

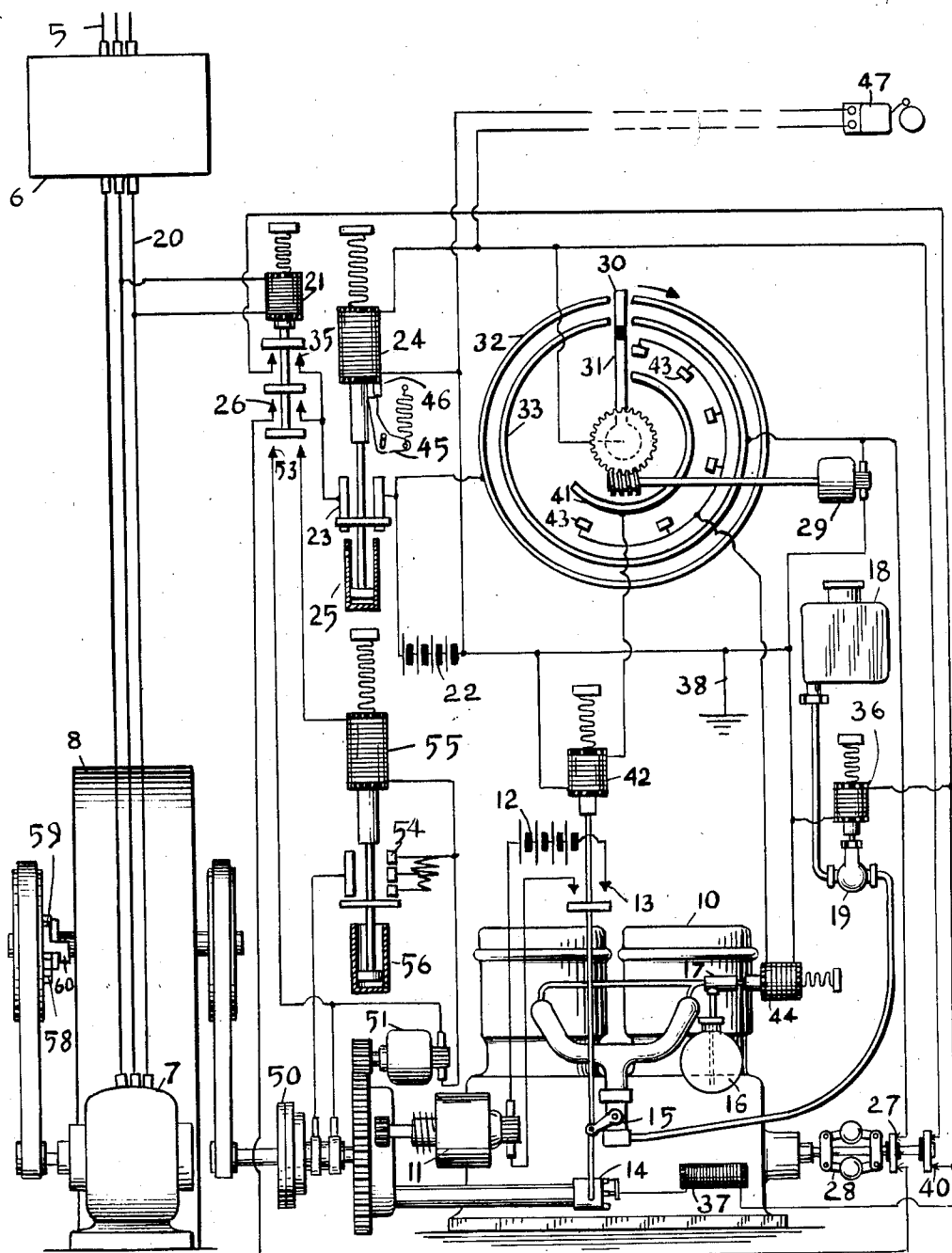
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AUTOMATIC STARTER FOR INTERNAL COMBUSTION ENGINES

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AUTOMATIC STARTER FOR INTERNAL-COMBUSTION ENGINES.

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This invention has been made particularly for safeguarding the operation of machinery which needs to be insured against more than momentary stoppage, but which has to be located where it is inconvenient to continually keep an attendant. It has been developed for safeguarding the operation of mine fans wherein three-phase current supplied to a motor driving the fan is the main source of power, but the invention is not limited to machines for such purposes, or to any particular main source of power. The invention includes an internal-combustion engine, a starting motor, and a source of power for the starting motor as a storage battery. These may be of any of the usual types for such purposes.

One object of the invention is to provide a system which will be operative to start the engine with a light starting battery.

Another object of the invention is to provide, as part of the automatic starting equipment, means for temporarily retarding the spark, means for choking the normal flow of fuel and air to the engine, means for injecting priming fuel into the intake between the choking means and the engine, means for connecting the current supply to the starting motor, and means for controlling a valve in the line from the main fuel supply.

