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H. G. HAINES

2,550,414

AUTOMATIC ENGINE STARTING EQUIPMENT

Filed May 24, 1949

2 Sheets-Sheet 1

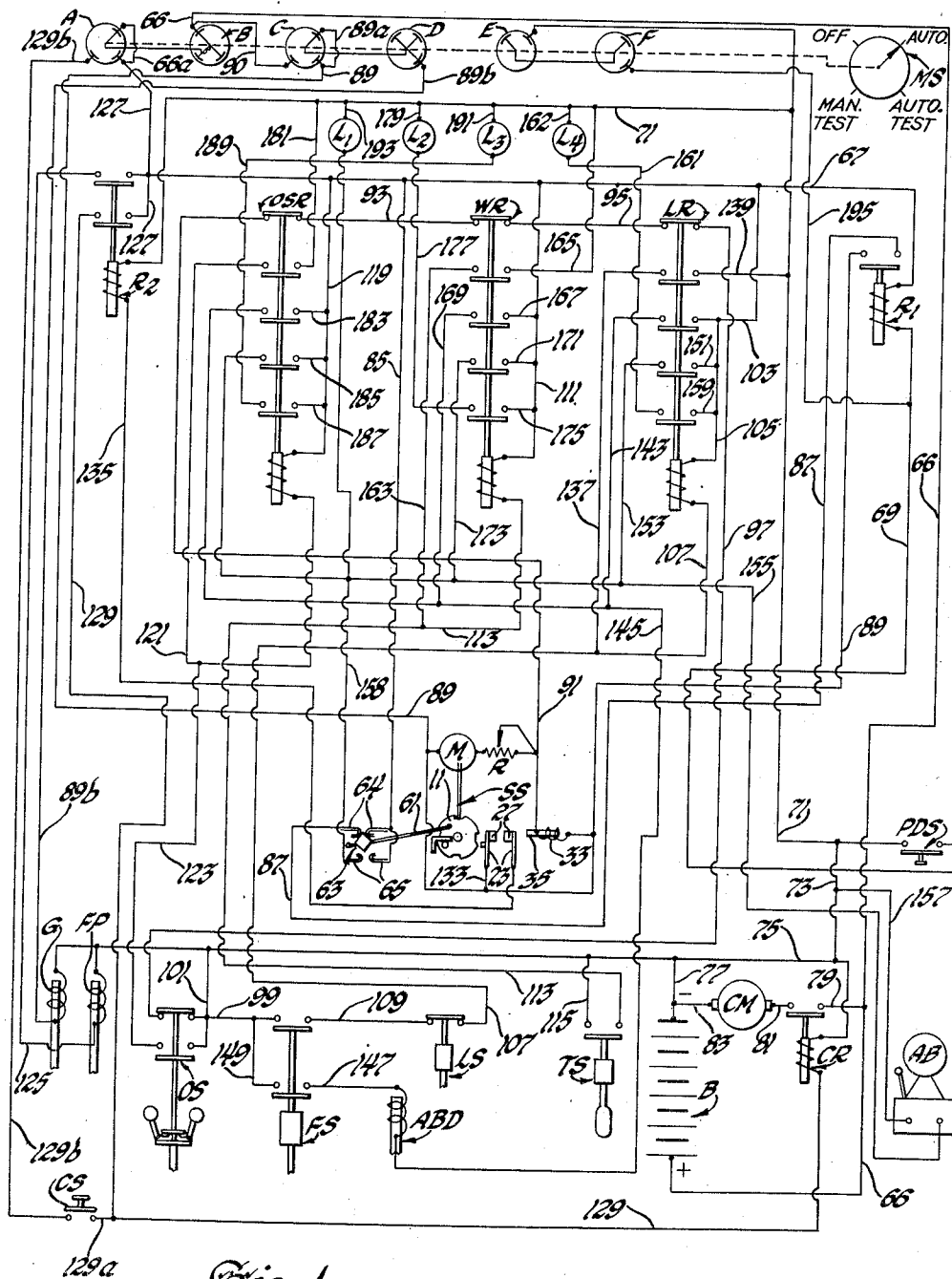


Fig. 1

Inventor
Harold G. Haines

By
Spencer, Willett, Helwig & Prallie
Attorneys

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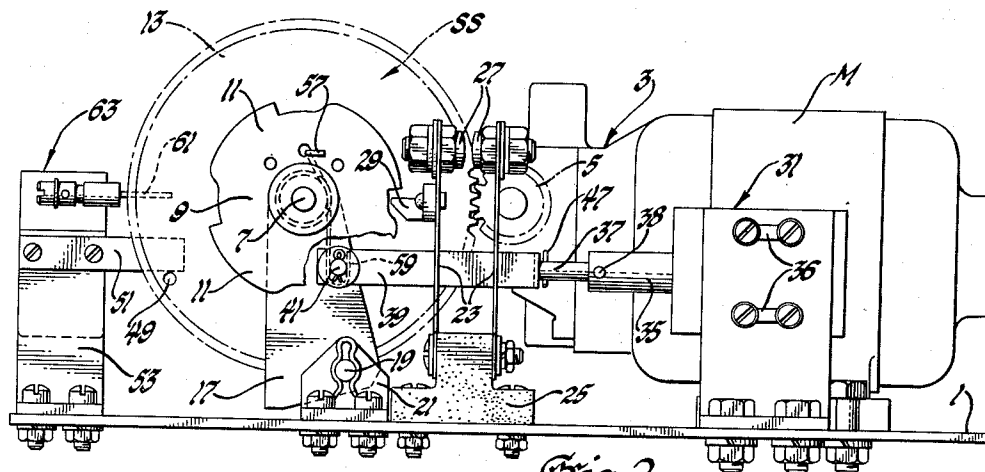


