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F. A. SHERRER ET AL

SLIDE RULE

Filed April 11, 1922

Fig. 1,

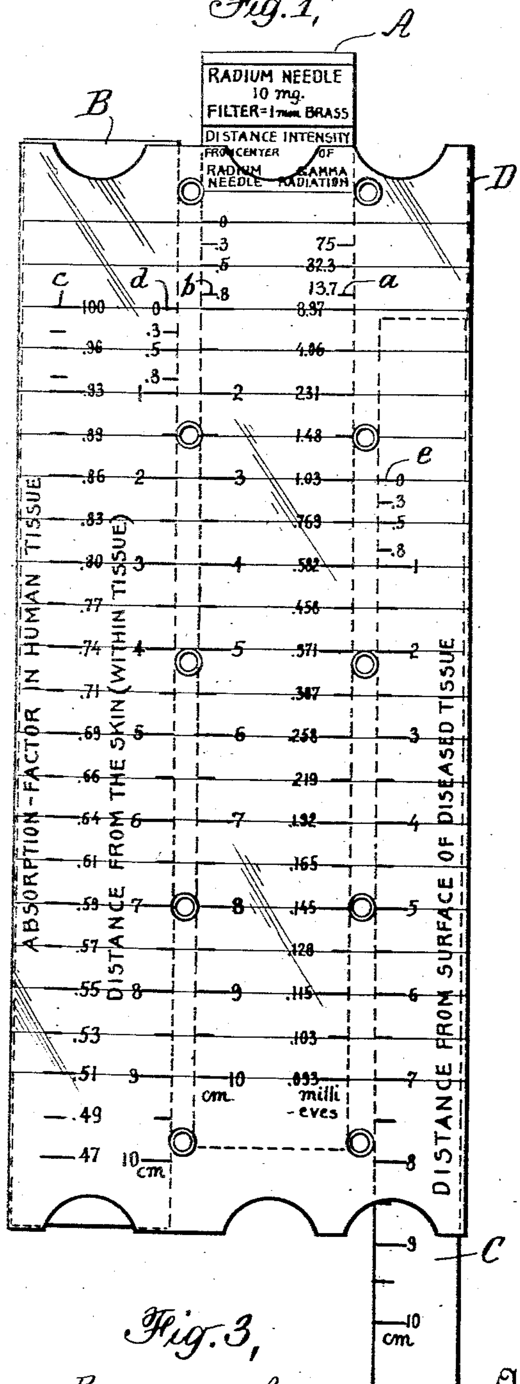


Fig. 2.

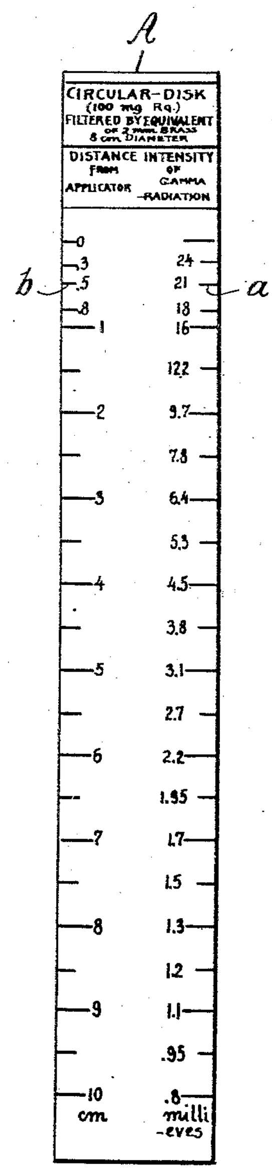
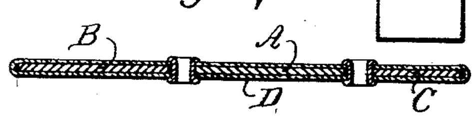


Fig. 3,



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UNITED STATES PATENT OFFICE.

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SLIDE RULE.

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This invention relates to adjustable tabular charts and involves the provision of an adjustable tabular chart of an improved construction which may be employed for various uses.

