Nov. 28, 1939. F. DESSAUER ET AL 2,181,775

SWITCH OR CONTROL ARRANGEMENT FOR OPERATING X-RAY APPARATUS

Filed Aug. 17, 1937 2 Sheets-Sheet 1

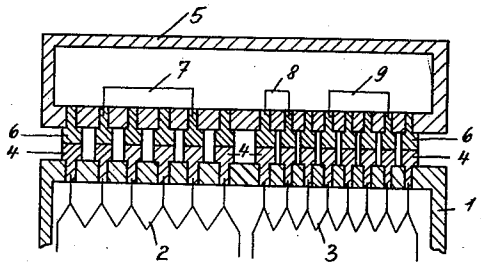

Fig. 1

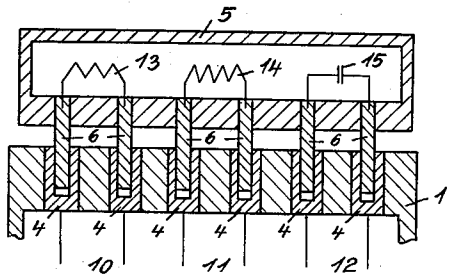

Fig. 2

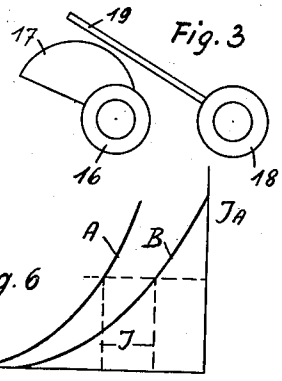

Fig. 3

Fig. 6

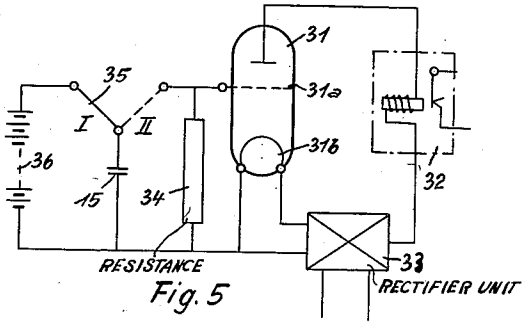

Fig. 5

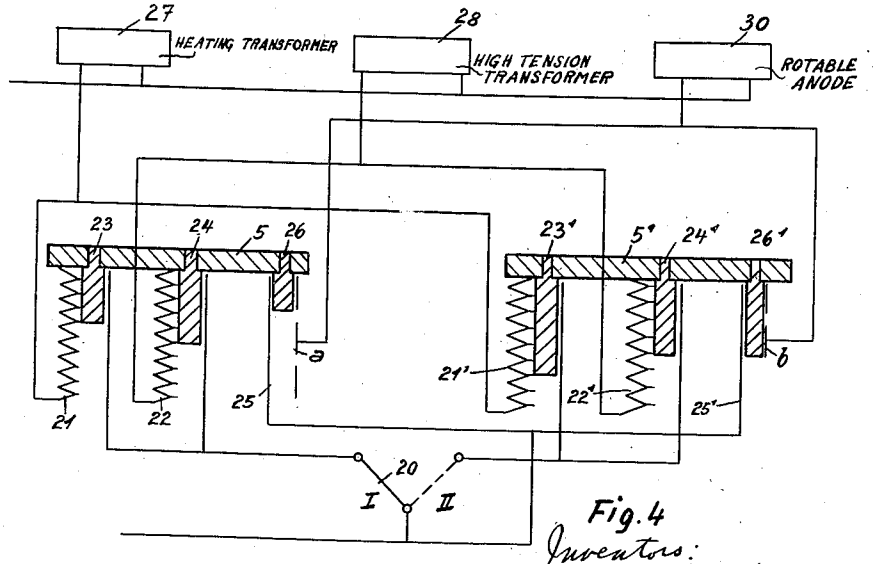

Fig. 4

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SWITCH OR CONTROL ARRANGEMENT FOR OPERATING X-RAY APPARATUS

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Fig. 7.

