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METHOD OF CALIBRATING ROENTGENOGRAPHIC MACHINES

Filed March 18, 1940

Fig. 4.

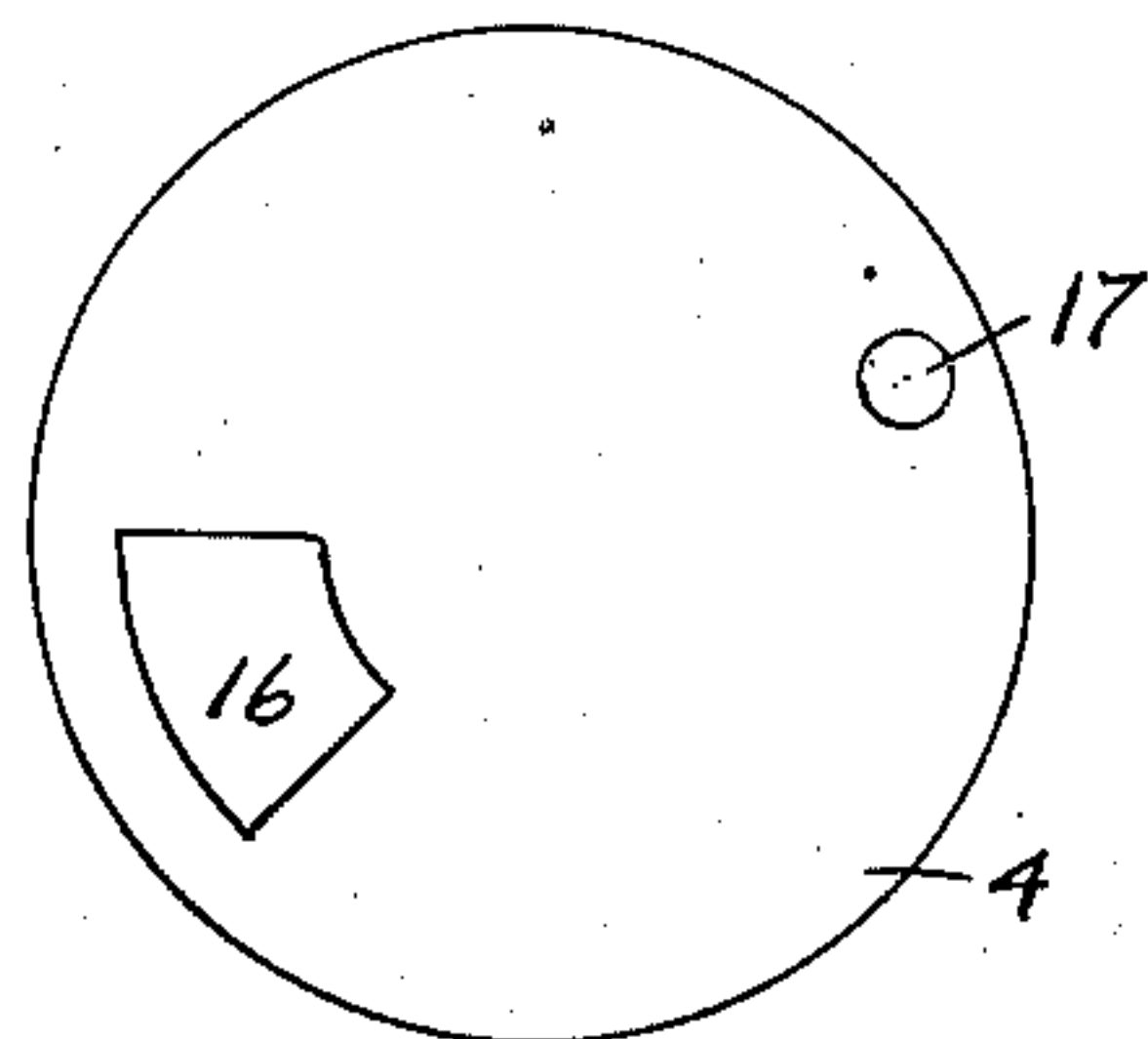


Fig. 5.

