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A Mobile Automatic Telephone Exchange

R. W. PALMER, A.M.I.E.E., and G. A. O. ABBOTT

U.D.C. 621.395.3.4 621.395.722 629.113 621.355

The Post Office has built a standard Unit Automatic Exchange No. 12 for 100 lines in a vehicle which can be towed to rural sites for temporary service. This experimental mobile exchange is self-contained, and the authors describe the construction of the trailer, the transport and telephone facilities, and the alternative arrangements for charging the batteries from the petrol engine charging set or from a public A.C. supply.

Introduction.

AN automatic telephone exchange suggests to the mind a permanent building housing an assembly of equipment and power plant for the purpose of controlling the switching of circuits within an area and thus providing a continuous telephone service for a period of years. The time taken for the provision of a small automatic exchange of the unit type may vary from six months, when suitable accommodation is available, to over a year, when difficulties in obtaining a site occur. The desirability of being able to provide an exchange at very short notice has led the Post Office to design and build experimentally a trailer vehicle completely equipped as a small unit automatic exchange for not more than 100 subscribers.

The need for the urgent provision of a rural or small urban exchange occurs more often than is generally realised, and some of the special circumstances for which a temporary unit is required to serve an area until permanent plant can be installed are : --

(*a*) Replacement of a small manual exchange following the sudden termination of the service of a caretaker-operator by death or other unforeseen circumstance.

(*b*) Replacement of a unit automatic exchange while it is being replaced by one of a larger size within the confines of the original permanent building.

(*c*) Replacement of a small automatic or manual exchange which has been damaged by fire or flood.

(*d*) Provision of a new exchange to meet unexpected development such as in connection with the defence services.

(*e*) Provision of exchange service to cover unavoidable delays in the scheduled erection or extension of a U.A.X. building or in the acquisition of a suitable site.

(*f*) Relief to a non-director automatic exchange.

It will be realised that the provision of an exchange may require the finding and negotiation of a site ; the renting or erection of a building ; the delivery of exchange equipment ; the cabling of the units ; the provision of the power plant ; and the final acceptance testing of the exchange as a whole.

Under emergency conditions, any scheme which would enable a telephone service to be provided in the shortest possible time is of advantage to the public as well as to the Post Office revenue and prestige. The provision of an exchange complete in every detail, and the reduction of the site problem to one of negotiation for vehicle parking space, materially reduce the time required to provide service and permit the normal procedure to be followed for the subsequent provision of the permanent exchange.

The modification of the subscribers' instruments and lines is work which would be necessary in any conversion from manual to automatic working and this work can be commenced before the mobile unit arrives.

General Design.

The first step towards the provision of a mobile exchange was taken in the Scottish Region where urgent service was provided successfully by installing a unit automatic exchange in a trailer caravan. The trailer was not built for carrying any great load and it was necessary to install the equipment after the vehicle had been positioned on site, but the success of the experiment was such as to justify the building of an exchange that would be fully mobile and completely self-contained. It was originally suggested that a mobile exchange unit should be designed with capacity for 25 subscribers and should be capable of being transported either by road or by rail. After protracted discussions, it was finally decided in April, 1938, that the provision of a single exchange of this type should be produced experimentally by the Circuit Laboratory of the Engineer-in-Chief's Office, no precise specification being given. In the first place, rail transport had to be ruled out because it was desired to use standard U.A.X. units which are 6 ft. 10 in. high, and would therefore involve difficulties in keeping within the limits of the railway loading gauge, and in transferring this heavy equipment to road transport, to complete the journey to some rural site.

Lack of time precluded any attempt to design a vehicle specially to accommodate exchange equipment, and it was decided to utilise the basic design of a 4-wheeled trailer vehicle used by the Defence Services.