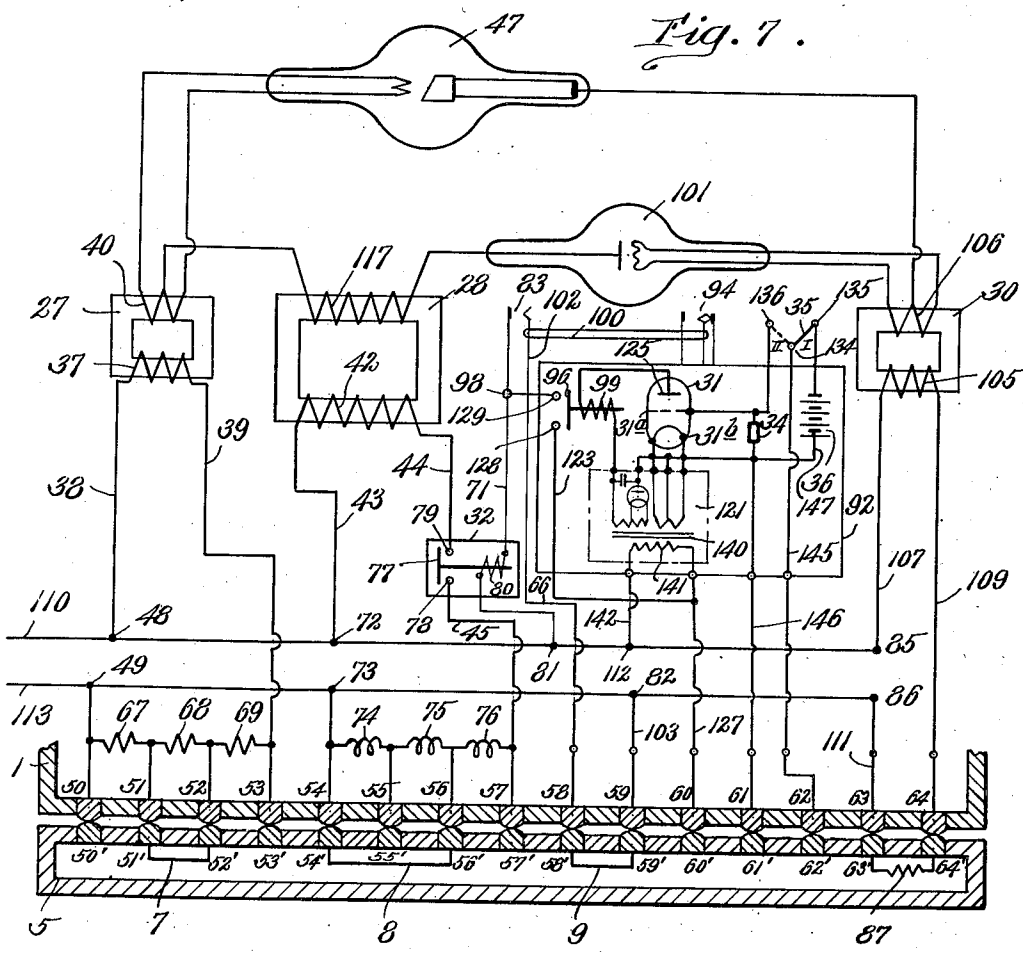
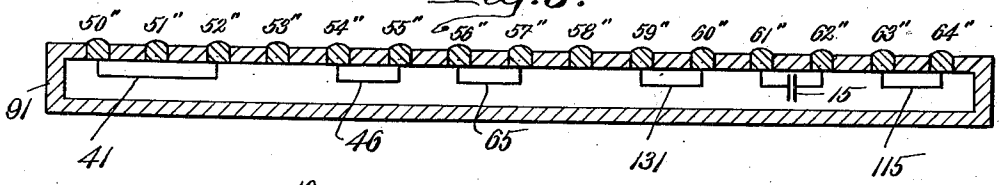


Fig. 8.



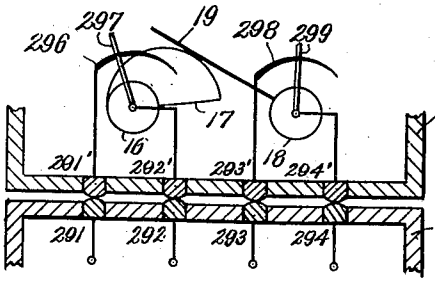


Fig. 9.

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SWITCH OR CONTROL ARRANGEMENT FOR OPERATING X-RAY APPARATUS

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16 Claims. (Cl. 250—95)

Up to the present the adjusting of X-ray apparatus, more especially for the purpose of diagnostics, has, as a rule, been effected in such a manner that the various factors of the exposure such as the cathode-heating current of the valves, the current and the voltage of the X-ray tube, the sensitivity of the instruments, the duration of the exposure and so on were adjusted separately. Thereupon the X-ray tube is set in action by the main switch.

Switch or control arrangements of this kind of adjustment include the danger of a great number of errors or rather false adjustments. Furthermore they necessitate a highly trained operating person. In spite of the presence of such a person it may, however, happen that either the most favorable operating conditions are not followed or—which is by far more disagreeable—that the X-ray tube or the apparatus are overcharged and thereby damaged or even destroyed.

A great number of switch or control arrangements are already known, by which the possibilities of failures are supposed to be eliminated, or at least minimized. One means consists in reducing the possibilities of adjustment, thus limiting their free choice. The other retains the full adaptability at the expense of considerable complications.

The invention is based on the fact that in practice the same organ is always exposed with the same basic adjustments. For instance a radiograph of the lugs—once the most favorable adjustments have been established—is always made with the self same basic adjustments. Such basic adjustments require only slight variations in respect of the small differences of the particular cases in hand.

The switch or control arrangement for the working of X-ray apparatus according to the present invention comprises a basic device to be controlled by an additional, co-operating control device when combined with said latter device, said basic device being adapted to adjust or fix automatically a plurality of important working factors when co-operating with the control device, and a plurality of additional control devices differing from one another, each of said control devices being adapted to a group of typical working conditions of the X-ray apparatus to be operated and to be easily connected with and detached from the basic device.

The basic device may be constructed in the form of a control desk.

The control of the basic device by means of the additional control devices may be effected mechanically. In such a case the additional control devices are constructed in such a manner as to determine positions or ranges of positions of movable members on the basic device for adjusting the current of the X-ray tube, its anode potential, the duration of the exposure and so on. In this form of execution it is advisable that the basic device be fitted with driving means by which the adjustable members of the basic device may be moved automatically to those positions or to the limits of the ranges of the positions which are determined by each of the additional control devices. The driving means may consist in a small electromotor or electromagnets and so on. For the same purpose, however, also a driving device workable by hand could be used.

The forms of execution, however, are preferable in which the control of the basic device by the additional control devices is carried out electrically. For this purpose the basic device and the additional control devices are provided with contact means which correspond to and co-operate with one another, and the contact means of the additional control devices are associated with connections mounted inside the control devices and adapted in each case to a group of typical working conditions. The contact means of the control devices may, for instance, short-circuit different parts of circuit elements possessing steps and being mounted in the basic device, such as resistances, choking-coils, auto-transformers and so on. In another embodiment of the invention in which the control of the basic device is also effected electrically by additional control devices, the basic device is provided with circuit elements possessing steps, such as resistances, choking-coils, auto-transformers and so on, and the control devices are fitted with contact arrangements co-operating with these circuit elements the contact arrangement of each control device being adapted to a group of typical working conditions. The contact arrangements of the control devices may for instance be formed by more or less long longitudinal metal members which short-circuit a greater or lesser number of turns or windings of auto-transformers being mounted in the basic device, thus controlling the basic device in the desired manner.