Fig. 2

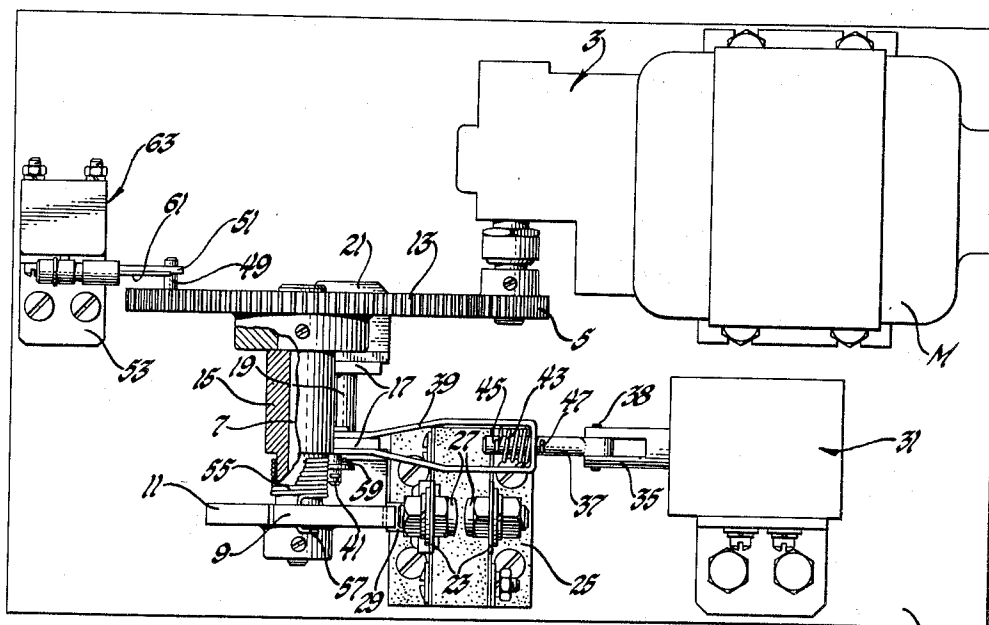


Fig. 3

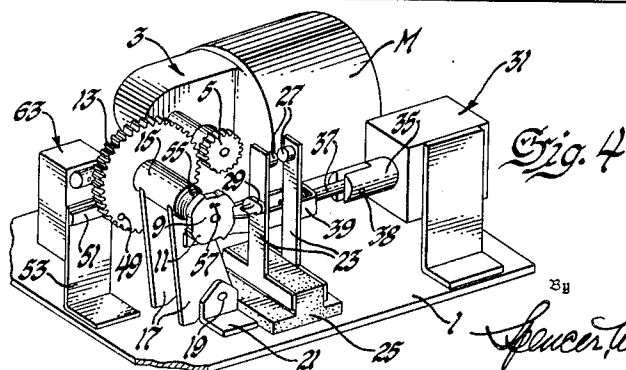


Fig. 4

Inventor
Harold G. Haines

Spencer, Willits, Helwig & Baillie
Attorneys

UNITED STATES PATENT OFFICE

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AUTOMATIC ENGINE STARTING
EQUIPMENT

Harold G. Haines, Detroit, Mich., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application May 24, 1949, Serial No. 95,099

10 Claims. (Cl. 290—30)

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The present invention generally relates to internal combustion engines and more particularly to automatic starting control systems therefor.

The principal object of the present invention is to provide a simple starting control system for internal combustion engines of the compression ignition type including control means responsive to a demand for power from the engine for controlling sequence control means interconnected with control means and signals responsive to operative and defective conditions of the engine and the combined starting control means therefor to provide a preselected number and duration of cranking and rest periods of the engine cranking means and including automatic resetting means for the sequence controlling means upon starting and operation of the engine when in operative condition and lockout means with manual resetting means therefor to prevent cranking of the engine when not in operative condition and deenergization of the combined control system after failure of the engine to start after a preselected number of cranking and rest periods with signals indicating the particular defective condition of the engine.

The combined control means and control connections therebetween of this control system by which the above object is accomplished, together with other protective features provided thereby, will become apparent by reference to the following detailed description and drawings clearly describing and illustrating the details of this system.

Figure 1 is a wiring diagram of the automatic control system with the control apparatus and conventional engine cranking motor and fuel control apparatus shown in schematic form.

Figure 2 of the drawings is a side elevational view of certain control apparatus shown in Figure 1.

Figure 3 is a top plan view of the control apparatus shown in Figure 2.

Figure 4 is a reduced scale perspective view of the arrangement of the control apparatus shown in Figures 2 and 3.

As shown schematically in Figure 1 a conventional engine cranking motor CM is provided with any well known type of engageable drive means for operatively connecting the cranking motor CM to the engine crankshaft, not shown, when the cranking motor is energized and for disconnecting the drive upon deenergization of this motor. An electromagnetic cranking motor relay having a normally open pair of contacts which are bridged by an armature contact upon

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energization of the winding of this switch to control energization of the cranking motor CM. An electric battery B provides a source of energy for the cranking motor and the control and signal apparatus.

As best illustrated in Figure 1 the control apparatus for the engine and cranking motor includes a manually operable selector switch generally indicated at MS, a manually operable starting switch CS, an engine power demand switch PDS, a motor operated sequence switch SS, engine speed, fuel and lubricating oil pressure and temperature responsive switches OS, FS, LS and TS, electromagnetically actuated engine governor, fuel and induction air control devices G, FP and ABD and electromagnetic control and signal relays R1, R2, OSR, WR and LR, signal lights L1, L2, L3 and L4 and an alarm bell AB electrically interconnected with the battery B by conductors to be subsequently described.