Objects also are to provide, as soon as the engine begins to turn under its own power and exceeds the speed imparted to it by the starting motor, for the immediate advancement of the spark to its economical full speed position, to remove the choke, to disconnect the starting motor, and to cut off the priming fuel.

Objects also are to provide means which will immediately cut off the current supply to the ignition system and shut off the main fuel supply upon the restoration of the main source of power.

Objects also are to provide for the resetting of the switches by which the foregoing instrumentalities are caused to function, in the event of their being cut off in the midst of a switch operation.

Objects also are to provide an alarm at a place in the plant where someone is usually stationed, but which may be remote from the location of the automatic starting apparatus, the alarm being to give notice whenever the automatic apparatus has been called upon to function and to cease upon the functioning

of the auxiliary power or upon restoration of the main power.

Objects also are to provide for the automatic connection and disconnection of the engine and the driven machine in such manner that the engine will be given time to reach its full speed and power before being connected to the driven machine, and disconnection will be effected immediately upon restoration of the main source of power so that the main source of power will not be called upon to turn over the engine.

In the accompanying sheet of drawings which forms a part of this description the figure is a diagrammatic representation of the circuits and of the several elements of an automatic starter which embodies this invention together with a mine fan and the main source of supply therefor.

As shown, a three-phase line 5 leads through a suitable automatic starting box 6 which will be provided with the usual safety devices to open the circuits in event of any abnormality coming on the line, such as overload, drop in voltage, or reversal of phase, and which will reclose the circuits to the motor upon the restoration of normal conditions. From the starting box connection is to a three-phase motor 7 which is belted to a mine fan 8.

An internal-combustion engine 10 provides auxiliary power and is started by a motor 11 which has current supply from a storage battery 12 in a circuit through contacts 13. A usual type of connection between the motor and a gear on the engine shaft is shown wherein acceleration of the motor causes its pinion to engage the gear and the pinion is disengaged when the engine runs ahead of the motor. The gearing is proportioned for turning over the engine at approximately one-tenth of its normal speed when the starting motor is developing its full speed and the starting motor is of a high speed type so that a storage battery of relatively small capacity is ample for a high powered heavy engine. The engine is preferably provided with the usual constant-speed governor which throttles the supply of fuel to automatically keep the engine from exceeding its regular speed when running under its own power. The engine carries a distributor 14 by which the spark may be retarded or advanced as required. It also has a choke valve 15 in the intake manifold for the

carbureted fuel. A supply of gasoline is carried in a tank 16 and injected by a pump 17 into the intake manifold where the branches enter the engine. The main supply of fuel is carried in a tank 18 and is let through a spring-closed valve 19 to the intake manifold where it is carbureted.

From the leads 20 between the starting box and the main electric motor a connection is made to a magnet 21 which, with the contacts which it controls, is a master controller for the starting apparatus. While the main source of power is driving the fan this magnet is receiving current and holds open the contacts which it controls. A storage battery 22, preferably separate from the battery for the starting motor, is a source of power for the various instrumentalities of the starting system except the starting motor. Upon failure of the main source of power supply, a circuit is from this battery which leads through a limiting switch 23 under the control of a magnet 24 and retarded by a dashpot 25. Thence the circuit is through contacts 26 of the master controller and contacts 27 of a speed responsive means in the form of a governor 28 which is driven by the engine and is arranged to open the contacts which it controls as soon as a speed is reached which is materially above the speed imparted by the starting motor. Thence the circuit is through a switch-operating motor 29 to the other side of the battery. This initiates the revolution of a switch arm of a timing switch with two sets of bridging contact brushes 30 and 31 which are insulated electrically from each other. Immediately on starting, two rings 32, 33 are bridged and this provides an additional circuit from the battery to the first ring, thence through the arm brush to the second ring and through the switch-operating motor back to the battery. This circuit is independent of all other contacts and the switch arm will therefore be carried through a full revolution even if in the meantime the initiating circuit should be broken at the master controller or at the governor.

