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Lister

A. C.

START - O - MATIC
ELECTRIC GENERATING PLANT

R. A. LISTER & CO. LTD.,
DURSLEY, GLOUCESTERSHIRE,
ENGLAND

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THE LISTER A.C. START-O-MATIC GENERATING PLANT

2.5 k.W.	230 volts.	50 cycles.
2.5 k.W.	110 volts.	60 cycles.

General Description

The A.C. Start-O-Matic Generating Plant is entirely automatic in operation, starting up when a lamp, heater or small motor, with a consumption of 40 watts or more is switched on and continuing to run until all such appliances have been switched off.

ENGINE.

The Plant incorporates the Lister type 5/1 Single Cylinder Water-cooled Diesel Engine, developing 6 B.H.P. at 650 R.P.M. Full details are given in Engine Instruction Book No. 103.

The Alternator is of the self-excited rotating armature type. The armature carries two sets of windings, one the A.C. winding which is connected to a pair of slip-rings and the other the D.C. winding which is connected to a commutator and provides excitation current to the main field system. The alternator also incorporates series starting windings which combine with the D.C. armature winding to act as a series motor for cranking the engine. An auxiliary field winding is used in conjunction with a choke or current transformer and rectifier or rectifier and compound trimming resistance to provide the required voltage control.

CONTROL GEAR.

The bulk of the controlling switchgear is housed in a dust-proof cubicle. An exception is the starting contactor which is housed in a sheet steel cubicle mounted on the Alternator. This cubicle also contains the voltage regulation equipment.

STARTER BATTERY.

The 12 cell (24 volt) starter battery has a capacity of 100 ampere hours at the 20 hour rate, or 89 ampere hours at the 10 hour rate. A standard automobile battery is recommended and may be installed in two 6 cell units or four 3 cell units.

Alternatively, a battery comprising 20 nickel steel or nickel cadmium cells with an Alkaline Electrolyte can be used. The capacity must be at least 75 A.H. at the 10 hour rate of discharge.

The battery is charged from the D.C. armature windings whilst the plant is running and a change-over link is provided in the switchgear cubicle, its two positions giving alternatively 'high charge' or 'low charge.'

General Description of the System of Operation

The system of operation is described in complete detail on Page 6 but the following will serve to give a general outline of the scheme.

(1) PRELIMINARY.

On switching on a lamp, current flows from the 24 volt battery through the lamp and the detection coil of the load relay, which closes its contacts and feeds the load contactor coil.

(2) TURNING ON THE FUEL.

The load contactor, on closing its auxiliary contact, energizes the fuel control solenoid, thus allowing the fuel pump rack to move to the "start" position.

(3) CRANKING THE ENGINE.

The load contactor also completes a circuit to the coil of the starting contactor, which on closing its main contacts, connects the battery to the series starting windings and the D.C. armature winding of the self-excited alternator. The armature and starting windings behave as a series motor, thus rotating the engine.

(4) STOP CRANKING WHEN ENGINE FIRES AND IS GETTING AWAY.

The speed detection switch is operated by the engine governor lever. This switch on making contact, energizes a relay which breaks the circuit to the starting contactor coil. (This relay is provided also with separate contacts which complete the circuit for re-charging the starter battery).

(5) CLOSING OF MAIN SWITCH CONNECTING PLANT TO THE LOAD CIRCUIT.

The main contact of the load contactor completes the circuit from the alternator to the load circuit immediately the load relay operates. The plant will then continue to run until all the load has been switched off.

NOTE: If an initial demand is made and then immediately switched off, the plant will complete a full starting cycle before coming to rest.

A complete index of all alternator windings and control gear is given on the following pages, together with the precise duty of each coil and contact.

Reference should be made to the following illustrations:—

Schematic Connecting Diagram	... ..	Figs. 4 & 5.
Back of Board Wiring Diagram	... ..	Fig. 6. (7R4QR & K Series Alternators).
Back of Board Wiring Diagram	... ..	Fig. 7. (6S4QR Series Alternators).
Illustration of Control Cubicle	... ..	Fig. 8.

Contacts are referred to throughout as being normally closed (N/C) or normally open (N/O).

N/C indicates that the contact is closed when its operating coil is de-energised.

N/O indicates that the contact is open when its operating coil is de-energised.

Item and Description

Index Letter

- A. **BATTERY CHARGE AMMETER.** Centre zero type ammeter. Indicates value of battery charging current when plant is running.
- A.A. **ALTERNATOR A.C. WINDINGS.** Connected to a pair of slip-rings from which is taken the load current.
- A.D. **ALTERNATOR D.C. WINDINGS.** These are wound in the same slots as the A.C. windings, but are connected to a commutator. Their purpose is to provide excitation current for the field coils MF and also for re-charging the starting battery. These windings also combine with the starting windings SSF to act as a series motor for cranking the engine.
- A.F. **AUXILIARY FIELD WINDING.** Used in conjunction with the rectifier MR and the current transformer C (7R4QR & K Series Alternators) or the rectifier MR1 and compound trimming resistance CT (6S4QR Series Alternators) to provide the necessary voltage control.
- B.F. **BATTERY FUSE.** Protects the starting circuit in the event of the engine stalling.
- C. **CURRENT TRANSFORMER** (7R4QR & K Series Alternators). Used in the voltage regulation circuit, current proportional to the load current, is fed through the auxiliary field winding AF, so that as load increases the excitation of the machine is increased. Various tapings are provided which are selected on test to give the best results.
- CR. **BATTERY CHARGING RESISTANCE.** Controls the value of the charging current given to the battery whilst the plant is running. A change-over link L2 is provided on the panel to give "high charge" or "low charge" depending on operating conditions. The value of the "high charge" and "low charge" currents can be varied if necessary by adjustment of the slider clips on the resistances.
- CT. **COMPOUND TRIMMING RESISTANCE** (6S4QR Series ONLY). This resistance is used for tuning the auxiliary field circuit and has been set to give the correct "FULL LOAD" voltage.

- DR. 1 **DISCHARGE RESISTANCE.** Connected in parallel with the Fuel Control Solenoid FCS. Its object is to protect the contacts controlling FCS.
- ES. **ENGINE SPEED DETECTION SWITCH.** This switch is mounted on the engine and its contact ES/1 is controlled by the engine governor lever. It operates on the change of speed from motoring to running.
- ER. **ECONOMY RESISTANCE.** Inserted in series with the Fuel Control Solenoid FCS when contact N/1 is opened. Its purpose is to limit the current passing through the coil after its initial operation.
- FCS. **FUEL CONTROL SOLENOID.** This solenoid is mounted on the engine and controls a lever operating the fuel pump rack. When stopping the plant this solenoid is de-energized thus allowing a spring to move the fuel pump rack to the "off" position.
- FR. 1 **MAIN FIELD RHEOSTAT (7R4QR & K Series Alternators ONLY).** Controls the current flowing in the main field circuit. It is of the preset type and is mounted on the sheet metal cubicle on the alternator. This rheostat is set to give the correct "NO LOAD" voltage.
- FR. 2 **AUXILIARY FIELD RESISTANCE (7R4QR & K Series Alternators ONLY).** This resistance is used for tuning the auxiliary field circuit and has been set to give the correct "FULL LOAD" voltage.
- FR. 3 **MAIN FIELD RHEOSTAT (6S4QR Series ONLY).** The top half controls the current flowing in the main field circuit, while the bottom half acts as an extra resistance in the battery charging circuit. It is of the preset type and is mounted on the sheet metal cubicle on the alternator. This rheostat is set to give the correct "NO LOAD" voltage.
- J. **CIRCUIT BREAKER DELAY RELAY.** This relay is of the "thermal" type and consists of a "Bi-metal" strip upon which is wound a heater winding electrically connected in parallel with the starting contactor coil SC and is thus energized all the time the plant is motoring. A similar "Bi-metal" strip, which has no heater winding is mounted alongside the wound strip, which after 45 seconds warps sufficiently for the two strips to make contact. Under normal circumstances the feed to the heater winding is broken by contact N/3 before this time has elapsed. The two strips mounted side by side automatically compensate for changes in room temperature.
- J/1. **N/O Contact.** Under conditions of plant failure, this contact on closing energizes the circuit-breaker trip coil K.
- K. **CIRCUIT BREAKER.** The contacts of this switch are held in the closed position by means of a toggle mechanism which is released when the circuit breaker trip coil is energized by the delay relay contacts J/1. The contacts are opened by the spring tension of the contact fingers. The circuit breaker can be tripped by hand if necessary.
- K/1. Held in closed position. When the circuit-breaker is tripped this contact opens and breaks the feed to the load contactor coil P, which on opening its contact P/2 breaks the feed to FCS, ES, SC, J & K, thus isolating the engine control circuits from the battery. P/2 opens and isolates the main load circuit.
- K/2. Held in closed position. On opening breaks the detection circuit through load relay coil TDC thus isolating the load circuit from the battery.
- L.1. **LOAD CIRCUIT CHANGE-OVER LINK.** This link is used when failure of the automatic control gear renders the plant unusable. It enables the plant to be run direct on the load circuit and instructions will be found on Page 12.
- L.2. **BATTERY CHARGING CHANGE-OVER LINK.** This link gives a choice between 'high charge' and 'low charge' and its position will depend upon operating conditions.

- MF. **MAIN FIELD WINDING.** This field winding provides the main excitation of the alternator. It is energized from the Alternator D.C. windings.
- MR. **VOLTAGE REGULATION RECTIFIER** (7R4QR & K Series Alternators ONLY). This is a full-wave metal rectifier and rectifies the alternating current output from the current transformer C to direct current which is fed to the auxiliary field AF.
- MR.1. **VOLTAGE REGULATION RECTIFIER** (6S4QR Series Alternators ONLY). This is a full-wave metal rectifier through which part of the main alternator current flows; the rectified direct current is then fed through the auxiliary field A.F.
- N. **CHARGE CONTACTOR.** This contactor has one main and two auxiliary contacts. Its coil is energized from the 24 volt battery when Engine Speed Detection Switch Contact ES/1 closes.
- N/1. **N/C Contact.** On opening inserts Economy Resistance ER in series with fuel control solenoid FCS.
- N/2. **N/O Contact.** On closing completes the battery charging circuit from the charging resistance CR to battery positive.
- N/3. **N/C Contact.** On opening breaks the feed to coils SC, J and TDC.
- P. **LOAD CONTACTOR.** This contactor has one main and one auxiliary contact. Its coil is energized from the 24 volt battery immediately the load relay contacts T/1 close.
- P/1. **N/O Contact.** Completes main circuit from alternator to load circuit.
- P/2. **N/O Contact.** Completes circuit to control coils FCS, N, SC, J, and K.
- SB. **24 VOLT STARTER BATTERY.** This battery is of the standard automobile type, having 12 cells rated 100 ampere hour capacity at the 20 hour rate or 89 ampere hours at the 10 hour rate.
- SC. **STARTING CONTACTOR.** This contactor has one main contact. Its coil is energized from the 24 volt battery when contact P/2 closes and the feed is broken when contact N/3 opens.
- SC/1. **N/O Contact.** Completes main starting circuit from battery positive to series starting field SSF and D.C. windings AD.
- SSF. **SERIES STARTING FIELD WINDING.** Incorporated in alternator. Operates in conjunction with starter battery and D.C. armature winding to give the necessary torque for cranking the engine.
- T. **LOAD RELAY.** This relay comprises two separate coils on two separate iron circuits. The one coil TDC is energized by direct current from the battery and is used for initial detection and also as a hold-on coil during the starting cycle. The other coil TAC is in the main A.C. circuit and takes over from the D.C. coil when the plant is up to speed.
- T/1. **N/O Contact.** Completes circuit to the load contactor coil P, which on operating institutes starting cycle.

Detail of System of Operation of A.C. Start-O-Matic Generating Plant

(1) LOAD IS SWITCHED ON TO STATIONARY PLANT.

Referring to Fig. 1 when load is switched on, the detection circuit is completed as follows:— Starting from Battery positive current flows through the Charge Ammeter A, Charge Contactor Contact N/3, Circuit Breaker Contact K/2, Load Relay Coil 1DC, Change-over Link L1 to the Load and returns through the Current Transformer C or the Compound Trimming Resistance CT, the Alternator Windings AA and Battery Fuse BF to Battery negative.

(2) LOAD RELAY CONTACT CLOSING GIVING FEED TO LOAD CONTACTOR.

Still referring to Fig. 1, the closing of Load Relay Contact T/1 completes the circuit to the Load Contactor Coil P, the circuit from Battery positive being through the Charge Ammeter A, Circuit Breaker Contact K/1, Load Relay Contact T/1, to the Load Contactor Coil P, and returning via Battery Fuse BF to battery negative.

(3) LOAD CONTACTOR OPERATES COMPLETING MAIN CIRCUIT AND CIRCUIT TO CONTROL COILS.

Referring to Fig. 2 as soon as the Load Contactor operates, its main contact P/1 completes the circuit from the alternator winding to the load circuit through the Load Relay A.C. coil TAC.

The closing of Contact P/1 also completes a maintaining circuit which is operative throughout the starting cycle. The feature of the maintaining circuit is to ensure that once a load demand has been made, the plant will complete a full starting cycle before shutting down even though the load has been switched off almost immediately after being switched on. This prevents the starting contactor contacts SC/1 from breaking heavy starting surges.

The maintaining circuit is as follows. Starting from B +ve through Charge Ammeter A, Charge Contactor Contact N/3, Circuit Breaker Contact K/2, Load Relay Coil TDC, Change Over Link L1, Load Relay Coil TAC, Battery Fuse BF and so to Battery -ve. The Load Relay Coil TDC then keeps contact T/1 closed. The maintaining circuit is broken when the plant is up to speed and contact N/3 opens.

Contact P/2 on closing completes a circuit to the various control coils, FCS, SC and J, as described in the following sections.

(4) FUEL IS SWITCHED ON. Fig. 2.

With the closing of Contact P/2 a circuit is completed from Battery -ve through the Battery Fuse BF, and contact P/2 to the Fuel Control Solenoid FCS returning through Charge Contactor Contact N/1 and charge Ammeter to Battery +ve. On operating, the Fuel Control Solenoid FCS allows the fuel pump rack to move to the "start" position.

(5) STARTING CONTACTOR IS ENERGIZED AND CLOSING ITS CONTACT—Fig. 2.

The closing of Contact P/2 also energizes the starting Contactor Coil SC. The circuit from Battery -ve is through Battery Fuse BF, Contact P/2, Starting Contactor Coil SC, returning to Battery +ve through Charge Contactor Contact N/3 and the Charge Ammeter A.

The Starting Contactor on closing its contact SC/1 completes the main starting circuit from Battery +ve to the series Starting Field Winding SSF, and the D.C. Armature winding AD, and so back through the Battery Fuse BF to Battery -ve. The series winding and armature behave as a high torque motor thus cranking the engine for starting.

(6) ENGINE FIRES AND RUNS UP TO SPEED: VOLTAGE IS GENERATED ACROSS THE SLIP RINGS—Fig. 3.

The Engine is now rotated; fuel is being delivered to the injector, and after a few revolutions the engine will fire and run up to speed.

A voltage is generated across the slip rings and at a predetermined speed the engine speed detection switch ES/1 makes contact thus energizing the charge Contactor N.

