Sept. 6, 1955 S. W. SCOTT 2,717,317

ENGINE TURNING MECHANISM

Filed April 12, 1954 5 Sheets-Sheet 1

Fig. 1.

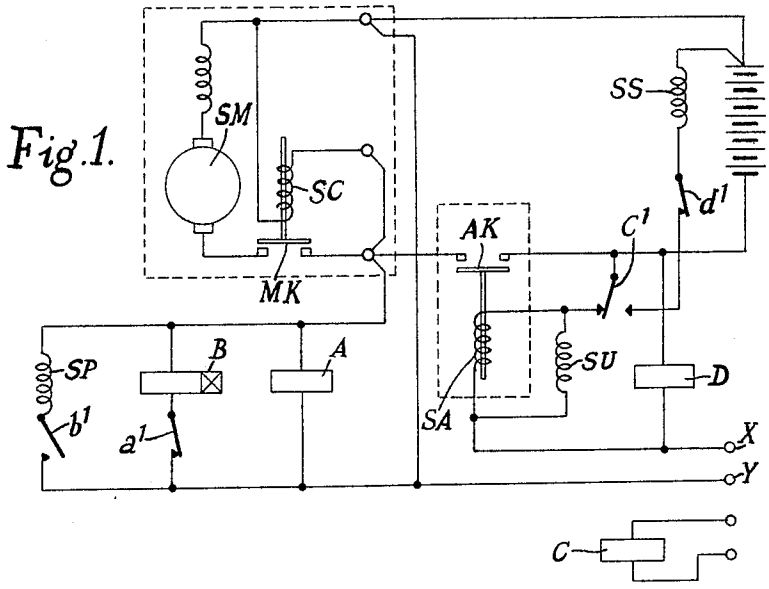
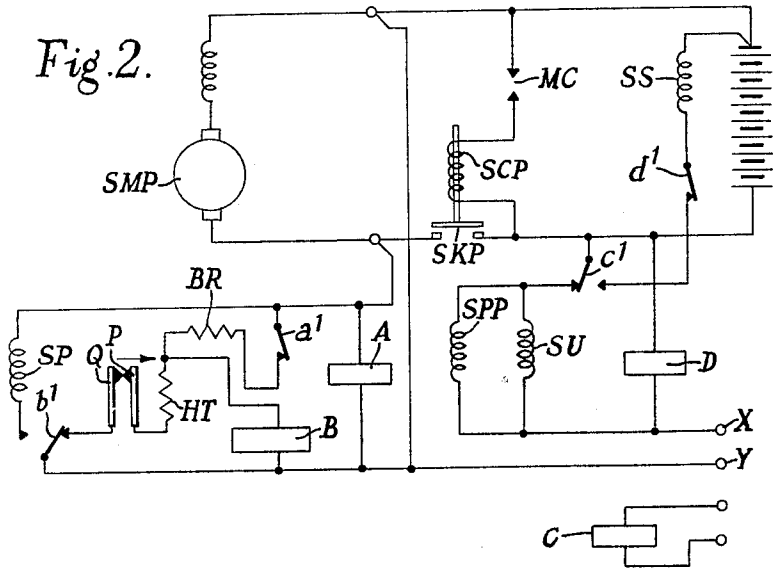


Fig. 2.



