A New Portable Generating Set for Manhole Lighting

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The new "Generator, P.E.D., Portable," described in this article, is for use in conjunction with a 24-V battery to give improved lighting of manholes. The automatic voltage regulation is such that a compensated output voltage characteristic is obtained, making the plant suitable both for battery charging, and for possible use in operating equipment such as cable driers and soldering irons.

Introduction.

FOR many years the acetylene lamp has been the standard means of lighting Post Office underground plant. It has long been realised, however, that this method of illumination, although providing adequate light, has a number of disadvantages, e.g. the risk of ignition of combustible gases, the emission of fumes and heat which may be distressing to operators when the lamp is used in a confined space and the difficulty in disposing of spent carbide.

Prior to 1939, efforts were made to develop a suitable portable electric lamp, and field trials were conducted with the "Handlamp, Electric, No. 3A," but it was found that the illumination provided was insufficient and difficulty was experienced in providing charging facilities.

At the outbreak of war further development work was abandoned, and it was not until 1945 that the matter again came under active consideration. It then appeared that the only satisfactory method of obtaining an adequate light in manholes for prolonged periods was by a portable generating set, and experiments were carried out under practical conditions with a petrol-engine-driven set lent by a manufacturer ; promising results were obtained.

In 1946, however, supplies of war-surplus petrol-engine-driven battery charging sets became available, and after examining a number of types, it was decided that a 24V, 300W set of U.S.A. manufacture was the most suitable for the Department's purpose. The set consists essentially of a 68 c.c. four-stroke petrol engine with an extended crankshaft which carries the generator armature. As the engine is fitted with coil ignition, a secondary battery is necessary and 12V, 22 Ah lead-acid batteries were therefore obtained from the same source as the generating sets. This type of battery is contained in a wooden case with a hinged lid and carrying strap, the output being terminated on a two-pin, non-reversible, weatherproof socket.

A combined clip and stand lamp was developed for general use in underground plant, and 40W traction type lamps used because of their more robust construction.

The complete equipment is illustrated in Fig. 1.

Experience with Generating Sets in Service.

Distribution of the war-surplus equipment commenced in 1947 and it has proved extremely popular with external staff as a result of the great improvement experienced in working conditions in manholes.

However, with the introduction of these sets, maintenance difficulties also began to arise as many sets were found to be damaged or incomplete on receipt, and the small stock of spares, which could not be replaced, was quickly dissipated in making them serviceable. Many of the batteries were also found to be unserviceable from the effects of prolonged storage or damage sustained in transit.

Day-to-day maintenance of generating sets and batteries is carried out by the external staff using the equipment, but larger overhauls and repairs are handled by Motor Transport staff who have been obliged to exercise much ingenuity in order to overcome the shortage of spares.

Design of Replacement Generating Sets.

In 1948, the design of a generating set to supplement and ultimately replace the war-surplus equipment came under consideration.

The following features appeared to be desirable :—

a) The voltage should be retained at 24V to facilitate interchangeability with the existing equipment but the output should be increased to 500W to allow for

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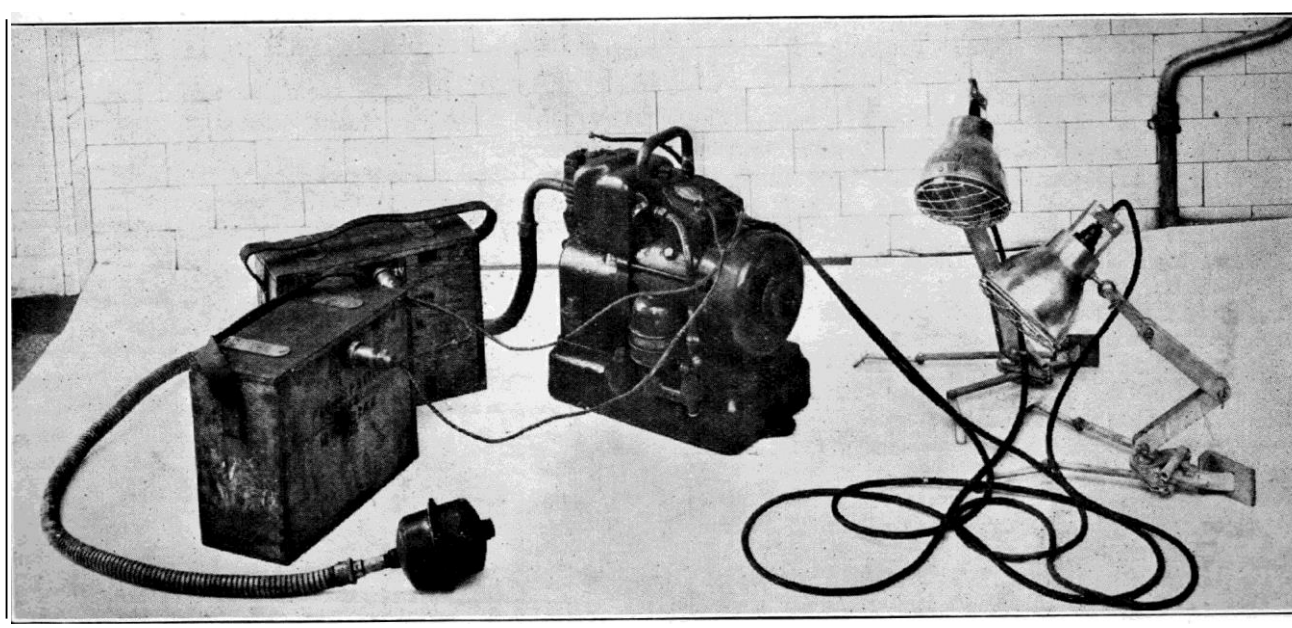

