

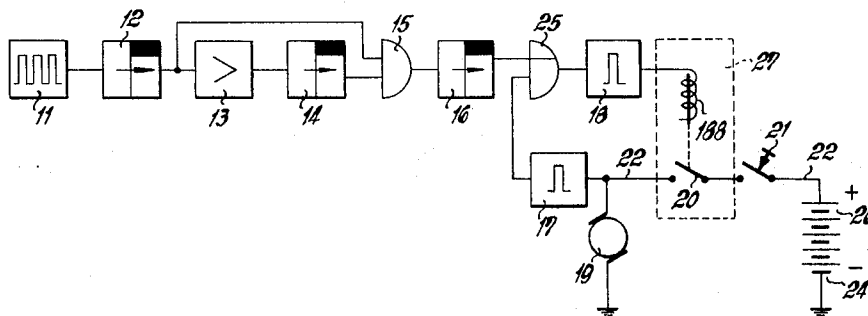
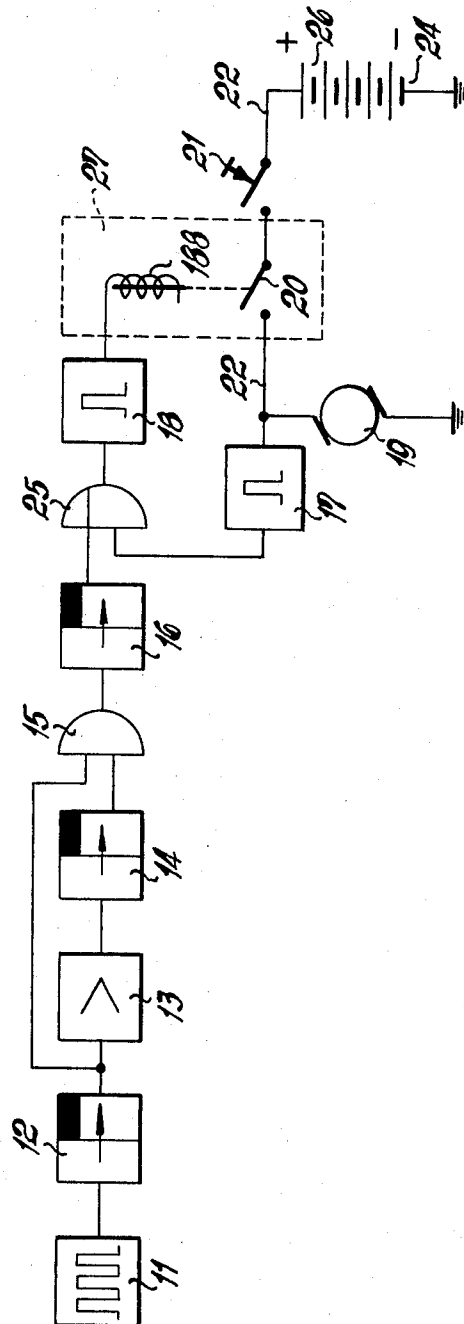


