April 3, 1928. 1,664,610

L. O. FRENCH

FUEL FEEDING SYSTEM

Original Filed Jan. 8, 1925 2 Sheets-Sheet 1

Fig. 1.

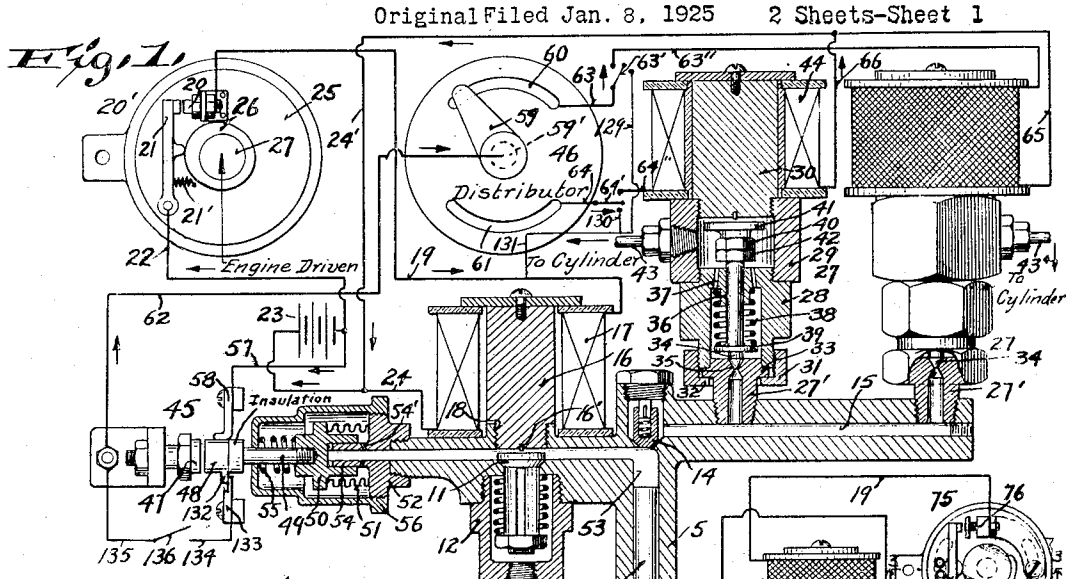


Fig. 3.

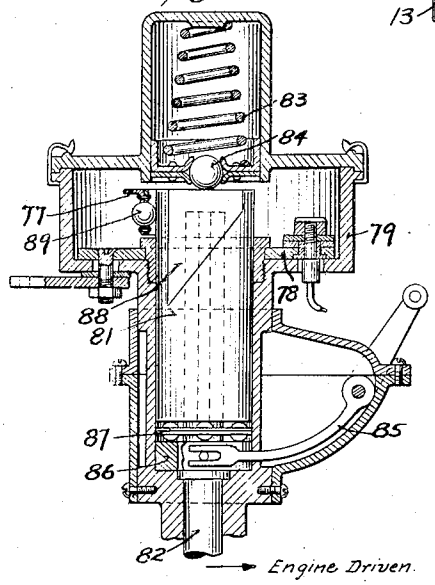


Fig. 2.

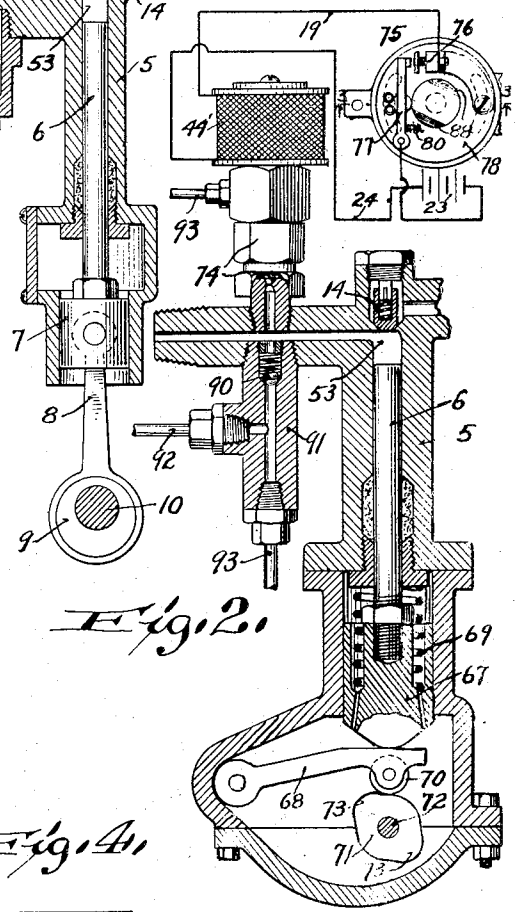
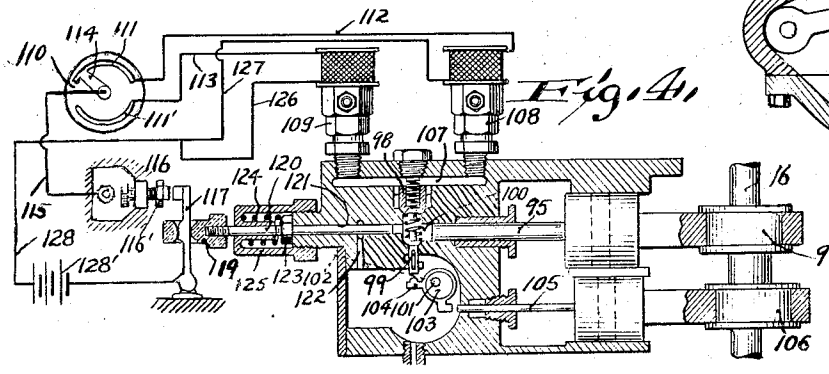


Fig. 4.



INVENTOR.

Louis O. French

April 3, 1928. 1,664,610

L. O. FRENCH

FUEL FEEDING SYSTEM

Original Filed Jan. 8, 1925 2 Sheets-Sheet 2

Fig. 5.

