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O. GREBE ET AL

2,988,614

HIGH SPEED REVERSING SWITCH

Filed April 17, 1959

2 Sheets-Sheet 1

Fig. 1

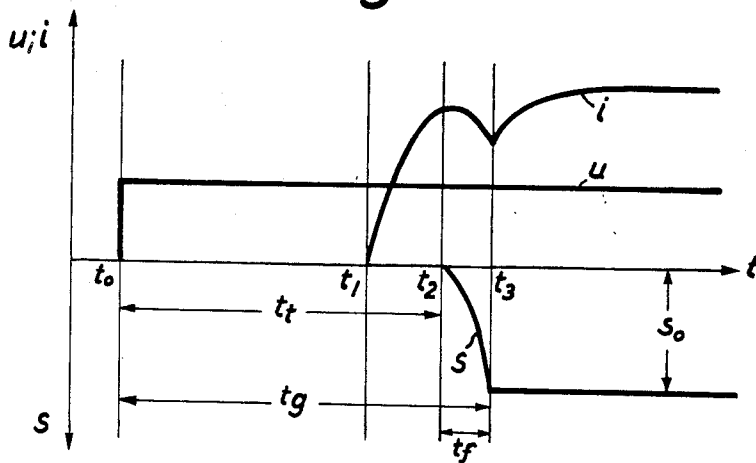
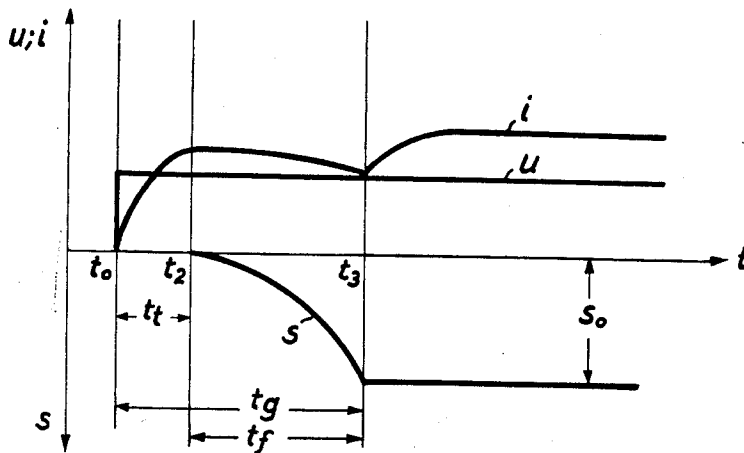


Fig. 2



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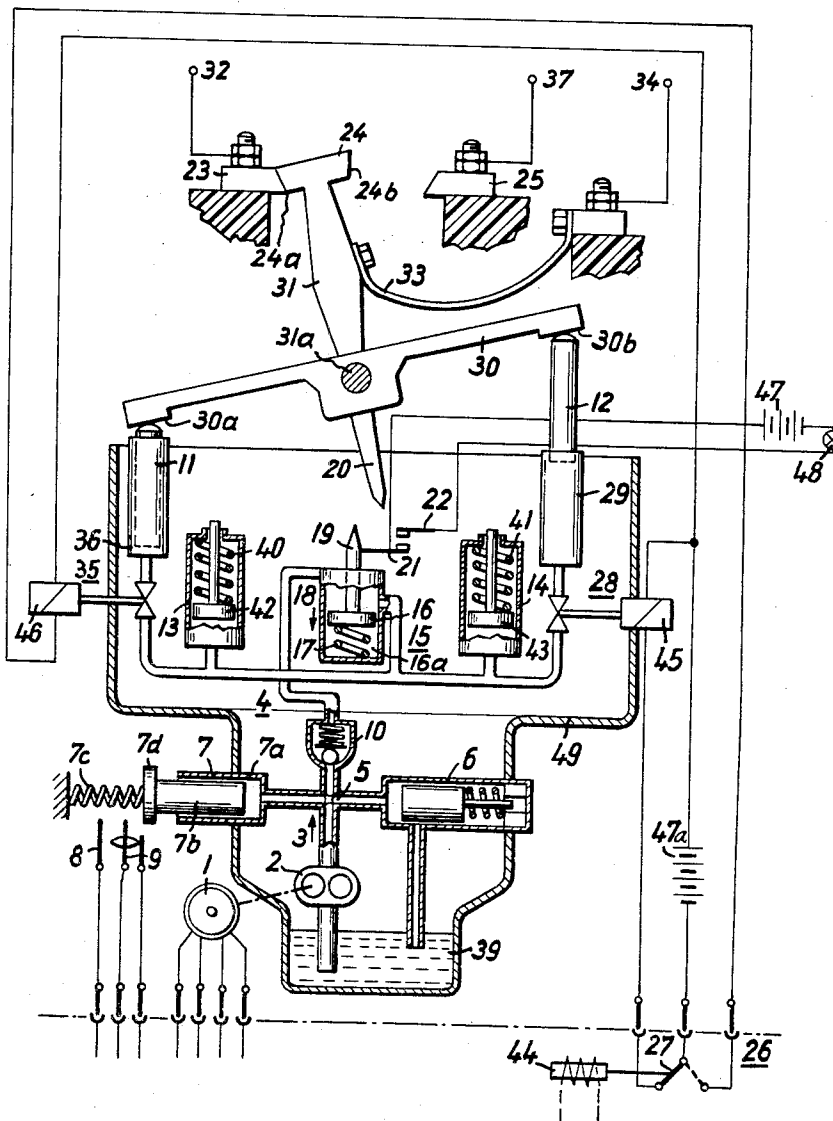
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Fig. 3