FIG. 1



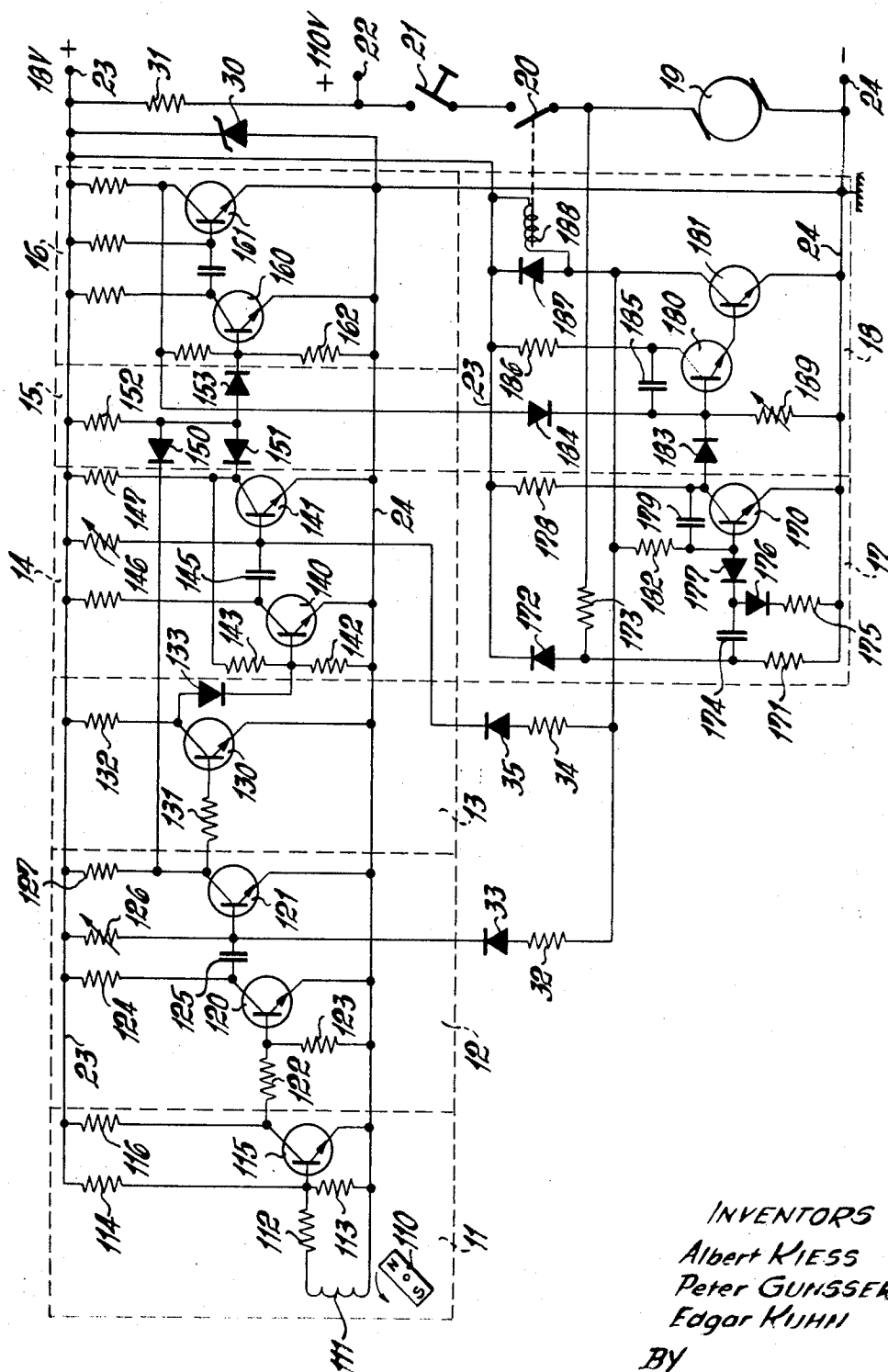
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FIG. 2



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SAFETY ARRANGEMENT FOR STARTING MOTOR IN INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

This invention relates to a safety arrangement for starting means used to start an internal combustion engine. In particular, it relates to such arrangements wherein the operating circuit of a starting motor is interrupted when a predetermined engine speed is exceeded. In particular, in known arrangement of this type, a relay is used whose winding is energized when the speed of the engine exceeds a predetermined minimum speed and which then opens contacts which de-energize the starting motor. The relay winding, in these known arrangements, is connected with pulse generating means whose frequency corresponds to the engine speed.

In known arrangements of this type, an integrating arrangement is connected between the pulse generating means and the relay. Further, a Schmitt trigger is connected to the output of the integrating means. The integrating means yield a voltage which increases with increasing pulse frequency or repetition rate. When the voltage at the output of the integrating means achieves a predetermined voltage value, the Schmitt trigger energizes the relay in such a manner that the starting motor is de-energized. The above-described safety arrangements function adequately when used in conjunction with internal combustion engines having a low-power output. However, when used in conjunction with high-power internal combustion engines as used for example for driving locomotives or ships, then the speed of the engine, especially if started in a warm condition, may increase above the highest permissible frequency for the starting motor within two or three rotations. However after two or three rotations, the integrating means have not yet reached a sufficiently high voltage. This causes the starting motor to be disconnected too late.

SUMMARY OF THE INVENTION

It is an object of the present invention to furnish a safety arrangement which has a very short response time and does not have the delay which is created by integrators.

