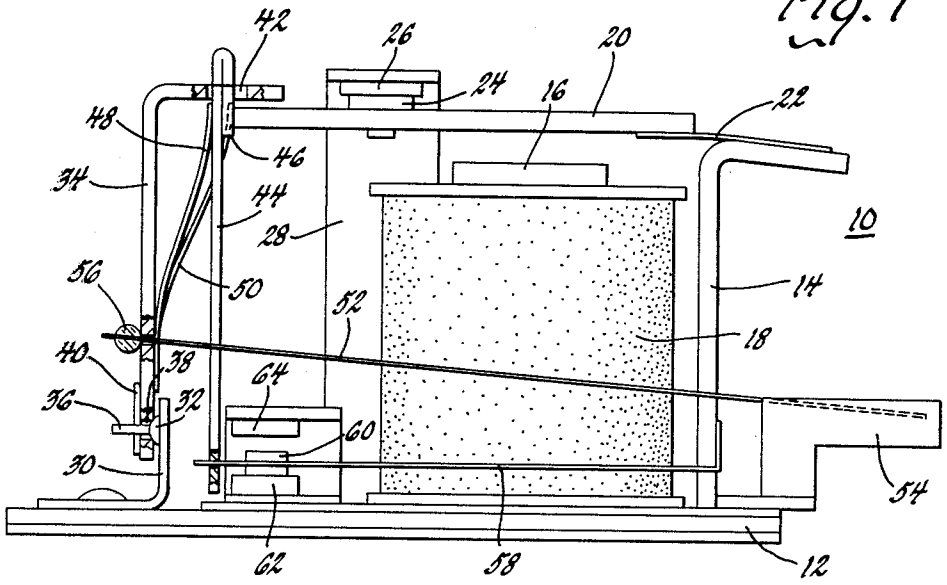
Jan. 26, 1965 H. J. CROMWELL 3,167,659

AUTOMATIC STARTING CONTROL

Filed July 12, 1960 2 Sheets-Sheet 1

Fig. 1



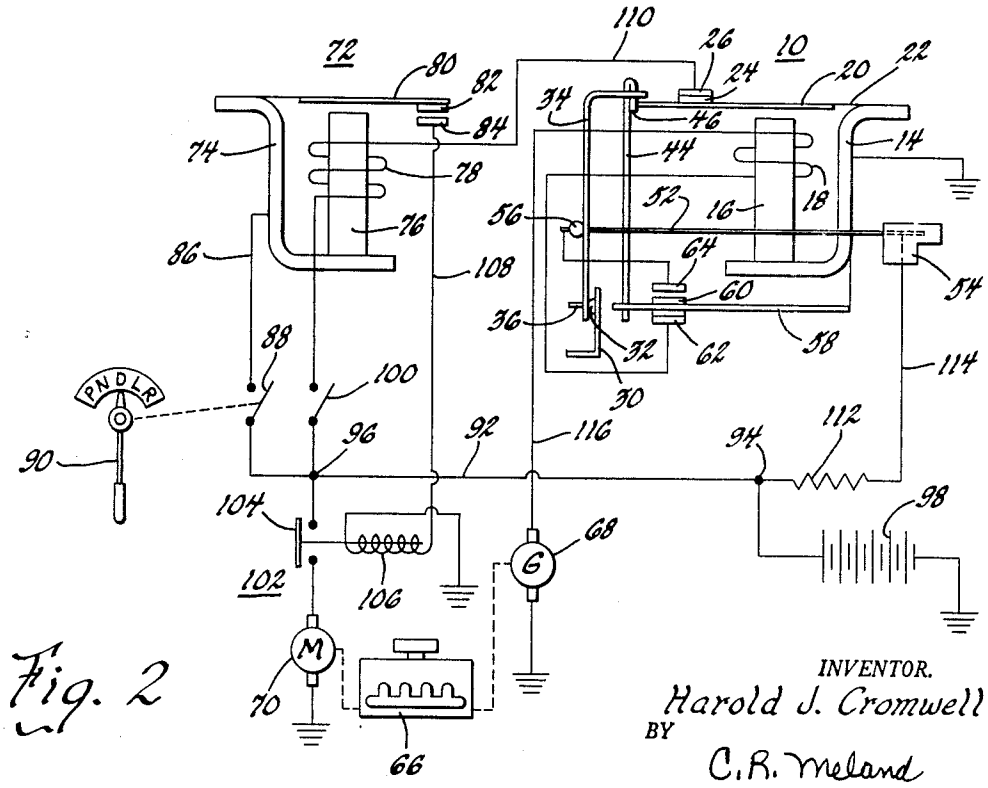


Fig. 2

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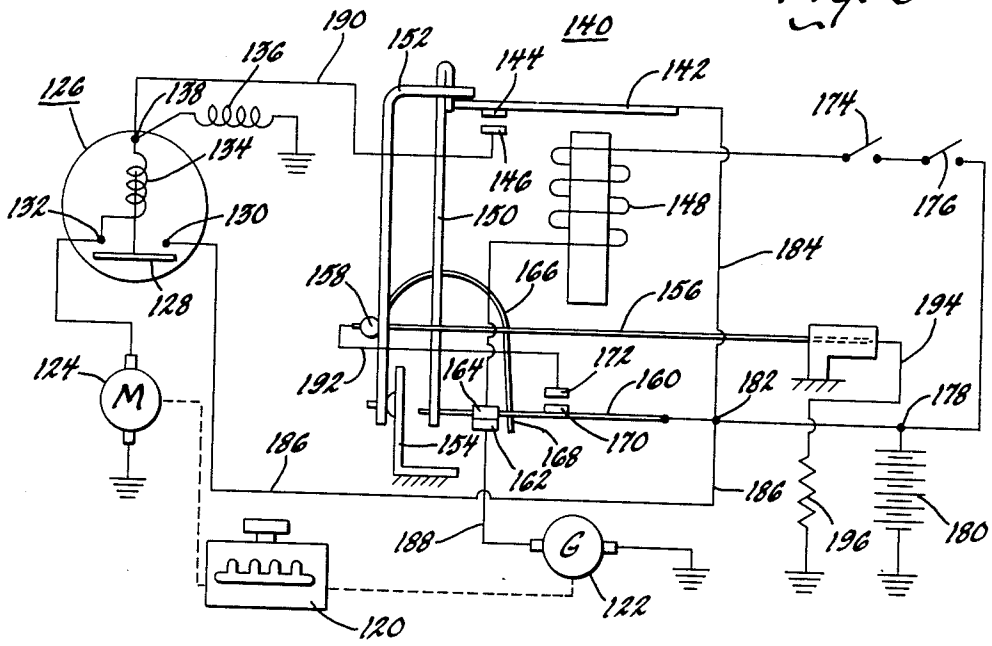
2 Sheets-Sheet 2

Fig. 3