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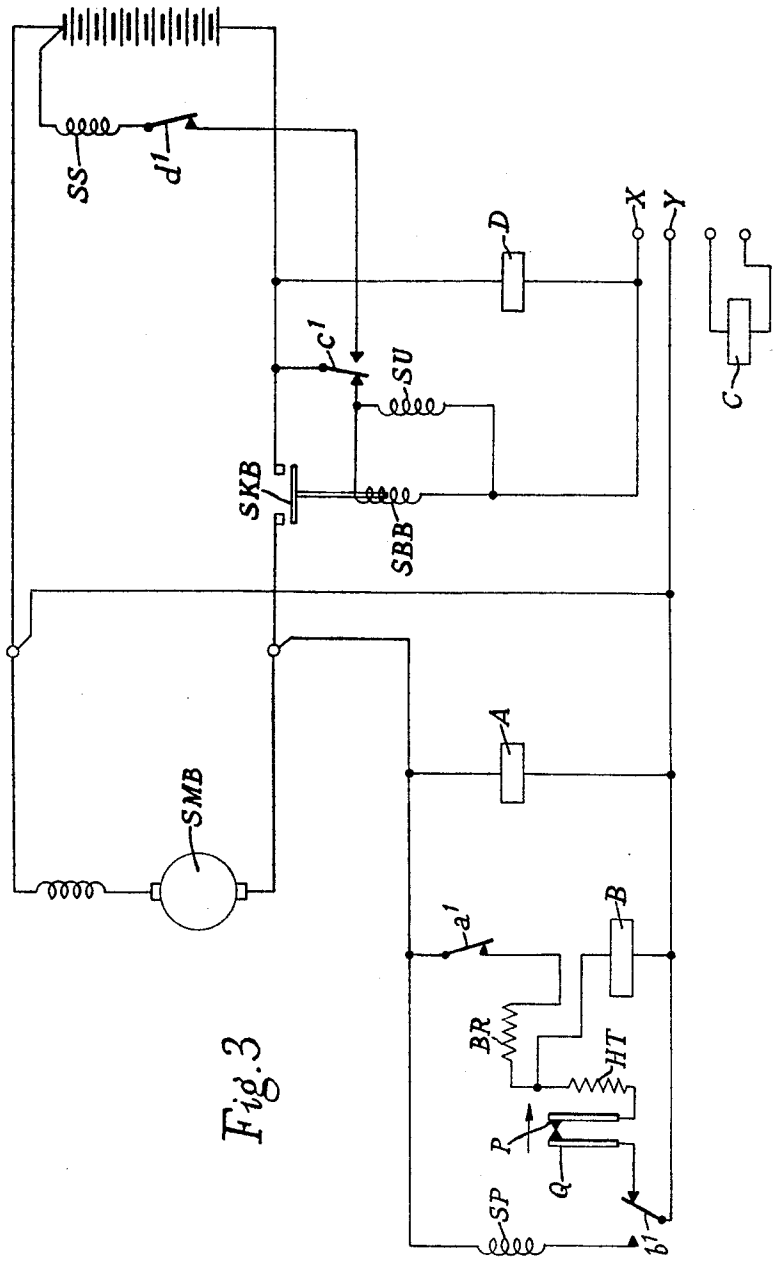


