

Jan. 24, 1961

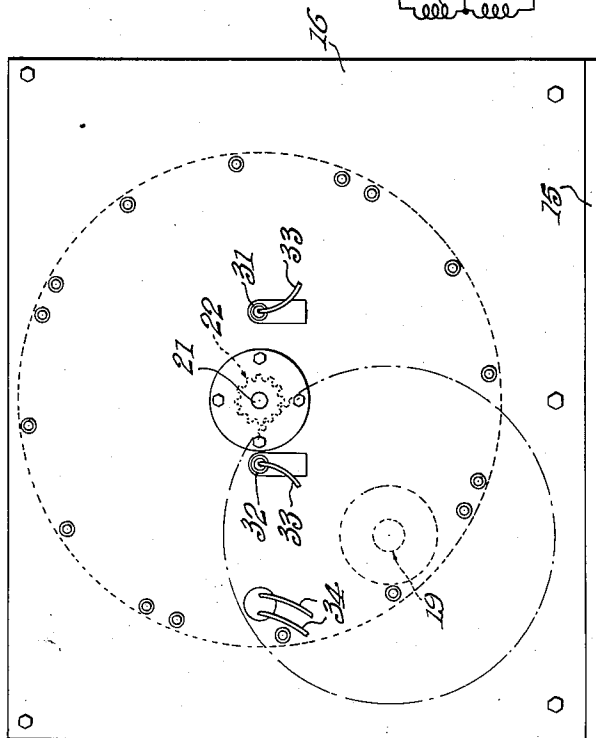
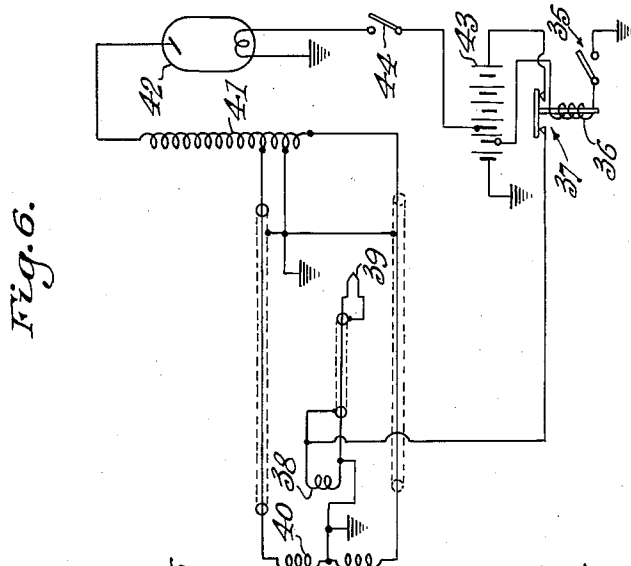
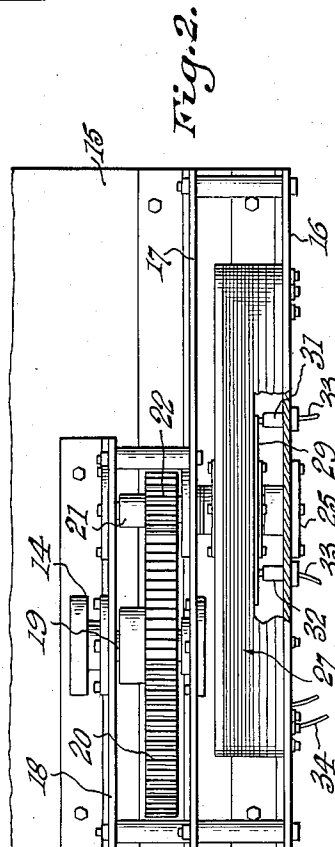
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2,969,464