(7) ENGINE SPEED DETECTION CONTACT CLOSURES THEREBY ENERGIZING CHARGE CONTACTOR—Fig. 3.

With the closing of the engine speed detection contact ES/1 a circuit is completed from Battery -'ve through the Battery Fuse BF, load Contactor Contact P/2 and Speed Detection Contact ES/1 to the Charge Contactor Coil N. The return to Battery +'ve is through the charge ammeter. On operating, the charge contactor affects three separate circuits as follows:

(a) Contact N/1 opens and thereby inserts the economy resistance ER in series with the fuel control Solenoid FCS.

(b) Contact N/2 closes and completes the battery charging circuit from the positive terminal of the excitation armature AD, through the battery charging resistance CR, contact N/2 and the charge ammeter to Battery +'ve.

(c) Contact N/3 opens and breaks the circuit to the starting contactor Coil SC and the Circuit Breaker Delay J. It also breaks the detection and maintaining circuit through the load relay Coil TDC.

(8) LINE VOLTAGE REACHES MAXIMUM. PLANT CONTINUES TO RUN UNTIL LOAD IS SWITCHED OFF.

The line voltage will now have reached its correct value and the plant will continue to run until the last 40 watt lamp is switched off, thereby opening the load relay contact T/1.

(9) SHUT DOWN OF PLANT.

As stated in the preceding section the plant shuts down when the last 40 watt lamp is switched off. This allows the load relay contact T/1 to open which in turn breaks the feed to the Load Contactor Coil P. Contact P/2 then breaks the feed to the Fuel Control Solenoid FCS which on being de-energized allows the fuel pump rack to be moved to the "off" position under the action of tension springs.

PLANT FAILURE AT STARTING—Fig. 4 or 5.

To avoid unnecessary discharge of the battery, protective devices described below have been incorporated in the A.C. Start-O-Matic system which ensure that should the plant fail to start, then battery +'ve is completely isolated from the switchgear and detection circuit. The heater winding J of the circuit breaker delay relay is connected in parallel with Starting Contactor Coil SC and as long as SC is energized the heater winding J will continue to warm up. If the plant fails to start, the engine speed detection switch ES/1 does not close, and therefore the charge contactor coil N is not energized. Its contact N/3 therefore continues to feed the starting contactor coil SC and the heater strip winding J until, after approximately 45 seconds, the heater strip warps sufficiently to complete its contact J/1 which energizes the trip coil K of the circuit breaker. The circuit breaker on operating trips the toggle mechanism which holds its contact K/1 and K/2 in the closed position and the contacts open. With the opening of Contact K/1 the load contactor Coil P becomes de-energized and its contact P/2 opens: thus interrupting the feed to the starting contactor Coil SC and the Fuel Control Solenoid FCS.

Contact K/2 opens and interrupts the detection circuit through Load Relay Coil TDC, thus isolating the battery from the load circuit.

PLANT FAILURE WHILST RUNNING.

If the plant fails whilst running, through lack of fuel for example, the speed of the engine will decrease and the speed detection switch contact ES/1 will open thus breaking the feed to the charge contactor coil N. The contact N/3 will then close and the plant will begin to motor. The circuit-breaker delay relay will then operate in exactly the same way as described under "Plant Failure at Starting."

Installation, Operation And Maintenance

Owing to the varying duties of this type of plant it is difficult to lay down an exact Maintenance Schedule, but the following points will serve as a good indication of what is necessary to keep the plant in first rate running order. Particularly we would stress regular attention to the Starter battery as the load detection circuit, operation of coils and starting of the plant are absolutely dependent upon it.

INSTALLATION

Instal plant in a dry and well ventilated room. Typical layout drawings will be furnished on request, the size of rooms shown being the smallest recommended.

FOUNDATION.

Mount generating set on a concrete block 2' 3" deep, including 3" above-floor level, and 3" wider and longer than the baseplate. When pouring concrete leave four holes 4" square x 15" deep for holding down bolts.

When the concrete block is hard the set should be levelled up and a grouting mixture of cement and sand worked in under the bearing surfaces of the baseplate. The bolts should be grouted in but not tightened down until the grouting has also set hard.

EXHAUST AND FUEL PIPING.

The exhaust piping should slope downwards from the engine, preferably into an expansion chamber. The exhaust system must be arranged so that it can be easily dismantled using flanged joints where necessary. If anti-vibration mountings are used a length of flexible exhaust piping and fuel piping must be inserted in the respective systems as near as possible to the engine.

SERVICE FUEL TANK.

Mount the service tank so that its outlet connection is at least 18" above the fuel pump outlet. It will often be found more convenient to instal a bulk fuel storage tank with a pipe-line and semi-rotary pump for replenishing the service tank.

LIGHTING.

If possible the plant room should have windows in at least two sides. A pendant with 60 watt lamp should be arranged over the Generating Set. A point should also be connected to the 24 volt Starter battery so as to allow the use of a 24 volt portable lamp when the plant is stationary.

BATTERY.

This must be readily accessible as regular attention to the starter battery is very important.

SWITCH CUBICLE.

This is supplied with a stand which should be bolted down preferably on to a concrete plinth from 3" to 6" above floor level and it should be free from abnormal vibration. The switch cubicle is provided with an earthing terminal.

WIRING AND CONNECTING UP.

We strongly advise that the house wiring and connecting up of the plant is performed by a competent electrical engineer.

Three pin sockets should be used throughout and all fittings correctly bonded to earth. One side of the A.C. line is connected to an earthing stud from which connection must be made to a good earth. This is the only point at which the A.C. line should be earthed. Non-earthed conductor is colour coded red.

All connections are made at the Works between the control cubicle and the generating set. The only connections required to be made on site are those to the house distribution switch fuse, the earth connections and the battery connections. The battery connections should not be made until everything is ready for operation.

OPERATION

(a) Do not run the plant for long periods on a very light load. Try to arrange for at least one third of the output of the plant to be used. Running on less than one third of full load is false economy.

(b) Switch a light on to keep the plant running continuously when using any appliance like a vacuum cleaner or thermostatically controlled iron that is constantly being switched on and off.

With frequently repeated starts the battery cannot be kept charged unless the plant is run for a sufficient number of hours each day.

This particularly applies to equipment like electric refrigerators or pressure operated electric pumping sets.

The starter battery takes about 15 minutes to re-charge after each start with a charging current of 4 amperes.

(c) If it is required to use fluorescent lighting it is advisable to start the plant from another point before switching on the fluorescent lamp otherwise the life of the tube may be shortened.

RADIO & TELEVISION RECEIVERS.

Television Receivers have been operated satisfactorily from the plant but we suggest that care should be exercised in the purchase of a receiver, and that it should be tried out on the user's premises before the purchase is completed. A radio interference suppressor is fitted to the alternator for Radio or Television Receivers.

MOTORS.

A.C. Motors up to and including 1 h.p. may be operated from the plant. It is important that in all cases the power factor of the motor circuit should be corrected to unity by fitting a suitable condenser, otherwise the voltage regulation will be affected.

Motors up to $\frac{1}{2}$ h.p. are suitable for automatic operation. Motors rated at over $\frac{1}{2}$ h.p. and up to 1 h.p. are only suitable for hand control and the plant must be started before the motor is switched on.

The following types of motor may be used satisfactorily:—

- (1) Capacitor Start-Induction Run with separate power factor correction condenser.
- (2) Capacitor Start-Capacitor Run (which includes power factor correction condenser incorporated with motor).
- (3) Repulsion Start-Induction Run with separate power factor correction condenser.

The following sizes of condensers will usually be found to be suitable with motors 1 and 3:—

$\frac{1}{4}$ h.p.	—	20 Micro-farads.
$\frac{1}{2}$ h.p.	—	40 Micro-farads.
1 h.p.	—	60 Micro-farads.

The power factor correction condenser must be switched on and off with the motor. Over correction must be avoided as this will lead to a high alternator voltage.

ESSENTIAL SERVICES.

Discretion must be exercised regarding the number of appliances, heaters and motors which can be operated at one time. If the plant is overloaded it will automatically slow up and there will be an excessive voltage drop which may cause the failure of some of the equipment. When there are some essential services which must not be interrupted, such as a milking machine, special arrangements should be made to prevent this occurring. One method of arranging this would be to have the lighting circuit permanently connected to the plant; the power circuit to be divided into two sections, one of which would supply essential equipment, and the other equipment which is not so important. The two sections of the power circuit would then be connected to the plant through a change-over switch, permitting the use of essential or non-essential equipment as desired.

Apparatus which cannot be switched off in the normal manner should not be connected to the load circuit, otherwise the detection circuit will be affected. e.g. if a kilo-watt hour meter or electrical running hour recorder is installed, the voltage coil must be connected to the plant side of the load contactor main contact.

MAINTENANCE

For general engine maintenance see Engine Instruction Book No. 103.
Regularly replenish engine oil sump, fuel tank and water system.
Maintain oil level about 1" below top of filler.

BATTERY.

Care of the battery cannot be overstressed. Keep exterior of the battery clean and dry, and filling plugs and connections tight. Keep terminals and connections free from corrosion and coated with pure 'Vaseline' or Petroleum Jelly.

Regularly inspect level of acid in each cell and add **distilled water** (not acid), so as to cover plates by $\frac{1}{2}$ ". If large quantities of distilled water have to be added this is usually a sign of overcharging and the charge rate should be reduced.

A change-over link L2 is provided in the Battery Charging circuit. This gives a choice between 'High Charge' and 'Low Charge' and its position will depend upon operating conditions.

The specific gravity of the acid in the cells is the best indication of the state of charge or discharge of the cells.

The following table gives typical specific gravity readings. The actual values should be obtained from the makers of the batteries.

Condition of Cells	In climates with max. air temp. ordinarily below 90°F. (32°C.)			In climates with max. air temp. ordinarily above 90°F. (32°C.)		
	Actual Hydrometer Readings at Temperature of:—			Actual Hydrometer Readings at Temperature of:—		
	50°F. 10°C.	70°F. 21°C.	90°F. 32°C.	70°F. 21°C.	90°F. 32°C.	110°F. 43°C.
Fully Charged	1.288	1.280	1.272	1.210	1.202	1.195
Half Discharged	1.208	1.200	1.193	1.160	1.153	1.147
Fully Discharged	1.116	1.110	1.104	1.100	1.093	1.087

The specific gravity of the acid in the cells when fully charged should be within .005 (5 points) above, or .010 (10 points) below the value given in the table. If an alkline battery is used, similar values should be given in the maker's instructions.

MONTHLY OR EVERY 150 HOURS.

- (1) Examine tension of Vee-Rope Drive. Adjust if any slip can be detected whilst starting.
- (2) Lubricate all Governor Gear and Fuel Control Mechanism and see that everything is quite free in operation.

QUARTERLY OR EVERY 450 HOURS.

- (1) Examine all switchgear contacts and clean with very fine emery cloth if necessary. Take great care not to bend contact strips and take the precaution of disconnecting the battery.
- (2) Wipe the top of the battery with clean rag and recoat terminals with 'Vaseline.'

HALF-YEARLY.

- (1) Clean out Exhaust System.
- (2) Clean out Fuel Oil Tank.
- (3) Examine Brush Gear, Commutator and Slip Rings. The alternator bearings need greasing only about once a year.

IMPORTANT.

Before attempting any engine or electrical adjustments always trip circuit-breaker switch 'K' or better still disconnect the battery.

Hints On Fault Finding

(1) **PLANT FAILS TO START WHEN LAMP OR APPLIANCE IS SWITCHED ON.**

- (a) Check on lamp or appliance by switching on another appliance.
- (b) Check fuses in distribution box.
- (c) See if circuit breaker has tripped. Check Contacts K/1 and K/2.
- (d) Check fuse in starter circuit.
- (e) Check state of Battery Charge.
- (f) Look for loose, broken or dirty connections in battery leads or load circuit.
- (g) Check load relay coil TDC and contacts T/1.
- (h) Check Load Contactor Coil P and Contact P/1.
- (i) Check adjustment of Engine Switch Contact ES/1.
- (j) Check contact N/3.
- (k) Check starting contactor Coil SC and Contact SC/1.

Contacts that appear dirty or burnt should be carefully cleaned off.

If everything is satisfactory up to this point, and

(2) **PLANT FAILS TO ROTATE OR STALLS AGAINST COMPRESSION.**

- (a) Check engine by turning over with starting handle.
- (b) Check brushgear. Commutator may need polishing with fine glass paper. Brushes must be absolutely free in holders and brush springs must be adequately tensioned.
- (c) Check cable connections to and in alternator cubicle.
- (d) Check adjustment of valve lifter mechanism. If tappet is down on wedge the fuel control solenoid lever should operate without withdrawing wedge, which will follow up under the action of the tension springs as the tappet lifts.
See that exhaust valve wedge is returning under tappet. When Sets have been in operation a number of years the end of the wedge may be found to be rounded. This can be overcome by removing it and replacing it the other way up.

(3) **ENGINE WILL NOT FIRE ALTHOUGH BEING MOTORED.**

- (a) Fuel tank empty.
- (b) Air lock in fuel system.
- (c) Fuel control solenoid not operating. Check mechanism for mechanical stiffness. Check Contact N/1. If this is not making good contact resistance ER will be inserted for starting.
- (d) Check injector and fuel pump.
- (e) With valve wedge out check engine compression.

(4) **LAMPS DULL.**

- (a) See that engine is firing and not being motored (see 3). The circuit breaker would normally trip the circuit in 45 secs. in any case.
- (b) Engine speed too low.
- (c) Check with one lamp only. If satisfactory the main field rheostat and field windings are correct, but auxiliary field circuit requires attention. Check for loose or broken connection.
- (d) Faulty Rectifier MR or MR1.
- (e) If lamps glow during starting and then go out even though plant continues to run, check connections main field MF, and main field rheostat FR1.

(5) **VOLTAGE HIGH.**

- (a) Engine speed too high. Inspect governor and fuel pump for sticking.
- (b) Main Field Rheostat FR1 or FR3 requires adjusting.

(6) **ENGINE FIRES AND RUNS FOR APPROX. 45 SECS. OR LESS AND THEN SHUTS DOWN ALTHOUGH LOAD IS SWITCHED ON.**

- (a) Circuit breaker delay relay out of adjustment.
- (b) Engine speed detection switch faulty or mal-adjusted. (If faulty a new replacement is necessary).
- (c) Contact N/3 out of adjustment and failing to break.
- (d) Economy resistance ER or connections to it faulty.
- (e) Fault on house wiring sufficient to operate load relay detection coil TDC, but not enough to hold in on main coil TAC.
- (f) The last two faults would give rise to a repeated cycle of starting and stopping until the circuit breaker trips.

(7) **ENGINE WILL NOT STOP WHEN ALL LOAD IS SWITCHED OFF.**

- (a) Fault on house wiring or plant connections resulting in leakage current sufficient to operate load relay.
- (b) Fuel control solenoid mechanism or fuel pump rack jammed.
- (c) Excessive wear on tip of valve wedge or return spring weak.
- (d) Load relay out of adjustment or sticking.
- (e) Load contactor contacts P/2 out of adjustment.

(8) **PLANT FAILS BUT CIRCUIT BREAKER WILL NOT TRIP.**

- (a) Battery flat.
- (b) Contact J/1 dirty or out of adjustment.
- (c) Circuit breaker coil K or Coil connections faulty.

