Aug. 21, 1934. E. RUPP 1,971,277

DEVICE FOR ANALYZING THE STRUCTURE OF MATTER

Filed June 24, 1932

Fig. 1.

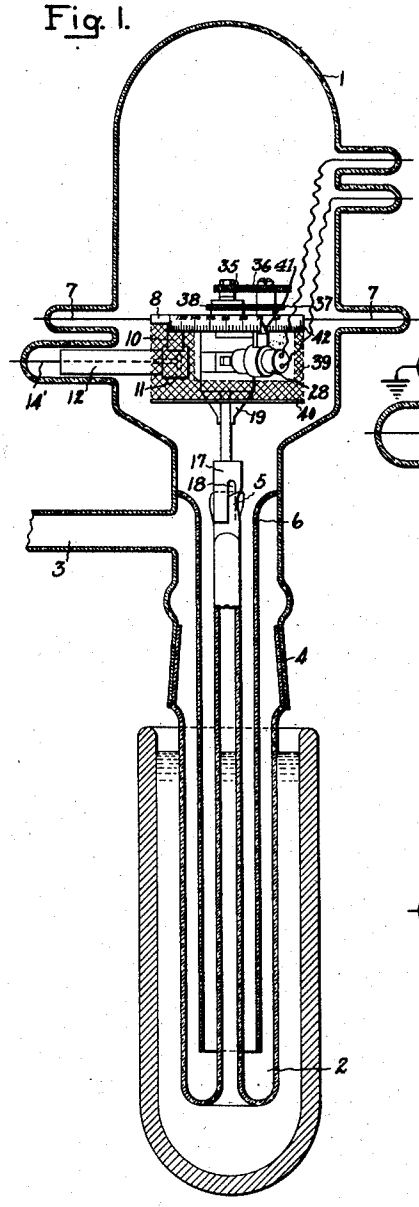


Fig. 2.

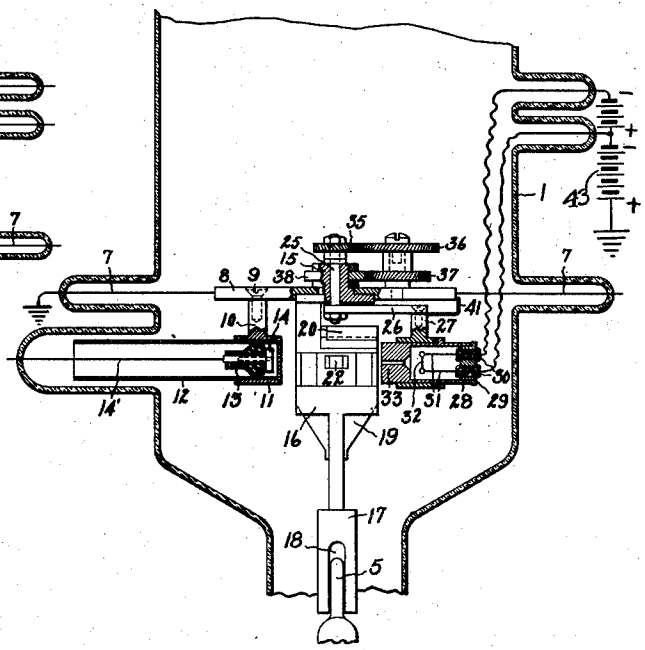
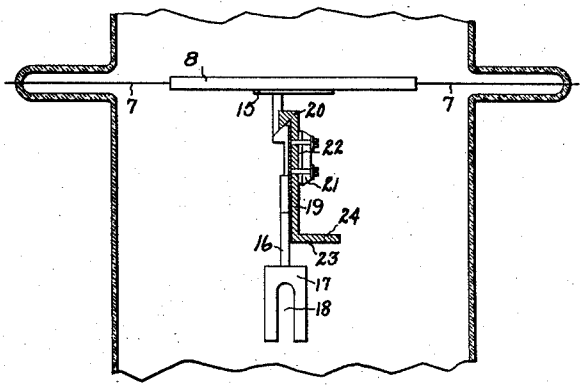


Fig. 3.