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HIGH SPEED REVERSING SWITCH

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6 Claims. (Cl. 200—82)

The present invention relates to circuit breakers. More particularly, the present invention relates to high-speed reversing switches adapted for high currents and a great frequency of operation.

It is known to use D.C.-current motors for driving heavy rolls or drums and conveying devices. When used for that purpose the sense of rotation of the motor must be very frequently reversed. The process for reversing the sense of rotation is initiated by reversing the polarity of the D.C.-current motor. In order to effect this, it is necessary to interrupt comparatively great currents. In addition, the requirements of automatic control call for a speedy operation of this reversing process, and the circuit making and breaking of the elevated currents has to be effected in a comparatively short time, for example, in the order of 50 milliseconds.

In order to meet these requirements, quick reversing switches have been devised comprising a rocking lever mounted on a rotatable shaft. The rocking lever is actuated, thereby turning the shaft by a certain angle. The shaft bears further levers which are provided with contacts for making the desired circuit connections.

In these known quick reversing switches the rocking lever is actuated by electromagnets. Comparatively great electromagnets have to be used and they require a comparatively great amount of energy for being actuated since the masses of the levers to be actuated are comparatively great and a great torque is required in order to accelerate the shaft with the levers. In view of the great amount of energy consumed by these electromagnets the making of the exciting current has to be effected with the aid of special intermediate relays.

The known quick reversing switches suffer from great disadvantages. A comparatively great deadtime occurs between the input signal produced by switching in the intermediate relays on the one hand and the moment in which the contacts are lifted. The entire switching time is composed of the time used for switching the intermediate relay, the time which is required for raising the magnetic field of the quick reversing switch to the desired value and the flying time proper of the contacts, the latter being determined by the interval between the moment in which the contacts are first lifted and the moment in which the movement is ended. This total switching time must not exceed a predetermined length following the particular requirements of automatic control. Accordingly, the flying time of the contacts should be very short. This, in turn, calls for elevated accelerating forces and, furthermore, results in a high speed of the movement of the contacts. Consequently, the latter are subject to particular strain and wear due to the great impact when hitting against each other. The bearings of the switches as well as the contacts and the locking members of these known quick reversing switches are, therefore, easily worn and the service life of the known devices is undesirably short.

It is an object of the present invention to provide a quick reversing switch adapted for high currents and a great frequency of operation in which the total switching time is greatly reduced compared with known devices.

It is another object of the present invention to provide a quick reversing switch adapted for high currents and a great frequency of operation in which the share of the

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dead time is smaller and the fling time of the contacts is greater than in known devices, while the total switching time is greatly reduced.

It is a further object of the present invention to provide a quick reversing switch adapted for high currents and a great frequency of operation in which the movement of the contacts making and breaking the circuit is slower than in known devices and wherein the impact of the contacts when hitting each other is greatly reduced.

It is still another object of the present invention to provide a quick reversing switch adapted for high currents and a great frequency of operation in which the wear of the various elements of the switch and particularly the bearings and the contacts is greatly reduced, and the service life of the entire device is considerably lengthened.

