PATENT SPECIFICATION

Application Date: May 30, 1927. No. 14,539/27.

299,735

Complete Left: Feb. 29, 1928.

Complete Accepted: Oct. 30, 1928.

PROVISIONAL SPECIFICATION.

Process and Apparatus for Producing Rapidly Moving Electrons and for Subjecting Matter thereto.

I, HAROLD EDWIN POTTS, M.Sc., Chartered Patent Agent, of 12, Church Street, Liverpool, in the County of Lancaster, subject of the King of Great Britain, do hereby declare the nature of this invention which has been communicated to me by Hermann Plauson, of Villa Weingarten, Naters bei Brig, Switzerland, a citizen of Esthonia, to be as follows:—

The present invention relates to a process and apparatus for producing rapidly moving electrons and for subjecting matter thereto.

The primary object of the invention is to provide means for accelerating chemical reactions, but with this object in view, it has been found possible to devise new processes and apparatus for producing rapidly moving electrons.

According to the invention chemical and physical processes are accelerated by subjecting matter (i.e. the reagents) to the action of electrons produced in a manner hereafter described. The invention also includes processes in which chemical reactions are accelerated by rapidly moving electrons (either natural or artificial beta rays) in more or less strong electric or electromagnetic fields. The invention further includes processes and apparatus for producing rapidly moving electrons as hereafter described and notably by heating a cathode in an evacuated space and passing the rapidly moving electrons through a conductive imperforate partition to an external anode or anodes. Other features of the improved apparatus will be apparent from the following description, e.g. the invention also includes metal high-vacuum tubes for generating β rays as hereafter described and special forms of conductive partitions or windows therefor. The invention also includes the novel process and apparatus for performing chemical reaction, especially between gases, in which said gases are passed through the region traversed by the rays and preferably between the partition and the anode.

Radio active elements in their disintegration, emit three types of radiation: alpha rays, beta rays, gamma rays. It is known that the β rays consist of rapidly moving elementary charges of negative electricity or electrons. It is also known that the cathode rays of an electric discharge tube consist of flying electrons shot out in straight lines from the negative electrode with varying velocities dependent on the type of tube and also the potential applied to the electrodes. If a window of thin metal foil is arranged in the wall of a discharge tube opposite the negative electrode, at the spot where the cathode rays fall, the cathode rays pass out of the tube and are then generally known as Lenard rays. Their velocities are of a lower order than β rays produced from radio active sources and the quantity is minute.

Cathode rays can be produced in much greater quantities than the β rays shot out from radium but only in highly evacuated vessels such as gas discharge tubes or in Coolidge tubes.

The object of the invention is to obtain large quantities of rapidly moving electrons in a reaction chamber or space in which the materials are treated. In a preferred form of the invention the electrons are produced by a heated cathode, situated in an evacuated vessel provided with a window of metal foil, through which the electrons pass into the reaction chamber under the attraction of one or more external anodes.

A separate anode is situated inside the vessel, insulated therefrom and from the cathode, and maintained at a lower potential than the external anodes. The provision of such auxiliary and main anodes greatly increases the penetrability of the rays. An electron stream of great density is produced by a heated or incandescent cathode. This cathode may consist of a wire coated with emissive materials and raised to a high temperature by passing a current through it, or a suitably heated mixture of certain metallic oxides which are known to emit copious quantities of electrons when heated.

In a preferred form of the invention the evacuated vessel containing the cathode is constructed entirely of metal, with the exception of the insulation for the electrodes, and the insulating base.

A metal vessel is much stronger mechanically, than a glass one and the invention includes a device which renders the seals of the electrodes unaffected by the expansion of the vessel when heated.

Many chemical processes and reactions which do not normally take place, or can be made to proceed only with difficulty take place under the action of β rays of sufficient intensity and velocity, preferably in electromagnetic fields. The following processes are given as examples.

Rubber or rubber solution after a short exposure to the rays is rendered insoluble, without an addition of sulphur.

Varnish and Chinese wood oil polymerised to the solid form.

A and B artificial resin of the phenol-formaldehyde type converted into the C form.

Luminous paints acquire greater luminosity.

Polymerisation of organic gases. Water gas or Blau gas is liquified to hydrocarbons.

Atmospheric nitrogen unites with oxygen to form nitric oxide. If desired, slightly radio active substances may be exposed to the rays. These reactions are further accelerated by constructing the electrodes in contact with the reacting substances of certain catalytic metals.

The apparatus is applicable to the rectification of alternating current or to the generation of electromagnetic waves.

The invention will be described by way of example with reference to the accompanying drawings, which diagrammatically show preferred forms of the invention.

Figure 1 shows the apparatus in elevation.

Figure 2 shows a modification using a cathode which forms part of the wall of the vacuum vessel and

Figure 3 shows a modification with a cathode heated by induction currents.

In the following description the electrons, when in rapid motion will be called β rays.

The metal vessel 1 contains an incandescent filament or cathode 2, of some metal with a high melting point, for example tungsten, tantalum, osmium or zirconium which, when heated emits a copious supply of electrons. This filament may be in the form of an open spiral or coil of wire mounted on suitable supports, the two leads 3 and 4 being sealed in the glass support 5. The leads 3 and 4 are brought out to the pin contacts 6 and 7. The glass mount 5 cannot be sealed directly to the wall of the metal vessel on account of the temperature changes and the different coefficients of expansion of metal and glass. The seal consists of a thin corrugated sheet of metal 8 having approximately the same coefficient of expansion as glass, for example, an alloy of approximately 36% nickel and 64% steel, or one of the alloys which are used in electric lamp manufacture to seal the leads in their passage through the pinch of the lamp. The disc 8 has a cylindrical extension 9 on its inner edge which is sealed into the base of the support 5, while the outer edge 10 is sealed to the wall of the vessel. Any expansion of the wall of the vessel or the glass caused by heat from the glowing cathode is thus absorbed in the corrugated disc. The thickness of the glass seal should be sufficient to prevent any possibility of electrical breakdown between the leads and the sealing disc under the applied potentials and the strength of the insulation may be increased by sealing the edge of the corrugated disc into the outer edge of a glass bell while the support 5 passes through the centre.

The contacts 6 and 7 make contact with terminals 11 and 12 fixed in an insulating block 56 in the base of the apparatus. The vessel is exhausted through a side tube 13. This tube may be sealed after expansion or the apparatus may be permanently connected to a suitable high vacuum pump, by which the vacuum is kept at the desired state of hardness during the process.

The β rays produced by the heated cathode escape through the window 14, of thin metal foil. As the window is quite close to the hot cathode it is preferably of heat resisting metal, for example nickel or cobalt foil. In the construction of the window a compromise must be effected. The window must be sufficiently strong to withstand a pressure possibly greater than atmospheric, and it must be sufficiently thin to offer the least resistance to the β rays.

In the present invention the very thin foil forming the window is supported against the external pressure by a grating 15, fixed to the walls of the vacuum chamber 1. One feature of the invention is to enable a large window to be used thereby increasing the quantity of β rays. The grating 15 may be integral with the foil of the window, as in the case when the complete window element is produced by stamping or some similar process, the ribs being thicker than the foil of the window and the mesh of the grating chosen according to the size of the window. If desired when a separate grating is used, the foil may be soldered to the ribs. A possible modification for large windows is to use a sheet of foil having a small mesh grating integral with the foil supported on a grating of larger mesh. This separate grating may be attached to the wall of the vacuum chamber 1.

The metal window may have a number of sharp needle points on the surface towards the anode to dissipate any acquired negative charge.

The foil is attached at its outer periphery to a metal ring 16 and this ring is soldered or welded, if desired by electrical welding, to the wall of the vacuum chamber 1 making an absolutely airtight joint.

To remove heat generated by the impact of the cathode rays on the metal foil and to avoid possibility of leakage through expansion of the joint 16 a water jacket 18 is arranged either in the upper flange of the vacuum vessel or in the base of the reaction chamber 33 directly in contact with the ring 16. Pipes 19 and 20 serve to convey and remove the cooling medium.