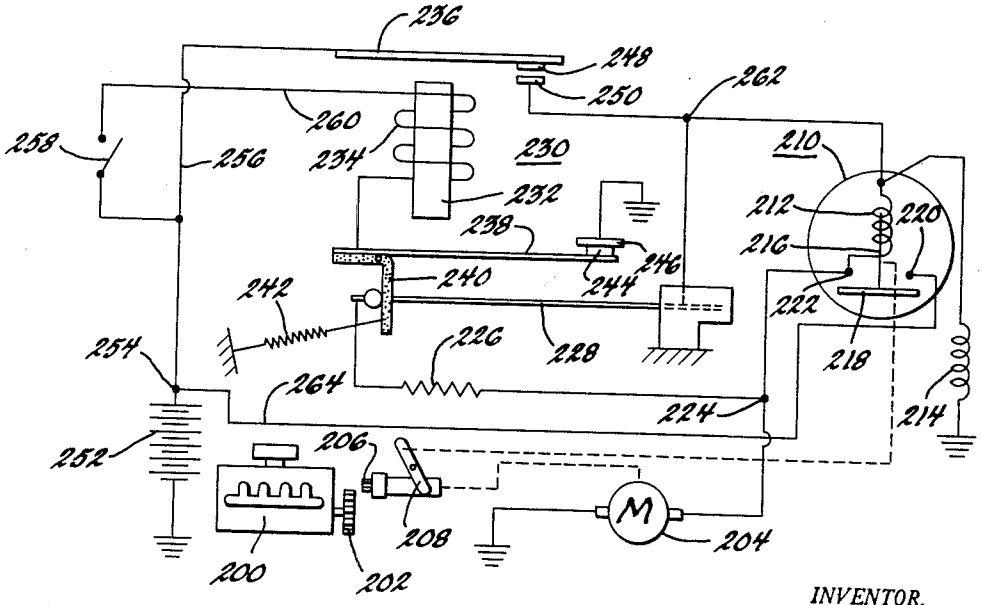


Fig. 4

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AUTOMATIC STARTING CONTROL

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5 Claims. (Cl. 290—38)

This invention relates to systems and apparatus for controlling the cranking of an internal combustion engine.

