HIGH VOLTAGE RELAY CONTROL CIRCUIT FOR X-RAY APPARATUS
PREVENTING ACTIVATION THEREOF IN RESPONSE TO RELAY MALFUNCTION
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HIGH VOLTAGE RELAY CONTROL CIRCUIT FOR X-RAY APPARATUS PREVENTING ACTIVATION THEREOF IN RESPONSE TO RELAY MALFUNCTION

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ABSTRACT OF THE DISCLOSURE

X-ray apparatus wherein kilovoltage level of energization of an X-ray tube is adjusted by selective closure of kilovoltage-determining relay contacts affiliated with different turns of an autotransformer in the primary circuit of a high tension transformer. A protection circuit sensitive to a closed condition of any one of such relay contacts prevents contact-closing operation of any of the relays.

BACKGROUND OF THE INVENTION

Field of the invention
X-ray kilovoltage control apparatus.

Description of the prior art
X-ray kilovoltage control apparatus conventionally employs an autotransformer having different taps which are selectively switched into the primary of a high tension transformer to provide different kilovoltages across an X-ray tube. A plurality of selectively operable relays, contacts, is a convenient way to perform such selective tap switching, but short-circuiting of autotransformer turns can occur if the contacts of more than one of such contacts are closed simultaneously, such as calling for closure of a particular kilovoltage-selecting contact when another such contact may be stuck closed due to friction or welding. Since the impedance of such an autotransformer is low, the current flow through any such short-circuit will be excessively high, hence damaging to the autotransformer turns and relay contacts concerned. Mechanical interlocking to prevent such dual contact closure is impractical where more than merely several contacts are employed, and the use of fuses in the contact lines is costly and excessively space-demanding at the load current values involved.

SUMMARY OF THE INVENTION

The protection circuit of the present invention employs a protector relay in the control circuits of the kilovoltage-determining relays to prevent contact-closing operation of any such relays when one of their kilovoltage-determining contacts is stuck closed. The protector relay is effectuated in response to a flow of current from the kilovoltage-adjusting autotransformer via any such stuck contact. A voltage regulating means is interposed between the protector relay and kilovoltage-determining autotransformer to enable such relay to be operated satisfactorily in response to flow of current through any one of the kilovoltage-determining relay contacts throughout the voltage range of such contacts. In addition, the X-ray circuit including the kilovoltage-determining relay and autotransformer may be three-phase, and the invention includes means for operating the protector relay upon sticking of the kilovoltage-determining contacts of any of the three phases.

BRIEF DESCRIPTION OF THE DRAWING

The single figure is a circuit diagram of the X-ray apparatus embodying the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, the exemplified embodiment of the present invention comprises an X-ray tube 2 which is energized from a three-phase high tension transformer and rectifier means 4 at a kilovoltage, kv, determined by the selection of the desired kv tap (140 kv, 100 kv, 20 kv, for example) of the autotransformer windings 6, one of which is shown within a circuit component group 7 for phase one of the three-phase supply lines, and the others of which for the other two phases are included in corresponding circuit groups 8 and 9 for phase two and phase three, respectively.

During normal operation of the control apparatus, kv selection for energization of X-ray tube 2 is made by manipulation of an operator's kv selector switch 12 to selectively energize the coil 14 of a closed one of a plurality of kv-determining relays 13, three of which (14 kv, 100 kv, 20 kv) are shown for exemplification, but more of which are employed in actual practice.

Energization of the coil 14 of the selected one of the kv-determining relays 13 closes the three normally-open heavy-duty supply contacts 15a, 15b, 15c to establish a particular kv-determining voltage level of energization of the primary coils (not shown) of the high tension transformer (not shown) included in means 4, from the three supply line leads, the three autotransformer windings 6 of circuit groups 7, 8 and 9, a selected tap, such as 140 kv, 100 kv, or 20 kv, for example, of each of such windings 6, a corresponding electrical conductor 140 kv, 100 kv, or 20 kv, of each of such taps, the closed contacts 15a, 15b, and 15c of the energized one of the relays 13, high tension transformer supply conductors 20a, 20b, and 20c, respectively to such contacts, the primary windings (not shown) of the high tension transformer (not shown), and via neutral line 21, indicated by the symbol for ground, back to one end of the kv-determining autotransformer windings 6, it being understood that the usual electrical exposure contactor means (not shown) will be employed to open and close such high tension transformer energizing circuit.