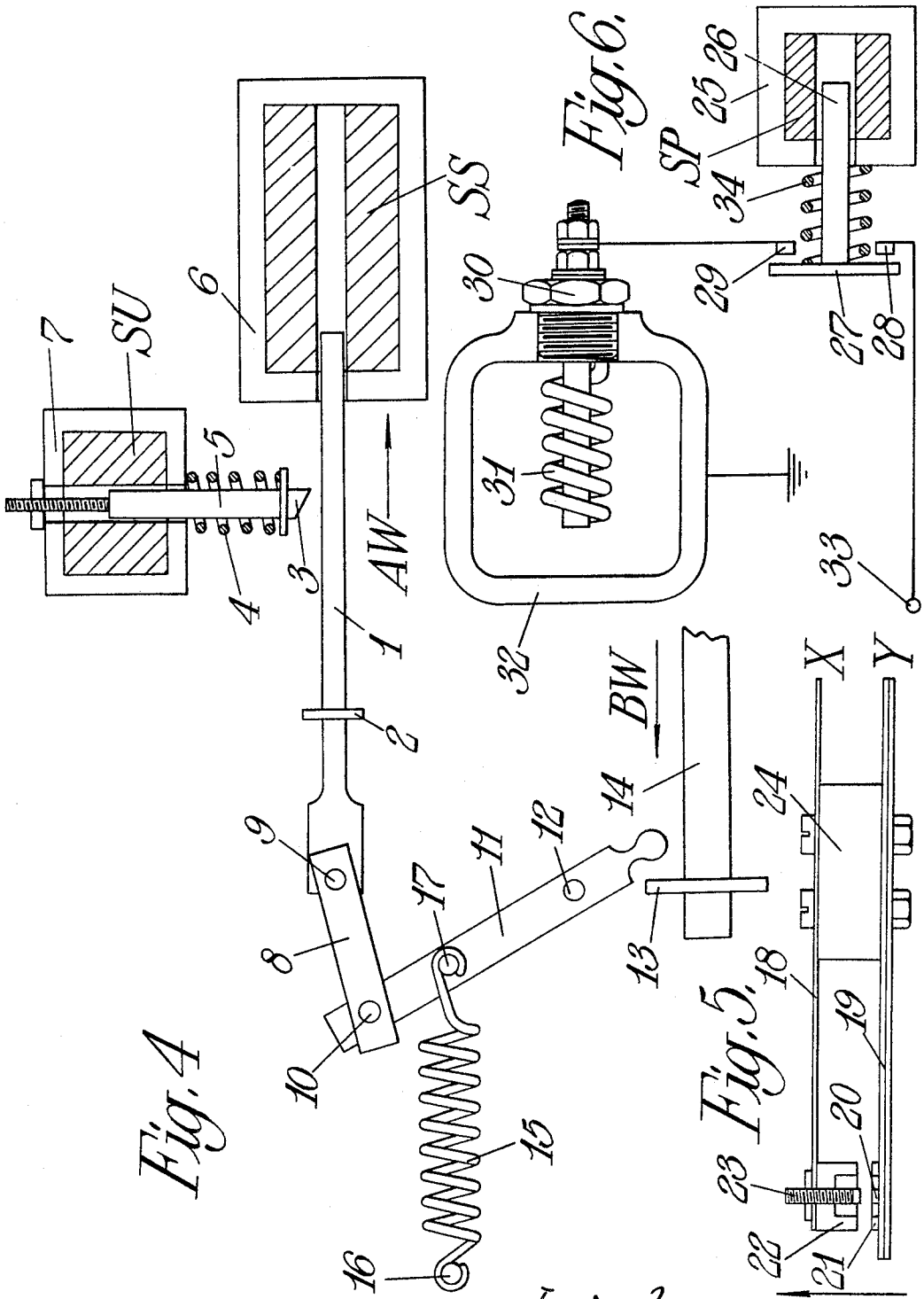
Fig. 3

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ENGINE TURNING MECHANISM

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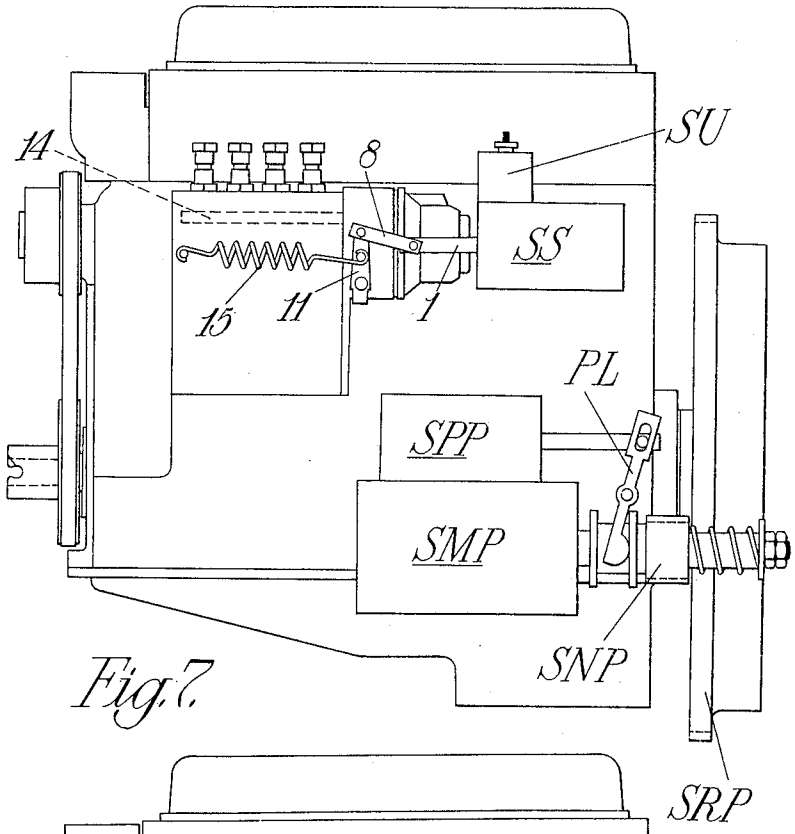