(9) **BATTERY AMMETER WILL NOT SHOW CHARGE.**

- (a) Battery already fully charged.
- (b) Charging resistance CR out of adjustment.
- (c) Engine speed too low (this will normally show on the lights as well).
- (d) Faulty ammeter. Check if it reads discharge during starting.

HAND STARTING OF ENGINE.

In the event of trouble developing on the switchgear or control solenoids, the engine can readily be started by hand and the plant run direct on to the load circuit by following the instructions below:—

- (1) Trip circuit breaker K to the 'off' position.
- (2) Change over link L, from the right hand to the left hand top stud.
- (3) Screw in change-over valve handwheel and use starting handle as described in the engine Instruction book.
- (4) Operate fuel control solenoid bell crank lever by hand and insert the collar provided between it and the top of the coil case.

Important

SPARE PARTS—DIRECTIONS FOR ORDERING

Always quote the Plant No., Part No. and Description of the Part when ordering Spare Parts. The Plant No. will be found on the Brass Plate attached to the Baseplate.

PARTS LIST

LOAD RELAY "T." Fig. 9.

Item	Description	No. per Set	Part No.
	Relay complete	1	
1	Magnet frame	1	64-7137
2	Armature	2	64-7138
3	Armature carrier D.C.	2	64-7139
4	" " A.C.	1	64-7140
5	Coil D.C. 24 volt	1	64-7141
6	" " A.C. 220 volt	1	64-7142
	" " A.C. 110 volt	1	64-7143
7	Contact post	1	64-7168
8	Spindle for Items 3 & 4	1	64-7144
9	Spring for Item 3	4	64-7145
10	" " 4	1	64-7146
11	Locknut for spring anchor	1	64-7147
12	Spacing collar for Items 2, 3, 4	2	64-7148
13	Contact screw with contact for Item 7	4	64-7149
14	Studs for Item 6 2BA x 2-1/4" Long	1	64-7150
15	" " 5 4BA x 2-1/4" Long	2	64-6723/24
16	Connection stud for Item 4 4BA x 1-1/2" long	2	64-6723/23
17	Stud for Item 7 4BA x 1-3/8" long	1	64-6723/3
18	Screw for Item 1 4BA x 3/4" long CH. HD.	1	64-6723/25
19	" " 9 & 10 6BA x 3/4" long Hex. HD	8	64-6617/25
20	" " 3 6BA x 5/8" long Hex. HD.	2	64-7039/13
21	Simmonds nuts for Item 14 2BA.	1	64-7039/12
22	" " 15 & 16 4BA.	2	64-6649/3
23	Nuts for Item 14 2BA.	3	64-6649/2
24	" " 15, 16, 17, 18 4BA.	6	64-6614/3
25	" " 6BA.	24	64-6614/2
26	Locknut for Item 13 4BA.	1	64-6614/1
27	Plain washers for Item 14 2BA.	1	64-6613/1
28	" " Items 15, 16, 17, 18 4BA.	6	64-6618/4
29	" " Item 8 5BA.	35	64-6618/3
30	Spring washer " 14 2BA	8	64-6618/14
31	" " 15, 16, 17 & 18 4BA	4	64-2582/2
32	Split Pin for Item 8 3/64" x 3/8" long	18	64-2582/1
		8	64-6722/44

CIRCUIT BREAKER "K." Fig. 10.

Item	Description	No. per Set	Part No.
	Circuit breaker complete	1	
1	Toggle bracket & Pole Piece Assembly	1	64-7119
2	Magnet Frame	1	64-6677
3	Plunger	1	64-6678
4	Operating screw	1	64-6679
5	Indicator plate	1	64-6680
6	Toggle assembly	1	64-7114
7	Split pin 3/32" Dia. x 1-1/8"	1	64-7113
8	Spacing collar	1	64-6722/13
9	Contact panel	2	64-6683
10	Break contact	1	64-6684
11	Make contact	2	64-6685
12	Contact finger bush	2	64-6686
13	" " " pin	2	64-6687
14	Moving contact finger	1	64-6681
15	Contact block	2	64-6688
16	Coil	1	64-6689
17	Screws for Item 10 & 15 4BA x 13/16" CH. HD.	1	64-6692
18	Screw for Item 1 6BA. x 1/8" CH. HD.	4	64-6617/23
19	Fixing screws for Item 2 4BA. x 1/4" CH. HD.	1	64-6617/2
20	Studs for Item 14 & 15 5BA x 1-1/8" long	4	64-6617/3
21	Nuts " 17, 19, 20 4BA.	4	64-6723/2
22	Locknuts " 4 4BA	22	64-6614/2
23	Plain washers for Item 17, 20 4BA.	2	64-6613/1
24	Spring washers " 17, 19, 20 4BA	42	64-6618/2
25	" " 18 6BA.	22	64-2582/1
26	Resetting knob	1	64-2582/7
27	Stirrup	1	64-7116
28	Taper pin	1	64-7117
29	Washer for Item 26 1/4" Dia.	1	64-7118
30	" " " 26 1/4" Dia.	1	64-6618/6
		1	64-6618/15

CIRCUIT BREAKER THERMAL DELAY "J." Fig. 11.

Item	Description	No. per Set	Part No.
	Thermal Delay Switch complete	1	64-6668
1	Heater strip	1	64-4959
2	Compensating strip	1	64-4960
3	Strip fixing pillar	2	64-6669
4	Adjusting screw pillar	1	64-6671
5	Fixing Screw for Item 1 & 2 4BA x 3/16" CH. HD.	2	64-6617/24
6	Adj. Screw " 4 4BA. x 15/16" Hex. HD.	1	64-7039/11
7	Fixing Stud also for Item 3 4BA. x 1-1/2" long	4	64-6723/3
8	" " for Item 4 4BA x 1-1/4" long	1	64-6723/22
9	Nut for Item 6 4BA. Special	1	64-6673
10	Nuts for Items 7 & 8 4BA. Special	10	64-6614/2
11	Simmonds Nuts for Item 7 4BA.	2	64-6649/2
12	Plain Washer " 7 8 4BA.	23	64-6618/2
13	Spring Washers for Items 5, 7, & 8 4BA.	9	64-2582/1

CHARGE CONTACTOR "N" LINE CONTACTOR "P."

Fig. 12.

Item	Description	No. per Set	Part No.
	Charge Contactor complete	1	64-7120
	Line Contactor complete	1	64-7169
1	Magnet Frame	1	64-7121
2	Pole Piece	1	64-7122
3	Armature	1	64-7123
4	Armature Stop Plate	1	64-7124
5	Main Contact Pillar	1	64-7125
6	Main Fixed Contact	1	64-7126
7	Moving Main Contact	1	64-7127
8	Coil	1	64-7128
9	Double Aux. Contact Arm "N"	1	64-7129
	Single Aux. Contact Arm "P"	1	64-7130
10	Aux. Contact Spacer	*2	64-7131
11	Moving Aux. Contact	*2	64-7132
12	Fixed Aux. Contact	*4	64-7133
13	Spring Spindle	1	64-7134
14	Contact Spring	1	64-7135
15	Armature Spring	1	64-7136
16	Stud for Item 2 5/16" Whit. x 1-5/8" long	1	64-7037/34
17	" " 8 2BA. x 2-1/4" long	2	64-6723/23
18	" " 5 2BA. x 1-3/4" long	1	64-6723/5
19	" " 12 4 BA. x 1-1/4" long	*4	64-6723/22
20	Screws for Items 10, 11 4 BA. x 1/2" long CH. HD.	*2	64-6617/6
21	" " 3, 4 4BA. x 3/8" long CH. HD.	2	64-6772/13
22	Nut for Item 16 5/16" Whit.	1	64-6611/8
23	Locknut " 6 1/4" BSF	1	64-6613/7
24	Nuts for Items 17 & 18 2BA.	12	64-6614/3
25	" " 19 & 20 4BA.	*10	64-6614/2
26	Plain Washer for Item 16 5/16" Dia.	1	64-6612/8
27	" " " 17 & 18 2BA.	14	64-6618/4
28	" " " 19 & 20 4BA.	*14	64-6618/3
29	" " " 13 5BA.	1	64-6618/14
30	Spring Washer " 16 5/16" Dia.	1	64-2582/4
31	" " " 17 & 18 2BA.	8	64-2582/2
32	" " " 19 & 21 4BA.	†12	64-2582/1
33	Split Pin " 13 3/64" Dia x 3/8" long	1	64-6722/44

* Quantities to be halved for Line Contactor.

† 7 required instead of 12 for Line Contactor.

MISCELLANEOUS PARTS. Fig. 13.

Item	Description	No. per Set	Part No
1	Ammeter	1	64-7736
2	High-Low Charge Label	1	64-7153
3	Link	1	64-7154
4	Stud for Item 3 2BA. x 2-1/4" long	2	64-6723/24
5	" 3 Special	1	64-7155
6	Simmonds Nut for Item 4 & 5 2BA.	2	64-6649/3
7	Nuts for Item 4 & 5 2BA	6	64-6614/3
8	Washers " 4 & 5 2BA.	10	64-6618/4
9	Spring Washer for Item 4 & 5 2BA.	3	64-2582/2
10	Direct running Link	1	64-7156
11	Identification Washer per Set	10	64-7157
12	Terminal Stud 2BA x 2-1/4" long	13	64-6723/24
13	Simmonds Nut for Item 12 2BA	13	64-6649/3
14	Nuts for Item 12 2BA.	39	64-6614/3
15	Washers " 12 2BA.	87	64-6618/4
16	Spring Washers for Item 12 2BA.	26	64-2582/2
17	Screws for Item 1 6BA. x 3/8" CSK. HD.	4	64-6616/3
18	Nuts " " 1 6BA.	4	64-6614/1
19	Washers " " 1 6BA.	4	64-6618/1
20	Spring Washer for Item 1 6BA.	4	64-2582/7

ALTERNATOR CONTROL BOX. Fig. 14. 7R4QR & K Series Alternators.

Item	Description	No. per Set	Part No.
1	Current Transformer	1	{ State Plant
2	Rectifier complete	1	{ and
3	Shunt Regulator Block complete	1	{ Alternator Nos.
4	Starting Contactor complete	1	64-7171
5	Auxiliary Field Resistance	1	64-6957
6	Fuse Pillar	1	64-7096
7	" "	1	64-6938
8	Conduit Adaptor 1-1/4" — 1" Flexible	1	64-4226/14
9	" " 3/4" — 5/8" "	1	64-4226/9
10	Conduit Insulator 1-1/2" Conduit	1	64-4230/6
11	" " 1-1/4" "	1	64-4989/5
12	" " 3/4" "	1	64-4989/3
13	Identification Washer Earth	1	64-7005
14	" " Battery Negative	1	64-6936/1
	" " Battery Positive	1	64-6936/2
15	Insulator Bush	1	64-6943
16	Connecting Link	1	64-6940
17	Insulation Plate	1	64-6937
18	Terminal Block	1	64-7041/6
19	Label	4	64-6988
20	Flexible Mounting	1	64-7029
21	Fuse Blow-out Tube	9	64-6777
22	Cable Sleeves, per set	1	64-7110
23	Fuse Pillar Packing Piece	1	64-6935
24	Bolt for Item 6 3/8" Whit. x 1-1/8" Hex. HD.	1	64-7039/10
25	Bolts " 6 & 7 1/4" Whit. x 3/4" Hex. HD.	1	64-7039/8
26	Screw " 1 & 2 2BA. x 1/2" CH. HD.	4	64-6772/3
27	" " 4 2BA x 1" CH. HD.	1	64-6772/5
28	" " 4 2BA x 1-1/2" CH. HD.	1	64-6772/7
29	" " 5 4BA x 7/16" CSK.	4	64-6616/8
30	" " 18 4BA x 5/8" CH. HD.	2	64-6772/12
31	Parker Kalon Screw for Item 19	6	64-7175/1
32	Terminal Stud 3/8" Whit. x 2-1/2" long	3	64-6723/17
33	Simmonds Nuts for Items 20, 26, 27, 28 2BA	18	64-6649/3
34	" " 29 & 30 4BA	6	64-6649/2
35	Terminal Nut for Item 32 3/8" Whit.	10	64-6613/9
36	Locknut for Item 8 1-1/4" Conduit	1	64-4229/5
37	" " 11 1-1/2" Conduit	1	64-4229/6

ALTERNATOR CONTROL BOX. Fig. 14. (Contd.)

Item	Description	No. per Set	Part No.
38	Locknut for Item 9	1	64-4229/3
39	Washer " " 24, 43 3/8" dia.	11	64-6618/9
40	" " " 25 1/4" dia.	4	64-6618/6
41	" " " 26, 27, 28 2BA.	14	64-6612/4
42	" " " 29 & 30 4BA.	4	64-6612/3
43	Spring Washers for Items 24 & 32 3/8" dia.	6	64-2582/5
44	" " " 25 1/4" dia.	2	64-2582/3
45	Insulation Plate	1	64-7377
46	" "	1	64-7378

ALTERNATOR CONTROL BOX. Fig. 15. 6R4QR Series Alternators.

Item	Description	No. per Set	Part No.
1	Compound Trimming Resistance	1	State Plant and Alternator Nos.
2	Rectifier complete	1	
3	Shunt Regulator Block complete	1	
4	Starting Contactor complete	1	
5	Fixing Bolts for Item 1—13/16" x 1/4" Whit.	2	64-6771/27
6	Fuse Pillar	1	64-7096
7	" "	1	64-6938
8	Conduit Adaptor 1-1/4"—1" Flexible	1	64-4226/14
9	" " 3/4"—5/8" "	1	64-4226/9
10	Insulator 1-1/2" Conduit	1	64-4230/6
11	" " 1-1/4" "	1	64-4989/5
12	" " 3/4" "	1	64-4989/3
13	Identification Washer Earth	1	64-7005
14	" " " Battery Negative	1	64-6936/1
	" " " Battery Positive	1	64-6936/2
15	Insulator Bush	1	64-6943
16	Connecting Link	1	64-6940
17	Insulation Plate	1	64-6937
18	Terminal Block	1	64-7041/6
19	Label	1	64-6988
20	Flexible Mounting	4	64-7029
21	Fuse Blow-out Tube	1	64-6777
22	Cable Sleeves per Set	9	64-7110
23	Fuse Pillar Packing Piece	1	64-6935
24	Bolt for Item 6 3/8" Whit. x 1-1/8" Hex. Hd.	1	64-7039/10
25	" " 6 & 7 1/4" Whit. x 3/4" Hex. Hd.	1	64-7039/8
26	Screw for Item 1 & 2 2BA x 1/2" Ch. Hd.	4	64-6772/3
27	" " 4 2BA x 1" Ch. Hd.	1	64-6772/5
28	" " 4 2BA x 1-1/2" Ch. Hd.	1	64-6772/7
29	Simmonds Nuts for Item 26 1/4" Whit.	2	64-6649/6
30	Screws for Item 18 4BA x 5/8" Ch. Hd.	2	64-6772/12
31	Parker Kalon Screw for Item 19	6	64-7175/1
32	Terminal Stud 3/8" Whit x 2-1/2" long	3	64-6723/17
33	Simmonds Nuts for Items 20, 26, 27, 28 2BA.	18	64-6649/3
34	" " " 30 4BA.	2	64-6649/2
35	Terminal Nut for Item 32 3/8" Whit.	10	64-6613/9
36	Locknut for Item 8 1-1/4" Conduit	1	64-4229/5
37	" " 11 1-1/2" "	1	64-4229/6
38	" " 9	1	64-4229/3
39	Washer for Item 24, 43 3/8" dia.	11	64-6618/9
40	" " 25 1/4" dia.	4	64-6618/6
41	" " 27, 28 2BA.	14	64-6612/4
42	" " 30 4BA.	2	64-6612/3
43	Spring Washers for Items 24 & 32 3/8" dia.	6	64-2582/5
44	" " 25 1/4" dia.	2	64-2582/3
45	Washers for Item 26 1/4" dia MS. CP.	4	64-6612/6

FUEL CUT-OFF & EXHAUST VALVE LIFTER MECHANISM. Fig. 16.