It is still a further object of the present invention to provide a quick reversing switch adapted for high currents and a great frequency of operation in which an oil pump can be used having a much smaller conveying capacity than the oil pumps used in the known devices, thereby greatly reducing the costs of production and operation of the device and greatly lengthening the service life of the pressure oil.

Still a further object of the present invention is to provide a quick reversing switch adapted for high currents and great frequency of operation in which the locking device is rarely used, thereby greatly lengthening its service life.

These objects as well as further objects and advantages, which will become apparent as the description of the present invention proceeds, are accomplished by the high-speed reversing switch of the type adapted for operation of high currents and with a great frequency of operation of the present invention, which switch comprises and is actuated by a hydraulic driving system, whose operation is controlled by an electromagnetic control system.

Furthermore, there can be provided hydraulic-mechanical locking means for stopping the operation of the hydraulically operated switch.

Preferably, the hydraulic driving system comprises an oil pump having a capacity capable of providing but a small fraction of the pressure medium which is needed for the operation of the high-speed reversing switch. The other, large portion needed for that purpose, is furnished by at least one pressure reservoir provided according to the invention in the hydraulic driving system.

The invention will be more fully appreciated upon the following detailed description of the accompanying drawings, wherein

FIGURE 1 is a diagram illustrating the total switching time and the ratio of the switching time of the intermediate relays, the flying time of the contacts and the dead time in conventional high-speed reversing switches.

FIGURE 2 is a diagram illustrating the total flying time and the ratio of the switching time of the relays, of the flying time, and the dead time in the greatly improved high speed reversing switch of the present invention.

FIGURE 3 is a side elevational view, partly in section, of the high speed reversing switch of the present invention.

Referring now to the drawings somewhat more in detail and turning first to FIGURE 1, in the conventional devices the switching of the intermediate relay starting the excitation of the magnet for the reversing switch takes the interval t_0-t_1 , the operation of the relay being ended at t_1 . At this moment current is supplied to the magnetic coil of the high-speed reversing switch. Consequently, the current in the magnetic coil rises according to the diagram $i=f(t)$. At the moment indicated by

t_2 , that is after the interval t_1-t_2 has elapsed, the current has reached the requisite value for starting to move the contacts of the switch. The flying time of the contacts thus starts at t_2 and is ended at t_3 . It will be easily seen from the diagram shown in FIGURE 1 that the interval t_2-t_3 is comparatively short. During this time the contacts have covered the distance s_0 . The time interval t_0-t_2 designated as the dead time is much greater than the time interval t_2-t_3 constituting the flying time. The exciting voltage and the exciting current (i and u) are also shown in the diagrams.

The high-speed reversing switch of the present invention comprises the electric motor 1, the oil sump 39, and the oil pump 2. The pipe conduit system 4 branches off after the oil pump as at 5, one branch leading to the pressure relief valve 6, the other branch leading to the pressure control device 7, comprising the cylinder 7a housing the piston 7b, the latter being connected to a counter pressure spring 7c. The pipe conduit system also connects the oil pump 2 and the valve 6 and the control device 7 with check valve 10. It further communicates with the cylinders 29 and 36, respectively via the pressure reservoirs 13 and 14 and the electromagnetic control valves 35 and 28, respectively. The valves 28 and 35 comprise magnetic coils 45 and 46, respectively, supplied with current from an accumulator 47a.

Within the pressure reservoir cylinders 13 and 14 there are provided the pistons 42 and 43, and the pressure springs 40 and 41, respectively, tending to push the pistons 42 and 43 in downward direction.

The cylinders 29 and 36 house pistons 12 and 11, respectively. Associated with the cylinder and piston means 12, 29 and 11, 36 there is provided a rocking lever 31 ending in a downwardly projecting pin 20 and having, at its uppermost end, the contact 24 with lateral contact faces 24a and 24b. This rocking switch lever is fulcrumed at 31a and bears a transverse beam 30, the latter bearing, at its respective outer ends, the faces 30a and 30b adapted to come into contact with the pistons 11 and 12, respectively. Associated with the contact 24 of the rocking lever 31 there are provided the fixed contacts 23 and 25 connected with the terminal 32 and 37, respectively, and adapted to contact the contact faces 24a and 24b, respectively. The flexible wire 33 is connected with its one end to the rocking lever 31 leading with its other end to the terminal 34.