In accord with the present invention, the energization circuits for the kv-determining relays 13 includes a normally-closed protector relay contact 25 which is connected in series with the selector switch 12 and an electrical source 26 for energizing relay coils 14. As will be described, by providing for energizing the coil 30 of protector relay 24 to open the contact 25 whenever one of the kv-determining contacts 15a, 15b, 15c is stuck closed and the kv selector switch 12 is in its off position in which it is shown in the drawing, energizing of any of the coils 14 of the kv-determining relays 13 for closing of other such contacts 15a, 15b, 15c is prevented; the switch 12 being cut off from the source 26 for energizing a coil 14. Since, however, as will be described, energization of the protector relay coil 30 is responsive to flow of current through any one of the kv-determining contacts 15a, 15b, 15c at any time, each of the relays 13 includes a hold contact 34 connected in parallel with the protector relay contact, 25 to maintain energization of a kv-determining relay coil 14 when once effected by selector switch 12. The protection circuit can thus distinguished between a stick-closed contact condition and a normally-closed contact condition; it being appropriate that one contact, such as high current contacts 15a, 15b, 15c of a multi-contact relay can stick closed without affecting the ability of another contact, such as low-current hold contact 34, to properly open.

To provide for energizing the protector relay coil 30 at any time any one of the contacts 15a, 15b, 15c of any of the relays 13 is closed, such coil is operatively con-
nected across the outputs of the three autotransformer windings 6 via a line 36, resistor 37, a respective diode 38a, 38b, or 38c, and a respective phase isolating transformer 39 embodied in each of the circuit groups 7, 8 and 9 which has its primary winding 40 connected across the output of the autotransformer winding 6 via a branch of the respective high tension transformer supply conductor 28a, 28b, or 28c, and a respective auxiliary autotransformer 42 so connected to autotransformer winding 6 as to increase the voltage differential experienced across winding 40 a fixed amount irrespective of which kv.-
determining tap, 140 kv., 100 kv., 20 kv. etc., may be connected to winding 40 via a closed relay 13 contact 15a, 15b, or 15c. The purpose, however, is to raise the voltage differential available for operating the protector relay 24 at the lower kv. settings. For example, at the 20 kv. tap the voltage above neutral ground 21 may be about twenty-four volts, while autotransformer 42 provides a corres-
ponding voltage differential across primary winding 40 of one hundred twenty-four volts, for example, with trans-
former 42 extending one end of winding 40 one hundred degrees below neutral grounds 21. The transformers 39 can merely be at a one-to-one ratio and still provide ade-
quate voltage for operating protector relay 24 at even the lowest kv. taps of the autotransformer windings 6.

To protect the energizing circuit from excessive overvoltage at the higher kv. settings of windings 6, a voltage regulator tube 46 is connected across such coil.

A capacitor 48 is also connected across the protector relay coil 30 to assure its adequate energization even when only one phase may be in operation.

1 claim:

1. X-ray apparatus comprising,
an X-ray tube,
high tension transformer and rectifier means connected across said X-ray tube for supplying kilovoltage pulses of electrical energy thereto,
A.C. electrical supply line leads,
kilovoltage-determining autotransformer means con-
ected to said supply line leads for energization thereby and having different voltage taps for energiza-
tion of the high tension transformer to produce se-
lected kilovoltage outputs,
a plurality of kilovoltage-determining relays having re-
pective normally-open supply contacts closeable to connect respective ones of the autotransformer volta-
tage taps to the high tension transformer and having respective coils energizable to effect closure of such supply contacts,
operator's switch means operable to establish energizing circuits for said kilovoltage-determining relay coils selectively as well as to disestablish any such energiz-
ing circuits,
a protector relay having a normally-closed contact in series with said operator's switch means and ener-
gizable to open such contact to prevent establishment of energizing circuits for the kilovoltage-determining relay coils,
and an energizing circuit for said protector relay, in-
cluding said kilovoltage-determining autotransformer means and the supply contacts of said kilovoltage-
determining relays.
2. X-ray apparatus as set forth in claim 1, wherein:
said kilovoltage-determining relays also have respective normally-open hold contacts in parallel with the pro-
tector relay contact which close when the coils of such relays are energized.
3. The X-ray apparatus of claim 2, wherein:
the energizing circuit for the protector relay also in-
cludes an auxiliary autotransformer which increases the voltage level of such energizing circuit relative to that of the supply circuit to the high tension trans-
former means.
4. The X-ray apparatus of claim 1, wherein:
said high tension transformer and rectifier means are constructed and arranged for three-phase operation, said A.C. electrical supply line leads provide three-
phase operation of the apparatus,
said kilovoltage-determining autotransformer means in-
cludes three windings connected to said supply line leads respectively to the three phases of line power,
and the three windings include corresponding voltage taps,
the normally-open supply contacts of said kilovoltage-
determining relays are in triplicate respective to the three autotransformer windings,
and the energizing circuit for the protector relay in-
cludes respective diodes and isolating transformers coupling said protector relay to the three autotrans-
former windings and to the triplicate supply contacts.
5. The X-ray apparatus of claim 1, wherein:
said energizing circuit for the protector relay also in-
cludes voltage regulating means to protect such relay from excessive current when the higher voltage sup-
ply contacts of the kilovoltage-determining relays are closed.

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