Fig. 7.

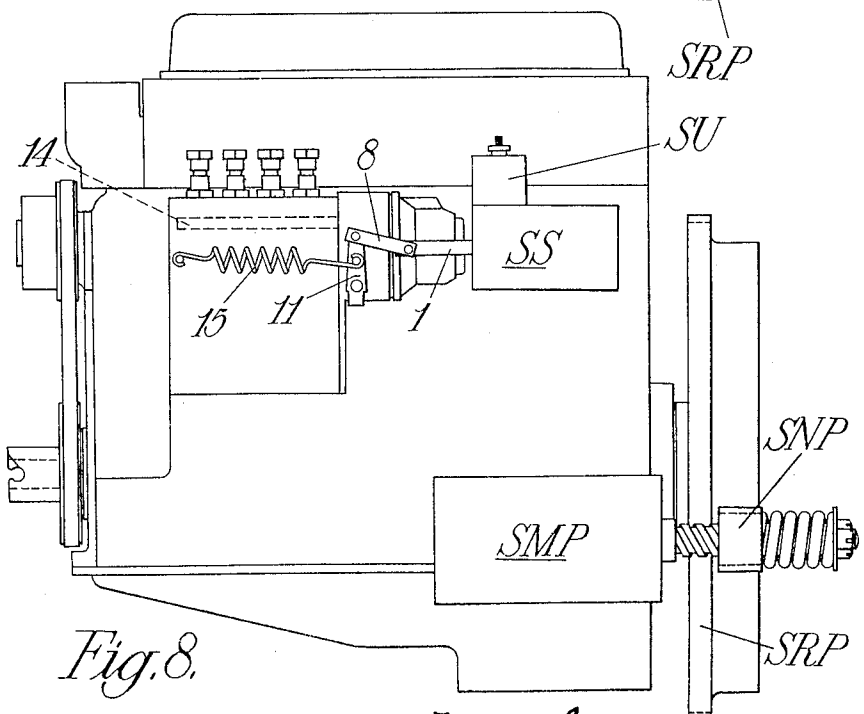


Fig. 8.

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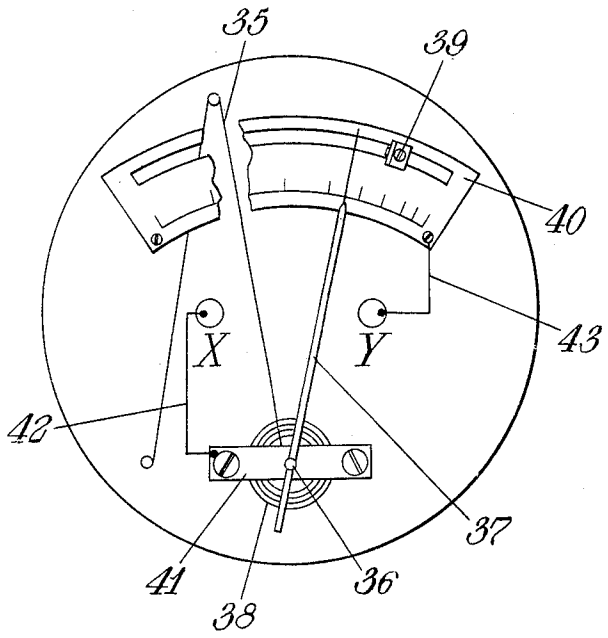


Fig. 9.