This defined the principal dimensions, the floor area

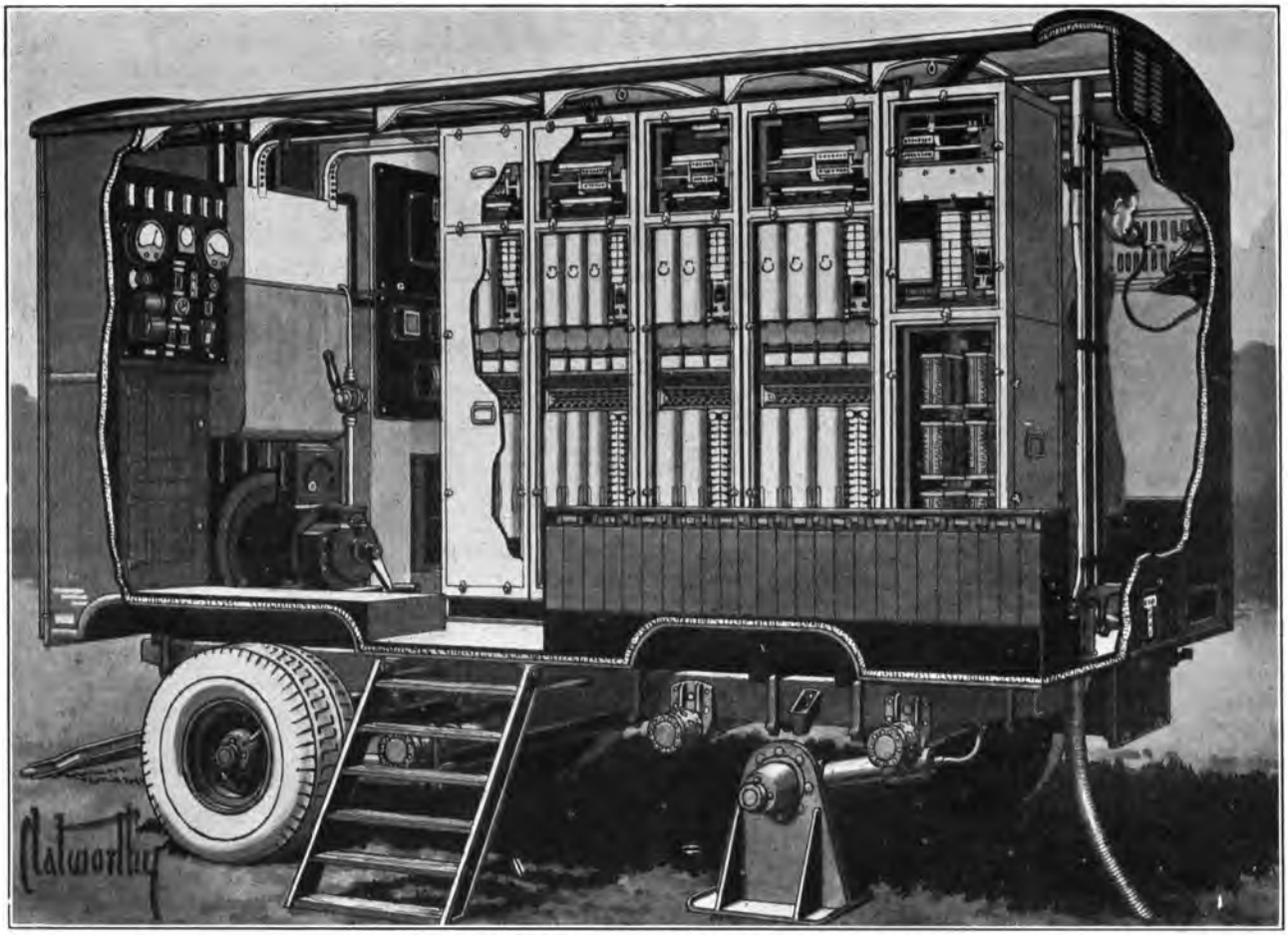

FIG. 1.—GENERAL VIEW OF THE VEHICLE AND EQUIPMENT.

being approximately equal to that of the equivalent standard U.A.X. No. 12 brick building, but it was necessary to rearrange the layout to provide balanced distribution of weight and low centre of gravity, and to meet other requirements of a road vehicle. A full-size model was constructed on the laboratory floor in canvas and timber in order to study the maximum amount of equipment which could be housed under these limitations. Some of the automatic exchange equipment was available for use in this model, and the remainder was simulated by rough shapes constructed mainly of cardboard. After many re-arrangements and practical tests for accessibility, it was found that the floor area of 15 ft. 9 in. × 7 ft. with a maximum height of 7 ft. was sufficient to house symmetrically a completely equipped U.A.X. No. 12 equipment for 90 subscribers and 10 junctions, together with duplicate batteries, duplicate charging plant (A.C. rectifier and petrol engine charging set), and all other standard facilities required in such an exchange. The final arrangement is shown in Figs. **1** and **2**. The necessary departures from standard equipment were limited to certain items of the power plant and were :—

(1) The adoption of traction type batteries (which are smaller) and the enclosing of these batteries in two lockers at floor level, so that they do not seriously impede access to the exchange units.

