Oct. 10, 1939. A. BRUNNER 2,175,681

CONTROL DEVICE FOR THE OPERATION OF INTERNAL COMBUSTION ENGINES WITH ELECTRIC POWER TRANSMISSION

Filed June 21, 1937 2 Sheets-Sheet 1

Fig. 1

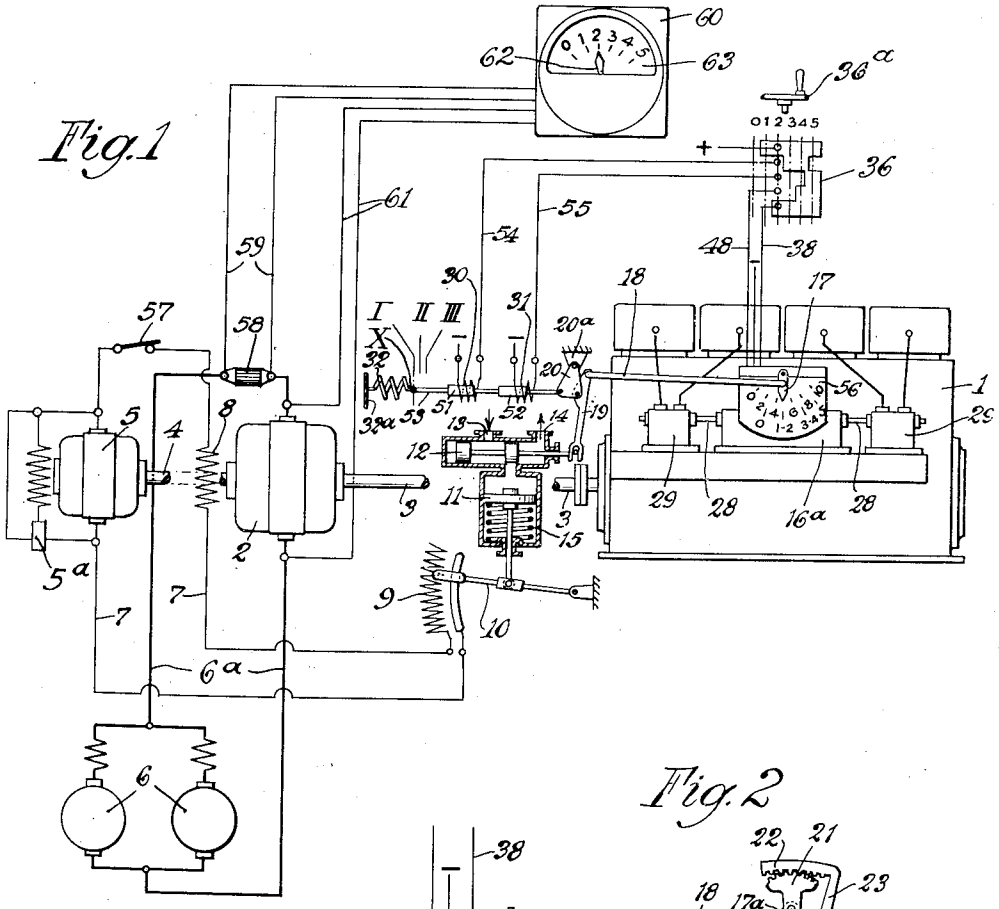
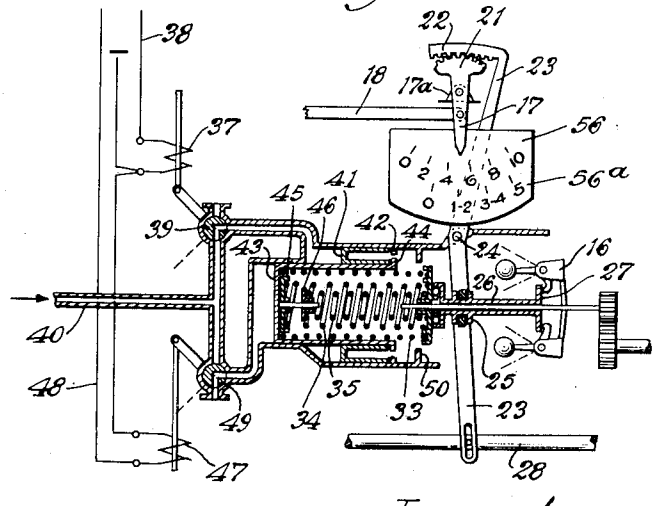


Fig. 2



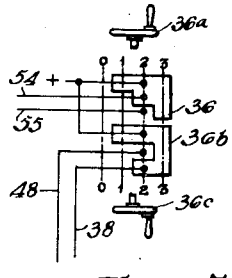


Fig. 5

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Filed June 21, 1937 2 Sheets-Sheet 2

Fig. 3.