A subsidiary internal anode 21 is mounted on a wide glass tube 22 surrounding the cathode 2 and protected by a second frusto conical tube 23 sealed at its smaller end to the tube 22. The connection to the anode 21 is made by a lead 24 protected by the glass sheath 25 extending to the terminal 26, which is mounted on an extension 27 of the vacuum chamber. The lead 24 is insulated in the same way as the leads 3 and 4, by a thin corrugated disc 28, of metal with approximately the same coefficient of expansion as glass. The disc has a cylindrical extension 29 on the inner edge sealed into the thickened end of the protective tube 25; the outer edge 30 is flattened and sealed to the flanged end of the extension. A porcelain or hard rubber shield 31 may protect the seal and prevent short circuit from the terminal 26 to the wall of the vacuum chamber. A similar shield 32 protects the cathode seal and prevents possible short circuit from the base of the apparatus to the metal vacuum chamber.

The vacuum chamber 1 may be enamelled both internally and externally. The enamel greatly reduces the possibility of leakage through porosity of the metal walls, and the internal coating of enamel improves the insulation, particularly preventing discharge taking place between the internal anode 21 and the walls of the vessel.

The whole apparatus is mounted on a porcelain base 53.

The reaction chamber 33 and the external anode 34 are arranged above the window 14.

The chamber may be of glass, porcelain, or in some cases of hard rubber or phenol-formaldehyde synthetic resin. The casing 33 is fixed directly above the window and may be bolted down to suitable projections 60 and 61 on the upper edge of the vacuum chamber. The perforated metal anode 34 has a tubular metal support 35 which serves as a lead to the anode and as a conduit for the introduction of the reacting substances. The tube 35 is preferably movable in the casing so that the distance of the anode from the metal window is adjustable but the anode may be fixed in the upper part of the reaction chamber if a sufficiently high voltage is applied to cause ionisation throughout the whole chamber. This tube has means for connecting it to the high tension source and, at the outer end, an insulating connecting piece for connection to the reservoir of the reacting substances. The products of the reaction are removed from the chamber through the outlets 36 and observation ports 37 may be provided.

Heat is generated by the impact of the electron stream on the anode 34 and it is desirable to include suitable cooling arrangements. The stream of reacting gases down the tube 35 will effect a certain amount of cooling while fins or radiators may be provided on the tube 35. With large apparatus the arrangements may include water cooling for the anode.

The electrical connections are as follows. The incandescent cathode is fed from a battery or the secondary of a low tension transformer, connections being made to the terminals 11 and 12. The negative pole of the source of high tension alternating current is connected to one of the cathode terminals and to earth 40 through an oscillatory circuit comprising a variable inductance 39, a condenser 41 in series with the inductance and a condenser 42 in parallel with it.

The positive pole 43 of the high tension source is connected directly to the contact on the tube 35 supporting the anode 34 and through one or more condensers 44 of suitable size arranged in series to the terminal 26. The effect of the condensers 44 is to reduce the original potential to the magnitude required for the electrode 21. Such variable voltages may also be obtained from a tapped secondary coil on the high tension transformer. It is necessary that the electrode 21 is maintained at a lower potential than the electrodes external to the tube ensuring that the electric fields external to the vacuum vessel are always of greater magnitude than the internal fields. Further, the effect of the β rays is more easily controllable under such circumstances and the safety of operation of the tube is thereby increased. The metal vacuum chamber, is connected to earth, either through the circuit of the inductance 39 or directly, by the lead 63 and the condensers 64. A high resistance or reactance (not shown in the drawings) may be arranged in parallel with the condensers 64.

The source of alternating current feeds two transformers. The secondary winding of the first transformer supplies the low tension current for heating the incandescent cathode 2. The secondary winding of the second transformer is designed to give very high voltages, which are preferably variable by a suitable reactance in the primary circuit. The high tension alternating current may be rectified, for example, with rectifying valves, alternate half cycles being suppressed, or, by the use of whole wave rectification, the sign of alternate half cycles reversed giving a pulsating direct current, which is transmitted by a condenser with scarcely less efficiency than a true alternating current. Such rectified high tension alternating current is applied to the electrodes 34 and 21, the negative pole being connected to the cathode as previously described.

When the hot cathode reaches a sufficiently high temperature it emits electrons, which move towards the window 14 under the attraction of the anode 34. The potential of the window, which is in metallic contact with the vessel, is not widely different from zero and the majority of the electrons have sufficient energy to pass through the foil, ionising the gas between the window and the electrode 34. The conductivity of the gas is thereby increased and the anode 34 can then be withdrawn from the window till the whole inner space becomes ionised. The voltage applied may be of the order of 500,000 to 700,000 V: normally however a voltage of 300,000 to 400,000 V is sufficient. The advantage of using high voltages is that the velocity of the β rays and thereby their penetrability is correspondingly increased. A velocity of 150—200 kilometres per second can be obtained by suitable choice of the working conditions, which in most cases is sufficient.

The movement of the anode maintained at such a high potential is effected by a lever or handle composed of a large number of small condensers arranged in series. For example, 500 to 1000 small condensers in series, built into a rod may be used to insulate the anode from the mechanism used to move it. Such an insulator will withstand even greater voltages than those mentioned.

The distinguishing features of the modifications shown in Figs. 2 and 3 are that in both forms only one electrode passes through the wall of the vacuum vessel, the heated cathode forming part of the wall of the vessel, and that two external anodes are provided. The reaction chamber is omitted in the drawings and the anodes are shown diagrammatically at 34 and 51.

The metal vacuum chamber is made in the form of an annular chamber between two cylindrical walls, the section being U shaped, in order to bring the cathode as near as possible to the metal window 14. The heated cathode 45 comprises a sheet of metal, thick enough to support the external pressures and cellular on the side towards the metal window. The emissive material is contained in the small cells stamped in the sheet. The cathode is welded or soldered round its edges to a thin corrugated sheet 46 as in the previous apparatus, and the corrugated sheet sealed to the metal wall of the vacuum chamber at 47. Leads 48 and 49 carry the current to a heating element 50, insulated and supported just below the lower surface of the cathode. The whole apparatus is mounted on a porcelain base 53 an internal extension 57 serving to enclose the leads 48 and 49 and to support the heating element 50. In the interior of the metal vessel 1 is inserted a thin walled glass or porcelain lining 58 supported on small projections 62, its use being to prevent a discharge taking place between the internal anode 21 and the walls of the vessel 1. The anode 21 is mounted on the inner end of this insulating lining and is connected, as in Fig. 1 to a terminal 26 through a side extension of the vacuum chamber. In this case the outer shield for the electrode is dispensed with, the other wall of the lining 58 serving the same purpose.

The metal window is either cellular with integral supports, or supported on a grating as in Fig. 1. A cooling jacket 18 is cast in the heavy metal ring 17 which holds the window ring 16 in position and pipes 19 and 20 supply the cooling medium. Lugs 60 and 61 are provided round the edge of the rim 17, to which the reaction chamber is secured.

The perforated anode 34 now acts as an auxiliary anode speeding up the β rays to assist their passage through the window 14. This anode may be cut out by a suitable switch in the high tension lead or by switching into circuit a large number of condensers arranged in series, as previously described. The main anode 51 is supported in the upper part of the reaction chamber and provided with a separate and well insulated contact for the high voltage supply. The scheme of connections is slightly different from that in Fig. 1 to allow the use of the auxiliary anode. The positive pole 43 of the high tension supply, which may be alternating or pulsating direct current is connected directly to the main anode 51, while the negative pole 38 is connected directly to the metal vessel 1 by way of the terminal 52, and to earth through an oscillatory circuit comprising a variable inductance 39, a condenser 41 in series with the inductance and a second condenser 42 in parallel with the inductance in the direct earth lead. The metal vacuum chamber is earthed through the same path.