Controlling means for operating X-ray apparatus are already known which are based, like the present invention, on the fact of experience, that in similar cases of diagnostics and therapy the same group of typical working conditions should be present. It is, for instance, already known to provide on a movable axis a number of control

disks which have radial extensions, each of these disks serving to adjust one of the working conditions. The radial extensions act like camshafts on levers for controlling the voltage of the X-ray tube, its amperage, the time of exposure and so on. This apparatus, however, did not meet with any approval owing to the deficiencies connected with it.

Furthermore, apparatus are known in which by means of plugs various connections between circuit elements being mounted in a table-like casing may be carried out. These apparatus which show some relationship with the apparatus according to the present invention have, however, the great drawback that their use calls for a very considerable reduction of the number of groups of working conditions. In practice at least twenty-five different adjusting combinations must be effected. This, however, is not possible with the apparatus referred to above for reasons of construction. Moreover, these apparatus are subjected to a number of other important deficiencies.

In using an apparatus being constructed according to the present invention the adjusting is effected very quickly, which in case of the physician is heavily burdened or the apparatus is hard worked or, in accident diagnostics is of vital importance. A further advantage is the absolute reliability of adjustment. As a rule various knobs have no longer to be turned, neither is it necessary to operate various plugs, switches or the like, which may lead to confusion, but by insertion of a definite control device in a certain place of the apparatus all or a number of adjustments are effected. A further very essential advantage is the fact that all possibility of faulty manipulation of the apparatus is eliminated without sacrifice in any way of accuracy of results. On the other hand, when using an apparatus according to the present invention there is no call for strict adherence to working conditions once the machine has been properly standardized, but by interchange of the control devices or modification of same the adjustments may be adapted to special circumstances. But in addition to all that, the construction of the X-ray apparatus itself may also be considerably simplified as will be seen from the following: The voltage being applied on an X-ray apparatus decreases when the load increases. Since when assembling a control device both amperage and voltage are known, the drop of the voltage can be taken into account and compensated already when dimensioning or designing the control device. The adjustment of the voltage may thus be effected by very simple means, for instance by a resistance. In an apparatus of this kind a number of measuring-instruments may be spared, as these instruments with the constructions known hitherto served chiefly for verifying the correctness of the adjustment.

The drawings show diagrammatically some embodiments of the invention.

Fig. 1 shows in cross section a part of a basic device and of a control device connected with it.

Fig. 2 shows in cross section another modification of a basic device and a control device. In Fig. 3 an additional adjusting arrangement is shown diagrammatically.

Fig. 4 shows a basic device which it fitted with two control devices.

Fig. 5 is the wiring diagram of a time switch for producing instantaneous Röntgenograms by means of an apparatus according to the present invention.

Fig. 6 shows the characteristics of the arrangement shown in Fig. 5.

Fig. 7 is a circuit diagram of X-ray apparatus embodying the present invention, illustrating a master control device and a cooperating control device of the type diagrammatically shown in Fig. 1.

Fig. 8 is a cross-section of a modified cooperating control device; and

Fig. 9 is a cross-section of a modified master control device and a cooperating control device.

According to Fig. 1 the two circuit-elements 2 and 3 e. g. auto-transformers being provided with taps, are mounted in the basic device. The taps of the circuit-elements 2, 3 are connected with the contact arrangements 4 of the basic device 1. The control device 5 is fitted with contact arrangements 6 which correspond and co-operate with the contact arrangements 4 of the basic device. In the control device 5 connections are provided being in contact with its contact arrangements 6 and adapted to a group of typical working conditions. In the arrangement shown in the drawings these connections are formed by short-circuit members 7, 8 and 9 short-circuiting parts of the circuit-elements or auto-transformer coils 2 and 3. Each of the control devices 5 which are intended to be used in conjunction with the basic device 1 possesses other connections and each group of these connections is adapted to a group of typical working conditions—working conditions for lungs, skull frontal, heart and so on.

It is of particular advantage that the circuit-elements 2, 3 being partly short-circuited by the device 5, are not continuously subdivided, but in a geometrical series or progression, since the greatest number of permutations, i. e. the finest subdivision results thereby. With a resistance having steps corresponding to the values 1, 2, 4, 8, 16, 32 64 subdivisions (from 0 to 63) may be effected.

According to Fig. 2 the basic device or master control device 1 is fitted with contact arrangements in the form of plug bushes or contact sleeves 4. The control device 5 shows plug pins 6 co-operating with the plug bushes 4. The control-device 5 is fitted with circuit-elements 13, 14, 15 (resistances, choke-coils, condensers and the like) designed to conform with a group of typical working conditions. The control device is formed in the shape of a casing and the circuit-elements 13, 14, 15 are mounted in it. According to the drawings the circuit 10 of the basic device 1 is closed by the circuit-element 13 of the control device 5. In a like manner the circuit-elements 14 and 15 of the control device 5 close the circuits 11 and 12 of the basic device 1. Therefore, the circuits 10, 11, 12 are controlled by the circuit-elements 13, 14, 15 and the current strength of the current of each circuit is determined by the design of the circuit-elements 13, 14, 15. The circuit-elements 13, 14, 15 of a control device 5 are adapted to suit the typical working conditions of a certain case and those of the other control devices destined to be used in conjunction with the basic device 1, are adapted to suit the typical working conditions of other cases.