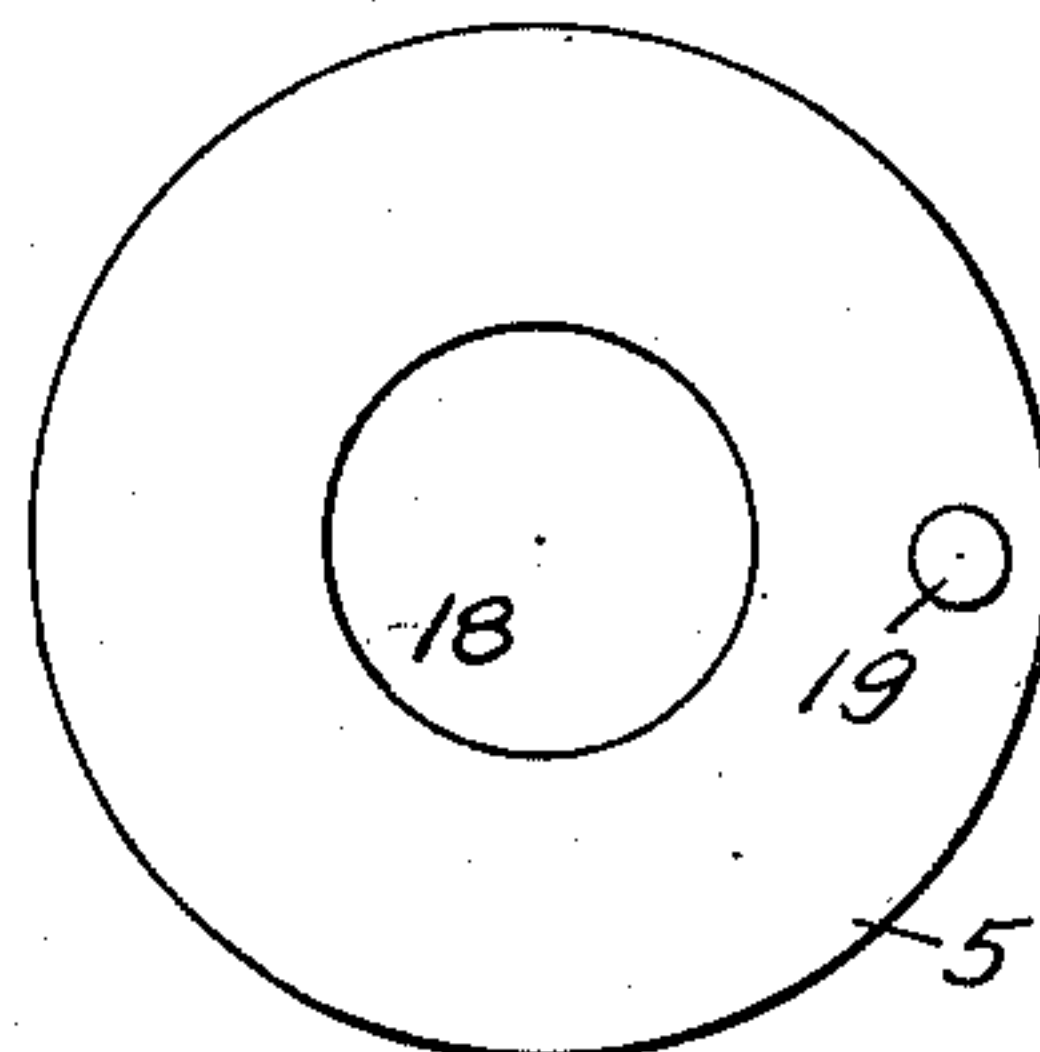


Fig. 1.