It is desirable that the auxiliary anode 34 should be maintained at a potential intermediate the potentials of the main anode 51 and the internal anode 21. It is therefore connected to some intermediate point on the chain of condensers 44, the number of condensers in series between the anode 34 and the pole 43 depending on the voltage it is desired to apply to the auxiliary anode. A further series of condensers is added to reduce the potential of the internal anode to the correct value. The β rays, under the combined effects of the two external anodes have a greatly increased range of action and, using an auxiliary anode it is also possible to apply greater voltages to the main anode without risk to the apparatus. Cooling arrangements may be provided for the anodes as before.

The apparatus shown in Fig. 3 is similar to that shown in Fig. 2 except that in this case the hot cathode is heated by inducing eddy currents in the metal on which the emissive material is spread. Alternating currents in the coil 54 induce similar currents in the body of the metal disc forming the cathode 45 and sufficient heat may be generated in this manner to cause emission of electrons from the surface of the cathode.

The metals of the electrodes 34 and 51 may have a catalytic effect on certain reactions and processes taking place in the reaction chamber. In certain circumstances the anodes 34 and 51 may be made of metals known to catalyse the various reactions. For example, nickel, palladium or platinum may be used for the electrodes for hydrogenation processes, or silver, chromium, and the like metals where condensation products are to be produced. Instead of making the electrodes of the catalytic metals, oxides of the metals or their salts may be spread or deposited on the surface of the electrodes. It has been found that certain metallic oxides and salts become powerful catalysts under the action of β rays.

An important feature of the invention is that the coil 54 may be replaced by a system of coils carrying single or preferably three phase alternating current. Such a system of coils can be arranged to produce a rotating magnetic field. The rapidly moving electrons possess the same properties as an electric current flowing in the opposite direction to the β rays, and it is known that a free conductor carrying a current in a magnetic field, will move in a direction perpendicular to the current and to the field. In the magnetic field therefore the electrons have a motion perpendicular to their original direction causing them to trace a spiral path in their passage through the reaction chamber. This turbulence of the β rays renders them enormously more active than the ordinary β rays in promoting chemical and physical changes.

It is not necessary to use an externally heated cathode to produce this turbulence in the β rays. Rotating β ray fields may be produced with the types of apparatus shown in any of the figures by winding an insulated coil of suitable diameter on the wall of the reaction chamber, or round the metal vessel at approximately the same height as the cathode or the metal window. The coil, which is not shown in the drawings, may be arranged inside the vacuum chamber immediately below the window. It should be of greater diameter than the window in order not to obstruct the passage of the rays.

A constant magnetic field may be produced by a steady direct current in the coil, but enhanced results are obtained when an oscillatory current of suitable frequency is passed through the coil. The oscillatory circuit 39, 40, 41 may be used in the production of these oscillators and the coil 39 may form the oscillatory coil.

The density of the electron stream may be increased by coating the upper surface of the window with a thin layer of radio active material or the radio active material may be replaced by or used in conjunction with a small quantity of cerium or thorium, preferably thinly spread. A window coated in this manner gives secondary β rays under the bombardment of the primary rays produced by the cathode, greatly increasing the quantity of rays. Similar results may be obtained from window foil of nickel, cobalt, tungsten or similar metal alloyed with from 0.1 to 1.5% or more of cerium or thorium. Certain chemical reactions are facilitated if, during the process the reaction chamber is illuminated with ultra violet light. The action of the ultra violet radiation is to ionise the gas in the chamber increasing the range and effectiveness of the β rays.

The gases may be supplied to the reaction chamber under reduced pressure or when treating other materials the reaction chamber may be evacuated to reduce the absorption of the β rays. Gases are preferably supplied to the reaction chamber in counter-flow to the electron stream.

The apparatus described above may be constructed wholly of glass if desired. The advantage of a metal vacuum chamber is that it is considerably stronger mechanically, and, especially when enamelled, equally proof against leakage. The action of the β rays is preferably applied in a varying magnetic field produced by a coil or system of coils through which is passed an alternating current. A rotating magnetic field can be produced by a suitable system of coils and three phase alternating current. An electromagnet, or a solenoid producing a magnetic field may be incorporated with the main anode if the anode is well insulated from the coil.

The electrons may be produced from a cold cathode covered with a layer of radio active substances and connected to the negative pole of the high tension supply, an anode connected to the positive pole being arranged opposite the cathode. The electrostatic field in the direction of the natural β rays increases their velocity and activity in producing chemical and physical changes in substances passed through the field, while a rotatory magnetic field may be applied as in the previous cases.

The cathode coated with radio active matter may be made the cold cathode of a Lenard tube, the internal anode, window of metal foil, auxiliary and main anodes being arranged as in the figures.

The invention does not include the mere application of radium or strongly radio active substances for the purpose of accelerating chemical reactions; the effect so produced is of negligible commercial importance.

Dated this 28th day of May, 1927.

W. P. THOMPSON & Co.,
12, Church Street, Liverpool,
Chartered and Registered Patent Agents.

COMPLETE SPECIFICATION.

Process and Apparatus for Producing Rapidly Moving Electrons and for Subjecting Matter thereto.

I, HAROLD EDWIN POTTS, M.Sc., Chartered Patent Agent, of 12, Church Street, Liverpool, in the County of Lancaster, subject of the King of Great Britain, do hereby declare the nature of this invention which has been communicated to me by Hermann Plauson, of Hagedornstrasse 51, Hamburg 37, Germany (formerly of Villa Weingarten, Naters bei Brig, Switzerland) an Esthonian citizen, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to a process and apparatus for producing and utilising rapidly moving electrons in the form of chemically active rays.

The primary object of the invention is to provide means for accelerating chemical reactions, but with this object in view it has been found possible to devise new processes and apparatus for producing rapidly moving electrons and means for enhancing the effect of such electrons.

Cathode ray tubes are known in which large quantities of high speed cathode rays can be produced through a thin metal window, supported on a metal grating, in one end of the tube, the rays passing down a funnel shaped metal tube which forms an equi-potential envelope to shield the walls of the tube from the rays, but the rays from these tubes are propagated rectilinearly through the window. Further, the acceleration of the rays is performed entirely within the tube itself.

It has also been proposed to utilise the heating effect produced by the impact of cathode rays on a solid body as a means of raising its temperature, or to subject radio-active materials to the action of cathode rays, and it has been suggested to subject gaseous mixtures to the action of X-rays and cathode rays in order to ionise them and render them conducting, before passing an electric discharge therethrough to cause them to react.

It has also been suggested to ionise a gas by means of pencils of cathode rays emitted from a discharge tube having a plurality of cold electrodes, fed with polyphase current, a different phase being applied to each electrode, so that a discharge through the gas between two electrodes independent of those supplying the rays will follow the paths of the various pencils of rays.

According to the present invention, in a process and apparatus for the production of chemically active rays, rotating electro-magnetic fields or intense electric and rotating electro-magnetic fields are applied to a stream of cathode rays.

A further feature of the invention is the acceleration of chemical reactions by spirally moving electrons.

A still further feature of the invention is a process for accelerating chemical reactions by means of a stream of non-rectilinearly or turbulently moving electrons, while an internal electric field is applied to a reaction chamber wherein the reacting substances are subjected to the rays.

Another feature of the invention consists in imparting to the cathode rays from a suitable cathode a circular component of motion by means of a rotating electro-magnetic field before they leave the vacuum tube and at the same time accelerating their velocity to pass through a window in the vacuum tube.

Further features of novelty as regards the construction is that the vacuum tube may be manufactured wholly of metal, and that in a metal tube a heated oxide-coated or incandescent cathode can form part of the wall of the tube, instead of providing a separate cold cathode or an incandescent cathode with wires fused into the glass of the tube. The concentration of the electrons produced with the same voltage applied to the electrodes is considerably greater when using heated oxide coated cathodes or strongly heated incandescent cathodes of metal wire than when using cold cathodes.

Further features of novelty will be apparent from the appended claims.

A further special characteristic of this invention consists in accelerating chemical reactions by the application of cathode rays set in rotation in the form of a spiral substantially in the direction of flight by the action of a rotating electro-magnetic field applied externally or internally, either in the reaction chamber or in the tube. The fact that each electron of the stream of rays traverses a substantially spiral or helical path imparts a species of turbulence to the stream.

