PUBLISHED

APRIL 27, 1943.

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DEVICE FOR CONVERTING A CONTROLLING IMPULSE INTO AN ALTERNATING CURRENT IMPULSE

Filed Sept. 5, 1939

Serial No. 293,523

2 Sheets-Sheet 1

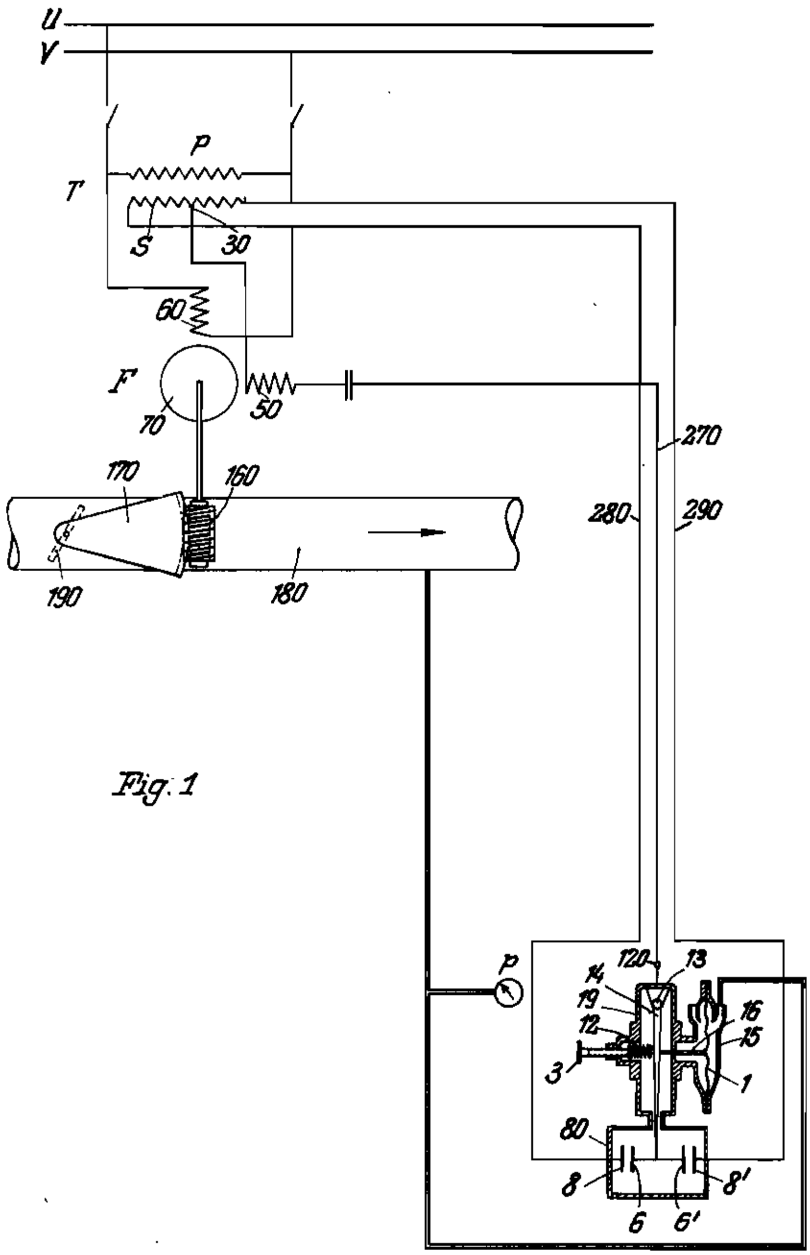

Fig. 1

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Fig. 2

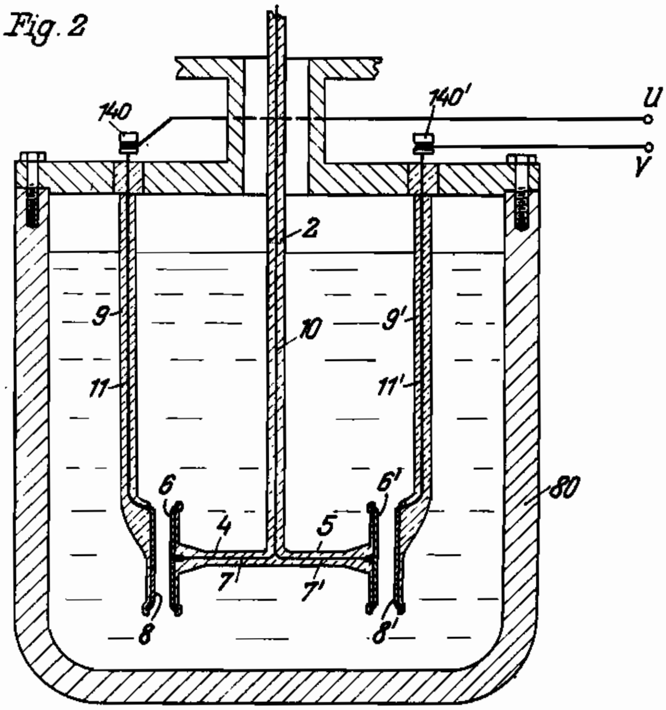


Fig. 3

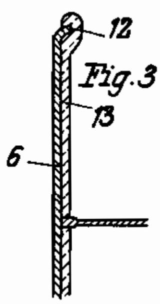


Fig. 4

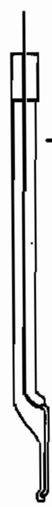
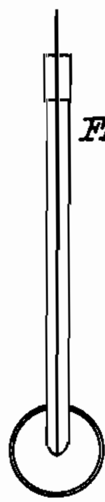


Fig. 5



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ALIEN PROPERTY CUSTODIAN

DEVICE FOR CONVERTING A CONTROLLING IMPULSE INTO AN ALTERNATING CURRENT IMPULSE

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Application filed September 5, 1939

The invention relates to improvements in devices in which an auxiliary force is controlled by measuring or regulating impulses for obtaining corresponding impulses of the auxiliary force. In particular the invention refers to devices of this kind in which a controlling impulse is to be converted into an electric current impulse. Such devices are specially suitable for controlling a physical condition, as for instance a temperature, a pressure, a quantity of a flowing medium, or for remote-transmission of a controlling impulse, such as a measuring or regulating impulse, as in such cases it is often necessary to adjust a controlled member, for instance an electric motor, in dependence on a controlling impulse.

The first object of the invention is to render the device suitable for converting even small impulses of any kind into considerably amplified electric a. c. impulses with a view to dispensing with additional current amplifying means. Furthermore the invention relates to the construction of the device so as to increase its reliability during operation and the accuracy of the measurement over the entire measuring range.

A further aim of the invention is to avoid in the device any reacting force prejudicially affecting the accuracy of the conversion of the controlling impulse.

The invention is more fully explained with reference to the accompanying drawings, of which

Fig. 1 shows an embodiment of the invention in which the device is designed for regulating purposes;

Fig. 2 shows a part of the device according to the invention in vertical section and in approximately natural size;

Fig. 3 represents a detail of the arrangement of Fig. 2 in cross section and on enlarged scale;

Figs. 4 and 5 show a further detail of the arrangement according to and on the same scale as Fig. 2 in two aspects, one representing a front view and one a cross section;