The present invention comprises a safety arrangement in an internal combustion engine having a starting motor. It comprises energizing means for energizing said starting motor upon external activation. The invention comprises pulse furnishing means which furnish a first pulse sequence, the pulse interval between consecutive ones of said pulses varying as a function of engine speed. Further provided are timing means, connected to the output of the pulse furnishing means, which furnish a timing signal in response to each pulse of the first pulse sequence, each of said timing signals extending a predetermined timing interval following the end of the corresponding first pulse. First logic means have a first input connected to said pulse furnishing means, a second input connected to said timing means and an output for furnishing a logic signal upon simultaneous occurrence of a signal at said first and second inputs. Further comprised are de-energizing means deenergizing said starting motor in response to said logic signal.

In the present arrangement, means are further provided for blocking a second starting attempt for a predetermined time interval following a first unsuccessful starting attempt. This is because in high-power engines as used for driving locomotives, large masses are being moved, so that the engine may continue to make several rotations even if no ignition has taken place prior to the final standstill condition. During this time, no new starting attempt should be carried out.

In accordance with the present invention, this problem is solved by furnishing a hold circuit responsive to the change in voltage in the motor coil upon de-energization, and connecting the output of this hold circuit, which exists for a predetermined time period, to the de-energizing means. Specifically, the output of this hold circuit may be connected to one input of an OR gate whose other input is connected to receive the logic signal, and whose output is connected to the de-energizing means.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a block diagram of an arrangement of the present invention; and

FIG. 2 shows a circuit diagram corresponding to the block diagram of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of the present invention will now be discussed with reference to the drawing.

FIG. 1 shows starting means, here a starting motor 19, which is connected via switching means, here a switch 21 to a source of electrical energy, here a battery 26. The energizing means comprise a pair of normally closed contacts 20 connected in series with contacts 21 and a relay coil 188, which, when energized, opens contacts 20. The positive voltage output line of battery 26 is designated by numeral 22, while the negative line is designated by numeral 24. Relay coil 188 is energized by an electronic circuit which will now be described. It comprises pulse furnishing means 11 which furnish a first pulse sequence whose repetition rate, and therefore the pulse interval between consecutive pulses, varies as a function of engine speed. Specifically, the interval between consecutive pulses becomes shorter the faster the engine runs. Connected to the output of the pulse furnishing means are first pulse forming means, here a monostable circuit 12. Connected to the output of monostable circuit 12 is an inverter 13 whose output is connected to the input of timing means, here a second monostable circuit 14. The output of monostable circuit 12 is connected to the second input of an AND gate 15 to whose first input is connected the output of the second monostable circuit 14. The output of AND gate 15, herein called logic means, is connected to the second pulse forming means, namely a third monostable circuit 16 whose

output is connected to one input of an OR gate 25. The second input of OR gate 25 is connected to the output of the second hold means, namely a bistable circuit 17 whose input is connected to the starting motor winding. The output of the OR gate is connected to first hold means, namely a bistable circuit 18. The output of bistable circuit 18 energizes relay coil 188.

The circuits within the blocks of FIG. 1 are shown in detail in FIG. 2. Pulse furnishing means 11 comprise a permanent magnet rotating with the crank shaft of the internal combustion engine. It further comprises an induction coil 111. Rotation of magnet 110 causes substantially sinocoidal output voltage to appear across induction coil 111. The substantially sinusoidal voltage furnished by coil 111 is applied via a resistance 112 to the input of an amplifier stage comprising a transistor 115 whose emitter is connected to line 24, while its collector is connected via a resistance 116 to line 23, which will be described below. Further a voltage divider comprising a resistance 114 and 113 is connected from line 23 to line 24, the base of transistor 115 being connected to the common point of resistors 113 and 114. In the present example, the output of the battery is 110 volts. Therefore a resistance 31 is connected from line 22 to a line 23 and a Zener diode 30 is connected between line 24 and line 23. In this way, the voltage on line 23 is maintained at 18 volts.

The first monostable circuit 12 comprises transistors 120 and 121 having collector resistors 124 and 127. Transistor 120 receives base current over resistances 122 and 123, while transistor 121 receives base current over an adjustable resistance 126. A coupling capacitor 125 connects the collector of transistor 120 to the base of transistor 121.

Connected to the collector of transistor 121 is inverter stage 113. The latter comprises a transistor 130 having a collector resistance 132 and a base resistance 131. A diode 133 is connected between the collector of transistor 130 to the second monostable stage 14 in such a manner that only positive pulses are conducted. The second monostable stage 14 comprises transistors 140 and 141 and is identical to the first monostable stage 12 with the exception that a resistance 143 is connected between the collector of the second transistor 141 and the base of the first transistor 140. The actual values of the various components used in stage 14 also differ from that used in stage 12, since the two stages are required to furnish pulses of different pulse widths.

