Oct. 11, 1932.　　T. H. FORDE ET AL　　1,881,448

X-RAY METHOD AND MEANS

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Fig. 1.

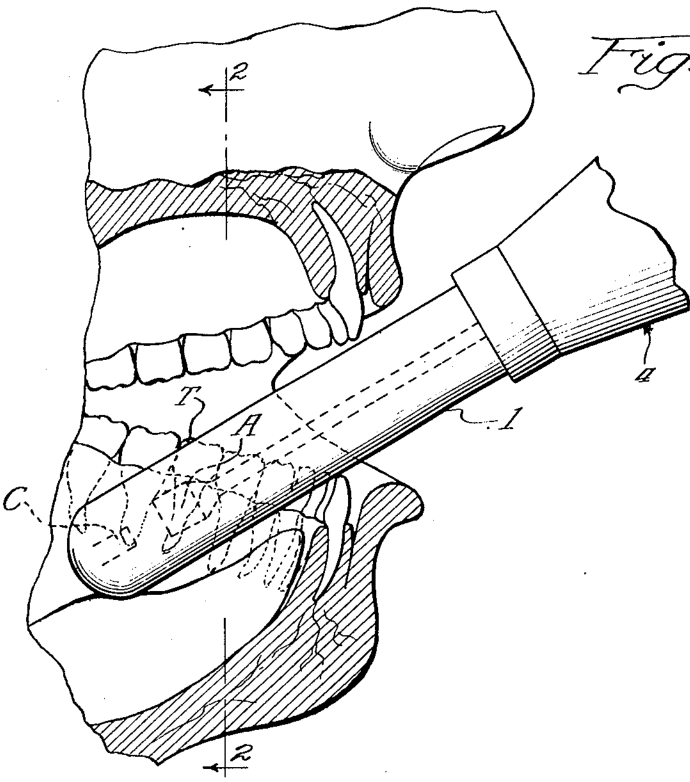
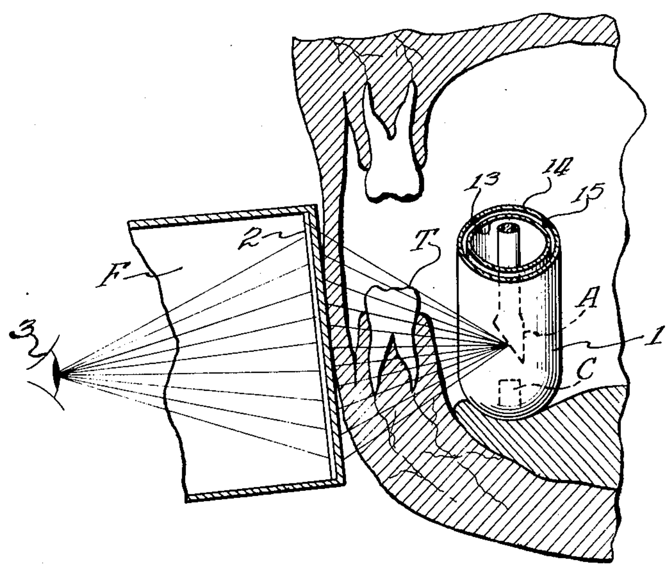


Fig. 2.