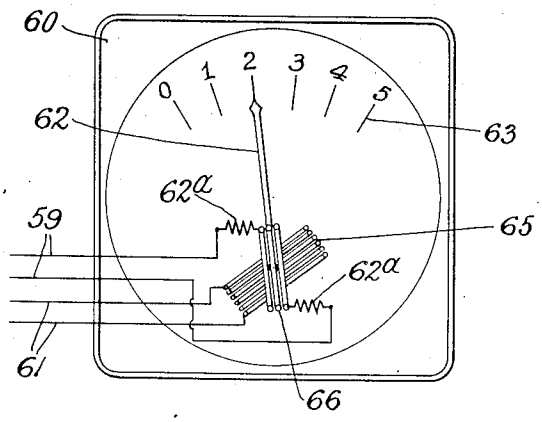
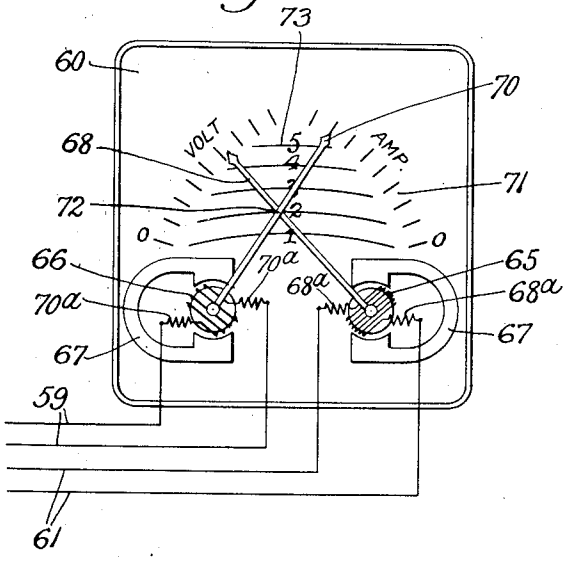


Fig. 4.



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Patented Oct. 10, 1939

2,175,681

UNITED STATES PATENT OFFICE

2,175,681

CONTROL DEVICE FOR THE OPERATION OF INTERNAL COMBUSTION ENGINES WITH ELECTRIC POWER TRANSMISSION

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Application June 21, 1937, Serial No. 149,388
In Switzerland June 27, 1936

12 Claims. (Cl. 290—17)

This invention relates to a controlling device for controlling the operation of an internal combustion engine which is associated with an electric power transmission.

In the form of the invention illustrated herewith, the voltage of the generator which forms a part of the electric transmission is regulated in accordance with variations in the R. P. M. of the motor in such manner that the load of the internal combustion engine remains constant in proportion to the adjusted R. P. M. This is of particular importance when the invention is applied to internal combustion engines which operate vehicles through electrical transmissions, although it has other purposes and is not limited to this particular purpose or association.

An object of the invention is, therefore, to provide an automatic control of the type indicated.

Another object is to provide in connection with such an automatic control an indicating apparatus connected to the transmission and acting to serve as an indicator to measure the electric power. With this indicating device there is associated an additional indicating device operated to indicate variations in the quantity of fuel being supplied to the internal combustion engine. The two indicators, the engine and the transmission are so related that variations in the indicating device indicate positively and automatically disturbances or unsatisfactory operation either in the engine or in the transmission and it is, therefore, one of the purposes of the invention to provide an indicating apparatus of the type indicated which will automatically and positively indicate the conditions of operation, both of the engine and of the transmission, and will also indicate positively and automatically the location of unsatisfactory operations or unsatisfactory conditions in the total installation of the apparatus so that an operator or observer can tell at once when unsatisfactory operation occurs just what part of the total assembly is not operating satisfactorily.

Other objects will appear from time to time in the specification and claims.