One of the objects of this invention is to provide an automatic starting system including control means that is operable to stop cranking of the engine once the engine has started and is operative to permit cranking of the engine only at a predetermined time delay following stopping or cutting off of the engine.

A further object of this invention is to provide an automatic starting system that is operative to permit cranking of an engine and, wherein the cranking is stopped in response to the development of an output voltage by an engine driven generator, and further wherein cranking is once more permitted at a predetermined time delay following a reduction in the output voltage of the generator due to a shutting down of the engine.

Still another object of this invention is to provide a latching relay that is useful in automatic starting control systems wherein the unlatching of the relay is controlled by an electrically energizable device such as a length of resistance wire.

Another object of this invention is to provide a control system for controlling a cranking motor of the type having a solenoid that controls energization of the motor and which also shifts a pinion into mesh with a ring gear, the system being operative to automatically provide repeated attempts at moving the pinion into mesh with the ring gear following an initial end tooth abutment between the pinion and ring gear.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred form of the invention is clearly shown.

In the drawings:

FIGURE 1 is a side elevation of a latching relay made in accordance with this invention.

FIGURE 2 is a schematic circuit diagram of an automatic starting control system employing the relay of FIGURE 1.

FIGURE 3 is a schematic circuit diagram of an automatic starting control system made in accordance with this invention.

FIGURE 4 is still another modified automatic starting control system made in accordance with this invention.

Referring to the drawings and more particularly to FIGURE 1, the reference numeral **10** has been used to generally designate a latching relay which is used in the system of FIGURE 2. The relay **10** comprises a base member **12** which carries an upstanding frame **14**. The base **12** also supports a core **16** and a coil winding **18** wound on the core. The upstanding frame or bracket **14** supports a movable armature **20** which is connected with the frame **14** by means of a spring hinge **22**.

The armature **20** carries an electrical contact **24** which is normally engaged with a fixed contact **26**. The fixed contact **26** is carried by a frame member **28** which is suitably supported by the base **12**. The contacts **24** and **26** are normally held in engagement due to the fact that the spring hinge **22** tends to bias the armature **20** upwardly.

The base **12** of relay **10** carries a support member **30** having a spherical portion **32** that forms a pivot for a shiftable lever **34**. The bracket member **30** also has a finger **36** which passes through an opening **38** formed in

the lever member **34**. The finger **36** has an opening to receive a hairpin spring **40** and it thus is seen that the lever **34** may pivot around the spherical portion **32** of the bracket **30** but is also supported by the bracket **30**.

The lever **34**, as is clearly apparent from FIGURE 1, has an opening **42** which receives the top end of a latch lever designated by reference numeral **44**. The latch lever has a reverse bent portion at its top end providing a latching surface **46** which at times engages the top side of the armature member **20** in a manner to be more fully described hereinafter. A leaf spring **48** is welded to the lever member **34** and engages the latch lever **44**. A second leaf spring **50** is welded or otherwise secured to the lever member **34** and engages an end of the armature member **20**.

The movement of lever member **34** is controlled by a length of resistance wire designated by reference numeral **52** which is anchored at one end to the support member **54** and which carries a glass bead or other type of insulator **56** that engages the lever member **34**. The resistance wire **52** is of any well-known type that will lengthen when it is heated by the passage of a current therethrough and which shortens in response to cooling of the same. It can be seen that when a current is passed through the resistance wire **52**, the wire will tend to lengthen and the lever member **34** will therefore be moved counterclockwise around spherical member **32**. On the other hand, when the resistance wire **52** is cooled and shortens, the lever member **34** will be moved to the right or clockwise in FIGURE 1.

The latch lever **44** is connected with a spring contact member **58** which carries the contact **60**. The contact **60** cooperates with the fixed contacts **62** and **64** depending upon its position with respect to these contacts. It can be seen that when the latch lever **44** is moved upwardly the contact spring **58** will be moved therewith to cause the contact **60** to leave the contact **62** and to engage the contact **64**. The operation of this contact **60** is more fully described hereinafter in connection with the system of FIGURE 2.

Referring now more particularly to FIGURE 2, the reference numeral **66** designates the engine of a motor vehicle. The engine **66** is connected to drive a generator **68** and is at times cranked by a starting motor **70**.

