

[54] **INSTALLATION FOR CONTROLLING
A COMBUSTION ENGINE**

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123/111, 114, 119, 119 CE, 119 C, 139,
139.17, 139.18, 140, 140.3, 32 EA

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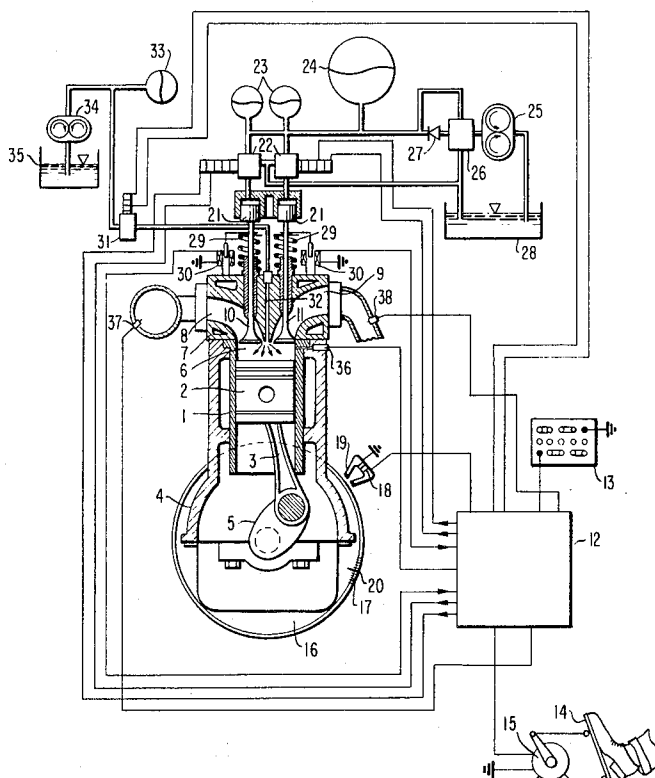
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[57] **ABSTRACT**

An installation for the control of an internal combustion engine, particularly for motor vehicles, in which the opening of the inlet and outlet valve as well as the fuel supply takes place dependent on the phase angle of the crankshaft; an electronic control apparatus is provided which is adjustable by means of the drive pedal; the electronic control apparatus includes a device for detecting the phase angle of the crankshaft and is connected to the actuating mechanisms for the inlet and outlet valves as well as for the fuel injection.

