Oct. 25, 1955 A. VAN RYAN ET AL 2,721,969

LINE VOLTAGE REGULATOR

Filed Sept. 11, 1950 2 Sheets-Sheet 1

Fig. 1

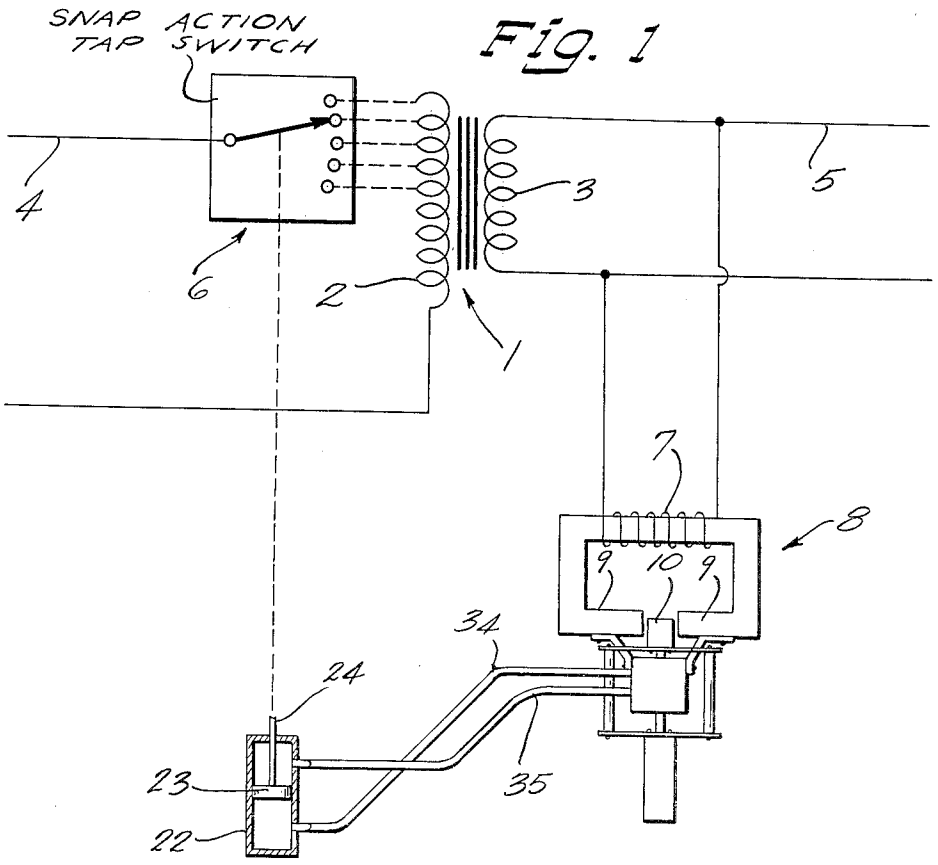
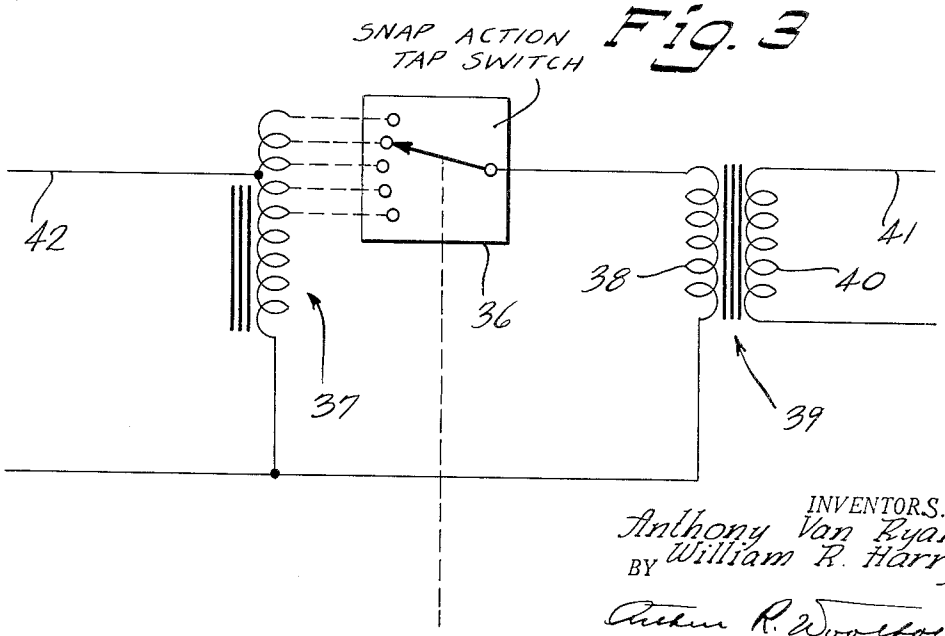