The manual selector switch MS is of the multi-gang contact type having six gangs A, B, C, D, E and F of stationary contacts, a rotary shaft provided with a knob movable between automatic-start, automatic-test, manual-start, and off positions. A pair of rotary contacts are provided on the shaft between the stationary contacts of gangs A—B, C—D, and E—F and the switch knob is shown in the automatic position for starting and operation of the engine, not shown, in response to actuation of the power demand switch PDS.

The power demand switch PDS includes a pair of stationary contacts and a contact movable into bridging relation thereby by any well known means responsive to the conditions in a power system requiring the starting and operation of the engine driving a power generator to supply the increased power demand on the power system, such as an electrical or fluid pressure power system and the like. The engine speed responsive switch OS includes two pair of stationary contacts and a pair of contacts cooperating therewith and movable by centrifugal weights driven by the engine for opening one pair of contacts upon operation of the engine above cranking speed and for closing the other pair of contacts upon operation of the engine at a speed in excess of operating speed.

The engine fuel pressure responsive switch FS includes two pair of stationary contacts and a pair of contacts cooperating therewith and movable by any well known pressure responsive means connected with the engine driven fuel

pump, not shown, to act upon proper build-up in fuel pressure delivered by this pump.

The engine lubricating oil pressure responsive switch LS includes a pair of stationary contacts and another contact normally in bridging relation therewith and movable out of bridging relation by another similar pressure responsive element, not shown, upon proper build-up in lubricating oil pressure to a safe value.

The engine cooling water temperature responsive switch TS includes a pair of stationary contacts and a contact movable into bridging relation therewith by a conventional thermostatic element, not shown, upon an abnormal rise in temperature of the engine coolant water.

The electromagnetically operated engine control device G includes a winding and a plunger for moving the speed and load setting means of the engine governor, not shown, to the operating position from the normal engine shut down position.

The electromagnetically actuated engine fuel control device FP also includes a winding and a plunger for moving the engine fuel rack or regulator to the operating position during cranking to obtain prompt starting of the engine.

The electromagnetically operated engine induction air control device ABD also includes a winding and a plunger for closing an air valve or actuating a tripping device for a spring closed air valve to shut off the supply of induction air to the engine in order to promptly shut down the engine.

The electromagnetic control and signal relays R1, R2, OSR, WR and LR include one or more pairs of stationary contacts, an armature having one or more contacts cooperating with the stationary contacts when moved from the normal position upon energization of the winding provided on each relay.

The motor operated sequence switch SS, as best shown in Figures 2, 3 and 4, includes a mounting base 1, a driving motor M secured thereto and operatively connected by speed reducing gearing, included in a housing and generally indicated at 3 on the motor, and including a driving pinion 5. A camshaft 7 having a cam 9 provided with four angularly spaced cam lobes 11 and a gear 13 secured thereto, is rotatably supported about an axis parallel to the axis of the driving pinion 5 in a bearing housing 15 having depending leg portions 17, the lower portions of which are pivoted by pivot pins 19 in brackets 21 on the base 1 arranged on an axis parallel to and between and below the pinion and shaft axes so that the bearing housing 15 is normally rocked by gravity counterclockwise, as viewed in Figures 2 and 4, about the axis of the pivot pins 19 and away from the pinion 5 so that the lower corners of the legs 17, below the shaft axis, normally rest on the mounting base 1 and the gear 13 is normally held disengaged and spaced from the driving pinion 5, as best shown in Figure 4. A pair of resilient contact arms 23 are secured in vertically spaced relation to an insulating block 25 secured to the base 1 alongside the cam 9. A contact 27 is secured to each arm 23 so that the contacts 27 are normally spaced apart. A cam follower 29 is secured to the contact arm 23 adjacent the cam 9 for engagement by the cam lobes 11 when the bearing housing 15 is rocked clockwise to the position shown in Figures 2 and 3 to cause engagement of the gear 13 with the driving pinion 5 and thereby cause intermittent closure of the contacts 27 upon intermittent engagement of the

cam follower 29 upon rotation of the cam 9 and gear 13 by the pinion 5.

An electromagnet, generally indicated at 31 secured to the base 1 and including a winding 33, shown in Figure 1, and a plunger 35 movable to the right therein upon energization of the winding through the winding terminals 36 serves to rock the bearing housing 15 clockwise against gravity about the pivot pins 19 from the normal gear disengaged position, shown in Figure 4, to the position shown in Figures 2 and 3 to cause driving engagement of the gear 13 by the driving pinion 5 and intermittent closure of the contacts 27 upon engagement of the follower 29 on one contact arm by the cam lobes 11. A resiliently extensible linkage connects the plunger 35 of the electromagnet 31 with one leg 17 of the bearing housing 15 to insure proper meshing of the teeth of the pinion and gear.

This linkage mechanism includes a link rod 37 pivoted at the outer end by a pin 38 to the outer end of the plunger 35. The inner end of the link rod 37 extends through an opening in the inner transverse loop portion of a U shaped link 39, the opposite end of the legs of which extend along either side of a leg 17 of the bearing housing 15 and are pivoted thereto by a pin 41. A helical compression spring 43 is placed over the inner end of the link rod 37 within the U shaped link 39 and a cotter key 45 is placed in an opening adjacent the inner end of the link rod so that one end of the spring 43 bears on this key and the other end bears on the loop portion of the link 39 and tends to foreshorten this linkage. Another cotter key 47 is placed in an opening in the link rod outside the loop portion of the U shaped link and the outer face of this loop portion normally bears on the key 47 and limits foreshortening of this linkage mechanism. It will be evident that this resiliently extensible linkage permits movement of the magnet plunger 35 and link rod 37 to the right relative to the U shaped link 39 compressing the spring 43, should the top of the tooth of the gear 13 initially contact the top of the tooth of the pinion 5 and that the compressed spring accordingly causes further movement of the gear into proper mesh with the pinion upon slight relative rotation thereof by the motor M with respect to the gear.