A second circuit from the battery and through the limiting switch is closed by the master controller at contacts 35. This leads through a magnet 36 back to the battery and opens the valve for the main fuel supply. Another branch leads to the ignition coil 37 and spark-plug circuits and returns to the battery through a ground 38 on the engine frame. A third branch of this last circuit through the master controller is through a second pair of contacts 40 of the governor and the magnet of the limiting switch. A fourth branch also includes the governor contacts 40 and is to the brushes 31 on the switch arm and thence to a segment 41 which the switch arm is about

fifteen seconds in traversing. This gives current to a magnet 42, and during the interval while traversing the segment the magnet connects the current supply of the starting motor to the starting motor, chokes the normal fuel and air supply and retards the spark. Also the brushes 31 through contacts 43, 43 intermittently energizes a pump magnet 44 to reciprocate the pump piston in one direction, return movement being effected by a spring, and priming fuel is thereby injected into the intake manifold between the choke and the engine. As on this first application of power to the engine shaft by the starting motor the engine may fail to continue under its own power, the current is turned off for a period of about eight seconds to give the pinion time to disengage and to give the starting motor time to come to rest in case that it has been disengaged by a false start, and to give the fuel time to dissipate if failure to start was due to flooding. Then additional trials are made as the switch arm makes additional revolutions until terminated by the limiting switch reaching the limit of its travel when all of the circuits are broken except the circuit through the two outer rings of the timing switch and the motor which continues the movement of the switch to the initial position shown. The timing switch permits this repeat action through a period of three to five minutes, for if starting is not effected in this time there is probably something wrong which requires attention and it is necessary to stop further dissipation of the energy of the batteries which is not likely to be of avail. If the limiting switch makes its full stroke, a latch 45 engages and prevents return until released by hand. As this switch cuts off the current from its own magnet the latch is caused to release from a stop 46 and on engagement with the switch rod fully opens the contacts.

While the starting apparatus is functioning there is also a circuit through contacts of the master switch and the governor to an alarm 47. This alarm is located where someone is likely to be in attendance and gives notice that the auxiliary power has been required. If the alarm continues for the period for which the limiting switch has been set, the attendant then knows that there has also been a failure of the auxiliary power.

As the engine is preferably started when not under load, a magnetic clutch 50 is inserted in the driving connection from the engine to the fan, and a generator 51 driven from the engine is provided to supply current to the clutch. The circuit is through contacts 53 on the master controller and contacts 54 of an automatic rheostat which is slowly cut out by a magnet 55 retarded by a dash pot 56. The generator does not gener-

ate its voltage until at practically full speed, and consequently the closure of the circuit to the clutch through the rheostat is not made until the engine is in a condition to have the load put on it without stalling.

In operation, should any abnormality come on the supply line, as drop of voltage, overload, phase failure, or phase reversal, the circuits to the regular driving motor are automatically opened at the starting box, the magnet of the master controller is cut off and the contacts controlled thereby are closed, the limiting switch starts to move, and the arm of the timing switch starts to turn, and in any event makes a complete revolution. Priming fuel is injected into the engine, the air and normal carbureter fuel intake is choked, the current supply to the starting motor is connected, the spark is retarded, the current is connected to the ignition circuits, the valve in the main fuel line is opened, and the alarm is sounded. As soon as the engine begins to turn under its own power, exceeds the speed imparted by the starting motor, and operates the governor, the priming pump is shut down, the alarm is cut off, the limiting switch coil is cut off and the switch drops back, circuits are opened which cut off the magnet 42, and thereby the current is cut off from the starting motor, the choke is removed from the main carbureted fuel supply, and the spark is advanced. The clutch generator, driven by the engine begins to generate current when the engine reaches its speed. This current first flows through the magnet 55 which gradually admits current through a rheostat to the magnetic clutch so that the load is applied gradually to avoid exceeding the full load torque of the engine and causing it to stall.

Should the engine fail to turn under its own power on the first revolution of the timing switch arm it will make additional revolutions until the engine develops its own power and runs ahead of the starting motor speed and its governor contacts open or until all of the starting equipment is cut off by the limiting switch. If at any time during these operations the main power should be restored, the master controller will at once open its contacts and in addition to cutting off the current supply to the starting equipment will cut off the generator from the magnetic clutch and cut off the current from the magnet which holds open the fuel valve, and open the ignition circuits.

In order that the auxiliary power may not have to turn the main motor, a ratchet 58 is keyed to the fan shaft and is engaged by a pawl 59 which is carried by the pulley. The pawl is overbalanced by a weight 60 which is set nearer to the axis of the shaft than the pawl pivot and throws the pawl into engagement by centrifugal action and

acceleration. By using opposite connected pawls the effect of gravitation is eliminated and the pawls will not be clicking on the ratchet when the pulley is not driving.

I claim,—

1. The combination of a driven machine, a main source of power therefor, an internal combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, means operating on the failure of the main power supply for retarding the spark and for connecting the current supply to the starting motor, and speed-responsive means operating when the engine exceeds the speed imparted by the starting motor to prevent the retarding of the spark and to prevent the connecting of the current supply to the starting motor.

2. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, means operating on the failure of the main power supply for choking the normal flow of air and carbureted fuel to the engine, for injecting a fuel supply between the choking means and the engine and for connecting the current supply to the starting motor, and speed-responsive means operating when the engine exceeds the speed imparted by the starting motor to prevent the choking of the normal flow of air and carbureted fuel and to prevent the connecting of the current supply to the starting motor.

3. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, a pump for priming auxiliary fuel supply, means operating on the failure of the main power supply for operating the pump and for connecting the current supply to the starting motor, and speed-responsive means operating when the engine exceeds the speed imparted by the starting motor to prevent the operation of the pump and to prevent the connection of the current supply to the starting motor.

4. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, a timing switch for intermittently connecting the current supply to the starting motor, speed-responsive means operating when the engine exceeds the speed imparted by the starting motor to prevent the connecting of the current supply to the starting motor, means for the operation of the timing switch through its closed positions which is independent of the speed-responsive means, and means for

initiating the operation of the timing switch when the speed-responsive means is not operating.

5. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, a timing switch for intermittently connecting the current supply to the starting motor, a master controller which operates during failure of the main power supply, speed-responsive means operating when the engine exceeds the speed imparted by the starting motor to prevent the connecting of the current supply to the starting motor, means for operating the timing switch through its closed positions which is independent of the speed-responsive means, and means for initiating the operation of the timing switch when the master controller is operated.

6. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, a timing switch for intermittently connecting the current supply to the starting motor, a master controller which operates during failure of the main power supply, speed-responsive means operating when the engine exceeds the speed imparted by the starting motor to prevent the connection of the current supply to the starting motor, and means operated by the master controller for initiating the operation of the timing switch when the speed-responsive means is not operating and to prevent the connecting of the current supply to the starting motor when the master controller is in its normal position.

7. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a source of fuel supply for the engine including a tank and a fuel line, a valve in the fuel line, a master controller which operates during failure of the main power supply, means for closing the valve when the master controller is in its normal position, means for opening the valve when the master controller is operated, and means for starting the engine when the master controller is operated.

8. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, auxiliary apparatus therefor, a current supply for the starting motor, a timing switch for intermittently connecting the current supply to the engine, and means for limiting the number of intermittent operations of the timing switch and for cutting off the current from the starting motor and its auxiliary apparatus.

9. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, a timing switch for intermittently connecting the current supply to the starting motor, a master controller which operates during failure of the main power supply, speed responsive means operating when the engine exceeds the speed imparted by the starting motor, the connections also being such that the connection of the current supply to the starting motor is also opened on the return of the master controller to normal position, means for operating the timing switch through its closed positions which is independent of the master controller and of the speed-responsive means, and means for initiating the operation of the timing switch when the master controller is operated.

10. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, speed-responsive means operating when the engine exceeds the speed imparted by the starting motor, contacts controlled thereby, a source of fuel supply for the engine including a tank and a fuel line, a valve in the fuel line, a magnet for operating the valve, ignition circuits, a master controller which operates during failure of the main power supply, circuits leading through the master controller when operated and through the contacts of the speed-responsive means for effecting the connection of current supply to the starting motor, circuits leading through the master controller when operated and independent of the contacts of the speed-responsive means for operating the valve magnet and for supplying the ignition system, and a source of supply for the circuits.

11. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, speed-responsive means operating when the engine exceeds the speed imparted by the starting motor, contacts controlled thereby, a master controller which operates during the failure of the main power supply, a circuit leading through the master controller when operated and through the contacts of the speed-responsive means for effecting the connection of current supply to the starting motor, an alarm circuit through the master controller when operated and through the contacts of the speed-responsive means, and a source of supply for the circuits.

12. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a

starting motor for the engine, a current supply for the starting motor, a master controller which operates during failure of the main power supply for connecting the current supply to the starting motor, a clutch for connecting the engine to the driven machine, a power source for closing the clutch which is operated by the engine, and a control for the clutch by the master controller.

10 13. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, a master controller which operates during failure of the
15 main power supply for connecting the engine to the driven machine, a clutch for connecting the engine to the driven machine, a power source for closing the clutch which is
20 operated by the engine, means for delaying the full application of the clutch, and a control for the clutch by the master controller.

25 14. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, a master controller which operates during failure of the

main power supply for connecting the engine to the driven machine, a clutch for
30 connecting the engine to the driven machine, a power source for closing the clutch which is operated by the engine and is constructed to operate only when the engine is at its full
35 speed, means for delaying the full application of the clutch, and a control for the clutch by the master controller.

15. The combination of a driven machine, a main source of power therefor, an internal-combustion engine for auxiliary power, a starting motor for the engine, a current supply for the starting motor, a timing switch for intermittently connecting the current supply to the starting motor, a limiting
40 switch for limiting the number of repeat operations of the timing switch, current supply for the operation of the timing switch and of the limiting switch, a master controller, a circuit for the operation
45 of the timing switch through its closed positions which is independent of the other switches, and means for initiating the operation of the timing switch and carrying it
50 through its open positions under the control of the limiting switch.
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