The invention is illlustrated more or less diagrammatically in the accompanying drawings, wherein:

Figure 1 is a diagram with some parts shown diagrammatically and other parts in section or elevation, and in connection with which wiring diagram for the electrical parts of the assembly is also shown;

Figure 2 is a sectional diagram with parts shown in elevation and parts in section, of the engine indicator assembly.

Figure 3 is a diagrammatic section illustrating the internal mechanism and the wiring connections of the indicating apparatus 60, shown in Figure 1; and

Figure 4 is a similar view of a modified form of indicating apparatus.

Figure 5 illustrates a modified form of the switch mechanism of Figure 1.

Like parts are designated by like numerals throughout the specification and drawings.

The numeral 1 indicates an internal combustion engine. This drives a main generator 2 through a shaft 3. Through a shaft 4 it drives an auxiliary generator 5 which serves for outside excitation of the main generator 2. Current from the main generator may go to any desired load but as here shown it is led to motors 6 which may for example act as the traction means of a locomotive or other vehicle. The wires 7 define the circuit of the auxiliary generator 5 and in this circuit is inserted or included the excitation winding 8 of the main generator 2, and a variable resistance 9 is also shown as inserted in that circuit. It serves the purpose of regulating the excitation current. The lever 10 is adjusted by a servo piston 11 of a servo motor as shown particularly in Figure 1. The operation of the servo motor is in part controlled by a slide valve 12 which controls the admission of a pressure agent which enters through the port 13 and is discharged through a port 14. A spring 15 may be positioned within the housing of the servo motor and bears at one end on that housing and at the other on the piston and resists the effect of the pressure agent upon the opposite face of the piston.

The position of the control lever 10 is controlled and varied by the movement of the engine governor 16. As shown in Figure 1 the governor is enclosed in a housing 16*a*. 17 is a lever pivoted on any suitable support, such as 17*a*, and arranged as will be described below, to be moved by the governor. Movement of the lever 17 is communicated through the rod 18 to the lever 19 supported on a shifting fulcrum plate 20 which is itself supported upon a suitable base 20*a*.

As shown particularly in Figure 2, the lever 17 is provided on its upper end with an arcuate toothed portion 21 which engages a correspondingly toothed portion 22 of a lever 23. This lever is pivoted as at 24 on the governor housing or at any other suitable point. It engages a collar 25

which forms part of or is attached to a sleeve 26 which is itself directly or by means of a flange 27 arranged to be acted upon by the elements of the governor 16. At its lower end the lever 23 is extended to engage the rod 28 which is attached to means for varying the quantity of fuel conveyed to the fuel pumps 29 which are shown in place adjacent the engine in Figure 1. The details of the fuel control are unimportant and the invention is not limited to any particular fuel control valve or other mechanism and hence such parts are not shown in detail herewith. The control may be accomplished by varying the position of the valves, by rotating the plungers of the pumps or otherwise. Variation in the governor speed effects movement of the sleeve which in turn moves the lever 23, the lever 17, the rod 18, the lever 19 and the valve 12. The details of this movement and its relationship to the movements of the other parts of the assembly will be described more in detail below.

The fulcrum plate 20 is movably mounted as above described and although it may be moved by a number of means, the particular means here shown include a pair of magnets or solenoid 30 and 31 and a spring 32 secured to a suitable base 32*a*.

Associated with the governor 16 and the sleeve 26 are a plurality of regulating springs. As here shown there are three of such springs, 33, 34 and 35. These springs are preferably mounted one within the other, 33 being the outermost, 34 the intermediate and 35 the inner spring. One or another of these springs is brought into use for adjustment of the engine to the desired R. P. M. by an electro-pneumatic means which will now be described. An electric switch 36, which is moved by a handle 36*a*, is provided as shown in Figure 1. It has a variety of positions as indicated in Figure 1. These may be numbered from 0 to 5 or a different number of switch positions may be provided. In the control positions 0 or 1 of the switch 36, the sleeve 26 in Figure 2 is under the action of spring 33 alone. In the positions numbered 2 and 3 of the valve, a solenoid or magnet coil 37 is energized through the line 38 and the valve 39 is moved to the position shown so that a pressure agent coming from any desired source may pass through the conduit system 40 to act upon the annular piston 41 and thus move it to the position of Figure 2 and bring the intermediate spring 34 into operation, since the pressure fluid acting on the piston 41 moves it to the right, as shown in Figure 2, until it contacts the stop 42. It is this movement of the piston 43 which brings the intermediate spring 34 under compression and, therefore, into operation, as a load upon the sleeve 26.