42 Claims, 6 Drawing Figures



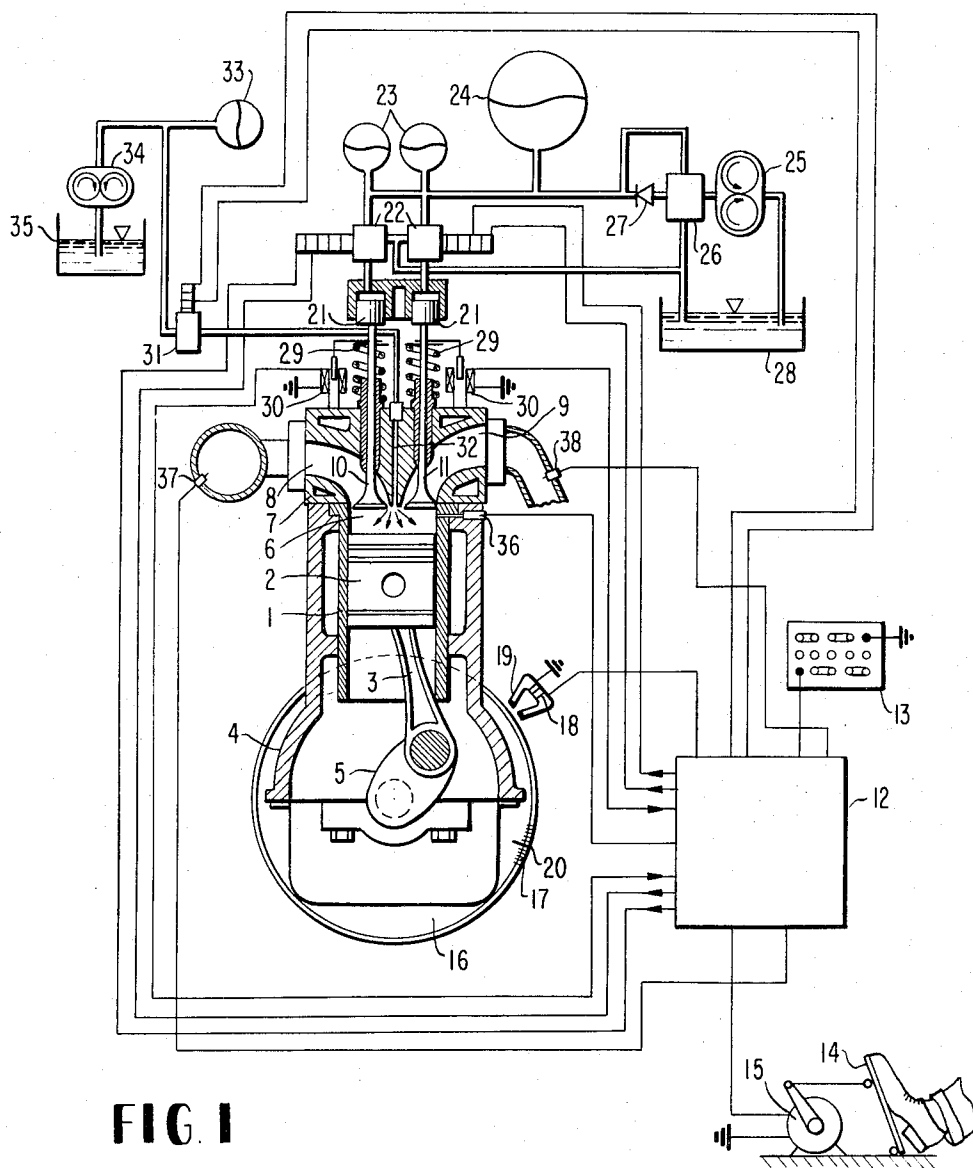


FIG. 1

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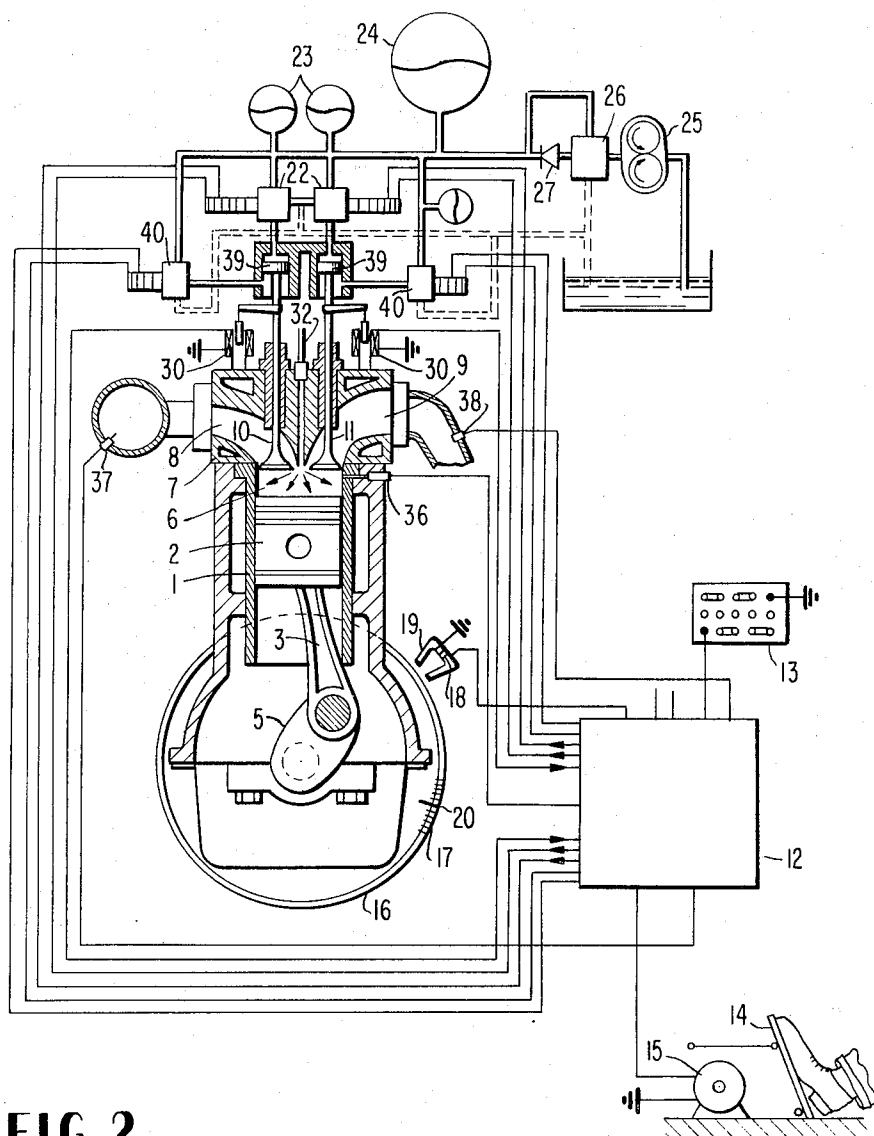