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ENGINE TURNING MECHANISM

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Application April 12, 1954, Serial No. 422,581

9 Claims. (Cl. 290—38)

This invention relates to engine turning mechanisms and is particularly applicable to compression ignition and other engines or motors where the effort or power required to start the engine or motor into operation varies according to the temperature of the atmosphere or other ambient conditions.

In most engine turning mechanisms heretofore known, and particularly those in which an electric starter motor is employed, the current taken by the starter motor is proportional to the torque output of the motor and inversely proportional to the speed of rotation, with the result that when the resistance of the engine to cranking rises due to a fall in ambient temperature or other conditions, the voltage across the starter motor falls owing to losses in the connecting cables, and according to the state of the batteries, and at the same time the starting effort available becomes too low to start the engine into operation without auxiliary starting aids.

The present invention has for its main object to overcome this difficulty, and the invention accordingly consists in an engine turning mechanism of the kind referred to in the preceding paragraph, comprising means whereby an auxiliary starting aid mechanism is automatically brought into operation when the conditions are such that the starter motor by itself is unable to start the engine.

According to the preferred arrangement, the aforesaid means comprises two electric relay members, one of which controls the circuit of the starting aid mechanism, but has its energising circuit controlled by the other relay, such other relay being adapted to operate when the voltage across the starter motor exceeds a predetermined value so as to render the starting aid mechanism inoperative, the relay controlling the starting aid mechanism being adapted to operate after a predetermined delay so as to actuate the starting aid mechanism when the voltage across the starter motor falls below the value required to operate said other relay.

The circuit for actuating the starter motor and/or the starting aid mechanism may be controlled by a temperature or humidity sensing element whereby the engine turning mechanism is automatically brought into operation upon the temperature or humidity of the ambient atmosphere reaching a predetermined value, and if desired means may also be provided for automatically stopping the engine when the temperature or humidity of the ambient atmosphere is such as to no longer require its operation.

The invention will be more completely understood from the following detailed description which is given in conjunction with the accompanying drawings, in which:

Figure 1 shows a circuit arrangement for controlling the starting and stopping of a compression ignition engine;

Figures 2 and 3 show circuit arrangements of modified form;

Figure 4 shows the component parts of the stop mechanism and fuel pump rack;

Figure 5 shows a typical temperature sensitive switch with an adjustable differential;

Figure 6 shows a typical form of starting aid mechanism;

Figure 7 shows in skeleton form a compression ignition engine using a starter motor having a pinion controlled by a solenoid;

Figure 8 shows in skeleton form a compression ignition engine using a starter motor of the Bendix type; and

Figure 9 shows a typical form of humidity sensing element.