Fig. 6 shows a modification of the device according to the invention designed for remote-transmission of measuring values, while

Fig. 7 shows a part of the device according to Fig. 6 in vertical section and approximately natural size.

Fig. 1 shows diagrammatically an arrangement for maintaining a constant pressure in the conduit **180** by means of the throttle **190**. *p* stands for controlled pressure behind the throttle **190**. A pressure responsive means **15** having a diaphragm **1** acted upon by the pressure *p* is secured to the relay casing **19**. The motion of this diaphragm is transmitted by means of a pin **18** to a lever **14** which is mounted in the casing **19** for movement around the axle **13**. A spring **12** counteracts the pressure *p*, the counter-acting force of the spring being adjustable by means of a manipulated screw **3** screwed into the casing **19**. The lower part of the relay casing **19** is constructed as a vessel **80** filled with an electrolyte. The lever **14** carries at its lower end two electrode plates **8**, **6′** being electrically connected to and remote from one another. These electrodes are electrically connected, by means of a conductor in the interior of the lever **14**, to a terminal **120**. Each of the electrodes **6**, **6′** faces one of two outer electrodes **8**, **8′** which are rigidly connected to the wall of the vessel **80**. The four electrodes are arranged in such a manner that the center electrodes **6**, **6′** may be moved relative to the outer electrodes **8**, **8′** in two opposite directions. The outer electrodes **8**, **8′** are connected by mains **260**, **290** parallel to the center tapped secondary winding S of a transformer T, the primary winding P of which is fed by the a. c. power source U, V. For the purpose of adjusting the throttle **190**, a Ferraris motor F is provided. The Ferraris motor conventionally has two magnetic exciting field windings **50**, **60** arranged vertically to each other. The winding **50** of the Ferraris motor is connected by a main **270** between the terminal **120** of the center electrodes **6**, **8′** and the center tap **30** of the secondary transformer winding S. In this arrangement the device **80**, **6**, **6′**, **8**, **8′** acts as a potentiometer. The other winding **60** of the Ferraris motor is directly connected to the a. c. network U, V. The rotor **70** of the Ferraris motor F moves a worm **160** which engages a worm wheel segment **170** connected to the throttle, a movement of the worm **160** causing a movement of the segment **170** and consequently a movement of the throttle **190**.