The use of the hitherto generally used mechanical time switches for the production of instantaneous Röntgenograms presents certain difficulties with the apparatus according to the present invention. It is therefore advisable to use a time switch in conjunction with it, the switch times of which are determined by electric factors,

for instance a time switch based on the loading or discharging of a condenser. In using such a time switch the element determining the switch times may be lodged in the control device. In Fig. 2 the condenser 15 lying in the circuit 12 being the circuit of the time switch serves for determining the duration of the exposure. Therefore, according to the present invention, circuit-elements for the circuit of the time switch are fitted into the control device, for instance condenser, said circuit-elements determining the switch times and being adapted to suit with the other typical working conditions of the control device in hand.

Generally speaking the circuit-elements which according to the present invention ought to be mounted into the control device 5 may not only be formed by resistances, coils or condensers, but for the same purpose, i. e. for controlling the basic device 1, also relays, valves, bi-metal strips and so on may be used.

Regardless of the standardization of the working conditions it is advisable to provide regulating devices that are workable by hand and by which the working conditions determined by the control device may be varied within comparatively narrow limits. These regulating devices may be arranged on the control devices and they permit variation of the working conditions within the limits determined by each of the control devices so as to adapt them in the best possible manner to the peculiarities of the case in hand. In making a Röntgenogram of a bone it may be preferable to work with constant voltage at the X-ray tube and to vary the value of milliamperage and exposure time, while in the case of an exposure on soft parts a regulation of the voltage on the X-ray tube produces better results. Thus a control device for exposures on soft parts may be provided with an additional regulating means workable by hand which allows to vary the voltage of the X-ray tube within restricted and comparatively narrow limits.

In the case of control devices being provided with several regulating means to be operated by hand it may be advisable to provide a device limiting reciprocally their free movement in such a way that adjustments causing overloads of the X-ray tube are prevented thereby. Fig. 3 shows a regulating arrangement of this kind, where at one of the regulation elements a notch-like curved disk and at the other a co-operating abutment is provided. As to the device according to Fig. 3, mention has to be made of the following:

For many purposes, more especially for fluoroscopy or radioscopy, a free choice of the current strength and voltage is often desired. Therefore a control device should be used with which both factors may be adjusted separately. Since the maximum current strength depends on the voltage lying at the X-ray tube, the operating knob 16 which serves to adjust the voltage is connected with a curved disk 17. The operating knob 18 which serves to adjust the current-strength is provided with a stop- or abutment-lever 19. The limits of the positions of the knob 18 for the regulation of the current strength are therefore determined in each case by the positions of regulating knob 16. When designing the disk 17 the load capacity of the X-ray tube is to be taken into account.

In Fig. 9, for example, there are disclosed a master control device (or a portion of the same) 151, having a plurality of contact members 291', 292', 293' and 294', adapted, respectively, to engage contact members 291, 292, 293 and 294 of a cooperating control device 153. An impedance 296 is connected to the contact member 291' and an impedance 298 to the contact member 293'. The impedance 296 is adjustable by means of a contact arm 297 through the medium of the knob 16 and the impedance 298 by means of a contact arm 299 through the medium of the knob 18. The curved disk 17, rigid with the knob 16, limits the range of adjustment of the knob 18. One of these impedances may, for example, control the voltage and the other the current. As an illustration, the impedance 296 may be constituted of one of the hereinafter-described resistors 67, 68 and 69, and the impedance 297 one of the hereinafter-described windings 74, 75 and 76.

According to Fig. 4 the basic device is adapted to the simultaneous reception of two control devices 5 and 5'. By operating the change-over switch 20 the two control devices 5 and 5' may be brought to action successively. The basic device is provided with circuit-elements e. g. windings 21, 22, 21', 22' possessing taps. The control devices 5, 5' have contact arrangements 23, 24, 23', 24' co-operating with these taps, said contact arrangements being adapted to a group of typical working conditions. The circuit-elements or windings 21, 22, 21', 22' may be short-circuited more or less by the contact arrangements 23, 24, 23', 24'. Moreover, the basic device shows two contact arrangements 25, 25' co-operating with the contact members 26, 26' of the two control devices 5, 5'. The apparatus according to Fig. 4 serves for the purpose of producing exposures in the manner set forth below by means of an X-ray tube with rotatable target. Similar arrangements may, however, also be used for other purposes. The current is led to the contacts or taps of the circuit-elements 21, 22, 21', 22' by means of the change-over switch 20, whereas the current is led directly to the contact means 25, 25'. The current is led from the taps of the circuit-elements 21, 21' to the heating transformer 27 of the X-ray tube and from the taps of the circuit-elements or coils 22, 22' to the high tension transformer 28 producing the anode potential for the X-ray tube. Of the contact arrangements 25 and 25' only the contact members *a* and *b* leading to the rotatable anode 30 may be considered. It may be assumed that for the time being only the control device 5 serving for radioscopy is inserted in the basic device. The rotatable target then stands still to avoid unnecessary wear. Now, after the physician has found the organ he wishes to expose on, the exposure control device 5' is inserted. Thereupon, without the switch 20 being changed over to the control device 5' a current flows over the contact arrangement 25' to contact *b* and the rotatable anode or target begins to rotate, i. e. the exposure is prepared but not yet executed. In the same manner an increased valve heating, the time switch, the diaphragm for scattered radiation, the sensitivity of the instruments and so on may be switched on ready for the exposure. As soon as the phase the physician intends to expose on takes place, by simple changing-over switch 20 from the position marked I to the position marked II the control device 5' is brought into action and the exposure is effected.

The apparatus according to the present invention further allows to compensate in a very simple manner the unreliabilities of the distribution network to which the X-ray apparatus is

connected, either in respect of the voltage drop or of the variations of the voltage.