Inventor:
Emil Rupp,
by Charles C. Mullen
His Attorney.

Patented Aug. 21, 1934

1,971,277

UNITED STATES PATENT OFFICE

1,971,277

DEVICE FOR ANALYZING THE STRUCTURE OF MATTER

Emil Rupp, Frohnau, near Berlin, Germany, assignor to General Electric Company, a corporation of New York

Application June 24, 1932, Serial No. 619,132
In Germany June 26, 1931

8 Claims. (Cl. 250—1)

My invention relates to devices for analyzing the structure of matter, more particularly by means of electrons.

It is well known in the art to analyze the surface structure of matter by reflecting from this surface a beam of electrons giving rise to electron waves producing interference effects from which the structure of the surface can be calculated. In carrying out this method a beam of electrons strikes the surface to be analyzed and the amount of reflected electrons is measured by means of a collecting and measuring device in a plurality of positions, this device being arranged in its first position with an angle equal to the angle of incidence of the electron beam and being thereafter rotated about an axis extending in the reflecting surface. Interferences will occur if Bragg's equation

$$n.\lambda=2.d.\sin\phi$$

is fulfilled. In this equation, n is the order number,

$$\lambda=\sqrt{\frac{150}{\gamma}}$$

the wave length, d=the distance of the net planes, ϕ=the angle of diffraction. Reference is made in this connection to an article by W. L. Bragg entitled "The Structure of Some Crystals as Indicated by Their Diffraction of X-rays" appearing in the Proceedings Royal Society of London, 1913, volume 89A, pages 248 to 277 inclusive.

If only electrons below an acceleration voltage of 1000 volts are used, a very perfect high vacuum must be maintained within the testing bulb. Therefore hitherto a separate bulb had to be provided for every material to be tested.

It is an object of my invention to provide an analyzing device comprising rotatable parts and a replaceable support or holder for the material to be analyzed. It is a further object of my invention to provide a testing bulb with a stationary collecting device and a rotatable support for the test piece and a rotatable electron emissive means, which are rotated simultaneously in such manner that the angles of incidence and reflection of the electrons with respect to the test piece are kept constant.

According to my invention this is accomplished in the following manner: In a bulb evacuated to a high degree and permanently connected to an evacuating pump the electron collecting device is rigidly secured on a base, on which is also rotatably arranged a support for the test piece holder. An electron supply is further rotatably arranged on the base, the driving means for the electron supply being coupled with the driving means for the test piece holder in such manner that the angle between the electron supply and the surface of the test piece is always equal to the angle between the test piece and the collecting device.

In the drawing forming part of this application a preferred embodiment of my invention is illustrated diagrammatically by way of example.

In the drawing

Fig. 1 is a side elevation, partly in section.

Fig. 2 is an enlarged side elevation, partly in section, of the upper portion of the device,

Fig. 3 is a side elevation, partly in section, of the bulb and the test piece holder.

In the drawing 1 is the bulb containing the testing mechanism. The bulb is connected to the pump line 3 by means of a cooling vessel 2, which is formed by a cylindrical body of annular cross section, the outer surface of which is ground at 4 in order to form a vacuum-tight connection with the glass body 1. The inner portion of the cooling body is extended upwardly and its end is formed by a flat-pressed portion 5. 6 is a pipe-shaped extension of the glass body 1 projecting into the cooling vessel so that any vapors developed at the connection 4 must pass through the lowermost portion of the cooling vessel. In this manner the interior of the bulb 1 is kept free from grease vapors. The cooling vessel 2 is cooled in any suitable manner, for instance by means of a Dewar vessel (not shown) filled with liquid air. The bulb 1 may consist of any suitable kind of glass, preferably of glass having a high melting point or, if necessary, of quartz.