A still further feature of the invention is the application of a mixture of X-rays and cathode rays for accelerating chemical reactions in intense electric and/or rotating electro-magnetic fields.

Such rotating cathode rays have considerably greater powers of chemical action, the action becoming greater the higher the velocity of revolution of the rotary electro-magnetic field applied.

The rotary electro-magnetic fields for the production of rotating β-rays may be applied in the reaction chamber, but it is more advantageous to produce the effect in the interior of the cathode ray tube during and after the formation of the cathode rays. Further, the effect increases in proportion to the frequency of the field.

In practice, this rotation of the cathode rays can also be produced in a high-vacuum cathode ray tube with an incandescent cathode by utilising a two or three phase current for heating the incandescent cathode.

It is known that it is very difficult to produce alternating currents having a frequency of more than 1000 cycles per second with alternating current dynamos, and that there are great inherent difficulties in setting up magnetic fields with such alternating currents. The ordinary alternating current varies between 50 and 100 cycles, and produces only a small angle of rotation in the direction of the axis of flight as the beta rays move with a velocity of 100,000 to 250,000 kilometres per second. Thus for example, with a frequency of 100 cycles per second and a velocity of flight of 100,000 kilometres only one rotation occurs over 1000 kilometres flight of a beta particle. Although a greatly increased chemical action is obtained, even with rays rotating under the action of current of 50 cycles per second it is advantageous to obtain as high a rate of rotation of the electro-magnetic field as possible, in order to produce a rotation of the angle of the beta rays in the direction of flight of at least 90° (at which they have apparently the greatest effect). To produce a rotary electro-magnetic field by direct current, a commutator giving 500 to 1000 cycles is preferably used, as with higher velocities of revolution the self-induction and other electro-magnetic phenomena give difficulty. Rotary fields cannot be produced with much more than 10,000 cycles per second and it is very difficult to obtain a uniformly acting rotary electro-magnetic field with this number of cycles.

It has now been discovered that in addition to using rotary fields from alternating current generators, it is also possible to bring cathode rays into rotation with single phase alternating current having a moderately high frequency of oscillation. This is more especially possible when the rotary effect of the electro-magnetic or electro-inductive field acts directly on the cathode rays during the period before they leave the cathode ray tube.

It has also been discovered that it is possible to produce the effect of rotary electro-magnetic fields on the cathode rays by a hysteresis phenomena of iron.

The simplest method of carrying out the process is when a magnetic rotary field is produced by a continuous magnetic wave. This can be effected by an iron cylinder in which a continuous magnetic wave is excited, and which encloses preferably internally, one-quarter, two-thirds, or one-half the circumference of the cathode ray tubes. The phase of the magnetic induction at one end of the reaction of the tubes is displaced relatively to the other end of the section. This applies also to the magnetic lines of induction which escape at the end and centre. Thus two relatively perpendicular alternating magnetic fields are produced in the chamber, which are in effect equivalent to a rotary electro-magnetic field. The same result is also obtained when the cylinder terminates in a semicircle about the tube, so as to form a kind of hook.

Instead of only using one such cylinder or hook on the cathode ray tube as described above, two such hooks or cylinders can be mounted on the tube, so that the formation of the rotary field is completed on the opposite side by a second hook, and the action on the cathode rays in the tube is increased.

The construction can also be modified by mounting a coil on the point of the hook by which the rotational moment can be suitably amplified or regulated.

Magnetic rotary fields are produced from single phase alternating current in practice by electricity meter motors, but such synchronous rotary fields have never been used for producing rotary cathode or chemical rays.

If it is desired to produce a rotary field without introducing iron into the circuit a spiral of para-magnetic or dia-magnetic metal may be used, surrounding one-third, one-half, or two-thirds externally, or preferably, internally, of the cathode ray tube similarly as with the iron cylinder, particularly when the number of turns in the spiral, its inductance and the oscillating circuit, are so chosen that the natural frequency of the spiral is some exact multiple or sub-multiple of the basic frequency of the oscillator. If such a spiral is inserted in parallel with an oscillating circuit external to the tube consisting of an inductance and a variable condenser it is possible to vary the frequency, and consequently, to control the rate of rotation, by varying the capacity outside the tube.

The invention is more particularly described with reference to the accompanying drawings in which:—

Figure 1 shows a longitudinal section through a glass cathode ray tube.

Figures 2, 3, 4 and 5 are details of the tube of Fig. 1.

Figures 6 and 7 show a modified device for producing a rotating electro-magnetic field.

Figures 8 and 9 show a device for producing a rotating field by passing an oscillating current through a spiral coil.

Figure 10 shows a metal tube, in which the means for heating the cathode and producing the rotating field are arranged external to the tube.

In Figure 1 a glass pear shaped vessel 1 bulging particularly at the point 1 is extended in one direction by a conical glass tube 2, and is drawn out in the other direction in the form of a straight walled glass cylinder up to the contacts 4, 5, 6, 7, and terminates in a metallic sleeve 3. Three leads 4, 5, and 6 are taken from these contacts to a three-legged incandescent filament 8, and a fourth lead 7, which is connected to the point of intersection of the three wires, is used to connect the cathode to the high tension system.

The incandescent cathode shown in Fig. 7 or Fig. 9 as three heavy lines meeting in a point in the centre of the electro-magnet, is connected up with the three-phase current supply on the star system. Hence, as each arm of the filament is heated in turn by each current pulse it momentarily emits a greater quantity of electrons, so that the cathode beam, taken as a whole, has a spiral formation.

The rotation of the rays is amplified by alternating current magnets 12 having additional poles 17, 18, 19 and 20, shown in section in Figure 4. In Figures 1 and 4, a magnet is shown suitable for two-phase alternating current, but the result is unaltered if three-phase or the like current is used instead. The rotary magnetic field is produced by electro-magnets 13, 14, 15, 16 (Figure 4) while the additional poles 17, 18, 19, 20 are secured by non-conducting well insulated packing 21, so that it is impossible for the additional poles to be displaced under the electro-magnetic forces. If the poles 4, 5, and 6 of the incandescent cathode filaments are connected with a three-phase low voltage current transformer, the incandescent cathode glows at the point 8, and emits electronic rays in a spiral or rotary form having the same period as the alternating current supply. The spiral motion of the cathode rays is amplified by the electro-magnets 12, which may be excited by the alternating current transformer used for heating the filament. The filaments may be in a plane, but may also have a certain conical inclination as shown in the drawings, which results in the rays being emitted in the form of a beam in the centre of the tube 28, so that they travel up to the transparent window in the form of a cone. A metal sleeve 9, slotted at 10 to fit snugly, is mounted behind the cathode to act as a reflector, and for the purpose of screening the filament. A thin metallic coating may be applied to the glass such that the electro-magnetic lines can penetrate it, e.g. a silver coating, to reflect the cathode rays impinging thereon to a suitable extent. A conical glass tube 23 is mounted over the incandescent cathode 8, and is supported at the cathode end by the ridge 24, while its other end is rigidly sealed to the metal rim 30 by means of a metallic ring 27. Thin metal laminæ are mounted in series on this tube (connected internally by 25 and externally by 26) in such a way that the glass tube is provided with a plurality of condenser faces arranged in series, and the last condenser face is soldered at the top to the metallic window holder. The action of this condenser is important. The cathode rays which travel down the tube 23 provided with internal and external metal coatings 25 and 26 are considerably accelerated by the charged condenser faces connected in series. In the first place it is hereby possible to give the beta rays a greater kinetic energy, and secondly, to distribute the whole voltage over the number of condenser coatings connected in series, whereby the penetrability of the tube between the window membrane 30 and the electric contact devices 4, 5, 6 and 7 is considerably increased. The beta rays are initially driven by a small field, and are successively subjected to stronger potential fields as the rays pass through the sections of the condenser. It is known to use a metal tube in order to accelerate the beta rays produced in any incandescent cathode tube. In a known cathode ray tube however, the whole voltage is concentrated at the point of the tube opposite the incandescent cathode producing the beta rays.