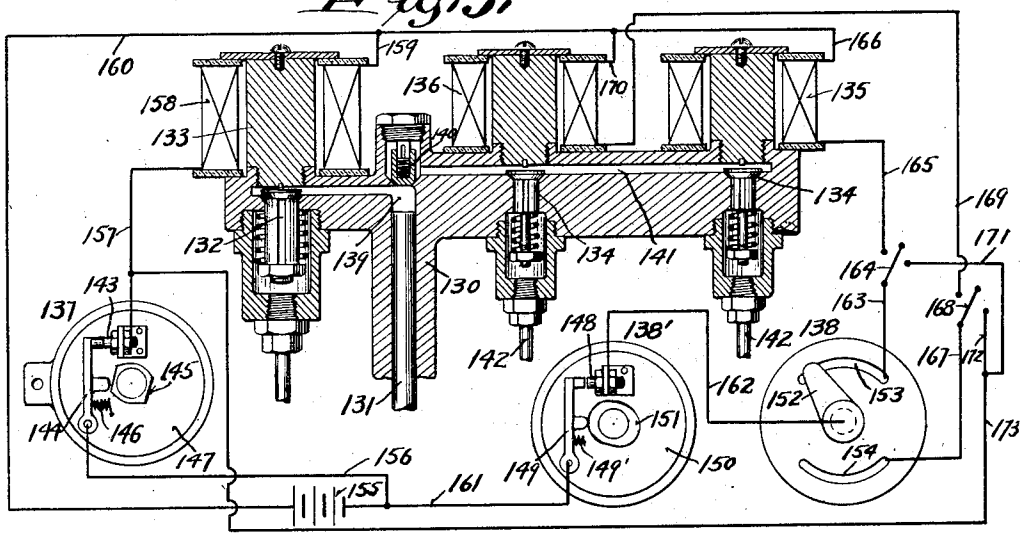


Fig. 6.

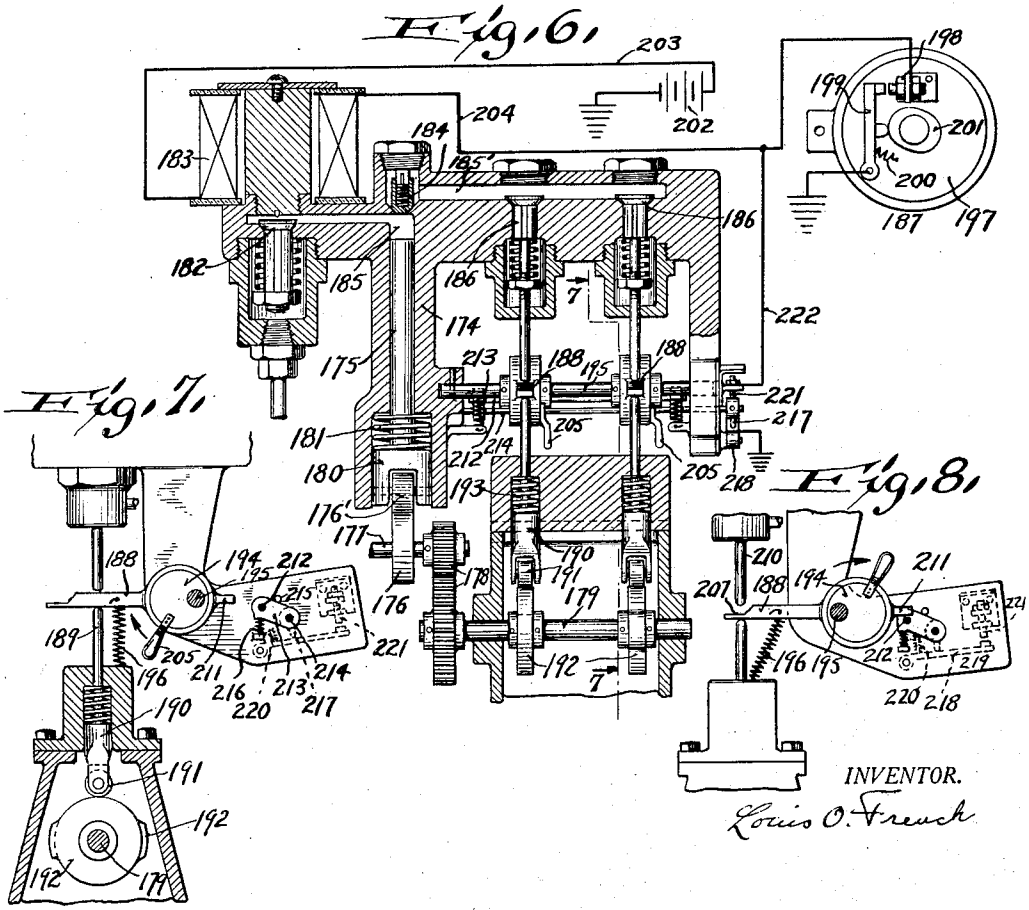


Fig. 7.

Fig. 8.

INVENTOR.

Louis O. French

Patented Apr. 3, 1928. 1,664,610

UNITED STATES PATENT OFFICE.

LOUIS O. FRENCH, OF MILWAUKEE, WISCONSIN.

FUEL-FEEDING SYSTEM.

Application filed January 8, 1925, Serial No. 1,328. Renewed July 18, 1927.

The invention relates to fuel feeding systems for internal combustion engines.

The invention relates to that type of fuel feeding apparatus for internal combustion engines in which a pump of variable delivery is used to supply its metered charges of fuel to the cylinders of a multi-cylinder engine in predetermined order by the operation of distributor valves, one for each cylinder.

One of the objects of the invention is to provide a fuel feeding apparatus of the type above described in which the distributor valves are electrically controlled, and more specifically to provide distributor valves, each enclosed in the conduit it controls, without outside connections that would be liable to leakage and hence might tend to defeat the equal distribution of charges of the pump to the cylinders.

A further object of the invention is to provide a fuel feeding apparatus of the type above described in which electrical means are provided to control the distributor valves and the delivery of the pump.

A further object of the invention is to provide a fuel feeding apparatus of the type above described in which the electrical control for the distributor valves is effected substantially in synchronism with the pump delivery so that the electrical energy required to operate said valves is conserved.