FIG. 2

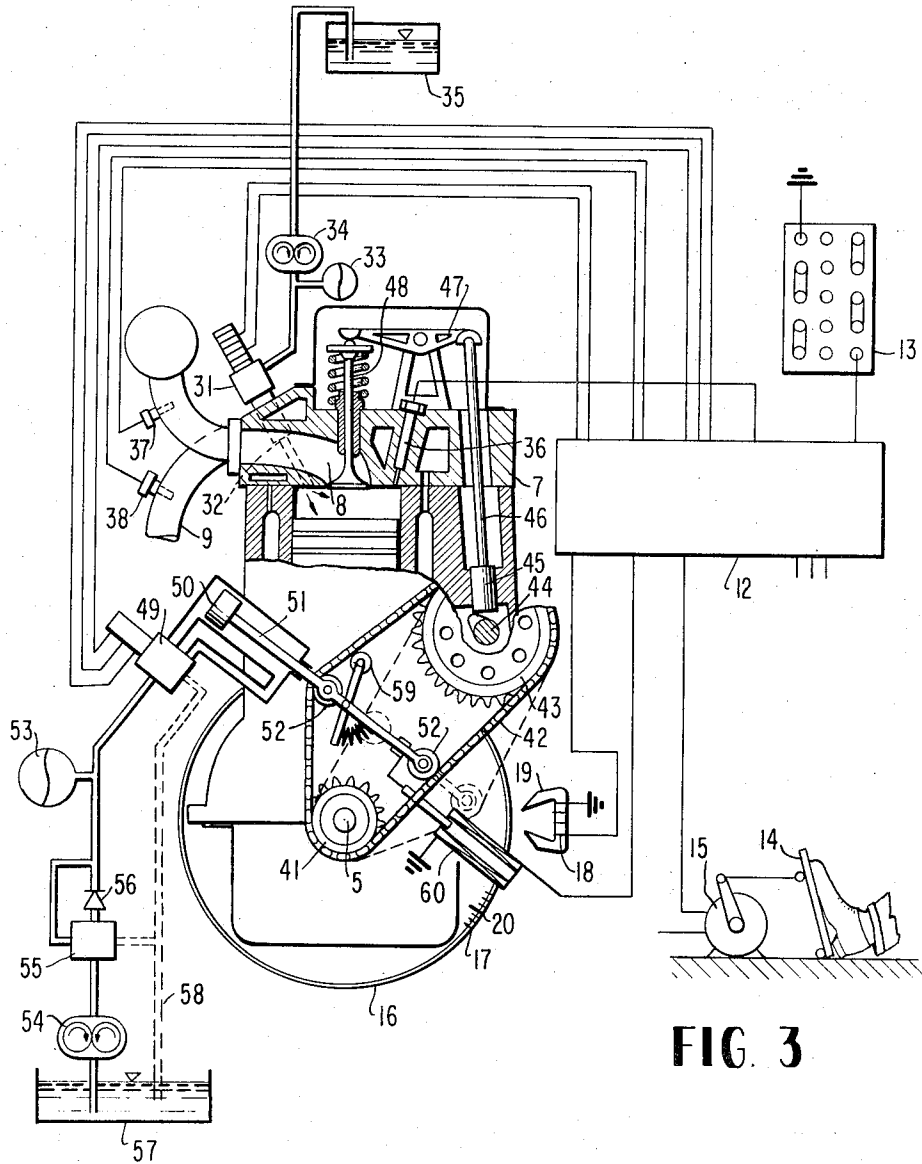


FIG. 3

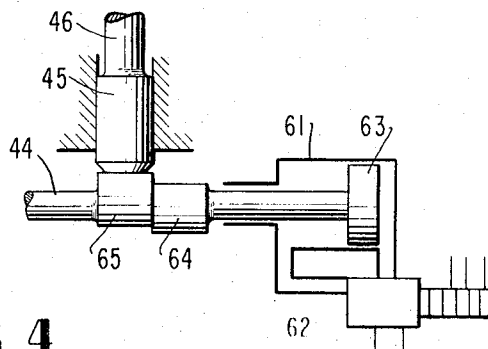


FIG. 4

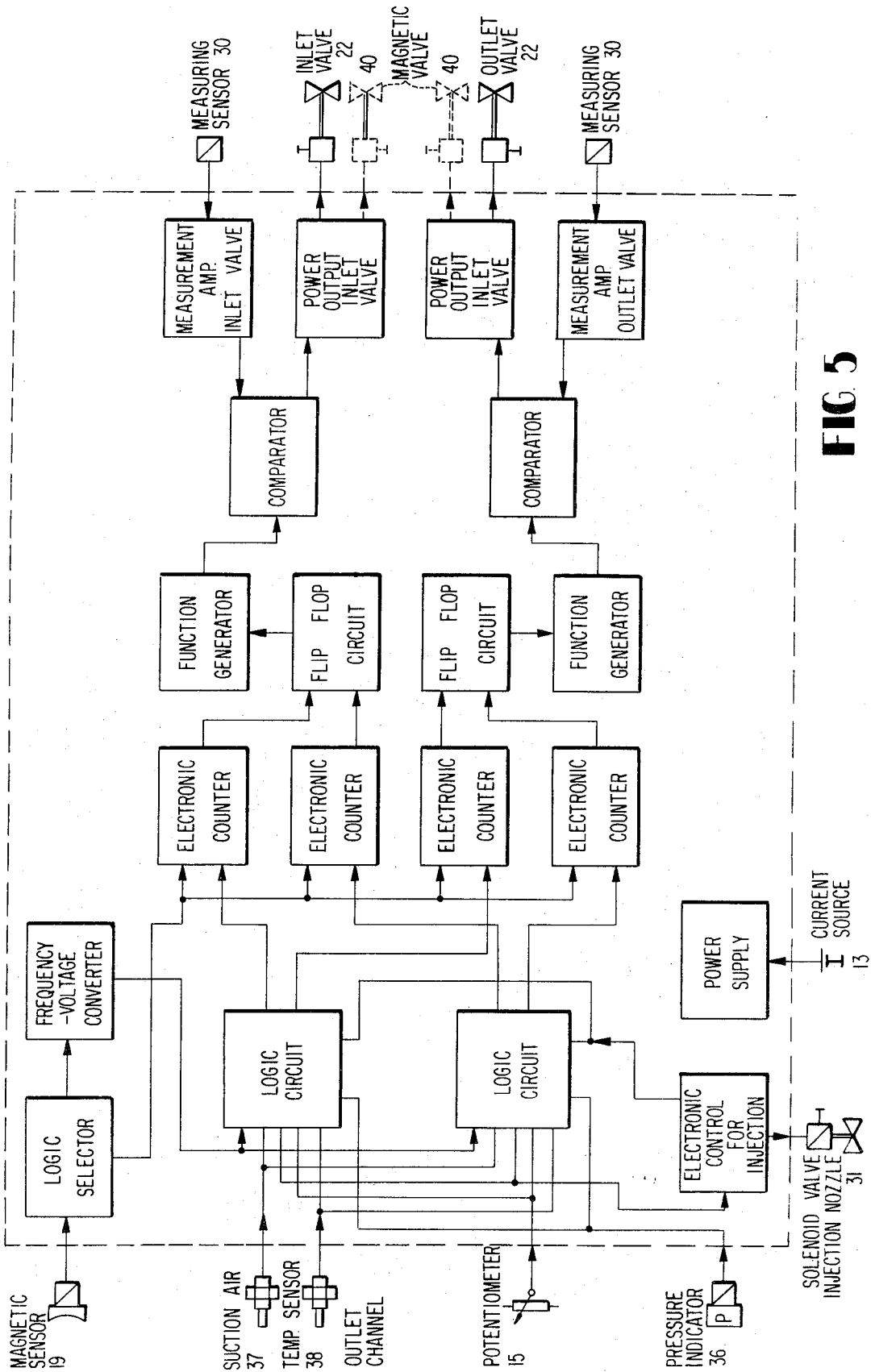
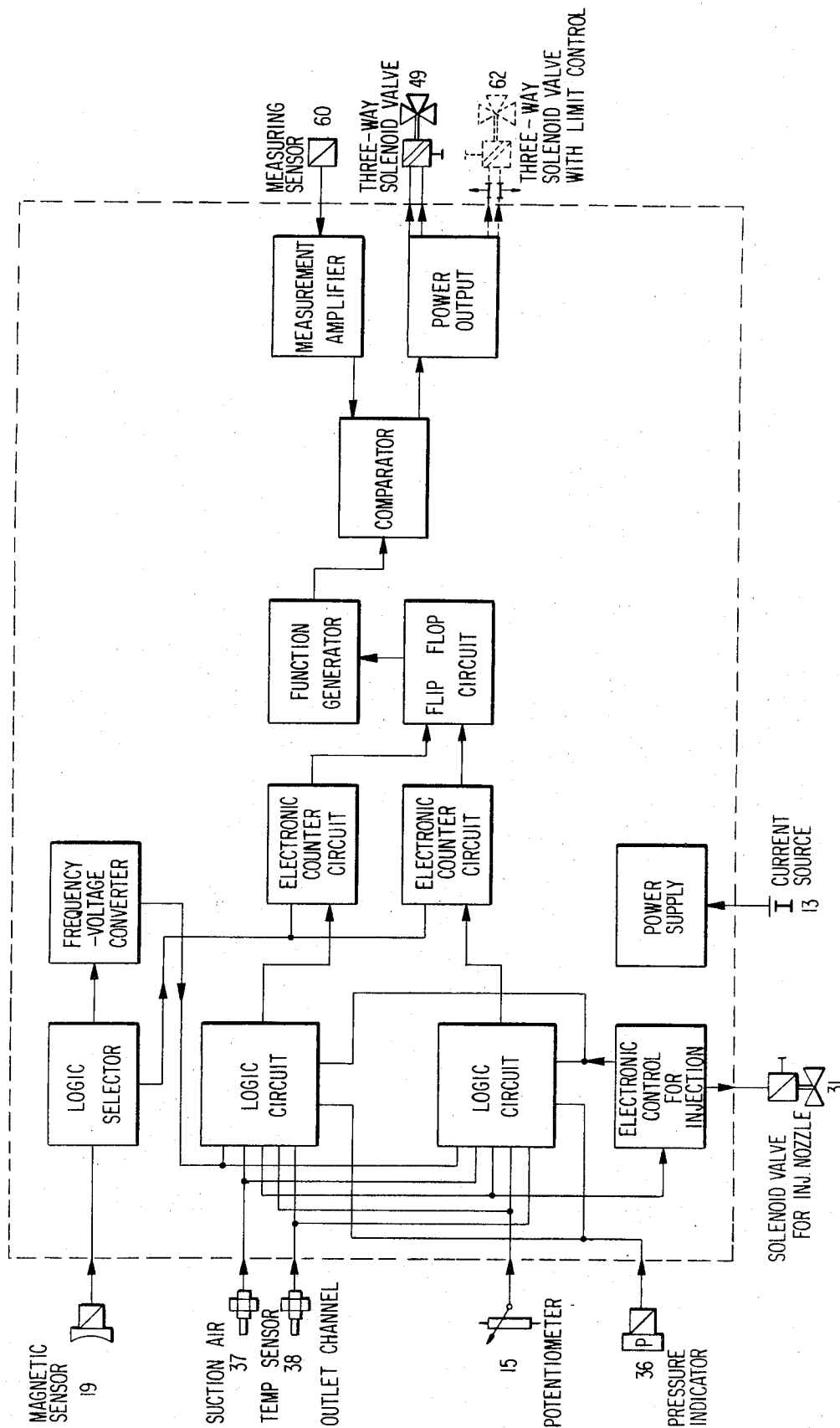


FIG 5

FIG. 6



INSTALLATION FOR CONTROLLING A COMBUSTION ENGINE

The present invention relates to an installation for the control of an internal combustion engine, especially for motor vehicles in which the opening of the inlet valves and of the outlet valves as well as the fuel supply takes place dependent on the phase angle of the crankshaft.

With the known internal combustion engines, a purely mechanical connection between the crankshaft and the control members, properly speaking, is provided for the engine control. An injection pump is customarily actuated from the crankshaft by way of a cam shaft. Additionally, a cam shaft is driven from the crankshaft by way of gears, which cam shaft force-lockingly controls a cam shaft either directly or by way of tappets, push rods and rocker arms the inlet and the outlet valves which are retained in the closed position thereof by springs. The opening takes place against the spring force. These mechanical control systems have the disadvantage that the control characteristics cannot be matched or adapted to the requirements of the different types of operation and/or operating conditions at a different rotational speed, torque, smoke development, or the like.

The present invention is based on the aim to avoid these disadvantages and to create an installation of the aforementioned type which permits an arbitrary change at will of the control characteristics in dependence on the desired torque, rotational speed and power-utilization and/or which permits an adjustment to optimum predetermined operating conditions.