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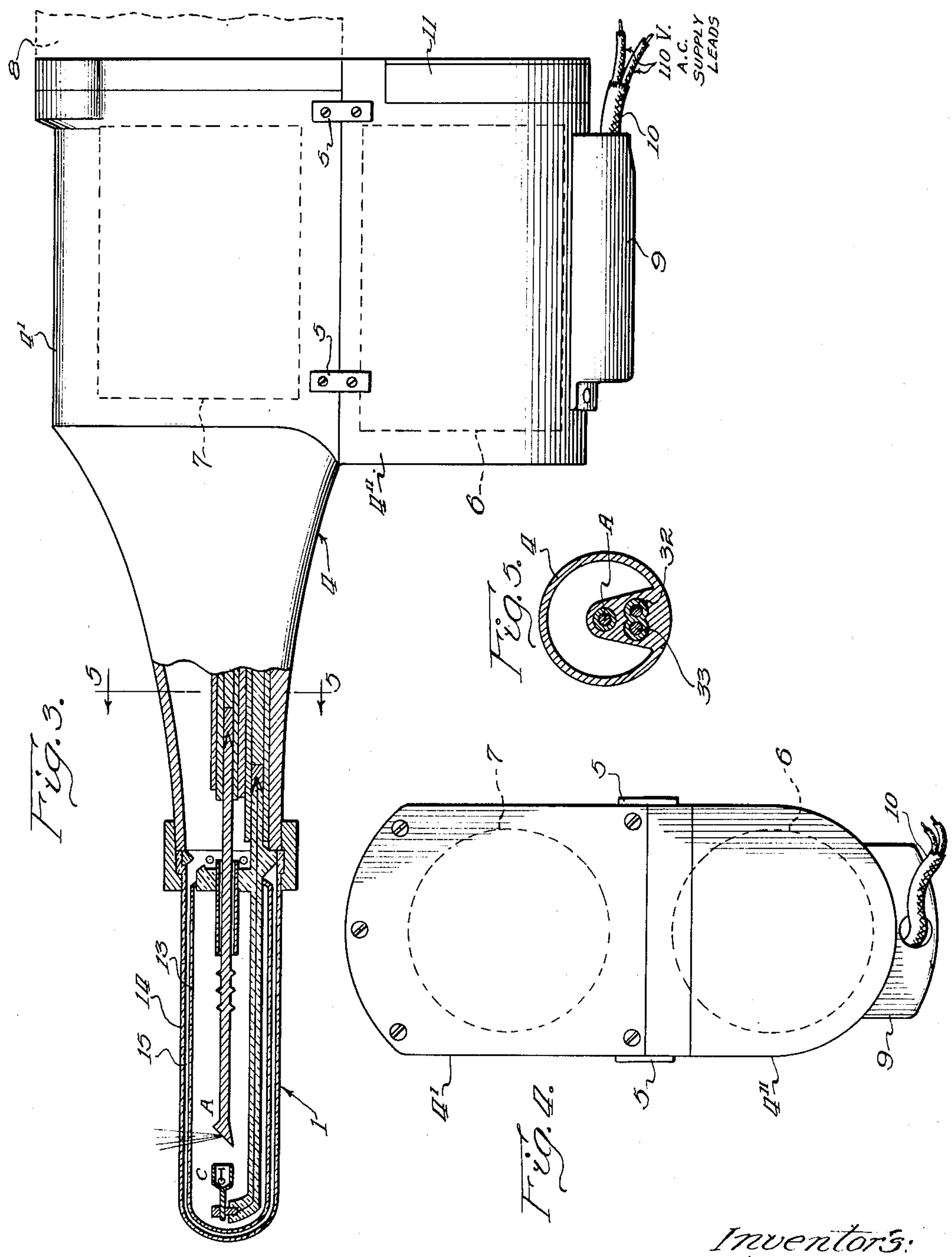