A further object of the invention is to provide a fuel injection system in which the metering of the fuel by the pump is electrically controlled and associated with the electrical control of the distributor valves so as to secure close synchronism or sequential operation.

A further object of the invention is to provide a pump apparatus of the general type described, whether the distributor valves are mechanically or electrically controlled, with electrical means to permit of cutting out the fuel delivery to any one or more of the cylinders being supplied without interfering with the normal operation of the pump in supplying the remaining cylinders with their proper charge, and in which the association is such that not only is the distributing valve of the cylinder effected rendered inoperative, but also the pump through the release of fluid to the supply side during the time the cut out cylinder would normally receive its charge.

The invention further consists in the several features hereinafter set forth and more particularly defined by claims at the conclusion hereof.

In the drawings: Fig. 1 is a vertical sectional view through an apparatus embodying the invention, some parts being shown diagrammatically;

Fig. 2 is a detail sectional view of modifications of certain parts shown in Fig. 1;

Fig. 3 is a detail sectional view taken on the line 3—3 of Fig. 2;

Fig. 4 is a vertical sectional view through another embodiment of the invention.

Fig. 5 is a view similar to Fig. 1, showing another embodiment of the invention;

Fig. 6 is a view similar to Fig. 1, showing another embodiment of the invention;

Fig. 7 is a detail sectional view taken on the line 7—7 of Fig. 6;

Fig. 8 is a view of parts shown in Fig. 7, showing them in another position.

In Fig. 1 the numeral 5 designates the pump barrel or casing, preferably of bronze or other nonmagnetic material, 6 the plunger working in a bore in said barrel, 7 the plunger cross-head or guide, 8 the connecting rod operatively connecting said head 7 with the eccentric 9 mounted on a shaft 10 driven by the engine at n times the speed of the crank shaft for a two cycle and $\frac{n}{2}$ times the speed of the crank shaft for a four cycle where n equals the number of cylinders, 11 the suction valve of suitable magnetic material and having a fluted stem admitting fuel to the pump chamber from a fitting 12 connected by a pipe 13 with a source of supply, and 14 a spring-closed discharge valve past which the fuel is forced during the delivery stroke of the pump to a distributing chamber or conduit 15.

The pump shown in Fig. 1 is of the type in which variable quantities of fuel are delivered by the holding open of the suction valve for varying periods of time, accomplished in this instance through the use of an electromagnet having its core 16 acting directly on the face of the suction valve, the core being magnetized by its coil 17 and having a fluid-tight connection 18 with the casing. The coil 17 is connected by a conductor 19 with the fixed contact 20 of a switch 20′, the movable pivoted contact 21 of which is connected by a conductor 22 with one side of a battery 23, the other side of the coil

being connected by a conductor 24 to the other side of the battery. The contacts 20 and 21, suitably insulated from other parts, are mounted to move with a casing 25 that may be turned by governor or hand control to vary the time of operation of the switch, the contact 21 being normally urged into engagement with the contact 20 by a spring 21′ and moved out of engagement therewith by a timing cam 26 mounted on a shaft 27 driven by the engine, in this showing, at the same speed as the pump shaft 10. The profile of the cam is preferably such as to allow closing of the switch contacts, when in one position of adjustment, for more than the expressing stroke of the pump so that the suction valve 11 will be held open for this period to prevent any delivery of fuel, and from this extreme the other positions of adjustment of the switch, by the turning of the casing relative to the cam, permit of holding the suction valve open for fractional parts of the stroke so that varying amounts of fuel will be delivered, the deenergization of the magnet permitting the suction valve to close and thus determine the time of injection delivery. With the timing cam above described, the power of the magnet is such as to hold the valve open when brought into close attractive relation therewith during the suction stroke and then be held open during the working stroke of the pump if the current is on, but not so great as to lift said valve against the delivery pressure of the pump so that even if the magnet should be energized after the pump has started its expressing stroke and the suction valve is closed the suction valve will remain closed. As the action of the pump on its suction stroke lifts the suction valve, said valve will be readily brought into magnetic or attractive relation with the core of the magnet so that the magnetic force is used more as a means for holding the valve open from the end of suction to such a time in the delivery stroke as to permit the pump to deliver the desired quantity of fuel after said valve closes and during the remainder of its stroke.

Thus, with the foregoing construction a measured or metered amount of fuel is delivered by the pump to the distributing chamber 15 and from this chamber is distributed in the desired cyclic sequence to the cylinders of the engine (not shown) by electro-magnetically-operated control devices 27, each of which control passage of fuel through their respective conduits. Each device 27 comprises a casing formed by a pipe connector and valve seat member 27′, a conduit section and valve guide member 28 of non-magnetic material, a conduit section 29 of non-magnetic material having a fluid-tight threaded engagement at its lower end with the member 28 and similar engagement at its upper end with the core 30 of the electro-magnet. The member 27 is removably secured, in a fluid-tight manner, to the lower threaded end of the member 28 by a nut 31 having an annular flange 32 engaging an annular flange 33 of said member 28 seating against the lower end of the member 28. The member 27′ has a threaded pipe connection with the chamber 15. A needle valve 34 seats on the seat 35 at the upper end of the passage through the member 27′ and has its stem guided in the bore of a partition 36 having fuel passages 37. A spring 38 interposed between said partition and a flange 39 on said stem normally acts to hold the valve closed against fuel delivery pressure. The upper end of the stem projects into the conduit formed by the member 29 and is threaded to receive an adjustable sleeve nut 40 formed integral with or secured to a disk 41 of magnetic material, which unit is secured in adjusted position by a locknut 42. The separable connection between the parts 28 and 29 permits of ready adjustment of the disk to a position which will give the proper air gap distance between the disk and the face of the core 30, as well as control the lift of the valve, and will also permit grinding of the valve, assisted by the separability of the parts 29, 28, 27′ and 31. A pipe line 43 leads from the conduit section 29 to the cylinder to be supplied with fuel. The spool of the magnet coil 44 fits over the core and seats on the top of the casing and when said coil is energized the magnetized core 30 attracts the disk 41 and moves the valve to open position against the difference in pressure between the spring and the pressure of fuel in chamber 15.

The coil 44 of each magnet receives current from the battery 23 in proper sequence through a switch mechanism 45 and a current distributor 46 of any suitable construction.