Furthermore, there is provided a locking device 15 adapted for arresting the movement of rocking lever 31 and communicating the pipe conduit system 4. It comprises the cylinder 16a housing piston 16, the latter being connected with one end of the counter pressure spring 17 and bearing at its other end a rod 19 upwardly projecting in the direction in which there extends the downwardly projecting pin 20 of the rocking switch lever 31. The rod 19 can be connected with the contacts 21 and 22 of an alarm circuit, further comprising a suitable current source as, e.g. the accumulator 47, and a signal device, e.g. the signal lamp 48, connected in series with the accumulator 47.

In the circuit connecting the electric motor with the contacts 8 and 9 and the electromagnetic valves 28 and 35 provision is made for a control switch 26 comprising a contact lever 27.

The high-speed reversing switch of the present invention operates in the following manner:

The oil pump 2 is driven by the electric motor 1, pressing the pressure medium, for example pressure oil, from the oil sump 39 into the pipe conduit system 4. The pressure relief valve 6 determines the maximum pressure of operation in the system. The pressure control device 7 is gauged to a certain maximum pressure. If this pressure is exceeded, the piston 7b is pressed against the influence of spring 7c and its end plate 7d closes the contacts 8 and 9 of the first alarm circuit. The check valve

10 prevents the oil conduit system from being emptied should the oil pump 2 be out of operation.

The pressure reservoirs 13 and 14 are adapted to supply additional pressure oil which may be temporarily needed for the switching operation. The pressure reservoirs 13 and 14 are charged with pressure oil by the continuously running oil pump during the intervals between the switching operations. The pressure oil thus supplied to the pressure-reservoir cylinders pushes the pistons 42 and 43 upwardly, thereby tensioning the pressure springs 40 and 41. As soon as one of the two valves 28, 35 is opened, the pressure reservoirs are discharged, i.e. the pressure oil stored therein is pressed into the pipe conduit system 4 by the spring actuated pistons 42 and 43, and through the pipe conduit system 4 to the cylinders 29 or 36, respectively, thereby actuating the pistons 11 or 12, respectively, and effecting a switching operation. Its conveying capacity can, therefore, be much smaller than in the known circuit breakers.

The rocking lever is swivelled in one direction or the other towards the contacts 23 and 25, respectively, by means of the pistons 11 and 12, pushing the left or the right end, respectively, of the transverse beam 30 upwardly. Thereby contact is established by the contact faces 24a and 24b with the contacts 23 or 25 and the terminals 32 or 37, respectively, according to the position of the rocking lever 31. The movement of the rocking switch lever 31 is controlled by the control switch 26. If the contact lever 27 is brought into the position by a relay, as shown in FIGURE 3 of the drawings, or by hand, the electromagnetic valve 28 is opened and admits oil to the cylinder 29, thereby pushing the piston 12 in upward direction and moving the rocking lever into the position shown in the drawing in which contact is made with terminal 32. The main current then flows from the terminal 32, via the fixed contact 23, the movable main contact 24 and the flexible wire 33 to the terminal 34.

If the contact lever 27 is brought into the position indicated by the dashed line in FIGURE 3, the left contact of the control switch 26 is opened and the circuit via the magnet coil 45 of valve 28 is interrupted. Immediately thereafter, the circuit with the magnet coil 46 of the valve 35 is closed. Consequently, valve 28 blocks the passage of oil from the pipe conduit system 4 to the cylinder 29, whereas valve 35 is opened, and pressure oil is admitted to the cylinder 36. Piston 11 is lifted and the rocking lever 30 is pushed upwardly so as to cause the contact faces 24b to come into contact with contact 25 and establish a connection with terminal 37. The main current then flows from the terminal 37 via the fixed main contact 25, the movable contact 24 and the flexible wire 33 to the terminal 34.

Since the contact lever 27 can assume only one of the two afore-described positions, i.e. either the position as indicated by the bold line or the position as indicated by the dashed line in FIGURE 3, the change from the opening and closing of valves 28 and 35 or vice versa is effected by one and the same switching operation.

The magnetic coils 45 and 46 are excited with current supplied by the accumulator 47a.