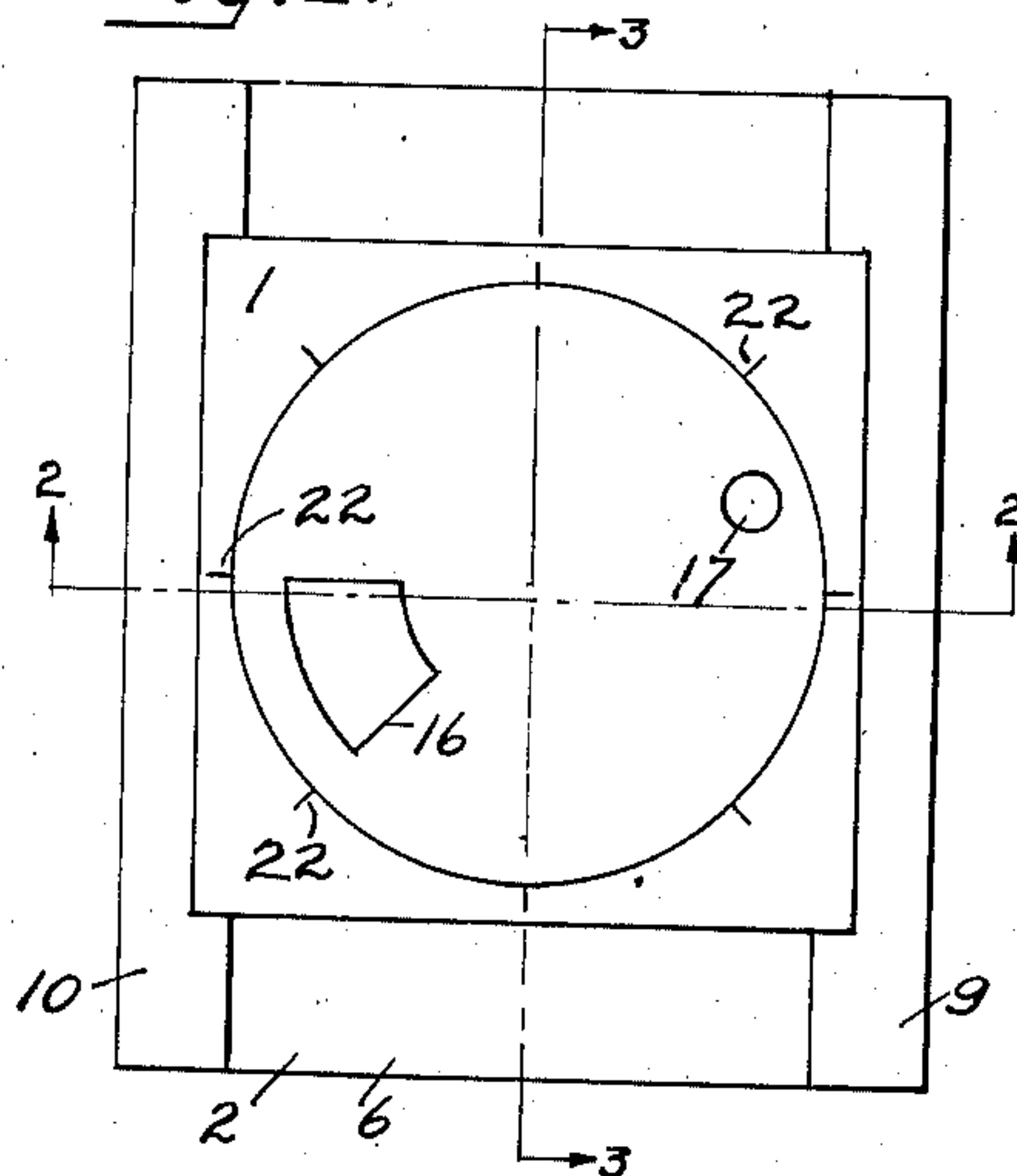


Fig. 3.