The gear 13 is continuously urged clockwise to hold a stop pin 49 secured thereto into contact with a stop arm 51 secured to a bracket 53 on the mounting base 1 by a helical spring 55 on the shaft 7 having one end 57 shown projecting through an opening in the cam 9 and the other end 59 hooked on the pin 41 by which the legs of the U shaped link 39 are pivoted to the leg 17 of the bearing housing 15. Upon engagement of the gear 13 with the pinion 5 and proper meshing of the teeth thereof, the motor M drives the pinion clockwise and the gear, shaft and cam counterclockwise and further tensions the spring 55 between the cam and leg of the bearing housing. The stop pin 49 on the gear 13 is positioned to contact and move the contact arm 61 of a limit switch, generally indicated by the character reference 63, on the bracket 53 when the gear is rotated approximately one revolution to open one pair of contacts 64 of this switch and close another pair of contacts 65, shown in Figure 1, in which position the contact arm is retained by gravity and friction. This causes deenergization of the motor M and electromagnet 31 and the spring 43 causes the gear 13, when disengaged by gravity from the pinion 5, to be reset to its former

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position with the stop pin 49 held in contact with the stop arm 51. The contact arm 61 of the limit switch can only be set to its original position manually to permit reenergization of the motor M and electromagnet winding 33.

It will be noted in Figure 1 that with the manual selector switch MS in the automatic position, as shown, for setting up automatic operation of this engine starting and control system the upper right-hand stationary contact of gang A and the upper left-hand stationary contact of gang B are bridged by rotary contacts electrically interconnecting these stationary contacts which are shown connected in series with the winding of the relay R1 and the normally open pair of contacts of the power demand switch PDS across the battery B by conductors 66, 66a, 127, 67, 69, 71, 73, 75 and 77. The conductor 66a connects the right-hand upper and lower stationary contacts of gang A. The normally open contacts of the cranking motor relay CR and cranking motor CM are connected in series across the battery B by conductors 66, 79, 81, 83 and 77. The normally closed contacts 64 of the limit switch 63, the normally open contacts of the relay R1, the bridged upper right stationary contact of gang C and right lower stationary contact of gang D of the switch MS and the winding of electromagnetically actuated governor speed setting device G are connected in series between the conductors 67 and 75 by conductors 85, 87, 89, 89a and 89b. The conductor 89a connects the right upper and lower stationary contacts of gang C and the left-hand lower contact of this gang is connected by a conductor 90 to the conductor 66. One terminal of the motor M and the electromagnet winding 33 of the sequence switch SS are connected in parallel with the conductor 89. The opposite terminal of the motor is connected in series with a rheostat R, one terminal of which and the other terminal of the electromagnet winding 33 are connected to conductor 91 included in series return circuit relation with the normally closed upper pair of contacts of the relays OSR, WR and LR and the upper closed contacts of the switch OS by conductors 89, 91, 93, 95, 97, 99, 101, 75 and 77.

The normally open upper contacts of the fuel switch FS, the normally closed contacts of the lubricating oil switch LS and winding of the relay LR are connected in series between conductors 67 and 99 by conductors 103, 105, 107 and 109.

The winding of the relay WR and the normally open pair of contacts of the water temperature switch TS are connected in series between the conductors 67 and 75 by conductors 111, 113 and 115.

The winding of the relay OSR and the normally open pair of contacts of the speed switch OS are connected in series between conductors 67 and 101 by conductors 119, 121 and 123.

The normally open upper pair of contacts of the relay R2 and winding of the electromagnetically actuated engine fuel control device FP are connected in series between conductors 67 and 75 by the conductor 125.

The lower normally open contacts of the relay R2 and winding of the cranking motor relay CR are connected in series between conductors 67 and 75 by conductors 127 and 129. The normally open contacts of the manual starting switch CS are connected in series between conductor 129 and the left lower stationary contact of gang A of the manual selector switch MS by conductors 129a and 129b. The winding of the relay R2 and normally open contacts 27 on the cam operated

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contact arms 23 of the motor operated sequence switch SS are connected in series between conductors 89 and 71 by conductors 133 and 135.

The normally open pair of contacts second from the top of the relay LR are connected in series between conductors 107 and 71 by conductors 137-139. The normally open pair of contacts of the relay LR third from the top, the winding of the electromagnetically actuated engine induction air shut-off device ABD and the lower normally open contacts of the fuel switch FS are connected in series between conductors 103 and 99 by conductors 143, 145, 147 and 149. The normally open pair of contacts of the relay LR second from the bottom and the alarm bell AB are connected in series between conductors 105 and 73 by conductors 151, 153, 155 and 157 and the normally open contacts 65 of the limit switch 63 are connected in series between the conductors 85 and 155 by a conductor 158. The lower pair of normally open contacts of the relay LR and signal lamp L4 are connected in series between conductors 105 and 71 by conductors 159, 161 and 162.

The pair of normally open contacts second from the top of the relay WR are connected in series between conductors 113 and 71 by conductors 163 and 165. The third pair of normally open contacts from the top of the relay WR are connected by conductors 167 and 169 in series between conductors 111 and 145. The normally open pair of contacts second from the bottom of the relay WR are connected in series between conductors 111 and 155 by conductors 171 and 173 and the normally open bottom contacts of this relay and the signal lamp L2 are connected in series between conductors 111 and 71 by conductors 175, 177 and 179.

The pair of normally open contacts second from the top of the relay OSR are connected in series between the conductors 121 and 71 by conductor 181. The normally open contacts of this relay third from the top are connected in series between conductors 119 and 145 by a conductor 183. The normally open pair of contacts second from the bottom of the relay OSR are connected by a conductor 185 in series between conductors 119 and 155 and the bottom normally open contacts of this relay and the signal lamp L3 are connected in series between conductors 119 and 71 by conductors 187, 189 and 191. The other signal lamp L1 is connected in series between conductors 155 and 71 by a conductor 193.