IMPULSE POWERED X-RAY APPARATUS

Filed June 2, 1959

3 Sheets-Sheet 1



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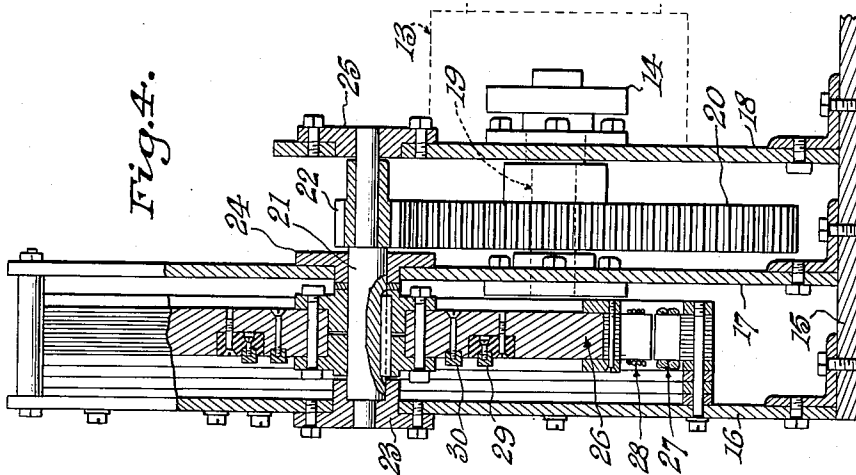
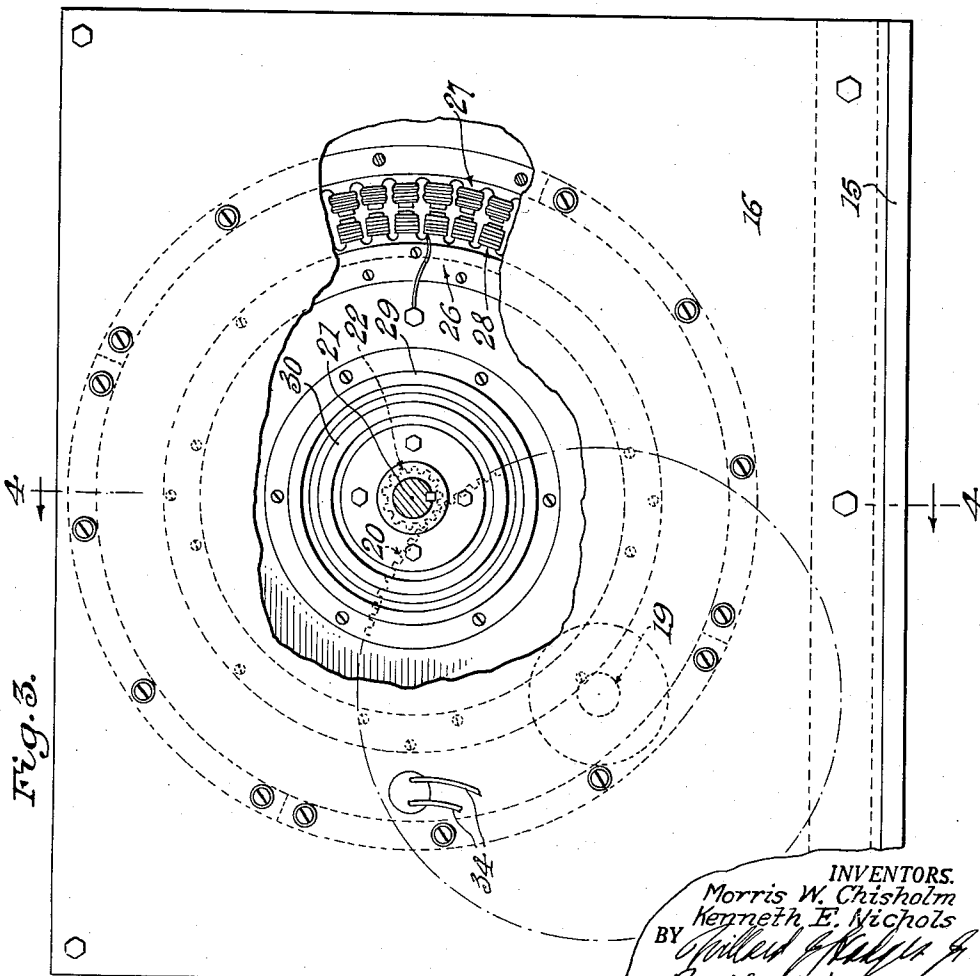
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IMPULSE POWERED X-RAY APPARATUS

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3 Sheets-Sheet 3

Fig. 5.