Item	Description	No. per Set	Part No.
1	Bracket	1	64-6578
2	Bracket Fixing Screws 3/8" Whit. x 1" long	2	S203
3	Spring Washers	2	64-2582/5
4	24 Volt Fuel Cut-Off Solenoid complete For use with 12 ohm Economy Resistance	1	64-6733
5	24 Volt Coil	1	64-6734
6	Fuel Cut-Off Fixing Screws 3/16" Whit.	1	8-1/H53
7	Terminal Block	1	8-1/H119
8	" Screw 1/4" Whit.	1	64-1552
9	Nuts 1/4" Whit.	4	64-2577/6
10	Washer 1/4"	4	64-2580/6
11	Cover Fixing Stud 2BA. x 2" long	2	64-4357/3
12	Nut 2BA.	4	64-2577/3
13	Washer 2 BA.	4	64-2580/4
14	Terminal Box Body } Supplied in	1	64-4663
15	" " Cover } Pairs		
16	Conduit Adaptor	2	64-2487/1
21	Flexible Conduit 5/8" Bore x 9" long	1	64-4839/2
22	" " 5/8" Bore x 11" long	1	64-4839/10
23	Set-Screws 2BA. x 1/4" long	4	64-2575/4
24	Bell Crank Lever	1	5-1/H126
25	Adj. Screw 1/4" BSF	1	5-1/H139
26	Locknut 1/4" BSF	1	64/2578/6
27	Fulcrum Pin	3	8-1/H55
28	Split Pin 1/2" x 5/64"	2	S122
29	Fuel Cut-Off Spring	1	5-1/H133
30	Exhaust Lifter Spring	2	J127
31	Pye Switch	1	64-6584
32	Fixing Screws 4BA x 1-3/8" long	2	64-6772/16
33	Nuts 4BA.	2	64-6610/2
34	Washer 4BA.	2	62-6612/2
35	Spring Washer 4BA.	2	64-2582/1
36	Striker Pin Bracket	1	64-7636
37	Locknut 1/4" Whit.	1	64-6610/5
38	Adjusting Screw	1	64-6580
39	Locknut 2BA.	1	64-6611/3
40	Bell Crank Lever	1	64-6581
41	Fork	1	12380
42	Adjusting Spindle	1	64-3931
43	Nut 1/4 Whit.	1	S8
44	Spring Link Adjuster	1	64-3930
45	Spring Link	1	64-3929
46	Spring	1	J127
47	Screw 2BA. x 1" long	1	64-3408/5
48	Nut 2BA.	2	64-2579/3
49	Spring Washer 2BA.	1	64-2582/2
50	Fulcrum Pin	1	3376
51	Split Pin 1/2" x 5/64"	2	S122
52	Exhaust Valve Lifter	1	5-1/H124
53	Coupling Rod	1	5-1/H125
54	Valve Lifter Bracket	1	5-1/H123
55	Set Screw 1/2" Whit. x 2 5/16" long	1	27/2118
56	" " 5/16" Whit. x 1" long	1	S189
57	Spring Washer 5/16"	1	64-2382/4
58	Valve Lifter Lever	1	5-1/H127
59	Fulcrum Pin for Lever	1	5-1/H128
60	Taper Pin	2	S132
61	Shut Off Lever	1	5-1/H129
62	Shut Off Pin	1	D60
63	Nut 3/8" BSF	1	S714
64	Bolt 1/4" Whit. x 1/2" long	1	64-6771/24
65	Spring Washer 1/4" dia.	1	64-2582/3

SWITCHGEAR CUBICLE.

Description	No. per Set	Part No.
Switchgear Case (Less Cover)	1	64-7158
Panel	1	64-7159
Fixing Bolts for Item 2	4	64-7039/14
Nuts for Item 2	4	64-6614/18
Washers	4	64-6618/6
Spring Washers for Item 2	4	64-2582/3
Front Cover complete	1	64-7160
Back Cover complete	1	64-7161
Perforated Cover	1	64-7162
Fixing Screws for Item 9 2BA. x 1/2" CH. HD.	4	64-6617/2
Washers for Item 9 2BA	4	64-6618/4
Spring Washer for Item 9 2BA.	4	64-2582/2
Battery Charge Resistance CR.	1	64-6053
Fuel Cut-Off Economy Resistance ER.	1	64-5969
" " Discharge Resistance DR1.	1	64-6711
Fixing Studs for Items 13, 14 & 15 5/16" x 5-5/8" long	4	64-7037/35
Nuts for Items 13, 14, 15, 5/16" Whit.	12	64-6614/11
Washers for Items 13, 14, 15 5/16" dia.	12	64-6618/8
Spring Washers for Items 13, 14, 15 5/16" dia.	8	64-2582/4
Connections for Resistance Units (Complete Set)	9	64-7165
Conduit Adaptor for 3/4" Flexible	1	64-4226/9
Locknut for Item 21 3/4" Conduit	1	64-4229/3
Bush for Item 21	1	64-7164/2
Conduit Adaptor for 1" Flexible	1	64-4226/14
Locknut for Item 24 1-1/4" Conduit	1	64-4229/5
Bush for Item 24	1	64-7164/5
Earth Socket	1	64-5368/2
Screw for Item 27 2BA. x 3/4" dia. CH. Hd.	1	64-6617/13
Nut " " 28 2BA	1	64-6614/3
Locknut for Item 28 2BA.	1	64-6613/2
Washer " 28 2BA.	4	64-6618/4
Spring Washer for Item 28 2BA.	2	64-2582/2

BASEPLATE.

Baseplate complete	1	8-8-523
Set Pins for Engine	4	27-2118
Spring Washers	4	27-394
Square Headed bolts for Alternator	4	S76
Spring Washers	4	27-394
Nuts	4	27-4
Foundation bolts	4	S586
Spring washer	4	27-396
Plain washers	4	27-538
Nuts	4	S2

BELT DRIVE.

Alternator pulley (50 cycles)	1	8-8-522
" " (60 cycles)	1	8-8-524
" " key	1	
" " Set Pin	1	S32
Flywheel pulley	1	8-8-261
" " bolt	3	S955
" " washer	3	27-395
V Belt	2	105-B

COMPRESSION RATIO CHANGE OVER VALVE.

C.O.V. Auxiliary Plug	1	10-3-259
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FLYWHEEL.

Flywheel (grooved)	1	8-8-160
" key	2	5162
" key guard	1	5-1/E10

FUEL TANK.

Description	No. per Set	Part No.
Fuel tank complete, comprising	1	10-7-61C
" " Drain Plug	1	11-13-693
" " " joint	1	5197
" " lid	1	10-7-72
" wheel valve	1	8-1/G50
" " " joint	1	12406

EXHAUST PIPES & SILENCER.

2" Pipe x 90° Bend	1	S262
2" " x 6" long	1	27/2312
2" " x 135° Bend	1	S446
2" " x 15" long	1	27/3558
2" " x 90° Bend	1	S262
2" " x 15" long	1	27/3558
2" " x 36" long	4	S265
Flange	2	R96
Joints	2	R89
Bolts with Nuts and Washers	4	27/2363
2" Pipe x 18" long	1	27/3515
2" " x 42" long	2	S488
2" " x 90° Bend	1	S262
2" Sheet Metal Silencer	1	R176
2" Socket	8	S230

SLIDE RAILS.

Slide rails	2	10-8-301
" " set pins	4	S496
" " spring washers	4	27/394

COOLING SYSTEM.

Cooling Tank 70 gallons	1	5405
---------------------------------	---	------

WATER CONNECTIONS.

Inlet—Tank to Engine.

1" Hex. Nipple	1	S171
1" 3 way Cock	1	S170
1" Pipe 8" long (for drain)	1	27/3848
1" Pipe 8" long	1	27/3848
1" Socket	2	S172
1" Pipe 14" long SOE	1	27/2345
1-1/4" Bore Hose 12" long	1	S175
1" 90° Bend	1	S382
1" Pipe 15" long	1	S147
Clips for Hose	2	3404

Outlet—Engine to Tank.

1" Pipe 15" long	1	S147
1" Socket	4	S172
1" Bend 90°	1	S382
1-1/4" Bore hose 12" long	2	S175
Clips	4	3404
1" Pipe 8" long	1	27/3848
1" Bend 120°	1	S174
1" Pipe 4" long	1	S406
Lid for Cooling Tank	1	3409
1" Pipe 30" long	1	S783

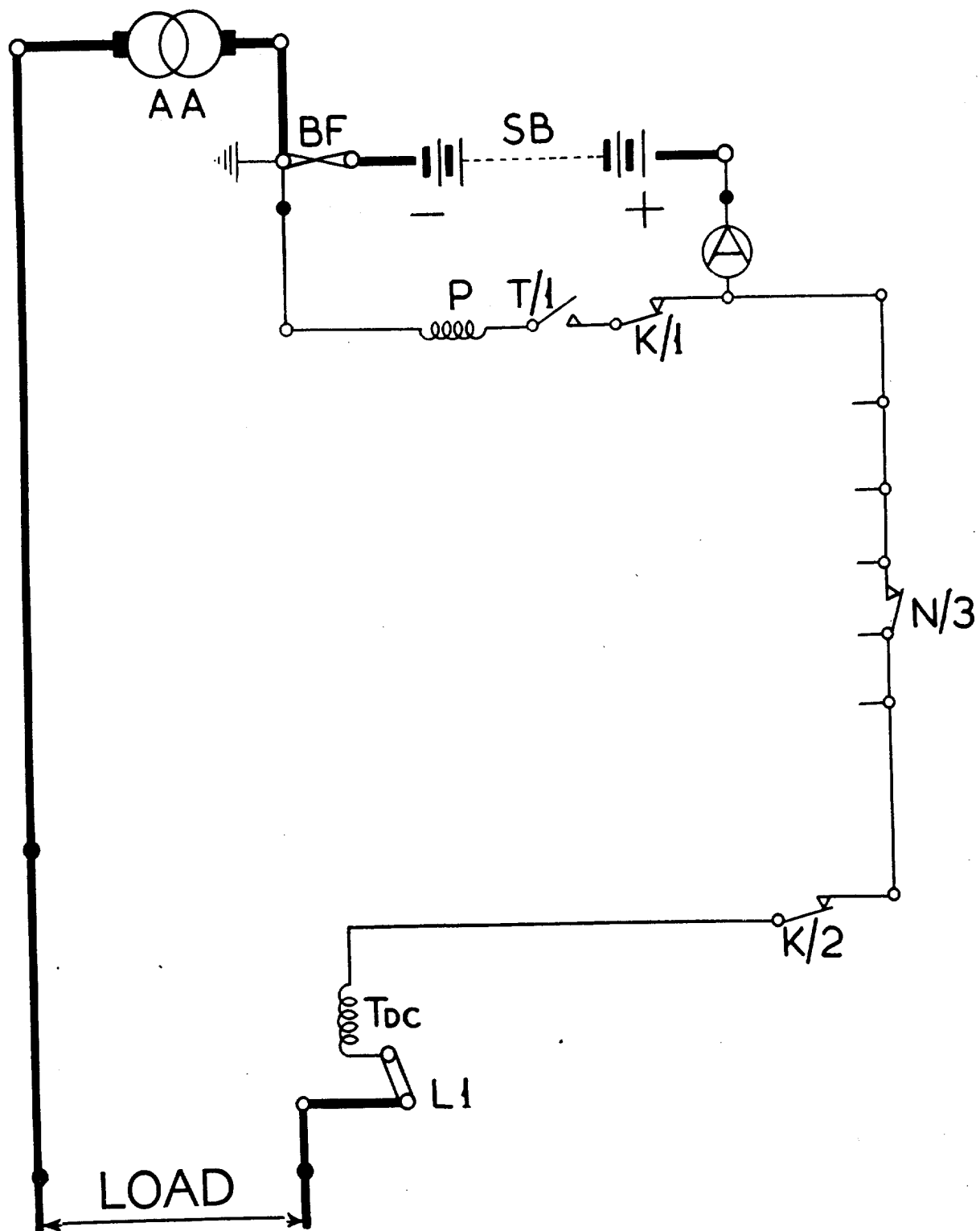


Fig. 1. Load Switched on to Stationary Plant.

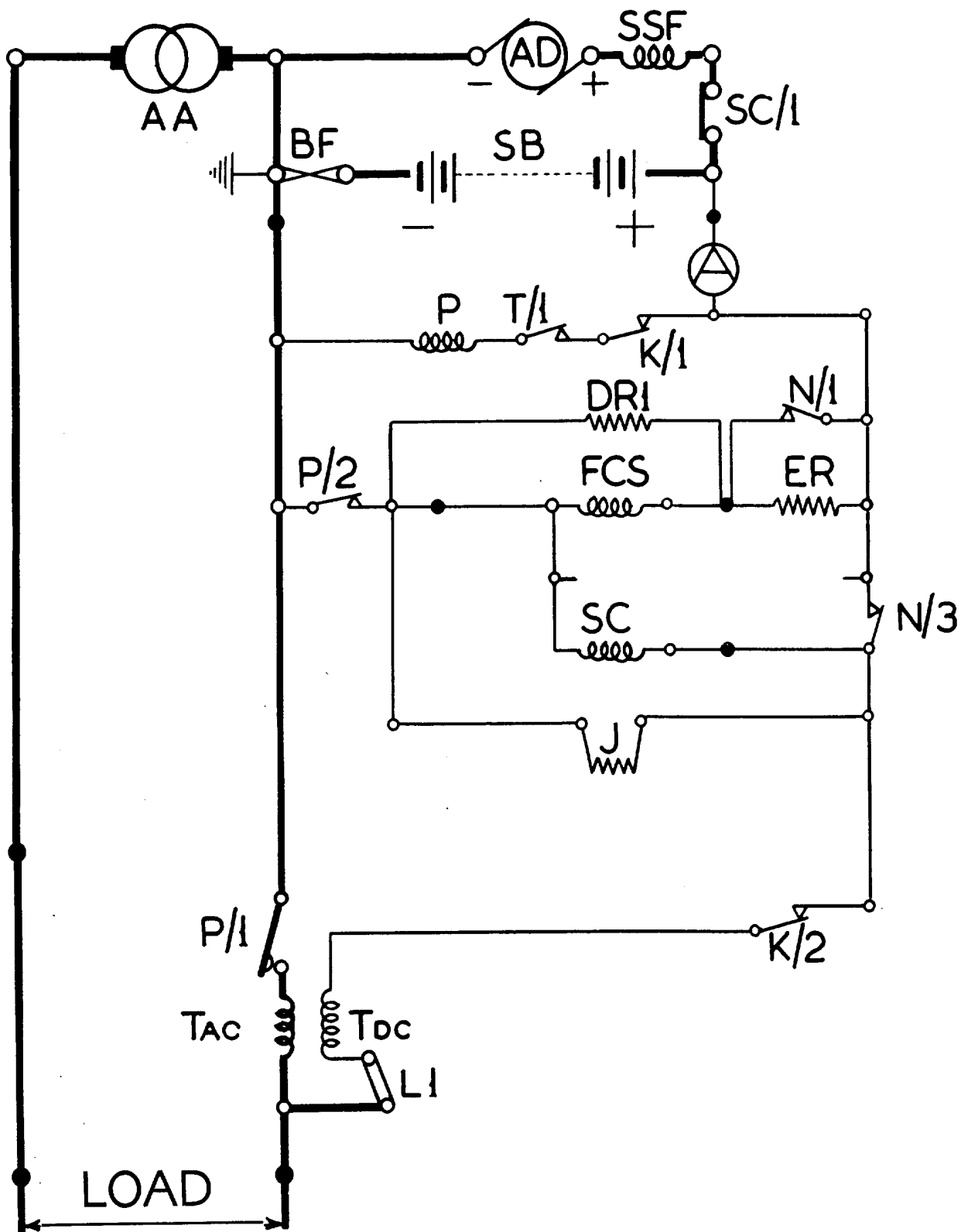


Fig. 2. Load Detection Relay Closes.