Fig. 3



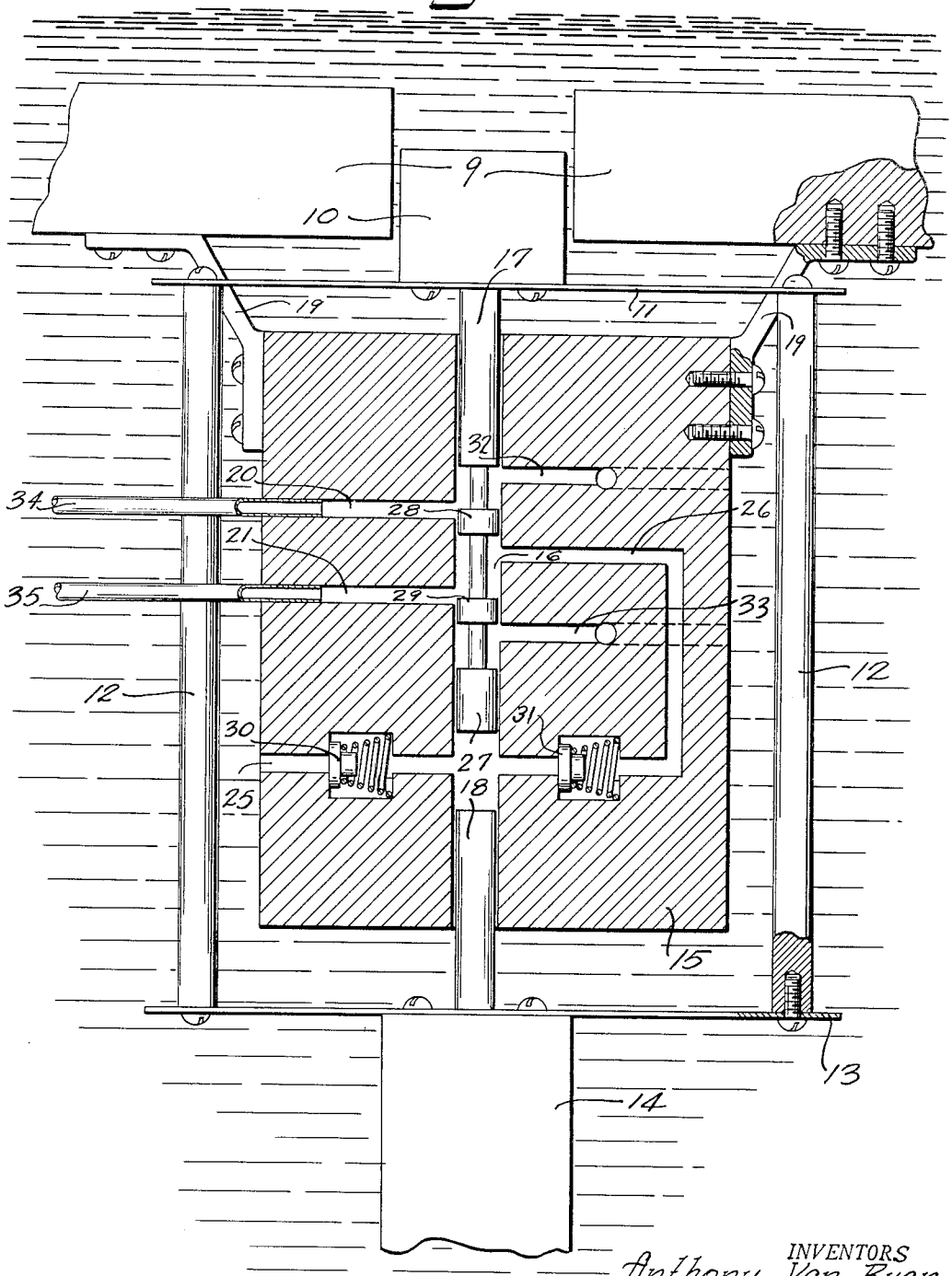
INVENTORS.
Anthony Van Ryan
BY William R. Harry.
Arthur R. Woolfolk
Attorney