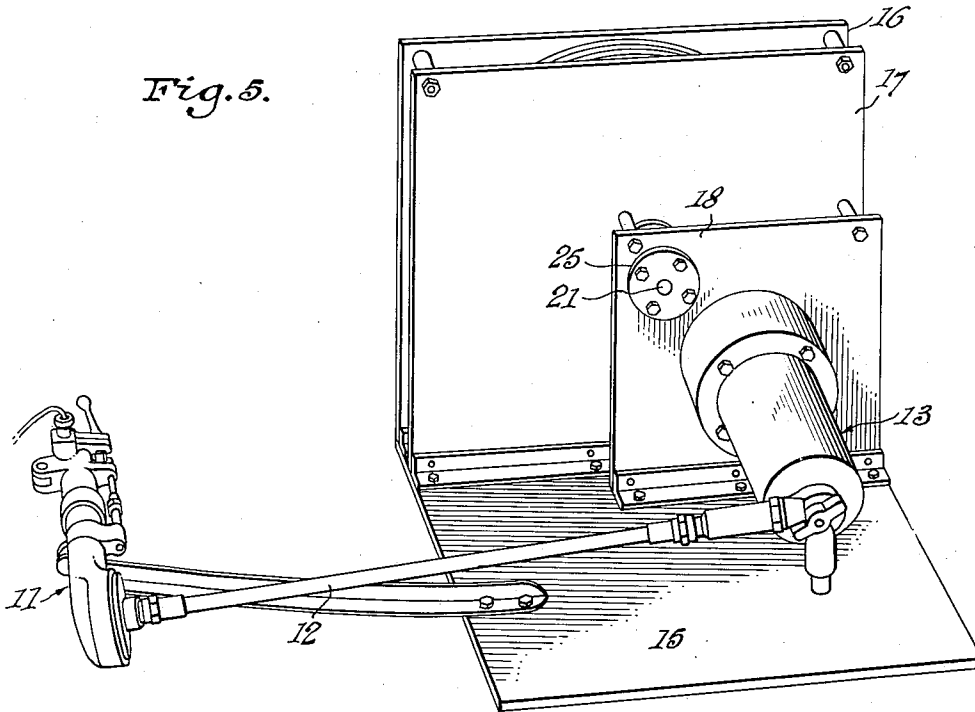
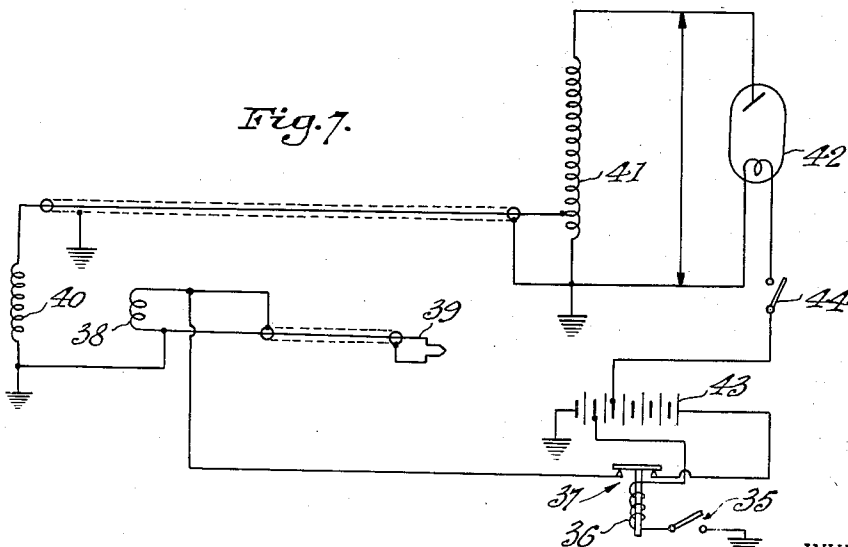


Fig. 7.



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IMPULSE POWERED X-RAY APPARATUS

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5 Claims. (Cl. 250—102)

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The invention disclosed herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

The present invention relates to devices for generating high-voltage electricity, and particularly to such a device adapted to power radiographic X-ray tubes. Still more specifically, this invention relates to a portable X-ray unit powered by a pulse of high-tension electricity which lasts only during the period of radiographic exposure.

Conventional X-ray units for making radiographs of the type used by doctors for diagnostic purposes require a high-tension electrical current of the order of 50 to 120 kilovolts. However, an X-ray tube need be energized only for a brief period of time, normally a fraction of a second, when used for radiographic purposes. Also, the amperage required to power an X-ray tube is of the order of milliamperes. Nevertheless, it is customary to use heavy, bulky, power supply systems designed to continuously deliver peak power of sufficient potential to operate an X-ray tube. Transportation of such an X-ray unit by the various military medical corps in the time of war to battlefield hospitals is always a critical problem. Another of many instances where a highly portable X-ray unit is needed is in the fight against tuberculosis. Many other practical uses may be imagined for a portable X-ray unit and for a high-voltage generating device.

Therefore the principal object of the present invention is to provide a lightweight, highly reliable, self-powered, high-potential generating device which will only operate and instantly provide peak output during the interval of a radiographic exposure.

Another object of the present invention is to provide a lightweight, compact, self-powered, portable X-ray unit for diagnostic radiographic purposes.