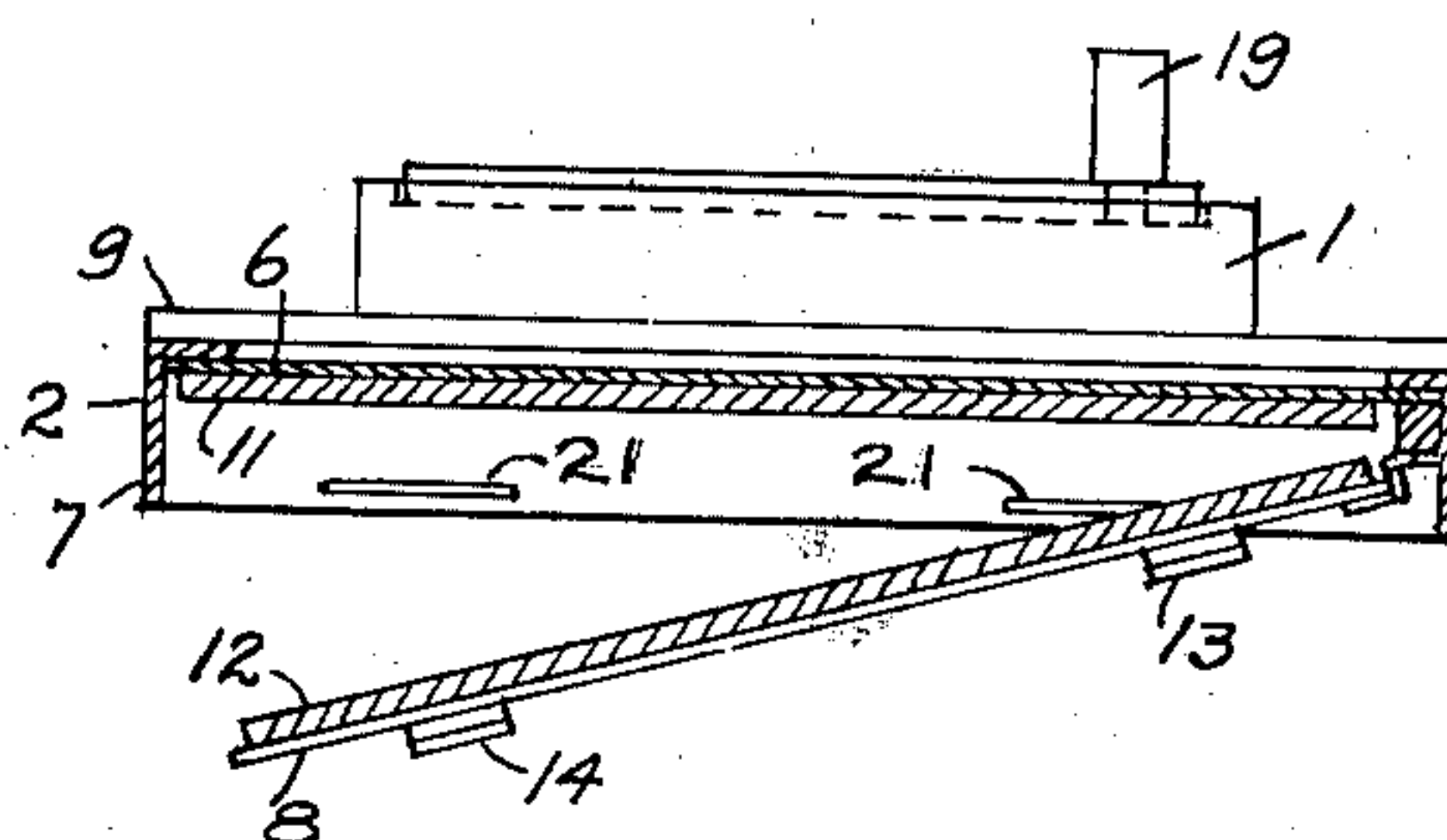


Fig. 6.