The present invention essentially consists in that an electronic control apparatus is provided adjustable by way of the drive pedal, which includes an installation for detecting the phase angle of the crankshaft and which is operatively connected to actuating installations for the inlet valve or valves and the outlet valve or valves as well as the fuel injection. The electronic control apparatus possesses the possibility to permit any desired adjustment by means of present programs and/or by way of data taken off at different places of the engine, by adapting the opening of the moment of the valve and the injection moment of the fuel.

Advantageously, a pulse transmitter dependent on the rotation of the crankshaft may serve as installation for detecting the phase angle of the crankshaft. As a result of such an arrangement, the electronic control apparatus possesses exact informations concerning the accurate phase angle of the crankshaft and the rotational speed thereof. In a structurally advantageous manner, the pulse transmitter may consist of an electromagnetic toothed arrangement mounted at the flywheel and constructed in the manner of a recording tape and of a magnet provided with windings and constructed in the manner of a recording head whose windings are connected with the control apparatus. The electronic control apparatus is thus informed by way of an electric or electronic pulse counter of conventional construction concerning the phase angle of the crankshaft and the rotational speed thereof.

It is structurally advantageous if the inlet and outlet valve are connected with hydraulic pistons which are adapted to be connected with a pressure tank or reservoir by way of magnetic valves controlled by the con-

trol apparatus. In order to realize also the closing of the valves hydraulically, both sides of the hydraulic pistons may be actuatable with the pressure medium. In order to be able to monitor and check the position and also the load of the valves, displacement pick-ups or transmitters may be connected with the inlet valves and the outlet valves which are operatively connected with the control apparatus. These displacement pick-ups or indicators permit to the electronic control apparatus to calculate velocity and acceleration of the valves whereby a possibly predetermined maximum acceleration may lead to the limitation of the stroke or of the actuating velocity in order to avoid a fluttering of the valves after the closing under spring force. However, it is particularly advantageous in order to prevent at high rotational speed a valve-jumping after the closing if a throttling means is provided in the discharge of the pressure spaces to be emptied out during the closing operation of the inlet valves and of the outlet valves. This throttle means prevents a sudden closing of the valves.

In another embodiment of the present invention, a conventional valve drive equipped with a camshaft driven by way of a chain may be provided for the inlet and the outlet valves in which the length of the chain between the camshaft gear and the crankshaft gear is adapted to be changed by way of a chain guidance connected with the control apparatus. It becomes possible thereby to influence the control characteristics by the adjustment of the camshaft with respect to the crankshaft. It is thereby appropriate if the chain guidance is equipped with a preferably inductive displacement pick-up or transmitter connected with the control apparatus. In order to achieve changes in time of the control characteristics, it is additionally possible to arrange the camshaft in a displaceable manner which is connected with a servo-mechanism that is operatively connected with the control apparatus. It is thereby also advantageous for purposes of monitoring and controlling to provide the camshaft with a preferably inductive displacement pick-up or transmitter operatively connected with the control apparatus.

According to a further advantageous feature of the present invention, a magnetic valve adapted to be controlled by the control apparatus may be provided as actuating installation for the fuel injection which is connected with a pressure tank and with the injection nozzle. It is structurally advantageous if the magnetic valve and the injection nozzle are combined into a structural unit.

In order to attain an optimum combustion, a measuring apparatus operatively connected with the control apparatus and detecting the condition of the combustion air may be arranged in the suction line. The informations supplied by this measuring apparatus to the electronic control apparatus permits the control apparatus to correspondingly adapt the control characteristics.

Furthermore, a pressure and/or temperature indicator may be arranged in the combustion space which is operatively connected with the control apparatus. With the use of such indicating apparatus the load of the engine may be monitored and controlled by the electronic control apparatus.

Therebeyond, it may be advantageous if an apparatus measuring the smoke number and the temperature is arranged in the exhaust gas line which is operatively connected with the control apparatus. The quality of the combustion can be monitored thereby and also controlled.

Accordingly, it is an object of the present invention to provide an installation for the control of an internal combustion engine which avoids by simple means the aforementioned shortcomings and drawbacks.

Another object of the present invention resides in an installation for controlling a combustion engine which permits an adaption of the control characteristics to the requirements of the different types of operation and operating conditions.

A further object of the present invention resides in an installation for the control of a combustion engine which permits any suitable change in the control characteristics to assure optimum operating conditions, yet is simple in construction and reliable in operation while utilizing standardized, commercially available parts.

These and further objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing which shows, for the purposes of illustration only, several embodiments in accordance with the present invention, and wherein:

FIG. 1 is a schematic view, partly in cross-section, of an installation for the control of an internal combustion engine in accordance with the present invention;

FIG. 2 is a schematic view, similar to FIG. 1, of a modified embodiment of a control installation in accordance with the present invention;

FIG. 3 is a schematic view, similar to FIGS. 1 and 2, of a still further modified embodiment of a control installation in accordance with the present invention;

FIG. 4 is a partial, somewhat schematic view illustrating certain details in an embodiment corresponding to FIG. 3;

FIG. 5 is a schematic block diagram illustrating schematically the control apparatus 12 of FIGS. 1 and 2; and

FIG. 6 is a schematic block diagram illustrating schematically the control apparatus 12 of FIGS. 3 and 4.