The upper right-hand and lower right-hand stationary contacts of gangs E and F of the manual selector switch are connected in series between conductors 69 and 71 by conductor 195.

With the contacts of the switches and relays in the position shown, an energizing circuit is set up from the battery B including the bridged contacts in gangs A and B of the manual selector switch MS, the normally open contacts of the power demand switch PDS and winding of the relay R1 and conductors 66, 66a, 127, 67, 69, 71, 73, 75 and 77. This circuit is completed by closure of the contacts of the power demand switch PDS causing closure of the contacts of the relay R1. This causes energization of the driving motor M and electromagnet 31 of the selector switch SS and driving engagement between the motor driven pinion 5 and camshaft gear 13 and engagement of one lobe 11 of the cam 9 with the cam follower 29 on one contact arm 23 and movement of this arm and contact thereon into contact with the contact 27 on the other contact arm and tensioning of the spring 55 between the cam

and the leg 17 of the bearing housing 15 supporting the camshaft in the manner previously described. The winding of the electromagnetic governor speed and load setting means G is also energized to move the governor speed and load setting means to the operative position. The energizing circuit for the motor M and electromagnet 33 of the sequence switch SS includes the bridged contacts of gangs A—B of the manual selector switch MS, closed contacts 64 of the limit switch 63 of the sequence switch, the closed contacts of the relay R1 and the closed upper contacts of the engine water temperature, lubricating oil pressure and overspeed relays WR, LR and OSR and conductors 66, 66a, 127, 87, 85, 87, 89, 91, 93, 95, 97, 99, 101, 75 and 77. A branch energizing circuit is also established through conductor 89, bridged gang contacts CD of the manual selector switch MS, conductors 89a, 89b, winding of the electromagnetic governor setting means G and conductors 75—77 to set the governor to the engine operating speed and load position.

Upon initial closure of the contacts 27 by the first cam lobe 11 of the motor sequence switch SS a branch energizing circuit is also completed through the winding of relay R2 through these contacts and conductors 89, 133, 135, 71, 73, 75, 77. This causes simultaneous closure of both the upper and lower pairs of contacts of the relay R2. Closure of the upper pair of contacts of the relay R2 completes an energizing circuit through the winding of the electromagnetic engine fuel control device FP to move the engine fuel rack to the proper speed and load setting desired for prompt starting. This energizing circuit comprises the conductors 67, 125, 75 and 77. Closure of the lower contacts of the relay R2 completes an energizing circuit through conductors 67, 127 and 129, the winding of the cranking motor relay CR and conductors 75 and 77 to cause closure of the contacts of this relay to cause energization through conductors 66, 79, 81, 83 and 77 of the engine cranking motor CM to crank the engine. Cranking of the engine and energization of the engine electromagnetic fuel control means FP continues for an interval determined by the angular length of the cam lobes 11 and interval these lobes engage the cam follower 29 to retain the contacts 27 of the sequence switch SS closed, after which these contacts open for an interval determined by the angular depression between the lobes of the cam to cause deenergization of the engine cranking motor CM and fuel control device FP. With the Diesel engine in normal starting and operating condition fuel oil pressure builds up sufficiently during cranking to cause closure of both pairs of contacts of the fuel switch FS and starting and operation occurs during this initial cranking period which causes the upper pair of contacts of the overspeed switch OS to open. This deenergizes the sequence switch SS and electromagnet 31 which in turn permits contacts 27 to open thereby deenergizing relay R2 which in turn deenergizes fuel control device FP and to simultaneously deenergize the cranking motor relay CR and motor M and electromagnet 31 of the sequence switch and thereby cause disengagement of the driving connection between the motor driven pinion 5 and gear 13 on the camshaft 7 and permit rocking movement by gravity of the camshaft bearing housing 15 and cam lobe out of contact with one of the contact arms 23 of this switch and thereby open the contacts 27 on these arms and allow the spring 55

on the camshaft to reset this shaft to its normal position with the stop pin 49 on the gear 13 to contact the stop arm 51 of the sequence switch.

Should the engine speed rise to an abnormal value after starting due to defective governor operation the lower contacts of the overspeed switch will close and cause energization of the winding of the relay OSR, serving as an overspeed relay, through conductors 67, 119, 121, 123, 101, 75 and 77. This causes the opening of the upper pair of contacts and closure of the other pairs of contacts of the overspeed relay OSR. Opening of the upper pair of contacts opens the return circuit from the motor M and electromagnet 31 of the sequence switch SS to prevent further cranking of the engine. Closure of the second pair of contacts from the top of the relay OSR completes a holding circuit for the relay winding comprising conductors 67, 119, 121, 181, 71, 73, 75 and 77. Closure of the third pair of contacts from the top of the relay OSR completes an energizing circuit comprising conductors 67, 133, 145, 147, the closed lower pair of contacts of the fuel switch FS and conductors 149, 101, 75 and 77 to the winding of the electromagnetic engine induction air shutoff means ABD to shut the engine down. Closure of the fourth pair of contacts from the top of the relay OSR completes a holding circuit to the alarm bell AB through conductors 67, 119, 135, 155, 157, 73, 75 and 77 and closure of the lower pair of relay contacts completes an energizing circuit to the signal lamp L3, serving as an overspeed signal, through conductors 67, 119, 187, 189, 191, 71, 73, 75 and 77.