FIG. 1.-COMPLETE EQUIPMENT USING WAR SURPLUS CHARGING SET AND BATTERIES.

operation of various other items of equipment at present under consideration.

a) The weight should not greatly exceed that of the war-surplus set (93 lb.).
b) The set should be of unit construction for lightness and compactness.
c) The set should be simple to operate and voltage regulation should be automatic.
d) The set should be operated in conjunction with a 24V battery. This is necessary because it is undesirable from the noise aspect to run the engine at night when shift work is being carried out in a residential area ; also, the provision of a battery saves unnecessary wear and tear on the engine since the set may be shut down when light loads are connected and started up only when it is necessary to recharge the battery.
e) A four-stroke engine should be employed. Two-stroke engines are not favoured because of (i) noise and (ii) the lubrication system relies on mixing oil with the petrol, a requirement which is apt **to** be overlooked by the operator, with consequent damage to the engine and increased major maintenance.
f) It should be possible to supply a load from the generator whilst battery charging is in progress.
g) The ignition should be switched off automatically when the battery voltage reaches a predetermined figure in order to avoid unnecessary engine wear.

In the production form of the generator set, known in the Post Office as "Generator, P.E.D., Portable," unit construction was found to be too expensive, and standard commercial engine and generator units had to be employed with inevitable increase in weight.

Description of Generator, P.E.D., Portable.

Illustrations of the new generator set appear in Fig. 2. The engine drives the generator through a flexible coupling and both units are mounted on a bed-plate fabricated from sheet steel.

A control panel is mounted on the guard frame over the generator with the output of the generator terminated on five 2-pin non-reversible weatherproof sockets connected in parallel and mounted on the front of the control panel. At the back of the panel are housed the combined voltage regulator and cut-out unit and the voltage sensitive relay, a lid protecting these units from dirt and water.

Also mounted on the control panel are a moving coil ammeter reading 0 to 30 amps., and a 25 amps. slydlock fuse, both of which are connected in the generator circuit. The starter and voltage sensitive relay reset buttons are mounted on top of the control box for convenience in operation.

A petrol tank, having a capacity of one gallon (sufficient for 5 to 6 hours' running on full load) is mounted on the guard frame as shown in the illustrations.

Engine. The engine, a single-cylinder four-stroke air-cooled unit, develops 1.3 b.h.p. at 3,000 r.p.m., and is maintained at this speed by a centrifugal governor enclosed in the crankcase. The governor operates the throttle butterfly valve by means of an external linkage and provision is made for the speed of the engine to be varied within small limits by adjustment of a tension spring attached to the linkage.

A fan is attached to the flywheel, air being directed over the cylinder by a cowling to cool the engine. Flywheel-magneto ignition is employed, which makes it possible for the set to be operated without batteries if necessary, and the ignition system is fully screened to avoid interference with radio reception. A pulley fitted on the end of the crankshaft remote from the generator enables hand starting to be effected by a rope in the event of the battery charge being so low that it will not motor the generator. The engine is fitted with two controls only—the choke, which consists of a shutter on the air intake filter, and the magneto cut-out button.

Generator. The generator is a two-pole shunt wound machine, fan-cooled and of drip-proof type with grease-packed ball bearings. The armature conductors are wound in semi-enclosed slots, the slot insulation being glass fibre, and an auxiliary field winding is provided to enable the machine to be motored from the battery when starting.