(2) The abandonment of full accessibility to the petrol engine from within the bodywork, access to one side being from the outside of the vehicle.

(3) The adoption of radiator cooling for the petrol engine in place of tank cooling.

At this stage, a provisional specification for the vehicle was prepared but some details of the bodywork had to be settled in co-operation with the contractor while erection was proceeding. After completion of the bodywork the empty vehicle was brought to the West Postal Yard in King Edward Building where the exchange equipment was installed, cabled, and

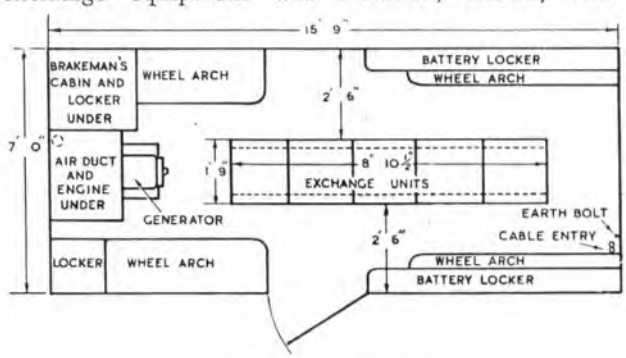

FIG. 2.—FLOOR PLAN.

finally tested out. On completion the vehicle was inaugurated by the Postmaster-General at a ceremony described previously in this JOURNAL[1].

Chassis.

The 4-wheel torsion bar trailer chassis, Fig. **3**, was supplied by Messrs. J. Brockhouse & Co., Ltd., West Bromwich, and is the same as that commonly employed by the Royal Air Force for carrying special

FIG. **3**.—TORSION BAR TRAILER CHASSIS.

signalling equipment at speed over rough country. The independent springing consists of four torsion bars, one for each wheel. The bars are about 5 ft. long and $1\frac{7}{8}$ in. in diameter, and are of silico manganese spring steel, oil-hardened and tempered, with an ultimate tensile strength of 85-100 tons per square inch. Each one is encased in a tube extending across the whole width of the chassis and one end is anchored to the chassis by a splined sleeve. The other end passes through a bearing and is then splined to a tubular crank arm, termed the "oscillating arm," at the extremity of which is a stub axle on which the wheel is mounted. The load on the wheel is therefore taken up by the twisting of the torsion bar and this provides a system of springing which is very smooth, completely adjustable and capable of following the contour of rough ground with a minimum of disturbance to the level of the body of the vehicle.

The two front wheels are mounted on a turn-table with freedom to rotate 45° on either side of the straight-forward position, and the draw bar attached to this turn-table terminates at a steel coupling eye.

Ministry of Transport regulations limit the speed of a 4-wheel trailer to 20 m.p.h. and also demand that there shall be independent control of the trailer brakes when positive control by the driver of the towing unit is not provided. Over-run brake systems are not permitted on heavy trailers.

As it is not known what type of tractor will be hired on the occasions when the exchange is to be moved, it is essential to have facilities for independent control by a brakeman, for whom a cabin is provided on the trailer as seen in Fig. **4**. In addition to the brake lever in this cabin, there is a second brake lever located on the near side of one of the main chassis members for use as a parking brake when the trailer is being manœuvred into position by hand.

Each of these brakes will operate, independently, the Lockheed hydraulic brake system on the four wheels.

[1]*P.O.E.E.J.*, Vol. 31, p. 285.

