

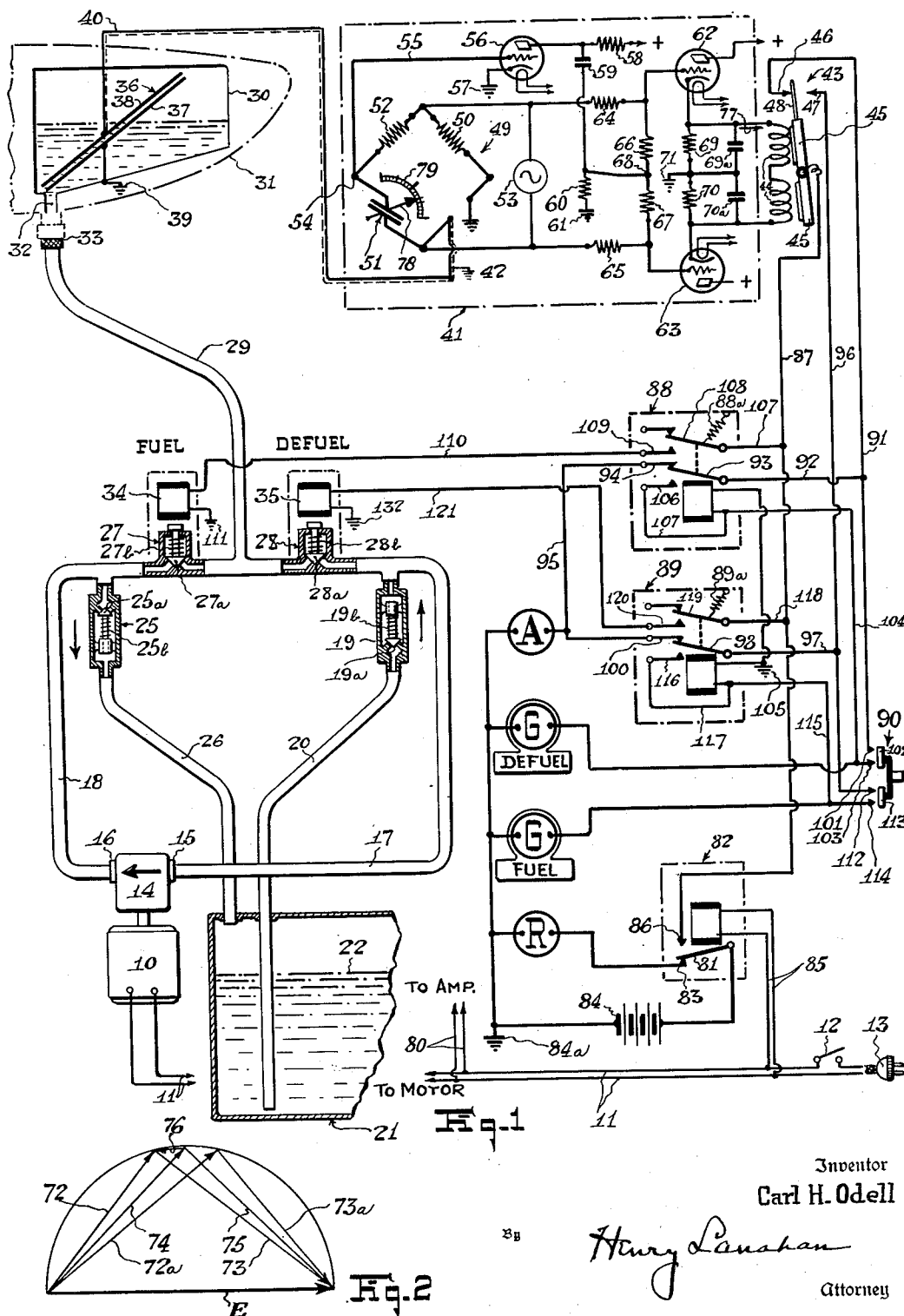
Oct. 20, 1953

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2,655,933

LIQUID-CONTROLLING SYSTEM

Filed April 10, 1948



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UNITED STATES PATENT OFFICE

2,655,933

LIQUID-CONTROLLING SYSTEM

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Application April 10, 1948, Serial No. 20,231

15 Claims. (Cl. 137—392)

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This invention relates to liquid-controlling systems for filling tanks and, more particularly, to automatic systems for filling a tank to a preselected percentage of its total liquid capacity irrespective of the initial contents of the tank. The invention is especially adapted for fueling aircraft tanks, particularly such tanks which have their inlet openings at their under sides, and is herein illustrated and described in terms of such a fueling system.