The spring **12** is so adjusted that the center electrodes **6**, **6′** have at a certain pressure approximately the same distance with respect to the outer electrodes **8**, **8′**, i. e. zero potential. In this case the voltages between each of the electrodes **6**, **6′** and each of the corresponding outer electrodes **8**, **8′**, respectively, are equal, so that no current flows through the exciting winding **50** of the Ferraris motor. As soon as the pressure changes, the lever **14** is displaced to the left or right and therefore a voltage is produced between the center electrodes **6**, **6′** and the center tap **30** of the transformer T, the amount and phase of which corresponds to the amount and direction of the displacement of the lever from its initial position. In consequence thereof a current flows through the winding 50, the intensity and the phase of this current determining the rate and direction of the movement of the Ferraris motor. If the pressure at 15 is too large, the throttle 190 is moved by the Ferraris motor towards its closing position or vice versa.

The construction of the vessel containing the electrodes is more fully explained with reference to the drawings 2–5. As shown in Fig. 2, a supporting rod 2 of insulating material, preferably glass, is connected to the free movable end of the lever 19. The supporting rod 2, into which a conducting wire 10 is fused, possesses at its lower end two lateral extensions 4, 5 of glass, each of which encloses a conducting wire 7, 7', respectively, which are connected to the conducting wire 10. The lateral ends of the conducting wires 7, 7' carry the electrode plates 6, 6', said electrode plates 6, 6' forming together the center electrode. Each of the electrodes 6, 6' at a distance of about 3 mm faces one of the respective outer electrodes 8, 8' which are carried by the glass supporting members 9, 9' rigidly secured to the walls of the vessel 80. Two conducting wires 11, 11' fused into the glass supporting members 9, 9' are connected to the electrodes 8, 8', respectively, on the one hand and on the other hand to the terminals 140, 140', respectively, on the walls of the vessel 80, while the conductor 10 of the center electrodes 6, 6' is connected to the terminal 120 (Fig. 1). All electrodes are insulated on the reverse and at the edges, as may be seen in particular from the representation in Fig. 3 showing the mode of insulation of one of the center electrodes (6) in cross section on enlarged scale. The edge 12 of the electrode 6 is bent backwards. 13 represents a glass layer at the back of the electrode, which layer also encloses the edge 12. Figs. 4 and 5 show one of the fixedly mounted electrodes 8, 8' in two different views on the same scale as Fig. 2. This arrangement has the advantage that the a. c. power may be controlled practically free from an undesired reacting force, as the displacement of the movable electrodes is very small and friction between contacts non-existent. The device may be controlled by any kind of mechanical impulse; such mechanical impulses may likewise be derived by way of conversion of an electrical impulse shifting the movable electrodes of the liquid resistance, for example by electromagnetic means. By constructing the center electrodes of two electrically connected remote parts 6, 6', each facing a fixed electrode 8, 8', respectively, a considerable reduction of waste current between the two outer electrodes is achieved. In addition, the inevitable heat production is distributed over two places separated in space which favors the heat exchange in the surrounding liquid.

By insulating the reverses of the electrode plates it is ensured that the current flows only between the immediately juxtaposed surfaces of outer and center electrodes and no current is produced between the reverses of the opposed electrodes. The insulation of the electrode edges prevents a higher current density at these places than between the electrodes immediately facing each other. Thus the current flows only between the facing electrode surfaces with approximately the same current density. Consequently the steepness of the characteristic of the relay, i. e. the dependence of the controlled current fed by the center electrode on its displacement of the latter, is enhanced, which is of great importance for the operation of the relay. The insulating glass layer is fused on to the electrodes which latter are advantageously made of platinum black.