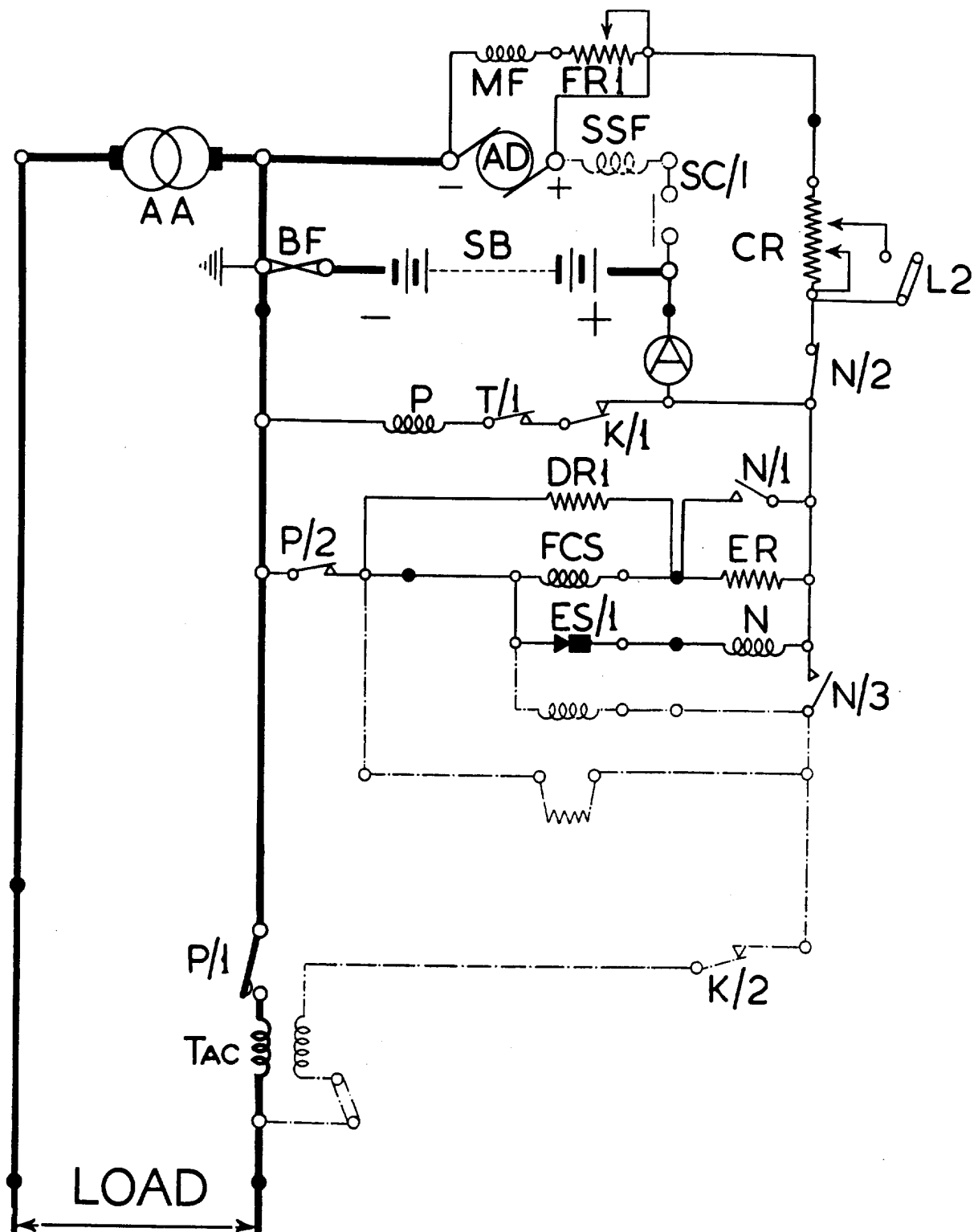
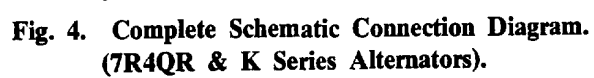


Fig. 3. Engine Speed Detection Contact Closes.



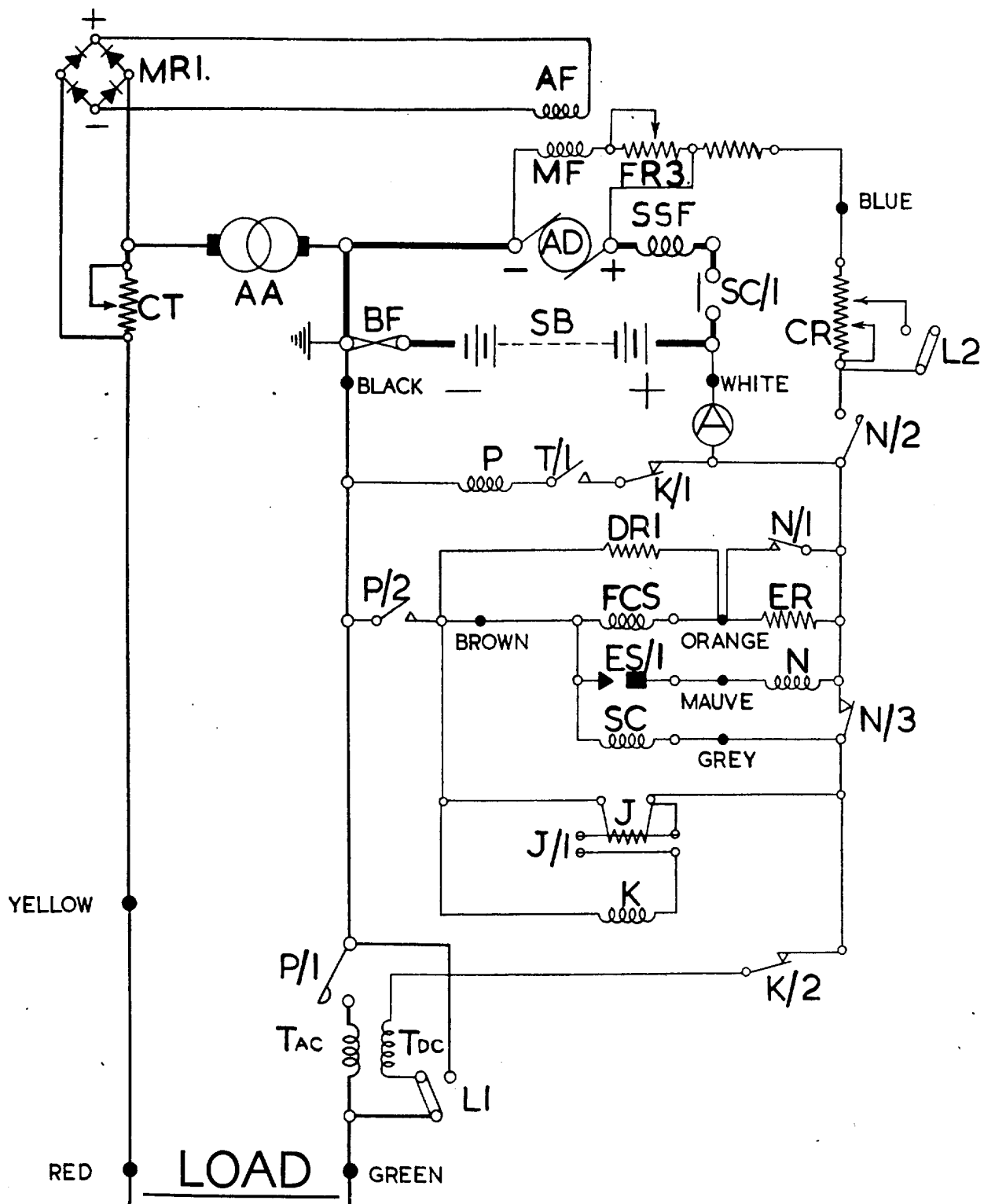
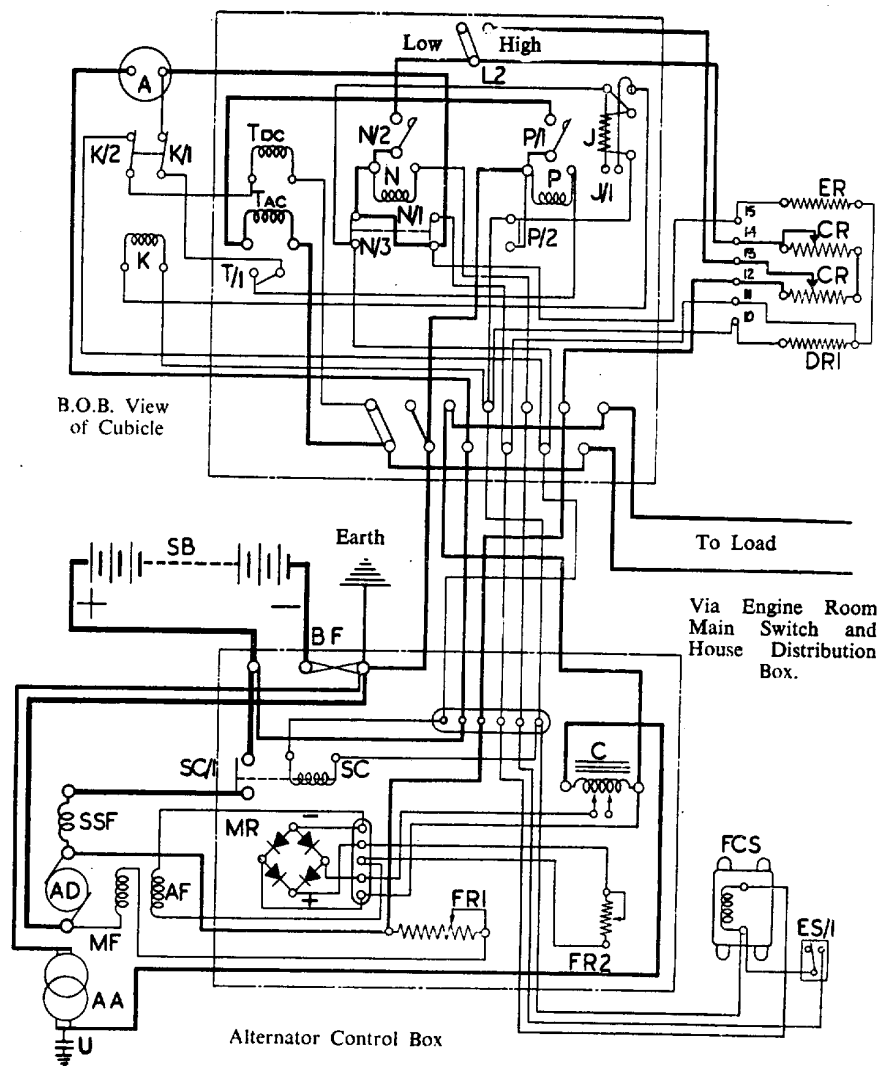
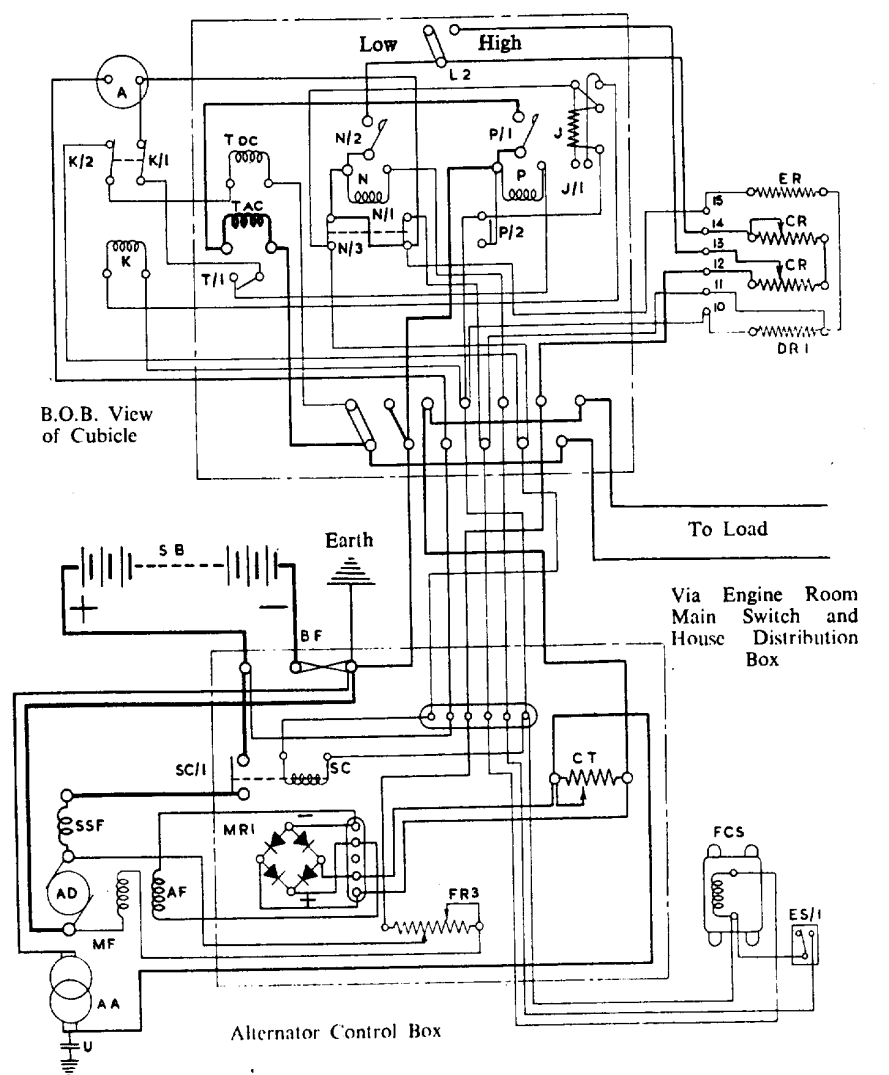


Fig. 5. Complete Schematic Connection Diagram (6S4QR Series).