It is not necessary to provide a separate return pipe conduit for the pressure medium. Oil that is left in the cylinder 29 after the electromagnetic valve 28 has been closed and which is, therefore, not subject to any pressure, is pressed out of the cylinder 29 by the downward movement of piston 12. The leakage oil is collected in the casing 49 and then flows to the oil sump 39, from where it can again be supplied to the oil pump 2 and the pipe conduit system 4.

The locking device 15 protects the reversing switch against any false operation in case the oil pressure should be too low. As long as the pressure needed for a satisfactory operation is prevailing in the pipe conduit system 4, piston 16 of the locking device is pushed against the influence of the counter pressure spring 17 in the direction

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of arrow 18 and is thereby kept in the position shown in FIGURE 3 of the drawings. Accordingly, oil is admitted to the two cylinders 36 and 29. If the pressure falls below a certain, predetermined minimum not capable of satisfactorily effecting a hydraulic driving of the switch, the spring 17 pushes the piston 16 in the opposite direction of the arrow 18, thereby causing the rod 19 to project into the path of the pin 20 of the rocking switch lever 31, thus arresting its movement. Any switching operation is thereby made impossible until the minimum pressure has again been reached. In the latter instance the increased pressure pushes the piston 16 with the shaft 19 out of the path of pin 20, thereby allowing the movement of the rocking lever.

If there are provided the two contacts 21 and 22 with the second alarm circuit these contacts are closed simultaneously with the rod 19 being pushed into the arresting position.

The high-speed reversing switch of the present invention offers considerable advantages over any of the devices known in the art.

The control system with the electromagnetic valves 28 and 35 consumes but a very small amount of electric energy. It is, for example, possible to effect the control of the hydraulic switch with an input of 1 watt and even less and, hence, intermediate relays for switching the controlled current can be dispensed with. Furthermore, the time needed by a small magnet of, for example, 1 watt in order to respond is very small and, in addition, the hydraulic driving means of the present invention need an infinitely small time in order to respond and effect the driving. As a consequence, the total switching time of the high-speed reversing switch of the present invention is as follows, and as illustrated in the diagram of FIGURE 2.

The total switching time is designated by t_g . The dead time is represented by the small time interval $t_2 - t_0$ which is determined by the time needed for response by the small control magnet, and the time needed by the hydraulic driving means in order to become effective. Since the latter is negligibly small, it is not indicated in the diagram. The diagram shows that the flying time t_f of the contact 24 is considerably greater as shown by the time interval $t_3 - t_2$ than the corresponding interval shown in the diagram of FIGURE 1, even though the total switching time is considerably shorter. Herefrom follows that with the identical distance covered by the contacts as in the diagram of FIGURE 1, that is, as s_0 , the flying speed of the movable contacts 24a and 24b is much smaller. Due to the reduced kinetic energy of movable contact 24 the impact of the contact faces 24a and 24b upon the fixed contacts 23 and 25, respectively, is correspondingly reduced and less severe than in any of the known devices. It has been found that in a high-speed reversing switch constructed according to the present invention, the flying speed of the electro-hydraulically moved contacts was only 30% of the flying speed of electromagnetically operated contacts in known electromagnetic reversing switches. In accordance therewith the kinetic energy of the hydraulically driven contacts is only 10% of the kinetic energy of electromagnetically driven contacts. This results in a tremendously reduced wear of the bearings and contacts of the high-speed reversing switch, even though the total switching time has been decreased to one-third of that used by the electromagnetic high-speed reversing switches known heretofore.

A further advantage resides in the provision of the locking device of the invention, which has been described further above and which is also hydraulically-mechanically operated. Since the locking shaft or rod 19 is projected into the path of the rocking lever with the projecting pin 20 only whenever the oil pressure falls below a predetermined medium level, it is only rarely used. Consequently, the wear of this locking device is much

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smaller than the wear of the locking devices of the known high-speed reversing switches.

In the known switching devices, the service life of the entire switch is shortened by the reduced service life of the locking device, which has to come into operation after each individual switching operation. In the known electromagnetic switches the armature is mechanically locked after each switching operation, in order to be able to switch off the exciting coils for the comparatively great magnets with a view to obtain a comparatively short relative switching-in period. In the switch of the present invention, it is unnecessary to effect a locking after each switching operation. As a result, the service life of the entire switch is not impaired by the frequent wear of the locking device as in the known high-speed reversing switches.