In the starting system of FIGURE 2, the relay illustrated in FIGURE 1 is once more designated by reference numeral **10**. In addition to this relay, the starting system of FIGURE 2 employs a relay generally designated by reference numeral **72** having a frame **74**, a core **76**, an actuating coil winding **78**, and an armature **80** which is pivotally supported by the frame **74**. The armature **80** carries a contact **82** which is normally out of engagement with the fixed contact **84** but which is shifted into engagement with this contact when the coil winding **78** is energized.

The frame member **74** is connected with lead wire **86** which, in turn, is connected to one side of a neutral safety switch **88** operated by a transmission control lever **90**. The transmission control lever and neutral safety switch **88** are connected in the usual manner with the neutral safety switch being closed when the transmission lever is in the park or neutral positions and being opened when the transmission lever is in the drive, low or reverse positions. The opposite side of the neutral safety switch **88** is connected with a lead wire **92** which is, in turn, connected with junctions **94** and **96**. The junction **94** is connected to one side of a storage battery **98** whereas the junction **96** is connected to one side of an ignition switch **100** and to one side of a solenoid controlled switch **102** that includes the shiftable contactor **104**. The contactor **104** is shifted into engagement with the fixed contacts of switch **102** whenever the solenoid coil winding **106** is

energized. It can be seen that when the contactor 104 is shifted to a closed position, a circuit is completed between junction 96 and the starting motor 70.

The manually operable ignition switch 100 is connected between the junction 96 and one side of the coil winding 78. The opposite side of coil winding 78 is connected with the fixed contact 26 of the latching relay 10 via a lead wire 110. One side of solenoid coil winding 106 is connected to ground whereas the opposite side of this coil winding is connected with fixed contact 84 of relay 72 via the lead wire 108.

The junction 94, that is connected to one side of storage battery 98, is connected with a resistor 112, the opposite side of the resistor being connected with lead wire 114. The lead wire 114 is connected to one side of the resistance wire 52, the opposite side of the length of resistance wire 52 being connected with the fixed contact 64.

One side of coil winding 18 of relay 10 is connected to one side of the generator 68 via lead wire 116, the opposite side of this coil winding being connected with the fixed contact 62. The frame 14 of the relay 10 is connected directly to ground, as is clearly apparent from an inspection of FIGURE 2.

In the operation of the system illustrated in FIGURE 2, when it is desired to crank the engine 66, the transmission selector lever 90 is shifted to the park or neutral positions causing a closure of the neutral safety switch 88. The ignition switch or start switch 100 is also closed. With switch 100 closed, it can be seen that a circuit for the relay coil winding 78 may be traced from battery 98, junction 94, lead wire 92, junction 96, switch 100, coil winding 78, lead wire 110, switch contacts 26 and 24, and thence through the armature 20 and frame 14 to ground. The energization of relay coil 78 causes contacts 82 and 84 to engage and completes a circuit for the energization of solenoid coil winding 106. This circuit may be traced from battery 98, junction 94, lead wire 92, neutral safety switch 88, lead wire 86, frame 74 of relay 72, through armature 80, through contacts 82 and 84, through lead wire 108, and thence through the solenoid coil winding 106 to ground. The energization of solenoid coil 106 completes a circuit for the starting motor 70 by movement of the shiftable contactor 104 into engagement with the fixed contacts. The engine 66 will therefore be cranked and at some point on the cranking operation the engine 66 will start and will drive the generator 68.

Once the engine starts and the generator 68 is being driven, it will develop an output voltage which is applied to the coil winding 18 of latching relay 10. This circuit can be traced from the generator 68, through lead wire 116, through the relay coil winding 18, through contacts 62 and 60 to the spring contactor 58 and thence from the spring contactor 58 to the frame 14 and to ground. When relay coil 18 is energized, it causes the armature 20 to move downwardly and therefore open the contacts 24 and 26. This will cause the circuit for relay coil 78 to be broken and therefore prevent further energization of the starting motor 70 and therefore prevent further cranking of the engine 66.

When the amature 20 moves downwardly, due to the energization of coil winding 18, the end of the armature 20 will be moved downwardly a sufficient distance so that the latching lever 44 will move rightwardly with the latching surface 46 engaging the top surface of the armature 20. The latching lever 44 will be urged to this latching position by the leaf spring 48 and will therefore latch the armature 20. The parts of the system will remain in this position as long as the engine 66 is operating since the generator 68 will be continuously developing an output voltage and will therefore hold the armature 20 down and the contacts 24 and 26 in an open position.