The switch mechanism 45 is designed to establish current flow conditions after the suction valve closes and the pump is delivering fuel to the chamber 15. For this purpose I have shown a switch comprising a fixed contact 47 and a movable contact 48 which is suitably insulated from and carried by a rod 49 secured to a guide 50 slidable upon the tubular extension 54, provided with holes 54′ of a pipe fitting 52 connected with the pump chamber 53. This fitting and guide 50, together with a multiple diaphragm or metal bellows 51 connected to them at its ends, in a fluid-tight manner, forms a chamber communicating with the pump chamber. A spring 55 interposed between the guide 50 and a cap 56, mounted on fitting 52, normally acts to hold the contact 48 out of engagement with contact 47, but when pressure builds up in the pump chamber the contact 48 will move into contact with contact 47. The release position of contact 48 may be de-

termined by engagement of guide 50 with the extension 54 or by means hereinafter described. Current from the battery 23 passes through conductor 57 to a fixed brush 58 in sliding contact with the movable contact 48.

The distributor 46 includes the rotatable current-carrying arm 59 mounted on a shaft 59′ driven by the engine at cyclic speed, that is, at engine speed in a two cycle and one-half engine speed in a four cycle, said arm coacting with fixed contacts 60 and 61.

A conductor 62 leading from the fixed contact 47 is suitably connected to arm 59 in any well-known manner. Conductor 63, switch 63′ and conductor 63″ connect the contact 60 with an end of one coil 44, and conductor 64, switch 64′ and conductor 64″ connect the contact 61 with an end of the other coil 44 during normal operation, the return circuit for the respective coils being through respective conductors 65 and 66 to a conductor 24′ connected with the conductor 24 leading to the battery 23.

When the suction valve 11 closes, fuel delivery to chamber 15 starts and pressure preferably below the delivery pressure of this fluid in chamber 53 moves contact 48 into engagement with contact 47 and current then passes from battery 23 through conductor 57, brush 58, contacts 48 and 47, conductor 62 to arm 59. At this time arm 59 has been actuated by the engine to establish contact with either of the contacts 60 and 61, the arm being shown in contact with contact 60 and, with the switch 63′ positioned to connect conductors 63 and 63″ together, current then flows from arm 59 to contact 60, conductor 63, switch 63′, conductor 63″ to coil 44, shown in full, thereby completing the circuit to the battery through conductors 65 and 24′ to energize the magnet which acts in conjunction with the fuel pressure then or shortly thereafter existing in conduit 15 to lift the valve 38 to allow fuel, metered by the pump, to pass to the engine cylinder whose pipe connection is associated with this valve. As soon as the pump has completed its delivery stroke, the pressure in chamber 53 drops, switch 45 opens, breaking the coil circuit, and valve 34 closes. During the next stroke of the pump the arm 59 has turned to contact with contact 61 and when switch 45 closes current is established as before to contact 61 and then flows through conductor 64, switch 64′, conductor 64″ to the coil, shown in section, of the next distributor valve to be operated, and completes the circuit to the battery through conductors 66 and 24′ to energize the magnet, and the valve 38 is then lifted like the preceding valve and fuel passes to another cylinder, it being understood that there are as many distributor valves and circuit connections between the coils of said valves and contacts on the distributor as there are cylinders, and that these are arranged to secure the desired sequential working of the cylinders during a complete cycle of the engine.

The contacts 60 and 61 are preferably of such a length as to establish contact with arm 59 before switch 45 closes under any conditions of operation of switch 20′ so that either one makes contact with arm 59 before the end of the suction stroke and remains in contact during the entire delivery stroke and for a slight period after it so that the switch 45 is the actual current interrupter and the distributor contacts are relieved of wear due to any arcing.

In Fig. 2 I have shown the pump plunger 6 working in the barrel 5 with its guide 67 held in contact with a pivoted lever 68 by a spring 69, the lever having a roller 70 acting on a cam 71 mounted on a shaft 72 driven by the engine, the plunger being lifted by the cam and returned by the spring. This cam may have as many lobes 73 on it as there are cylinders to be supplied, and is driven at cyclic speed, or it may have a single lobe and be driven like shaft 10.

Regulation of the fuel delivery and its timing is effected through an electro-magnetically-operated needle by-pass valve 74 similar in construction to the control device 27, and the coil 44′ of the magnet is shown as controlled by a switch 75 including a fixed contact 76 and a pivoted switch contact 77, both mounted on and suitably insulated from a plate 78 rotatably mounted in a casing 79, contact 76, being urged by a spring 80 into contact with contact 76 and being held out of contact by a cam 81 which is slidably keyed to a shaft 82 driven by the engine, is moved in one direction by spring 83 acting on a bearing member 84 in contact with the cam, and in the opposite direction by a pivoted lever 85, either manually or governor actuated, associated with a collar 86 and thrust bearing 87. This cam is cylindrical except for one or more parts of its surface, the number depending upon what kind of drive is used for shaft 82, each of which is in the form of a tapered flat relief 88 with one side preferably parallel with the axis of the cam. This straight side may be the advancing or trailing side of the cam, depending upon whether it is desired to start or end the time of pump delivery at a definite period for any setting of the switch 75, it being noted that the movement of the cam up or down brings different parts of reliefs 88 into operative relation with the ball 89 on the contact 77 and thus the switch will be closed for shorter or longer relative periods of time and hence the relative duration of energization of the coil 44, which may be connected in the circuit shown in Fig. 1 by the conductors 19 and 24 where the switch contacts are suitably insulated, may be varied. As the plate 78 is turned relative

to the cam the timing of the energization periods of the coil 44′ may be varied. Thus the time and duration of energization of the coil 44′ may be varied and hence the by-pass valve may be held open at and for varying periods of time so that more or less fuel may be delivered by the pump either starting on the completion of suction and ending during the available delivery period, or starting after the delivery stroke begins and ending with the completion of the available delivery stroke. Where such a by-pass valve is used, a spring-pressed suction valve 90 admits fuel to the pump chamber 53, from a fitting 91 connected by a pipe 92 with a source of supply, and the fuel by-passed from chamber 53 past valve 74 returns to the supply by way of this fitting and a pipe connection 93 between it and the conduit above the valve formed by the part previously described in connection with the distributor valve device 27. Where the switch cam 81 is driven at cyclic speed it is provided with as many relief surfaces 88 as there are cylinders. It will be noted that the suction valve 11 and the by-pass valve 74 both control the return of fuel to the supply. The valve 74 is held closed against delivery pressure by its spring except when the magnet is energized. The switch mechanism shown in Figs. 2 and 3 may also be used in connection with the suction valve 11 to produce a variable delivery, and the pump drive shown in these figures may also be used in Fig. 1, in which instance a plurality of lobes may be used on the cam 26 and the shaft 27 driven at cyclic speed.