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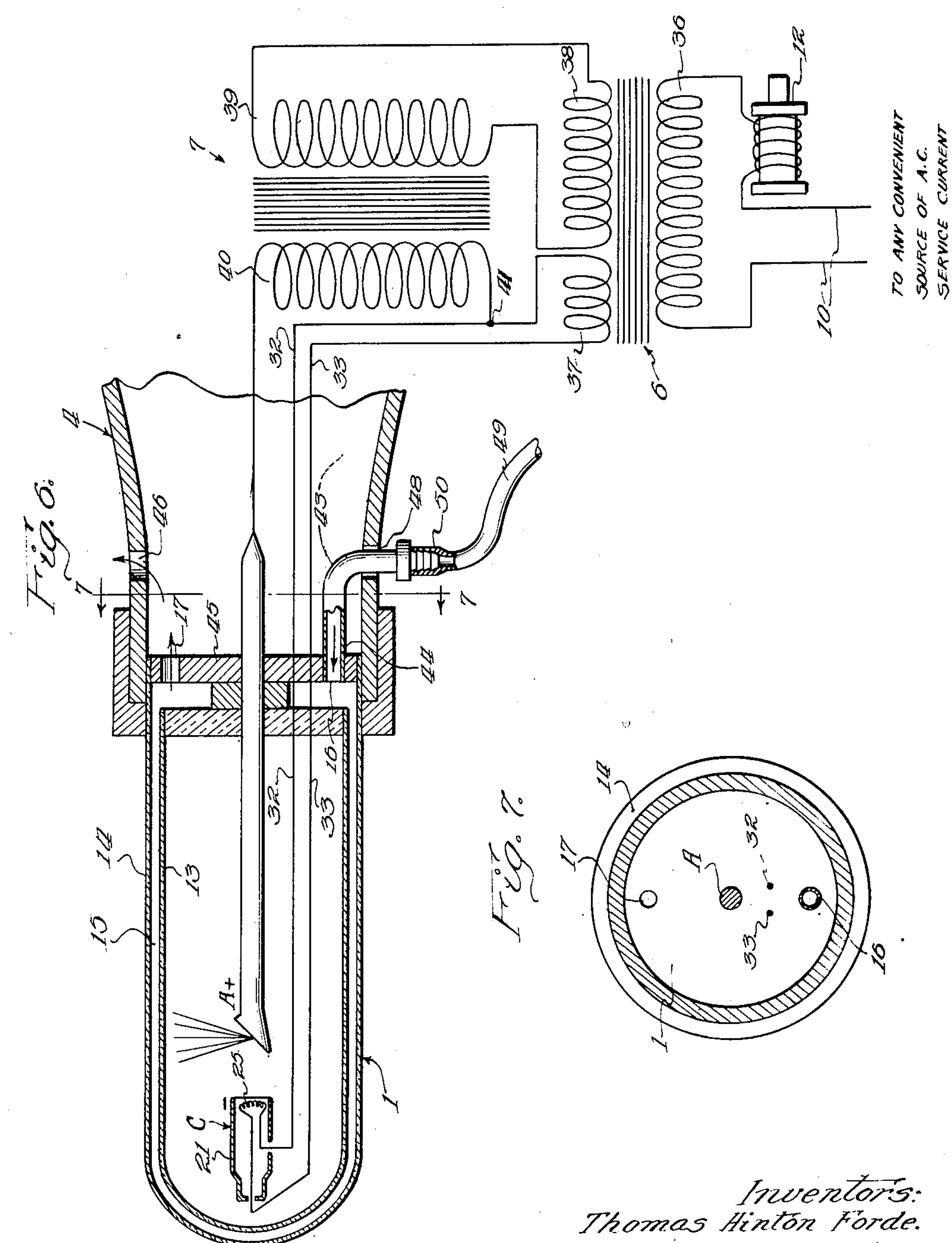