If the engine 66 is now stopped so that the generator 68 is no longer developing an output voltage, the relay coil 18 is, of course, not energized so that the armature 20 now moves upwardly due to the force applied to it by the spring hinge 22. As the armature 20 moves upwardly, it will now carry the latch lever 44 with it and this latch lever will cause the spring contact member 58 to also move upwardly to a position wherein the contacts 60 and 62 are disengaged and the contacts 60 and 64 are engaged. It is important to note that when the relay coil 18 is de-energized to permit an upward movement of armature 20, the contacts 24 and 26 do not become re-engaged since this upward movement is stopped by the closure of contacts 60 and 64. In other words, the dimensions of relay 10 are such that when the latch lever 44 moves upwardly to thereby carry the spring contact member 58 with it, the contacts 64 and 60 will close to prevent further upward movement of latch lever 44 and will close prior to the closure of contacts 24 and 26.

When contacts 60 and 64 are closed, a circuit is now completed for the length of resistance wire 52. This circuit may be traced from battery 98, junction 94, through resistor 112, lead wire 114, resistance wire 52, through contacts 64 and 60, through spring contact 58, and thence through the frame 14 of the relay to ground. When the resistance wire begins to heat during passage of current flow therethrough, it will lengthen and the spring 46 will therefore cause the lever member 34 to move leftwardly or counterclockwise in FIGURE 1. At some point in this movement, the lever 34 will carry the top end of latching lever 44 with it and will move the latching surface 46 out of engagement with the top side of armature member 20. Armature member 20 is then free to move upwardly to cause a reclosure of contacts 24 and 26. Since the latching lever 44 is now disconnected from the armature member 20, it will move downwardly due to the force supplied by spring contact member 58. This will cause contacts 60 and 64 to separate and cause contacts 60 and 62 to become re-engaged. It can be seen that this series of switching will de-energize the resistance wire 52 to cause it to move back to its original shape and position and will also now permit another cranking of the engine since the contacts 24 and 26 are closed.

It can be seen from the foregoing that with the system of FIGURE 2 cranking of the engine will occur whenever the switches 88 and 100 are closed. If the engine is now stopped due to an opening of ignition switch 100 or when the generator is developing an output voltage, the cranking of the engine is stopped. Cranking will also cease when neutral safety switch 88 is opened. It can be seen that the system of FIGURE 2 is not only effective upon a complete shutdown of the engine but is also effective in the cases of false starts to provide a determined time delay before cranking can once more commence. It is also apparent that where the engine is stopped for any reason the starting control system of FIGURE 2 is always operative to provide a predetermined time delay before cranking can be resumed due to the constructional features of the latching relay 10.

Referring now more particularly to FIGURE 3, a modified starting control arrangement is illustrated which is in some respects similar to the system illustarted in FIGURE 2 and which employs a control relay similar to that illustrated in FIGURE 1. In FIGURE 3, the reference numeral 120 designates an internal combustion engine which drives the generator 122 and which is cranked by the electric starting motor 124. The starting motor is controlled by a solenoid switch generally designated by reference numeral 126 including a shiftable contactor 128 which, at times, connects the fixed contacts 130 and 132. The solenoid switch 126 has a pull-in winding 134 and a hold-in winding 136 which are operative to shift the contactor 128. It is seen that both of these windings are connected with the junction 138 and that one side of the pull-in winding 134 is connected with the fixed contact 132 which is, in turn, connected to one side of the starting motor 124.

The starting control arrangement of FIGURE 3 uses a latching type of relay which is generally designated by

reference numeral **140**. This relay includes a pivotally mounted armature **142** which carries the contact **144**. The contact **144** cooperates with a fixed contact **146** and these contacts are pulled to an engaged position whenever the relay coil **148** is energized. The relay **140** further includes a latching lever **150** and a lever **152** which is pivoted to the bracket **154**. The parts **150**, **152** and **154** may be made in a manner identical with the equivalent parts illustrated in FIGURE 1, and the lever **152** is provided with a pair of leaf springs, not shown, similar to leaf springs **48** and **50** illustrated in FIGURE 1. The latching relay **140** further includes the length of resistance wire **156** which has a glass bead **158** engaging the lever **152**. The relay **140** includes a spring contact arm **160** which is mounted for pivotal movement and which, in its "at rest" position, causes an engagement of the contacts **162** and **164**. The contact **164** is carried by the spring contact arm **160** and is insulated therefrom. It can be seen that the latch lever **150** is connected with one end of the spring contact arm **160** in a manner similar to the structure illustrated in FIGURE 1. A finger **166** is carried by the lever **152** and has a tang **168** which, at times, becomes engaged with the lower end of the spring contact arm **160**. It can be seen that the spring contact arm **160** carries a contact **170** which, at times, becomes engaged with the fixed contact **172**.