It is to be noted that the term "filling" is herein used broadly as covering the operation of bringing the liquid in a tank to any predetermined percentage of fill of the tank, and is intended to include either flowing liquid into the tank or removing liquid therefrom, depending upon the initial contents of the tank, in order to bring the percentage of fill of the tank to the desired value.

It is an object of my invention to provide a fueling-control system, adapted especially for under-wing fueling of aircraft tanks, which permits a high rate of flow, is substantially independent of human error and is universal in that it is adapted for filling tanks of any size.

It is another object to provide an automatic system which when manually started will fill the tank and then shut off.

It is another object to provide an automatic system which can be preset to fill a tank to any selected percentage of fill and then shut off.

In the aircraft field it is especially important that each airplane be supplied with a definite amount of gasoline for each flight, which will be sufficient to provide a suitable margin of safety but be not excessive to reduce unnecessarily the pay load of the airplane. Usually, of course, each filling operation is one of adding gasoline to the tank but at times the tank may already contain more than the required amount for the flight so that gasoline has to be removed.

A further object of my invention is to provide a fueling control system which has automatic directional sensing to pump gasoline into the tank when the initial content thereof is less than the preselected percentage of fill and to remove gasoline from the tank when the initial content thereof is greater than that percentage of fill.

Still another object is to provide such fueling control system which has both automatic directional sensing and automatic shut-off.

These and other objects and features of my invention will be apparent from the following description and the appended claims.

In the description of my invention reference is had to the accompanying drawings, of which:

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Figure 1 is a diagrammatic view of circuits and mechanism, with parts broken away and parts shown in section, illustrating a preferred embodiment of my invention; and

Figure 2 is a vector diagram illustrating certain voltage conditions in the control system of the present embodiment.

My invention may be utilized with different hydraulic pumping systems but I prefer to use a system such as is shown in Figure 1. This hydraulic pumping system comprises a motor 10 connected by leads 11 through an on-off toggle switch 12 to an electrical plug 13 which is to be connected to any suitable source of A. C. power. The motor 10 drives a pump 14 which has inlet and outlet ports 15 and 16 connected to respective conduits 17 and 18. The inlet conduit 17 is connected to the outlet end of a one-way valve 19 and the inlet end of this valve is connected to a conduit 20 leading to the bottom of a supply container 21 of gasoline 22. The valve 19 is a conventional one having an internal valve member 19a urged closed under predetermined pressure by a compression spring 19b so that when a given amount of suction is applied to its outlet end the valve will open and allow gasoline to be pumped from the container 21. The outlet conduit 18 of the pump 14 is connected to the outlet end of a one-way valve 25 which, like the valve 19, has an internal valve member 25a urged closed under predetermined pressure by a compression spring 25b. The outlet end of this valve 25 is connected to a conduit 26 which leads to the upper part of the supply container 21.

The inlet and outlet conduits 17 and 18 of the pump 14 are also connected by respective valves 28 and 27 to a conduit 29 which leads to a tank 30 to be filled. In the present instance the tank 30 is shown as being in a wing 31 of an airplane. The conduit 29 is connected to an opening 32 at the bottom of the tank and at the under side of the wing by a fitting 33 suitable for this purpose, such fittings being now well known in the art and which are adapted to allow gasoline to be pumped either into or out of the tank, as desired. The valves 27 and 28 have respective valve members 27a and 28a biased closed by respective springs 27b and 28b. These valve members are moved to open positions against the force of the respective biasing springs by respective solenoids 34 and 35, each solenoid and respective valve being herein sometimes referred to as a "solenoid valve."

The present hydraulic pumping system is one wherein the motor 10 is let run to drive the

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pump 14 continuously not only so long as fueling or defueling is carried out but also whenever the system is on stand-by for immediate use. If the control apparatus herein next described calls for fueling, solenoid 34 is energized to open the valve 27, this being herein sometimes referred to as the fueling valve. For instance, when this condition occurs, and the valve 28 is closed, the suction at the inlet end of the pump will open the valve 19 so that gasoline is drawn from the container 21. The pump 14 overcomes the hydraulic head between it and the tank 30 and forces this gasoline by way of the valve 27 and conduit 29 into the tank. In order that none of this gasoline will be directed back to the supply container through the valve 25, this valve is biased closed with a pressure suitably greater than the maximum pressure head against which the pump is to operate.