Referring now to the drawing wherein like reference numerals are used throughout the various views to designate like parts, and more particularly to FIG. 1, this figure illustrates a cross section through a schematically illustrated internal combustion engine in which a piston 2 reciprocating within a cylinder linear 1 drives a crankshaft 5 supported in a crank housing 4 by way of a connecting rod 3. The combustion space 6 disposed above the cylinder is closed by a cylinder head 7 whose inlet channel 8 and outlet channel 9 are closed, respectively, by an inlet valve 10 and an outlet valve 11. Additionally, the cylinder head 7 is provided with an injection nozzle projecting into the combustion space for the fuel supply.

An electronic control apparatus 12 is provided for the control of the combustion engine which is connected with a battery 13. The desired adjustment of the torque is preset for the electronic control apparatus 12 by means of a potentiometer 15 connected with the drive pedal or gas pedal 14. The control apparatus 12

(FIGS. 1 and 5) is of conventional construction, utilizing commercially available components and involving circuits, known as such in the prior art and therefore not described in detail herein.

The electronic control apparatus 12 is provided with an installation for detecting the phase angle α of the crankshaft 5, which transmits accurate informations concerning the phase angle α of the crankshaft 5 and the rotational speed thereof. The installation for detecting the phase angle of the crankshaft 5 and the rotational speed consists of an electric pulse transmitter. For that purpose, an electromagnetic toothed arrangement 17 constructed in the manner of a recording tape, is provided at the flywheel 16 that is rigidly connected with the crankshaft 5. The toothed arrangement 17 rotates past a magnet 19 provided with a winding 18 and effective in the manner of a recording head. The pulse counting commences with a zero position 20. Simultaneously, the electronic control apparatus 12 is pre-set by way of the potentiometer 15 coupled with the driving pedal 14 to pre-select the torque of the engine to be produced.

The electronic control apparatus 12 processes in a conventional manner the information reaching the same into electric pulses which are transmitted to the actuating installations of conventional construction for the inlet valve 10 and the outlet valve 11 as well as for the fuel injection. The inlet and outlet valves 10 and 11 are each provided with a hydraulic piston 21 which are adapted to be connected by way of a respective magnetic valve 22 shifted by the pulses of the control apparatus 12 with a respective local high pressure tank 23. The local high pressure tanks 23 are fed by way of a supply line from a central pressure tank 24 which is refilled by way of a high pressure pump 25, a pressure regulator 26 and a check valve 27 from a supply tank 28. Compression springs 29 are provided in this embodiment for the closing of the inlet and valves 10 and 11. The inlet and the outlet valves 10 and 11 are additionally equipped each with a displacement pick-up or transmitter 30 which feed back to the electronic control apparatus 12 the instantaneous position of the valves 10 and 11. From these informations, the electronic control apparatus 12 calculates the velocity and the acceleration whereby a possibly predetermined maximum acceleration may lead to the limitation of the stroke or of the actuating velocity in order to avoid a fluttering of the valves 10 and 11 after the renewed closing under spring pressure. Another possibility, in order to avoid at very high rotation speeds a valve-jumping or skipping after the closing, essentially consists in installing into the discharge lines of the magnetic valves 22 a throttle means so that the oil pressure is not suddenly reduced in the pressure spaces to be emptied during the closing. The data transmitted to the control apparatus 12 are compared in a conventional manner with intended or pre-set values which, themselves are a function of engine, rotational speed and torque. Possibly necessary corrections are then carried out conventionally by the electronic control apparatus 12. Since such electronic control apparatus 12 as well as its logic circuit elements are known in the art and form no part of the present invention, the overall arrangement of such conventional circuits is merely indicated schematically in block diagram in FIG. 5 while a detailed description is dispensed with herein.

A further magnetic valve 31 is provided for the fuel injection which connects an injection nozzle 32 with the high pressure tank 33 containing a fuel in the presence of a pulse from the control apparatus 12. It is appropriate in practice to construct the injection nozzle 32 and the magnetic valve 31 as a unit. The high pressure tank 33 is re-charged or re-supplied with fuel from a tank 35 by way of a high pressure fuel pump 34.

By the accommodation of a pressure indicator 36 in the combustion space 6 as well as of a temperature and humidity measuring device 37 in the suction channel 8 for the combustion air and of a smoke-number and/or temperature-measuring device 38 in the exhaust or exhaust channel 9, which are all connected to the electronic control apparatus 12, the data thereof can be conventionally evaluated by the electronic control apparatus 12. It is possible thereby, in conjunction with the position of the foot pedal 14 to so control the injection quantity and valve control periods that all of the engine operating conditions desired by the driver such as minimum consumption, minimum smoke development and emission, optimum charging degree, possibly a maximum torque in case of need, momentary overloads or favorable noise behavior, for example, by the limitation of the pressure rise as a function of the phase angle of the crankshaft 5, may be selectively adjusted. It is also possible therebeyond to so convert the engine torque characteristics that with a decreasing rotational speed the torque increases in order to achieve thereby a more stable behavior and a reduction of the number of speeds of the transmission. Furthermore, it is possible to utilize the engine as exhaust brake without any constructive change-over. In that connection, also the inlet valve 10, in addition to the outlet valve 11, could be kept closed for the reduction of the reaction in the inlet channel 8. The compression work can then be dissipated by temporary opening of the exhaust valve 11. A higher engine braking output may be achieved thereby without additional brake elements than is possible with the known exhaust brakes. Additionally, the maximum rotational speed range of the engine can be increased by the limitation of the valve stroke at higher rotational speeds.