One side of the coil winding **148** of the relay **140** is connected with a manually operable start switch **174** and it is seen that this switch is connected in series with a neutral safety switch **176** that is operated in a fashion similar to the operation of switch **88** in FIGURE 2. The switch **176** is connected with the junction **178** which is, in turn, connected to one side of storage battery **180**. The junction **178** is connected to one side of the spring contact arm **160** and therefore is connected with the contact **170**. The junction **178** is also connected with a junction **182** which is, in turn, connected with lead wires **184** and **186**. It can be seen that lead wire **186** is connected with the fixed contact **130** of solenoid switch **126**, whereas the lead wire **184** is connected with the armature **142** of the relay **140**.

The contact **164** which is insulated from and carried by spring contact arm **160** is connected to one side of coil winding **148**. The contact **162** which cooperates with contact **164** is connected to one side of the generator **122** via the lead wire **188**. The fixed contact **146** of control relay **140** is connected with the junction **138** via a lead wire **190**. It is seen that the fixed contact **172** of control relay **140** is connected to one side of the length of resistance wire **156** via the lead wire **192**. The opposite end of the resistance wire **156** is connected to ground via lead wire **194** and the resistor **196**.

In the operation of the system illustrated in FIGURE 3, and assuming that both switches **174** and **176** are closed, relay coil **148** will be energized from battery **180** via junction **178**, through switches **176** and **174**, through coil winding **148**, through contacts **164** and **162**, through lead wire **188**, and thence through the generator **122** to ground. With relay coil **148** energized, the armature **142** is pulled downwardly to cause a closure of contacts **144** and **146**. At this time the latching lever **150** will snap over the top end of the armature **142**. With contacts **144** and **146** in a closed position, the coil windings **134** and **136** will be energized via junction **178**, junction **182**, lead wire **184**, armature **142**, contacts **144** and **146**, and thence through the lead wire **190** to the junction **138**. With solenoid windings **134** and **136** energized, the contactor **128** will connect the fixed contacts **130** and **132** to complete a circuit for the starting motor **124**. These coil windings **134** and **136** in some types of starting apparatus will also cause the pinion of a starter to be forced into mesh with the ring gear of the engine. It can be seen that as a result of the closure of switches **174** and **176**, the starting motor will now crank the engine and at some point of time the engine will become operative.

When the engine **120** becomes operative and drives the generator **122**, it will develop an output voltage and this voltage will be applied to one side of the relay coil winding **148** through the closed contacts **162** and **164**. Relay coil **148** will now have substantially equal potentials impressed across it with the generator output voltage being slightly higher than the battery voltage and therefore the armature **142** will move upwardly to open the contacts **144** and **146**. This will, of course, cause a de-energization of coils **134** and **136** and thus prevent further cranking of the engine.

As the armature **142** moves upwardly, contacts **144** and **146** are opened and it will carry the latch lever **150** with it and this latch lever will likewise carry the spring contact arm **160** upwardly with it. As a result of this, the contacts **162** and **164** will be opened, whereas the contacts **170** and **172** will be closed. With contacts **170** and **172** closed, a circuit is now complete for the length of resistance wire **156** which may be traced from the battery **180**, junction **178**, junction **182**, spring member **160**, contacts **170** and **172**, lead wire **192**, resistance wire **156**, and thence through lead wire **194** and resistor **196** to ground. When the resistance wire **156** lengthens due to its having been heated by passage of current therethrough, the lever member **152** will be moved counterclockwise or leftwardly in FIGURE 3 to cause the lever **150** to be shifted out of engagement with the top side of the armature **142**. As a result of this, the lever **150** is free to drop under the influence of the spring member **160**. Immediate reclosure of contacts **162** and **164** is prevented, however, by the finger member **166** since the tang **168** of this finger member engages the underside of spring member **160** during this period. As the resistance wire **156** now cools down, however, due to an opening of contacts **170** and **172**, the lever **152** will move back to its original position and the tang **168** will move down thus permitting a delayed reclosure of contacts **162** and **164**. The control relay is now ready for another cycle of operation in controlling the energization of the cranking motor **124**.