In the 0 position of the switch the two pistons 41 and 43 are to the left of the position that they occupy as shown in Figure 2 since no pressure fluid is active upon either of them and the spring disc or piston 45 is at some distance from the bottom of the piston 43 just as the spring disc 46, in the position of the parts shown in Figure 2, is out of contact with the spring disc 45.

When the switch is in position 4 or 5, the solenoid or magnet coil 47 is energized through the line 48 and the valve 49 is then moved 90° from the position shown in Figure 2 and pressure fluid through the conduit system 40 may be admitted to the rear of piston 43. When that movement occurs the piston is moved further to the right from the position shown in Figure 2 until it contacts a stop 50. The edge or flange 44 of the piston 43 is moved out of contact with the piston 41 and the piston 43 as a whole moves to the right sufficiently to bring the spring disc 46 into contact with the spring disc 45 and the spring 35 is thus added to the load effective upon the sleeve 26. Movement of either the valve 49 or the valve 39 from the positions in which they permit pressure fluid to move toward one or another of the pistons occurs when the magnets 37 or 47 are de-energized and then the springs are effective to return one or another of the pistons and to force pressure fluid out through the valve.

As explained above, the fulcrum point of the lever 18 is not fixed because the fulcrum plate 20 upon which it is fulcrumed may be moved. If this fulcrum plate 20 were stationary, then when the lever 17 is moved by any adjustment of the R. P. M. by means of the control switch just described, through manipulation of the handle 36, to cause movement of one or another of the pistons 41 or 43, or of both of them, an equilibrium between the load and the performance of the internal combustion engine will be established and the lever 17 would always assume the same position if the slide valve 12 is closed. Since, as pointed out above, the fulcrum plate 20 moves, the position which the lever 17 may occupy in response to variation in the governor movement is not always the same and is controlled in this respect by the operation of the switch through the handle 36 and this determines the position of the fulcrum point of the lever 19 since it may cause movement of the fulcrum lever 20.

In the position from 0 to 2 of the switch, the solenoid or magnet coils 30 and 31 are not energized and the armatures 51 and 52, which are attached to each other and may, as shown, be carried upon a single member 53, are in their outermost position, the point X occupying position I. The member 53 is secured at one end to the fulcrum plate 20. At its other end it is attached to the spring 32 which tends, when free to do so, to move it and the armatures which move with it, to the left.

In the control switch positions 3 and 4, magnet or solenoid 30 is energized through the line 54 so that the armatures 51 and 52 are moved to the right against the spring 32 until the point X is in position II.

If the control valve is moved to position 5 the solenoid or magnet 31 is energized through the line 55 and the magnet 30 is de-energized. The armature 52 is thus drawn into the solenoid 31 and the point X is brought to position III. For each of the positions of the armatures the lever 17 is moved and preferably the parts are so arranged that when the point X is at I lever 17 is at 1—2, as shown on the scale 56. For position II it is at 3—4 and for position III it is at 5.

While it has been said that the current generated might be utilized for any purpose or conducted to any desirable place of use, the particular use here shown is merely illustrative of one possible use and comprises the motors 6 connected to the generator by wires 6*a*.

57 is a switch in the circuit formed by the wires 7 and may be used to disconnect the excitation circuit and generator, when the internal combustion engine 1 is running. There may be provided in the armature circuit of the main generator 2 a shunt 58. Wires 59 are connected to each side of the shunt and lead to the current coil in an indicator 60. Wires 61 are connected to opposite

poles of the main generator 2 and lead to the voltage coil of the indicator 60 which is arranged to operate in the known manner in connection with electric performance meters. The indicator 60 is provided with a pointer 62 and a dial 63 which are arranged to be movable one with relation to the other. As shown in Figure 1, the dial 63 is arranged in accordance with the calculated values of performance of the generator 2 and corresponding to the range of positions from 0 to 5 of the control switch 36 and is also provided with the numbers 0 to 5 in accordance with the various range of positions from 0 to 5 of the said switch 36.

The lever 17, in the form shown in both figures, serves also as an indicating device and the dial 56 has indications on it throughout the range from 0 to 10 and this serves as a measure of the movement of the governor sleeve 26. The dial 56 also carries a group of markings 56a, divided to indicate the calculated values of performance of the internal combustion engine which indications conform to the positions from 0 to 5 of the switch 36.