If the control apparatus calls for defueling, the solenoid 35 is energized to open the valve 28, this valve being herein sometimes referred to as the "defueling valve". When this defueling valve is open, and the fueling valve 27 is closed, the pump will receive fuel at its inlet from the tank 30 under a pressure head because of the tank being normally above the pump. The pump may however be of higher elevation than the tank 30 so that suction is required to draw the fuel from the tank, it being only required that the pressure with which the valve 19 is biased closed is greater than the maximum suction head ever required at the inlet end of the pump so that the valve 19 will not open to cause the pump to draw gasoline from the container 21 when defueling is desired. The fueling valve 27 is biased closed at a pressure substantially greater than that with which the valve 25 is held closed so that when the solenoid 34 is not energized the gasoline from the pump is forced through the valve 25 back into the supply container.

When the quantity of gasoline in the tank 30 is at the desired value so that neither fueling nor defueling is called for, both of the valves 27 and 28 will be closed as will be hereinafter apparent. The suction head at the inlet end of the pump will then cause the valve 19 to be open and the pressure head at the outlet end of the pump will cause the valve 25 to be held open, with the result that the pump will merely circulate gasoline from the tank by way of the conduit 20 and back into the tank by way of the conduit 26. This circulating of the gasoline occurs when the pumping system is on stand-by for immediate use and represents an ineffective condition of the system. On the other hand, as the valve 27 is opened the system is placed in effective condition for fueling the tank and as the valve 28 is opened the system is placed in effective condition for defueling the tank.

The advantage in controlling fueling and defueling by respective solenoid valves, while leaving the pumping mechanism in operation, is that high rates of flow of the order of 250 gallons per minute or more are permissible and yet substantially instantaneous shutoff of either fueling or defueling, as the case may be, is effected as soon as the respective solenoid valve is closed.

The control apparatus for this pumping system comprises an impedance sensing device in the tank 30 which is adapted to have an impedance value according to the amount of gasoline in the tank. The impedance quantity may be resistive, inductive or capacitive but the last is preferred when the liquid being controlled is

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gasoline. Accordingly, the impedance device may be a suitable electrical condenser having two adjacent conductor elements 37 and 38 with an intervening open space adapted to be filled with gasoline to the level thereof in the tank and with air above this level. These conductor elements are disposed from a lowermost part of the tank to the uppermost part thereof preferably along a so-called gravity line of the tank, which is a line running through the geometric centers of successive horizontal cross sections of the tank. Since gasoline has a dielectric constant of the order of 2 and air has a constant of the order of 1, the electrical capacitance of the tank condenser will vary according to the amount of gasoline in the tank. In fact, it is found that the electrical capacitance varies accurately according to the pounds of fuel in the tank. By having the tank condenser at the gravity line, the capacity thereof is not influenced substantially by the altitude of the tank.

The tank condenser 36 is preferably constructed so that its capacity varies substantially linearly with the pounds of fuel content of the tank, but variations from linearity are permissible and may, if such variations are present, be compensated in other parts of the system if desired. The tank condenser is preferably adapted moreover to have a given overall range of capacity regardless of the size of the tank being served. This is so that the control apparatus is universal to control the percentage of fill of any tank without requiring any pre-adjustment of the apparatus with respect to the size of the tank.

The conductor element 37 of the tank condenser 36 is grounded at 39 and the other conductor element 38 is connected by a shielded lead wire 40 to an electrical control transmitter 41, the shielding of the lead wire being grounded as at 42. This transmitter 41 controls a sensitive master relay 43 which may have, by way of example, one or two field coils 44, two being shown, a pivoted permanent-magnet armature 45, two semistationary contacts 46 and 47 and a cooperating switch pole 48 carried by the armature 45. The armature 45 is biased lightly over center either by magnetic or mechanical means which need not be herein shown. Being of a permanent-magnet nature, the armature will be propelled in one direction to move the pole 48 against one of the contacts 46-47 when current is passed through the coils 44 in one direction and will be propelled to move the pole 48 against the other of these contacts when that current is reversed. The transmitter 41 is adapted to shift the relay 43 from one of its two operate positions to the other to shut off the pumping system—i. e., put it in ineffective condition as above described—when the percentage of fill of the tank 30 reaches the desired value. In a further respect, when directional sensing control is also accomplished, the transmitter holds the relay initially in one or the other of its operate positions depending upon whether fueling or defueling is called for, and then shifts the relay to shut off the system when that fueling or defueling operation, as the case may be, is completed.