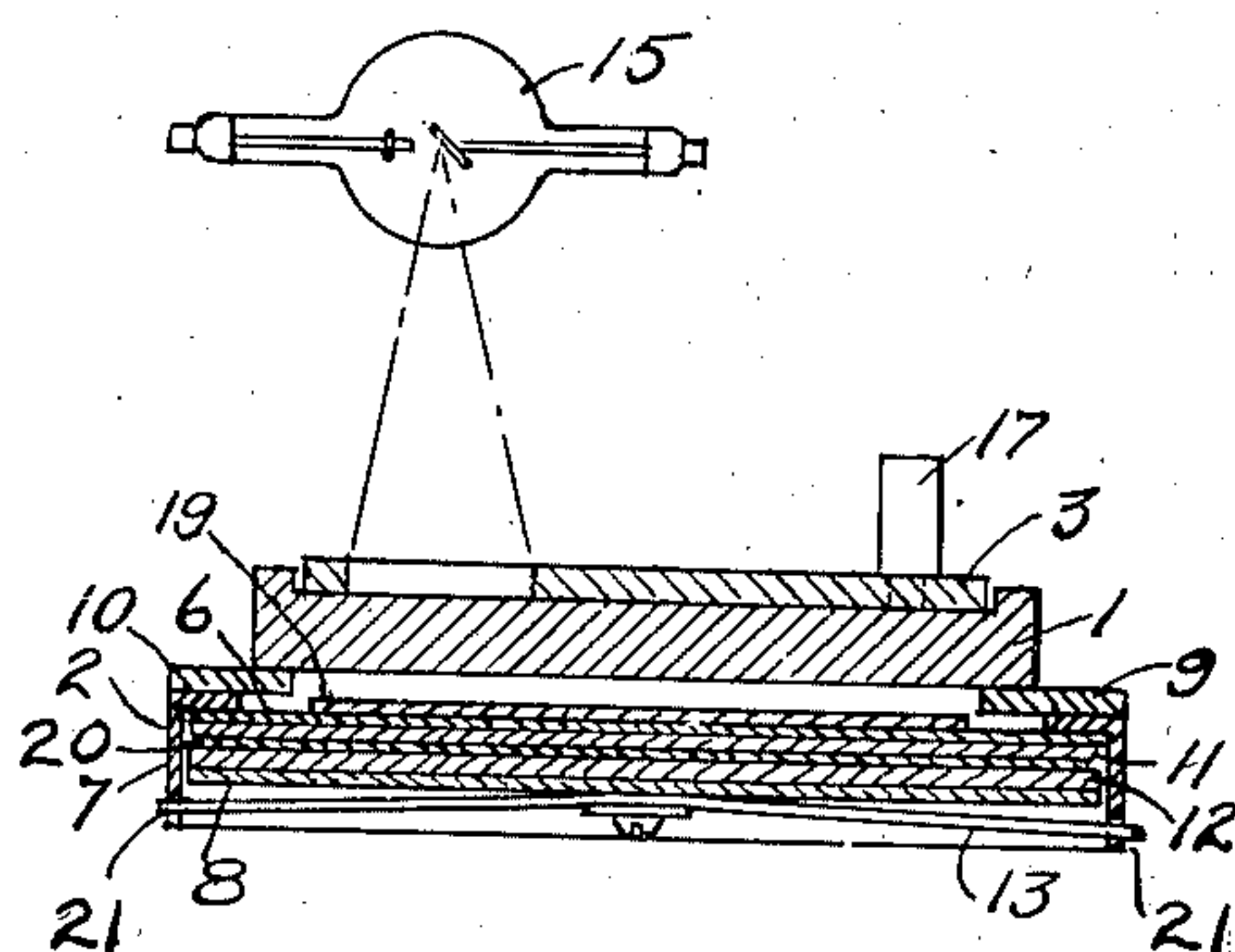
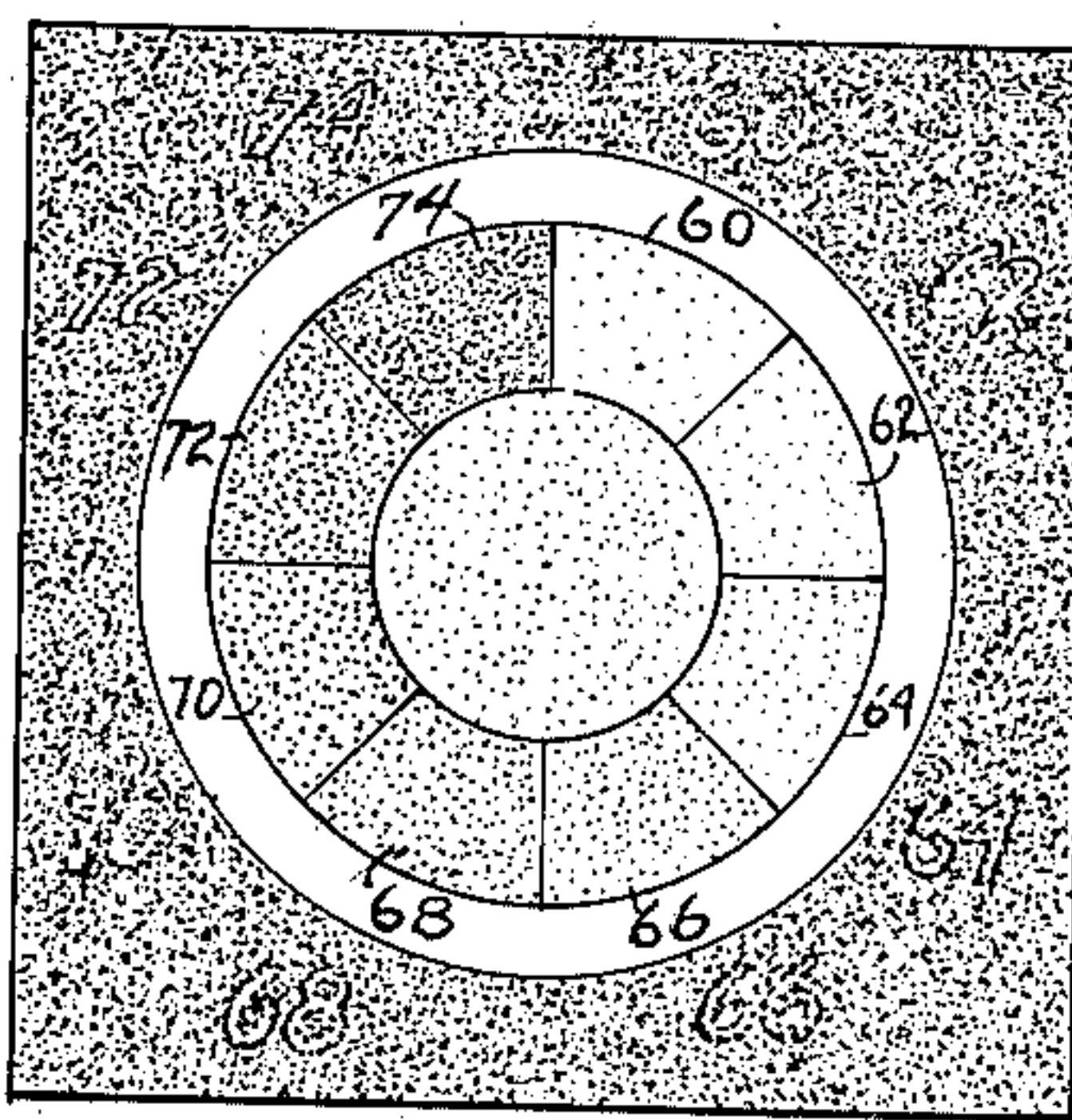


Fig. 2.