- | | | | | | |
|-----|-------------------------------|-----|-----------------------------------|-----|--|
| A | Battery Charge Ammeter | ER | Economy Resistance | MR | Voltage Regulation Rectifier |
| AA | Alternator A.C. Windings | FCS | Fuel Control Solenoid | N | Charge Contactor |
| AD | Alternator D.C. Windings | FR1 | Main Field Rheostat | P | Load Contactor |
| AF | Auxiliary Field Winding | FR2 | Auxiliary Field Resistance | SB | 24-Volt Starter Battery |
| BF | Battery Fuse | J | Circuit-Breaker Deley Relay | SC | Starting Contactor |
| C | Current Transformer | K | Circuit-Breaker | SSF | Series Starting Field |
| CR | Battery Charging Resistance | L1 | Load Circuit Change-over Link | T | Load Relay |
| DRI | Discharge Resistance | L2 | Battery Charging Change-over Link | U | Radio Interference Suppression Condenser |
| ES | Engine Speed Detection Switch | MF | Main Field Winding | | |

**Fig. 6. Back of Board Wiring Diagram of Mk. I Switch Gear Control Unit.
(7R4QR & K Series Alternators).**



A	Battery Charge Ammeter	ER	Economy Resistance	N	Charge Contactor
AA	Alternator A.C. Windings	FCS	Fuel Control Solenoid	P	Load Contactor
AD	Alternator D.C. Windings	FR3	Main Field Rheostat	P	Load Contactor
AF	Auxiliary Field Windings	J	Circuit-Breaker Delay Relay	SB	24-Volt Starter Battery
BF	Battery Fuse	K	Circuit-Breaker	SC	Starting Contactor
CR	Battery Charging Resistance	L1	Load Circuit Change-over Link	SSF	Series Starting Field
CT	Compound Trimming Resistance	L2	Battery Charging Change-over Link	T	Load Relay
DR1	Discharge Resistance	MF	Main Field Winding	U	Radio Interference Suppression Condenser
ES	Engine Speed Detection Switch	MR1	Voltage Regulation Rectifier		

Fig. 7. Back of Board Wiring Diagram of Mk. III Switch Gear Control Unit (6S4QR Alternators).

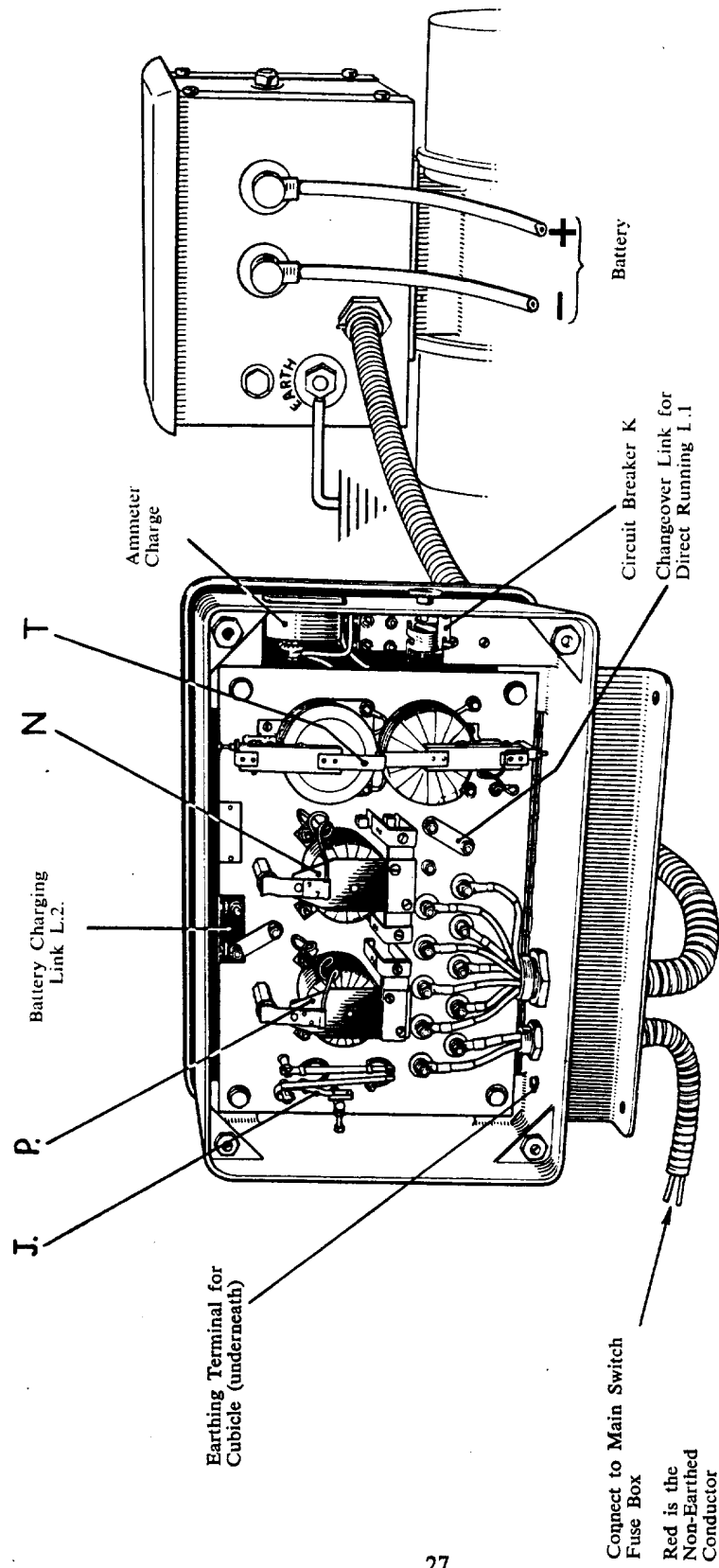


Fig. 8. Illustration of Control Unit.

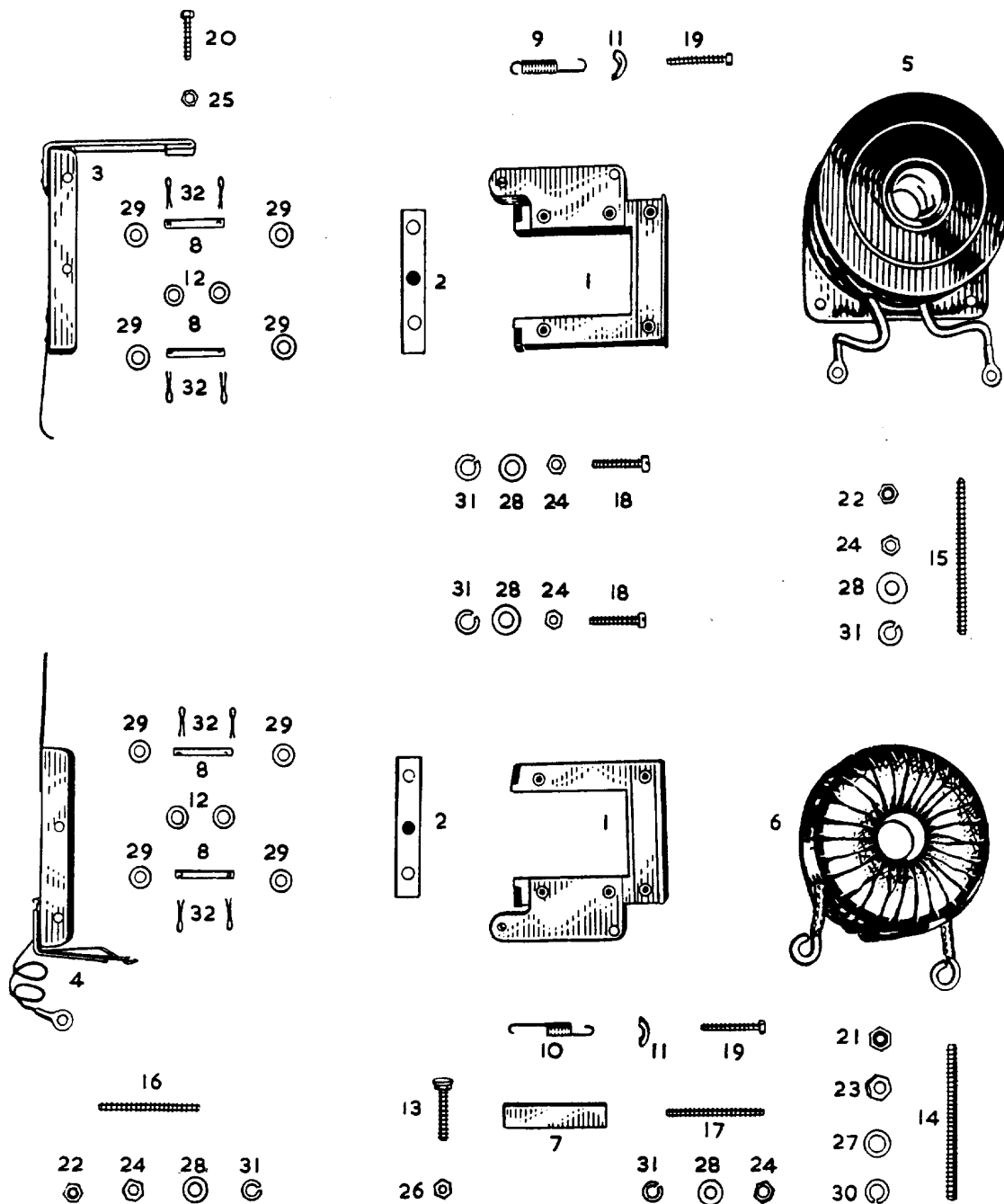


Fig. 9. Load Relay "T."

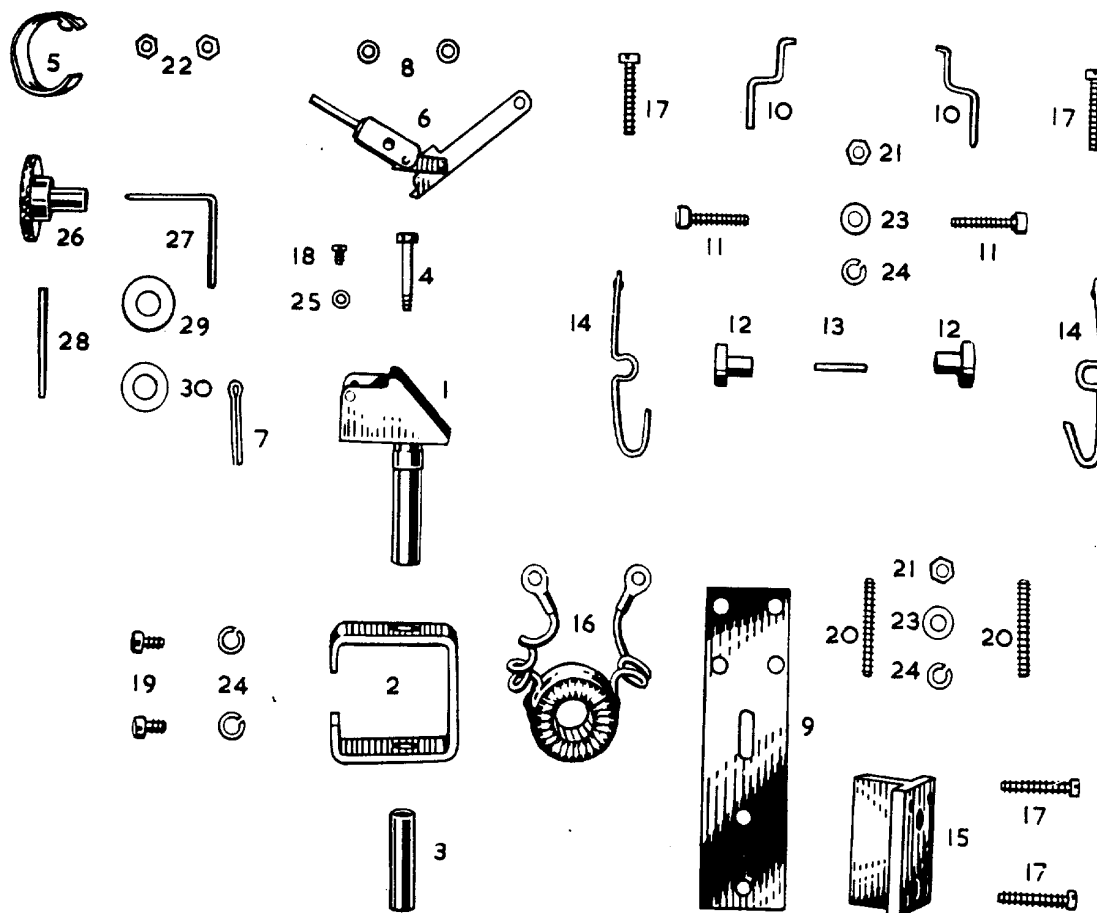


Fig. 10. Circuit Breaker "K."

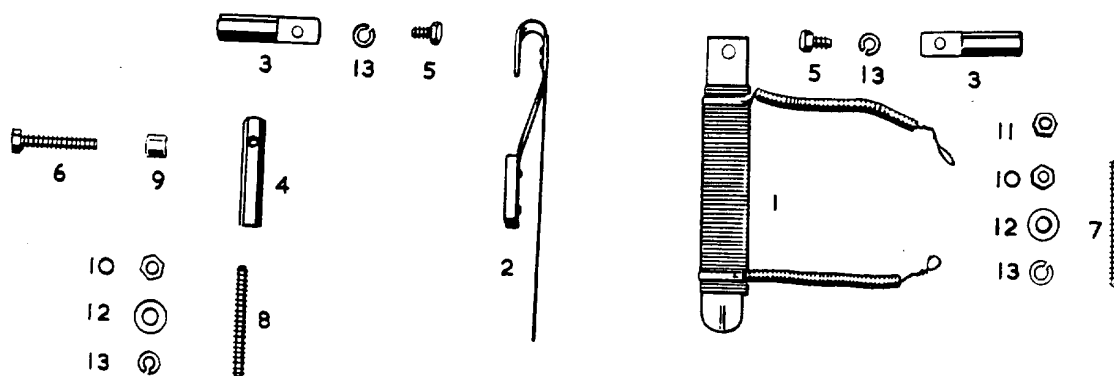


Fig. 11. Circuit Breaker Terminal Delay "J."