The transmitter 41 comprises a resistance-capacity non-frequency sensitive electrical bridge 49 which has two branches in parallel of which one includes the tank condenser 36 and a resistor 50 in series and the other includes a variable condenser 51 and a resistor 52 in series, the two

branches being connected across an oscillator 53 having an output shielded from ground and operated typically at a frequency of the order of 15 kilocycles per second. From the cross arm of the bridge—i. e., from the junction 54 between the condenser 51 and resistor 52 to the diagonally-opposite junction which is the grounded side of the tank condenser 36—there is obtained a signal whose amplitude passes through zero and whose phase reverses as the bridge passes through a condition of balance. This signal is fed by a lead 55 to the grid of an amplifier tube 56. The cathode in this tube is connected to ground at 57 and the plate thereof is connected to a source of D. C. potential through a plate load resistor 58. The amplified signal is led off from the plate through a blocking condenser 59 across a resistor 60 connected to ground at 61.

The signal from the cross arm of the bridge and the signal of the oscillator 53 are applied to a phase detector or demodulator comprising two amplifier tubes 62 and 63 connected as cathode followers in push-pull arrangement. For instance, the oscillator is connected through resistors 64 and 65, which are connected in balanced arrangement, across two resistors 66 and 67 connected in series. The junction 68 between the latter pair of resistors is connected to the resistor 60 receiving the amplified phase-controlled signal above described and the other ends of these resistors 66 and 67 are connected to the grids of the tubes 62 and 63 respectively. The plates of these tubes are connected to a source of D. C. potential, and the cathodes thereof are connected through respective resistors 69 and 70 to ground at 71; also, these cathodes are interconnected through the field coils 44 of the relay 43. The tubes 62 and 63 operate as rectifiers and to improve the efficiency of their rectification condensers 69a and 70a are connected across the respective cathode load resistors 69 and 70.

Typically, the capacity of the tank condenser 36, taken with the stray capacity of the connecting lead wire 40, will vary from 600 to 1000 mmfcs. between empty and full conditions of the tank 30. At a frequency of 15,000 cycles per second, the effective reactance of the tank condenser will therefore vary from about 17,600 ohms to 10,600 ohms. The variable condenser 51 may have the same capacity range, and the resistors 50 and 52 may each typically have approximately 14,000 ohms. When the tank is empty the resistive and capacitive voltage components appearing across the resistor 50 and tank condenser 36 will be approximately as shown by the respective vectors 72 and 73 in Figure 2. The vector E shown in this figure is the voltage of the oscillator 53. When the tank 30 is full these respective voltage components will be approximately as represented by the respective vectors 72a and 73a. Since the impedance elements 52 and 51 of the other branch have respectively the same value and range as have the elements 50 and 36, the voltage components across these elements will vary from 72—73 at one extreme value of the condenser 51 to 72a—73a at the other extreme value of this condenser. If, for example, the condenser 51 is set to the value which the tank condenser 36 has when the tank is half full, the resistive and reactive voltage components across the elements 52 and 51 will be approximately as represented by the equal vectors 74 and 75 in Figure 2. If the tank is now empty, the signal voltage of the cross arm of the bridge

is represented by the vector 76. As shown, this signal is approximately in phase opposition to the voltage E of the oscillator. The tube 56 reverses this phase so that the signal voltage from the cross arm appearing across the resistor 60 is substantially in phase with the voltage from the oscillator 53 appearing across the resistor 66. On the other hand this signal voltage across the resistor 60 is substantially in phase opposition to the voltage from the oscillator appearing across the resistor 67. Accordingly, in this unbalanced condition of the bridge the grid voltage of the tube 62 is substantially greater than that of the tube 63. The rectified pulses of current in the cathode circuit of the tube 62 are therefore greater than are those of the tube 63 with the result that a D. C. current 77 flows through the coils 44 to hold the pole 48 against the contact 46, this being the position of the master relay to place the system in effective condition for fueling as will hereinafter appear.

On the other hand, if the tank is full so that the voltage components 72a and 73a appear across the elements 50 and 36 respectively, and the condenser 51 is still at the same setting corresponding to a half-full tank, the signal voltage of the cross arm will be reversed from that of the component 76. This causes a signal voltage to be applied to the tube 63 which is greater than that applied to the tube 62, with the result that the current 77 is reversed and the pole 48 is held against the contact 47 to place the system in effective condition for defueling.