In the arrangement of the present invention the acceleration is increased at regular intervals and the voltage of the tube is used to considerably better effect than in known cathode ray tubes.

The glass tube 2 has a cylindrical fold 28 (Figure 1) at the top into the outer edge of which a ring 29 of steel nickel alloy, platinum or its alloys or other metals or metallic alloys having a similar expansion to glass are fused, thus making an airtight closure between the metal membrane and the glass. The metal ring is electrically connected with a disc 30 consisting of a light metal alloy, such as an aluminium alloy etc. A tube 33, 34, is mounted on this disc 30 to which a cooling liquid (e.g. alcohol or aniline) can be supplied through two thin pipes and valves 31, and can be led away at 34 and 31. A second disc 36 is mounted on this first circular disc 30 and is provided with a spiral tube 32, shown in horizontal section 33, and strengthened by radially mounted thin transverse ribs. The purpose of this membrane mounting 36 with the spiral cooling tube is to cool the metal window membrane, and at the same time to provide a strengthened support below the thin membrane 35. The inner cooling spiral 32 (Figure 3) is connected at the points 33 and 34 (Figure 1) to the cooling tube located in the lower metal mounting, and has inlet and outlet valves 34, and 31. The actual membrane, 35, penetrable by beta rays, is now mounted on these strengthened ribs 32 with thin transverse ribs 46. The membrane consists either of flat or cellular metal foil suitably penetrable to the beta rays, such as for example, nickel, aluminium, magnesium, beryllium, or preferably alloys thereof. It is possible by making the membrane 35 of cellular construction and the use of the cooling spiral ribs 32 to make the flat portions of the membrane very thin at both the top and the bottom, which greatly increases the penetrability of the membrane. The membrane itself is flat at the edges and is soldered to the lower mounting ring at the point 36.

Alloys of beryllium, magnesium, and aluminium, for example 100 parts of beryllium, and only 2 to 5% of aluminium, when rolled into foil, give very good results as membranes for the window.

In order to protect the surface of the membrane towards the reaction vessel from chemical action the surface is coated with a thin deposit of gold 0.001—0.0015 mm. thick, platinum, nickel, cobalt and other inactive metals can be used if they do not cut down the strength of the β-rays by too great an amount. The membrane is completely cooled by a cooling coil, and the danger of fusing through long exposure avoided. Obviously, the membrane can be made thicker, and by the use of beryllium-aluminium foil 0.05 to 0.1 mm. thick a window of the same penetrability as a nickel window 0.005 mm. thick is obtained.

The tube can be connected direct with

the high tension positive pole through a contact 38 if it is necessary to produce the rays in the open air e.g. for the purpose of sterilizing food stuffs, etc. If it is desired to carry out chemical reaction, a reaction apparatus 37 as in Figure 1 is attached by bolts 38 to the metal flange 30 of the tube. In such a case the flange 30 must be supported so that the weight of the reaction vessel does not rest on the glass tube.

The reaction vessel is provided with a number of baffles 45, shown in cross section in Figure 2. The reacting substances are introduced through the opening 39, traverse the tube in a circuitous manner round the baffles 45, and leave the apparatus through the opening 40. In this portion the substances meet the β-rays streaming through and react accordingly. The baffles 45 and also the outer walls 37 of the reaction apparatus are preferably formed of a high insulating material, such as glass, quartz, porcelain, or hard rubber or a phenol-formaldehyde condensation product. In order to subject the reaction chamber simultaneously to an intense electrical field, the positive lead is connected to the point 43, where a metallic surface (indicated by 41, 42) is arranged on the surface of the reaction vessel and applies an intense field to the reaction products.

A second electrode preferably consisting of a metal grid (not shown in the drawings) may be arranged opposite the metal window. If it is desired that the potential applied to this auxiliary anode, or to the metal window, should be less than that applied to the main anode (so that an electric field exists between the auxiliary anode or the window and the main anode) the auxiliary anode, and/or the metal window may be connected to the positive pole of the high-tension source through a plurality of condensers connected in series which serves to reduce the magnitude of the potential applied to the desired lower value.

The action of the apparatus is as follows:—

The heated cathode 8, connected to the negative pole of the high voltage system at 7, is heated by low voltage 3-phase (or 2- or multiple phase) current and produces a rotating beam of electrons. The rotation of this cathode-ray stream is increased by an electro-magnet 12, supplied with current of the same frequency as the current applied to the cathode. The rays are accelerated by the condenser tube 23, pass through the cooled membrane 35 and through the reaction chamber 37. The action of the β-rays can be regulated to a certain extent by the field applied to the reaction chamber.

The vacuum should be the highest obtainable and the parts of the tube preferably degasified in known manner. To prevent or suppress the production of residual gas lithium metal may be used. Metallic lithium is provided in a side tube or as in Figure 1, covered with a porous glass disc so that the lithium does not fall into the tube when it is inverted. The air is exhausted and replaced with pure nitrogen. The nitrogen is then exhausted with known high vacuum pump and the tube is baked to remove occluded gas, and afterward sealed.

Lithium has the property of removing the remainder of the nitrogen at ordinary temperatures, forming lithium nitride, whereby it is possible to produce a high vacuum in the tube.

The enlargement 1 of the tube may be omitted, and replaced by the cylindrical or slightly conical tube 2. The action of the electro-magnet on the cathode rays can then be varied by moving it up or down the tube.

An additional security against short circuit is provided in Figure 1 by a disc 22 of high quality insulating material mounted on the tube. The disc 22 can be used as a mounting if the chemical reaction apparatus is arranged below, so that the tube is supported on the disc, the weight of the plate being taken by a foundation or insulating stand.

A modification of the tube of Figure 1 is shown in Figures 6 and 7. Figure 6 shows the tube in longitudinal section, while Figure 7 shows a cross section. In this modification a slightly different method is used for producing rotation in the β-rays. The electro-magnet consists of thin soft iron lamellæ 47, separated from one another by thin mica sheets. In order to produce a better rotating field, small incisions 48 are made in 47. This magnet is rigidly mounted in the interior of the glass tube, while the end of the hook projects sidewards from the tube. A coil 49 fed with alternating current through the leads 50 and 51 is fixed on the glass end 60, whereby the hook like electro-magnet 47 is periodically magnetised. For the rest the tube is constructed as in Figure 1. A glowing filament is supplied with current through the contacts 5, 6 and 7, and is also connected with the negative high tension leads at 7. Beyond the cathode 10 is mounted a series-connected condenser system on a glass cylinder 23 as an accelerator for the cathode rays. The window is arranged as in Figure 1. In this apparatus ordinary alternating current is used to produce the rotating field.

instead of three phase current. The beta rays rotate as previously described under the influence of the rotating field.

Figures 8 and 9 show a similar arrangement to that of Figures 6 and 7, with the difference that instead of a bent hook a metal spiral 52 of substantially hook form, of non-magnetic (or magnetic) material is arranged in the interior of the tube. The transmission of the current from the interior to the exterior is effected by a condenser system. The condenser surface 55 is charged with high frequency current from the high voltage lead 57. This charges the condenser surface 53 in the interior of the tube (Figure 9), from which the oscillating current passes through the windings of the spiral 52, producing a rotating field in the tube, to the condenser surface 54 at the other end, and from thence back to the source via the condenser surface 56. The spiral 52 may be chosen so that its natural frequency of oscillation is equal to some multiple or sub-multiple of the frequency of the oscillating circuit.

The advantage of using oscillatory current consists in that the action on the rays can be controlled as desired by varying the resonance by a variable condenser connected in parallel with the coil and the oscillatory circuit.

In Figure 9 the spiral is shown as a semi-circle. It is possible however to arrange a second spiral in the reverse direction somewhat removed from the other, to produce a further action on the beam of β-rays. Obviously, the same thing is possible when a hook like electromagnet is used.

In Figures 1 to 9 a glass or fused silica vessel can be used for the vacuum tube.

