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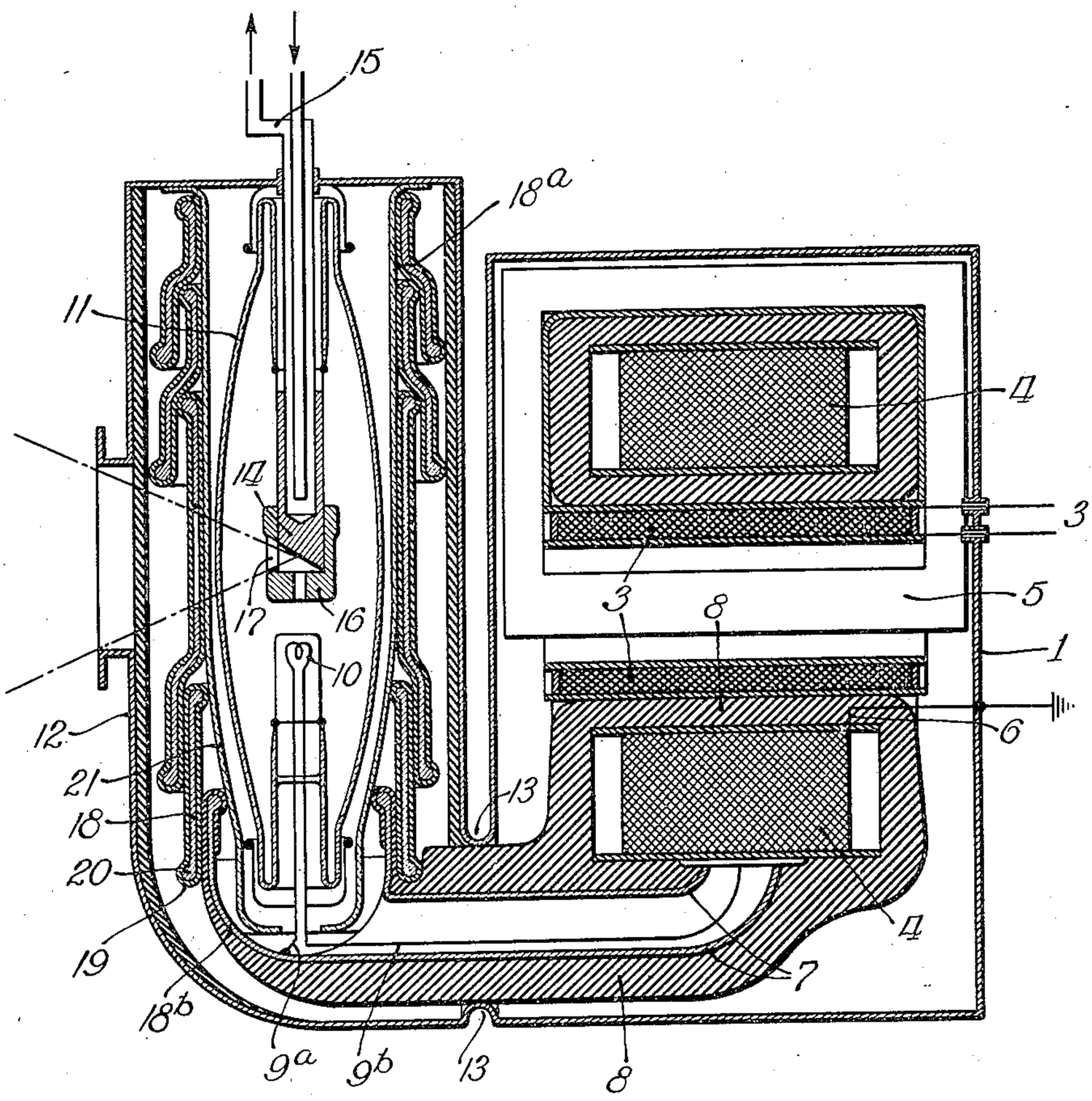

Inventors:
Carl Niemann
Kurt Bischoff
By: Richardson and Auer
Attys.

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RÖNTGEN APPARATUS

Carl Niemann and Kurt Bischoff, Erlangen, Germany, assignors to the firm Siemens-Reiniger-Werke Aktiengesellschaft, Berlin, Germany

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This invention relates to Röntgen apparatus, and is particularly concerned with novel and improved means for operating Röntgen tubes with high tension, such as applied, for example, in deep therapy. The invention is especially directed to the provision of apparatus furnishing complete high tension and irradiation protection and characterized by relatively small weight and greatly reduced dimensions.

