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3,368,155

APPARATUS FOR PRODUCING RADIATIONS PENETRATING LIVING CELLS

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Patent No. 3,280,816, dated Oct. 25, 1966. Divided and
this application July 11, 1966, Ser. No. 564,336

Claims priority, application France, June 1, 1962,
899,414, Patent 1,342,772

22 Claims. (Cl. 328—233)

This is a divisional application of my co-pending application Ser. No. 282,604 filed May 23, 1963 now Patent 3,280,816, granted Oct. 25, 1966.

This invention relates in a general way to radiations capable of penetrating matter. More precisely, the present invention has for its object to provide an apparatus for obtaining a combination of radiations of different kinds capable of penetrating matter, and more particularly of penetrating intimately into living organic tissues and producing certain effects therein and most notably in human tissues for therapeutic purposes, without destroying therein such essential elements as the enzymes for instance.

In accordance with the present invention, electrically charged particles are emitted into a cavity, and into this emission is superimposed a centimetric electromagnetic radiation the wave-length of which preferably lies between 3 cm. and 80 cm., and the resulting radiation issuing from said cavity is directed onto the target to be irradiated.

The applicant has noted that the penetration and particularly the curative effects are very markedly improved when the frequency of the electromagnetic radiation is determined according to the organ or tissue to be penetrated or treated. For example, a wavelength of 14 cm. is suitable for the liver and a wavelength of 19.5 cm. for the spleen.

The charged particles radiated are preferably accelerated in a particle accelerator in order to increase the penetration force.

The resulting radiation is preferably applied to and directed at the target, namely at the tissue to be penetrated, by means of a tube which is the seat of accelerating and directing magnetic fields and electrical fields, said radiation being with advantage directed and/or reflected by a rotary deflecting device placed within the tube.

In many cases it will be of advantage to modulate the particle radiation or to produce it rhythmically by means of varying magnetic and/or electrical fields whereby to further increase the penetration force. Such a rhythm is preferably tuned, particularly in medical applications, to the natural period (oscillation time) of the tissue to be penetrated or of the tissues adjacent thereto, an example being the muscles. These natural periods are well known in medicine and are applied for diathermy in particular; they lie in the range of wavelengths extending from 1 m. to 50 m. and more specifically from 1 m. to 18 m.

Means are preferably provided for modulating the emitted radiations, the accelerating electrical and magnetic fields, and possibly also the rotary deflecting device, in step with the patient's heartbeats.

It would appear that the positive results obtained with this invention in the treatment of disorders of the living cells (be they vegetable or animal), are due to certain phenomena which will be discussed hereinafter, it being

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of course understood that such discussion in no way limits the spirit and scope of the invention.

Depending on its electro-physico-chemical constitution, the cellular protoplasm-nucleus couple is endowed with electrical conductivity which is related directly to the ionic exchange motions caused by metabolic phenomena. Indeed one notes in the tissues the presence of accumulations of electricity under potentials that differ according to the varying cell densities of the tissues.

The work conducted by Renshaw, Forbes, Morison, Amassian, De Vito, Buser, Albe-Fessard, Tauc, Adrian, etc. . . ., has demonstrated with the aid of micro-electrodes the existence of a slow-oscillation-type elemental electrical activity within the cells, while the pace-maker can be regarded as being provided by the oscillating electromagnetic system formed by the cell nucleus. Basically, indeed, the nucleus consists of tubular filaments of insulating material (akin to chitin) containing therein an electricity conducting saline liquid, and these filaments, twisted onto themselves, can be likened to veritable little oscillating circuits.

Recent work carried out by Warson in America, as well as other work carried out by French researchers, including a paper by Messrs. Polonsky, Douzou and Sadron, read on May 16, 1960, before the Academy of Science by Professor Francis Perrin (Collected Weekly Reports, Tome 250, No. 20, pages 3414 to 3416), brought out the fact that the experimental solid deoxyribonucleic acid samples used revealed properties similar to the familiar properties of ferro-electric bodies, thus giving verisimilitude to the hypothesis that a difference of potential can exist across the nucleus and the periphery of the cells. Certain recent theories even go further and liken the cell to an electronic receiving-emitting device that operates in the normal state with a frequency attuned to the ambient media. In accordance with these recent theories, the cell nucleus forms a damped-wave oscillating system which obeys the laws governing semi-conducting bodies.

The applicant has come to the firm conclusion that, in the normal state of physico-electrical equilibrium, the cell nucleus is positively charged but that it can become negatively overcharged following phenomena similar to polarization. It is believed that the results obtained by the applicant by treating living cells with the resulting radiation of the invention are due to restoration of a correct electrical potential of the nuclei.

The description which follows with reference to the accompanying drawing, which is filed by way of example only and not of limitation, will give a clear understanding of how the invention can be performed, such particularities as emerge either from the description or the drawing naturally falling within the scope of this invention.

In the drawing filed herewith:

FIGURE 1 shows in schematic section a device for producing and emitting a combined electromagnetic field in accordance with the invention;

FIGURE 2 shows in front elevation the cathode as seen from the right of FIGURE 1;

FIGURE 3 is a sectional view taken through the line III—III of FIGURE 1;

FIGURE 4 is a block diagram of the electrical supply system;

FIGURE 5 is a view corresponding to FIGURE 1; showing an alternative embodiment;

FIGURE 6 is a sectional view through the line VI—VI of FIGURE 5;

FIGURE 7 is a schematic illustration of a device for pulsing the electric current;

FIGURE 8 is the circuit diagram of an amplifier for operating the device of FIGURE 7 in pace with a patient's heartbeats; and

FIGURE 9 is the circuit diagram of an oscillator for modulating the electric current to a wavelength included between 1 m. and 18 m.