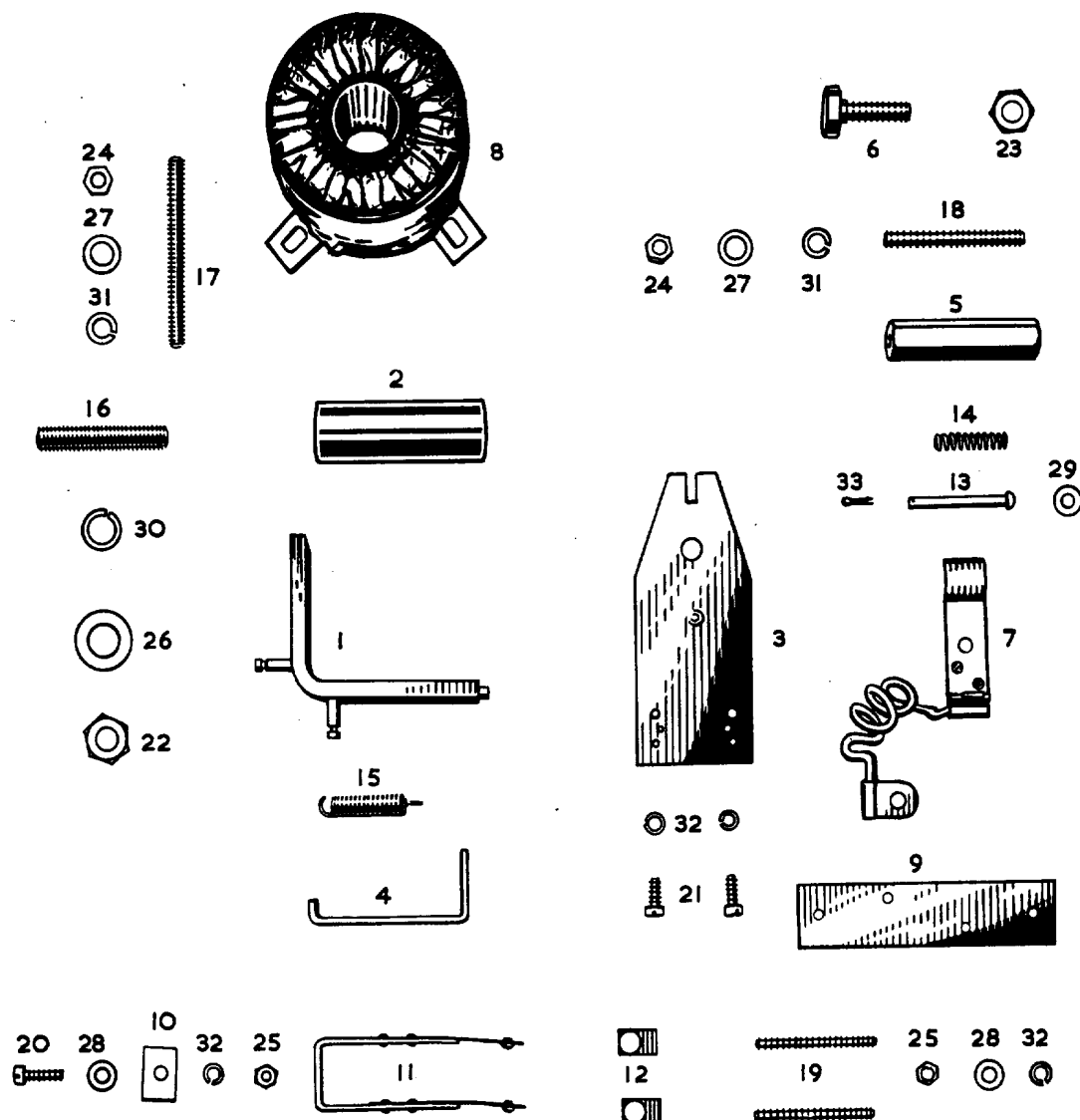


Fig. 12. Charge Contactor "N," Line Contactor "P."

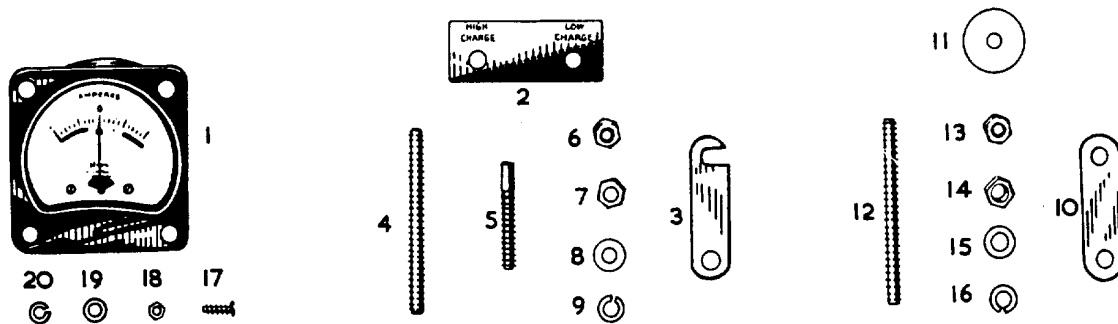


Fig. 13. Miscellaneous Parts.

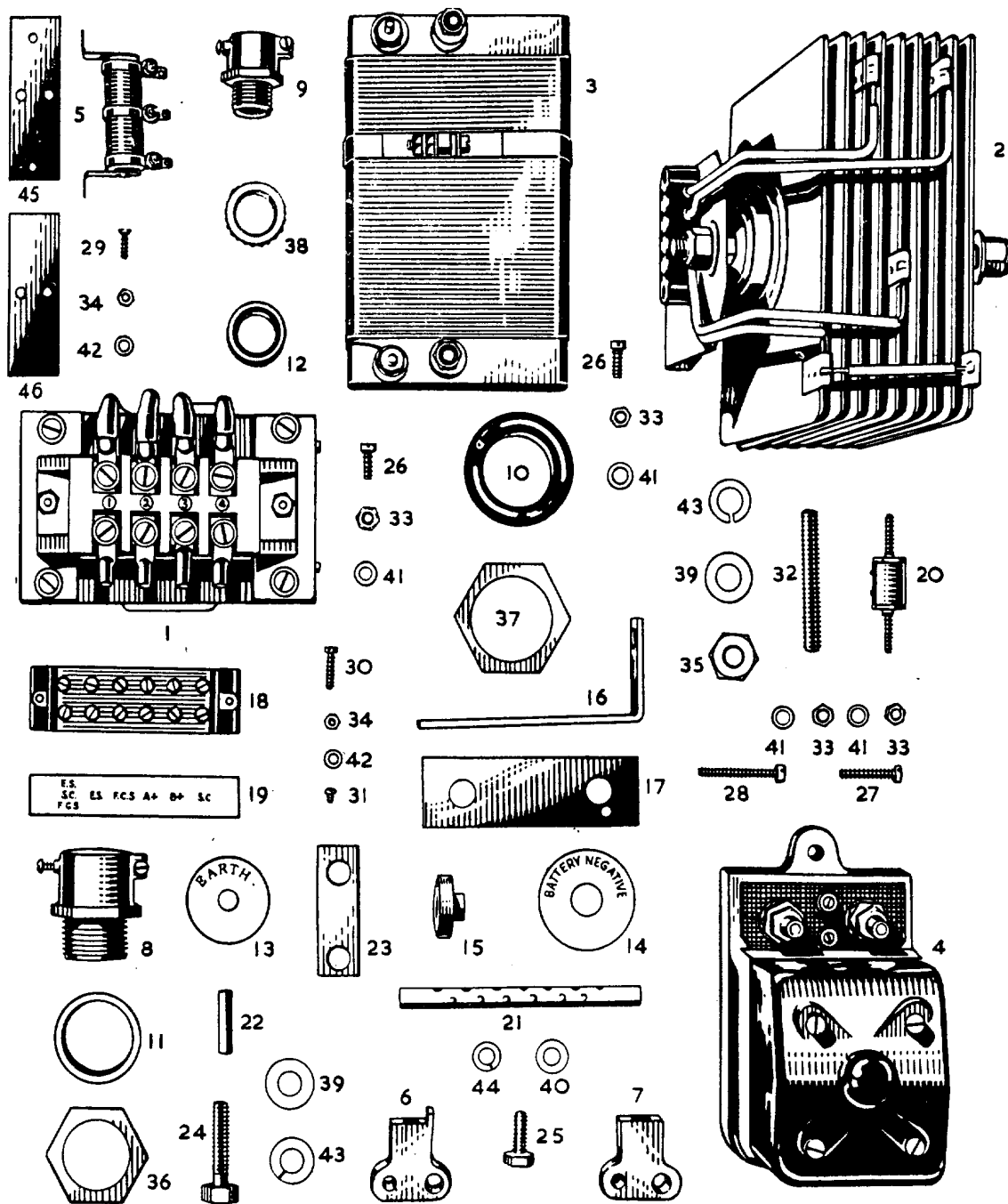


Fig. 14. Alternator Control Box (7R4QR & K Series Alternators).

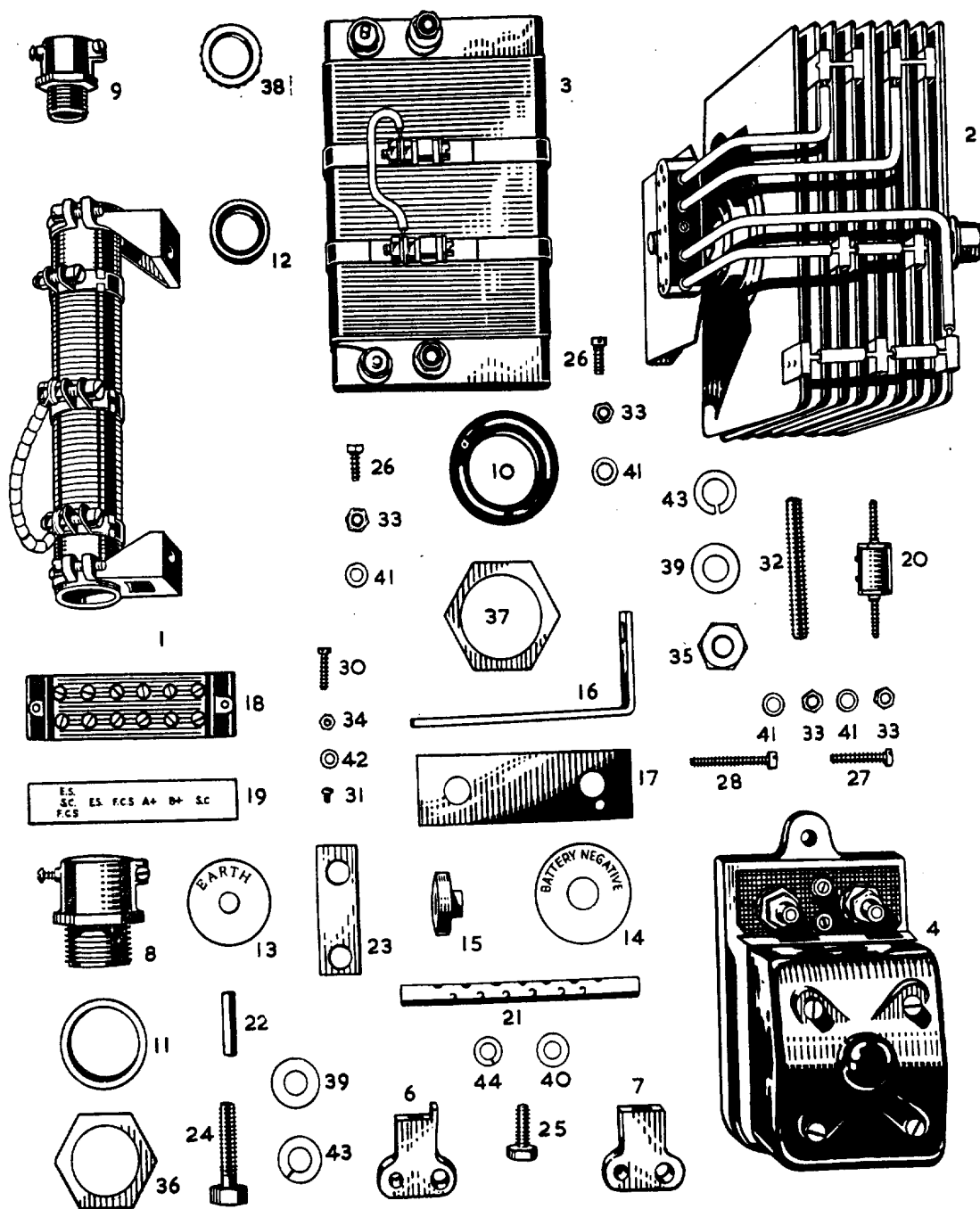


Fig. 15. Alternator Control Box (6S4QR Series Alternator).

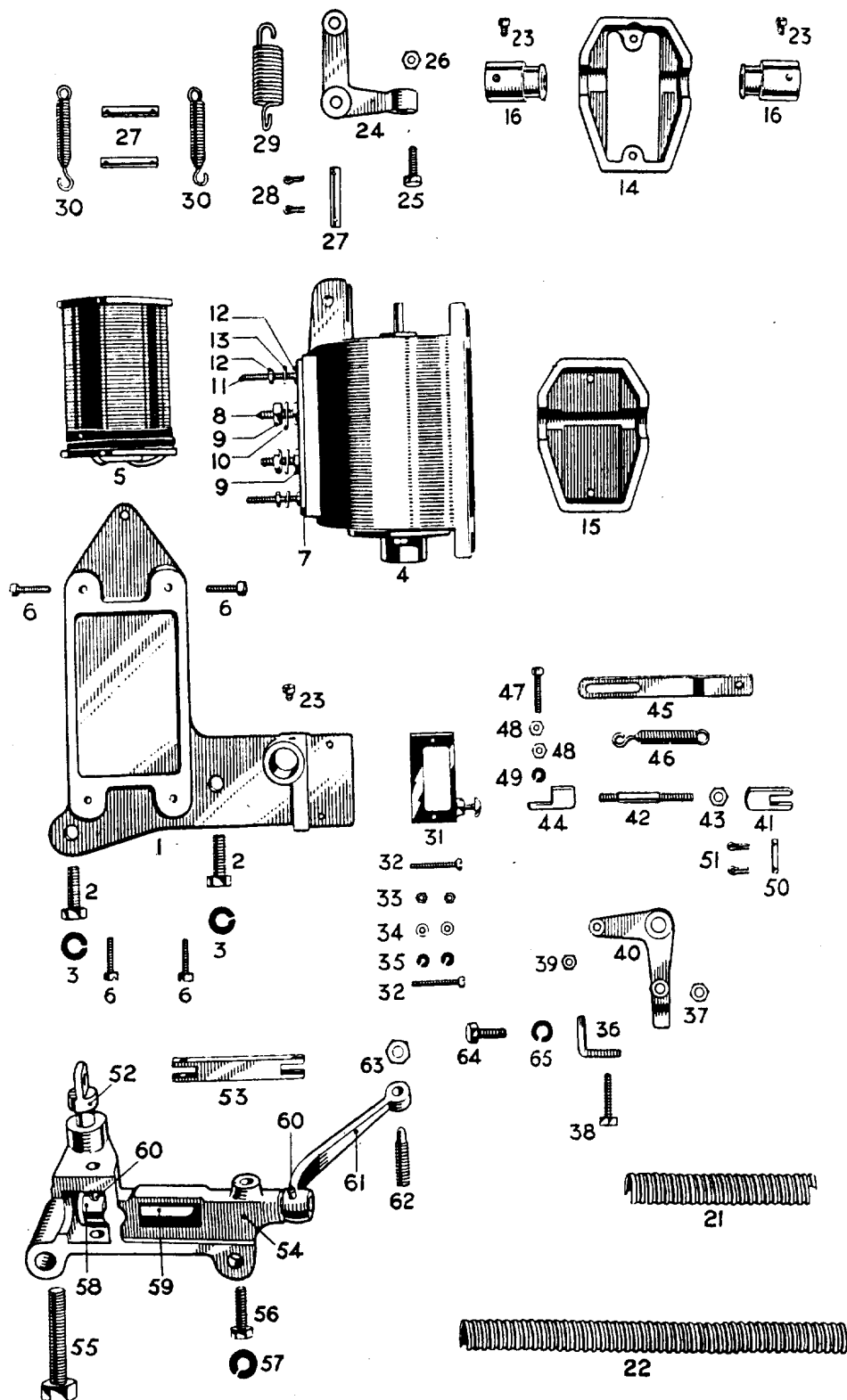


Fig. 16. Fuel Cut-off and Exhaust Valve Lifter Mechanism.