Should the lubricating oil pressure fail to build up to a safe value during engine cranking or fall below this safe value when operating at proper speed and load the contacts of the lubricating oil switch LS will remain closed to set up a circuit through these contacts, the winding of the relay LR serving as a lubricating oil relay, the closed upper pair of contacts of the fuel switch FS and conductors 67, 103, 135, 107, 109, 99, 101, 75 and 77 to cause the opening of the upper pair of contacts of the lubricating relay LR and simultaneous closure of all of the other pairs of the contacts of this relay. The opening of the upper pair of relay contacts will cause the opening of the above mentioned return circuit to the sequence switch motor M and electromagnet 33 and thereby automatically resetting the sequence switch to the normal position to cause opening of the circuit to the winding of the relay R2 and the contacts thereof which causes deenergization of the winding of the cranking relay CR and engine fuel control device FP to discontinue cranking of the engine by the cranking motor CM. Closure of the second pair of contacts from the top of the relay LR completes a holding circuit to the relay winding through conductors 67, 103, 135, 107, 137, 139, 71, 73, 75 and 77. Closure of the third pair of contacts from the top of the relay LR establishes an energizing circuit through the engine air shutoff ABD, closed lower contacts of the fuel switch FS and conductors 67, 103, 143, 145, 147, 149, 99, 101, 75 and 77 to cause shut down of the engine. Closure of the fourth pair of contacts from the top of the relay LR establishes a circuit through the alarm bell AB and conductors 151, 153, 155, 157, 73, 75 and 77 and closure of the lower pair of relay contacts completes a circuit to the signal light L4, serving as a lubricating oil signal, through conductors 67, 103, 159, 161, 162, 71, 73, 75 and 77.

Should the engine coolant water temperature rise to an abnormal value when operating or after stopping due to opening of the power demand switch PDS causing deenergizing of the winding of the relay R1 and the opening of the relay contacts thereby causing deenergizing of the winding of the engine governor speed setting means causing it to move to the engine shut down position, the contacts of the temperature switch will close. This completes a circuit through the winding of the relay WR, serving as a water temperature relay and conductors 67, 111, 113, 115, 75 and 73 and causes the opening of the upper pair and closure of the other pairs of contacts of the water temperature relay WR. Opening of the upper pair of contacts of the relay WR likewise opens the return circuit from the motor M and electromagnet 31 of the sequence switch SS and the energizing circuit to the winding of the engine fuel control device FP to prevent cranking of the engine. Closure of the second pair of contacts from the top of the relay WR establishes a holding circuit through the relay winding and conductors 67, 111, 113, 163, 165, 71, 73, 75 and 77. Closure of the third pair of contacts from the top of the relay WR completes a circuit through the engine air shut-off device ABD and conductors 67, 111, 167, 169, 145, 147, 149, 99, 101, 75 and 77 to cause shut down of the engine if operating. Closure of the fourth pair of contacts from the top of the relay WR completes a circuit through the alarm bell and conductors 67, 111, 171, 173, 155, 157, 73, 75 and 77 and closure of the lower pair of relay contacts completes a circuit through the signal lamp 12, serving as an overtemperature signal, and conductors 67, 111, 175, 177, 179, 71, 73, 75 and 77.

Should the engine fail to start due to lack of fuel oil pressure the fuel switch contacts will remain open and after the first engine cranking and rest period the other cam lobes of the sequence switch SS will successively reclose the contacts 27 thereon to cause a second, third and fourth cranking period for the engine and rest periods after the second and third periods. During the fourth cranking period the stop pin 49 on the camshaft gear 13 of the sequence switch contacts and moves the contact arm 61 of the limit switch 63 out of contact with contacts 64 and into contact with contacts 65 of this switch. Opening of the contacts 64 of the limit switch 63 on the sequence switch SS opens the circuit through the contacts of the relay R1 to the motor M, electromagnet 31 and contacts 27 of the sequence switch, governor speed setting means G, operating coil of relay R2 which in turn opens the circuit to the winding of the engine fuel control device FP to render the sequence switch SS inoperative to cause further cranking of the engine unless the arm 61 of the limit switch is manually reset to its normal position in contact with the switch contacts 64. Closure of the other switch contacts 65 completes a circuit comprising conductors 67, 85, 158, 193, 71, 73, 75 and 77 to the signal lamp L1, serving as an overcranking signal and also completes a circuit comprising conductors 158, 155, 157, 73, 75 and 77 to the alarm bell AB. A test for automatic operation of the control system may be made by rotating of the manual selector gang switch clockwise one-quarter revolution from the automatic position shown, to the automatic test position. This causes bridging of the lower right contact of gang A with the upper left contact of

gang B, bridging of the lower right contacts of gangs C and D and bridging of the upper right contact of gang E with the lower right contact of gang F. Bridging of the above contacts in gangs A—B—E—F establishes an energizing circuit through the winding of the relay R1 and conductors 66, 127, 67, 195, 71, 73, 75 and 77 causing closure of the contacts of the relay R1. This establishes a branch energizing circuit through the contacts 64 of the sequence switch SS, closed contacts of the relay R1, motor M and electromagnet 33 of the sequence switch, closed upper pair of contacts of each of the relays OSR, WR, LR and speed switch OS and conductors 67, 85, 87, 89, 91, 93, 95, 97, 101, 75 and 77. Another branch circuit is established through the bridged contacts of gang contacts C—D and winding of the governor speed setting means G and conductors 89, 89b, 75 and 77. This causes the engine governor speed setting means to be set in the engine operating speed and load position and causes rotation of the camshaft causing closure of the contacts 27 of the sequence switch to cause four engine cranking periods accompanied by operation of the engine fuel rack setting means with rest periods therebetween followed by opening of the limit switch contacts 64 and closure of the contacts 65 to deenergize the cranking motor CM, sequence switch motor causing resetting of the sequence switch and energizing the over cranking lamp L1 and alarm bell AB in the same manner as previously described should the engine fail to start during any of the four cranking periods. As explained it is necessary to reset the limit switch 63 manually in order to render the sequence switch operative after an unsuccessful start in four cranking periods of the engine. If the engine starts the speed switch will open and discontinue operation of the sequence switch and cranking motor and the sequence switch will be automatically reset.