Referring first to FIGURE 1, the apparatus shown thereon includes a device 1 emitting electrically charged particles 2 into a cavity or duct 3, a cyclotron 4 for accelerating particles 2 and sending them into a conduit 5 in communication with a further cavity 6 forming a waveguide for an electro-magnetic radiation of centimetric frequency emitted by a magnetron 7. The cavity 8 formed by the union of conduit 5 with waveguide 6 leads to a tube 9 for accelerating and directing the resulting radiation. The cavity jointly formed by elements 1, 3, 5, 6, 8 and 9 contains argon under a pressure of 2 mm. of mercury.

The particle emitter 1 consists of an electron gun having a plate 10 and a cathode 11.

Cathode 11 is made of molybdenum and is shaped in the very special manner shown in FIGURES 1 and 2. It includes a rim 11a which is joined through two diametrically opposed radii 11b to a hub 11c embodying a hole 11d of axis XX'. Rim 11a is made up of two parts (as shown in FIGURE 1) assembled together by means of screws, or the like, and embodies a cavity of revolution 11e in the walls of which are provided a plurality of uniformly spaced pairs of opposed holes 11f parallel with axis XX'. Within cavity 11c is disposed a heating filament 12 connected to the supply leads 12a.

The best results are obtained with a cathode 11 made of molybdenum. However, the applicant obtained satisfactory, though less good, results with tungsten cathodes. It so happens that molybdenum, and to a lesser extent tungsten, are metals the valence of which is nearest the mean valence of the chemical molecules that make up living tissue and more particularly human tissue. Whereas a scientific explanation based on observation of the phenomena involved could be attempted, it is to be clearly understood that the invention is by no means limited by any such scientific explanation. Further, insofar as the low-pressure gas in the device is concerned, optimum results are obtained with argon. However, the applicant also obtained satisfactory, though less good, results with the other gases of the family of rare gases.

Surrounding the tube forming the electromagnetic chamber are disposed an electromagnet 13 with its coil 13a, placed level with the cathode, and the accelerating coils 14 and 15. Further accelerating coils 14a, 15a, 16a and 14b, 15b and 16b are likewise arranged about cavities 3 and 5 respectively.

The two semi-circular boxes or D's 4a of cyclotron 4 are placed in the customary fashion between the frame poles, and said frame is surrounded by accelerating windings 4b and 4c.

Magnetron 7 is of any convenient known design and must be capable of emitting into cavity 3 a centimetric radiation of wavelength adjustable between 3 cm. and 80 cm.

Accelerating and directing tube 9 is provided in its lower part with a cathode 17 similar to cathode 11, together with a heating filament 17a. Cathode 17 is supported on a hollow base 18 embodying holes 18a adjacent where it joins the end closure of tube 9. Said base 18 communicates with a tube 18b which has an open end adjacent a rotary deflector 19 provided with two rings of graphite plates 19a inclined at 45° to the vertical. The shaft 19b of the rotary deflector is rotatably supported in a bearing 20 fixed into tube 9 and bears at its upper and magnetic fly-weights 19c which set it in rotation by co-acting with magnetic fly-weights 21a rigid with the shaft 21b of a motor 21. The lower extremity of rotary deflec-

tor 19 consists of a pyramid-shaped molybdenum or tungsten part 19d the apex of which is situated opposite the open end of tube 18b to deflect the radiation downwardly towards the target. The lower part of bearing 20 forms the plate or anode 22 of tube 9.

Hollow base 18 and tube 18b can be made of some boro-silicated glass of low coefficient of expansion, such as the type of glass sold under the trade name Pyrex. Alternatively, they can be made of quartz. Tube 9 likewise be made of Pyrex-type glass, or of any other glass of the quality commonly used for manufacturing electron tubes, but its end closure 9a, through which the radiation passes, is preferably made of quartz.

Conduit 8 communicates with tube 9 via a plurality of pipes such as 8a and 8b directed at a certain angle, along vertical planes, towards plates 19a, said angle being preferably in the region of 22.5 degrees. About cathode 17 is disposed an electromagnet 23 similar to the electromagnet 13 of radiating tube 1. About tube 9 are likewise disposed accelerating coils 24. At the points shown on the drawing, tube 9 also includes three electrodes 25, 25a and 25b surrounded respectively by coils 26, 26a and 26b. On the drawing are also represented the feeders 17b and 17c of the cathode and its filament, and 22a of the anode.

The power supply circuit diagram is shown on FIGURE 4. The main supply 27 supplies low-voltage alternating current to a first branch comprising a rectifier 28 (a kenotron, for instance), the rectified current from which is modulated to a rate adjustable between 30 and 120 pulses per minute by means of a resistor 29 the control system of which will be described hereinafter with reference to FIGURES 7 and 8. The current modulated thus is applied to electromagnets 13 and 23 whereby to cause them to generate, at the level of cathodes 11 and 17, a modulated unidirectional field of 10,000 to 20,000 gauss.