Referring now more particularly to FIGURE 4, a starting control system is schematically illustrated wherein repeated attempts are automatically made at causing a pinion to become meshed with a ring gear of an engine even though there may be an initial end tooth abutment between the pinion and ring gear preventing the meshing engagement. In FIGURE 4, the reference numeral **200** designates the engine to be cranked which has a ring gear **202**. The starting apparatus which cranks the engine **200** includes a starting motor **204**, a shiftable pinion **206**, a link member **208** for shifting the pinion into engagement with the ring gear **202**, and a solenoid actuator generally designated by reference numeral **210**. The solenoid actuator includes the pull-in coil **212** and the hold-in coil **214**. The coils **212** and **214** control the movement of an armature **216**. The armature **216** performs the function of shifting the lever **208** to shift the pinion into mesh with the ring gear **202** and also operates a switch contactor **218** which, at times, connects the fixed contacts **220** and **222**. This type of starter is well known to those skilled in the art and in one type of this starter, as, for example, a heavy-duty starter it is important that the pinion **206** become meshed with the ring gear **202** before the contactor **218** shorts the contacts **220** and **222**. The starting apparatus is therefore arranged so that the pinion **206** becomes meshed with the ring gear **202** before the contactor **218** connects the contacts **220** and **222**. If there is an end tooth abutment between the pinion **206** and the ring gear **202**, the contactor **218** will not connect the fixed contacts **220** and **222**. The circuit of FIGURE 4, however, operates to provide repeated attempts at causing a meshing of the pinion **206** with the ring gear **202** as will become more readily apparent hereinafter.

It can be seen that the electric starting motor **204** is connected between ground and a junction **224**. The junc-

tion 224 is connected to one side of a resistor 226 and this resistor is connected to one side of a length of resistance wire designated by reference numeral 228. The length of resistance wire forms a part of a control relay which is generally designated by reference numeral 230 and which includes the resistance wire 228, the core 232, the coil winding 234, the armature 236, and a contact arm 238. The arm 238 is carried by a pivotally mounted bracket member 240 which is urged in a clockwise direction in FIGURE 4 by a spring 242. The arm 238 carries a contact 244 which cooperates with the grounded fixed contact 246. The armature 236 carries the contact 248 which cooperates with a fixed contact 250.

The reference numeral 252 designates a storage battery, one side of which is grounded and the opposite side of which is connected with a junction 254. Junction 254 is connected with a lead wire 256 which, in turn, is connected to one side of armature 236 and contact 248. The lead wire 256 is connected to one side of a manually operable start switch 258, the opposite side of this switch being connected with coil winding 234 via the lead wire 260. The opposite side of coil winding 234 is connected with the arm 238 and is therefore connected with contact 244. The contact 250 of relay 230 is connected with junction 262 and it is seen that this junction is connected to one side of the solenoid coil windings 212 and 214 and is also connected to one side of the length of resistance wire 228. The contact 222 of solenoid switch 210 is connected with junction 224 and therefore to one side of the starting motor 204. The contact 220 is connected with junction 254 via the lead wire 264.

In the operation of the system of FIGURE 4, the switch 258 is closed whenever it is desired to crank the engine 200. The closure of switch 258 completes a circuit for the relay coil winding 234 which may be traced from junction 254, through switch 258, through lead wire 260, through coil winding 234, through arm 238, and thence through contacts 244 and 246 to ground. With coil winding 234 energized, the contacts 248 and 250 are pulled to a closed position and complete a circuit for the pull-in and hold-in windings 212 and 214. When windings 212 and 214 are energized, they cause the pinion 206 to be shifted into engagement with the ring gear 202 and also cause the contactor 218 to connect the contacts 220 and 222 to complete a circuit for the starting motor 204. If there is no end tooth abutment, it is apparent that the engine 200 will now be cranked.

It is important to note that when the contactor 218 engages the contacts 220 and 222, the opposite ends of the resistance wire 228 will be at substantially the same potential so that no current flow will exist in the resistance wire and therefore no heating of the resistance wire will occur. It can be seen that opposite ends of the resistance wire are at the same potential since the junction 262 is connected through contacts 248 and 250 with junction 254, whereas the other end of the resistance wire 228 is also connected with junction 254 via resistor 226, contactor 218 and lead wire 264.