AND gate 15 comprises a resistance 152 which has a first terminal connected to line 23 and a second terminal connected to the anodes of three diodes, namely diodes 150, 151, and 153. The cathode of diode 150 is connected with the collector of transistor 121, the cathode of diode 151 is connected with the collector of transistor 141, while the cathode of diode 153 is connected with the input of the third monostable stage 16.

The third monostable stage 16 comprises two transistors 160 and 161, and again has the same circuit as the second monostable stage 14. Again it differs from stage 14 only in the value of the individual components.

A diode 184 connects the collector of the second transistor 161 of the third monostable stage 16 to the input of hold means 18. The hold means 18, as shown here, are a Miller integrator. Since the Miller integrator

output must have sufficient current carrying capability for energizing relay coil 188 of relay 127, the Miller integrator comprises a Darlington circuit having a preamplifier transistor 180 and a power transistor 181. The collector of power transistor 181 is connected through coil 188 with line 23. A diode 187 is connected in parallel with winding 188. Transistor 180 has a collector resistance 186. A capacitor 185 is connected from the collector to the base of transistor 180. The base of transistor 180 is connected via an adjustable resistor 189 with minus line 24. Further, the output of stage 17 is connected to the base of transistor 180 via a diode 183. Diodes 183 and 184 together constitute OR gate 25. Second hold means 17 comprise a further Miller integrator. This is constructed from a transistor 170 having a collector resistance 178, and a capacitor 179 connected from collector to base of transistor 170. A resistance 182 connects the base of transistor 170 with the collector of power transistor 181. The base of transistor 170 is further connected to a differentiating circuit comprising resistors 171 and 175, as well as a capacitor 174. Since the differentiating circuits furnish both positive and negative impulses, diodes 176 and 177 are provided to block the positive impulses and permit only negative impulses to reach the base of transistor 170. The voltage appearing at the winding of motor 19 is furnished to the input of the differentiating circuit via a resistance 173. The voltage at the input of the differentiating circuit is clamped to 18 volts by means of a clamping diode 172.

In order to obtain a hysteresis effect, the collector of transistor 181 in stage 18 is connected to the base of transistors 121 and 141, respectively, via a resistance 32 in series with a diode 33, and a resistance 34 in series with a diode 35.

The above-described circuits operate as follows:

The pulse generator 11 generates a pulse sequence of either sinusoidal shape or rectangular shape, depending upon whether or not transistor 115 is over-driven. Of course other pulse furnishing means, such as photoelectric means, may be used instead of the inductive means shown here. For Otto motors, the base of transistor 115 can simply be connected to the primary winding of the ignition coil.

The pulses furnished by the pulse furnishing means are converted into rectangular pulses of predetermined width and variable repetition rate by means of the first monostable stage 12. It should be noted that the monostable stage 12 differs from standard monostable multivibrators in that no coupling resistance is furnished from the collector of transistor 121 to the base of transistor 120. This allows the safety arrangement to remain operative even during high rotational speeds of the engine even though stage 18 has already disconnected the starting motor.

For high engine speeds, the pulse width of the first monostable stage 12 is automatically shortened since no coupling resistance is furnished.

In the stable state for the first monostable stage 12, transistor 121 is conductive. Thus the output pulses of the first monostable stage 12 have positive polarity. Inverter stage 13 is a simply inversion stage. It yields output pulses of negative polarity whose pulse width is exactly equal to the pulse width furnished by monostable multivibrator 12.