The variable condenser 51 is manually settable to any desired value within its range and is provided with a pointer 78 and scale 79. The latter is calibrated in terms of percentage fill of the tank, this calibration being such that when the content of the tank reaches the indicated value corresponding to the setting of the condenser the bridge will be substantially balanced. Thus, whether the system is fueling or defueling, the signal voltage of the cross arm of the bridge will be reversed to cause the relay 43 to be thrown to its other operative position as the percentage fill of the tank reaches the value corresponding to the setting of the condenser 51. By this operation of the relay 43 the system is shut off as will appear.

It may here be noted that the transmitter 41 may be adjustable in any one of various ways to cause the relay 43 to operate whenever the percentage fill of the tank reaches a preselected value. Purely by way of example, the condenser 51 may have a fixed value and either of the resistors 50 and 52 may be varied in its stead, it being only necessary to calibrate suitably the resistor so that the bridge passes through a condition of balance as the percentage fill of the tank reaches the value corresponding to the setting of the variable element.

In Figure 1 the leads 80 designated "AMP" are to lead to the transmitter 41 to supply the necessary heater and plate voltages for the tubes 56, 62 and 63 and the oscillator 53, it being understood that the plate voltages are obtained by suitable rectification but which need not be herein described.

When the on-off toggle switch 12 is in "off" position, the armature pole 81 of a relay 82 makes with contact 83 of that relay to connect a battery 84 across a signal lamp R adapted to give a red light to indicate the "off" or inoperative condition of the system, the negative side of this battery being grounded at 84a. When the toggle

switch 12 is thrown to "on" position power is supplied by leads 85 to the relay 82 to cause the pole 81 to make with the other contact 86 of this relay. This shuts off the signal light R and supplies current from the battery 84 by way of the lead 87 to the pole 48 of the master relay 43. This master relay controls two slave relays 88 and 89 according to its positioning, but only when the system is put into operation to fuel or defuel by the operator of the system pressing a manual push switch 90. However, when the push switch 90 is released and the master relay 43 is in fueling position, both as shown, current from the pole 48 is carried by way of the contact 46 and leads 91 and 92 to a pole 93 of the relay 88. The relay 88 is now not energized and is held as by a suitable biasing spring 88a in the position shown. In this position of the relay, the pole 93 makes with contact 94 connected by a lead 95 to a signal lamp designated A having the other side grounded at 84a. Thus, the battery 84 is connected across this lamp by way of the lead 87, pole 48 and contact 46, leads 91 and 92, pole 93 and contact 94 and lead 95. When so energized the signal lamp A gives off a light, for example of amber color, to indicate that the system is in a stand-by ineffective condition wherein the pump 14 is driven continuously merely to circulate the gasoline as above described. Also, the signal lamp A is energized when the toggle switch 12 is in "on" position, the master relay 43 is in defueling position and the push switch 90 is released. For this latter condition, current from the pole 48 of relay 43 is carried by way of contact 47 and leads 96 and 97 to a pole 98 of relay 89. This relay, being now not energized, is held by a biasing spring 89a in the position shown wherein the pole 98 makes with a contact 100 connected also to the lead 95 running to the signal lamp A.

When the push switch 90 is depressed, energizing current is supplied to either relay 88 or 89 depending upon the positioning of the master relay 43. If the master relay is in the fueling position shown in Figure 1, relay 88 is energized by way of the circuit running from ground 84a, battery 84, pole 81 and contact 86 of relay 82, lead 87, pole 48 and contact 46 of the master relay, lead 91 to contact 101 of the push switch 90, cross bar 102 and associated contact 103 of this push switch, lead 104 to the coil of relay 88 and then through this coil to ground at 105. As the relay 88 is thus operated, a holding circuit therefor is completed so that the relay is held in its operated position after the push switch 90 is released. This holding circuit is completed by way of the circuit running from ground 84a through battery 84, pole 21 and contact 26 of relay 82, lead 87, pole 48 and contact 46 of master relay 43, leads 91 and 92, pole 93 and a contact 106 of relay 88, lead 107 and then through the coil of this relay to ground at 105. At the same time as the relay 88 is operated, current is supplied to the solenoid 34 of the fueling valve 27 from the battery 84 by way of the leads 87 and 107, pole 108 and contact 109 of the relay 88, lead 110 and then through the solenoid to ground at 111. Thus, upon depressing the push switch 90 when the master relay 43 is in fueling position, solenoid valve 27—34 is opened to start instantaneous fueling of the tank 30. When the tank becomes filled to the setting of the condenser 51, the master relay 43 is thrown to defueling position wherein pole 48 makes with contact 47. The immediate effect of this operation of the

master relay is to break the abovedescribed holding circuit for the relay 88. As this holding circuit is broken relay 88 is returned to its initial position by the spring 88a to break the current supplied to the solenoid 34 so that the fueling valve 27 will be closed, under influence of its biasing spring, and the pumping system will be restored to ineffective condition.