The embodiment according to FIG. 2 is changed in that the springs 29 of FIG. 1 for the closing of the inlet valve 10 and of the outlet valve 11 are dispensed with. In this embodiment, both the opening as also the closing of the inlet valve 10 and of the outlet valve 11 takes place by one double-acting hydraulic piston 39 each provided on a respective valve stem, the valve which is adapted to be acted upon with the pressure medium on both sides. Two further magnetic valves 40 are necessary therefor which during closing of the valves 10 and 11 let pressure act on the bottom side of the hydraulic pistons 39.

In the embodiment according to FIG. 3, a mechanical valve drive has been maintained. In this embodiment the crankshaft 5 is provided with a sprocket wheel 41 which drives by way of a chain 42 and a sprocket wheel 43, a camshaft 44 which, in its turn, actuates the corresponding valve 48 by way of a tappet 45, a pushrod 46 and a rocker arm 47. In the drawing, only the control of the inlet valve 48 is illustrated whereas the control for the outlet valve, which takes place in the same manner, is not shown. In order to be able to change the control periods of the valves, a chain

guide means is provided, by means of which a phase shift between the crankshaft 5 and the camshaft 44 is possible. A magnetic valve 49 fed with pressure oil serves for this purpose which is able to adjust by way of a servo-mechanism the chain guide means so that the length of the pulling section of the chain and therewith also the phase between the camshaft and the crankshaft is changed. The chain guide means consists of a piston chain 51 connected with a piston 50 which includes two chain rollers 52. For the adjustment of the piston 50, pressure oil may be supplied pursuant to a pulse of the electronic control apparatus 12 (FIG. 6), to the piston 50 of the piston rod 51 by way of the valve 49 from a high pressure tank 53. The high pressure tank 53 is charged or refilled by a high pressure pump 54 by way of a pressure regulator 55 and a check valve 56. The magnetic valve 49 is provided with a return-line 58 leading back to the supply tank 57. The chain guidance means 50, 51, and 52 is additionally provided with a chain-tensioning roller 59 which is under a spring-load. The feedback concerning the instantaneous position of the inlet and outlet control periods takes place by way of an inductive displacement pick-up or transmitter 60 which is connected with the chain guide means and transmits its signals to the electronic control apparatus 12. The data transmitted from the inlet channel 8 and the exhaust channel 9 as well as from the combustion space as well as the preset program of the electronic control apparatus 12 are influenced also by this feedback from the inductive displacement transmitter 60.

In order to be able not only to shift the control periods but also to change the same, the camshaft 44, as illustrated in FIG. 4, may be additionally arranged in a displaceable manner. For this purpose, for example, a servo-motor 61 with a magnetic valve 62 may be provided which is also connected with pressure supply lines and which is controlled by a pulse of the electronic control apparatus 12. The extension of the camshaft 44 is attached to the piston 63 of the servo motor 61. In the illustrated embodiment according to FIG. 4, two different cam tracks or configurations 64 and 65 are provided. The influencing of the duration or length of the control periods takes place thereby by way of the magnetic valve 62 which is shifted by the electric control apparatus 12 in accordance with the data, made available, as already described, of the engine and/or according to a preset program of the magnetic valve 62. In order to feedback the duration of the control periods to the electronic control apparatus 12 (FIG. 6), a similar inductive displacement pick-up or transmitter may be provided as is utilized for the chain guidance 50, 51 and 52 with the shift of the control periods.

As mentioned above, the electronic control apparatus 12 of the various embodiments is of conventional construction utilizing conventional logic elements in its circuits in a conventional manner, FIGS. 5 and 6 being illustrative of such control apparatus, illustrating in block diagram the conventional connections of such commercially available logic elements.

While I have shown and described only several embodiments in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to those skilled in the art, and I therefore do not

wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

I claim:

1. An installation for controlling a combustion engine of the type having inlet and outlet valve means, fuel supply means, and a crankshaft wherein the actuation of the valve means and the fuel supply means is dependent upon the phase angle of the crankshaft; the installation comprising an output adjusting member for the combustion engine providing an electrical output signal indicative of the output desired, means for detecting the rotational speed and phase angle of the crankshaft for providing an electrical output signal indicative thereof, and electronic means responsive to operating parameters of the engine including the output signals from the output adjusting member and the crankshaft detecting means for providing separate electrical output signals to each of the inlet and outlet valve means for controlling at least one of the stroke and timing of one of the inlet and outlet valve means independently of at least one of the stroke and timing of the other of the inlet and outlet valve means, said electronic means also providing an electric output signal to the fuel supply means for controlling the supply of fuel to the engine independently of at least one of the stroke and timing of the inlet and outlet valve means.

2. An installation according to claim 1 characterized in that a pulse transmitter means dependent on the rotation of the crankshaft serves as means for detecting the phase angle of the crankshaft.

3. An installation according to claim 2, characterized in that the pulse transmitter means includes electromagnetic teeth means provided at a flywheel and constructed in the manner of a recording tape and magnet means having winding means and constructed in the manner of a recording head, said winding means being operatively connected with said electronic control means.

4. An installation according to claim 3, characterized in that the inlet and outlet valve means include hydraulic piston means which are adapted to be connected with a pressure tank containing a pressure medium by way of magnetic valve means controlled by the electronic control means.

5. An installation according to claim 4, characterized in that both sides of the hydraulic piston means are adapted to be acted upon by the pressure medium of the pressure tank for movement of the piston means in different directions.

6. An installation according to claim 5, characterized in that the inlet and outlet valve means includes displacement transmitter means providing an output indicative of the displacement of the inlet valve and outlet valve means, and connecting means operatively connecting said displacement transmitter means with said electronic control means.

7. An installation according to claim 6, characterized in that the inlet and outlet valve means includes a throttle means provided in the discharge from the pressure spaces of the piston means for throttling during closing operation of the inlet and outlet valve means.