The output pulses of inverter 13 drive the second monostable stage 12. In the second monostable stage, transistor 141 is conductive under quiescent conditions, while transistor 140 is blocked. As long as inverter 13 furnishes a negative output pulse, the second monostable stage 14 remains in its stable state. As soon as the output pulse furnished by inverter 13 ends, the second monostable stage changes to its unstable state. Thus the output pulse of the second monostable stage 14 is furnished immediately upon cessation of the output pulse of the first monostable stage 12. In the embodiment shown here, the pulse width of the output pulses of stages 12 and 14 have a ratio of approximately 2:3. The starting motor will be disconnected when the pulse interval between two consecutive pulses furnished by monostable stage 12 (that is, the distance between the trailing edge of one pulse and the leading edge of the subsequent pulse) is shorter than the width of the output of the second monostable stage 14. When this happens, the subsequent output pulse of the first monostable stage starts before the output of the timing means (second monostable stage) has ended. This results in an output signal from AND gate 15. AND gate 15 switches the third monostable stage 16 in which in the quiescent condition, transistor 161 is conductive and transistor 160 is blocked. Transistor 116 in the third monostable stage (second pulse forming means) can be switched to the conductive state when it receives base current via diode 153. This is only possible when transistor 121 of the first monostable stage, as well as transistor 141 of the second monostable stage 14, are in the blocked condition, that is when both the first monostable circuit and the timing circuit are in the unstable state. If, for example, only transistor 121 is blocked and transistor 141 is conductive, then the base current required for transistor 160 of stage 16 flows over diode 151 and the collector-emitter circuit of transistor 141. The arrangements of diodes 150, 151 and 153 thus acts as an AND gate, the inputs to this AND gate being the cathodes of diodes 150 and 151.

Theoretically, the output of AND gate 15 could be used directly to trigger the first hold means, namely stage 18. However, when the engine speed first approaches the predetermined speed where the starting motor is to be disconnected, the overlapping of the output pulses from stages 12 and 14 is small, and would result in a very narrow output pulse from AND gate 15. Thus the critical speed could not be fixed very exactly. For this purpose, a third monostable stage 16 is inserted between stage 15 and stage 18. Stage 16 comprises second pulse forming means which give an output pulse of predetermined amplitude and width, regardless of how small the overlap in the outputs of stage 12 and 14.

The hold circuit 18 may be embodied, for example, in a Miller integrator and furnishes a saw-tooth output voltage to winding 188 of relay 27. The period of such a saw-tooth output voltage is fixed at approximately 10 seconds, so that the engine has definitely come to a standstill before the starting motor may be started anew. Actually, for activating the relay, it would be more desirable to work with a stage 18 which furnishes rectangular rather than saw-tooth voltages. However, the amount of equipment required would be greater than is for a Miller integrator and the relay operates re-

liably even in spite of the fact that a saw-tooth voltage is being used, since the circuit is designed in such a manner that it pulls in for a steep leading edge, and falls out on the slanted edge of the saw tooth.

In order to ensure that the engine starts in cold weather, the starting speed may be fixed to a relatively high value, for example 500 rotations per minute. It is possible that the idling speed of the engine upon starting first stabilizes at approximately 400 revolutions per minute. In this case, the safety arrangement must exhibit some hysteresis so that a new starting attempt is delayed longer than 10 seconds. This is achieved via components 32 through 35. Before the starting motor is disconnected, transistor 181 is blocked, so that resistance 32 in series with diode 33 is parallel to resistance 126, while resistance 34 in series with diode 35 is parallel to resistance 147. After the starting motor is disconnected, diodes 33 and 35 are blocked because transistor 181 is conductive so that only resistors 126 and 146 determine the time constant of monostable stages 12 and 14, that is, the time constants are increased after the starting motor is disconnected. This allows the transistor 181 to become conductive when the engine speed exceeds 500 revolutions per minute, and to be blocked again when the engine speed is at or below 200 revolutions per minute longer than 10 seconds.

The circuit described up to this point thus causes the normally closed contacts 20 to be opened when the maximum permissible speed of the starting motor 19 is exceeded. At this point, the starting motor 19 is no longer energized and simultaneously, the connection between the starting motor and the engine is interrupted. This allows the starting motor to be insured against excessive speeds. However, in starting arrangements for internal combustion engines, another frequent source of errors exists. It is possible for example that after an unsuccessful starting attempt, it is attempted to re-start starting motor 19 before the crank shaft of the engine has come to a complete standstill. This inevitably causes damage to the gearing which transmits the torque of the starting motor to the crank shaft. In order to eliminate this damage, second hold means, stage 17, are provided. It is the function of stage 17 to keep the normally closed contact 20 opened after any starting attempt for a sufficient length of time that it is certain that the crank shaft is standing still. In a particularly preferred embodiment of the present invention, the voltage which energizes motor 19 is used to activate stage 17. It will be noted that the motor voltage is a D.C. voltage which makes a positive abrupt change when the motor is energized, and undergoes an abrupt negative change when the motor is de-energized. Stage 17 operates in response to the negative change and energizes stage 18 in response thereto, as will be detailed below.