The main supply 27 also powers a variometer 30 which is adapted to be operated to modulate the current therefrom, at a rate which is adjustable between 30 and 120 pulses per minute, and the current issuing from variometer 30 supplies the remainder of the system, to wit:

The magnetron 7;

A converter set 31 the excitation of which is modulated at a frequency adjustable from 300 to 900 c.p.s.; this provides a direct current for supplying coils 15, 16 and 26, which is doubly modulated (first at 30 to 120 pulses per minute, then at a frequency of 300 to 500 c.p.s.);

A further converter set 32 producing low-voltage direct current modulated to a rate of 30 to 120 pulses per minute by virtue of variometer 30; this current supplies motor 21, together with the motors driving variometer 30 and the control device of resistor 29.

The current produced by converter set 32 additionally feeds a voltage step-up device 33 comprising a vibrator followed by a transformer and a rectifier and generating a direct current the voltage of which varies in step with the 30 to 120 pulses per minute rate imposed by variometer 30. The maximum value of this voltage produced by device 33 could be 300,000 volts for instance, but this figure can vary either way, depending on the power to be brought into play.

The current produced by voltage step-up device 33 feeds the windings 4b of the cyclotron and 24 of the tube 9, as well as a rheostat 34 which permits adjusting the voltage to the desired value between 5,000 volts and 70,000 volts. This voltage is applied to an oscillating circuit 35 which imparts thereto oscillations of frequency adjustable as desired between wavelengths of 1 m. and 18 m. The current available across the output terminals 35a and 35b of oscillating circuit 35 is consequently high tension current that is initially modulated to 30 to 120 pulses per minute (by virtue of variometer 30) and subsequently to a wavelength of 1 m. to 18 m. This current supplies the coils 4c and 14. Electrodes 25a and 25b are respectively connected to terminals 35a and 35b, while electrode 25 is connected to the mid-point 35c.

The cathodes 11 and 17, the cyclotron D's 4a and the plates 10 and 22, which are not shown on the block diagram of FIGURE 4, are connected to the output and of voltage step-up device 33, the preheat current for filaments 11e and 17a being furnished by resistor 29.

To use the apparatus according to this invention, the control system of resistor 29 and variometer 30 is set to the required pace which, in medical applications, is preferably the patient's pulse rate: this rate is thus imposed upon the system as a whole. Cathode 13 emits a stream of positively charged particles 2 leftwardly, which particles are concentrated by electromagnet 11 and accelerated by windings 14, 15 and 16 and by cyclotron 4. To this radiation of particles is added, in conduit 8, the electromagnetic radiation of magnetron 7 which is adjusted to a wavelength shown by experience to be the most favourable for the cells to be penetrated, examples being 14 cm. for the liver and 19.5 cm. for the spleen. The resulting radiation is directed and accelerated in tube 9 and then directed by the base thereof towards the target to be penetrated.

It should be noted that the unidirectional magnetic field of coils 15, 16 and 26 is modulated by converter set 31 to a frequency adjustable between 300 and 900 c.p.s. The result of this modulation is to concentrate the particles, i.e. detach them from the conduit walls, and also to enable a substantial saving to be made on the weights of the iron cores of the coils.

The unidirectional magnetic fields of the cyclotron coils 4c and the accelerating coils 14, and the electrical field of the electrodes 25, 25a and 25b, are modulated by oscillating circuit 35 to a wavelength selected between 1 m. and 18 m. In medical applications in particular, the wavelength chosen is that best suited to the organ to be treated, or to such adjacent parts thereof as the muscles. As already stated, diathermy experiments will enable the most appropriate wavelength to be determined.

It should be noted that the resulting radiation already possesses considerable penetration force in conduit 8 (see FIGURE 1). The device hereinbefore described can therefore be used without tube 9 and by bounding the cavity at the extremity of conduit 8 by means of a glass or quartz end closure, the resulting radiation being accelerated and directed immediately upstream thereof, for instance by an ultimate coil (not shown) surrounding conduit 8. However, tube 9 substantially improves the results obtained.

Reference is next had to FIGURES 5 and 6, which illustrate an alternative embodiment of the apparatus according to this invention, wherein components performing like functions are designated by the same reference numerals as those of FIGURES 1 and 3, followed by the "prime" symbol.

In FIGURE 5, the disposition of the conduits with respect to tubes 1' and 9', magnetron 7' and cyclotron 4', differs from that of FIGURE 1 and has been used with success by the applicant. The waveguide 6' of magnetron 7' is connected to the extremity of tube 1', while conduit 3' conveying the resulting radiation divides into two branches: branch 36, surrounded by accelerating coils 14c' and 15c', which conveys the radiation directly to tube 9' and branch 37 which conveys it to cyclotron 4'. The latter arrests the electromagnetic radiation and accelerates the radiated particles which are dispatched into tube 9' through conduit 38.

This particular disposition can be used with particle-emitting and accelerating-and-directing tubes similar to tubes 1 and 9 of the preceding figures. However, the tubes 1' and 9' of FIGURES 5 and 6 are designed differently insofar as their cathodes and anodes are concerned.

Tube 1' includes a first electrode 11' exactly similar to the cathode 11 of tube 1, and a second identical electrode 39 provided with a heating filament 39a. Tube 9' (see FIGURE 6) includes in its lower part a first electrode 17' with its heating filament 17'a, and a second identical electrode 40 with its heating filament 40a.

In normal operation, i.e. to produce a radiation identical to that described with reference to FIGURES 1 through 4, electrode 11' serves as a cathode and electrode 39 is subjected to a positive potential and performs the function of plate 10 of FIGURE 1, the filament 39a not being heated. Electrode 40 and its filament 40a are placed out of circuit, and cathode 17' and plate 22' are energized as in the case of FIGURE 3.