Movement of the manual selector switch knob and rotary contacts counterclockwise a half revolution from the automatic-test to the off position causes opening of the stationary contacts in each of the gang contacts of the selector switch.

Movement of the selector switch knob and rotary contacts a quarter revolution from the off position to the manual test position causes the bridging of the left lower and upper stationary contacts of the contact gangs A—B and the bridging of the left and right lower stationary contacts of the contact gangs C—D. Bridging of the contacts of gangs A—B sets up a circuit to the manual starting switch CS and winding of the cranking relay CR, comprising conductors 66, 129b, 129a, 129, 75 and 77, and this circuit is completed upon manual closure of the starting switch to cause closure of the cranking motor relay contacts which energizes the cranking motor CM through conductors 66, 79, 81, 83 and 77 to crank the engine. The bridging of the contacts in the selector switch gangs C—D completes a circuit through conductors 66, 90, 89b and the winding of the governor speed and load setting means to aid in starting of the engine. The engine fuel control device FP is not energized at this time to obtain as prompt starting as when the selector switch is in automatic or automatic-test positions.

The above described automatic starting and control system for internal combustion power plants enables these power plants to be located in remote districts and interconnected by a power

line to start automatically upon a demand for power on the line. Frequent servicing of these power plants is unnecessary on account of the protective means included in the control system which prevent damage to the engine and starting means due to defects therein by locking out the starting control means after providing a given number of engine cranking and rest periods and leaving signal indications of the defects preventing starting of the engine. These signals and the manual selector switch provide means whereby the defects may be readily detected, quickly corrected and a test made to determine if the system is capable of automatic operation.

I claim:

1. In an engine starting system, an engine cranking motor, a source of energy therefor, energizing connections including switching means interconnecting said cranking motor and energy source, said switching means including a motor operated, spring reset cam switch for alternately energizing and deenergizing said cranking motor to provide engine cranking and rest periods, an engine driven speed responsive switch operable upon starting and operation of the engine to deenergize said motor operated cam switch and cause spring resetting thereof, and a power demand switch operable upon a demand in power from the engine for energizing said motor operated cam switch.

2. In an engine starting system, an engine cranking motor, a source of energy therefor, energizing connections including a plurality of switching means interconnecting said cranking motor and said energy source, said switching means including a motor operated, spring reset cam switch for alternately energizing and deenergizing said cranking motor, a limit switch manually movable to a closed position to maintain said motor operated cam switch energized and operably connected thereto and operable to an open position upon a preselected number of alternate energizing and deenergizing periods of said cranking motor to deenergize said motor operated cam switch and limit operation thereof upon failure of the engine to start and to cause spring resetting of said cam switch, an engine operated switch operable upon starting and operation of said engine at normal speed to deenergize said motor operated cam switch and also cause spring resetting thereof, and a power demand switch operable upon a demand for power from the engine to control energization of said motor operated cam switch.

3. In an engine starting system, an engine cranking motor, a source of energy therefor, energizing connections including switching means interconnecting said cranking motor and said energy source, said switching means including a motor operated cam switch alternately controlling energization and deenergization of said cranking motor to provide a preselected number of engine cranking and rest periods, a limit switch manually movable to one position to maintain energization of said motor operated cam switch and operably connected thereto and movable to a deenergizing control position to limit movement of said cam switch upon failure of the engine to start after a preselected number of cranking and rest periods, a power demand switch operable only upon a demand in power on the engine for controlling energization of said motor operated cam switch, an engine operated switch operable upon normal operating speed of the engine to deenergize said motor op-

erated cam switch, a manually operable control switch and manually operable switching means movable to one position for connecting said power demand switch in said energizing connections for automatic control of said motor operated cam switch, said manually operable switching means being operable to another position to connect said manually operable control switch for directly controlling energization of said cranking motor.

4. In an engine starting control system, an engine cranking motor, a source of energy therefor, energizing connections including switching means interconnecting said cranking motor and said energy source, said switching means including a motor operated cam switch alternately controlling energization and deenergization of said cranking motor to provide a preselected number of engine cranking and rest periods, a limit switch manually set to an energizing control position for maintaining energization of said motor operated cam switch and operable thereby to cause deenergization thereof after a preselected number of energization and deenergization control periods, a power demand switch automatically operable upon a demand in power from the engine to control energization of said motor operated cam switch, a manually operable cranking motor control switch to control energization of said cranking motor, a manually operable selector switch movable to an automatic control position to connect said power demand switch in the energizing connections for automatic control of said motor operated cam switch, movable to a manual test position to connect said cranking motor control switch in said energizing circuit connections to said cranking motor, movable to an automatic test position to shunt said power demand switch for directly controlling energization of said motor operated cam switch, and movable to an off position for opening said energizing control connections and an engine operated switch operable only in response to operation of said engine at normal speed to deenergize said motor operated cam switch.

5. In an engine starting system, an engine cranking motor, a battery, electromagnetic fuel and speed setting control means for said engine, a motor operated cam switching means comprising a driving motor, a camshaft, a switch operable by said camshaft, electromagnetic means for connecting said camshaft in slow speed driving engagement with said motor to cause alternate closure and opening of said cam operated switch, a spring biasing said camshaft to a starting position, a limit switch manually operable to a closed position and operably connected to said camshaft for movement to an open position upon a preselected movement of said camshaft by said motor, a power demand switch movable to a closed position upon a demand in power from said engine, an engine speed responsive switch movable from a closed to an open position upon starting and operation of said engine to normal speed, electrical control connections interconnecting said camshaft operated switches in control relation with said cranking motor, said electromagnetic fuel setting means and said speed responsive switch and energizing control connections interconnecting said power demand switch in energizing control relation between said battery and said camshaft driving motor, said electromagnetic speed setting means, said electromagnetic connecting means for the motor and camshaft and the switching means operable by said camshaft.