As the weight of the complete vehicle, when loaded, is 5 tons 14 cwt. it is not possible to manœuvre it by hand except on concrete or similar level surfaces, and, even then, about twelve men are required for the purpose. When the mobile exchange has arrived at the temporary exchange site, it is desirable that the pneumatic tyred wheels should be removed to a place of safety, if only to avoid the damaging effects of the weather on the rubber, and the more usual system of jacking up the chassis has been abandoned in favour of the provision of heavy steel feet which can be bolted on to the axles in place of the wheels. These feet, or dummy wheels, can be seen in use in Fig. **1**, and are normally carried on the vehicle. This scheme of supporting the weight on the axles instead of on the main chassis members has the advantages that distortion of the chassis and body is reduced if the foundation is uneven, the material for supports is always to hand, and the operation can be carried out by one man.

Bodywork.

The body was supplied by Messrs. E. G. Brown & Co., Ltd., Tottenham, and, although the general construction is in agreement with the standard designs previously produced by that company the arrangement of the steel channel members forming the framework has been altered to suit the particular location of the telephone exchange equipment. All joints in this framework are welded in order to obtain the advantage of strength and freedom from bolts or rivets which might rust or become loose. A further protection against distortion is the addition of small webs of heavy sheet steel

FIG. **4**.—VIEW SHOWING BRAKEMAN'S CABIN.

welded into the angles at the top and bottom of each vertical member. (Fig. **1**). The floor framework is specially strengthened where securing bolts for equipment are required, and the floor itself consists, first of sheet steel laid on the frame members, then a 1 in. layer of insulating cork, then a second covering of sheet steel, and finally a covering of $\frac{3}{16}$ in. rubber, which is provided mainly as a protection against electric shock from the A.C. power supplies. The floor covering is turned up where it meets the side walls so that there are no sharp angles or corners to collect dust. To maintain a low centre of gravity, the floor is built as near as possible to the chassis members. This necessitates wheel arches rising 6 in. above floor level to provide wheel clearance. These wheel arches are, however, arranged with flat tops and are covered with rubber, in the same way as the rest of the flooring, in order that they can be used as an effective part of the available floor area.

The whole of the walls and roof are similarly constructed with 1 in. of cork insulation between the steel sheets but no rubber insulation was considered necessary. Special steps were taken to guard against rust, the screws securing the steel panels being tinned and treated with an additional rust-resisting preparation. The door is located on the near side in a position selected with reference to the problem of getting the exchange units into the vehicle. The door itself is also constructed of metal panels and cork insulation and the edges are specially designed to make a weather-proof joint when the door is shut. A Yale type standard U.A.X. lock is fitted and a letter box has also been incorporated for use when it is necessary to send official correspondence or instructions direct to the mobile exchange at the site which it may be occupying. For access at the doorway, a flight of steel steps is provided for bolting into position when the unit is on site. When travelling, the steps are housed in a simple fixing underneath the main chassis members.

The brakeman's cabin encroaches considerably on the space available inside the body, but, by careful arrangement of the accessories mounted in the forward end of the vehicle, and by using the space underneath the brakeman's seat for a tool locker, accessible from the inside, the loss of effective space has been reduced to an absolute minimum. The walls between the brakeman's seat and the interior of the vehicle contain cork insulation, but no such insulation is necessary in the other boundaries of the cabin. The cabin is accessible only from the outside, the door being opened and folded back flush with the forward wall of the body when the vehicle is travelling. On arrival at site, the cabin door is shut and locked with a standard U.A.X. lock and it was specially arranged that the brake lever in the cabin has to be in the " ON " position before the cabin door can be shut.

The window beside the brakeman is capable of being opened in order that hand signals can be given to following traffic, but the four windows in the main part of the vehicle are permanently shut in order to reduce the risk of dust entering the telephone exchange equipment. These windows are provided with sliding steel shutters on the inside so that they can be closed while the vehicle is unattended and will prevent damage to the equipment even if a window should be smashed accidentally or otherwise. This precaution is taken in addition to the provision of Triplex glass. Ventilation is provided by five ventilators, two on each side and one at the rear end, each being fitted with a gauze filter and an adjustable shutter to control the aperture. The outside face of each ventilator is covered by louvred panelling to exclude rain.

