Nov. 22, 1938. E. B. GRAVES 2,137,647

X-RAY APPARATUS

Filed Oct. 28, 1937 2 Sheets-Sheet 1

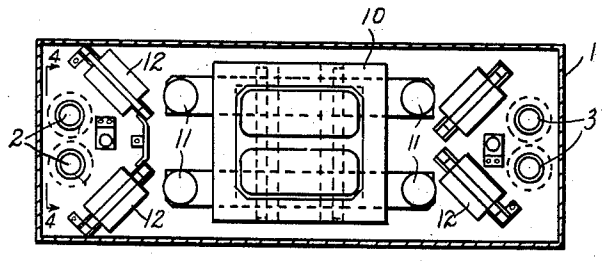

FIG.-1

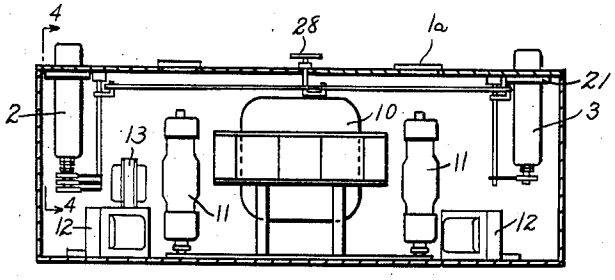

FIG.- 2

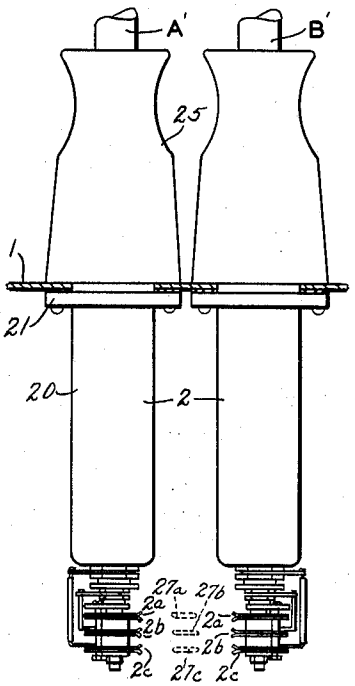

FIG.- 4

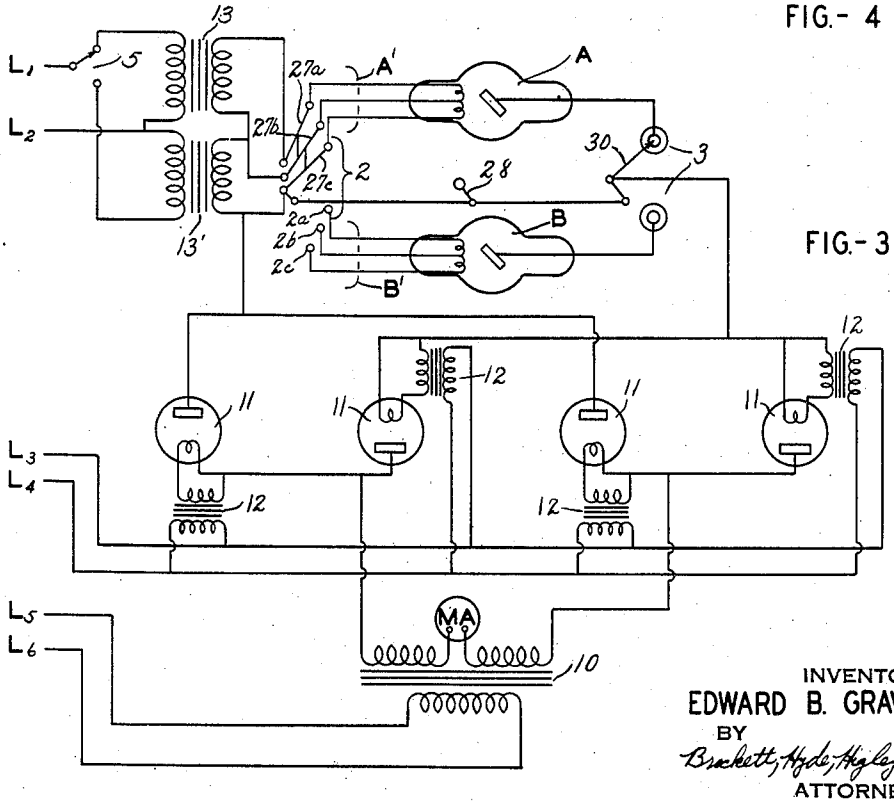

FIG.- 3

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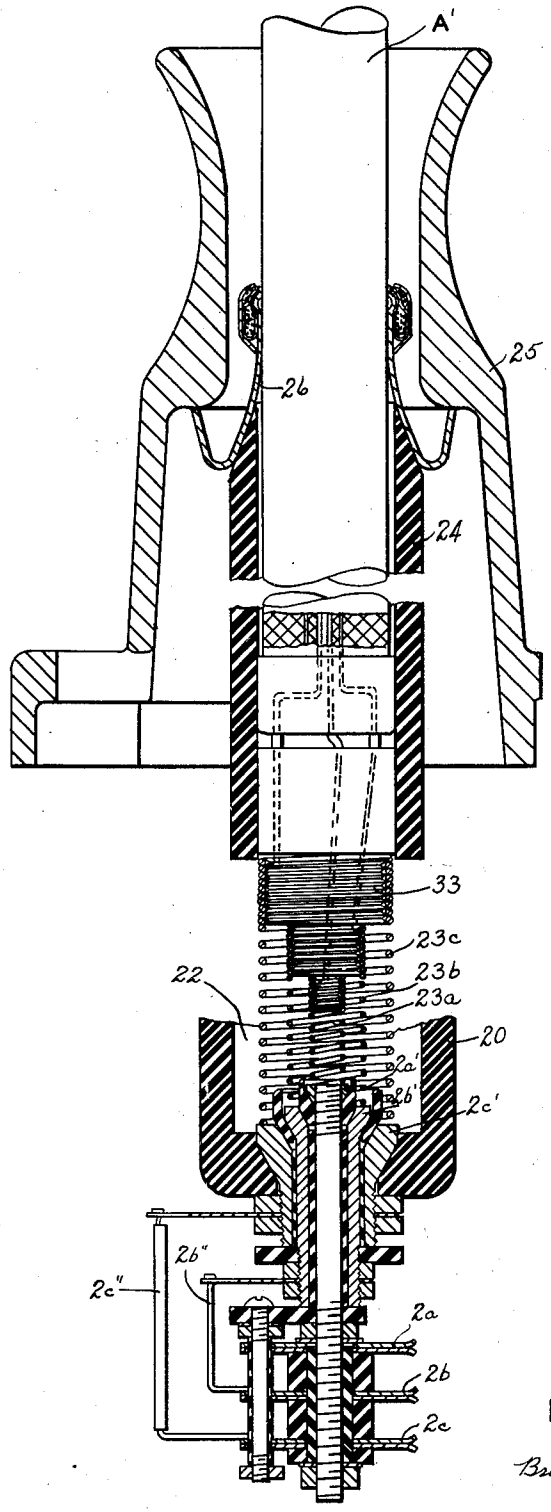

FIG. - 5

FIG. - 6

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X-RAY APPARATUS

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Application October 28, 1937, Serial No. 171,503

9 Claims. (Cl. 250—87)

This invention relates to transformer apparatus for selectively operating, and controlling, a pair or more of X-ray tubes. Apparatus employing such tubes, indicating their manner of employment, is more fully disclosed in application, Serial No. 154,227, filed July 17, 1937 by Edwin R. Goldfield, wherein it will be seen that a single transformer unit is provided for selective operation of either of two tubes.

The present invention has for its general object the provision of a transformer unit for selective operation of any of a plurality of X-ray tubes, which unit shall be of minimum size, with its parts compactly arranged and, if desired, to provide a long narrow form.

Another object of the invention is to serve X-ray tubes of the type having a plurality of filaments as for double focus, and provide for selective energization of the filaments of the selected tube.

The invention contemplates immersion of the elements of the transformer unit in a single body of fluid dielectric such as oil, housed in a single container, and another particular object of the invention is to provide novel means for connecting the transformer unit to the tube to be served. Such means includes a novel type of high tension terminal carrying contactors submerged within the dielectric of the transformer unit and making dry connection with high tension cables leading to the tubes as will appear.