To obtain unusually penetrating radiation, the polarities are reversed: electrode 11' becomes an anode and its filament 11'e is placed out of circuit, while electrode 39 is energized as a cathode and its filament 39a is heated; electrode 17' (the filament 17'a of which is out of circuit) and electrode 22' become anodes, while electrode 40 is connected as a cathode and its filament 40a is heated. By way of example, it is possible to establish a potential of 250,000 volts across electrodes 40 and 17', and of 50,000 volts across electrodes 40 and 22'. It will be appreciated that, this being so, cathode 39 will emit a stream of electrons leftwardly, which will be concentrated, modulated and accelerated by the various coils as well as in the cyclotron, the polarities of which must manifestly be established in the suitable sense. This electron radiation is combined with the centimetric radiation emitted by magnetron 7', and there results in tube 9' a very hard emission, modulated to the chosen frequencies, of X-rays combined with the centimetric radiation of desired frequency.

Thus, the apparatus of FIGURES 5 and 6 permits obtaining at will either this very hard X-ray emission, or the radiation described with reference to the preceding figures. If the very hard X-ray emission is obtained, converter set 31 is preferably adjusted to feed coils 15', 16' and 26' with a current modulated at the highest frequencies (i.e. close to 900 c.p.s.).

The description which follows with reference to FIGURES 7 through 9 relates to a number of features of the devices utilized for obtaining modulation of the electric current.

FIGURE 7 is a schematic illustration of the control system of resistor 29 and variometer 30. Adjustable resistor 29 is provided with a graphite helical member 29a immersed in a conductive liquid 29b into which dips partly a graphite electrode 29c to which a reciprocating motion is imparted by a connecting-rod 41a pivotally connected to a flywheel 41. The latter is rotated through an endless screw transmission 41b by a shaft 42 which can be driven through a double clutch 42a, 42b, either by a motor 43 or by the shaft 30a of variometer 30, which variometer is in turn driven by a motor 44 through an endless screw type transmission 44a. Reciprocating movement of electrode 29c will vary the surface thereof which dips into the conductive liquid 29b, and accordingly will vary the resistance between electrodes 29, 29a of resistor 29, at a rhythm which is equal to the r.p.m. imparted to flywheel 41. Rhythmically variable resistor 29 is shunted by a resistor which is shown diagrammatically, resulting in a component having a rhythmically variable resistance, which is inserted in the line (FIGURE 4) feeding electromagnets 13, 23 with rectified current delivered by rectifier 28.

If flywheel 41 is driven by motor 43 at suitable speed, resistor 29 will vary the current energizing electromagnets 13 and 23 (FIGURES 1 and 4) at the chosen rhythm which, as explained above, can be included between 30 and 120 pulses per minute and which can be monitored by means of a revolution-counter represented schematically at 45. When this is the case, motor 44 of variometer 30 can be stopped, thus no longer subjecting the remainder of the system to a set pace. Conversely, if the drive to flywheel 41 is engaged at 42b and released at 42a, motor 44 will act as a pace-maker for variometer 30 and resistor 29.

The rotational speed of motors 43 or 44 can be adjusted to an appropriate speed corresponding substantially to the patient's pulse rate, by operating on the

exciter of said motors by means of a manually adjustable rheostat. Should it be preferred to have the speed of motors 43 or 44 governed directly by the patient's pulse rate, a device such as the one illustrated schematically in FIGURE 8 can be resorted to. In FIGURE 8, a contact type microphone is connected at 46 and produces pulses when placed on the patient's heart. These pulses are amplified in the circuit shown and are applied to an electromagnet represented at 47, of which the moving core operates a rheostat for adjusting the excitation current to motors 43 or 44.

FIGURE 9 is the circuit diagram of oscillating circuit 35. The rectified voltage adjustable between 5,000 and 70,000 volts by means of rheostat 34 (see FIGURE 4) is applied across terminals 48 and 48a. Terminal 35c (which is also connected to electrode 25 in FIGURES 2 and 4) is connected to the neutral point, on the high tension side, of the transformer which is a component part of voltage step-up device 33 (see FIGURE 4). Terminals 49 and 49a receive the heating current produced by resistor 29. Adjustable capacitors 50 and 50a permit of adjusting the current available across the output terminals 25a and 25b of the oscillator represented to the desired wavelength (which, as already indicated, lies between 1 m. and 18).

Although the specific embodiments described hereinbefore have been experimented with successfully, it goes without saying that they are given by way of example only and could be variously modified without departing from the spirit and scope of the invention. In particular, the electron gun 1 or 1' could be replaced by any other convenient particle emitter.

What is claimed is:

1. An apparatus for obtaining a combination of an electrically charged particle radiation and an electromagnetic radiation that is capable of penetrating matter and notably of ensuring intimate penetration into living tissue and of producing certain effects therein, and more particularly into human tissue for therapeutic purposes, comprising a particle emitter, means for ducting said particles into a cavity serving as a waveguide for an emitter of electromagnetic radiation the wavelength of which lies within the range of centimetric waves, means for generating, and concentrating magnetic fields in the cavity, and means for concentrating and accelerating the resultant radiation issuing from the cavity.

2. An apparatus as claimed in claim 1, wherein the electromagnetic radiation emitter has a wavelength adjustable between 3 cm. and 80 cm.