Metal tubes with relatively low voltages may be used to apply the rays to the sterilization of foodstuffs, polymerisation, chlorination or the like. The invention permits the construction of metal tubes of special design, in order to carry out a series of chemical reactions while a constructional advantage is that metal tubes may be made shorter than ordinary glass tubes. Such an electron-tube is shown in Figure 10. It consists of two metal vessels 61 and 62 separated from one another and embedded in a vessel of highly insulating vitreous material 63.

A conical glass tube is arranged in the centre as in Figure 1, 6 or 9 with series connected condenser surfaces 25 and 26 arranged thereon. The mode of production of the β-rays is as follows.

The electron emitting surface consists of a thick pressure resisting concave or dished metal plate 65, preferably with an upper surface cellular in form. The cells are filled with a metal or compound used for coating low temperature cathodes or with calcium or like metal which produces large quantities of β-rays at low temperatures. Behind the surface 65 is an electromagnet 68 arranged to produce a rotating field with two or three phase alternating current. The heating is by induction, the inner surface 65 acting as a secondary winding and being raised to red-heat by the induced eddy currents. In order to compensate for the expansion of the hot cathode the heated surface 65 is surrounded by a ring like spiral 66 of heat resisting metal with a corrugated surface, the expansion of the heated plate 65 being absorbed without any risk of the apparatus leaking. The other end of the spiral is secured to the metal ring 69 which is fixed to the metal vessel 62. A cooling tube 70 is arranged in the thickest part of the ring 69, cooling fluid being supplied and removed through the pipes 71. The upper part of the vessel 61 is also welded to the upper ring which carries the permeable window, the end of the metal condenser 27 being attached in the same way. The window is of the type previously described and is cooled by a spiral cooling tube 32 which is supplied from the tubes 33, 34, the flow being controlled by the valves 31.

The reaction vessel is secured at 38 to the metal ring 36 and contains baffles as in Figure 1. The electrical connections are the same as in Figure 1. The reacting substances are introduced through the port 39 and removed through the port 40 in the end of the reaction chamber. Any tendency of the system to short circuit is prevented by the insulating disc 22. This disc can serve to support the apparatus on a foundation. Such a tube produces β-rays in great quantities, but, if the applied voltage does not exceed 50—150,000 volts, with smaller velocities than the other tube.

By increasing the number of series-connected, condenser like insulated metal casings the applied voltage may be increased, and thereby the velocity of the beta rays. The action of the rays is greatly increased by applying a rotating field, making for example 100 revolutions per second, during the production of the β-rays. By the use of a further high voltage anode in the upper part of the reaction chamber the apparatus can be worked in the majority of cases with a lower voltage on the tube. The potential applied to the window may be reduced to a suitable value by connecting a plurality of condensers in series between the window and the positive pole of the high tension supply.

A plate coated with radio-active material which emits β-rays may take the place of the hot cathode; such a cold cathode operates like a hot cathode and has the advantage that a larger surface can be used. The negative electrons produced in this manner are either subjected to a rotating magnetic field or accelerated through a condenser tube and applied to the reacting substances.

The performance of the chemical rays can be varied if a part of the β-rays are converted into X-rays, either in the tube itself (by inserting pieces of quartz, mica or glass in the line of flight of the electrons) or external to the tube. In the latter case the target from which the X-rays are produced may be arranged on the permeable window. The mixture of beta and X-rays has a specially great action, because it penetrates deeper into the reacting substances. If high voltages are applied the secondary β-rays themselves produce X-rays while the X-rays produce secondary β-rays. It appears that the action of the X-rays is also increased by the presence of the rotating field.

The mode of construction of metallic tubes without the introduction of electrodes is part of the novelty and is included in the scope of this invention.

The chemical rays are applicable to different chemical reactions in liquids, solids, gases, or vapours. Further the rays are applicable for sterilization synthesis of chemical compounds, polymerisation, oxidation, chlorination, etc. Also for example, in the polymerisation of isoprene, which can be converted in a short time to rubber with the aid of the rays. In the hydrogenation of inorganic oils and similar substances, even without catalysts the conversion proceeds considerably quicker. In chlorination most substances give a compound with chlorine. Nitrogen can be synthesised to nitrogen oxides with oxygen, and in presence of water vapour also to nitric acid. The application of rays produced according to the invention to different reactions is included within the scope of this invention.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, as communicated to me by my foreign correspondent, I declare that what I claim is:—

1. Process and apparatus for the production of chemically active rays in which rotating electro-magnetic fields or intense electric and rotating electro-magnetic fields are applied to a stream of cathode rays substantially as described.

2. A process for accelerating chemical reactions by means of spirally moving electrons substantially as described.

3. A process for accelerating chemical reactions by means of a stream of non-rectilinearly or turbulently moving electrons, while an intense electric field is applied to a reaction chamber wherein the reacting substances are subjected to the rays substantially as described.

4. Process and apparatus for the production of chemically active rays in which a mixture of cathode rays and X-rays is applied in intense electric and/or rotating electro-magnetic fields substantially as described.

5. Apparatus suitable for the purposes of Claim 2 or 3 in which rotating electro-magnetic fields, or intense electric and rotating electro-magnetic fields are applied to a stream of cathode rays substantially as described.

6. Apparatus as claimed in Claim 5 in which the rotation of the cathode rays is produced by a rotating electro-magnetic field applied to the rays before they have left the vacuum tube wherein the rays are produced substantially as described.

7. Apparatus as claimed in Claim 5 in which further intense electric and/or rotating electro-magnetic fields are applied to the cathode rays externally to the cathode ray tube e.g. in a reaction chamber substantially as described.

8. Apparatus as claimed in Claim 5 in which the discharge tube is constructed principally of metal and the heated cathode is heated externally by induction through a rotating electro-magnetic field substantially as described.

9. Apparatus as claimed in Claim 5, 6, 7 or 8 in which a rotating magnetic field is produced by the combined action of two or more inclined alternating magnetic fields differing in phase substantially as described.

10. Apparatus as claimed in Claim 9 in which the rotating field is produced by an electro-magnet having a hook-shaped core extending over substantially one half of the cathode ray tube, and excited by alternating current substantially as described.

11. Apparatus as claimed in Claim 9 in which the rotating field is generated by a single spiral coil extending over substantially one half of the cathode ray tube and fed with alternating current substantially as described.

12. Apparatus as claimed in Claim 10 or 11 in which the devices generating the rotating field constitute a part of an oscillating circuit, the frequency of which

can be controlled by varying the components, and preferably the capacity thereof, substantially as described.

13. Apparatus as claimed in Claim 4 in which rotating fields are applied to both the primary cathode rays and to secondary beta-rays generated by X-rays substantially as described.

14. Apparatus as claimed in Claim 5 in which the cathode rays are generated in a vacuum tube and leave the tube through a metal window penetrable to cathode rays, supported on a strengthened cooling coil substantially as described.

15. Apparatus as claimed in Claim 14 in which the cathode ray tube is constructed chiefly of metal and has two or more walls, separated from one another and embedded in a vessel of highly insulating vitreous material and connected in series in condenser-like manner, substantially as described.

16. Apparatus as claimed in Claim 15 in which the heating means for the cathode and the means for producing the rotating field are arranged externally to the tube substantially as described.

17. Apparatus as claimed in Claim 7 in which a main anode is arranged in the reaction chamber and raised to a high positive potential substantially as described.

18. Apparatus as claimed in Claim 17 in which a perforate auxiliary anode is arranged in the reaction chamber between the main anode and a window from which the rays are ejected substantially as described.

19. Apparatus as claimed in Claim 18 in which the auxiliary anode and/or the metal window are connected to the positive pole of the high tension source through a plurality of condensers connected in series which serves to reduce the potential applied to a lower value substantially as described.

20. A process for the acceleration of cathode rays consisting in subjecting the rays to an electric field of increasing intensity in the direction of the rays substantially as described.

21. Apparatus as claimed in any of the preceding claims in which the velocity of the cathode rays is accelerated in the interior of the tube by passing the rays along an insulating tube carrying a plurality of conducting condenser surfaces connected in series, the last surface being connected to the positive pole of the high potential source substantially as described.