The voltage drop in the distribution network causes that in case of exposures with heavy loads the primary voltage decreases and that consequently the voltage being applied to the X-ray tube, as well as the cathode-heating voltage of said tube and thereby the emission current are reduced. Since, as mentioned above, when designing the control devices the intended rate of current strength and voltage are known, the voltage drop in the distribution network may be taken into account and compensated for.

Fig. 5 shows the connections of a time switch for the production of instantaneous Röntgenograms, the switch times of which depend on the applied voltage of the line in such a way as to compensate for the voltage drop occurring in the distribution line or network by increasing the times of exposure.

The relay 32 is arranged in the anode circut of a discharge tube or valve 31 being controlled by the grid 31*a*. The current of the X-ray tube is switched on or off by means of relay 32. The discharge tube 31 is connected to the output circuit of a rectifier-unit 33, the in-put circuit of said unit being connected to the distribution line or network. The grid 31*a* is connected by means of a grid-leak resistance 34 with the cathode 31*b*. The working conditions are chosen in such a way that relay 32 attracts its armature and consequently interrupts the current of the X-ray tube. A condenser 15 (see also Fig. 2) is connected to the cathode 31*b*. The condenser 15 is connected by means of change-over switch 35 to the D. C. current source 36 of constant voltage, e. g. a battery, and is charged by it. The charge of condenser 15 is effected in such a way that the positive pole is connected to the cathode 31*b*. If for the purpose of exposure the change-over switch 35 is switched from position I to position II the negative pole of the condenser 15 is connected with the grid 31*a*. Therefore, the anode current is interrupted and the relay 32 is de-energized and thereby closes the anode circuit of the X-ray tube. The closure can be effected by means of an additional electromagnetic relay or another suitable switch mechanism. The condenser 15 discharges during the time of closure over the resistance 34. After an interval of time being determined by the design of the condenser 15, of the resistance 34 and of the voltage of the battery 36 the voltage of the grid 31*a* has again attained such a value that the anode current of the discharge tube 31 attracts the relay 32 interrupting thereby the anode current of the X-ray tube.

The anode current strength with which the relay 32 functions, is reached according to the position of the characteristics of the discharge tube 31 with different grid voltages. The positions of the characteristics again depend on the working voltages i. e. on the voltage of the line or the in-put voltage of the rectifier-unit 33. With higher primary voltage a characteristic according to A of Fig. 6 results, whereas with lower primary voltage a characteristic according to B of Fig. 6 is produced. The current J with which the relay 32 attracts its armature is reached with different grid voltages, i. e. after different time intervals, after the condenser 15 has been connected to the grid 31*a*. Thus, a compensation of the kind referred to above may be effected and realized by suitable choice of the type of the grid-controlled valve 31*a*, the operating voltages of same, the current strength of response of the relay 32, the charge voltage as well as the capacity of the condenser 15 and the value of the resistance 34.

It will easily be seen that the above described method of compensation can be effected with sufficient accuracy only within the narrow limits of a definite type of exposures and therefore is not appropriate when using an X-ray device adapted to be freely operated.

It is often necessary that the main current circuits of the X-ray apparatus are switched off when inserting the control device into the basic device or taking it away from same. On the one hand, it will be possible by switching in the absence of current, to use control devices with not too great contact systems also for X-ray apparatus of comparatively high output or capacity, on the other hand, short-circuits are thereby avoided. However it is not important to switch certain circuits as for instance the circuits of the rotatable anode, the cooling pump, the time switch and so on in the absence of current, because with these devices a wear of the contacts on switching under current is of no appreciable account. In the embodiment of the invention shown in Fig. 4 therefore a device should be provided for avoiding that the control device is inserted or taken off, when the change-over switch 20 stands in the position marked I. For that purpose a locking device may be controlled by the change-over switch 20 preventing the insertion or taking off of a control device, if the change-over switch 20 is in the switch-on position of said control device.

The method of manipulation of an X-ray apparatus being fitted with a control arrangement as set forth above is, as a matter of fact, particularly simple. Such a control arrangement dispenses with the necessity to use the complicated control means as practised hitherto including complicated switch and control arrangements and causing difficulties of communication with the staff. The table for radiological diagnosis or clinoscope may be combined into a unit with the basic device adapted to receive the control devices and the X-ray tube may, if desired, be provided at another place of the room. Furthermore, several basic devices into which control devices may be inserted at will, may be fitted inside or outside the room serving for diagnosis.

Some adjustments cannot be effected directly by means of the control devices or only in a comparatively complicated manner, for instance the winding up of the scattered ray diaphragm or the adjustment of the prescribed focus-film distance and so on. These adjustments can be made easily noticeable while working by inscriptions on the control device. In order to verify whether these adjustments are properly effected the control devices or the basic device may be fitted with a signal that shows whether the diaphragm was wound up and so on.

The control devices may be distinguished by color, form, inscribed figures and so on. This is more particularly useful e. g. when it is intended to carry out diagnostics and therapy with the same instrument.

In some cases it is advisable to build up the control devices from interchangeable, normalized parts, so as to allow their easy alteration. In other cases it is useful, if the control devices are constructed in such a way as to prevent their optional alteration, so that such an alteration could be effected only after damaging a seal or

an envelope. This form of execution is particularly suitable, if from the side of a producer firm, for the sake of given factory guarantees, a faulty adjustment of an X-ray apparatus is meant to be guarded against.