3. An apparatus as claimed in claim 1, wherein the particle emitter is an electron gun the anode of which is positioned at the extremity of the cavity and the cathode downstream of the anode, said cathode being hollow and being placed in the magnetic field of an electromagnet whereby to cause particles to be radiated in a direction downstream of the cavity.

4. An apparatus as claimed in claim 3, wherein the cathode includes a rim which is joined to a hub by at least two radial members and embodies an annular housing containing a heating filament, the opposite walls of said housing being provided with a plurality of pairs of opposed holes extending through the rim transversely.

5. An apparatus as claimed in claim 3, wherein the cathode is made of a metal of which the valance is close to the mean valance of the chemical molecules constituting a tissue to be penetrated.

6. An apparatus as claimed in claim 5, wherein the metal constituting the cathode is chosen from the family consisting of tungsten and molybdenum.

7. An apparatus as claimed in claim 1, wherein the cavity contains a rare gas in a near vacuum of about 2 mm. of mercury.

8. An apparatus as claimed in claim 7, wherein said rare gas is argon.

9. An apparatus as claimed in claim 1, wherein the

cavity is provided with a conduit for conveying at least part of the particle radiation into a cyclotron and with a conduit for returning into the cavity the radiation accelerated in said cyclotron.

10. An apparatus as claimed in claim 1, wherein the cavity extends through a plurality of coils supplied with electric current to produce magnetic fields in the cavity.

11. An apparatus as claimed in claim 10, wherein the current energizing the various coils is modulated at different frequencies.

12. An apparatus as claimed in claim 1, wherein the downstream extremity of the cavity terminates at an intermediate part of a tube comprising, at the end from which the resultant radiation is to issue, a cathode and an electromagnet surrounding the same; an anode at the opposite end of said tube; a rotary deflector consisting of a plurality of plates which are set round the rim of a rotor facing the extremity of the cavity at an angle such that the deflected radiation be directed towards the cathode; and a plurality of coils energized with electric current and distributed over the length of the tube.

13. An apparatus as claimed in claim 12, wherein said cathode and said electromagnet are identical to the cathode and the electromagnet of an electron gun constituting the particle emitter.

14. An apparatus as claimed in claim 12, wherein the tube comprises electrodes supplied with oscillating current and generating an electrical field lever with the rotary deflector, each of said electrodes being surrounded by a coil, and means for energizing said coils with a modulated current.

15. An apparatus as claimed in claim 12, comprising means for modulating the current energizing the electromagnets to a rate adjustable between 30 and 120 pulses per minute.

16. An apparatus as claimed in claim 15, comprising means for modulating the current supplying said apparatus as a whole at a rate adjustable between 30 and 120 pulses per minute.

17. An apparatus as claimed in claim 14, comprising means for modulating the current energizing said coils at a frequency comprised between 300 and 900 cycles per second.

18. An apparatus as claimed in claim 17, wherein the cavity extends through a plurality of coils, comprising means for modulating the current energizing said coils at said frequency included between 300 and 900 cycles per second.

19. An apparatus as claimed in claim 14, comprising means for modulating the current energizing said electrodes to a wavelength adjustable between 1 m. and 50 m.

20. An apparatus as claimed in claim 19, wherein said means permit of modulating the wavelength to a value adjustable between 1 m. and 18 m.

21. An apparatus as claimed in claim 20, wherein the cavity comprises a conduit for ducting at least part of the particle radiation into a cyclotron and a conduit for returning into the cavity the radiation accelerated by the cyclotron, said cyclotron comprising coils generating and accelerating magnetic field and means for modulating the current energizing said coils to said wavelength adjustable between 1 m. and 50 m.

22. An apparatus as claimed in claim 1, wherein the particle emitter is an electron gun having a hollow anode and a hollow cathode identical to each other, the cathode being disposed downstream of the anode within the magnetic field of an electromagnet whereby to cause particles to be radiated downstream of the cavity, and wherein the downstream end of the cavity terminates in an intermediate part of a tube comprising:

(a) at the end from the resultant radiation is to issue, a system of electrodes comprising two identically disposed electrodes identical to the hollow anode and hollow cathode of the electron gun, with an electromagnet surrounding the downstream electrode;

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- (b) an anode at the opposite end of said tube, and
(c) a rotary deflector consisting of a plurality of plates arranged about the periphery of a rotor facing the extremity of the cavity, the angle at which said plates are set in said rim being such that the deflected radiation be directed towards said system of electrodes, a plurality of accelerating coils supplied with electric current being distributed along the length of the cavity and the tube, and means being provided for simultaneously reversing at will the polarities of the

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electrodes of said system of electrodes and the polarities of the hollow anode and hollow cathode of the electron gun, as well as the direction of flow of the current energizing said coils.

No references cited.

JAMES W. LAWRENCE, *Primary Examiner*.