The exact nature of the invention together with further objects and advantages thereof will be apparent from the following description taken in connection with the accompanying drawings, in which Figs. 1 and 2 are plan and side elevation views respectively, of parts of the transformer unit, as with the near container sides removed, and showing the relative disposition of the parts; Fig. 3 is a diagrammatic view showing the circuits by which the parts function to serve the X-ray tubes; Fig. 4 is an enlarged section as in the plane of line 4—4, Figs. 1 and 2, showing a pair of high tension terminals with the switch parts carried thereby; and Figs. 5 and 6 are further enlarged sectional elevations showing further details at one of the terminals.

With reference now to the drawings, 1 is a transformer unit container, housing a high tension transformer 10, high tension rectifying valve tubes 11, a filament transformer 12 for each valve tube and a pair of X-ray tube filament transformers 13, 13'.

Physically, these parts are disposed within the container 1 as indicated in Figs. 1 and 2, the high tension transformer 10 in the middle, two valve tubes 11 on either side of the transformer, the filament transformers 12 beyond their tubes and thereadjacent, and the X-ray tube filament transformers 13 above transformers 12, it being understood that these parts are surrounded by fluid dielectric which substantially fills the container 1. Preferably the top wall of the container is provided with removable closures 1a, one for each valve tube providing individual removal of these tubes for replacement.

The transformer unit is provided at each end with a set of terminals, one for each X-ray tube to be served, so that for each X-ray tube there are a pair of terminals, one at each end of the transformer unit.

In the drawings for simplicity but two X-ray tubes A and B are illustrated as to be served, although more than two may be served, so that as shown there are but two terminals each generally indicated at 2 at the left end of the unit and correspondingly two terminals each generally indicated at 3 at the right end.

Electrically the parts within the container 1 are interconnected as indicated in Fig. 3, served by lines L_1 to L_6 leading from a suitable control unit not shown but well known in the art, to the transformer unit. Of these lines L_1 and L_2 selectively energize the primary windings of either of the X-ray tube filament transformers 13, 13' by manipulation of switch 5, lines L_3 and L_4 coincidentally control the filament transformers 12 of all four valve tubes 11, and lines L_5 and L_6 control the high tension transformer 10.

Each X-ray tube A, B, having two filaments as indicated, three connections are necessary at the filament end of the tube for selective energization of its filaments; a single connection only being sufficient for its anode end.

The two terminals 2, one for each X-ray tube, which terminals serve the filament or cathode ends of the tubes, both include switch means for selecting between the X-ray tubes and make connection with multi-conductor shockproof cables A', B', as indicated in Figs. 4, 5 and 6.

Each terminal comprises a bushing 20 of insulating material having a flange 21 for its securement against the top wall of the container 1 and recessed to provide a socket 22 preferably extending below the level of the dielectric within the container. Each bushing 20 extends above the container as shown in Fig. 2. The portion above the container embraces the sleeve 24 within the collar 25 and provides insulation about the cable. As illustrated in Figs. 4 and 6, three

switch contactors 2a, 2b and 2c are mounted in aligned relation along the bushing, at the bottom end of the bushing, and correspondingly the base of the socket 22 is provided with three cable contactors 2a', 2b', 2c'. These cable contactors are arranged concentrically with respect to the bushing 20, the contactor 2a' being centrally located and the other contactors 2b' and 2c' being annular thereabout and also preferably slightly spaced longitudinally. The switch contactors are insulated from each other by cylindrical elements and the cable contactors are insulated from each other by the cylindrical and conical elements indicated, these latter insulating elements extending upwardly into the socket 22 between their contactors—all as illustrated Fig. 6. Also as illustrated, each switch contactor has electrical connection with its corresponding one of the cable contactors. As here shown the switch contactor 2c has connection with its cable contactor 2c' by conductor 2c'', the switch contactor 2b has connection with its cable contactor 2b' by conductor 2b'', and the switch contactor 2a has direct connection with its cable contactor 2a', the latter extending downwardly in the form of a bolt as illustrated.