RECOMMENDED SPARE PARTS TO BE HELD FOR STOCK

Mark I and Mark II A.C. Start-O-Matic Cubicle 2.5 K.W. 110 and 230 Volts.

Switchboard Component	Description	No. per Cubicle	Depot Spares Covering			Resistance	Part No.	Reference No.
			18 Plants	12 Plants	6 Plants			
Circuit Breaker	Relay Complete	1	2	1	1		64-7119	MC23014
	Relay Coil 24 Volt	1	2	1	1	38 Ohms	64-6692	
	Break Contact	2	3	2	2		64-6685	SK23030
	Moving Contact Finger	2	3	2	2		64-6688	SK23039
Circuit Breaker Thermal Delay	Circuit Breaker Thermal Delay Complete	1	2	—	—		64-6668	CS23514
	Heater Strip	1	3	2	2	139 Ohms	64-4959	
	Compensating Strip	1	2	2	2		64-4960	
	Fuel Cut-off Coil 24 Volt	1	3	2	2	7.5 Ohms	64-6734	
Fuel Cut-off Solenoid								
Resistances	Battery Charge Resistance	2	5	3	2	3 Ohms	64-6053	60RSSA
	Fuel Cut-off Economy Resistance	1	3	2	2	12 Ohms	64-5969	60RSS
	Fuel Cut-off Discharge Resistance	1	3	2	2	40 Ohms	64-6711	60RSS
Engine Speed Switch	Engine Speed Switch	1	2	1	1		64-6584	
Starting Contactor	Starting Contactor Complete	1	3	2	1	6 Ohms	64-7171	

List No. 64-7170/2

Mark I and Mark II A.C. Start-O-Matic Cubicle 2.5 K.W. 110 and 230 Volts.

Switchboard Component	Description	No. per Cubicle	Depot Spares Covering			Resistance	Part No.	Reference No.
			18 Plants	12 Plants	6 Plants			
Charge Contact "N" and Line Contact "P"	Charge Contact "N" Complete ...	1	2	1	1		64-7120	MC26083
	Line Contact "P" Complete ...	1	2	1	1		64-7169	MC26083
	Coil 24 Volt ...	2	3	2	2	75 Ohms	64-7128	2DC28
	Fixed Main Contact ...	2	3	2	2		64-7126	SK26096
	Moving Main Contact ...	2	3	2	2		64-7127	
	Fixed Auxiliary Contact ...	6	4	3	2		64-7133	
	Moving Auxiliary Contact ...	3	3	2	2		64-7132	
	Armature Spring ...	2	3	2	2		64-7136	SK26094
	Contact Spring ...	2	3	2	2		64-7135	SK26098
	Load Relay Complete ...	1	2	1	1		64-7137	MC26181
Load Relay	Detection Coil 24 Volts ...	1	3	2	2		64-7142	
	Series Coil 230 Volts ...	1	3	2	2		64-7143	
	Series Coil 110 Volts ...	1	3	2	2		64-7168	
	Fixed Contact Screw ...	1	3	2	2		64-7150	
	Moving Contact ...	1	3	2	2		64-7141	
	Armature Spring ...	1	2	2	2		64-7146	SK26203
	Contact Return Spring ...	1	2	2	2		64-7147	SK26471
	Ammeter 1 1/2" Dial M.C. 10-0-10 Amps.	1	2	1	1		64-7152	
Meter								

List No. 64-7170/1

Mark III A.C. Start-O-Matic Cubicle 2.5 K.W. 110 and 230 Volts.

Switchboard Component	Description	No. per Cubicle	Depot Spares Covering			Resistance	Part No.	Reference No.
			18 Plants	12 Plants	6 Plants			
Circuit Breaker	Relay Complete	1	2	1	1		64-7119	MC23014
	Relay Coil 24 Volt	1	2	1	1	38 Ohms	64-6692	
	Break Contact	2	3	2	2		64-6685	SK23030
	Moving Contact Finger	2	3	2	2		64-6688	SK23039
Circuit Breaker Thermal Delay	Circuit Breaker Thermal Delay Complete	1	2	—	—		64-6668	CS23514
	Heater Strip	1	3	2	2	139 Ohms	64-4959	
	Compensating Strip	1	2	2	2		64-4960	
	Fuel Cut-off Coil 24 Volt	1	3	2	2	7.5 Ohms	64-6734	
Fuel Cut-off Solenoid								
	Battery Charge Resistance	1	2	2	1	4.5 Ohms	64-7930	
	Battery Charge Resistance	1	2	2	1	9 Ohms	64-7931	
	Fuel Cut-off Economy Resistance	1	3	2	2	12 Ohms	64-5969	60RSS
Engine Speed Switch	Fuel Cut-off Discharge Resistance	1	3	2	2	40 Ohms	64-6711	60RSS
	Engine Speed Switch	1	2	1	1		64-6584	
Starting Contactor								
	Starting Contactor Complete	1	3	2	1	6 Ohms	64-7171	

List No. 64-7932/2

Mark III Start-O-Matic Cubicle 2.5 K.W. 110 and 230 Volts

Switchboard Component	Description	No. per Cubicle	Depot Spares Covering			Resistance	Part No.	Reference No.
			18 Plants	12 Plants	6 Plants			
Charge Contact "N" and Line Contact "P"	Charge Contactor "N" Complete ...	1	2	1	1		64-7120	MC26083
	Line Contactor "P" Complete ...	1	2	1	1		64-7169	MC26083
	Coil 24 Volt ...	2	3	2	2	75 Ohms	64-7128	2D.C.28
	Fixed Main Contact ...	2	3	2	2		64-7126	SK26096
	Moving Main Contact ...	2	3	2	2		64-7127	
	Fixed Auxiliary Contact ...	6	4	3	2		64-7133	
	Moving Auxiliary Contact ...	3	3	2	2		64-7132	
	Armature Spring ...	2	3	2	2		64-7136	SK26094
	Contact Spring ...	2	3	2	2		64-7135	SK26098
	Load Relay Complete ...	1	2	1	1		64-7137	MC26181
Load Relay	Detection Coil 24 Volts ...	1	3	2	2	175 Ohms	64-7142	
	Series Coil 230 Volts ...	1	3	2	2		64-7143	
	Series Coil 110 Volts ...	1	3	2	2		64-7168	
	Fixed Contact Screw ...	1	3	2	2		64-7150	
	Moving Contact ...	1	3	2	2		64-7141	
	Armature Spring ...	1	2	2	2		64-7146	SK26203
	Contact Return Spring ...	1	2	2	2		64-7147	SK26471
Meter	Ammeter 1 7/8" Dial M.C. 4-0-4 Amps.	1	2	1	1		64-7736	

List No. 64-7932/I

Alternator and Voltage Control Spare Parts List

ALTERNATORS WITH "K" SERIES SERIAL NUMBERS

Components	Description			No. per Set	Part No.
Bearings ...	Drive End	Size L.S.13	1 1/2" x 3 1/4" x 1/4" Ball	...	64-7258
	Non-Drive End	" M.S.10	1" x 2 1/2" x 1/4" Ball	...	64-7259
Brush Holder ...	D.C. Complete with Brush Spindle	...	...	...	64-7260
	A.C.	"	...	...	64-7261
Brush Spring ...	D.C.	...	...	...	64-7262
	A.C.	...	...	...	64-7263
Brushes Machines up to No. 29518K	D.C. 7/8" x 1 1/2"	GRADE HM6	...	...	64-7264
	A.C. 20 x 8 x 20 m/m	GRADE SB5	...	...	64-7265
Field Coils Machines up to No. 39752K	Combined Auxiliary and Starting Coil	...	...	...	64-7266
	" Main	"	...	...	64-7267
Condenser ...	Interference Suppression	350V. D.C. Wrk	...	...	64-7737

TOTAL RESISTANCE OF FIELD COILS

230 Volt 50 Cycles	Main Shunt	...	5.8	Ohms
	Auxiliary Shunt	...	4.1	"
	Starting Series	...	0.02	"
110 Volt 60 Cycles	Main Shunt	...	5.8	"
	Auxiliary Shunt	...	2.8	"
	Starting Series	...	0.02	"

List No. 64-7290/1

Alternator and Voltage Control Spare Parts List

ALTERNATORS WITH "K" SERIES SERIAL NUMBERS

Components	Description			No. per Set	Part No.
Bearings	Drive End	Size L.S.13	1 1/2" x 3 1/4" x 1/4" Ball	...	64-7258
	Non-Drive End	" M.S.10	1" x 2 1/4" x 1/4" Ball	...	64-7259
Brush Holder ...	D.C. complete with Brush Spindle	...	...	4	64-7260
	A.C.	"	...	4	64-7261
Brush Spring ...	D.C.	...	...	4	64-7262
	A.C.	...	...	6	64-7263
Brushes Machines above 29518K	D.C. 1" x 1/2" x 1 1/4"	GRADE HM6	...	4	64-7721
	A.C. 20 x 8 x 20 m/m	GRADE SB5	...	4	64-7265
Field Coils Machines above 39752K	Combined Auxiliary and Starting Coil	...	...	2	64-7844
	" Main	"	...	2	64-7845
Condenser	Interference Suppression	350 V. D.C. Wrk.	...	1	64-7737

TOTAL RESISTANCE OF FIELD COILS

230 Volt 50 Cycles	Main Shunt	...	6.4	Ohms
	Auxiliary Shunt	...	3.35	"
	Starting Series	...	0.0185	"
110 Volt 60 Cycles	Main Shunt	...	5.0	"
	Auxiliary Shunt	...	2.4	"
	Starting Series	...	0.0185	"

List No. 64-7290/2

Alternator and Voltage Control Spare Parts List
ALTERNATORS WITH "K" SERIES SERIAL NUMBERS

Components	Description					No. per Set	Part No.
Shunt Field Regulator	110 Volt	60 Cycles	15 Ohms	4 Amps	...	1	64-7050/19
	230 "	50 "	" "	" "	...	1	64-7050/19
Rectifier	110 "	60 "	Type 12A61	...	...	1	64-7046
	230 "	50 "	" "	" "	...	1	64-7046
Choke	110 "	60 "	35T. 2 x 13 S.W.G. D.C.C. Tappings @ 0, 25, 31, 35	...	...	1	64-7045
	230 "	50 "	86T. 2 x 16 S.W.G. EN. "	0, 74, 80, 86	...	1	64-7044
Tuning Resistance	110 "	60 "	3.5 Ohms	2.9 Amps	...	1	64-6957
	230 "	50 "	" "	" "	...	1	64-6957

List No. 64-7290/3

Rectifier 12A61 Supersedes Type 12A20 Fitted to the first few Machines.
12A61 will be supplied for all Replacement Spaces.

Alternator and Voltage Control Spare Parts List

ALTERNATOR WITH 7R4QR SERIES. SERIAL Nos. 386-425 & 438-447

Components	Description			No. per Set	Part No.
Bearings ...	Drive End	Size R.L.S. 13	1½" x 3¼" x ¾" Roller	...	64-7272
	Non-Drive End	" M.S. 12	1¼" x 3⅛" x ⅞" Ball	...	64-7273
	D.C. Complete	...	...	4	64-7274
Brush Holder ...	A.C.	...	...	4	64-7275
	D.C.	...	...	4	64-7276
Brush Spring ...	A.C.	...	...	8	64-7277
	A.C. 7" x 1"	Grade CM6	...	4	64-7278
Brushes ...	A.C. 5" x 1½"	"	...	8	64-7279
	Combined Auxiliary, Main and Starting Series Coil	...	...	4	64-7280

TOTAL RESISTANCE OF FIELD COILS

230 Volt 50 Cycles	Main Shunt	...	3.52	Ohms
	Auxiliary Shunt	...	5.2	"
	Starting Series	...	0.172	"
110 Volt 60 Cycles	Main Shunt	...	6.96	"
	Auxiliary Shunt	...	3.4	"
	Starting Series	...	0.172	"

List No. 64-7291/1

Alternator and Voltage Control Spare Parts List

ALTERNATOR WITH 7R4QR SERIES. SERIAL Nos. 386-425 & 438-447

Components	Description					No. per Set	Part No.
Shunt Field Regulator	110 Volt	60 Cycles	5 Ohms	6 Amps	...	...	64-7050/17
	230 "	50 "	3.5 "	6 "	...	...	64-7050/20
Rectifier	110 "	60 "	Type 13A45	...	...	...	64-7289
	230 "	50 "	12A61	...	...	...	64-7046
Choke	110 "	60 "	60T .15" x .07"	D.C.C. Tappings at 0, 30, 50, 60	...	...	64-7043
	230 "	50 "	70T .072" dia.	D.C.C. Tappings at 0, 50, 60, 70	...	...	64-7042
Tuning Resistance	110 "	60 "	3.5 Ohms	2.9 Amps	...	...	64-6957
	230 "	50 "	"	"	...	...	64-6957

List No. 64-7291/2

Alternator and Voltage Control Spare Parts List
ALTERNATORS WITH "6S4QR" SERIES SERIAL NUMBERS.

Components	Description				No. per Set	Part No.
Bearings ...	Drive End	Size	R.L.S. 13	1 1/2" x 3 1/4" x 3/4" Roller	...	64-7272
	Non-Drive	"	L.S. 12	1 1/4" x 2 3/4" x 1 1/8" Ball	...	64-7833
Brush Holder ...	D.C. Complete	...	...	...	4	64-7834
	A.C. "	...	...	...	2	64-7835
Brush Spring ...	D.C. Main	...	...	...	4	64-7836
	D.C. Tension	...	...	...	4	64-7837
	A.C. "	...	...	...	4	64-7838
Brushes ...	D.C. 3/8" x 3/8" x 1 1/2"	Grade EGO	Morgan	Crucible	...	64-7839
	A.C. 3/8" x 5/16" x 1 1/4"	"	CM5H	"	4	64-7840
Field Coils ...	Combined Auxiliary, Main and Starting Series Coils				4	64-7841
Condenser ...	Interference Suppression 1000 V. D.C. Wrk.				1	64-7843

TOTAL RESISTANCE OF FIELD COILS

230 Volt 50 Cycles	Main Shunt	...	13.8	Ohms
	Auxiliary Shunt	...	0.5	"
	Starting Series	...	0.0316	"

List No. 64-7842/1

Alternator and Voltage Control Spare Parts List
ALTERNATORS WITH "6S4QR" SERIES SERIAL NUMBERS.

Components	Description				No. per Set	Part No.
Shunt Field Regulator	230 Volt	50 Cycles	15 Ohms	4 Amps	...	...
Rectifier	230	"	50	"	Type 12A62	...
Compound Trimming Resistance	230	"	50	"	3 Ohms to Carry 4.0 Amps	...
					1	64-7050/19
					1	64-7771
					1	64-7765

List No. 64-7842/2