Oct. 25, 1955 A. VAN RYAN ET AL 2,721,969

LINE VOLTAGE REGULATOR

Filed Sept. 11, 1950 2 Sheets-Sheet 2

Fig. 2



INVENTORS
Anthony Van Ryan
William R. Harry
BY
Arthur R. Woolfolk
Attorney

United States Patent Office 2,721,969
Patented Oct. 25, 1955

2,721,969

LINE VOLTAGE REGULATOR

Anthony Van Ryan, South Milwaukee, and William R. Harry, Milwaukee, Wis., assignors to McGraw Electric Company, Milwaukee, Wis., a corporation of Delaware

Application September 11, 1950, Serial No. 184,212

6 Claims. (Cl. 323—43.5)

This invention relates to control means and to a system of control and is particularly directed to a system of voltage control, though it is to be understood that in its broader aspect this invention can be followed in the control of different quantities.

Objects of this invention are to provide a control means which does not consume much energy, which is positive and reliable in its operation, and which may be cheaply produced.

Specific objects of this invention are to provide a simple system of voltage control and a simple and easily constructed device for securing such control without the use of auxiliary, expensive, or complicated equipment.

Further objects are to provide an electrical control device which does not have any contacts for the operating or driving mechanism but which instead utilizes an oil pump whose flow may be directed to either end of a cylinder to move an operating piston in either direction and to provide for the discharge of oil from either end of the cylinder, the direction of flow of the oil to and from the cylinder being controlled directly by the pump in response to variations in voltage or some other electrical quantity such as current, reactive volt amperes, or power.

Embodiments of the invention are shown in the accompanying drawings, in which:

Figure 1 is a diagrammatic view showing the system of regulation in which a tap changer is operated from the voltage sensitive device.

Figure 2 is a fragmentary, enlarged sectional view of the pump mechanism for operating the tap changer.

Figure 3 is a diagrammatic view showing a modified form of the invention.

Referring to Figure 1, a transformer has been indicated generally by the reference character **1**. It is provided with a primary **2** and a secondary **3** connected, respectively, to the power line **4** and the load line **5**. A tap changer indicated generally by the reference character **6** is provided on the primary side of the transformer. This tap changer **6** is preferably of the multiple point, snap action type very commonly and widely used.

Across the load or secondary line **5**, the energizing coil **7** of an electromagnetic voltage sensitive device indicated generally by the reference character **8** is connected. This voltage sensitive device is, in reality, a pump and is provided with pole pieces **9** between which an armature **10** is positioned. This armature is arranged to vibrate up and down in the gap between the pole pieces **9** due to the cyclic changes in the alternating current. This structure is most clearly shown in Figure 2 to which attention is now directed. The armature **10** is a magnetic member and is attached to an upper leaf spring **11**, which latter is connected at opposite ends by means of connecting rods **12** with a lower leaf spring **13**. The lower leaf spring **13** is provided with a weight **14**.

The body portion or pump is indicated by the reference character **15** and is rigidly attached to the poles **9**. This

body portion of the pump is provided with a vertically extending passageway or cylinder **16** within which the upper piston **17** and the lower piston **18** are positioned. The upper piston **17** is rigidly attached to the armature **10** and the lower piston **18** is rigidly attached to the weight **14**. The weight **14** provides a suitable mass so that it will not respond to rapid vibrations, due to cyclic variations in the alternating current, and tends to hold the plunger **18** stationary, except as will be described hereinafter. However, the upper piston **17** vibrates with the armature **10** in accordance with the cyclic variations of the alternating current supplied the coil **7**, see Figure 1. The vibrations are axially of the pump and are rapid. The leaf springs and the mass of the weight **14** prevent transmission of this rapid vibration to the weight **14**.

The pump is provided with a pair of passageways **20** and **21** which are connected adjacent opposite ends of the hydraulic work cylinder **22**, see Figure 1. This work cylinder is provided with a piston **23** whose piston rod **24** is operatively connected to the snap action tap changer **6**, so that if the piston is shifted in a manner hereinafter described, the tap changer will select the appropriate tap with a snap action.