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X-RAY METHOD AND MEANS

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Fig. 8

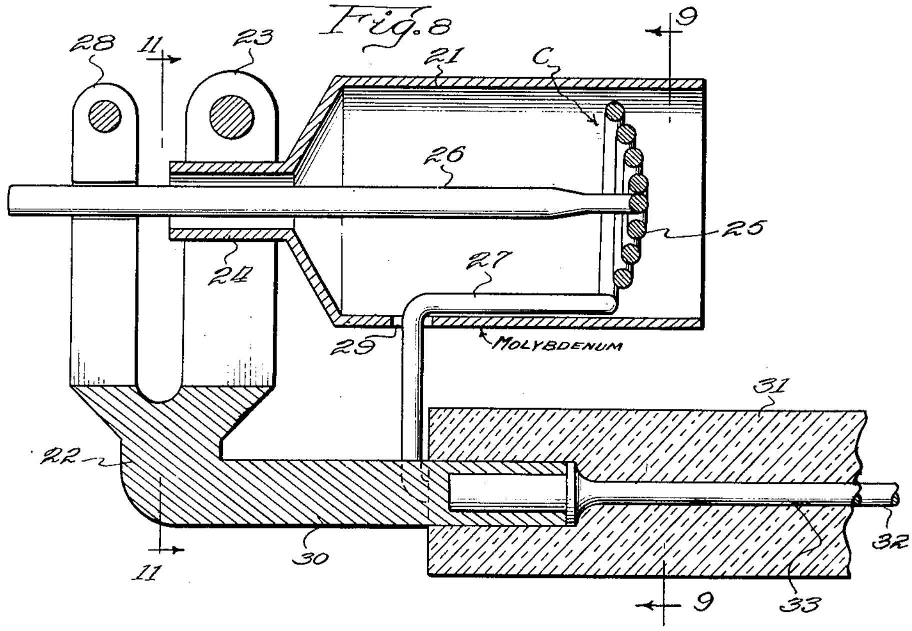


Fig. 9.

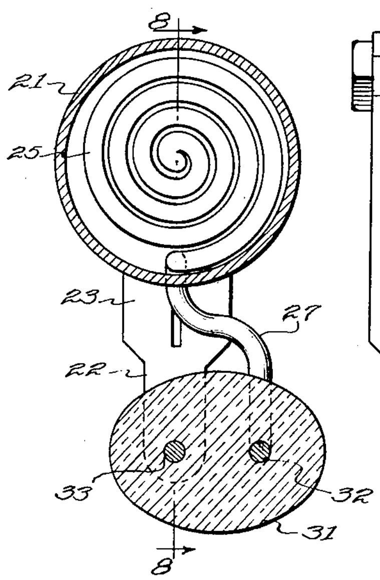


Fig. 11.

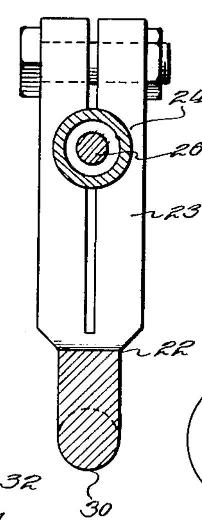
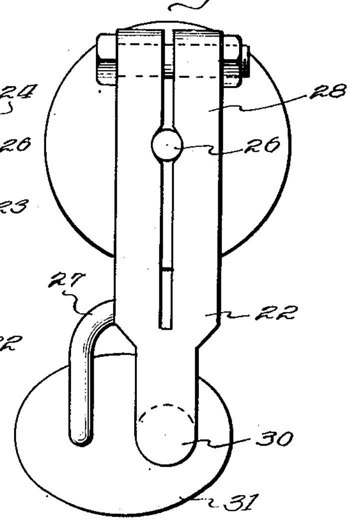


Fig. 10.



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UNITED STATES PATENT OFFICE

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X-RAY METHOD AND MEANS

Application filed August 15, 1928. Serial No. 299,650.

This invention relates to diagnostics and physical therapy and especially to the use of X-ray and fluoroscopic devices and to the structure, form, and operation of X-ray tubes and accessories therefor.

Heretofore it has been customary to generate the X-rays externally and to apply them inwardly, as for instance in obtaining shadowgraphs of the teeth, and also in examining the teeth fluoroscopically, the receiving screen being made small and arranged for insertion into the mouth. This limitation to outside generation of the rays was necessitated by the unaccommodating size and character of tubes available for generating the rays. Moreover visual observation of the image on a small screen located in the mouth is subject to such limitations as to size and access as to leave much to be desired, both in point of accuracy and convenience. These same considerations largely apply also in connection with other cavities of the body, such as hereinafter mentioned.