Automatic Voltage Regulator. A combined cut-out and voltage regulator unit is fitted. The cut-out is provided with shunt and series windings and is adjusted so that the points close when the generator voltage reaches 24.5V, thus completing the circuit between generator and load. The series coil is connected to assist the shunt winding under these conditions. If a battery is connected, however, and the generator voltage falls below the battery voltage, a reverse current will flow. The magnetic field of the series winding then opposes that due to the shunt winding, causes the armature to release, opens the cut-out points and thereby prevents the battery from discharging through the generator. **Release** occurs when the reverse current is between 3 and **4** amps.

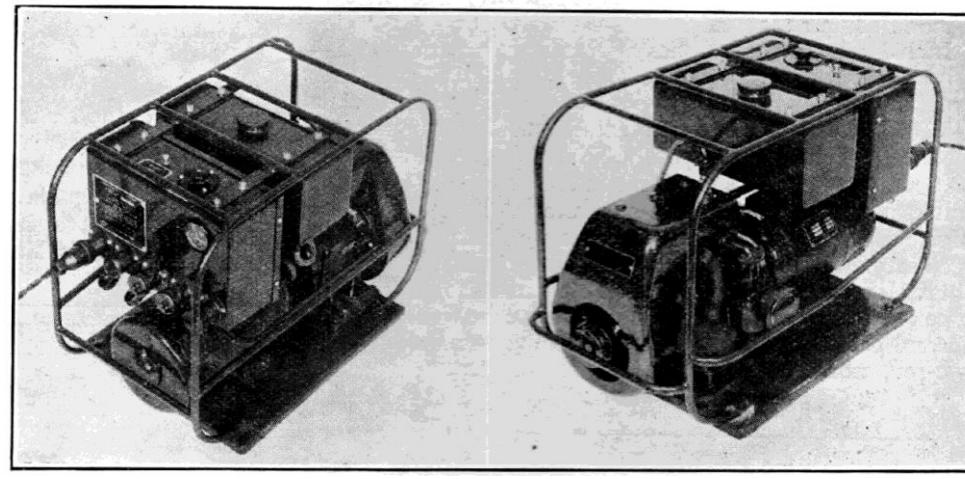

FIG. 2.—TWO VIEWS OF A GENERATOR, P.E.D., PORTABLE.

The voltage regulator electromagnet also carries shunt and series windings. As the generator voltage rises, the magnetic effect of the shunt winding increases until the armature operates and the moving contact C1 (see Fig. **3),** which is normally held against the fixed contact A, moves

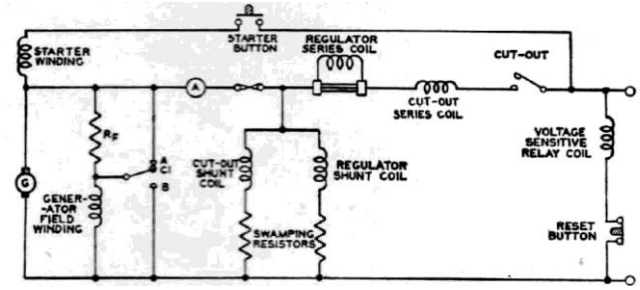

FIG. 3.—CIRCUIT DIAGRAM OF GENERATOR, **P.E.D.,** PORTABLE.

to its mid-position thus removing the short-circuit on the series field resistor, R_F. The generator field is weakened therefore and the generated voltage reduced. Under this condition the pull of the shunt coil also diminishes and the armature of the voltage regulator therefore restores to normal. Contact C1 then makes again with the fixed contact A, thus short-circuiting the field resistor, R_F, and strengthening the generator field, and the generator output voltage is thus held substantially constant as the generator speed increases. Ultimately a speed is reached at which the required output voltage is generated with the resistor R_F permanently in circuit. Above this speed the contact C1 makes with the fixed contact B, short-circuits the generator field windings and connects the resistor R_F across the generator armature thus almost completely destroying the excitation. The moving contact continues to alternate between its mid-position and the fixed contact B until, if the speed were increased to a value above the normal operating range, a point would be reached at which the required voltage would be generated solely due to the residual magnetism of the machine. The series turns aid those of the shunt winding and by arranging for the former to carry a proportion of the load current, a compensated voltage characteristic is obtained. The heavier the load current, the lower is the voltage at which regulation occurs, thereby ensuring that the generator is not overloaded, and limiting the initial current when a completely discharged battery is connected in circuit.