An inlet passageway or port **25**, see Figure 2, is provided in the body portion of the pump and this passageway communicates with the upper portion of the cylinder **16** by means of the passageway **26**. However, it is to be noted that the lower portion of the cylinder **16** is the pumping portion of such cylinder as the pumping piston **27**, rigidly attached to the upper piston **17**, vibrates up and down with the armature **10**. Upper and lower slide valve structures indicated by the reference characters **28** and **29**, respectively, are also rigidly attached to or carried by the piston **17** and are, therefore, rigidly connected with the pumping piston **27**.

It is apparent, therefore, that as the armature **10** vibrates, the pumping piston **27** will vibrate and will vary the volume of oil between the pistons **27** and **18**. This variation in volume is utilized to produce a pumping action. A spring pressed inlet valve **30** and a spring pressed outlet valve **31** are provided so that the oil will be drawn inwardly through the inlet passage **25** and delivered through the passage **26** to the space between the upper and lower slide valves **28** and **29**. When the voltage is normal, the valves **28** and **29** close the passageways **20** and **21**. As the voltage drops below normal the entire assembly consisting of the armature **10**, the valves **28** and **29**, the pumping piston **27**, the lower piston **18**, and the weight **14** settles downwardly to the position shown in Figure 2, thus connecting the passageways **20** and **21** with a discharge passage **32** and with the passage **26**, respectively. Under these conditions, oil is pumped through the passage **21** to the upper portion of the work cylinder **22** and oil is allowed to discharge from the lower portion of the work cylinder **22** through the passage **20** and the discharge passage **32**.

This will cause the piston **23** to descend as viewed in Figure 1, and will operate the tap changer **6** to raise the voltage on the load line or secondary line **5**. When the voltage on the secondary line **5** reaches the proper point, the floating assembly namely, the armature **10**, the valves **28** and **29**, the pumping piston **27**, lower piston **18**, and the weight **14** will rise as a unit, and the valves **28** and **29** will close the passages **20** and **21**. If the voltage should rise above normal, the assembly described immediately hereinabove will rise and the valves **28** and **29** will move to such a position as to connect the passage **20** with the passage **26**, so that pressure oil is fed to the lower portion of the work cylinder **22**. Oil is discharged from the upper portion of the work cylinder **22** through the passage **21** to a second discharge passage **33** and the piston **23** is, therefore, forced upwardly thereby shifting

the tap changer **6** and causing the voltage on the secondary line **5** to be lowered to the proper value.

It is to be noted that the passageways **20** and **21** are connected by means of pipes **34** and **35** with the lower and the upper end of the work cylinder **22**.

The invention may take other forms. For example, the tap changer on the transformer may be dispensed with and instead a tap changer **36**, see Figure 3, may be arranged to selectively connect taps of an auto-transformer **37** to the secondary **38** of a transformer **39** whose primary **40** is connected to the power line **41**. The load line is indicated by the reference character **42**.

It is to be noted particularly that the voltage sensitive device does not require the use of contacts or auxiliary relays or equipment of this general type. Instead, the voltage sensitive device is in the form of an electromagnetic pump and is complete in itself and determines the direction of motion of the actuated or driven member automatically and without any assistance from any outside apparatus.

It is to be understood that the voltage sensitive device is submerged in oil as indicated in Figure 2. For example, if desired, the voltage sensitive device could be submerged in oil in the same compartment that houses the tap changer or it could be submerged in oil in a separate compartment.

It is also within the scope of this invention to so proportion various parts of the device that resonance is approximated approaching the 120 cycle period of the armature. For example, the mass of the armature and its attached parts and the upper spring **11** may be so proportioned as to approximate resonance to the cyclic variation in pull exerted on the armature, allowance of course being made for the fact that the device is submerged in oil.

It is to be distinctly understood that although the device has been shown as a voltage sensitive device, it can respond to widely different quantities, such as voltage as described, or current variations or power variations or reactive voltage ampere variations. Also, it is to be understood that the working piston or power operated member driven from the sensitive device can be used to effect other changes than that produced by a tap changer. For instance, it could be made to do any kind of mechanical work desired to cause operation of voltage control mechanisms, such as tap changers, as shown, or induction regulators, or other devices.

It is to be noted that there is a direct coaction between the pump whose piston has the rapid vibrations and small volume per stroke and the relatively large work cylinder. The parts are so arranged that the small diameter pump piston will produce a relatively high oil pressure which, acting on the relatively large work piston, will produce powerful thrust for operating the tap changer or other mechanism to which it may be connected. There is also, a definite cooperation between the parts of the device for the small piston will have to execute a large number of vibrations before the tap changer moves to a new tap and thus the device will not respond to every transient disturbance on the line. It will only respond to a sustained demand for an appreciable interval of time as compared with the interval of transient disturbances. This coaction prevents needless and undesirable operation of the device.