Referring to Fig. 7, current is supplied to the X-ray apparatus, shown as an X-ray tube 47, from the mains 110 and 113. The X-ray tube is provided with a heating transformer, a voltage transformer, and a further transformer for energizing the filament of a rectifying tube 101. To accord with Fig. 4, the heating transformer is designated by the numeral 27, the voltage transformer by 28, and the further transformer by 30. The circuit of the primary winding 37 of the heating transformer 27 extends from a terminal 48, connected to the main 110, by way of a conductor 38, through the primary winding 37, by way of a conductor 39, and through resistors 69, 68 and 67, to a terminal 49 connected to the main 113. The resistor 67 is connected to contact terminals 50 and 51, the resistor 68 to contact members 51 and 52, and the resistor 69 to contact members 52 and 53 of a master control device. Though, to accord with Fig. 1, this master control device is designated by the numeral 1, it is shown provided with a number of contact members additional to those designated 50 to 53, indicated at 54 to 64.

A control device for cooperating with the master control device 1, and designated, to conform with Fig. 1, by the numeral 5, is shown provided with contact members 50' to 64', for respectively cooperating with the contact members 50 to 64 of the master control device 1. The cooperating control device 5 is one of many cooperating control devices that may be substituted, one for another, so as to cooperate with the master control device 1. A further such cooperating control device 91 is illustrated in Fig. 8, shown provided with contact members 50'' to 64'', for respectively cooperating with the contact members 50 to 64 of the master control device 1.

In the cooperating control device 5 of Fig. 7, the contact members 51' and 52' are shown connected together by a conductor, so as to short circuit the resistor 68. In order to show the relation between Fig. 7 and Fig. 1, this conductor is designated by the numeral 7. The current supplied to the primary winding 37 in order to energize its secondary winding 40 of the transformer 27, will thus be reduced by the resistance of the resistors 67 and 69, thereby to heat the cathode of the X-ray tube 47 to a proper value. As the contact members 50' and 51', as well as the contact members 52' and 53', are not similarly connected together by conductors, the resistors 67 and 69 will not be short-circuited. In the cooperating control device 91, however, the contact members 50'' and 52'' are shown connected together by a conductor 41, though the contact members 52'' and 53'' are not connected together. When the cooperating control device 91 has been juxtaposed into cooperating relation to the master control member 1, however, in substitution for the cooperating control device 5, therefore, with the contact members 50'' to 64'' in cooperative relation to the contact members 50 to 64, the resistors 67 and 68 will both be short-circuited from the circuit of the primary winding 37, but the resistor 69 will not be short-circuited. With the resistors 67 and 68 short-circuited, a greater heating current will be applied to the secondary winding 40 of the heating transformer 27 and, therefore, to the filament of the X-ray tube 47. The degree of heating of the cathode of the X-ray tube 47 is thus controlled by suitable combinations of the resistors 67, 68 and 69 through the medium of suitable cooperating control devices, two of which are illustrated at 5 and 91.

The primary winding 42 of the voltage transformer 28 is connected into a circuit extending from a terminal 72, that is connected to the main 110, by way of a conductor 43, through the primary winding 42, and by way of a conductor 44, to contact members 79 and 78. When these contact members 79 and 78 are bridged by a contact member 77, the circuit continues, by way of a conductor 45, through inductance coils or windings 76, 75 and 74, to a terminal 73, that is connected to the main 113. The winding 74 is connected to the contact members 54 and 55, the winding 75 to the contact members 55 and 56, and the winding 76 to the contact members 56 and 57. The contact members 54' and 56' are shown connected together by a conductor that, to correspond to the showing of Fig. 1, is designated by the numeral 8. When the cooperating control device 5 is employed, therefore, as illustrated in Fig. 7, since the windings 74 and 75 become short-circuited by the conductor 8, the circuit of the primary winding 42 contains the winding 76 only. The contact members 54'' and 55'' of the cooperating control device 91, however, are shown connected together by a conductor 46, and the contact members 56'' and 57'' by a conductor 65, the contact members 55'' and 56'' being not connected together. When the cooperating control device 91 is employed, therefore, in substitution for the cooperating control device 5, the coils 74 and 76 will be short-circuited, and the circuit of the primary winding 42 will contain the coil 75 alone.

The contact member 77 is actuable into bridging engagement with the contact members 78 and 79 by means of a coil 80, the circuit of which may be traced from a terminal 81, that is connected to the main 110, by way of a conductor 66, through the coil 80, by way of a conductor 71, to a terminal 98. From the terminal 98, the circuit continues through a manually operable switch 83, by way of a conductor 102, to the contact member 58. As the contact members 58' and 59' are shown short-circuited by a conductor that may be designated by the numeral 9, to agree with the showing of Fig. 1, the circuit continues, from the contact member 58, through the contact members 58' and 59' and the conductor 9 connecting them, and the contact member 59 and, by way of a conductor 103, to a terminal 82, that is connected to the main 113. When the cooperating control device 5 is employed, therefore, the coil 80 becomes energized merely upon the manual closing of the switch 83, to effect the bridging of the contact members 79 and 78 by the contact member 77.

When the cooperating control device 91 is employed, however, as might be desired in radioscopy, in substitution for the cooperating control device 5, as the contact members 58'' and 59'' are not connected together, this circuit of the coil 80 will remain open, notwithstanding the manual actuation of the switch 83. In such case, the circuit of the coil 80 may be under the control of a time switch, designated by the numeral 92. This will be described more fully hereinafter.

The circuit of the primary winding 105 of the transformer 30 may be traced from a terminal 85.

that is connected to the main 110, by way of a conductor 107, through the primary winding 105, by way of a conductor 109, to the contact member 64. When the cooperating control device 5 is employed, in which event the contact members 63' and 64' are connected together through a resistor 87, the circuit continues through the contact members 64 and 64', the resistor 87, the contact members 63' and 63 and, by way of a conductor 111, to a terminal 86, that is connected to the main 113. The circuit is the same when the cooperating control device 91 is employed, except that the contact members 63'' and 64'' are connected together by a conductor 115, instead of through the resistor 87. In the former case, therefore, the current applied to the primary winding 105 will be less than in the latter case.