The differentiating circuit comprising resistors 171 and 175 and capacitor 174 yields a positive impulse for the positive step of the motor voltage described above, and a negative impulse when the starting motor is disconnected. The negative impulse is transmitted to the base of transistor 170 via diode 177. Transistor 170 is conductive as long as stage 18 is in the quiescent state, since it then receives base current via resistance 182. Transistor 170 and its associated components are

connected as a Miller integrator. It is temporarily blocked by means of a negative impulse and yields a saw-tooth output voltage of positive polarity at its collector which causes stage 18 to switch via diode 183.

Instead of the Miller integrator, other types of monostable stages could be used in stage 17. Again, more components would be required without improving circuit performance. Thus, stage 17 eliminates the second source of error for starting means, namely, upon disconnecting of starting motor 19, it cannot be re-started for at least 10 seconds, approximately.

In large internal combustion engines, a main switch 21 is generally a relay switch. In this case the normally closed contacts 20 are not directly connected to the winding of motor 19, but are instead connected to the coil of the relay. Further, of course, relay 27 can be replaced by a thyristor switch. Suitable pulse forming means then have to be interposed between the thyristor and hold stage 18 in order to insure reliable ignition and quenching of the thyristor.

While the invention has been illustrated and described as embodied in pulse forming, timing hold and switching circuits, it is not intended to be limited to the details shown, since various modifications, structural and circuit changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. In an internal combustion engine having starting means and energizing means energizing said starting means upon external activation, an arrangement for de-energizing said starting means when the rotational speed of said engine exceeds a predetermined speed, comprising, in combination, pulse furnishing means furnishing a first pulse sequence, the pulse interval between consecutive ones of said pulses varying as a function of engine speed; timing means connected to said pulse furnishing means for furnishing a timing signal in response to each of said pulses of said first pulse sequence, each of said timing signals extending a predetermined time interval following the end of the corresponding one of said first pulses; first logic means having a first input connected to said pulse furnishing means, a second input connected to said timing means, and an output, for furnishing a logic signal at said output in the simultaneous presence of a signal at said first and second inputs; and de-energizing means de-energizing said starting means upon receipt of said logic signal.

2. An arrangement as set forth in claim 1, wherein said starting means comprise a starting motor having a winding; and wherein said energizing means comprise a source of electrical energy, and switching means con-

necting said winding of said starting motor to said source of electrical energy when closed.

3. An arrangement as set forth in claim 2, further comprising first hold means interconnected between said logic means and said de-energizing means, for furnishing an extended logic signal in response to each of said logic signals, said extended logic signal having a width in time exceeding the width of said logic signal.

4. An arrangement as set forth in claim 2, wherein said de-energizing means comprise additional switching means having a quiescent state connecting said winding of said starting motor to said source of electrical energy and an activated state disconnecting said winding from said source of electrical energy, in response to said logic signal.

5. An arrangement as set forth in claim 4, wherein said additional switching means comprise relay means having a pair of normally closed contacts and a relay coil.

6. An arrangement as set forth in claim 3, further comprising first pulse forming means connected to the output of said pulse furnishing means.

7. An arrangement as set forth in claim 6, wherein said first pulse forming means comprise monostable circuit means.

8. An arrangement as set forth in claim 6, wherein said timing means comprise second monostable circuit means; further comprising inverter means connecting the output of said first pulse forming means to the input of said second monostable circuit means.

9. An arrangement as set forth in claim 8, wherein said logic means comprise an AND gate having a first input connected to the output of said second monostable circuit means and a second input connected to the output of said first pulse forming means.

10. An arrangement as set forth in claim 9, further comprising second pulse forming means connected to the output of said AND gate.

11. An arrangement as set forth in claim 2, wherein said source of electrical energy is a D.C. source; further comprising second hold means connected to said winding of said starting means for furnishing a second hold signal in response to de-energization of said winding; and connecting means connecting the output of said second hold means to said de-energizing means.

12. An arrangement as set forth in claim 11, wherein said connecting means comprise OR gate means having a first input connected to said second hold means, a second input connected to said logic means and an OR gate output connected to said de-energizing means.

13. An arrangement as set forth in claim 3, wherein said first hold means comprise Miller integrator means.

14. An arrangement as set forth in claim 11, wherein said second hold means comprise Miller integrator means.

15. An arrangement as set forth in claim 14, further comprising differentiating circuit means connected to the input of said Miller integrator means and furnishing a positive impulse upon energization of said winding and a negative impulse upon de-energization of said winding.

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