8 is a base secured within the bulb 1 by means of holders 7 sealed into the glass wall in a suitable manner. The electron collecting device is attached to the base 8 by means of a screw 9. It comprises a holder 10 carrying a perforated cap 11, preferably formed integral with the holder. The perforation of the cap is arranged in the direction of the electrons reflected by the test piece so that the cap acts as a diaphragm. The cap is grounded by its connection to the base 8. 12 is a pipe, one end of which fits into the cap 11. 14 is the collecting device proper arranged within the pipe 12 and supported by means of a quartz body 13. In the embodiment shown in the drawing, the collector is a simple plate which may, however, be replaced, if desired, by a Faraday cage. 14' is an electrical connection sealed into the glass bulb and elec-

trically connecting the collector 14 to a suitable instrument, for instance an electrometer (not shown). It should be noted that the collecting device is stationary within a grounded casing so that its capacity remains constant during the testing.

15 is a member rotatably connected to the base 8 to which a holder 16 is eccentrically secured. The holder forms a frame having a downwardly directed cylindrical extension 17 provided with a slot 18 fitting over the upper end portion 5 of the inner portion of the cooling vessel. By rotating the cooling vessel, therefore, the holder and the test piece can be rotated. This rotating means is of a very simple kind and will not impair the vacuum within the bulb. 19 is a test holder arranged on the holder 16, and comprising a hooked upper extension 20, by which it is suspended from the upper cross bar of the holder 16. Against lateral displacement the holder 19 is secured by a suitable guide. At the level of the collecting device, the test holder 19 is provided with an opening into which the element 22 to be tested is pressed from the rear by means of a plate 21 connected to the holder by means of screws. At its lower end the test holder is provided with an extension 23 having a threaded perforation 24. When the test holder is removed, the cooling vessel may be taken off and a rod (not shown) having at its upper end a thread corresponding to that of the perforation 24 introduced into the bulb 1 and screwed into the perforation 24 so that the test holder 19 may be lifted and removed.

25 is a shaft rotatably arranged in a bore of the member 15. 26 is an arm secured to the shaft 25 and carrying at its other end a holder 27 for the electron supply. The lower portion of holder 27 comprises a cylindrical tube portion surrounding a tube 28. The right hand closing plate of tube 28 is provided with perforations containing glass seals 30 through which pass the current leads and holders 31 for the electron emissive heating filament 32. At the other end, the tube 28 is closed by a diaphragm of suitable dimensions. The current leads 31 are sealed into the bulb 1.

Shaft 25 is connected by means of a gearing 35, 36, 37 to a gear wheel 38 secured to member 15. The gear wheels are preferably formed with inclined teeth. The ratio of the gearing is chosen in such manner that if the test holder is rotated by rotating the cooling vessel 2 about an angle, the electron supply is rotated about the double angle. In this manner the angles of incidence and reflection of the electron beam with respect to the test surface are equal in all positions of the holders. 41 is a pointer secured to the electron supply and cooperating with graduation 42 to indicate the angular position of the electron supply. In the arrangement described, the surface of the test piece always remains in coincidence with the axis of the device.

Back lash of the toothed wheels is avoided in a manner well known in the art. 39 is a wire network shielding the device against electrostatic charges occurring on the glass wall. 40 is a disc closing the lower portion of the network.

The operation of the device is as follows:—

Be it assumed that the element to be tested is contained within the bulb. The cooling vessel is taken off and the test holder removed from the bulb by means of a rod in the manner indicated above. The test piece to be analyzed is placed into the test holder and the latter introduced into the bulb by means of the rod which is unscrewed after the holder has been brought into its correct position. Now the cooling vessel is applied to the lower part of the bulb 1 and the bulb is evacuated. After evacuation, the heating filament 32 is energized and the interference of the electron beams reflected by the test piece are observed for different angles of incidence and reflections which are varied by rotating the cooling vessel.