Upon the closing of a line switch (not shown), therefore, current will be supplied from the mains 110 and 113 to the primary windings 37 and 105 of the respective transformers 27 and 30. The filament of the rectifying tube 101 will become energized by the secondary winding 106 of the transformer 30. If no timing switch 92 is employed, the switch member 83 will then be manually operated, at the proper time, to energize the coil 80, thus to actuate the contact member 77 into bridging engagement with the contact members 78 and 79, whereupon the primary winding 42 of the transformer 28 will become energized. A unidirectional current flow will thereupon become established in the circuit of the X-ray tube 47, this circuit including the secondary winding 117 of the transformer 28 and the rectifier 101.

When the cooperating control device 91 is employed, as before stated, not only are different currents applied to the primary windings 37, 42 and 105, but the bridging of the contact members 79 and 78 by the contact member 77 will be controlled by the time switch 92, and not manually by the switch 83. The circuit of the coil 80 may, in this case, be traced from the terminal 81, by way of the conductor 66, and through the coil 80, to the terminal 98, as before. The circuit continues to terminals 129 and 128, when bridged by a switch contact member 96, by way of conductors 123 and 127, to the contact member 60. As the contact members 60'' and 59'' are connected together by a conductor 131, the circuit continues through the contact members 60 and 60'', the conductor 131, the contact members 59'' and 59, by way of the conductor 103, to the terminal 82. The switch contact member 96 is under the control of a coil 99. The circuit parameters are so chosen that the normal current through the anode circuit of the tube 31 will energize the coil 99 to a degree sufficient normally to maintain the contact member 96 out of engagement with the contact members 128 and 129, thus normally preventing energization of the coil 80. As described hereinafter, the circuit of the coil 99 will become closed, however, after a predetermined time interval, determined by the time switch 92.

The time switch is shown provided with a transformer 140 the primary winding 141 of which is shown connected in a circuit extending from a terminal 112 that is connected to the main 110, by way of a conductor 142, through the primary winding 141 to the conductor 127 which, as before described, is connected to the main 113 through the terminal 82. The time switch 92 is further provided with a glow-cathode tube 121 for controlling the tube 31, provided with the cathode 31*b*, the grid 31*a*, and an anode 125.

This time switch 92 is under the control of a condenser which, to accord with the showing of Fig. 1, may be designated by the numeral 15, and which is shown connected between the contact members 61'' and 62''.

In one of its positions, the two-way switch 35 connects a contact member 134 with a contact member 135. In its other position, it connects the contact member 134 with a contact member 136. In the first-named position, the condenser 15 will become charged by a circuit extending from one side of the battery 36, through the contact member 135, the switch 35, and the contact member 134, by way of a conductor 145, through the contact members 62 and 62'', the condenser 15 and the contact members 61'' and 61 and, by way of conductors 146 and 147, to the other side of the battery 36. The negative pole of the battery 36 is shown connected to the contact member 62 and the positive pole to the contact member 61. So poled, the condenser 15 will, after a predetermined time interval, upon the actuation of the switch 35 to its said other position, impose a charge upon the grid 31*a*, so as to stop the flow of current through the coil 99 and permit the bridging of the contact members 128 and 129 by the contact member 96.

The circuit of the condenser 15 and the coil 99 is controlled by a manually operable switch 94. The time switch 92 will not, therefore, operate until a predetermined time has elapsed after the closing of the manually-controlled switch 94.

The resistor 34 is connected between the cathode 31*b* and the grid 31*a*. The purpose of the resistor 34 is to dissipate the energy in the condenser 15, thereby gradually reducing the negative charge on the grid 31*a*, until it finally obtains a value such as to permit current to flow through the tube 31 once more. The coil 99 thereupon becomes again energized to again actuate the switch 96 out of contact with the contact members 128 and 129, thereby to deenergize once more the coil 80.

Of the two manually controlled switches 83 and 94, the former has been described as employed in connection with the cooperating control member 5, and the latter in cooperation with the cooperating control device 91. In order to make certain that one only of these switches 83 and 94 may be operated at a time, they are mechanically connected together by a link 100, which may itself serve as the medium for closing and opening the respective switches 83 and 94.

We claim:

1. X-ray control apparatus having, in combination, a master control device, and a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to determine different pluralities of coordinated working factors, each group of control elements comprising contact means, and the master control device having contact means adapted to be engaged by each of the contact means of the respective cooperating control devices when the cooperating control devices are in respective cooperative relation to the master control device to control the operation of the X-ray apparatus according to the

working factors determined by the respective cooperating control devices.

2. X-ray control apparatus having, in combination, a master control device having a plurality of impedances, and a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to render selectively different portions of the impedances effective in the respective circuits of the X-ray apparatus when the cooperating control devices are respectively in cooperative relation to the master control device to control the operation of the X-ray apparatus according to a plurality of predetermined coordinated working factors, the plurality of predetermined coordinated working factors differing according to the groups of control elements of the respective cooperating control devices.

3. X-ray control apparatus having, in combination, a master control device having a plurality of impedances, and a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having means for selectively short-circuiting different portions of the impedances to control the operation of the X-ray apparatus according to a plurality of predetermined coordinated working factors, the plurality of predetermined coordinated working factors differing according to the short-circuited portions of the impedances.