A locker, with access only from the outside, is built underneath the floor at the rear end to accommodate the four steel feet and other heavy tackle associated with the transport aspect of the vehicle. Two interior lockers, one of which is provided with drawers to accommodate small tools, are built into the forward end of the bodywork, Fig. **5**, one underneath the brakeman's seat, and the other in the opposite corner, where it forms a support for some of the power switchgear. The most important of the lockers are those for housing the batteries, the weight of which is such that a symmetrical arrangement is essential. The two batteries, weighing approximately $\frac{1}{4}$ ton each, are, therefore, housed separately, one above each of the rear wheel arches, Figs. **1** and **6**. This also keeps the centre of gravity as low as possible. The steelwork in these lockers has been specially treated with anti-corrosive paint, and the cells themselves stand on wood blocks. The lockers enclose the batteries completely and are provided with their own small ventilators, giving direct access to the outside air. Since none of the lockers can form a table as normally provided in a unit automatic exchange, and also as space is not available for a fixed table, a folding table and seat are provided under one of the windows where they obstruct the gangway only when in actual use. Figs. **5** and **6** are photographs taken before the exchange units were installed, but the two girders on which the units are to be mounted can be seen.

Provision had to be made for the following cable entries through the floor or walls of the bodywork.

(1) Entry through the floor at the forward end for an underground electric supply cable, and for an earth wire for connection to the supply company's switch gear.

(2) Entry through the top of the forward end wall for an overhead electric supply cable.

(3) Entry through the floor at the rear end for an earth wire for connection to the bodywork and telephone equipment, independently of the power supply earth.

(4) Entry through the floor at the rear end for an underground telephone cable.

The telephone cable required special consideration, and it has been arranged for the cable to be protected between the ground and the underside of the vehicle by a 2 in. diameter flexible metal tube which can be attached by a screwed coupling.

The complete vehicle is painted the standard Post Office green on the outside, with the addition of the G.P.O. monogram and the inscription " Mobile Automatic Telephone Exchange " on the two sides

FIG. 5.—INTERIOR VIEW—FRONT END.

FIG. 6.—INTERIOR VIEW—REAR END.

and on the rear panel. Up to shoulder level the interior is painted a light grey to match the telephone exchange units and to give as much reflected light as possible. Lockers and metal fittings are painted green, and the roof, together with the upper part of the walls, is painted white in order to help in obtaining adequate natural light under conditions of plant congestion.

Six bulkhead lighting fittings of an attractive type, supplied by Messrs. Holophane, are spaced three on each side wall, the four corner fittings (60 watts each) being connected to the electric supply mains, and the two centre units (25 watts each) being connected to the exchange battery. Each of these lighting systems is provided with a time switch to guard against the lights being left on when the vehicle is unattended. Local switches in the circuits permit either set of lights to be operated at will, and all wiring is enclosed in steel conduit.

Power Supplies.

The duplicate secondary batteries each consist of twenty-five 72 ampere-hour cells of the traction type, manufactured by the D.P. Battery Co. The principal battery charging equipment from the point of view of accommodation in the vehicle is the petrol engine set, which is a standard unit as supplied to the Post Office by Messrs. Petters of Yeovil for all small unit automatic exchanges. It consists of a 2 h.p. water-cooled single cylinder petrol engine directly coupled to a 500 watt D.C. generator, and is mounted centrally on the floor at the forward end (Fig. 5) on rubber anti-vibration washers and a galvanised steel tray with drainage for surplus water or oil which otherwise might collect.

There is, however, an important difference from the standard U.A.X. equipment in that radiator cooling has been adopted in place of tank cooling in order to save space and weight. A pulley, fitted at the forward end of the petrol engine, is coupled by a whittle belt to the fan associated with the large radiator immediately above the engine. Access for inspection of this belt and of other parts of the engine on that side is facilitated by a door in the wall of the vehicle. Incidentally, this door is used as the means of entry for the engine during installation or replacement. The radiator fan draws air through louvres in the forward end of the vehicle, forces this air through the radiator and discharges the heated air through an enclosed duct. This air duct terminates at louvres high up in the end wall and prevents the hot air from circulating in the main body of the mobile exchange.