In Fig. 4 I have shown the electrical distributing system applied to a mechanically-operated pump of well-known construction, in which 95 designates the pump plunger suitably connected and driven from a shaft 96 by an eccentric or cam member 97, 98 the spring-closed discharge valve, 99 the suction valve that may be moved to closed position by a light spring 100, 101 a shaft operated by the governor through a rod 102, shown in dotted lines, 103 an eccentric on said shaft 101, 104 a dog mounted to turn on said eccentric and moved into engagement with the suction valve, to hold it open for longer or shorter intervals, depending upon the position of the eccentric 103, during the delivery stroke to vary the amount of fuel delivered, by a tappet member 105 suitably connected and driven by an eccentric 106.

The distributing system includes the distributor chamber 107 and the distributor valves 108 and 109, each like the valves 27. The distributor 110 has one of its contacts 111 connected by a conductor 112 to one end of the coil for the valve 108 and its other contact 111′ connected by a conductor 113 with one end of the coil for the valve 109. The current-carrying arm 114 of the distributor driven at cyclic speed is connected in any suitable manner by a conductor 115 to a fixed contact 116′ of a switch 116 whose movable contact 117 is in the form of a pivoted member connected with one side of the battery 128′ and mounted to move with the insulated head 119 of a rod 120 whose inner end works in a bore 121 in the pump body communicating with the pressure chamber of the pump, a drain passage 122 to the suction side being provided. The rod carries a stop-nut 123 and a spring 124 is interposed between said nut and a cap 125 to normally hold the switch 116 open. Conductors 126 and 127 connect with conductor 128 leading to the other side of the battery 128′, connected at its other side with contact 117.

With this construction, when the suction valve 99 closes the switch 116 closes under the action of the fuel pressure in the pump and at a time when the distributor has established contact with one of the contacts 111 or 113, and the distributor valve associated with this contact is then opened by passage of current through its coil and fuel pressure, and fuel passes to the engine cylinder associated therewith and thereafter the other distributor valve is operated in proper sequence in the manner previously described in connection with Fig. 1, the circuits being similar to those of Fig. 1.

It has been previously pointed out that it is desirable to cut out the supply of fuel to one of the cylinders without interrupting the operation of the other cylinders, and where the valve is electrically operated this may be done as shown in Fig. 1. For this purpose the contacts 60 and 61 of the distributor may be respectively connected through conductor 63, switch 63′ and conductor 64, switch 64′ to conductors 129 and 130 connected by a conductor 131 to conductor 19 supplying current to the coil 17. The contact 48 has a projecting portion 132 adapted to contact with a fixed contact 133 which in this case forms a stop to limit the open position of contact 48, and contact 133 is connected by conductors 134 and 135 and switch 136 to the conductor 62. Thus, when it is desired to cut out the cylinder associated with the distributor valve whose coil connects with conductor 63, switch 136 is closed and switch 63′ is moved to break the circuit connection between conductors 63 and 63″ and establish connection between conductors 63 and 129, thus cutting off supply of current to the coil of the valve whose spring 38 then holds it closed, and establishing a circuit connection with the coil 19 from battery 23, conductor 57, brush 58, contacts 48, 132, conductor 134, switch 136, conductors 135 and 62, arm 60 through circuit connections above described to 19, coil 17 and conductor 24 back to the battery which thereby holds the suction valve 11 open and, as previously pointed out, since the contacts 60 and 61 are

of a length to supply current for more than the delivery stroke of the pump it follows that during the time arm 59 is passing over the contact 60 the action of the switch 21, 20 will have no effect, the valve 11 will be held open and no fuel will be delivered by the pump. Thus, during this particular period, the distributor valve in question is closed and the valve 11 open. Under the circuit conditions above mentioned, when the arm 59 contacts with 61 current will flow from battery 23 to conductor 57, brush 58, contacts 48, 133, conductor 134, switch 136, conductors 135 and 62, arm 59, contact 61, conductor 64, switch 64′, conductor 64″ to the coil for the other distributing valve and by way of conductors 66, 24′ and 24 back to the battery, but this will have no effect upon the distributor valve because until the suction valve 11 closes there is no fuel pressure acting to aid the current in opening this valve, as it has been previously pointed out that the current for the distributor valve only acts to open said valve because of differences in pressure. Hence this valve will not be opened and the normal action of the switch 20, 21 will not be interferred with and thereafter the closing of the suction valve causes the switch 45 to operate, opening contacts 48 and 133 and establishing normal circuit conditions for operating the distributor valve associated with conductor 64, as previously pointed out. In a similar manner, bringing switch 64′ into contact with conductor 130 puts the distributor valve associated with contact 61 out of action and holds the suction valve open to prevent fuel delivery.

The switch 136 is provided so that the trouble circuit above described may be put out of action until needed and this will relieve electrical wear on contacts 132 and 133.

The coil 44′ for the valve 74 may be associated in the same way with the system of Fig. 1 as the coil 17 and the same circuit connections used for cutting out the distributor, as above described, but in this case while both valve 74 and distributor control valves 27 are normally held closed against delivery pressure, said valves 27 and 74 are so designed that valve 74 may be lifted during a period of low pressure in the pump while valves 27 cannot be, so that when switch 63′ cuts out its distributor valve, bypass valve 74 is opened in the same way as valve 11 to prevent fuel delivery, and when the arm 59 comes into contact with 61 and circuit connections are established through switch 64′ and conductor 64″, the current will not operate this distributor valve associated with this circuit as long as valve 74 is held open, but as soon as the switch 20, 21 or 77, 76 opens to release valve 74, contact 48 engages contact 47 and the current then passing through the coil of the distributor supplied from contact 61 is then able, assisted by the fuel delivery pressure, to open the distributor valve as in normal operation. The variable action of the valves 74 and 27 may be secured by varying the areas of the orifices which these needle valves control, varying the spring pressure on the valves, or the current required for operating them, or a combination of these.