4. X-ray control apparatus having, in combination, a master control device having a plurality of impedances provided with contact members dividing the impedances into a plurality of portions the impedance values of which are in geometric proportion, and a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having cooperating contact members for engaging the first-named contact members to render different portions of the impedances effective in the respective circuits of the X-ray apparatus, thereby to control the operation of the X-ray apparatus according to a plurality of predetermined coordinated working factors, the plurality of predetermined coordinated working factors differing according to the engaged contact members of the cooperating control devices.

5. X-ray control apparatus having, in combination, a master control device, and a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a plurality of impedances, the pluralities of impedances differing from one another to determine different pluralities of predetermined coordinated working factors, and the master control device having means cooperating with the impedances of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the impedances of the respective cooperating control devices.

6. X-ray control apparatus having, in combination, a master control device, a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a casing and a plurality of impedances in the casing, the plurality of impedances differing from one another to determine different pluralities of predetermined coordinated working factors, and the master control device having means cooperating with the impedances of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the impedances of the respective cooperating control devices.

7. X-ray control apparatus having, in combination, a master control device, a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to determine different pluralities of coordinated working factors, the master control device having means cooperating with the groups of control elements of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the respective cooperating control devices, and means for manually varying the working factors corresponding to one or more of the cooperating control devices within predetermined limits.

8. X-ray control apparatus having, in combination, a master control device, a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to determine different pluralities of coordinated working factors, the master control device having means cooperating with the groups of control elements of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the respective cooperating control devices, and means on one or more of the cooperating control devices for manually varying the working factors within predetermined limits.

9. X-ray control apparatus having, in combination, a master control device, a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to determine different pluralities of coordinated working factors, the master control device having means cooperating with the groups of control elements of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the respective cooperating control devices, a plurality of means on each of one or more of the cooperating control devices for manually varying the working factors within predetermined limits, and means controlled by one of the plurality of means for

controlling the variation of another of the plurality of means to prevent overloading the X-ray apparatus.

10. X-ray control apparatus having, in combination, a master control device, a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to determine different pluralities of coordinated working factors, the master control device having means cooperating with the groups of control elements of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the respective cooperating control devices, a plurality of means on each of one or more of the cooperating control devices for manually varying the working factors within predetermined limits, and a cam controlled by one of the plurality of means and an abutment member engaged by the cam for limiting the variation of another of the plurality of means to prevent overloading the X-ray apparatus.

11. X-ray control apparatus having, in combination, a master control device, a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to determine different pluralities of coordinated working factors, the master control device having means cooperating with the groups of control elements of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the respective cooperating control devices, a normally open switch for controlling the operation of the X-ray apparatus to produce instantaneous exposures, means for electromagnetically controlling the switch, a space-discharge device for controlling the electromagnetic controlling means, and means in one or more of the cooperating control devices for determining predetermined times of operation of the space-discharge device.

12. X-ray control apparatus having, in combination, a master control device, a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to determine a plurality of coordinated working factors, the master control device having means cooperating with the groups of control elements of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the respective cooperating control devices, a normally open switch for controlling the operation of the X-ray apparatus to produce instantaneous exposures, means for electromagnetically controlling the switch, a space-discharge device for controlling the electromagnetic controlling means, means comprising a plurality of elements for controlling the flow of current through the space-discharge device, one of the elements being constituted of a condenser, a source of direct current of substantially constant voltage for charging the condenser, and a change-over switch for selectively connecting the condenser to the source of direct current and to the space-discharge device, whereby the switch becomes closed during the discharge of the condenser, one of the elements being comprised in one or more of the cooperating control devices.

13. X-ray control apparatus having, in combination, a master control device, a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to determine a plurality of coordinated working factors, the master control device having means cooperating with the groups of control elements of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the respective cooperating control devices, a switch for controlling the operation of the X-ray apparatus to produce instantaneous exposures, means for electromagnetically controlling the switch, a space-discharge device for controlling the electromagnetic-controlling means and having a cathode, an anode, and means for controlling the current flow between the cathode and the anode, means in one or more of the cooperating control devices for determining predetermined times of operation of the space-discharge device, a source of current for the X-ray apparatus, and a rectifier connected to the source for supplying energy for the flow of current between the cathode and the anode.

14. X-ray control apparatus having, in combination, a master control device, a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements the groups of control elements differing from one another to determine a plurality of coordinated working factors, the master control device having means cooperating with the groups of control elements of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the respective cooperating control devices, a normally open switch for controlling the operation of the X-ray apparatus to produce instantaneous exposures, means for electromagnetically controlling the switch, a space-discharge device for controlling the electromagnetic controlling means and having a cathode, an anode, and a control electrode, means comprising two elements, namely a resistor and a condenser, for controlling the flow of current through the space-discharge device, the resistor being connected between the cathode and the control electrode, a source of direct current of substantially constant voltage for charging the condenser, and a change-over switch for selectively connecting the condenser to the source of direct current and to the control electrode, whereby the switch becomes closed during the discharge of the condenser, one of the elements being comprised in one or more of the cooperating control devices.

15. X-ray control apparatus having, in combination, a master control device, a plurality of

separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to determine a plurality of coordinated working factors, the master control device having means cooperating with the groups of control elements of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the respective cooperating control devices, the master device being adapted to cooperate simultaneously with two of the said cooperating control devices, and a change-over switch for successively connecting the said two cooperating control devices to control successively the X-ray apparatus.

16. X-ray control apparatus having, in combination, a master control device, and a plurality of separate cooperating control devices adapted to be manually moved bodily under the control of the operator into and out of cooperative electrical relation to the master control device, the cooperating control devices each having a group of control elements, the groups of control elements differing from one another to determine different pluralities of coordinated working factors, and the master control device having means cooperating with the groups of control elements of the respective cooperating control devices to control the operation of the X-ray apparatus according to the working factors determined by the respective cooperating control devices.

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