The main objects of the invention are to minimize the voltages necessary for radiation such as referred to; to provide for more direct and efficient fluoroscopic examinations incident to radiation; to provide for a technique and operation satisfiable by "soft" tube radiation and corresponding low penetration, low heat and low potentials; to provide an improved form of X-ray tube adapted for insertion into apertures or cavities such as referred to and especially into the mouth for examining the condition of the teeth, as by fluoroscopic observation in such manner that the image may be examined directly and conveniently; to provide for safe and efficient operation of the device as a whole from ordinary low potential alternating current service mains; and to provide certain novel features of construction and design, adapting the device for the purposes herein specified.

First, we will discuss the general principles which pertain to the new type of instrument which we have developed for use both in dentistry and in medicine for the purpose of diagnosing and treating lesions of pathological nature occurring within various cavities or orifices of the human body, as for example, the oral cavity, the nares, the larynx, the pharynx, the nasal passages, the rectum and the vagina; which instrument we call a "diascope".

In our system the rays are emitted from a tube of minute proportions which is adapted to be activated by a low potential electric current. This use of low voltage and also the dependence on comparatively non-destructive fluoroscopic rays, which can also be used for the purpose of treating pathological tissue of embryonic nature, safeguards the patient and the operator. Pathogenic burning is minimized to a degree hitherto unknown in the field of radiology. In short, as may be seen, a tube of such small size may be operated efficiently on a voltage much lower than is usually employed in operating the smallest X-ray machines heretofore in vogue; and hence our margin of safety.

Other outstanding features of the "diascope" are direct radiation and limited penetration into the parts involved. Another important feature is that the rays do not have to be bent by prisms, nor emitted from a distance exceeding a half inch from the fluoroscope, the maximum penetration being about two inches under fluoroscopic conditions. Then too, the tube is introduced into the cavities and arranged in positions of effectiveness with comfort both to the patient and to the operator. Our method accomplishes two main things, namely, direct contact of the tube against tissues and the elimination of a technic of angles which is necessary when using a tube extra bodily. It may readily be seen that root canals can be filled while viewing the same with the tube next to the tongue and with the fluoroscope against the cheek or lips as the case may be. This feature is a great boon to dentistry, for canal filling is the most difficult procedure in the realm of root canal therapy and one where scientific accuracy is imperative. Broken roots or needles can be directly viewed, and while in view can be dislodged with the usual instrumentation.

Fractures of the mandible can be approximated while under the view of the diascope, and the inferior dental canal can be restored to its normal position of continuity. This feature in preserving the normal anatomy will be a step to scientific precision.

Another feature making this instrument distinctive is its bacterialytic properties. Tissues infected with organisms can be cleansed of such by radiation of a definite technic in which direct and intimate application of the rays and tube is employed.

The diascope can be operated from an ordinary light socket or from a radio storage battery, and it occupies only about the space of an ordinary sized kodak. It is most flexible in adjustment and use. Then too, it does not require as much penetration nor intensity of current as the former devices. The diascope can be in close proximity to the intraoral tissues or other tissues, without fear of burning. The greatest advantages is in the compactness of the diascopic unit. It does not require separate support from the wall or the chair arm, the transformers and all being so light as to be held easily in the hand. This unit, by slight modification of electrical equipment, can be operated from storage batteries, a valuable feature in Army and Navy work.

An illustrative embodiment of this invention is shown by the accompanying drawings, in which:—

Figure 1 shows, somewhat enlarged, a central front to back section of the human mouth with our X-ray tube in place therein, opposite the lower jaw.

Fig. 2 shows a section substantially on the line 2—2 of Fig. 1, with the X-ray tube and fluoroscope in position for examining the right side of the lower jaw.

Fig. 3 shows our X-ray generating unit as a whole, mainly in side elevation, but with the tube proper and adjacent parts in axial section.

Fig. 4 is a right end elevation of the device of Fig. 3.

Fig. 5 is a cross section at 5—5 on Fig. 3.

Fig. 6 shows mainly in a conventional way the arrangement of parts and the circuit diagram therefor, ventilation by air also being illustrated.

Fig. 7 is a cross-section at 7—7 on Fig. 6.

Fig. 8 is a much enlarged sectional view, on the line 8—8 of Fig. 9, showing the cathode cup, filament and adjacent supporting means.