Referring first to Figure 1 of these drawings, SM is a starter motor having a controlling solenoid SC and contactor MK associated with it, this starter motor being of any suitable form for turning the engine. SS is a solenoid for controlling the stopping mechanism and when this solenoid is energised it causes the armature **1** to move in the direction of the arrow AW until the collar **2** engages with the latch **3** which is normally held down by the spring **4**. The position of the latch **3** is controlled by the armature **5** which moves within the unlatching solenoid SU. The magnetic circuits of the stop and unlatching solenoids SS and SU are completed by the yokes **6** and **7** respectively. When the armature **1** moves, the link **8**, which is pivoted at **9** and **10**, pulls over the lever **11** which pivots about the pin **12**. This causes the end of the lever to engage on the collar **13** of the fuel pump rack **14** and move it in the direction of the arrow BW. When the full travel of the lever is reached, the fuel pump rack cuts off the supply of fuel to the fuel pump causing the engine to stop. This starter motor and contactor may be constructed in the form of a composite unit, and for the purpose of actuating such a starter motor I provide an auxiliary solenoid SA and contactor AK which is adapted to operate on the completion of the starter operating circuit so as to complete the circuit for the solenoid SC controlling the starter motor SM, current for the starter motor then being supplied through the contactors AK and MK of the two solenoids in series. At the same time a circuit is completed through the unlatching solenoid SU which on being energized lifts the latch **3** clear of the collar **2** and allows the spring **15**, which is anchored to the pins **16** and **17**, to pull the lever **11** into the position shown. In this position the fuel pump rack is free to operate in its normal manner without restraint. At the same time, a circuit is completed through relay D which breaks the circuit of the solenoid SS controlling the stop mechanism. On completion of the starter motor circuit, the energising circuit of a relay A which is so constructed as to operate only when the voltage across its winding exceeds a predetermined value, also closes. Also connected across the starter motor circuit and in parallel with this relay A is a second relay B which is slow to operate and has a contact *a'* in its energising circuit controlled by the first relay A. This second relay B has a contact *b'* which controls the circuit of a solenoid SP which in turn controls a starting aid mechanism such as that used in Figure 6. With this arrangement if the voltage across the starter motor SM is sufficient to energise the first relay A it will be sufficient to start the engine, and under these conditions the first relay A operates and breaks the circuit of the second relay B, thus rendering the starting aid mechanism inoperative. If, however, the voltage available across the starter motor SM is insufficient to start the engine, for example when the ambient temperature is low, or when the battery is in a partly discharged state, or if the connections to the battery are resistive, the available voltage will be below the value required to energise the first relay A so that this relay will remain de-energised and the second relay B will then operate, completing the circuit

of the solenoid SP controlling the starting aid mechanism so as to bring such mechanism into operation. In the arrangement shown in Figure 6 this mechanism consists of a device adapted to supply heated air to the engine intake. Thus when using this arrangement when the solenoid SP is energised, the armature 26, whose magnetic circuit is completed by the yoke 25, is attracted into the centre of the coil causing the contact bar 27 to short circuit the contacts 28 and 29. This allows current to flow over the terminal 33 which is connected to the battery through the contacts and contact bar to the heater plug 30 which is mounted in the air intake manifold 32 of the engine. The element 31 of the heater plug has its circuit completed through the air intake manifold to earth, one side of the battery being connected also to earth.

When the engine fires and runs up to a predetermined speed a relay C will operate so as to actuate its contact *c'* and break the starter operating and motor circuits and the circuit of the solenoid SU controlling the fuel rack and prepare the circuit of the stop solenoid SS over the front contact of the relay C, the circuit being completed over the back contact of the relay D which is energised during the time that the starter motor is in operation, and remains energised after the engine has started, and until it is required to stop the engine. When the solenoid SP is de-energised, the spring 34 will return the contact bar and armature to the position shown and disconnect the battery from the starting aid mechanism.

In cases where the arrangement is applied to an engine controlling a refrigerator or other storage device, the terminals X and Y controlling the start and stop circuits are connected across a temperature sensing element such as that shown in Figure 5 or a humidity sensing element such as that shown in Figure 9, so that when the ambient temperature or humidity reaches a predetermined value, the starter motor circuit is automatically completed so as to start the engine with or without the assistance of the starting aid mechanism, and upon the temperature or humidity being restored to the value at which the operation of the engine is no longer required, the stop solenoid SS is automatically operated so as to stop the engine.

The arrangement shown in Figure 5 takes the form of a temperature sensitive switch with an adjustable differential. Thus in this arrangement, the spring leaves 18 and 19 carry contacts 20 and 23 respectively. Spring leaf 19 is a bi-metal leaf which changes its position when the ambient temperature changes. When the ambient temperature falls, the spring leaf 19 moves in the direction of the arrow until the contacts 20 and 23 touch one another thus completing the starting circuit through the terminals X and Y shown in Figures 1, 2 or 3. A magnetic ring 21 fixed to the spring leaf 19 and the magnet 22 fixed to the spring leaf 18 provide an attractive force holding the contacts together, and this force may be adjusted by altering the position of the screwed contacts 23 which varies the air gap between the magnetic elements so that when the temperature starts to rise, the two contacts remain "made" until the force due to the bi-metal spring leaf overcomes that of the magnet and the contacts are disconnected from each other. The two leaf springs are insulated by the insulator block 24.