In order to attain these objects, the Röntgen tube is connected directly to the alternating current furnished by a high tension transformer, thereby dispensing with the usual valve tubes and disposing the Röntgen tube and the high tension transformer in a single protective housing or in two separate housings which are, however, closely connected to form a unitary structure. The high tension protective housing (or housings) is filled with a suitable insulating medium, such as oil, in order to reduce the dimensions further. One pole of the Röntgen tube and of the high tension transformer is conductively connected with the grounded exterior wall of the protective housing. This provision is particularly advantageous in case of grounding of the anode of the Röntgen tube, because the cooling of the anode can be accomplished in a simple manner directly from the grounded water supply.

The state of the art is briefly noted below and compared with the new structure, so that the invention may be fully understood and appreciated.

Devices are known wherein the Röntgen tube and the high tension transformer are provided in a common grounded and oil-filled container and equipped with a grounded water-cooled anode. It should be observed, however, that these known structures are not suitable for high tension operation as required in deep therapy because, while the anode of the Röntgen tube is dielectrically relieved at the grounded anode end, the tube is subjected to the full operating tension at the cathode end. In order to prevent dielectric breaks and gas eruptions, it would be necessary to dimension the housing at the cathode end of the tube so large that the apparatus would be unsuitable for practical operation.

It is possible, however, in accordance with the present invention, even in case of such a structure as intimated above, to keep the distance between the tube and the grounded housing very small by surrounding the tube with annular or tubular metallic members. The latter are arranged so that the distribution of the tension within the protective housing is substantially approximated to the normal distribution of tension along the tube due to the capacity effect of the ring-shaped members. By "normal distribution of tension along the tube" is meant that tension distribution which occurs upon free operation of the tube, and not upon operation within a grounded housing. This tension distribution is determined by the structure of the tube, and is particularly affected by conditions permitting electrons emitted from the electrodes to strike and charge the glass wall of the tube.

The provision of capacitatively coupled internal and external shields broadly in conjunction with gas-filled discharge tubes is likewise known, for the purpose of avoiding undesired gas discharges. However, such provisions are applied only with freely operated tubes and not with tubes disposed within a high tension protective housing wherein the detrimental influence of the grounded housing wall upon the normal tension distribution along the tube is to be compensated for or equalized.

Another known structure may be noted wherein the middle or central portion of a Röntgen tube disposed within a grounded oil-filled container, is surrounded by a ring-shaped control electrode for the purpose of preventing the formation of charges upon the outer surface of the tube. However, the Röntgen tube is connected in this arrangement to direct current with both poles on high tension. The central electrode does not serve the purpose of reducing the load or stress upon the tube wall by an electric alternating current field.

The new arrangement of annular or tubular metallic bodies surrounding the Röntgen tube, as disclosed herein, renders the advantage of keeping the distance between the tube and the housing wall very small. The longitudinal extent of the housing may be reduced in accordance with another feature of the present invention by using a Röntgen tube having a practically linear normal tension distribution, i. e., a tube wherein the longitudinal tension load (kV per cm of tube length) is smallest. Linear tension distribution along the tube may be attained by providing for a structure wherein the electrons emanating from electrodes cannot disturb the linear tension distribution formed normally under the influence of the operating current. Röntgen tubes provided with electrode hoods, double-walled tubes, and tubes with especially thick walls may be mentioned as examples of such structures. Tubes wherein the glass wall is subdivided by metallic members or intermediate electrodes, such as the

so-called cascade tubes, should not be used because their dimensions are too large for the instant purposes.

The invention may also be of advantage in devices wherein both poles of the Röntgen tube are connected to high tension. If desired or required, the potentials of the ring-shaped or tubular metallic members may be controlled separately from the outside by connecting thereto suitable current. Capacitative control of the potentials will, however, suffice in most general cases of use. Exterior control may necessitate undesirable increase of the size of the tube due to the space required for the highly insulated current conductors for the corresponding metal members.

The following detailed explanations are rendered with reference to the accompanying drawing illustrating an embodiment of the invention for the purpose of guiding others in its practical use. The drawing shows a somewhat schematic representation, partly in section, of a Röntgen tube and associated equipment, including the high tension transformer and the protective housing.

Referring now to the drawing, numeral **1** designates a metal container in which is disposed the high tension transformer with its primary winding **3**, secondary winding **4**, and iron core **5**. The terminals of the primary winding are indicated at **3***a*. One pole of the secondary winding, indicated at **6**, is grounded. The high tension current is conducted to the cathode **10** of the Röntgen tube **11** from the other pole of the secondary winding by means of the metal conduit **7**, which may be highly insulated, for example, by means of paper bandages **8**, and which is joined to the metallic member **18***b*. The latter is connected to the cathode **10** by a conductor **9***a*. Conductor **9***b* is a low voltage tap of the secondary winding and supplies heating current for the cathode. The Röntgen tube **11** is disposed in a grounded container **12**, which is joined with the container **1** at **13**, for example, by a soldered joint. The anode **14** of the Röntgen tube **11** is grounded and can therefore be cooled in a simple manner by circulating water from a grounded water supply through the cooling pipe **15**.