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METHOD OF CALIBRATING ROENTGENO-GRAPHIC MACHINES

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6 Claims. (Cl. 250—65)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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

This invention relates generally to the measurement of radiant energy, but more particularly to a method and means for calibrating X-ray machines by the comparison of the densities of photographic film areas which have been exposed to the tube of a machine used as a standard and to the tube of the machine being calibrated.

One object of the invention is to provide a calibrating device which is simple in construction and mode of operation, accurate in its indications and inexpensive to build.

Another object of the invention is to provide a calibration method and apparatus which can be used with all types of X-ray machines, including shockproof equipment, as no attachments to the machines are necessary.

Another object of the invention is to provide a calibrating device for the comparison of X-ray machines regardless of wave shape or peaks, and one which permits the transfer of radiographic technique from one machine to another with a minimum of factor changing.

Another object of the invention is to provide a calibrating device adapted to furnish in multiple a photographic record showing densities corresponding to a series of energizing voltages furnished from an X-ray machine used as a standard, and to which other machines may be compared.

In addition to the above objects relating to the use of the device for calibrating X-ray machines, it should also be noted that the calibration device may be used for the following purposes:

Determining the relative kilovoltage required to produce equal illumination of various intensifying screens;

Matching screens in a cassette to obtain those effecting equal intensification;

Checking saturation point of developing solutions;

Plotting the efficiency of one Roentgen-ray tube against another; and

Comparing the emulsion speeds of various types and makes of films.

With these and other objects in view, this invention consists in certain novel details of construction combination and arrangement of parts which will be more fully described and claimed.

Referring more particularly to the accompanying drawing in which corresponding parts are indicated by similar reference characters—

Fig. 1 is a top plan view of the calibrating device;

Fig. 2 is a sectionized elevation taken on the line 2—2 of Fig. 1, showing the operative position of the device with respect to an X-ray tube and the relative location and arrangement of the mask and film for obtaining desired exposures;

Fig. 3 is a sectionized elevation taken on the line 3—3 of Fig. 1, showing the lid of the plate holder in open position;

Fig. 4 is a plane view of a mask used in obtaining a series of equally timed exposures at various current strengths from the tube of an X-ray machine used as a standard;

Fig. 5 is a plan view of a mask used in obtaining a comparative exposure from the tube of a machine being calibrated.

Fig. 6 is a plan view of a film used for calibrating, which shows exposed segments with the corresponding voltages used, and also an exposed central portion.

Briefly stated, the calibration device comprises a mask support or block 1 which is mounted upon a cassette or plate holder 2.

The mask support 1 consists of an aluminum block provided with an upper circular countersunk surface 3 adapted for the reception of either of two circularly-shaped lead diaphragms or masks designated by the numerals 4 and 5.

The plate holder 2 upon which the mask support 1 is mounted comprises a boxlike structure having a top 6, transparent to X-rays, said top being attached at its edges to a rectangular frame 7 which forms the side walls of the plate holder as well as a support for a bottom or lid 8.

The rectangular frame 7 is surmounted by parallel supporting strips 9 and 10, to which the mask support 1 is attached. These strips separate the mask support or block 1 a slight distance from the plate holder 2, and thus provide a space between the block 1 and the upper surface of the top 6, for the insertion of one or more filters 19 as shown in Fig. 2. These filters are formed of rectangular sheets of copper of sufficient thickness (about 0.5 mm.) to effect the desired occlusion of X-rays.

On the inner surface of the top 6 and of the lid 8 of the plate holder 2 are attached intensifying screens 11 and 12, between which is placed a photographic film 20 (Fig. 2). When the lid is closed upon the film it is clamped in this position by resilient clamping members 13 and 14, which are pivotally attached to the lid and which are adapted to engage slots 21 formed adjacent the edges of the rectangular frame 7. The plate

holder 2, which is shown in connection with mask support 1, is of the type usually used with X-ray apparatus and is provided with calcium tungstate intensifying screens between which the film is retained.

In the operation of the device the calibration block is placed beneath the X-ray tube of a machine which is used as a standard, so that the film will be a predetermined distance from the focal point of the tube 15, as shown in Fig. 2. The mask 4, shown in Fig. 4, which is provided with an open segment 16 extending through an arc of 45°, is then placed within the circular countersunk portion 3 of the surface of the mask block 1, so that the open segment lies between adjacent radially marked lines 22 which are spaced at 45° intervals around the circumference of the countersunk portion. The film is then exposed to the radiation of the tube for a predetermined period, and at a fixed voltage. After the completion of this exposure the mask is then rotated through a 45° angle and the film again exposed to the radiation of the X-ray tube for the same period of time but at another voltage. Exposures are thus made in like manner until the mask is entirely rotated through 360°, thus producing an exposed annular strip made up of eight segmental exposures which show film densities corresponding to the voltages used in the energization of the tube, as shown in Fig. 6.