While 2a' might be a bolt with a suitably shaped head, the actual parts shown comprise a conical nut threaded on the upper end of the bolt. It will be noted that the parts 2a', 2b', and 2c' and the insulators between them are nested so that a threaded nut outside the bushing wall holds all of these parts in position firmly assembled on the central bolt. All of the conical and threaded parts are sealed by a compound which prevents entrance of oil into the internal socket of the bushing 20.

The three-conductor shockproof cable A' corresponding to the terminal parts just described, is arranged at its end as illustrated in Fig. 5 with three concentric helical contactor springs 23a, 23b, 23c. Each of these springs is insulated from the others by the stepped and threaded insulating element 33 but each has electrical connection with one of the cable conductors by the wiring indicated, in drilled passages in the element, each spring being retained upon the element by the threads indicated.

The diameters of the contactor springs are such that when the end of the cable A' is thrust into the socket 22 of the bushing 20, each of its contactor springs 23a, 23b and 23c will make contact with its corresponding contactor 2a', 2b', 2c' of the bushing, and thus establish separate connection with its corresponding switch contactor 2a, 2b, 2c.

The cable end part is maintained straight and aligned within the socket 22 of the bushing, so as to align the contactors, by a sleeve 24 of insulating material. A collar 25, about the sleeve, is secured on the top of the container 1 by any suitable means; and the cable is secured within the collar against endwise removal, by annular metal bushing 26, the arrangement permitting, however, rotation of the cable end about its axis, it being appreciated that such shockproof high tension cable is substantially stiff. Obviously the arrangement described and particularly the provision of freedom of the cable for adjustment about its axis, eliminates twisting of the cable and consequent bends and strains upon the cable at points removed from the transformer unit.

It will be understood that when the parts are fully assembled the cable and the sleeve 24 move down from the position of Fig. 5 into the bushing 20 so that the coil springs 23a, 23b, and 23c are compressed and make firm contact with the annular contactors 2a', 2b' and 2c' respectively.

As indicated in Figs. 1 to 4, the two terminals 2 are so disposed that their two sets of switch contactors 2a, 2b, 2c, face each other, with the two contactors 2a in the same plane and so on. Multi-pole multi-throw switch means is provided for selectively energizing either set of contactors from the current-producing means within the container 1, for energizing the filament end of the selected X-ray tube. Such means is here shown as a series of contactors 27 connected in the circuit as indicated in Fig. 3 and mounted for movement between the sets of contactors 2a, 2b, 2c, on the two terminals 2.

The multi-pole selector switch just described, is actuated by a controller 28 on the outside of the container 1 through the linkage including crank members at the movable switch parts and at the controller as conventionally indicated in Figs. 2 and 3.

The other pair of terminal units 3 carry current only to the anodes of the tubes A and B and therefore need only have one contactor each. Otherwise they are generally similar to the terminals 2 hereinbefore described, and a single-pole multi-throw switch 30 is arranged to selectively connect either terminal 3 to the high tension output of the transformer means, this switch 30 being so connected to the controller 28 as to be moved thereby in unison with the other, multi-pole, switch above described.

Consequently the arrangement is such that by operation of the controller 28 either X-ray tube A or B may have complete operative high tension connections established from the transformer unit.

Either X-ray tube being so connected, the low tension switch 5 permits selection between the filaments of that tube, for its desired focus.

What I claim is:

1. Apparatus for selectively operating a plurality of double-filament X-ray tubes comprising a pair of terminals for each tube, a source of high tension current, switch means arranged to selectively connect said source to any pair of said terminals, one terminal of each pair having a plurality of conductors providing connections for selective energization of the filaments of its tube, a pair of X-ray tube filament transformers, said switch means being arranged to simultaneously connect the secondaries of both transformers to the respective filaments of the selected tube, and means for selectively energizing the primary windings of said transformers.

2. Apparatus for selectively operating a plurality of double-filament X-ray tubes comprising a transformer unit having a source of high tension current, a pair of terminals for each tube, switch means arranged to selectively connect said source to any pair of said terminals, and a pair of X-ray tube filament transformers, one terminal of each first named pair having a plurality of conductors providing connections for selective energization of the filaments of the selected tube, said switch means being arranged to simultaneously connect the secondaries of both transformers to the respective filaments of the selected tube, and means outside said unit for selectively energizing the primary windings of said transformers.

