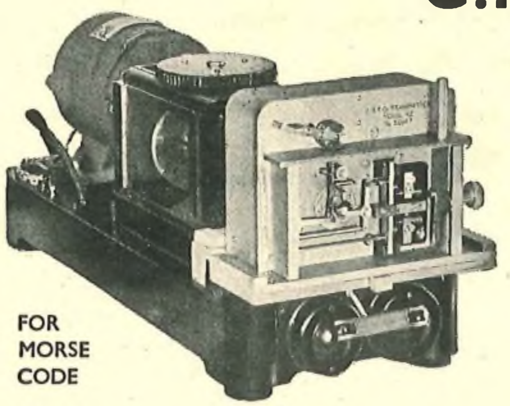

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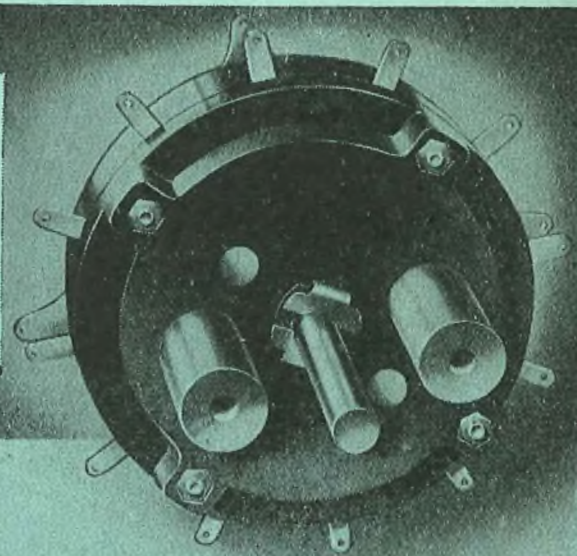

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