The engine runs unattended until the automatic trip comes into operation when the battery is fully charged, and one of the disadvantages of radiator cooling under these circumstances is the greater risk of overheating as compared with the more usual tank cooling system. Special steps are, therefore, necessary to reduce the risk of the radiator being short of water, and, for this purpose, arrangements are made to store water in a tank below the floor so that it can be pumped as required by a semi-rotary pump into the radiator until water is seen to spill from the overflow pipe on to the tray underneath the engine. As a further precaution, and in view of the difficulty of obtaining a supply of water in country districts, the rainwater gutters at the sides of the roof are connected by 1 in. pipes to the storage tank. It is, therefore, expected that there will usually be a supply of rainwater in the tank, and the instructions

to the maintenance man are that he should always operate the hand pump to ensure that the radiator is quite full before starting the engine. The storage tank has a water level gauge, an overflow vent, and an additional orifice on the outside so that it can be filled from a bucket when necessary. A two-gallon petrol tank, accessible only from the outside, is built into the near side front corner of the floor and a petrol gauge is provided.

A Tungar rectifier for charging from the A.C. supply mains, when available, is also fitted at the forward end and charge-discharge working of the batteries is adopted no matter which type of charging unit is in use. The rear wall of the brakeman's cabin is utilised for two wood panels, one for mounting the supply company's main fuses and meters, and the other for the main switches and fuses controlling the Tungar rectifier and the lighting units.

FIG. 7.—MOBILE U.A.X. ON SITE.

Telephone Equipment.

The exchange equipment (U.A.X. No. 12) is housed in five totally enclosed units which are standard in every respect[2] except that the individual steel channel iron feet and wood mounting blocks have been replaced by two lengths of heavy channel iron extending the whole length of the five units. Rigidity is provided by bracing the tops of the units to both sides of the body. Each unit is constructed of a mild steel framework surrounded by a sheet steel cavity-walled cabinet and the removable doors at the front and back are clamped against rubber cord to make the unit airtight. The complete suite of five units forms a rectangular block 8 ft. 10 in. × 1 ft. 9 in. × 6 ft. 4 in. high, leaving 2 ft. 6 in. gangways at the front and back, 2 ft. at the ends and 8 in. clearance below the roof of the vehicle.

The units are in the following order, commencing from the rear end of the vehicle :—

Auxiliary Unit (to which the telephone cable is connected).
A Unit (for 25 subscribers)
B Unit (for 20 subscribers)
A Unit (for 25 subscribers)
B Unit (for 20 subscribers)

Each of the subscribers' units is complete with a proportionate amount of junction equipment. The auxiliary unit has permanently connected to it a short length of telephone cable extending under the floor and terminating at a position on the rear wall adjacent to the incoming cable (Figs. **1** and **6**). On this wall is a demountable joint in which the pairs in the incoming cable can be jointed to those in the exchange cable, the whole being sealed against the ingress of moisture without the employment of plumbing operations. As this joint will be made and re-made fairly frequently, the end of the exchange cable will gradually have to be cut back, so the joint is bolted to a pair of vertical channel members extending from floor to ceiling. As first supplied, the exchange cable is of such a length that the joint is made near the ceiling, and as the exchange cable becomes shorter, the position of the joint is adjusted by two bolts. At some distant date, when the exchange cable has become too short, a new length of exchange cable will have to be installed. Fig. **1** also shows the shelf provided to accommodate the service telephone instrument.

Service.

The present mobile automatic exchange is definitely experimental, and for the purpose of proving the practicability of such a vehicle. Its first service has been the urgent replacement of a rural manual exchange at North Weald, Essex. Fig. **7** is a photograph of the Mobile U.A.X. on site and shows on the left, the overhead power supply, and on the right, the exchange distribution pole from which the lines are connected to the vehicle by a short length of underground cable. The replaced manual exchange was in the village Post Office, which is just visible on the left.

Although the first mobile automatic telephone exchange has been a product of the Post Office Circuit Laboratory, a special acknowledgment is made to Messrs. E. G. Brown & Co. for their contribution of ideas and interest in the many problems of meeting conflicting requirements. It will also be appreciated that the design of a self-contained mobile automatic telephone exchange has required the co-operation of many specialists, without whose willing assistance the work would have been seriously hampered.

[2] *P.O.E.E.J.* Vol. 28, p. 105.