In the particular form of control switch 36 shown here the following torques and revolutions per minute are indicated in the six possible positions of the control switch 36:

Controller position	0	1	2	3	4	5
R. P. M	0	n_1	n_2	n_2	n_3	n_3
Torque	0	M_1	M_1	M_2	M_2	M_3

In the case of the indicating apparatus showing the values n_1M_1a, n_2M_1a, n_2M_2a, n_3M_2a, n_3M_3a, in which the value "a" is approximately a constant, the markings 1–5 on the controller position of the switch 36 are arranged and the operation of the control device with these markings and values is as follows: If the lever 17 and the index pointer 62 of the gauge 60 are at the number which corresponds to the number set on the switch 36, then the reading of the gauges or indicating devices 56 and 60 indicates that both the internal combustion engine and the electrical generating and transmitting devices are in proper order and operating correctly. If, however, for some position of the control switch 36 the pointer 62 of the indicating apparatus 60 is below the number of the connecting position, indicated in the table above, then some drop or unsatisfactory condition in the performance is indicated. If the lever 17 is below the number of the connecting position indicated in the table above, the electrical power transmission is not operating properly. Many such improper or unsatisfactory conditions may develop in the power generation and transmission. For instance, a line may be interrupted or the generator may be reaching only a limited voltage because of disturbances in the excitation circuit or for other reasons. If, however, the lever 17 stands at the correct position for a given setting of the switch 36, and the indicating apparatus 60 stands at too low an indication, this indicates that the internal combustion engine is not operating properly. For example, an individual cylinder may be wholly or partially out of operation. Thus as a result of these indicating devices the source and approximately the nature of the disturbance in the total apparatus which causes the drop in performance may be determined at once and simply.

Another unsatisfactory condition which can occur is that in which the indicating apparatus 60 or the lever 17, or both of them, stand at a higher number than that which corresponds to the proper setting of the switch 36 as indicated in the table above, and this would indicate that one of the wires 38, 48, or 54, 55, is short circuited with the positive pole or with another wire, so that the magnet 51 or 52 or one of the governor valves 39 or 49 is improperly connected or operating incorrectly.

Although there is shown a single switch 36 for adjustment of the torques and the R. P. M., two related switches 36 and 36b having respectively handles 36a and 36c, as shown in Figure 5 might be used, one of which adjusts the torques and the other the R. P. M. This, of course, differs from the specific arrangement shown in Figures 1 and 2 and it would then be possible in connection with an individual or particular torque to adjust all R. P. M. values as might be desired within the range of performance of the apparatus or in connection with each R. P. M. value to adjust all torques within the range of performance of the apparatus.

While many different forms of indicators may be used, the indicator 60 having a needle or indicating arm 62 and a dial 63 is shown and in Figure 3 it is illustrated with the cover or housing removed so as to show the internal arrangement. As there shown the wires 61 are connected to a stationary voltage coil 65 and the wires 59 are connected by springs 62a to the current coil which is mounted to move with the needle or arm 62. The member 62a thus serves the dual purpose of connecting the current coil with the wires 59 and also, when free to do so, moving the arm 62 to the neutral or zero position.

Figure 4 illustrates the internal mechanism of a modified form of indicator in which two stationary permanent magnets 67 are mounted. In the right hand magnet 67 is mounted a volt indicating arm, which has mounted upon it, to move with it, a voltage coil 65. Springs 68a connect the wires 61 with this voltage coil and serve also, when free to do so, to move the indicating arm 68 to the neutral or zero position with respect to the voltage scale 69.

Mounted within the left hand permanent magnet 67, as shown in Figure 4, is an ampere indicating arm 70 which has mounted upon it the current coil 66 which is arranged by its movement and position to show the amperage on an ampere indicator 70. Springs 70a serve to connect the wires 59 to the current coil 66 and also, when free to do so, to return the indicator arm 70 to the neutral or zero position.