8. An installation according to claim 1, characterized in that the inlet and outlet valve means include hydraulic

lic piston means which are adapted to be connected with a pressure tank containing a pressure medium by way of magnetic valve means controlled by the electronic control means.

9. An installation according to claim 8, characterized in that both sides of the hydraulic piston means are adapted to be acted upon by the pressure medium of the pressure tank for movement of the piston means in different directions.

10. An installation according to claim 8, characterized in that the inlet and outlet valve means includes displacement transmitter means providing an output indicative of the displacement of the inlet valve and outlet valve means and connecting means operatively connecting said displacement transmitter means with said electronic control means.

11. An installation according to claim 8, characterized in that the inlet and outlet valve means includes a throttle means provided in the discharge from the pressure spaces of the piston means for throttling during the closing operation of the inlet and outlet valve means.

12. An installation according to claim 1, characterized in that the inlet valve and outlet valve means includes a valve drive means comprising chain and sprocket drive means in which the length of the pulling section of the chain between a camshaft sprocket wheel and a crankshaft sprocket wheel is adapted to be adjusted by a chain guidance means operatively connected with the control means.

13. An installation according to claim 12, characterized in that the chain guidance means includes displacement transmitter means operatively connected with the control means.

14. An installation according to claim 13, characterized in that the displacement transmitter means is an inductive displacement pick-up.

15. An installation according to claim 12, characterized in that the camshaft operatively connected with a servo-means is displaceably arranged and is provided with cams axially offset to one another, said servo-means being operatively connected by said connecting means with said electronic control means.

16. An installation according to claim 15, characterized in that the camshaft is connected with a displacement transmitter means operatively connected with the electronic control means.

17. An installation according to claim 16, characterized in that said displacement transmitter means is an inductive displacement pick-up.

18. An installation according to claim 16, characterized in that the chain guidance means includes displacement transmitter means operatively connected with the control means.

19. An installation according to claim 18, characterized in that the displacement transmitter means are inductive displacement pick-ups.

20. An installation according to claim 1, characterized in that the fuel supply means includes a magnetic valve means which is adapted to be controlled by the electronic control means, said magnetic valve means being operatively connected with a pressure tank and an injection nozzle of the fuel supply means for controlling the supply of fuel.

21. An installation according to claim 20, characterized in that the magnetic valve means and the injection nozzle are combined into a structural unit.

22. An installation according to claim 1, characterized by the electronic control means being responsive to measuring means for detecting the condition of the combustion air, the measuring means being arranged in the suction line of the engine.

23. An installation according to claim 1, characterized by the electronic control means being responsive to pressure indicator means arranged in the combustion space of the engine.

24. An installation according to claim 1, characterized by the electronic control means being responsive to temperature indicator means arranged in the combustion space of the engine.

25. An installation according to claim 22, characterized by the electronic control means being responsive to pressure and temperature indicator means arranged in the combustion space of the engine.

26. An installation according to claim 1, characterized by the electronic control means being responsive to measuring means arranged in the exhaust gas line of the engine.

27. An installation according to claim 26, wherein said measuring means measures the smoke factor.

28. An installation according to claim 26, characterized in that the measuring means measures the temperature.

29. An installation according to claim 25, characterized by the electronic control means being responsive to measuring means arranged in the exhaust gas line of the engine.

30. An installation according to claim 29, characterized in that said last-mentioned measuring means is operable to measure both the smoke number and the temperature.

31. An installation according to claim 1, characterized in that the output adjusting member is a drive pedal of a motor vehicle.

32. An installation according to claim 30, characterized in that a pulse transmitter means dependent on the rotation of the crankshaft serves as means for detecting the phase angle of the crankshaft.

33. An installation according to claim 32, characterized in that the pulse transmitter means includes electromagnetic teeth means provided at a flywheel and constructed in the manner of a recording tape and magnet means having winding means and constructed in the manner of a recording head, said winding means being operatively connected with said electronic control means.

trol means.

34. An installation according to claim 33, characterized in that the inlet and outlet valve means include hydraulic piston means which are adapted to be connected with a pressure tank containing a pressure medium by way of magnetic valve means controlled by the electronic control means.

35. An installation according to claim 34, characterized in that both sides of the hydraulic piston means are adapted to be acted upon by the pressure medium of the pressure tank for movement of the piston means in different directions.

36. An installation according to claim 34, characterized in that the inlet and outlet valve means includes displacement transmitter means providing an output indicative of the displacement of the inlet valve and outlet valve means, and connecting means operatively connecting said displacement transmitter means with said electronic control means.

37. An installation according to claim 36, characterized in that the inlet and valve means includes a throttle means provided in the discharge from the pressure spaces of the piston means for the throttling during the closing operation of the inlet and outlet valve means.

38. An installation according to claim 33, characterized in that the inlet valve and outlet valve means includes a valve drive means comprising chain and sprocket drive means in which the length of the pulling section of the chain between a camshaft sprocket wheel and a crankshaft sprocket wheel is adapted to be adjusted by a chain guidance means operatively connected with the control means.

39. An installation according to claim 38, characterized in that the chain guidance means includes displacement transmitter means operatively connected with the control means.

40. An installation according to claim 39, characterized in that the camshaft operatively connected with a servo-means is displaceably arranged and is provided with cams axially offset to one another, said servo-means being operatively connected by said connecting means with said electronic control means.

41. An installation according to claim 40, characterized in that the camshaft is connected with a displacement transmitter means operatively connected with the electronic control means.

42. An installation according to claim 33, characterized in that the output adjusting member is a drive pedal of a motor vehicle.

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