With this apparatus, solid surfaces can be tested with electrons having velocities of from 10 to 1000 volts. Liquid tests can be analyzed also, provided that the vapor pressure of the test does not exert a disturbing influence. As shown on the drawing, this voltage may be applied between the source of electrons 32 and the accelerating electrode 33. This electrode preferably is at ground potential and the electron source is negative with respect to ground on account of the battery 43. Thus, the electrons, after leaving the electrode 33 with high velocity, strike the element 22 and are reflected onto the collecting device 14 within a region in which there is no accelerating field. The diaphragm and the test piece are at ground potential but if desired, suitable biasing potentials might be applied to them. The metal members of the apparatus may be made of nickel, copper, brass, tungsten or some other metal suitable for vacuum apparatus.

I wish it to be understood that I do not desire to be limited to the exact details of construction shown and described for obvious modifications will occur to a person skilled in the art.

I claim:—

1. A device for analyzing the structure of matter by means of electron radiation comprising an evacuated bulb, a support for the test piece and an electron emissive means, both rotatably mounted in said bulb, a stationary device in said bulb for collecting the electrons reflected by the test piece and means for simultaneously rotating said support and said emissive means so as to hold constant the angles of incidence and reflection of the electrons with respect to the test piece.

2. A device for analyzing the structure of matter by electron radiation comprising an evacuated bulb, a support for the test piece and an electron emissive means, both rotatably mounted in said bulb, a stationary device in said bulb for collecting the electrons reflected by the test piece and means for simultaneously rotating said support and said emissive means so as to rotate said emissive means through twice the angle through which said support is rotated.

3. A device for analyzing the structure of matter by electron radiation comprising an evacuated bulb, a support for the test piece and an electron emissive means, both rotatably mounted in said bulb, a stationary device in said bulb for collecting the electrons reflected by the test piece, a member rotatably connected to said bulb, a ground connection between said member and said bulb, means for rotating said support by rotation of said member, and a 2:1 gearing between said support and said emissive means.

4. A device for analyzing the structure of matter by electron radiation comprising an evacuated bulb, a support for the test piece and an electron emissive means, both rotatably mounted in said bulb, a stationary device in said bulb for collecting the electrons reflected by the test piece, a cooling vessel rotatably connected to said bulb, a ground connection between said cooling vessel and said bulb, means for rotating said

support by rotation of said vessel, and a 2:1 gearing between said support and said emissive means.

5. A device for analyzing the structure of matter by electron radiation comprising an evacuated bulb, a support for the test piece and an electron emissive means, both rotatably mounted in said bulb, a stationary device in said bulb for collecting the electrons reflected by the test piece, a cooling vessel removably and rotatably connected to said bulb, a ground connection between said cooling vessel and said bulb, means for rotating said support by rotation of said vessel, and a 2:1 gearing between said support and said emissive means.

6. Electrical testing apparatus comprising in combination, an evacuated envelope constituted of two portions which are movable with respect to one another, an element to be tested and an electrical device for testing said element, said device including stationary and movable portions, all mounted in the stationary portion of the envelope, said element and the movable portion of the testing device being movable with respect to one another, and a mechanical connection between the movable portion of the testing device and the movable portion of the envelope for moving the said movable portion of the testing device with respect to said element and with respect to the stationary portion of the envelope.

7. Electrical testing apparatus comprising in combination, an evacuated envelope constituted of two portions which are movable with respect to one another, an element to be tested and an electrical device for testing said element, said device including stationary and movable portions, all movably mounted in the stationary portion of the envelope, and a mechanical connection between said element and the movable portion of the envelope, also between the movable portion of the testing device and the movable portion of the envelope for moving said element and the movable portion of the testing device with respect to one another and with respect to the stationary portion of the envelope.

8. In combination, an evacuated cylindrical envelope constituted of two portions hermetically sealed together by a ground joint whereby one portion is adapted to rotate about the other portion at the joint, a device to be tested, and electrical apparatus for testing said device, said apparatus including stationary and movable portions, all mounted in the stationary portion of said envelope, the movable portion of said apparatus being movable with respect to said device, and a mechanical connection between the movable portion of the testing apparatus and the rotatable portion of the envelope whereby the rotation of said envelope portion causes a relative movement between said device and the movable portion of the testing apparatus.

EMIIL RUPP.