Fig. 9 is a cross-section on the line 9—9 of Fig. 8, showing mainly the spiral filament and associated parts.

Fig. 10 is a left end view of the device of Fig. 8.

Fig. 11 is a cross-section at 11—11 on Fig. 8.

Referring first to Figs. 1 and 2, the method of using our improved apparatus is here shown as applied in examining the teeth fluoroscopically. Here the tube 1, is shown with its forward end inclined downwardly and disposed close to or against the inner side of the lower jaw, a fluoroscope F being disposed against the cheek opposite the tooth T, which is to be examined. As will be apparent, the X-rays emanating from the anode A will pass through the tooth and cast a shadow on the fluoroscope field plate 2 which is under direct observation of the physician whose eye is indicated conventionally at 3.

Next, referring mainly to Figs. 3, 4 and 5, the tube 1 which is of the jacketed and fluid cooled type is carried on the forward conoidal end of an oblong frame 4, in the rear end of which frame is mounted electric current supply and control means, the latter being shown in Fig. 6. Said frame 4 is made preferably in two parts or sections 4′ and 4″, the latter being merely a depending attachment relative to the main part 4′. These frame parts are detachably connected in any convenient way desired, as for instance, by means of side cleats 5.

A main double-secondary transformer 6 is mounted in the frame part 4″, and a simple single-secondary and relatively high tension transformer 7 is mounted in the rear end of section 4′. The circuit connections of these transformers are best shown by Fig. 6.

In order to provide for ventilation of the tube 1 as herein elsewhere referred to, the jacket chamber is connected to any desired source of appropriate fluid, air being generally preferred. With a view to providing for simplicity and unity the main casing part 4′ may be equipped with an extension 8 on the back end as indicated by dotted lines on Fig. 3, in which extension may be mounted a pump or blower of any desired style and of compact design and small weight, the construction of which is not shown, as such detail constitutes no part of the present invention.

The lower frame, part 4″, has an extension 9 formed thereon to accommodate the current supply leads contained in the cable 10. The rear end of said part 4″ has a compartment 11, in which is housed the stabilizer 12, shown in Fig. 6.

Referring now to the construction of the tube 1, and referring especially to Figs. 6 to 11 inclusive, said tube as a whole comprises an inner tube or wall part 13, having a sealed vacuum chamber as usual for such tubes, an outer tube or wall part 14, spaced therefrom to provide a jacket space or cooling chamber 15, an anode A, a cathode C, electric connections for these electrodes, and means for supporting said members in due relation, the jacket chamber 15 having an inlet 16, and an outlet 17, for ventilating fluid, as will be further explained. The inner and outer walls 13 and 14 are connected rigidly at the base of the tube and the three current conducting members are sealed in the tube wall in such a manner as not to interfere with the vacuum, as will be understood. The anode is substantially of the usual construction, and consists of a tungsten rod having an inclined reflecting face or target, from which the X-rays are deflected outwardly near the free end of the tube through the side of the tube, as indicated by the arrows. The cathode is of the hot filament type and in a broad sense resembles the so-called Coolidge tube.