Inasmuch as the electric power is a product of the voltage and the amperage, the point of intersection 72 of the indicator arms 68 and 70 is important and the lines 1, 2, 3, 4, 5 are shown on the dial 73 of Figure 4, and by means of these lines and the point of intersection 72, the magnitude of the electric power can be determined. For the dial 73 the lines 1 to 5, inclusive, are calculated and positioned to illustrate the theoretical value of the power for the five positions numbered 1 to 5, inclusive, of the controlling switch 36. In this connection any other desirable factors which influence the change in efficiency at different values of current may be considered in calculating and arranging the dial 73. Thus the theoretical values of the power input may be considered as multiplied or varied by the actual efficiency of the apparatus so that instead of showing the power delivered by the generator to the distributing system, the dial may be arranged to show the power received from the internal combustion engine by the generator at its shaft.

Of course, any other sort of volt meter or ammeter may be used instead of the coils 65 and 66, which latter are shown merely as illustrative of one form of suitable meter arrangement.

The control of the internal combustion engine and in particular the control of the quantity of fuel delivered to the individual fuel pumps may be effected in any desired manner, among which are the adjustment of an overflow valve, a turning of the pump plunger, changing the pump stroke and otherwise. The invention is not limited, therefore, to any particular means for controlling the supply of fuel to the fuel pumps.

While the control apparatus and method of the present invention are shown in connection with an internal combustion engine, and an electrical generating and transmitting apparatus, they may be applied and used in any connection in which there is an excitation circuit for a generator and in this manner the internal combustion engine may be adjusted in accordance with the R. P. M. One such arrangement is that in which the control is accomplished in connection with the excitation of the main generator in accordance with variations in the voltage of a speedometer generator operated by the internal combustion engine or in accordance with the pressure of an oil pump driven by the internal combustion engine. The adjustment of the torque in connection with controls of the type just indicated is accomplished in the customary manner by the adjustment of a resistance in the circuit of the speedometer, dynamo or generator, or by the adjustment of a throttle opening for supplying the oil. In connection with these controls in which the ercitation circuit is not changed directly in accordance with variations in the speed as they affect the governor of the internal combustion engine, the indicating pointer 17 may be arranged in the manner generally shown and described in connection with the figures herewith.

I claim:

1. In combination, a prime mover, an electric generator driven thereby, a governor responsive to the speed of the prime mover, means for adjusting the response of the governor to speed variations, and means for controlling the current generated by the generator in consonance with the governor adjusting means, and a visible electric indicator in circuit with said generator, and a second visible indicator operatively connected to said governor and indicating the conditions of engine operation.

2. In combination, an engine, an electric generator driven by it, a governor driven by the engine and adapted to control engine operation, means for adjusting the response of the governor to variations in engine operation, means for adjusting the rate of current generation by the generator and a connection between said means and said governor, means for adjusting the relationship between the governor and the electric control means, and manually operable means for simultaneously and in consonance setting the means for adjusting the governor response to the engine and the means for adjusting the response of the electrical control to the governor, and an electric indicator in circuit with said generator, and a second visible indicator operatively connected to said governor and indicating the conditions of engine operation, the first indicator and the second indicator being calibrated for undisturbed working of the engine and the generator in accordance with the setting positions of the manually operated means.

3. A control apparatus for unified control of an internal combustion engine and an electric generator driven thereby, having a transmission circuit connected to said generator, said control apparatus including a current controlling means and an electrical indicator in said circuit, and an engine controlling means and an engine indicator including means driven by said engine, the engine indicator indicating the conditions of engine operation and the electrical indicator indicating the conditions of current transmission and generation, and a control switch and means for moving it to a plurality of predetermined positions, and means operated in response to movement of said switch, to give controlling means and said engine indicator a predetermined setting, moving elements in said electrical indicator and engine indicator the positions of those elements being calibrated for undisturbed working of the engine and the generator in accordance with the predetermined positions of the switch.

4. A control assembly for the unified control of an internal combustion engine and an electric generating and transmitting assembly, including an electric circuit operated by said engine and comprising a governor driven by the engine, an indicator of fuel supply, an electric indicating device associated with said circuit adapted to indicate the current conditions prevailing in said circuit, a switch assembly comprising a switch, means for moving it, electrical circuits, and a controlling device, means for moving said controlling device, and a connection between said controlling device and said governor, the indicator and the indicating device being calibrated for undisturbed working of the engine and the generator in accordance with the predetermined positions of said switch.