Output Characteristics.

The compensated voltage characteristic is illustrated by the curves in Fig. **4,** which were plotted from the results of

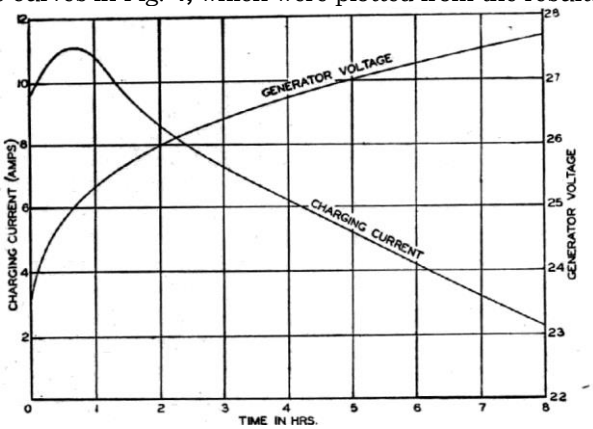

FIG. 4.-VARIATION OF GENERATOR OUTPUT DURING BATTERY CHARGING.

tests on the prototype generating set. The generator was connected to a 54Ah 24V battery which had been discharged to 1V per cell. In spite of the discharged state of the battery the initial charging current did not exceed 11 amps., the generator voltage being regulated to approximately 23V. As the battery terminal voltage rose on charge, the regulator allowed the generator voltage to increase at a somewhat slower rate, giving a battery charging current which gradually tailed off as shown.

At hourly intervals a resistive load was switched in circuit and the division of generator current between load and battery measured. These results are plotted in Fig. 5. The battery charge continued until the point was reached where the battery voltage equalled the generator voltage when a load was being taken from the set. From that point onwards, the battery commenced to take an increasing share of the load. The heavier the resistive load, the lower was the

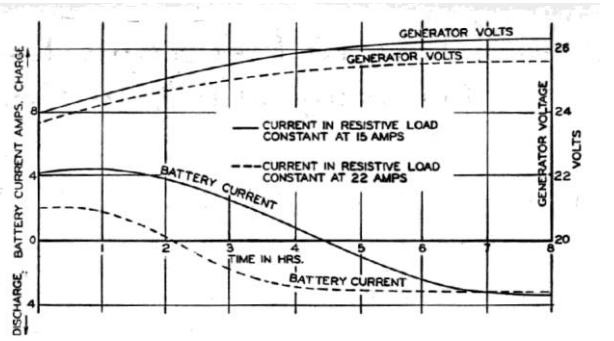

FIG. 5.—EFFECT OF RESISTIVE LOADS ON GENERATOR VOLTAGE AND BATTERY CHARGE AND DISCHARGE CURRENTS.

generator voltage and the lower the voltage at which the battery commenced to discharge.

The dual requirements of battery charging and operation of other equipment are conflicting since the former demands varying voltage characteristic whilst the latter requires that the voltage should remain as steady as possible. The compensated voltage control provides a compromise. Excessive charging currents are avoided and the output voltage variations are restricted to a reasonable amount, at the expense of a certain proportion of the battery capacity since the charge is stopped before gassing commences.

Electrical Circuit.

A voltage-sensitive relay, which may be adjusted to operate within the range 28-31V, is connected across the circuit on the battery side of the cut-out. The contacts are normally open, but when the battery voltage reaches the relay setting the relay operates and its contacts short-circuit the magneto contact-breaker points, thus stopping the engine. The relay will not restore to normal until the voltage applied to the coil falls to a low value. It is desirable, however, to be able to restart the set at any battery voltage, and a reset button is provided, therefore, to trip the relay by breaking the coil circuit.

Batteries.

A 24V 40Ah battery, with the Post Office title of "Battery, Secondary, Portable, No. 14," which is suitable for use with both Generators, P.E.D., Portable and the original generating sets has been produced in conjunction with the Telephone Development and Maintenance Branch of the Engineer-in-Chief's Office. The battery is contained in a reinforced hardwood case with a hinged lid, and the output is terminated on a 5 amp. non-reversible 2-pin weatherproof socket accessible from the outside of the box.

Future Developments.

250 Generators, P.E.D., Portable are now in course of delivery, but as there was insufficient time to carry out extensive field trials before a large number of the original sets required replacement, further modifications may be made to the specification as the result of experience gained with the new sets.

Consideration is also being given to the design of accessories for use with the generating sets, including a 500W portable cable drier, and an electric soldering iron.

Acknowledgments.

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