C. R. CAMPBELL, *Examiner*.

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A. PRIORE

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APPARATUS FOR PRODUCING RADIATIONS PENETRATING LIVING CELLS

Original Filed May 23, 1963

5 Sheets-Sheet 1

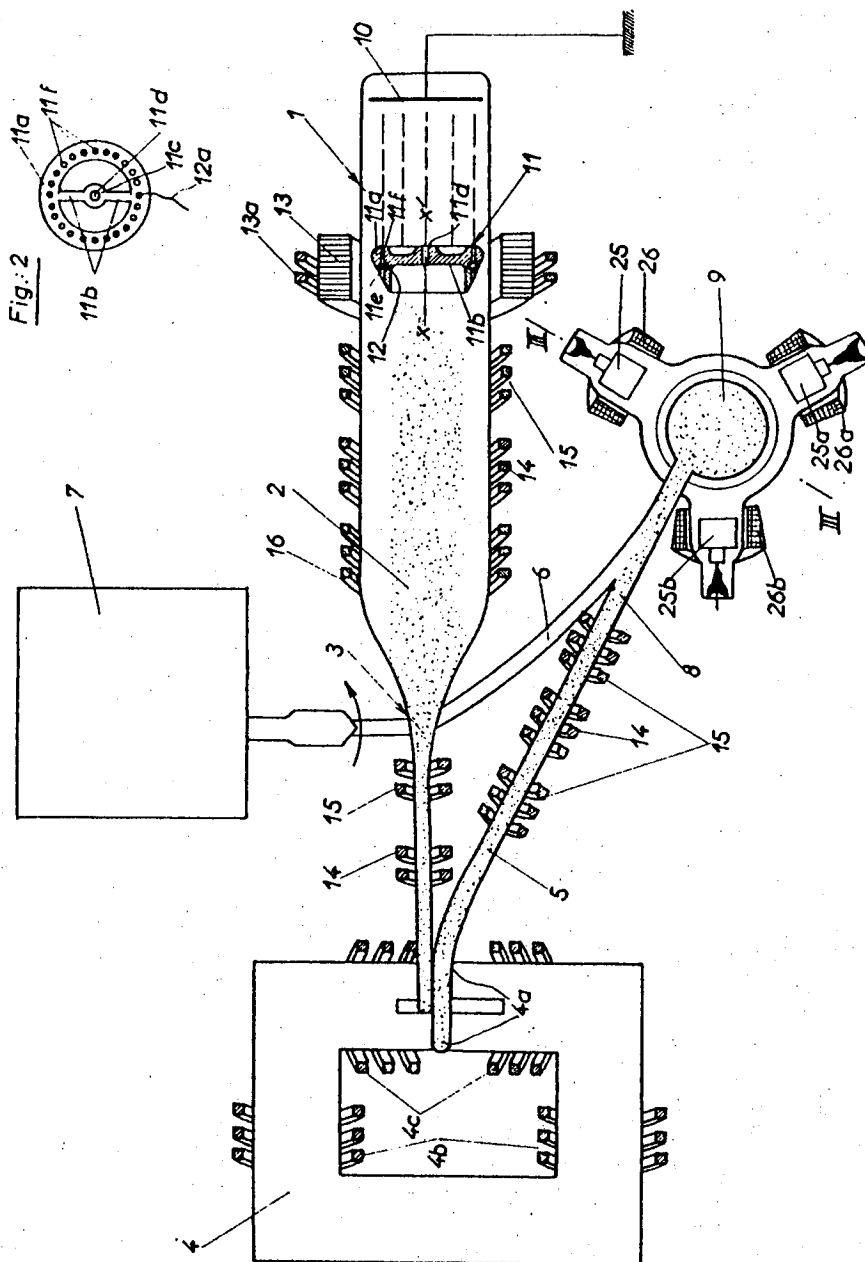


Fig.:1

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Fig. 3

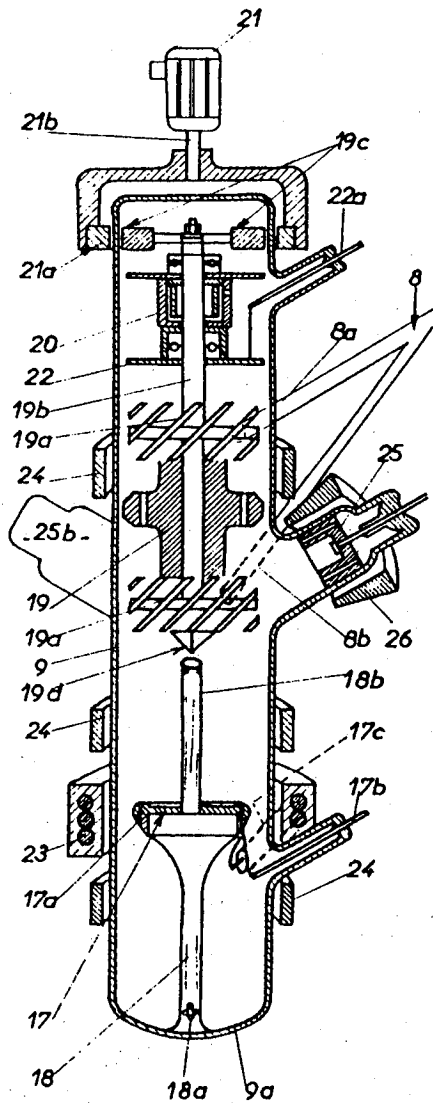
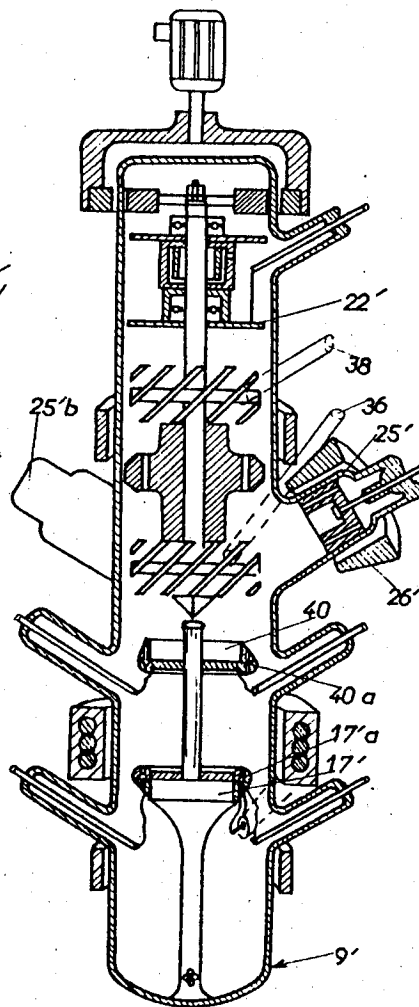