3. In an X-ray transformer unit of the class described, having high tension current-producing means, containing means therefor, fluid dielectric

within said containing means about said means, a plurality of pairs of terminal units for said means and adapted for connection with coating pairs of shockproof cables, each pair of cables leading to a separate X-ray tube, switch means for selectively energizing any pair of cables from said high tension current-producing means and comprising stationary contactor means carried by said terminal units and submerged in said dielectric, and contactor means connected to said high tension current-producing means and movable to establish connection selectively with the contactor means of any pair of said terminal units.

4. An X-ray transformer unit of long narrow form for the purpose described comprising high tension transformer means, valve tube means arranged to rectify the transformer output and disposed on opposite sides of said transformer means, filament transformer means for said valve tube means and located thereadjacent, a container housing said means and having side walls adjacent said transformer means and extending therebeyond adjacent said tube means, terminals disposed at the ends of said container beyond said tube means and including a plurality of terminals grouped at each container end, means providing high tension connection from said tube means to said terminals and including switch means for selectively energizing two of said terminals, one of each group, and coincidentally de-energizing the remaining terminals, and fluid dielectric within said container about said means.

5. In an X-ray transformer unit, high tension current-producing means including a transformer, containing means therefor, fluid dielectric within said containing means about said means, and a terminal unit for said means comprising an insulating bushing mounted in a wall of said containing means and extending thereinto, high tension switch means for said current-producing means and including a contactor carrier by said bushing and submerged in said dielectric, said bushing having a socket for receiving the end of a shockproof cable leading from said transformer unit and means providing electrical connection between said contactor and said cable while preventing access of said dielectric to said cable.

6. In an X-ray transformer unit, high tension current-producing means including a transformer, a containing means therefor, fluid dielectric within said containing means about said means, and a terminal unit for said means comprising an insulating bushing mounted in a wall of said containing means and extending thereinto, high tension switch means for said current-producing means and including a contactor carried by said bushing and submerged in said dielectric, said bushing having a socket for receiving the end of a shockproof cable leading from said transformer unit and also having means providing electrical connection between said contactor and said cable while preventing access of said dielectric to said cable, and said bushing extending outside said containing means to there provide insulation about said cable.

7. In an X-ray transformer unit, high tension current-producing means including a transformer, containing means therefor, fluid dielectric within said containing means about said means, and a terminal unit for said means comprising an insulating bushing mounted in a wall of said containing means and extending thereinto, high tension switch means for said current producing means and including a plurality of contactors carried by said bushing and submerged in said dielectric, said bushing having a socket for receiving the end of a multiple conductor shockproof cable leading from said transformer unit and also having means providing electrical connection between each of said contactors with one of said cable conductors while preventing access of said dielectric to said conductors.

8. Apparatus for operating a plurality of X-ray tubes comprising high tension transformer means, valve tube means arranged to rectify the transformer output, filament transformer means for said valve tube means, a plurality of pairs of terminals, one pair for each X-ray tube, and means providing high tension connection from said tube means to said terminals and including switch means for selectively energizing a plurality of said terminals, one of each pair, and coincidentally de-energizing the remaining terminals, and containing means housing all of said apparatus, and fluid dielectric within said containing means and about said apparatus.

9. Apparatus for selectively operating a plurality of double-filament X-ray tubes comprising a pair of terminals for each tube, a source of high tension current, switch means arranged to selectively connect said source to any pair of said terminals, one terminal of each pair having a plurality of conductors providing connections for selective energization of the filaments of its tube, a pair of X-ray tube filament transformers, said switch means being arranged to simultaneously connect the secondaries of both transformers to the respective filaments of the selected tube, containing means housing all of said above named apparatus except the X-ray tubes, a fluid dielectric in said containing means in which said apparatus is submerged, and means for selectively energizing the primary windings of said transformers.

EDWARD B. GRAVES.

CERTIFICATE OF CORRECTION.

Patent No. 2,137,647. November 22, 1938.

EDWARD B. GRAVES.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 3, claim 3, for "coating" read coacting; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 27th day of December, A. D. 1938.

Henry Van Arsdale

(Seal) Acting Commissioner of Patents.