22. Apparatus as claimed in Claim 4 in which substances are provided, preferably in a reaction chamber, whereon the cathode rays impinge to form X-rays substantially as described.

23. A cathode ray tube in which the cathode comprises a surface coated with radio-active material emitting beta-rays substantially as described.

24. Apparatus as claimed in any of the preceding claims in which the window through which the rays leave the tube is of beryllium substantially as described.

25. An apparatus for producing and applying chemically active rays comprising in combination a cathode ray tube having a penetrable window through which the rays are ejected, a reaction chamber, means too accelerate the velocity of the rays, and means to impart a rotational component to the motion of the rays.

26. A process for performing and accelerating chemical reactions comprising subjecting the reacting substances to the action of electrons moving at high speeds in substantially spiral or helical tracks in intense electric fields.

27. A process and apparatus for the production of chemically active rays substantially as described with reference to the accompanying drawings.

Dated this 28th day of February, 1928.

W. P. THOMPSON & Co.,
12, Church Street, Liverpool,
Chartered and Registered Patent Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1928.

SHEET 1

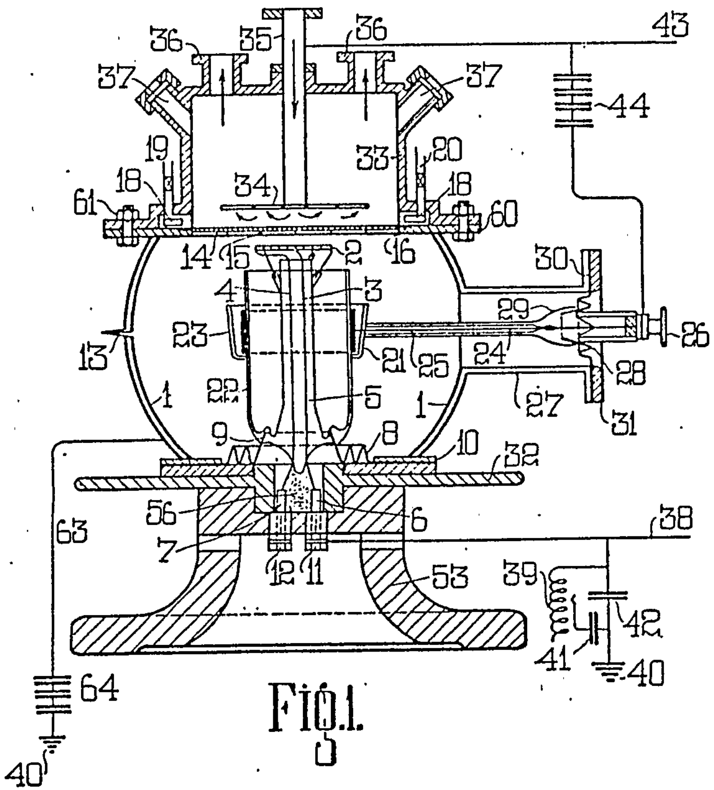


Fig.1.

SHEET 2

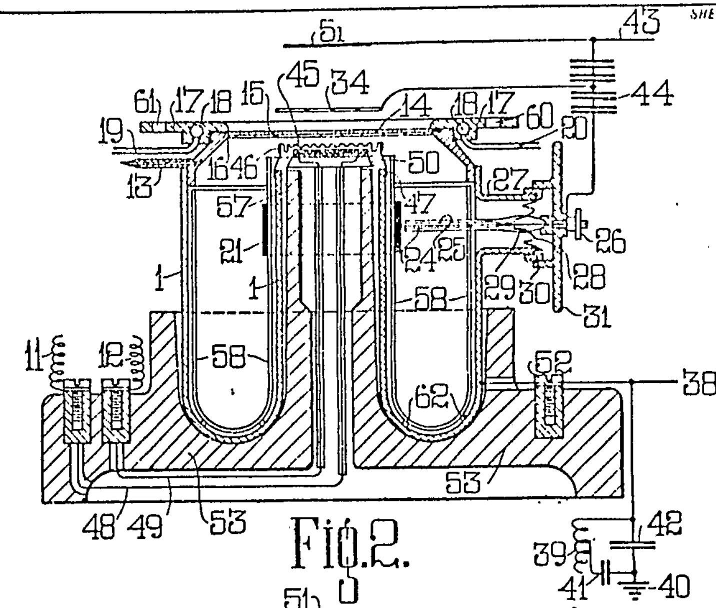


Fig.2.

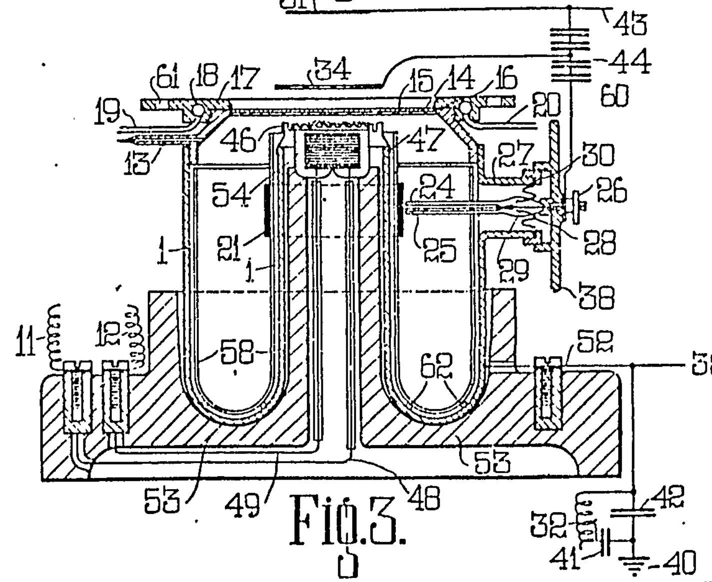


Fig.3.

[This Drawing is a reproduction of the Original on a reduced scale]

[This Drawing is a reproduction of the Original on a reduced scale.]