The densities as illustrated in Fig. 6 were obtained within a kilovoltage range of from 60 to 74 kv. (peak) through an added filter of 0.5 mm. of copper with the following factors: Distance 60"; milliamperes-seconds 60.

After thus exposing the segments around the entire periphery of the countersunk surface of the mask support 1, the segmental mask 4 is removed from the block 1 and the annular mask 5 then inserted within the countersunk opening 3. The calibration device is then removed to the machine to be tested, and the central portion of the film exposed through the circular opening 18, at a distance of 60" and for 60 milliamperes-seconds as in the former case. From a comparison of the densities of the exposed portion of the film, it will then be seen that the unknown peak is about 66 kv., since the segmental exposed portion of the film which is nearest in density to the central portion is the one which was exposed at 66 kv., as shown in Fig. 6. It will thus be seen that in the use of the device one portion of the film is used for a series of exposures on a machine whose calibration is known, and which may be graduated in either kilovolts or simply marked by buttons. (It will be noted that the accuracy of determination of the calibration of the "known" machine is not necessarily vital. The final result will be in terms of this machine and can be used by exact duplication of roentgenographic work, regardless of the actual kilovoltage of either machine.) Three exposures of the type mentioned above are enough to chart the average machine for any milliamperage. Experiments have shown that the following technique renders good results:

	Voltage range (2 kv. (peak) steps)	Distance inches	Ma- sec.	Additional filtration
Chart No. 1.	30 to 44 kv. (peak)	20	100	None.
Chart No. 2.	44 to 58 kv. (peak)	30	30	Do.
Chart No. 3.	60 to 74 kv. (peak)	60	60	0.5 mm. Cu.
Chart No. 4.	76 to 90 kv. (peak)	60	30	1.0 mm. Cu.

For purposes of illustration, it will be assumed

that four segmental film charts are made in accordance with the technique set forth in the above table. After exposure of the central portion of such of these film charts on the uncalibrated machine under like conditions of time and distance, the densities of the central portion of each of the charts is compared with the respective surrounding segments, as illustrated in Fig. 6.

Assuming, for example, the central circular portions of the film charts match in density the corresponding surrounding segments as follows:

Chart No. 1, central portion matches segment exposed at 40 kv.;

Chart No. 2, central portion matches segment exposed at 48 kv.;

Chart No. 3, central portion matches segment exposed at 66 kv. (see Fig. 6); and

Chart No. 4, central portion matches segment exposed at 84 kv.;

then these kv. points or markings, 44, 48, 66 and 84, can be marked as calibration points on the machine being calibrated, and intermediate graduations can be inserted by interpolation.

To promote accuracy in the comparison of exposure densities, it has been found by experiment that cassettes provided with intensifying screens should be used. The use of these screens render a more definite contrast scale, particularly at higher ranges. If the standard machine is not always near at hand, several films can be exposed, removed and replaced again in the plate holder or cassette when needed.

The filtration used depends upon the densities of the film required so that proper contrast will be seen between the various exposed areas. It was found by experiment that a mask holder formed of an aluminum block having a thickness of approximately 2 cm. could be used alone with lower voltages, such as from 30 to 58 kv. (peak). A filter comprising a sheet of copper having a thickness of 0.5 mm. was added to the aluminum block for voltages from 60 to 74 kv. (peak).

Better contrast was obtained in the the voltage range of 76 to 90 kv. (peak), when a copper filter having a thickness of 1 mm. was placed under the aluminum block. The kilovoltage increment between steps was taken as 2 kv. (peak). Since the block has eight comparison divisions of 45° each, this allows a range of 16 kv. (peak) per film. Interpolation between two of the voltage settings proves satisfactory. Settings can be obtained for use with the high milliamperage or "flash" technique. Comparative film can be made up, slightly varying the exposure to permit the exact milliamperage and time used for chest technique.

In this method of calibration by comparison as set forth herein, known and unknown exposures are made upon contiguous areas of the same film. This eliminates differences in dark room technique and variations in densities which might be caused by difference in film. Agitation of the film during development is desirable, but it is found in practice that failure to do this does not affect the results seriously. Reader error, which is the personal equation in the reading of the settings and the operation of the equipment, is less than with the sphere-gap method. The calibration block as described above can also be used to define eight densities on the known machine and eight on the unknown machine, on two halves of the same film. This gives a greater range than the first method described, but the densities are not as easily com-

pared and the agitation of the film during development is much more important.

Although the above description relates primarily to the comparison of the roentgenographic performance of two Roentgen-ray machines, the method and device described are not limited to this specific type of apparatus, but may be used for comparing the relative intensities of any two emission sources of radiant energy which are capable of producing a photoelectric effect on energized film.