If an end tooth abutment occurs, however, after the switch 258 is closed, the solenoid coil windings 212 and 214 will be energized but because of the end tooth abutment it will be impossible to move the contactor 218 a distance sufficient to connect contacts 220 and 222. In this mode of operation, the opposite ends of resistance wire 228 are not connected with equal potential and a current will therefore flow therethrough. This circuit may be traced from battery 252, through lead wire 256, through armature 236, through contacts 248 and 250, through junction 262 to one side of resistance wire 228, through the resistance wire, through resistor 226 to junction 224 and from junction 224 through the starting motor 204 to ground. The heating of this resistance wire 228 will cause it to lengthen and will therefore permit the spring 242 to rotate the bracket member 240 clockwise in FIGURE 4. This will cause the contact arm 238 to also move clockwise and will therefore cause the contact 244 to leave the contact 246. This will, of course, break the circuit to the relay coil 234 causing contacts 248 and 250 to open and therefore de-energizing coil windings 212 and 214 whereby the pinion 206 is moved back to its "at rest" position. The opening of contacts 248 and 250 now also breaks the circuit to the resistance wire 228 so that current no longer flows therethrough. As a result, the resistance wire 228 cools and shortens to pull the bracket member 240 in a counterclockwise direction and therefore reclose contacts 244 and 246. Another attempt will now be made at forcing the pinion 206 into mesh with the ring gear 202 since the reclosure of contacts 244 and 246 will set into motion a series of switching operations which causes the shiftable movement of pinion 206 and the energization of motor 204. The control of FIGURE 4 will therefore continue to attempt to force the pinion 206 into mesh with the ring gear 202 as long as end tooth abutments occur and at some point the pinion will be meshed with the ring gear 202 and cranking of the engine 200 will occur.

While the embodiments of the present invention as herein disclosed constitute a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. In combination, an internal combustion engine, an electric starting motor adapted to crank said engine, a generator driven by said engine, a storage battery, a starting circuit interconnecting said starting motor and said storage battery, and relay means controlling said starting circuit, said relay means including an actuating coil winding and a pair of normally closed switch contacts, means connecting said coil winding with said generator whereby said contacts are opened when said generator is developing a predetermined output voltage, latch means holding said contacts open when said generator develops said predetermined output voltage to cause said contacts to open, and means for releasing said latch means at a predetermined time delay following a reduction of generator output voltage below said predetermined value.

2. In combination, an internal combustion engine, an electric starting motor for cranking said engine, a generator driven by said engine, a storage battery, a starting circuit connecting said storage battery and said starting motor, relay means for controlling said starting circuit, said relay means including a pair of normally closed switch contacts and an actuating coil, means connecting said actuating coil with said generator whereby said contacts are opened when said generator is developing a predetermined output voltage, latch means for holding said contacts in an open position once said generator has developed said predetermined output voltage, and electrically energizable means for releasing said latch means to permit a reclosure of said switch contacts.

3. The combination according to claim 2 wherein the electrically energizable means comprises a length of resistance wire.

4. In combination, an internal combustion engine, an electric starting motor for cranking said engine, a generator driven by said engine, a battery, a starting circuit connecting said battery and said starting motor, relay means for controlling said starting circuit, said relay means including a pair of normally closed switch contacts and an actuating coil, means connecting said actuating coil with said generator whereby said contacts are opened when said generator is developing a predetermined output voltage, latch means for holding said contacts in an open position once said generator has developed said predetermined output voltage, electrically energizable means for releasing said latch means to permit a reclosure of said switch contacts, and contact means connected in circuit with said electrically energizable means, said contact means closing when the generator output voltage drops below a predetermined value.

5. In combination, an internal combustion engine, an

electric starting motor for cranking said engine, a generator driven by said engine, a battery, a starting circuit connecting said battery and said starting motor, relay means for controlling said starting circuit, said relay means including an armature carrying a contact and an actuating coil, a fixed contact cooperating with the contact carried by said armature, means connecting said actuating coil with said generator whereby the contact carried by said armature shifts away from its cooperating fixed contact when said generator is developing a predetermined output voltage, latch means for holding said contact carried by said armature away from its cooperating fixed contact once said generator has developed said predetermined output voltage, electrically energizable means for releasing said latch means to permit a reclosure of said contact that is carried by said armature with said fixed contact, and contact means controlling the

circuit for said electrically energizable means operated in response to movement of said armature.

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