The focal point of the Röntgen tube **11** is surrounded by an electron protective hood **16** having an aperture **17** provided with a beryllium disk. The Röntgen rays can therefore emanate substantially without loss while the electrons are retained. In case of irradiation of body cavities, the anode will take a tubular form, projecting in generally known manner from the container substantially centrally of the tube with the focal point provided at the end thereof.

The Röntgen tube **11** is surrounded by ring-shaped, annular or tubular metallic members **18** embedded within paper bandages **19** and thereby insulated from each other. Other suitable insulating means may be used, if desired. The ends or rims **20** of these metallic members **18** are enlarged in order to prevent a spraying effect, and overlap each other so that they assume charges by the influence of their potentials which correspond substantially to the normal tension distribution along the tube. The metallic members **18***a* and **18***b* are conductively connected with the anode and with the cathode, respectively, of the Röntgen tube.

The container portions or receptacles **1** and **12** are filled with oil or with another suitable high grade insulating medium in order to provide for the smallest possible dimensions of the structure. It is advisable for this purpose to dispose the Röntgen tube **11** within a casing or pot **21** which may be made of a suitable insulating material, such as porcelain, pressed material or plexigum, and the like. The Röntgen tube is thus separated from the tubular or annular bodies **18**, whereby its removal or replacement is considerably facilitated, with the further advantage of preventing mixture of the oil surrounding the Röntgen tube **11** with the oil contained in the receptacle or housing **12**, and thus substantially reducing the danger of detrimental discharges of the tube after replacement thereof.

It may be desirable to ground the cathode instead of the anode and thereby simplify the arrangement for heating the cathode. In such a case the anode would be connected with the high tension pole of the high tension transformer and would dissipate the heat by radiation.

The structure described in the foregoing is particularly adapted for deep therapy, but can also be applied for technical examination of materials with hard Röntgen rays.

Changes may be made, deviating from the precise showing of the structure illustrated in the drawing and described in the foregoing, and therefore it is understood that all embodiments are considered our invention, provided they fall within the spirit and scope of any or all of the appended claims, subject only to the showing of the prior art.

We claim as our invention:

1. Röntgen apparatus comprising an evacuated tube containing cathode and anode electrode elements, said elements being supported from opposite ends of said tube, respectively, a source of high tension current connected between said elements, a metallic protective housing surrounding said tube, said housing being connected to the anode and being of such small dimensions that at the cathode end where the full anode potential appears between the housing and cathode the spacing is insufficient to prevent disruptive discharges, means for preventing such discharges comprising a series of annular metallic rings insulated from each other and surrounding said tube from end to end inside the housing, and means connecting the two opposite end members of the series to the cathode and anode, respectively, whereby said rings constitute a capacitative shunt of the discharge path between said elements.

2. Röntgen apparatus comprising an evacuated tube containing electrode elements, a source of high tension current having its two poles connected to said elements, respectively, to produce discharge currents, a metallic protective housing conductively connected to one pole of said source and surrounding said tube at such a close distance therefrom as to tend to affect the discharge path between said elements, and means for preventing said housing from thus affecting the operation of the tube, said means comprising a series of annular metallic members inside said housing and surrounding said tube from end to end, said members being insulated from each other and the opposite end members being connected to said elements, respectively, whereby the said members form a capacitative shunt of the discharge path between said elements.

3. Röntgen apparatus comprising an evacuated tube containing electrode elements, a housing for said tube comprising an inner shell of insulating

material and an outer shell of conducting material, said tube being positioned within said inner shell, a series of overlapping annular metallic members positioned in the annular space between said shells, said members being insulated from each other, and connections from the opposite end members of said series to said electrode elements, respectively, whereby the said elements constitute a capacitative shunt of the discharge path between said electrodes.

4. Röntgen apparatus comprising a metallic housing, an inner shell of insulating material located in said housing, said shell being smaller than the housing so that an annular space is provided between the shell and the inner wall of the housing, a Röntgen tube removably positioned wholly inside said shell, a series of annular overlapping metallic members packed in the said annular space, and insulating wrappings for said members to prevent conductive contact between them.

5. Röntgen apparatus comprising a Röntgen tube provided with cathode and anode, a protective metallic housing surrounding said tube and having its wall relatively close to the wall of the tube, a source of high tension current having one pole connected to said housing and to the anode of said tube and having the other pole connected to the cathode of said tube, an annular metallic member surrounding said tube at one end, a second metallic member surrounding said tube at the other end, a plurality of intermediate annular metallic members surrounding said tube between said first and second members, all said members being inside said housing and being insulated from each other, a conductive connection from said first member to said housing and anode, and a conductive connection from the second member to said cathode.

CARL NIEMANN.
KURT BISCHOFF.