5. A control assembly for the unified control of an internal combustion engine and an electric generating and transmitting assembly, including an electric circuit operated by said engine and comprising a governor driven by the engine, an indicator of fuel supply, an electric indicating device associated with said circuit adapted to indicate the current conditions prevailing in said circuit, a switch assembly comprising a switch, means for moving it, electrical circuits, and a controlling device, means for moving said controlling device, and a connection between said controlling device and said governor, a member movable by said governor and means for variably resisting the movement of said member, the indicator and the indicating device being calibrated for undisturbed working of the engine and the generator in accordance with the predetermined positions of said switch.

6. A control assembly for the unified control of an internal combustion engine and an electric generating and transmitting assembly, including an electric circuit operated by said engine, and comprising a governor driven by the engine, an indicator of fuel supply comprising a dial and a pointer, connections between said governor and said pointer for moving said pointer, an electric indicating device associated with said circuit, adapted to indicate the current conditions prevailing in said circuit, a switch assembly comprising an electrical switch, means for moving it, electrical circuits, and a controlling device, means for moving said controlling device, and a connection between said controlling device and said governor, a member movable by said governor and means for variably resisting the movement of said member, the indicator and the in-

dicating device being calibrated for undisturbed working of the engine and the generator in accordance with the predetermined positions of said switch.

7. A control assembly for the unified control of an internal combustion engine and an electric generating and transmitting assembly, including an electric circuit operated by said engine, and comprising a governor driven by the engine, an indicator of fuel supply comprising a dial and a pointer, connections between said governor and said pointer for moving said pointer, an electric indicating device associated with said circuit, adapted to indicate the current conditions prevailing in said circuit, a switch assembly comprising an electrical switch, means for moving it, electrical circuits, and a controlling device, electrical and pressure means for moving said controlling device, and a connection between said controlling device and said governor, a member movable by said governor and means for variably resisting the movement of said member, the indicator and the indicating device being calibrated for undisturbed working of the engine and the generator in accordance with the predetermined positions of said switch.

8. In combination, with an internal combustion engine associated with an electric transmission, means providing a check on the working of said engine and transmission, comprising an electric power indicator adapted to indicate the power transmitted and a fuel supply setting indicator adapted to indicate the setting of the fuel supply of the internal combustion engine, and a controlling switch, the said indicators being so calibrated in accordance with the positions of the said controlling switch that faulty working of the engine or the transmission will be indicated by divergences of one or both of the said indicators from the appropriate readings.

9. In combination, with an internal combustion engine associated with an electric transmission, means providing a check on the working of said engine and transmission, comprising an electric power indicator adapted to indicate the power transmitted and a fuel supply setting indicator adapted to indicate the setting of the fuel supply of the internal combustion engine, and a controlling switch, the said indicators being so calibrated in accordance with the positions of the said controlling switch that faulty working of the engine or the transmission will be indicated by divergences of one or both of the said indicators from the appropriate readings.

10. In combination, with an internal combustion engine associated with an electric transmission, means providing a check on the working of said engine and transmission, comprising an electric power indicator adapted to indicate the power transmitted and a fuel supply setting indicator adapted to indicate the setting of the fuel supply of the internal combustion engine, and a controlling switch, a connection from said controlling switch to said fuel supply setting indicator, the said indicators being so calibrated in accordance with the positions of the said controlling switch that faulty working of the engine or the transmission will be indicated by divergences of one or both of the said indicators from the appropriate readings.

11. In combination, a prime mover, an electric generator driven thereby, a circuit supplied by said generator, a governor for said prime mover responsive to the speed thereof, means for controlling the fuel supply in accordance with variations in said governor, indicating means responsive to movements of said fuel supply control means, means for controlling the current generated by the generator, and manually operated control means provided with a plurality of predetermined positions and adapted for adjusting the relation between the governor and the current controlling means, and indicating means inserted in said generator circuit, the fuel supply indicating means and the indicating means inserted in said generator circuit being both calibrated for undisturbed working of the engine and the generator in accordance with the various predetermined positions of adjustment of said manually operated control means.

12. In combination, a prime mover and an electric generator driven thereby, a governor associated with said prime mover and responsive to its speed, means for controlling the fuel supply in accordance with variations of said governor, indicating means connected with said fuel supply controlling means, means for controlling the current generated by the generator, manually operable control means for adjusting the speed of said prime mover, said control means being provided with a plurality of predetermined positions of adjustment, indicating means in circuit with said electric generator, the said fuel supply indicating means and the indicating means in circuit with said generator being each calibrated for undisturbed working of the engine and of the generator in accordance with the several predetermined positions of said manually operable control means.

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