The cathode C and its connections are best understood by reference to Figs. 8 to 11. Here the thin-walled molybdenum cup 21, comprises a cylindrical body disposed about coaxially in the forward end of the tube 1, its open end facing the anode with which it is in coaxial alinement and the nearly closed opposite end being held adjustably by a platinum support or bracket 22, having a screw controlled clamp 23 for gripping the hollow shank 24 of the cup. Housed coaxially in said cup, somewhat back from its open end, is a nearly flat, spiral filament 25, of tungsten, disposed somewhat convexly toward the open end of the cup, which filament has two terminals 26 and 27, the former of which extends backward coaxially through the shank of the cup and is held adjustably by a second clamp 28, provided on said bracket 22. The other terminal 27, emerges from the cup through a hole 29, in the side. This terminal 27 and also the shank 30 of said bracket are set in the end of a glass supporting rod 31, wherein they are fused and wherein they have electrical connection through appropriate conductors 32 and 33 respectively, disposed longitudinally in said rod and which are extended back through the base of the tube and connected to the circuit as shown in Fig. 6. It will be noted that the X-ray generating and emanating members are disposed in the free end of the tube and that said end is constructed and arranged so as to be peripherally or circumferentially free from connection with an extraneous element as well as free from angular portions or outward projections of any kind, whereby the tube may be readily inserted into and freely adjusted within a relatively small cavity. By the term circumferentially or peripherally free we mean that the tube portion which houses the X-ray generating and emitting elements is in no way constructed or formed or connected in a manner which would in any way prevent a ready insertion of that portion and said X-ray members into a small cavity. Therefore, it will be clear that the X-ray generating and emitting members may be disposed close to the part or cavity region to be treated, with the advantageous result that long and "soft" X-rays may be effectively used for giving highly localized and precise treatments and without undue likelihood of pathogenic burning. Inasmuch as the use of the soft ray is thus made practicable, it will be seen that but a comparatively low voltage is required to generate said rays with the result that the entire X-ray equipment may be made as a comparatively small and compact portable unit subject to be being readily held in the hand of the operator during use thereof.

It is to be understood that the tube 1 may be composed of various appropriate materials, such as glass and "quartz" and that such tubes may be interchangeably mounted in the frame 4, so as to accommodate selectivity according to needs, as will be apparent, though not fully shown.

The electric circuit extends from the current supply leads of cable 10 through stabilizer 12 and the primary coil 36 of the iron core transformer 6. This transformer has two secondaries, one of which 37 is for low potential to heat the filament 25, and the other 38 is for relatively high potential to feed the primary coil 39 of the iron core transformer 7, the secondary coil 40 of which is for voltage sufficient to activate the tube 1 and generate the X-rays therein.

The circuit from coil 40 extends from one side to the anode rod A, thence by space discharge to the hot filament 25, and thence by conductor 32 back to the other side of said coil, said conductor 32 being common to the filament and space discharge circuits and having a common transformer connection at 41. (See Fig. 6.)

Attention is called to the fact that all the electrical conductors which enter the tube have their points of entry in portions of the tube other than those portions which house the X-ray generating and emitting elements contained therein. As here shown the points of entry of said conductors are at one end of the tube and the remaining portions of the tube are free from any peripheral or circumferential obstructions or formations which would prevent or render difficult the insertion of the tube into a small cavity and the disposition of said elements close to the part or surface to be treated. Furthermore it will be seen that the tube in having the conductors extended from their point of connection at one end of the tube, in parallel relation lengthwise of the tube to the X-ray generating elements at the other end of the tube, may therefore be provided with a comparatively small free end which carries the said elements and is readily disposable within small cavities and confined spaces in close relation to the surface or part to be treated.

The structural details of the transformer, their means for connection and their mode of mounting is immaterial to our claims, and hence no attempt has been made to show such details, as they may be supplied readily by any artisan skilled in the art. The same is true of the blower and its connections. (See extension 8 on Fig. 3.) This applies also to some of the other details.

The air cooling connections are best shown in Fig. 6. Here air under pressure is supplied from any convenient source through a tube 43, leading to the inlet hole 16 in the outer tube end wall 45. The air circulates freely through the chamber 15 and then escapes through the outlet holes 17 and 46. In case the air source is in the frame 4 the tube 43 extends directly thereto. But if the source is independent, the tube may extend outward through the wall opening 48. Here it may be connected to a supply pipe 49, by means of coupling 50. Although air is generally preferred, other fluid may be used. In any event, the small-sized X-ray tube takes but little current and does not generate much heat.