If it is desirable to avoid the loss of power occurring between the center electrode 6'' and the outer electrode 8'' not furnishing the controlled voltage and the heat development caused thereby, the relay system may be formed as shown in Fig. 6. This figure shows the relay built in a device for remote-transmission of a measuring value such as a quantity of a flowing medium. 90 represents a conduit line through which passes a medium in the direction of the arrow and the quantity of which has to be measured. 91 is an orifice plate in the line 90, the difference in pressure between the two sides of the orifice plate acting upon the differential pressure meter 100. The slack diaphragm 101 of this meter acts by means of a rod 92 upon a liver 94, rotatably mounted at 95, in the immediate vicinity of the pivot point of said lever. The lower end of the lever 94 carries an electrode 96 facing a fixedly mounted electrode 87 in such a way that the distance between the two electrodes may be varied if the lever is deflected. Both electrodes are immersed in a vessel 98 filled with an electrolyte. The liquid resistance created between the two electrodes is connected in series with a resistance 99 in the form of an induction coil. This series connection is supplied with electric energy by the a. c. network U, V. The a. c. voltage drop between the two electrodes resulting from a movement of the lever 94 in response to a measuring impulse is connected to the primary winding P_1 of the transformer T_1, the secondary winding S_1 of which feeds a full-wave rectifier R.

A coil 102 is secured to the upper end of the lever 94 thus forming a long lever arm. A fixed electro-magnetic coil 103 is provided, in whose field a coil 102 is movable. A series connection exists betweeen the output terminal 104, 105 of the rectifier R, the coils 102 and 103 and a d. c. meter 108 which is connected to coil 103 by the main F_1 and to the terminal 105 of the rectifier R by the main F_2.

The force delivered by the dynamometric system 102, 103 is proportional to the square of the d. c. flowing in the measuring circuit and counteracts the force acting upon the diaphragm 101 of the differential pressure meter 100. The counteracting force due to the displacement of the diaphragm 101 in response to the differential pressure increases until equilibrium is established between the counteracting force and the differential pressure. The d. c. in the measuring circuit consequently is an exact measure of the square root of the differential pressure. The differential pressure being proportional to the square of the quantity flowing through the orifice plate, i. e. the quantity to be measured being thus proportional to the square root of the differential pressure, the deflections of the electricity meter 106 are a measure of the total quantity flowing through the conduit during a certain period of time.

In the arrangement according to Fig. 6 the heat development in the liquid resistance is reduced to the unavoidable amount. By using the induction coil 99 in line with the liquid resistance, the power loss of the wiring arrangement may be further decreased to a considerable extent as compared with the utilizing of a liquid potentiometer as part of the relay.

Fig. 7 shows in detail the lower part of the relay shown in Fig. 6 in approximately natural size. The distance between the two electrodes 96, 97 is about 6 mm. The construction of the electrodes and of the supports for the electrodes exactly correspond to the construction shown in Fig. 2.

Experience has shown that a power of up to 30 watt may be obtained between the electrodes of the relay of the above described construction and of the size shown in Figs. 2 and 7.

Due to the loading of the current and the limited cooling, the electrolyte—if consisting of the usual aqueous solutions, as for instance a sodium chloride solution—is subject to a considerable rise of temperature, while its conductivity increases with increasing temperature. This causes an increase in the load current and an additional rise of temperature. Thus the heating of the liquid may easily reach an undesirable degree. This is due to the fact that the conventional aqueous solutions possess a positive temperature coefficient of electric conductivity, i. e. that their conductivity increases with a rising temperature.

This drawback may be eliminated by the use of a liquid of a constant or negative temperature coefficient. This results in the electric conductivity not changing with the temperature or its decreasing with a rising temperature. In any case, the load remains independent of the temperature. Such liquids are, for instance, a mannite-boric acid solution in the proportion of 121.1 g. of mannite and 41.2 g. of boric acid in a solvent of 1 liter of distilled water. The conductivity of this solution is 0.000953 cm^{-1} Ohm^{-1} at 18° C.

Even when using an a. c. of 50 periods or more, it is advantageous to operate with as low a tension as possible in order to avoid electrolytic decomposition and changes in the electrodes. The conductivity may be considerably enhanced by the addition of potassium chloride to the mannite-boric acid solution in the above-mentioned proportion. Fig. 8 shows the dependence of the conductivity on the temperature with reference to different additions of potassium chloride, while Fig. 9 shows the corresponding course of the temperature coefficient. If accordingly the addition of 0.125 g. of potassium chloride is chosen, the result is a solution of the greatest possible conductivity, possessing at the same time a negative temperature coefficient at a temperature lying above the operating temperature of about 48°. The conductive values of these solutions are as follows:

k=0.00118 cm^{-1} ohm^{-1} at 18° C
k=0.00123 cm^{-1} ohm^{-1} at 48° C (maximum)
k=0.00122 cm^{-1} ohm^{-1} at 65° C
k=0.00120 cm^{-1} ohm^{-1} at 85° C

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