It is to be noted particularly that the device is, as stated, self-contained and has the two main characteristics of furnishing the power for operating the driven member and also inherently controlling the direction of the motion of the driven member and that the device is automatically controlled or operated due to variations in any one of the above given quantities.

Although this invention has been described in considerable detail, it is to be understood that such description is intended as illustrative rather than limiting, as the invention may be variously embodied and is to be interpreted as claimed.

We claim:

1. An alternating current system of control for controlling an electrical quantity, adjustable control means for controlling said quantity, a work cylinder, a piston in said work cylinder for adjusting said control means, an electromagnetic vibratory pump actuated by the cyclic variations in the alternating current for selectively pumping liquid into either end of said work cylinder in accordance with variations of said quantity above and below a predetermined value, said pump having a single field structure and a single armature for both the pumping operation and for selectively determining which end of the work cylinder receives fluid from the pump.

2. An alternating current system of control for controlling the voltage, adjustable control means for controlling said voltage, a work cylinder, a piston in said work cylinder for adjusting said control means, an electromagnetic vibratory pump actuated by the cyclic variations in the alternating current and including an armature and a field structure, said pump including movable valve means controlled by the strength of the magnetic flux in said field structure for selectively directing liquid from said pump into either end of said work cylinder in accordance with variations of said voltage above and below a predetermined value.

3. An alternating current system of control comprising an adjustable voltage control means, a hydraulic work cylinder, a piston therein for adjusting said voltage control means, an electromagnetic vibratory pump actuated by the cyclic variations of the alternating current for selectively pumping liquid into either end of said work cylinder in accordance with variations in voltage above or below a predetermined value, said work cylinder being relatively large in comparison to said pump, whereby said pump will execute a multitude of vibrations before an appreciable change in the adjustment of said voltage control means is produced to thereby prevent unwanted adjustments of said voltage control means as a result of transient disturbances.

4. In an alternating current electric system comprising an electric line, the combination with said line of a continuously operating unidirectional electromagnetic motor energized continuously from said line and having three positions of continuous operation, one of which is a neutral position and the remaining two positions determining the direction of energy take-off of said motor, said motor being responsive to cyclic variations in said electric line and delivering energy due to said cyclic variations and assuming any of said three positions responsive to the magnitude of the voltage in said line, and energy take-off mechanism operated by said motor in either of the said remaining two positions and operated due to said cyclic variations in said line.

5. In an alternating current electric system, the combination of system regulating means for regulating an electrical quantity of said system, a continuously operating electromagnetic motor energized continuously from said system and having three positions of continuous operation, one of which is a neutral position and the remaining two positions determining the direction of energy take-off of said motor, said motor being responsive to cyclic variations in said system and delivering energy due to said cyclic variations and assuming any of said three positions responsive to the magnitude of the alternating current quantity regulated by said system regulating means, and energy take-off mechanism operated by said motor and operated due to said cyclic variations in said line when said motor is in either of the said remaining two positions, said system regulating means being actuated from said energy take-off mechanism.

6. In an alternating current electric system having a transformer connected to an input and an output electric line, the combination of an adjustable regulating device connected to one of said lines for regulating the output voltage, a continuously operated electromagnetic motor

energized continuously from one of said lines and having three positions of continuous operation, one of which is a neutral position and the remaining two positions determining the direction of energy take-off of said motor, said motor being responsive to cyclic variations in one of said lines and delivering energy due to said cyclic variations and assuming any of said three positions responsive to the magnitude of the voltage in the output line, energy take-off mechanism operated by said motor and operated due to said cyclic variations in said line when said motor is in either of the said remaining two positions, said adjustable regulating device being actuated from said energy take-off mechanism to control the magnitude of the voltage in said output line.

References Cited in the file of this patent

UNITED STATES PATENTS

1,897,490	Nobel et al.	Feb. 14, 1933
2,009,383	Blume	July 30, 1935
2,239,768	Artzt	Apr. 29, 1941
2,324,822	Champlin	July 20, 1943
2,374,593	Ernst et al.	Apr. 24, 1945
2,453,451	Moseley	Nov. 9, 1948

FOREIGN PATENTS

311,247	Germany	Mar. 13, 1919