The cooling fluid in the jacket chamber may or may not have ray filtering properties. Hence the fluid to be circulated is selected according to specific needs. For instance, air has practically no filtering effect, but other fluids, including liquids, have various well-known specific properties in this respect. The theory is essentially this. Radium radiates three rays, known as the alpha, beta and gamma rays. If a magnet containing two poles is placed so that a radium unit is lying between the poles, one ray passes straight upward from between the poles and this is known as the gamma ray. It has about the same speed as light and a very short wave length, hence it is easily absorbed by certain mineral elements and certain tissues. It especially affects embryonic tissue or cells, which are commonly new cells. It destroys these new cells because of their sensitiveness, whereas the older cells resist rays of this character for a longer period. This is where radium gets its therapeutic value in cancer work. The two remaining rays of radium are deflected through the pull of the magnetic poles, or perhaps it might be better to say, the attraction of the two poles deflects the rays, with the result that the negative pole attracts the alpha rays which are merely helium negative corpuscles. The remaining ray, the beta, is in reality a stream of electrons which are negative, but are attracted by the positive pole. This illustrates the fact that the therapeutic ray is the gamma ray. Now, this ray is the one which is emitted also by the X-ray tube, but its characteristic as controlled by the cathode stream of charged negative particles may be either soft or hard. That is, it may have a short or a long wave length and this wave length in turn determines the working qualities of the X-ray as before mentioned. The short waves are the deadliest and the long waves, or soft rays, are the least harmful of all. The filter which interests us merely throws a damper upon the short waves and causes them to become long or soft. In fluoroscopy we only require the long or soft rays which minimize burning, but they can, on the other hand, be regulated by the cathode flow of electrons. This regulation is accomplished by predetermining the capacity of the transformer which controls the filament circuit. We are, therefore, mainly concerned with the cooling circulation in our fluoroscopy feature, because we control our hard and soft rays in the filament unit and this is fixed for a definite purpose. But in therapy practice we may filter the rays by appropriate selection of a proper circulating fluid for the jacket.

Our electrical circuit ordinarily is fixed. We desire to cause the same effect every time the instrument is activated with current. Hence we set and create a standard which is fool proof. The value of this is apparent when one considers the possibilities of hard and soft rays, et cetera. In other words, for fluoroscopy we fix the machine so it will only give forth the long or harmless rays, which, because of intimate contact and direct access, accomplish our desired results in a better and more efficient manner.

With reference to therapy radiation, it is to be understood that the tube may be constructed of glass or "quartz" may be used. The reason for this is that some of the energized rays will pass through a quartz tube with greater rapidity than through the ordinary glass. In therapy this feature will be apparent for it means shorter radiation with more intense results. On the other hand, much of our radiation is determined by the type of glass used in tube construction. For example, glass which has lead impregnated therein dampens the rays while quartz does not. We bring out this idea to show the scientific control which we have on this instrument. We control our intensity of ray by fixing and predetermining our capacity of transformer and again we control our penetration, intensity and also activity of ray by the use of certain combinations of materials incorporated in the glass.

The reason that two transformers are used instead of one is mainly to minimize the possibility of ground with the patient and to better control our filament circuit as well as to establish a more even control of the current as it is being stepped up or down. Then too, by removing the lower case 4″, the 110 volt transformer may be replaced by a transformer which will handle 220 volts if necessary. Moreover this unit can be operated from an induction coil as well as from the usual power circuit.

Although certain specific embodiments of this invention and their mode of use have been selected to illustrate our improvements herein set forth, it is to be understood that some of the details of the construction shown may be altered or omitted without departing from the spirit of this invention as defined by the following claims:

We claim:

1. A device of the character described, comprising a frame member having a transformer in one end and an X-ray tube attached to the opposite end, said frame member having a removable extension member provided with and adapted to house a second transformer, electrical connections for said transformers and tube and means for cooling said tube.

2. A hot filament X-ray tube comprising an envelope having an anode mounted therein and a combination cup and hot filament cathode, together with supporting means for the latter, said means having a shank part and a forked part integral therewith, said envelope having an inwardly disposed glass support for said shank part and the forked part being split and provided with clamps whereby said cup and one of the filament terminals are adjustably supported.

Signed at San Francisco, California, this 7th day of August, 1928.

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