Figure 9 shows a typical humidity sensing element of the hair hygrometer type. A hair 35, fixed at one end, is wrapped around a spindle 36 to which is attached a pointer 37. The hair is kept taut by the control spring 38. When the hair is exposed to a humid atmosphere it will change its length and the pointer will then indicate the humidity on the scale 40.

An adjustable contact 39 is mounted on the scale 40 which is insulated electrically from the instrument case, and is connected to terminal Y by the lead 43.

When the pointer 37 makes contact with the adjustable contact 39, a circuit is completed between the terminals X and Y through the leads 42 and 43, the scale 40, adjustable contact 39, pointer 37, spindle 36 and bridge piece 41, completing the starting circuit.

The terminals X and Y correspond with those similarly designated in Figure 5 of the temperature sensing element and in Figures 1, 2 and 3.

While in the arrangement hereinbefore described and illustrated, the invention has been shown as applied to a compression ignition engine using a starter motor associated with a solenoid contactor, it may be equally well applied to engines using other forms of starter motors, and in Figure 2 a circuit arrangement is shown which is suitable for use with a starter motor of the kind shown in Figure 7 having a pinion SNP adapted to be engaged by means of a solenoid SPP through a lever PL. In this arrangement the starter motor SMP is controlled by a solenoid SCP and contactor SKP, and the starter motor pinion is controlled by a pinion SNP solenoid SPP arranged in the starter circuit in parallel with the unlatching solenoid SU of the fuel rack 14. Thus, in operation, current is supplied to the pinion solenoid SPP through the stop/start element terminals XY, while at the same time current is supplied to the unlatching coil SU controlling the fuel pump rack 14, and the relay D which breaks the circuit of the solenoid SS controlling the stop mechanism. When the pinion SNP is fully meshed with the starter ring, the circuit of the solenoid SCP in the main battery feed is completed through the mechanically operated contacts MC and the contactor SKP is thus actuated, causing current to flow to the starter motor SMP.

The control of the starting aid solenoid is effected by the discriminating relays A and B which are so arranged as to determine whether or not starting aid is necessary, but in the modification shown in Figure 2, the delayed action of relay B is obtained by means of a pair of bi-metallic contacts P and Q and a heater HT connected between the back contact *b'* of relay B and the back contact *a'* of relay A, the contact leaves P and Q being adapted to bend in the direction of the arrow when heated. With this arrangement, when current is passed to the starter motor SMP, current will also flow through the contact *a'* provided relay A has not operated, and through the ballast resistor BR. The current will then divide, and part will pass through the coil of relay B and back to the battery, while the remainder will flow through the heater HT, through the bi-metallic contacts P and Q, and through the contacts *b'* back to the battery. The ballast resistor BR is adjusted so that the potential available across relay B when current flows in the heater HT is too low to cause the relay to operate. The current flowing through the heater HT, however, will warm the bi-metal leaf P and cause it to bend in the direction of the arrow, and break the contact between the leaves P and Q so that when this occurs, the current passing through the ballast resistor BR will be reduced while the potential across relay B will be increased to a sufficient degree as to cause this relay to operate and complete the circuit for the starting aid solenoid SP, and at the same time break the circuit of the heater HT, whereupon the bi-metal leaf P will cool down and restore itself to its original position in contact with the other leaf Q in readiness for a further operation when required. If desired, however, the heater winding HT may be combined with the ballast resistor BR, the combined unit being suitably arranged to supply the heat required for operating the leaves P and Q.