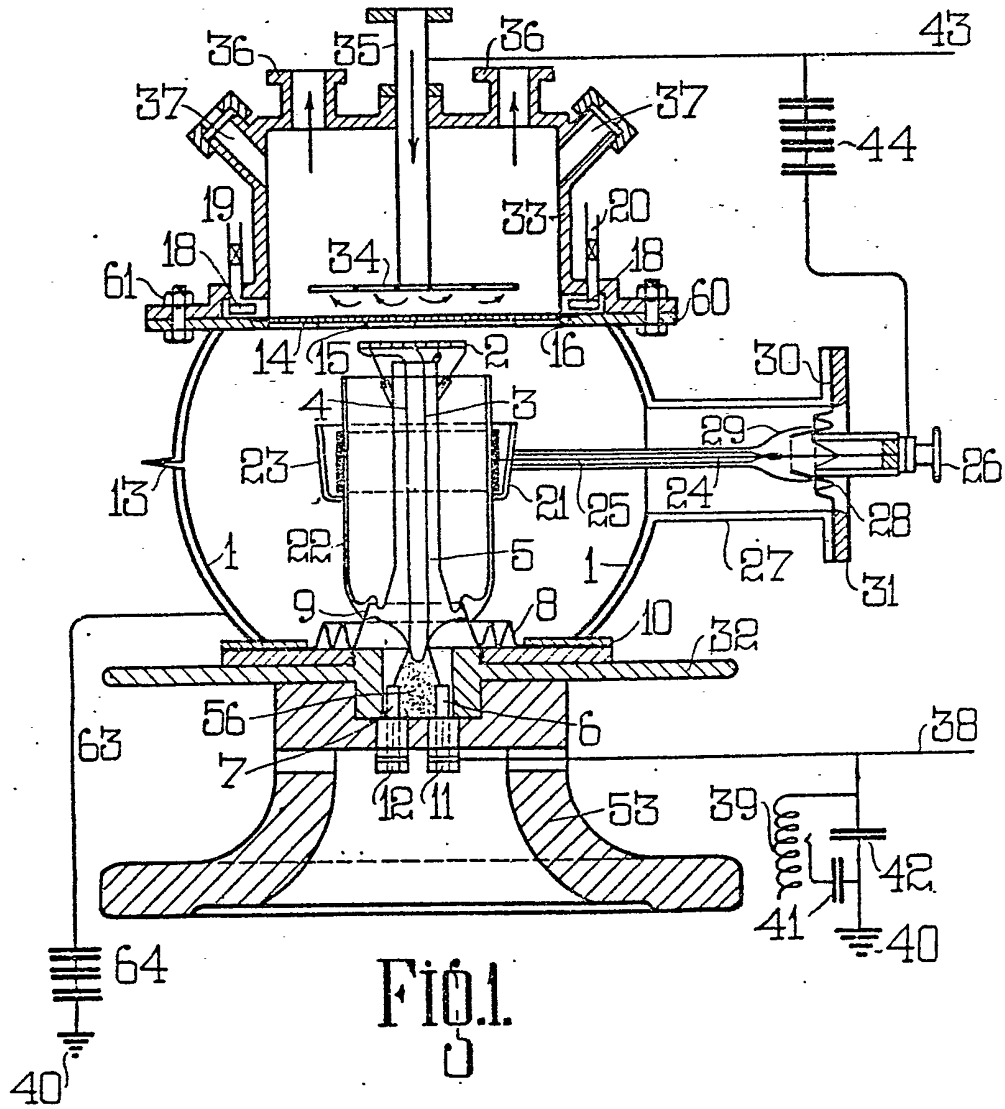
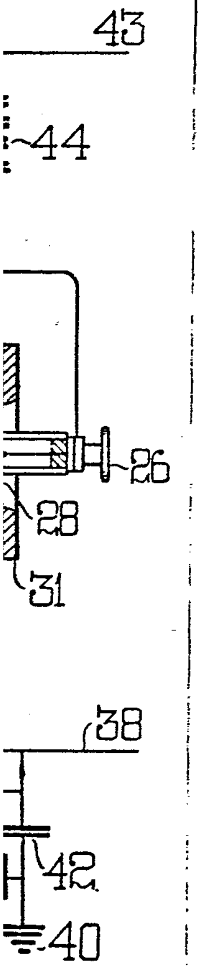


FIG.1.



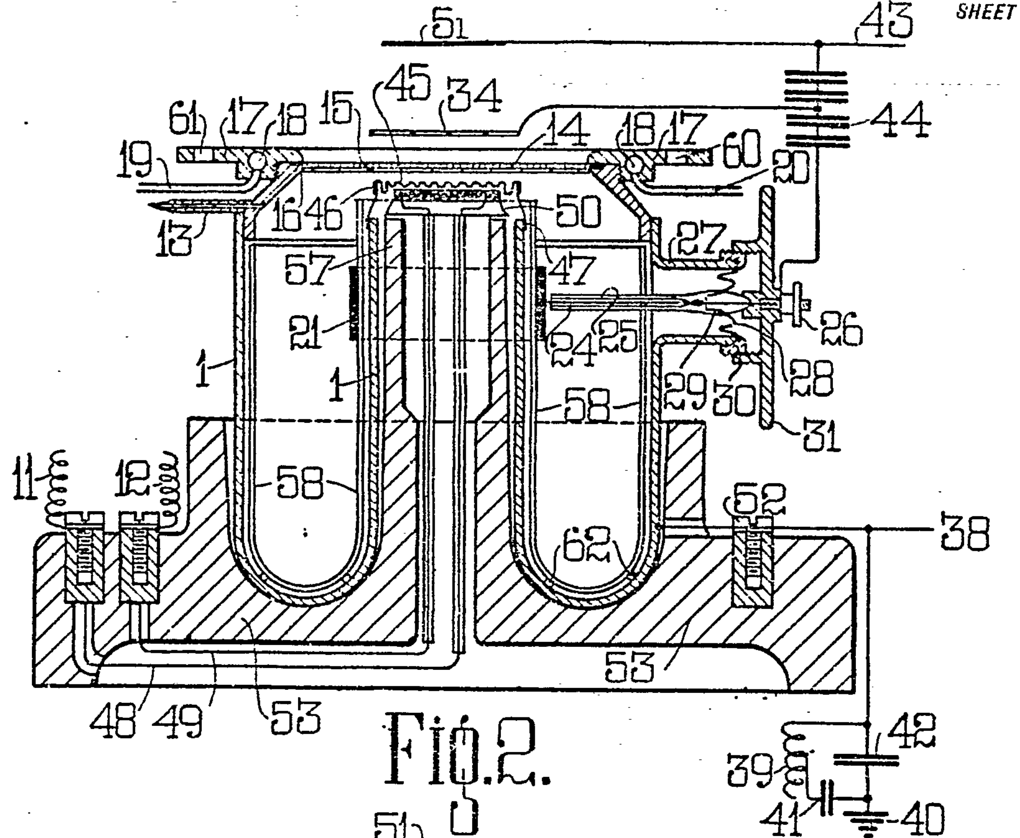


Fig.2.

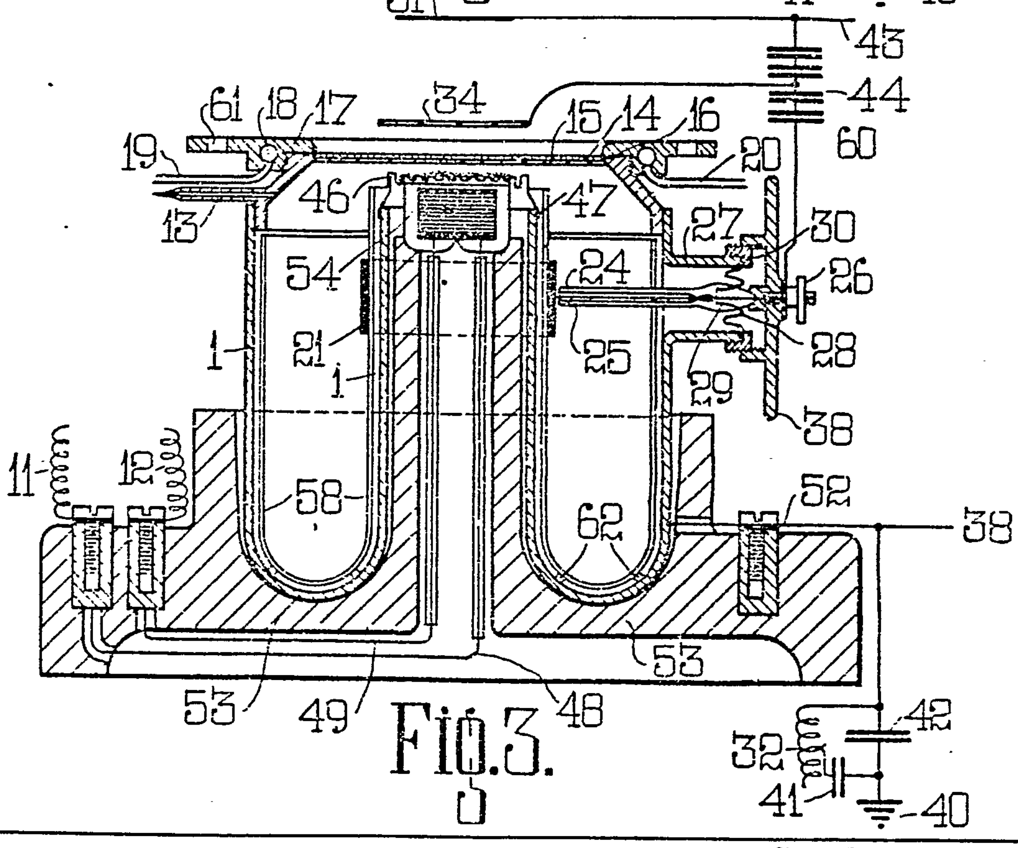


Fig.3.

Charles & Read Ltd. Photo Litho