Thus, with either an electro-magnetically-operated suction or by-pass valve associated with the distributor valves in Fig. 1, closing the switch 136 and connecting either the conductor 63 by switch 63′ with conductor 129 or conductor 64 by switch 64′ with conductor 131, depending upon the particular distributor valve to be put out of action, the supply of fuel to the cylinder associated with that valve will be cut off without interfering with the supply of fuel to the other cylinder or cylinders.

It will be noted that the magnets for the disturbuting valves act directly upon the disks 41 associated with said valves and that the valves are disposed in closed conduits, thus eliminating chances for leakage.

Where close synchronism is effected between the delivery of fuel and the opening of the selected distributor valve the discharge valves 14 and 98 are not necessary. Furthermore, the fluid-pressure-operated switches 45 and 116 may be connected with the conduits 15 and 107, respectively, instead of with the pump chamber without changing their operation, since in either case the fuel pressure is used to close the switch.

In Fig. 5 I have shown an arrangement in which the distributor valves are opened in predetermined order shortly before the delivery stroke, and held open during delivery by electro-magnetic control means. In this construction the numeral 130 designates the pump casing of non-magnetic material, 131 the pump plunger, which is operated as shown in Fig. 2, 132 the spring-closed suction valve, 133 the electro-magnet controlling said valve, 134 spring-closed distributor valves, 135 and 136 the electro-magnets respectively controlling said valves, 137 the control switch for the electro-magnet 133, 138 the current distributor for the electro-magnets 135 and 136, 138′ a control switch for the distributor, 139 the pump chamber, 140 the spring-closed discharge valve, 141 the distributor conduit, and 142 pipes, each leading to an engine cylinder from the conduit 141, and the flow of fuel through which is controlled by the distributor valves.

The switch 137 is similar to that shown in Fig. 1, and includes the relatively fixed contact 143 and the pivoted contact 144 held against the engine-driven cam 145 by a spring 146, said contacts being mounted on the angularly-adjustable casing 147. The cam 145 driven at cyclic speed is provided

with two lobes for a two cylinder engine. As in the construction shown in Fig. 1, this switch mechanism is adapted to hold the valve 132 open for varying periods during the delivery stroke of the pump to regulate the amount of fuel supplied.

The switch 138′ is generally similar to the control switch shown in Fig. 1 for the valve 11, and includes the fixed contact 148, the pivoted contact 149 mounted on a case 150, the contact 149 being held by a spring 149′ against the cam 151, driven by the engine at cyclic speed, which is provided with two lobes whose design is preferably such as to cause engagement of contacts 148 and 149 shortly before the pump begins its delivery stroke and continued contact during the entire delivery stroke.

The current distributor 138 includes the switch arm 152 driven at cyclic speed and engaging with contact segments 153 and 154. These contact segments are of such a length that contact is made before the switch 138′ closes and broken after said switch opens, so that the switch 138′ takes the arcing and thus relieves the distributor contacts of electrical wear.

The circuit connections are battery 155, conductor 156 to contact 144, contact 143, conductor 157 to coil 158 of electro-magnet 133 and return through conductors 159 and 160 to the battery to energize the coil 158. For the distributor valves a conductor 161 connects the battery with contact 149 and a conductor 162 connects contact 148 with the distributor arm 152. A conductor 163, switch 164 and conductor 165 connect contact 153 with one end of the coil for the electro-magnet 135, the other end being connected by conductor 166 to the return conductor 160 so that when contacts 149 and 148 are engaged and arm 152 is in contact with contact 153 the electro-magnet 135 will be energized. A conductor 167, switch 168 and conductor 169 connect conductor 154 with one end of the coil for the electro-magnet 136, the other end being connected by conductor 170 to the return conductor 160, so that with contacts 149 and 148 engaged and the arm 152 in contact with contact 154 the electro-magnet 136 will be energized. Conductors 171 and 172 connect with conductor 173 leading to conductor 157. With this construction, during each stroke of the pump the electro-magnet 133, controlled by its switch 137, determines the amount of fuel delivered by the pump, as explained in detail in connection with Fig. 1. The by-pass valve structure of Fig. 2 may also be used for this purpose. The energized magnet 135 lifts the distributor valve associated therewith slightly before the beginning of the pressure delivery stroke of the pump so that during the pressure delivery stroke fuel will flow through the pipe 142 to the cylinder associated with this valve, and upon the next stroke of the pump the energized magnet 136 lifts its valve in a similar manner to permit fuel to flow to another cylinder of the engine. While either of the valves 134 may be off their seat before actual delivery begins, the discharge valve 140 acts as a check to prevent passage of fuel from the conduit 141 to the pump chamber 139.

It will be noted that the valves 134 are disposed close to their control magnets so as to minimize the air gap, and that the magnets operate directly upon the valve, thereby insuring quick and efficient action.

For cutting out any one cylinder without interfering with the others, the connection of switch 164 with conductor 171 cuts the coil of magnet 135 out of circuit so that the valve 134 associated therewith cannot open, and establishes circuit connection between the distributor circuit from contact 153 to conductor 163, switch 164, conductors 171, 173, 157, coil 158, conductors 159 and 160 back to the battery so that the coil 158 is energized and the valve 132 held open, so that upon the delivery stroke fuel is returned to the supply, and the connection of switch 168 with conductor 171 in a similar manner cuts out the coil of magnet 136 so that its valve cannot open, and establishes circuit connection between the distributor circuit from contact 154 to conductor 167, conductor 172 to the coil 158, as before, so that valve 132 is held open, but in either instance the cutting out of one of the distributor valves does not interfere with the other whose coil is then connected with its own distributor contact.