Fig. 6



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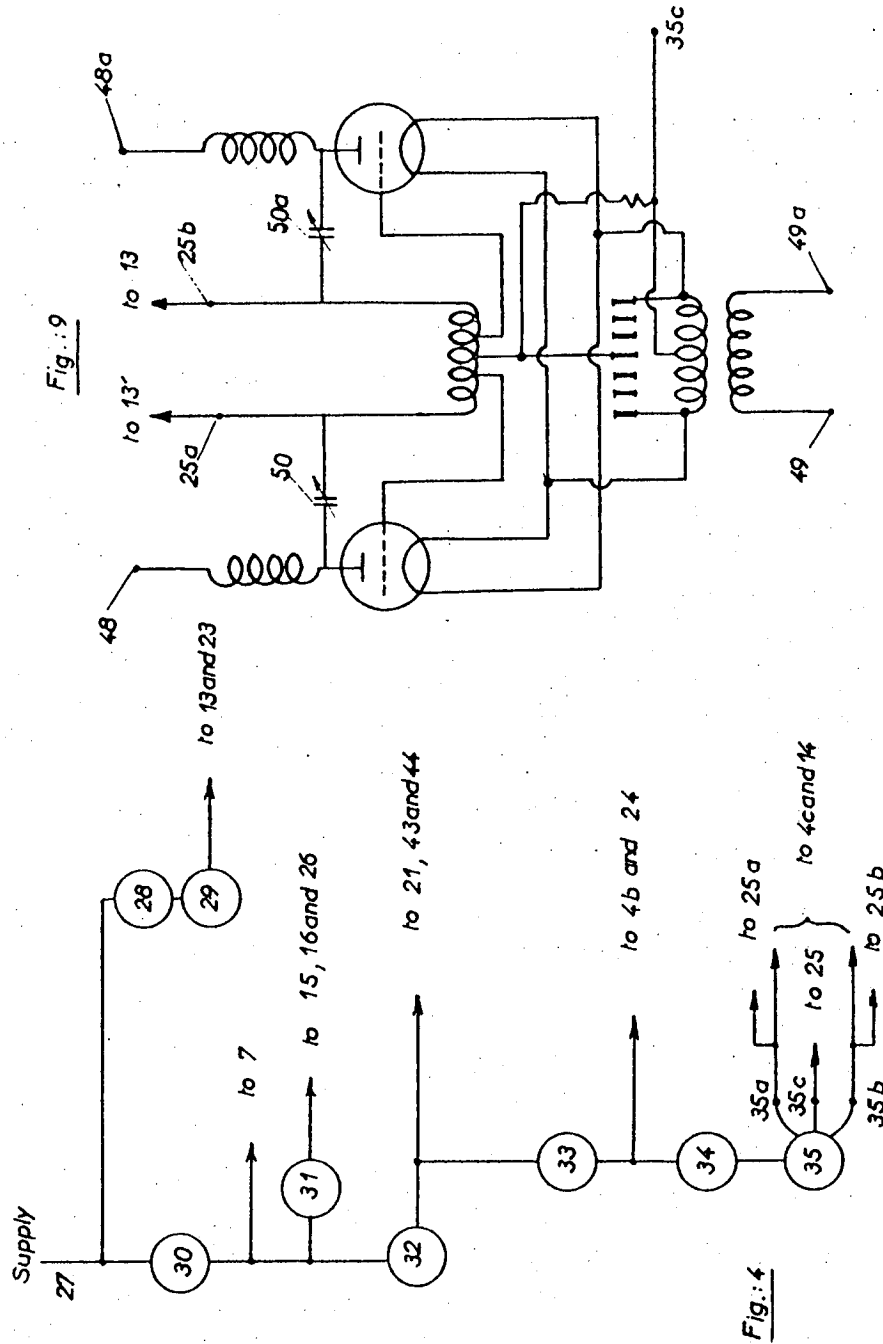
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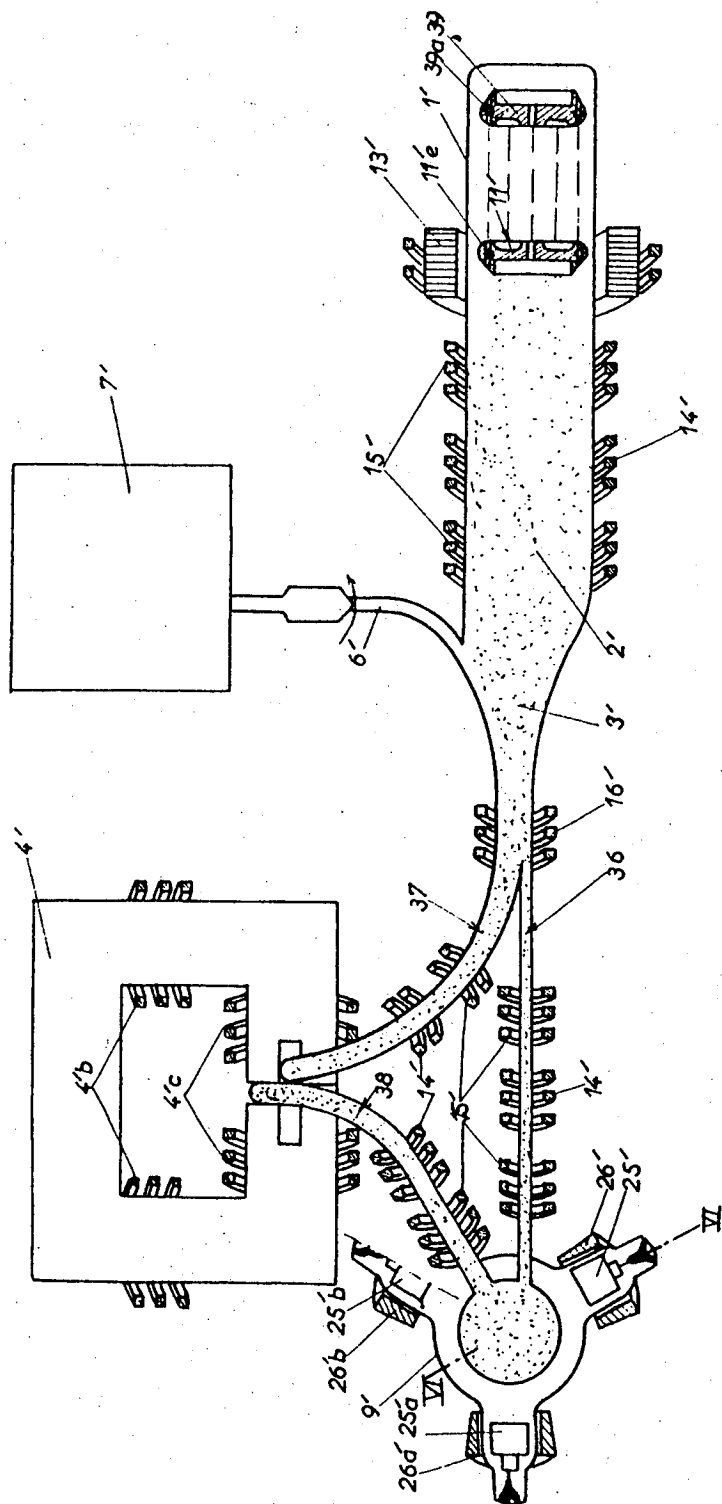