6. In an internal combustion engine starting system, an engine cranking motor, a battery supplying power thereto, power connections interconnecting said cranking motor with said battery and including electromagnetically operated engine control means, a motor operated cam switch, a plurality of switching means responsive to different engine operating conditions, said cam-switch and engine condition responsive switches being interconnected to control intermittent operation of certain of said electromagnetically operated engine control means and cranking motor, a power demand switch operable in response to a demand in power on said engine for controlling energization and operation of said motor operated cam switch, certain other of said electromagnetically operated engine control means, one of said engine conditioning responsive means being operable in response to normal operating speed of said engine to deenergize said motor operated cam switch, one of said electromagnetically operated engine controlling means serving to shut off the engine induction air supply and said engine condition responsive switches being connected in circuit relation therewith and operable in response to the occurrence of abnormal engine conditions to energize the electromagnetic engine induction air shutoff means.

7. In an internal combustion engine starting system, a cranking motor, a battery for supplying power to the cranking motor, electrical control connections interconnecting said cranking motor and battery and including an electromagnetically actuated engine speed and fuel control means and engine induction air supply shutoff means, a motor operated cam switch operable when energized to control intermittent energization of said cranking motor and said electromagnetically actuated engine fuel control means, a power demand switch operable upon a demand in power from said engine to control energization and operation of said motor operated cam switch and said electromagnetically actuated engine speed control means, a plurality of switches acting in response to normal engine starting and operating conditions and relays controlled thereby, said relays normally maintaining the motor operated cam switch energized and operable, one of said switches acting upon normal operating speed conditions for deenergizing said motor operated cam switch, each of said relays being connected by control connections to alarm signal means and said electromagnetically actuated engine induction air supply shutoff means for controlling energization thereof to shut down said engine and deenergize said motor operated cam switch, a manually operable cranking motor control switch and a manually operable selector switch for selectively connecting said cranking motor control switch and said power demand switch in control relation with said cranking motor.

8. In an internal combustion engine starting system, an engine cranking motor, a battery for supplying power thereto, power connections interconnecting said cranking motor and battery and including motor operated switching means, an engine driven switch normally acting to set up a power connection to said motor operated switching means from said battery with the engine at rest and operable upon starting and running of the engine at normal speed to open the power connection set up between and a power demand switch operable upon a demand in power from the engine to complete the power connection set up by said engine driven switch, said motor oper-

ated switching means comprising a base, a driving motor mounted thereon, said motor having a driving shaft, a driving pinion on said shaft, a bearing support pivotally mounted on said base and normally urged by gravity away from said driving pinion, a camshaft rotatably mounted in said bearing support, a gear on said camshaft normally spaced alongside said driving pinion, a stop on said gear, a spring urging said gear in one direction of rotation into contact with a portion of said base, a switch on said base adjacent said camshaft intermittently operated thereby from a normally open position to a closed position, a limit switch pivoted on said base and manually movable to a closed position and contactable and movable by said stop on said gear upon a pre-selected angular movement of said stop from engagement with said base, and electromagnetic means for moving said bearing support from its normal gravity urged position to engage said gear with said motor pinion for rotation thereby, said limit switch, said cam operated switch, said motor and said electromagnetic means being connected in said power connections in controlling relation between said power demand switch and said engine operated switch.

9. In an engine starting system, electrically operated engine cranking means, electrically operated means to increase the engine fuel for starting the engine, electrically operated engine speed setting means to control the speed of operation or shut down of the engine, an electrical power source, and power circuit connections and switching means interconnecting the power source and said electrically operated means, said switching means including an electric motor operated cam switch to control intermittent operation of the engine cranking and fuel varying means, engine speed responsive means to disconnect the motor operated cam switch upon starting of the engine and a control switch movable to a closed position to control operation of the engine speed setting means and the motor operated cam switch to cause starting and operation of the engine, said control switch being movable to an open position to disconnect the engine speed setting means in order to cause shut down of the engine.

10. In an engine starting system, an electrically operated engine cranking means, electrically operated engine fuel increasing means for starting the engine, electrically operated engine speed setting means, means to cause the engine to operate at normal speed, said engine speed setting means when deenergized causing shut down of the engine, an electric power source and power circuit connections and switching means interconnecting said source and said electrically operated means, said switching means including an electric motor operated cam switch to control intermittent operation of the engine cranking and fuel increasing means to cause starting of the engine, switching means operable upon abnormal engine operating conditions to disconnect the motor operated cam switch to prevent engine starting, a switch operable upon starting and operation of the engine to disconnect the motor operated cam switch and a control switch movable to a closed position to control operation of the motor operated cam switch to cause starting and normal engine operation and movable to an open position to deenergize the engine speed setting means and cause shut down of the engine.

HAROLD G. HAINES.

(References on following page)

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,406,731	Heard -----	Feb. 14, 1922
1,705,816	Ide -----	Mar. 19, 1929
1,735,163	Federle -----	Nov. 12, 1929
1,776,683	Larkin -----	Sept. 23, 1930
1,981,859	Frese -----	Nov. 27, 1934
2,197,726	Johnson -----	Apr. 16, 1940

Number
2,248,244
2,307,845
2,324,005
2,374,251
2,384,135
2,451,976

5

Number
696,046

10

16

Name	Date
Leece -----	July 8, 1941
Melcher -----	Jan. 12, 1943
Larkin -----	July 13, 1943
Wallace -----	Apr. 24, 1945
Scherry -----	Sept. 4, 1945
Reagan et al. -----	Oct. 19, 1948

FOREIGN PATENTS

Country	Date
Germany -----	Sept. 10, 1940