Furthermore, a temporarily increased need for additional pressure oil is taken care of by the two pressure reservoirs 13 and 14 and, therefore, the continuously operating oil pump 2 may have a much smaller conveying capacity sufficient for the current consumption. The greater amount of pressure oil needed for impelling one of the two pistons 11 and 12 can be supplied by one of these two pressure reservoirs. It will be easily apparent that a pressure pump of comparatively small capacity is much cheaper, both as to production and operation. In addition, the service life of the pressure oil itself is tremendously lengthened because the small conveying capacity of the oil pump results in a reduced circulation of the oil and a smaller friction of the oil produced by the pumping operation. Less heat is, therefore, imparted to the oil. The lengthening of its service life resulting therefrom is obvious if it is kept in mind that a lowering of the medium operational temperature of the oil by only 8% lengthens its service life by 50%.

The great reduction in conveying capacity of the oil pump used in the switch of the present invention will become apparent upon considering the following: If the working stroke volume of the pressure reservoirs 13 and 14 is 7.5 cm.³, if the stroke distance is 15 millimeters, and if furthermore the discharge time is 0.015 seconds, then the pressure reservoirs 13, 14, will each furnish an oil stream of 50 cm.³ per second, whereas the conveying capacity of the oil pump 2 is only 33 cm.³ per second.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions, and, accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

What we claim is:

1. A high-speed reversing switch of the type adapted for operation at high currents and with a great frequency of operation comprising a movable contact arm capable of assuming two switching positions, a hydraulic driving system for alternating the position of said movable contact arm between said two positions, and an electromagnetic control system including two solenoid valves and means for energizing them mutually exclusively for actuating said hydraulic driving system.

2. A high-speed reversing switch of the type adapted for operation at high currents and with a great frequency of operation comprising a movable contact arm, a hydraulic driving system for actuating said movable contact arms, hydraulic locking means dependent upon the hydraulic pressure in said system but independent from the position of said arm for arresting said hydraulic driving system and said movable contact arm, and an electromagnetic control system for actuating said hydraulic driving system.

3. A high-speed reversing switch of the type adapted for operation at high currents and with a great frequency of operation comprising a hydraulic driving system, a rocking switch lever driven by said hydraulic driving system, locking means dependent upon the hydraulic pressure in said system and operating independent from

the position of said lever engageable with said rocking switch lever, to arrest the movement thereof said locking means being operated by said hydraulic driving system and an electromagnetic control system for said hydraulic driving system.

4. A high-speed reversing switch of the type adapted for operation at high currents and with a great frequency of operation comprising a hydraulic driving system, a rocking switch lever driven by said hydraulic driving system and having a downwardly projecting pin portion, locking means engageable with said rocking switch lever comprising cylinder and piston means, a rod connected to said piston means, a pressure spring urging said rod into the path of movement of the projecting pin portion of said rocking switch lever, and a pipe conduit system for the pressure medium of said hydraulic driving system and communicating with said cylinder and piston means in said locking means, the operational oil pressure acting on said piston means to maintain said rod out of the path of movement of the projecting pin portion of said rocking switch lever, and an electromagnetic control system for said hydraulic driving system.

5. A high-speed reversing switch of the type adapted for operation at high currents and with a great frequency of operation comprising a hydraulic driving system, a rocking switch lever driven by said hydraulic driving system and having a downwardly projecting pin portion, locking means engageable with said rocking switch lever and comprising cylinder and piston means, a rod con-

needed to said piston means, a pressure spring biasing said rod into the path of movement of the projecting pin portion of said rocking switch lever, a pipe conduit system for the pressure medium of said hydraulic driving system and communicating with said cylinder and piston means in said locking means, the operational oil pressure acting on said piston means keeping rod out of the path of movement of the projecting pin portion of said rocking switch lever, contact means connected on said rod, an alarm circuit, said contact means closing said alarm circuit whenever said rod is in the position locking said rocking switch lever, and an electromagnetic control system for said hydraulic driving system.

6. A high-speed reversing switch as described in claim 4, said hydraulic driving system comprising an oil pump having a capacity capable of providing a predetermined, small fraction of the oil pressure needed for driving said rocking switch lever, and at least one pressure reservoir furnishing the remaining, large portion of pressure oil needed for actuating said rocking switch lever.

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