In the construction shown in Figs. 6 to 8, inclusive, I have shown an electrical control for the pump associated with a mechanical control for the distributor valves. In this construction the numeral 174 designates the pump casing, 175 the pump plunger, which is operated by a cam 176 mounted upon a shaft 177 connected by gearing 178 with a shaft 179, which runs at cyclic speed while shaft 177 runs at twice this speed, 176′ a roller engaging said cam and carried by a plunger guide 180 and held against the cam 176 by a spring 181, 182 the spring-closed suction valve, 183 the electro-magnet controlling said valve, 184 the spring-closed discharge valve, 185 the pump chamber, 185′ the distributor conduit, 186 the spring-closed distributor valves and 187 the control switch for the electromagnet 183.

Each of the distributor valves 186 is operated by a tappet lever 188 engaged by a tappet 189 whose guide 190 carries a roller 191 held against its cam 192 by a spring 193. Each lever 188 is pivotally mounted upon an adjustable eccentric 194 mounted upon a fixed shaft 195, said lever being held against its tappet by a spring 196.

The switch 187 is similar to the switch 137 and includes the angularly-adjustable casing 197 having the fixed contact 198 and pivoted contact 199, whose spring 200 holds it against the cam 201 driven by the engine at cyclic speed.

With this construction the relation of the cam 176 and the cams 192 is preferably such that each cam 192 starts to open its distributor valve just before the plunger 175 starts its expressing stroke, and during the expressing stroke the electro-magnetically-controlled suction or by-pass valve functions as previously explained to determine the charge delivered to the conduit 185′ and thence past one of the then open distributor valves to the piping leading to one of the engine cylniders. The circuit connections for the electric control are battery 202, conductor 203 to the coil of magnet 183, conductor 204, contacts 198 and 199 to ground and through ground to the other side of the battery.

For cutting out any one cylinder without interfering with the others, the eccentric 194 is turned by means of a handle 205, or other suitable means, until the relief end 207 of the lever 188 is under the valve rod 210, and then as the tappet 189 is moved up and down by its cam it fails to open said valve. To move the suction valve open under these conditions and keep it open during the delivery stroke of the pump, I have provided a projection 211 on said lever which, when said lever is moved from the running position shown in Fig. 7 to cut out position shown in Fig. 8, comes into the path of a rod 212 mounted upon arms 213 on a shaft 214, having a limited pivotal movement in one direction, determined by a stop pin 215 and normally held in its upper position by a spring 216, said shaft carrying an arm 217 normally engageable with the pivoted contact 218 of a switch 219, but which is swung out of engagement therewith by the downward swinging movement of the rod 212 which occurs as the projection 211 is swung downwardly when its other end is swung upwardly by the tappet 189, it being recalled that this movement commences just before the plunger starts its expressing stroke. The result of this action causes the spring 220 to swing contact 218 into engagement with the fixed contact 221 to energize the coil of the magnet 183 to hold the suction valve open on what would otherwise be the normal delivery stroke of the pump, the circuit connection being battery 202, conductor 203 to the magnet coil, conductors 204 and 222 to the contact 221, and through contact 218 to ground and then back to the battery. As the rod 212 extends across the path of the projections on both tappet levers when either one of said levers is moved to cut out position, the suction valve will be held open during the operation of the valve mechanism for this particular valve, but since after the movement of the tappet for one valve the arm 217 swings back, the switch 219 will be again opened so that the normal operation of the other valve is not interfered with. Thus, eccentrically mounted tappet levers form an adjustable means to prevent operation of the distributor valve and cause operation of the electrical control for the valve which controls the return of fuel to the supply side of the pump.

In each instance where electro-magnets control the valves a small brass pin, such as the pin 16′, is shown on the core of the magnet, which acts to just keep the valve from contact with the core to prevent any possibility of freezing.

From the foregoing description it will be noted that in combination with a pump of variable capacity, whether mechanically or electrically controlled as to its variable delivery, I have provided electrically-controlled distributor valves for controlling the delivery of fuel to the cylinders in the desired sequence; that I have provided a combination in which the metering of the pump and the action of the distributor valves are electrically controlled; and that where such metering is effected by the use of an electrically-controlled valve opening to return fuel to the supply side of the pump, I have provided for the cutting out of any one or more distributor valves, whether mechanically or electrically-controlled, without effecting the normal operation of the other distributor valves.

By the term "supplying fuel to the cylinders", I means supplying fuel to a fuel injector, a valve or inlet passage leading to the cylinder.

I desire it to be understood that this invention is not to be limited to any particular form or arrangement of parts except in so far as such limitations are included in the claims or necessitated by the prior art.

What I claim as my invention is:

1. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump of variable delivery for delivering a metered charge of fuel to each of a plurality of engine cylinders during a complete engine cycle, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, an electro-magnet for controling each valve, and means for supplying current to each electro-magnet in predetermined order, including a current distributor and timing circuit control mechanism associated with said distributor.

2. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump having a variable delivery to deliver a metered charge of fuel

to each of a plurality of engine cylinders during a complete engine cycle, a fuel conduit for each cylinder, a distributor valve in each conduit controlling the passage of fuel from the pump to its cylinder, an electro-magnet acting directly on each valve to control its operation, and means for supplying current to each electro-magnet in predetermined order, including a current distributor and timing circuit control mechanism associated with said distributor.

3. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump having a valve to control the passage of fuel to the supply side of the pump to control the amount of fuel delivered by the pump, adjustable electrical control means for said valve whereby to vary the output of the pump, said pump delivering a metered charge of fuel on each expressing stroke for use in one of a plurality of engine cylinders, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, an electro-magnet for controlling each distributor valve, and means for supplying current to each electro-magnet in predetermined order, including a current distributor and timing circuit control mechanism associated with said distributor.

4. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump of variable delivery for delivering a metered charge of fuel to each of a plurality of engine cylinders during a complete engine cycle, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, and electrical means for operating said valves in cyclic sequence and substantially in synchronism with the pump delivery whereby each of the cylinders associated with the pump receives its metered charge in predetermined order during a complete engine cycle.

5. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump of variable delivery for delivering a metered charge of fuel to each of a plurality of engine cylinders during a complete engine cycle, an electro-magnetically-operated distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, and means for supplying current to each electro-magnet in predetermined order and substantially in synchronism with the fuel pump delivery.

6. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump of variable delivery for delivering a metered charge of fuel to each of a plurality of engine cylinders during a complete engine cycle, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, a control electro-magnet for each valve, a current supply circuit for energizing said electro-magnets, circuit control mechanism rendering said supply circuit effective substantially in synchronism with the pump delivery, and current distributor mechanism for said electro-magnets associated with said circuit and circuit control mechanism to provide for operating said electro-magnets in predetermined order.

7. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump of variable delivery for delivering a charge of fuel to each of a plurality of engine cylinders during a complete engine cycle, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, a control electro-magnet for each valve, a current supply circuit for energizing said electro-magnets, circuit control mechanism controlled by delivery pressure for rendering said supply circuit effective substantially in synchronism with the pump delivery, and current distributor mechanism for said electro-magnets associated with said circuit and circuit control mechanism to provide for operating said electro-magnets in predetermined order.

8. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump having a valve controlling the passage of fuel to the supply side of the pump to control the amount of fuel delivered by the pump, adjustable electrical control means for said valve whereby to vary the output of the pump, said pump delivering a charge of fuel on each expressing stroke for use in one of a plurality of engine cylinders, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, an electro-magnet for controlling each valve, and means rendered operative upon the closing of said pump valve to supply current to each electro-magnet in predetermined order.

9. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump having a valve to control the passage of fuel to the supply side of the pump to control the amount of fuel delivered by the pump, electrical means to control said valve, a distributor valve for each of a plurality of engine cylinders connected to the discharge side of the pump, means to separately operate said distributor valves in predetermined order, and separately adjustable means to render said last-named means ineffective to open its distributor valve and render said electrical means operative to hold open said first-named valve during a pump delivery period.

10. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump, a valve to control

the passage of fuel to the supply side of the pump to control the amount of fuel delivered by the pump, an electro-magnet to control said valve, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, a control electro-magnet for each distributor valve, means including a current distributor to supply current to said distributor valve electro-magnets in predetermined order, and means for cutting off the supply of current to any of said distributor valve electro-magnets and establishing the supply of current to the electro-magnet of said first-named valve whereby to prevent operation of said distributor valve and open said first-named valve.

11. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump having a valve controlling passage of fuel to the supply side of the pump to control the amount of fuel delivered by the pump, an electro-magnet to control said valve, a distributor valve for each of a plurality of engine cylinders to control the passage of fuel from the pump to its cylinder, means to separately operate said distributor valves in predetermined order, and separately adjustable means to render said last-named means ineffective to open its distributor valve and render said electro-magnet operative to hold open said first-named valve during a pump delivery period.

12. In a fuel feeding system for multi-cylinder internal combustion engines, the combination of a pump having a valve controlling passage of fuel to the supply side of the pump to control the amount of fuel delivered by the pump, electrical means to control said valve, a distributor valve for each of a plurality of engine cylinders to control the passage of fuel from the pump to its cylinder, electrical means to control said distributor valves and cause their operation in predetermined order, and means for operatively associating said two electrical means whereby said pump valve will be held open while any of said distributor valves are closed during a pump delivery period without interfering with the normal operation of said pump and another distributor valve during another delivery period.

13. In a fuel feeding system for internal combustion engines, the combination of a pump having a variable delivery for supplying a metered charge of fuel to each of a plurality of engine cylinders during a complete engine cycle, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, each valve being of the needle type, a spring for each valve holding it closed against delivery pressure, an electro-magnet for each valve co-operating with the delivery pressure to open its valve, and means for energizing said electro-magnets in predetermined order and substantially in synchronism with the effective pump delivery periods.

14. In a fuel feeding system for internal combustion engines, the combination of a pump having a variable delivery for supplying a metered charge of fuel to each of a plurality of engine cylinders during a complete engine cycle, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, a spring to close each valve, an electro-magnet associated with each valve to open it, and means including a source of current, a current distributor, and timing switch mechanism for energizing said electro-magnets in predetermined order whereby separate metered charges of the pump are individually distributed to each cylinder during a complete engine cycle.

15. In a fuel feeding system for internal combustion engines, the combination of a pump having a variable delivery to supply a metered charge of fuel to each of a plurality of engine cylinders during a complete engine cycle, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, an electro-magnet facing and acting directly on the head end portion of each valve, means to energize each electro-magnet whereby to open its valve prior to a pump delivery period and hold it open during said period, and control means for said energizing means whereby said electro-magnets are rendered operative in predetermined order.

16. In a fuel feeding system for internal combustion engines, the combination with a pump of variable delivery for delivering a charge of fuel to each of a plurality of engine cylinders and having a valve to control passage of fuel to its supply side to control the amount of fuel delivered by the pump, means including an electro-magnet to control said valve, a distributor valve for each of said cylinders to control the supply of fuel from the pump to its cylinder, a control electro-magnet for each of said distributor valves, means for energizing said electro-magnets for the distributor valves including a current distributor, and means for associating said current distributor with the electro-magnet of said pump valve to hold it open and prevent operation of one of said distributor valves without interfering with the normal operation of the pump and of said distributor in connection with the electro-magnets of the other distributor valves.

17. In a fuel feeding system, a control device comprising a conduit section, an electro-magnet having one end closing off one end of said section, a valve guide and conduit section detachably secured at one end to the other end of said first conduit section, a

valve seat member detachably secured to the other end of said second conduit section, a valve cooperating with said seat member to control passage of fuel through said conduit sections and slidably mounted in said guide and having an armature portion disposed adjacent the aforesaid end of said electromagnet, and means for closing said valve.

18. In a fuel feeding system for internal combustion engines, the combination of a pump having a variable delivery to supply a metered charge of fuel to each of a plurality of engine cylinders during a complete engine cycle, a distributor valve for each cylinder controlling the passage of fuel from the pump to its cylinder, an electromagnet controlling the operation of each valve, means to energize each electromagnet, in predetermined order, to open its valve prior to a pump delivery period and hold it open during said period, including a source of current, a current distributor and timing circuit control mechanism associated with said distributor.

In testimony whereof, I affix my signature.

LOUIS O. FRENCH.