It is obvious that many changes may be made in the method and construction herein set forth without in any way departing from the material principles of the invention. It is not, therefore, desired to confine the invention to the exact form herein shown and described, but it is desired to include all forms which come within the scope of the appended claims.

Having described my invention, what I claim as new and wish to secure by Letters Patent is:

1. An apparatus for calibrating roentgenographic machines by comparison of their photographic effects, comprising a cassette adapted to retain a photographic film, exposing means comprising a mask support mounted above said cassette and spaced therefrom to form a filter support, said mask support being formed with an upper circularly countersunk surface, a circular disc-shaped mask formed with an eccentrically spaced exposure aperture, said mask being adapted to be rotated within said countersunk surface to form an annular group of sectors exposed to X-rays for equal time periods at different degrees of energization, a circular disc-shaped mask formed with a centrally located exposure aperture, said latter disc being adapted to be mounted within said countersunk surface to form a centrally located area adjacent the sectors within said annular group adapted to be exposed to another source of X-rays at a period equal to the exposure period of said annular group.

2. A method for calibrating the voltage values of Roentgen-ray machines, consisting in producing a series of photographic film exposures of increasing density, at corresponding increasing voltage strengths, and under similar exposure conditions of time and distance, with a Roentgen-ray machine used as a standard, and matching photographic film exposures made under like conditions with a machine being calibrated to obtain the corresponding voltages effecting like photographic densities.

3. An apparatus for determining voltage calibrations for roentgenographic machines by comparison of their photographic densities with those of a machine having known values, under like conditions of distance and exposure periods, comprising a cassette for retaining a photographic film, a mask block mounted above said cassette and formed with an upper circular countersunk surface, a circular disc-shaped mask formed with an eccentrically spaced exposure aperture rotatably mounted within said countersunk surface and adapted to form an annularly arranged group of equally spaced exposures at equal distance from said film, and corresponding respectively to equally stepped voltage values of the known machine, a circular disc-shaped mask formed with a centrally located exposure aperture adapted to replace said former disc within said countersunk surface and occlude said annularly exposed portions on said film and form a central exposed portion under like conditions

of time and distance to determine corresponding voltages for like densities on the machine being calibrated.

4. An apparatus for calibrating roentgenographic machines, by comparison of their photographic effects under conditions of equal exposure periods with increasing degrees of energization, comprising a cassette adapted to retain a photographic film, exposing means comprising a mask support mounted above said cassette, and formed with an upper circular countersunk surface, a circular disc-shaped mask formed with an eccentrically spaced exposure aperture, adapted to be rotatably mounted within said countersunk surface to form an annularly arranged group of exposed areas of increasing photographic densities upon said film when the same is exposed to X-rays for equal periods of time at increasing degrees of intensity, and a circular disc-shaped mask formed with a centrally located exposure aperture, said latter disc being adapted to be mounted within said countersunk surface to form a centrally located exposed area adjacent to and surrounded by said annular group of exposures of increasing densities.

5. An apparatus for calibrating roentgenographic machines with respect to different degrees of energization by comparison of their photographic effects with equally timed exposures, comprising a cassette adapted to retain a photographic film, exposing means comprising a mask support mounted above said cassette and spaced therefrom to form a filter support, said mask support being formed with an upper circular countersunk surface, a circular disc-shaped mask formed with an eccentrically spaced exposure aperture adapted to be rotatably mounted within said countersunk surface to form an annularly arranged group of substantially voussoir shaped exposed areas of increasing photographic densities upon said film when the same is exposed to X-rays for equal periods at varying degrees of intensity, and a circular disc-shaped mask formed with a centrally located exposure aperture, said latter disc being adapted to be mounted within said countersunk surface to form a centrally located exposed area adjacent to and surrounded by said annular group of exposures of increasing densities.

6. An apparatus for calibrating roentgenographic machines, by comparison of their photographic effects under conditions of equal exposure periods with various degrees of energization, comprising a cassette adapted to retain a photographic film exposing means comprising a mask support mounted above said cassette and formed with an upper circular countersunk surface, a circular disc-shaped mask formed with an eccentrically spaced exposure aperture, rotatably mounted within said countersunk surface and adapted to form an annularly arranged group of exposed areas of varying photographic densities upon said film when the same is exposed for equal periods of time to X-rays having different penetrating characteristics, and a circular disc-shaped mask formed with a centrally located exposure aperture, said latter disc being adapted to replace the former disc within said countersunk surface to form a centrally located exposure area adapted to be exposed for a time period equal to that of an eccentric area and at a predetermined degree of intensity for comparison of its photographic density with those of the eccentric areas.

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