Fig.: 5

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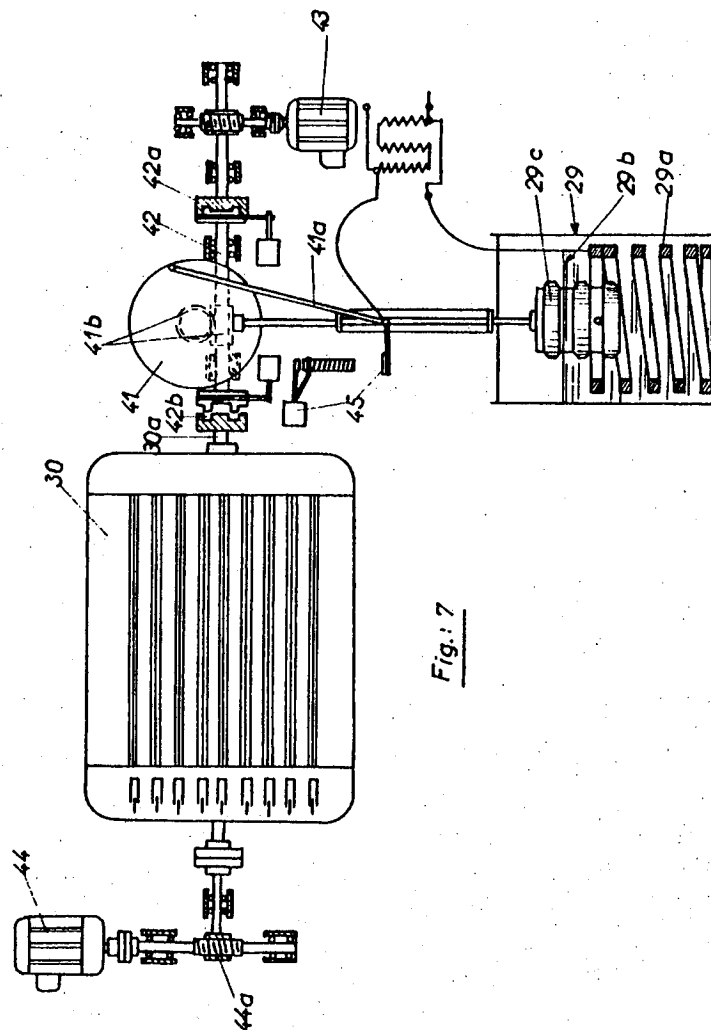


Fig. 7

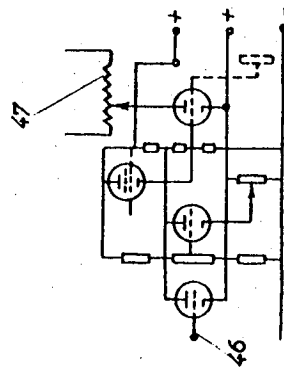


Fig. 8