In accordance with the present invention, a prime mover drives an electrical generator which generates a high-frequency, high-voltage output which is fed into a step-up transformer which in turn produces a sufficiently high potential to power a conventional X-ray tube. A simple, lightweight prime mover, which produces a high-energy mechanical force impulse almost instantaneously, accelerates an alternator to a high operating speed, thereby producing a pulse of energy which lasts only for the period of time required for a radiographic exposure. In this manner, both the customary heavy generator designed to constantly deliver peak electrical power and the heavy prime mover required to drive such a generator are eliminated. Further, by operating the device for only the fraction of a second required for a radiographic exposure, practically no heat is generated within the system and accordingly massive design requirements are eliminated.

Consequently, the mechanical device constructed in accordance with the present invention is light, compact, self-powered, and reliable, therefore constituting a highly satisfactory portable high-voltage generating device suitable for powering a diagnostic X-ray tube and many other equivalent discharge devices.

2

Additional objects and advantages of the present invention will be apparent from the following detailed description of the chosen embodiment and the accompanying drawings wherein:

Fig. 1 is a front elevation of a high-tension discharge device constructed in accordance with the present invention;

Fig. 2 is a top view of the device of Fig. 1 partially broken away to show features of construction;

Fig. 3 is a front elevation of the device of Fig. 1 partially broken away to show features of construction;

Fig. 4 is a cross-sectional view taken substantially along lines 4—4 of Fig. 3;

Fig. 5 is a perspective view looking from the back of the device of Fig. 1;

Fig. 6 is an electrical circuit diagram of the present invention; and

Fig. 7 is a modification of the electrical diagram of Fig. 6.

The high-voltage generating device is comprised of a prime mover, an alternator, and a step-up transformer. When used to power a conventional X-ray tube, the transformer and tube are contained in a common fluid-insulated housing in a manner which is well known to avoid having high-voltage transmission lines of any appreciable length. The transformer and X-ray tube are shown only on the electrical circuit diagrams, Figs. 6 and 7, hereinafter described in detail.

Referring to the drawings, the prime mover is comprised of a breech mechanism 11 of the type shown in U.S. Patent No. 2,191,676, issued February 27, 1940, a draft tube 12, and a combustion starter 13 of the type shown in U.S. Patent No. 1,951,032, issued March 13, 1934. The breech mechanism receives an electrically fired powder cartridge similar to a large shotgun shell. The draft tube 12 transmits the fluid pressure generated by combustion of the powder to the starter 13. The fluid pressure displaces a piston within the starter 13 and, by means of a screw thread arrangement, the motion of the piston is transformed into torque which is delivered to shaft 19 by coupling 14.

The alternator assembly, a gear train, and the combustion starter prime mover assembly are all supported by a base plate 15 to which upright front plate 16, upright middle plate 17, and upright rear plate 18 are attached. Rear plate 18 and middle plate 17 support bearings for drive shaft 19 which, by means of coupling 14, receives torque from the prime mover. A gear 20 mounted on shaft 19 meshes with pinion gear 22 which is carried by the rotor shaft 21. Rotor shaft 21 is bearing supported by all three upright plates at 23, 24, and 25. Rotor shaft 21 carries the alternator rotor 26. The alternator stator 27 is attached to front plate 16.

In the present embodiment, when a shell is fired in the breech mechanism, the gases generated during combustion of the powder charge reach a peak pressure of the order of 3500 pounds per square inch. The starter piston then travels through one stroke in less than one second, and rotates the starter shaft approximately seven-eighths of a revolution, developing approximately eleven horsepower. A maximum angular velocity of about 260 revolutions per minute is reached and through the one to ten ratio of gears 20 and 22, respectively, the generator rotor is accelerated to approximately 2600 revolutions per minute.

The essential requirements of the impulse prime mover are that it provides a high energy, substantially instantaneous output within seconds. The mechanical power output need only be of sufficient duration to rotate the alternator during the electrical power impulse which, when used in conjunction with an X-ray tube, need only rotate for the duration of the radiographic exposure. A mechanical

power impulse and electrical power impulse of longer duration would be undesirable because it would be wasteful of energy, would require heavier equipment, and would require some extra means for interrupting the electrical power to the X-ray tube to control the duration of the radiographic exposure. The single explosion type prime mover described above has proven fully satisfactory. However, other types of impulse prime movers could be employed, such as, for example, an inertial wheel driven by either a hand crank or a battery-operated electrical crank where portability is not a critical factor.