By varying the individual rates of bending of the leaves P and Q, the delayed action of relay B may be made to vary according to the temperature of the ambient atmosphere, so that the starting aid will be brought into action more quickly if the ambient temperature is low than when it is high. Thus, if the two leaves are so constructed that the rate of bending of the leaf Q is greater for a given temperature rise than that of the leaf

P, then the time delay of operation of relay B may be made dependent on the ambient temperature, so that if such temperautre is low, the time delay is a minimum, since the distance through which the leaf P must move before it breaks contact with the leaf Q will be reduced.

In the modification shown in Figure 3, a circuit arrangement is shown which is suitable for use with a starter motor of the Bendix type as shown in Figure 8 in which no pinion engaging solenoid is required. In this arrangement the general circuit arrangement is similar to that of Figure 1, except that the auxiliary solenoid contactor is omitted, and the delayed action circuit of relay B is similar to that of Figure 2. With this arrangement when the stop/start sensing element contact makes contact, current is supplied through terminals X and Y to the solenoid of SBB of contactor SKB in the main battery feed, allowing current to flow from the battery to the starter motor SMP, while at the same time current is supplied to the unlatching coil permitting fuel to be fed to the engine, and also through relay D which breaks the circuit of the stop solenoid SS. The operation of the rest of the circuit then takes place in the manner already described in connection with Figure 2, relays A and B discriminating in regard to the application of the starting aid mechanism.

I claim:

1. Engine turning mechanism comprising a starter motor, an auxiliary starting aid mechanism and control means comprising two electric relay members, one of which controls the circuit of the starting aid mechanism, but has its energising circuit controlled by the other relay, such other relay being operable when the voltage across the starter motor exceeds a predetermined value so as to render the starting aid mechanism inoperative, the relay controlling the starting aid mechanism being operable after a predetermined delay so as to actuate the starting aid mechanism when the voltage across the starter motor falls below the value required to operate said other relay.

2. Engine turning mechanism according to claim 1, wherein the relay controlling the starting aid mechanism comprises a slow acting relay.

3. Engine turning mechanism according to claim 1, wherein the relay controlling the starting aid mechanism has its energising circuit controlled by a delay circuit which normally absorbs part of the energising current, so as to render the delay inoperative, but which operates automatically after a predetermined time interval so as to allow the full energising current to be applied to the relay winding.

4. Engine turning mechanism according to claim 3, wherein said delay circuit comprises a ballast resistor connected in series with a pair of bi-metallic contacts and a controlling heater, said ballast resistor being so adjusted that the voltage available is insufficient to energise said relay while current flows through said heater, said bi-metallic contacts being constructed so as to separate after being heated for a predetermined time interval and reduce the current flowing through said ballast resistor to a sufficient extent as to cause the voltage across said relay to be increased to its operating value.

5. Engine turning mechanism according to claim 4, wherein said bi-metallic contacts comprise a pair of bi-metallic leaves constructed so as to bend in response to a change of temperature, and wherein the bending characteristics of the two leaves are individually adjusted so as to cause the delayed action of said relay to vary according to the temperature of the ambient atmosphere.

6. Engine turning mechanism according to claim 1, wherein the circuit for actuating the starter motor is controlled by a temperature sensitive element, whereby the engine turning mechanism is automatically brought into operation upon the ambient temperature reaching a predetermined value.

7. Engine turning mechanism according to claim 1, wherein the circuit for actuating the starter motor is controlled by a humidity sensitive element, whereby the engine turning mechanism is automatically brought into operation upon the ambient humidity reaching a predetermined value.

8. Engine turning mechanism according to claim 6, and comprising means for automatically stopping the engine when the ambient temperature is such as to no longer require its operation.

9. Engine turning mechanism according to claim 8, wherein the energising circuit of the starter motor is completed through a relay which operates to prepare the energising circuit of a solenoid controlling the engine stopping mechanism when the circuit of the starter motor is broken, the circuit of said solenoid being completed through a temperature sensing element, whereby said engine stopping mechanism is automatically brought into operation upon the temperature of the ambient atmosphere reaching a predetermined value.

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