As the push switch 90 is depressed while the master relay is in defueling position, energizing current is supplied to the slave relay 89 by way of the circuit running from ground 84a, battery 84, pole 81 and contact 86 of relay 82, lead 87, pole 48 and contact 47 of the master relay, lead 96, contact 112, cross bar 113 and contact 114 of the push switch 90, lead 115 and then through the coil of the relay 89 to ground 105. As the relay 89 is thus operated a holding circuit therefore is completed so that the relay is held operated after the push switch 90 is released. This holding circuit is completed by way of the circuit running from ground 84a, battery 84, pole 81 and contact 86 of the relay 82, lead 87, pole 48 and contact 47 of the master relay, leads 96 and 97, pole 98 and contact 116 of relay 89, lead 117 and then through the coil of the relay 89 to ground 105. At the same time as the relay 89 is operated, current is supplied to the solenoid 35 of the defueling valve 28 from the battery 84 by way of leads 87 and 118, pole 119 and contact 120 of relay 89, lead 121, and then through the solenoid 35 to ground 132. Thus, upon depressing the push switch 90 while the master relay 43 is in defueling position, solenoid valve 28—35 is opened to start instantaneous defueling of the tank 30. When the content of the tank falls to the percentage value corresponding to the setting of the condenser 51, the master relay 43 is thrown to fueling position wherein pole 48 makes with contact 46. The immediate effect of this operation of the master relay is to break the abovementioned holding circuit for the relay 89. As this holding circuit is broken relay 89 is returned to its initial position by its biasing spring 89a so as to break the current supply circuit to the solenoid 35 and cause the defueling valve 28 to be closed and place the pumping system into ineffective condition.

In summary of the above operations, it will be understood that each time the push switch 90 is depressed one of the slave relays 88 and 89 is operated to shift the system into effective condition for fueling or defueling according to the positioning of the master relay 43. Also, as soon as the push switch is depressed, a holding circuit which parallels the push switch is completed to hold that one of the slave relays in operated position. However, as the master relay is next operated in response to the bridge passing through a condition of balance, this holding circuit is broken and the system is restored to its ineffective condition.

A lamp marked "Fuel" is connected across the coil of the relay 88 to give a green signal light when the system is in fueling operation. Similarly, a lamp marked "Defuel" is connected across the coil of the relay 89 to give a green signal light when the system is in defueling operation.

If it is desired to have the system operated only for fueling purposes, one need only break the lead 96 so that the contact 47 of the master relay 43 is an idle one. Of course, apparatus not in use, such as the relay 89 and defueling solenoid valve 28—35, together with associated circuits, may be

then dispersed with to simplify the liquid-controlling system.

The embodiment of my invention herein particularly shown and described is illustrative and not necessarily limitative of my invention since the same is subject to changes and modifications without departure from the scope of my invention, which I endeavor to express according to the following claims.

I claim:

1. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total liquid capacity of the tank: the combination of an impedance type sensing device in said tank adapted to have an impedance whose value varies progressively according to the percentage of fill of the tank; an electrical controlling device having two operate positions; electric circuit apparatus operatively coupling said sensing device to said controlling device for shifting the latter between its said operate positions when the impedance of the sensing device reaches a predetermined value; a manually variable impedance remote from said tank operatively included in and influencing said intercoupling apparatus for preselecting a value of percentage fill of the tank at which said controlling device is operated; and liquid-pumping apparatus for said tank controlled by said controlling device.

2. In a liquid-controlling apparatus for causing a tank to be filled to a preselected percentage of the total liquid capacity thereof: the combination of a sensing device in said tank for producing a quantity having values varying with the percentage fill of the tank; a pumping system normally in ineffective condition and including means selectively operable into different effective conditions to cause said pumping system either to pump liquid into said tank or to draw liquid therefrom; a manually-settable device calibrated in terms of percentage fill of the tank; and means for controlling said pumping system comprising manual starting means for putting said pumping system into effective condition, and means controlled jointly by said sensing and settable devices as said starting means is operated for conditioning said pumping system to pump liquid into said tank or to draw liquid therefrom according to whether the actual fill of the tank is smaller or greater than the setting of said settable device.

3. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total liquid capacity of the tank: the combination of a sensing device in said tank for producing a quantity having values varying with the percentage of fill of the tank; a controlling device having two operate positions; apparatus operatively coupling said sensing device to said controlling device for shifting the latter between its said operate positions when the quantity produced by the sensing device reaches a predetermined value; a manually-settable device influencing said intercoupling apparatus for preselecting a value of percentage fill of the tank at which said controlling device is operated; a pumping apparatus including means placeable into respectively effective conditions for supplying liquid to and removing liquid from said tank; means for controlling the effective condition of said pumping apparatus by said controlling device; and manually-operable means for starting effective operation of said pumping apparatus.

4. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total

liquid capacity of the tank: the combination of a sensing device in said tank for producing a quantity having values varying with the percentage of fill of the tank; a controlling device having two operate positions; apparatus operatively coupling said sensing device to said controlling device for shifting the latter between its said operate positions when the quantity produced by the sensing device reaches a predetermined value; a manually-settable device influencing said intercoupling apparatus for preselecting a value of percentage fill of the tank at which said controlling device is operated; a pumping apparatus selectively placeable into an ineffective condition and respectively effective conditions to supply liquid to said tank and remove liquid therefrom; manually-operable means for shifting said pumping apparatus from ineffective to effective condition; means controlled by said controlling device for selecting between said effective conditions according to the positioning of said controlling device as said manual means is operated; and means responsive to said controlling device upon the same being shifted from one operate position to the next while said pumping apparatus is in effective condition for restoring the pumping apparatus to ineffective condition.

5. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total liquid capacity of the tank: the combination of a sensing device in said tank for producing a quantity having values varying with the percentage of fill of the tank; a controlling device having two operate positions; apparatus operatively coupling said sensing device to said controlling device for shifting the latter between its said operate positions when the quantity produced by the sensing device reaches a predetermined value; a manually-settable device influencing said intercoupling apparatus for preselecting a value of percentage fill of the tank at which said controlling device is operated; a pumping apparatus selectively placeable into an ineffective condition and respectively effective conditions to supply liquid to said tank and remove liquid therefrom; manually-operable control means coupled to said pumping apparatus and including a manual control member operable to cause the pumping apparatus to be shifted from ineffective to effective conditions when the manual control member is momentarily operated; and means controlled jointly by said controlling device and said push member for selecting the effective condition of said pumping apparatus when the manual control member is operated and for restoring the pumping apparatus to ineffective condition upon operation of said controlling device after the manual control member is returned to unoperated position.

6. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total liquid capacity of the tank: the combination of a controlling device having two operate positions; means for moving said controlling device from one operate position to the other as the percentage fill of the tank passes through a preselected value; a pumping apparatus placeable into respectively effective conditions to supply liquid to said tank and remove liquid therefrom; means for controlling the effective condition of said pumping apparatus by said controlling device according to the positioning of the latter; and manual means for starting effective operation of said pumping apparatus.

7. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total liquid capacity of the tank: the combination of a controlling device having two operate positions; means for moving said controlling device from one operate position to the other as the percentage fill of the tank passes through a preselected value; a pumping apparatus placeable into an ineffective condition and respectively effective conditions for supplying liquid to said tank and removing liquid therefrom; manual means operable for shifting said pumping apparatus from ineffective to effective condition; and means controlled jointly by said controlling device and manually-operable means for selecting the effective condition of said pumping apparatus according to the positioning of said controlling device as said manual means is operated and for restoring the pumping apparatus to ineffective condition upon said controlling device next moving to the other of its operate positions while said manual means is not operated.

8. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total liquid capacity thereof: the combination of a master electrical relay having two operate positions; means for moving said master relay from one operate position to the other as the percentage fill of the tank passes through a preselected value; a pumping apparatus for said tank placeable into effective and ineffective conditions; a slave relay adapted when in operated position to render said pumping apparatus effective and when in unoperated position to render the pumping apparatus ineffective, said slave relay being normally held in ineffective position; an energizing circuit for said slave relay including a push switch and completed when said master relay is in one of its said positions; and a holding circuit for said slave relay paralleling said push switch and completed only when said slave relay is operated and said master relay is in said other position.

9. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total liquid capacity thereof: the combination of a master electrical relay having two operate positions; means for moving said master relay from one operate position to the other as the percentage fill of the tank passes through a preselected value; a pumping apparatus including two solenoid valves respectively operable to cause said apparatus to pump liquid into and out of said tank; slave relays controlling said solenoid valves respectively and held normally in unoperated positions; a manual push switch; and circuit means connecting said push switch and master relay to said slave relays to cause one or the other of the latter to be operated according to the positioning of said master relay when said push switch is operated and to cause that one slave relay to be restored to unoperated position upon said master relay being next operated while said push switch is released.

10. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total liquid capacity of the tank, said apparatus including a source of potential: the combination of a master electrical relay having first and second operate positions; means for moving said master relay from one operate position to the other as the percentage of fill of the tank passes through a preselected value; a pumping apparatus placeable into respectively effective condi-

tions to pump liquid into and out of said tank; first and second slave relays operable to place said pumping apparatus into its said effective conditions respectively; a manual push switch; and circuit means including said push switch and master relay for connecting said potential source to energize said first slave relay when said master relay is in said first position and said push switch is operated and for connecting said potential source to energize said second slave relay when said master relay is in said second position and said push switch is operated, said first slave relay having a holding circuit completed with said potential source when the relay is operated upon said master relay being in said first position and said second slave relay having a holding circuit completed with said potential source when the relay is operated upon said master relay being in said second position, said holding circuits for said first and second slave relays being broken as said master relay is moved to said first and second positions respectively.

11. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total liquid capacity of the tank: the combination of an impedance-type sensing device in said tank adapted to have an impedance whose value varies with the percentage of fill of the tank; a manually settable impedance element calibrated in percentage fill of the tank; an electrical relay having two operate positions; circuit means including said sensing device and impedance element for causing said relay to shift from one operate position to the next as the percentage fill of the tank passes through the value corresponding to the setting of said impedance element; a pumping apparatus selectively controllable to pump liquid into and out of said tank; and means for controlling the functioning of said pumping apparatus according to the positioning of said relay.

12. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the total liquid capacity of the tank: the combination of an impedance-type sensing device in said tank adapted to have an impedance whose value varies with the percentage of fill of the tank; an electrical relay; an electrical bridge including said sensing device; circuit means controlled by said bridge to hold said relay in one operate position when the bridge is unbalanced in one direction and in the other position when the bridge is unbalanced in the other direction; an impedance element in said bridge adjustable to set the impedance value of said sensing device at which said bridge is balanced; and apparatus controlled by said relay to supply liquid to said tank and remove liquid therefrom according to the direction of unbalance of the bridge.

13. In a fueling-control system for causing a gasoline tank to be filled automatically to a preselected percentage of the total liquid capacity of the tank: the combination of an electrical sensing condenser in said tank adapted to have an electrical capacity variable with the percentage fill of the tank; an electrical bridge including said condenser as one arm thereof; an electrical relay movable between two operate positions; a control circuit including said bridge and adapted to shift said relay from one position to the other as said bridge passes through a condition of balance; a manually-variable impedance element calibrated in percentage fill of the tank and constituting another arm of said bridge to cause the bridge to be balanced when the percentage fill

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of the tank corresponds substantially to the setting of said impedance element; and fuel-pumping apparatus for said tank controlled by said relay.

14. The combination set forth in claim 13 including manually-operable means for starting effective operation of said pumping apparatus, and wherein said relay is adapted to automatically render said pumping apparatus ineffective when the percentage fill of said tank corresponds substantially to the setting of said impedance element.

15. In a liquid-controlling apparatus for filling a tank to a preselected percentage of the liquid capacity of the tank: the combination of a master relay having first and second operate positions; means for moving said master relay from one operate position to the other as the percentage fill of the tank passes through a preselected value; a pumping apparatus placeable selectively into either an effective condition to supply liquid to said tank or an effective condition to remove liquid therefrom; first and second slave relays operable to place said pumping apparatus into said respectively effective conditions; an energizing circuit for said first slave relay including said first operate position of said master relay and a first push switch; an energizing circuit for the other of said slave relays including the other

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operate position of said master relay and a second push switch; common means for operating said push switches; a holding circuit for said first slave relay paralleling said first push switch and completed only when said first slave relay is operated and said master relay is concurrently in its said first position; and a holding circuit for said second slave relay paralleling said second push switch and completed only when said second slave relay is operated and said master relay is concurrently in its said second position.

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