The generator in the present embodiment is a 60-pole alternator with field coils excited by a storage battery. The rotor coils 28 are connected in series and are wired to insulated collector ring 29 and grounded to the rotor body. A grounded collector ring is shown at 30. A pair of brushes 31 and 32 contact the collector rings and are connected to leads 33. Leads to the field coils are shown at 34. The generator provides an output having a peak frequency of about 1300 cycles per second and a peak potential of about ten kilovolts.

Referring to the circuit diagrams of Figs. 6 and 7, when the hand-operated switch 35 is closed, the coil 36 closes relay 37 which energizes the field coils 38 and fires the cartridge in the breech mechanism by the igniter shown at 39. The armature is rotated by the starter 13 and ten kilovolts are generated in the rotor windings 40. The ten kilovolts then pass through the conventional auto-transformer 41 which has a step-up ratio of ten to one. A potential of one hundred kilovolts is thereby impressed across the X-ray tube 42 which is a conventional, self-rectified, diagnostic tube. The X-ray tube filament is preheated by closing switch 44 which connects the filament to battery 43. The only difference between the diagrams of Figs. 6 and 7 is that in Fig. 6 the rotor coils and the transformer primary are center tapped and grounded to give a better field distribution in the transformer, and hence allow a lighter weight transformer to be used.

A prime consideration for any portable unit is weight. It will be appreciated that the embodiment described herein is structurally but a crude device devised for purposes of proving the practicability of the invention disclosed herein. Accordingly, it will be obvious to persons skilled in the art that many structural refinements could be made to reduce the over-all weight and bulkiness of the device, such as, for example, eliminating the excessive portions of plates 15, 16, 17, and 18. In addition, the storage battery can be eliminated and the field coils excited by a tap from the rotor coils, in which case the initial current generated in the rotor coils would be the result of residual flux in the iron core of the field poles, as in a conventional magneto. The insulating medium for the transformer should be a gas such as sulphur hexafluoride or dichloro-difluoro methane (Freon) rather than oil. Since a high-voltage, high-frequency is produced, the size and weight of the step-up transformer is greatly reduced. Because a current in the order of milliamperes is used for only the short period of time required for a radiographic exposure, the circuitry can be substantially overloaded, by conventional standards, without adverse heating effects, and therefore both the alternator and transformer can be designed to use smaller wiring and heat dissipating devices than is necessary for generating devices which are designed to operate continuously at peak load.

The present invention consists in combining with an

electrical discharge device a lightweight prime mover which is called upon to deliver only an impulse of high energy power to instantaneously accelerate a high-tension, high-frequency alternator to a high speed. The high-frequency, high-potential, low amperage current allows the use of a lightweight, simple step-up transformer. By combining the three components above, a pulse of electrical energy is produced of sufficient potential and duration to power an X-ray tube for the period of time required for a radiographic exposure, yet the resulting apparatus is very compact, light in weight, and economical due to the novel combination of the various elements.

We claim:

1. An X-ray apparatus comprising an X-ray tube, a source of high-potential connected to said tube, said potential source comprising a high-frequency step-up transformer, a high-voltage, high-frequency alternator connected to said transformer, a prime mover coupled to drive said alternator, said prime mover being adapted to deliver a single impulse of torque to instantly accelerate said alternator to a high speed thereby generating an impulse of electrical energy which lasts only for a period of time necessary for a radiographic exposure, and electrical circuit control means for simultaneously energizing said alternator and said X-ray tube.

2. An X-ray apparatus as set out in claim 1 wherein said prime mover comprises means utilizing a single explosive charge to generate fluid pressure and means to convert said pressure into torque.

3. An X-ray apparatus comprising an X-ray tube, a high-frequency step-up transformer connected to said tube, a high-voltage, high-frequency alternator connected to said transformer, a prime mover coupled to drive said alternator, said prime mover including means for instantaneously releasing a single impulse of power for instantly imparting a single impulse of torque to instantly accelerate said alternator to a high speed thereby generating an impulse of electrical energy which lasts only for a period of time necessary for a radiographic exposure, and electrical circuit means for simultaneously energizing said alternator and said X-ray tube.

4. An X-ray apparatus as set out in claim 3 wherein said prime mover is a combustion starter, and said circuit control means includes circuitry for simultaneously actuating said combustion starter and energizing said alternator and said X-ray tube.

5. A portable X-ray apparatus comprising an X-ray tube electrically connected to the secondary winding of a transformer, a high-frequency, high-voltage alternator electrically connected to the primary winding of said transformer, and a prime mover mechanically connected to rotate said alternator, said prime mover comprising a means utilizing a single explosive charge to generate fluid pressure and means to convert said fluid pressure into torque whereby said alternator is rotated only for a period of time sufficient to produce a radiographic exposure.

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