The special object of the invention is to provide a device for use in estimating the intensity of gamma ray radiations at different distances in selected directions from a source under such conditions that the radiations traverse media having different powers of absorbing them.

The invention is directed to the provision of an instrument which will assist the surgeon or operator, in the treatment of diseased tissues by means of radio-active material, to calculate rapidly and approximately the intensity of the gamma ray radiation at any distance within the tissues being treated when the applicator is placed at varying distances above the surface of the skin and also when applicators of different strengths and different configuration are employed. Another purpose of the invention is to enable the operator to make such estimates rapidly and conveniently with applicators in conjunction with filters of different materials and different thicknesses.

Conversely stated, the special purpose of the invention is to enable the operator, in the treatment of tissues with gamma rays to determine quickly the distance above the skin at which a given applicator of known power should be placed in order to secure a pre-determined intensity of radiation at any depth within the sound or diseased tissue, whether the diseased tissue is located at or below the surface of the skin, and in the latter instance, independently of the distance of the diseased tissue below the surface of the skin.

In the treatment of diseased tissues by means of gamma rays from radio-active material, such as a radium salt or radium emanation, in closed tubes or applicators, the amount of exposure or dosage which the sound tissue will stand without causing erythema and also the amount of exposure to which the diseased tissue should be subjected to get the best results must be carefully taken into account. This exposure or dosage is measured in terms of units of intensity of gamma ray radiation multiplied by the time of exposure. It is, therefore, necessary that the surgeon or operator in the treatment of tissues with such radiations, should be able to estimate the intensity of gamma ray radiation from any given applicator of any given radium content and with any given filter or container and at varying distances from the tissue. Moreover, he must be able to calculate or estimate this intensity at any given depth within either the sound or the diseased tissue, with varying distance of the diseased tissue below the surface of the skin.

It will be readily understood from the foregoing statements that a number of factors which must be taken into account in estimating the dosage or amount of exposure is unusually large and the calculation is correspondingly complicated. These complications introduce possible sources of error, which, unless carefully guarded against, introduce uncertainties in the treatment of tissues by this means which constitue one of the main objections to the method in actual practice.

The present invention affords means for readily overcoming these uncertainties and for making the method more amenable to control.

As illustrative of the number of factors which must be taken into account and of the intricate type of calculations involved in practical radio-therapy, reference may be made to an example. The applicator may consist of a needle containing 10 mg. of radium in the form of a salt contained in a 1 mm. brass container or filter, the radiations may traverse in succession 1 cm. of air and 1 cm. of sound tissue before reaching the diseased tissue, and it may be desired to determine the intensity at the surface of the skin and at ½ cm. within the sound tissue and also at 1 cm. within the diseased tissue. The necessary calculations of the intensity at the different points mentioned would ordinarily be made by first computing the transmitted intensity in accordance with the exponential absorption law for the first medium, then correcting this value in accordance with the inverse square law and then repeating these operations for each medium traversed. The method of correcting or computing the intensities in accordance with the inverse square law is well known and need not be discussed here. The calculation of transmitted intensity in accordance with the law of absorption is more complicated and not so well known to those skilled in radiotherapy. Ordinarily this computation is made by means of the formula,

$$I = I_0 10^{-\epsilon d}$$

in which I is the intensity of transmitted radiation, I_0 is the intensity of radiation entering medium, d is the total thickness in cm., ϵ is Bunsen's absorption coefficient and depends only upon the nature of the medium.

It will be observed that by this method a separate calculation of complicated character is required for each selected distance in each separate medium and therefore that numerous values must be held in mind or recorded. The calculation of the transmitted intensity by means of the formula

$$I = I_0 10^{-\epsilon d}$$

for any given distance within any selected medium may be carried out by means of an engineer's logarithmic slide-rule, but this operation, also, is a complicated one and must be repeated and the results carried in the memory or separately recorded as many times as there are media traversed by the radiation. This method of calculation, as previously stated, is objectionable in actual practice not only because of the well-known fact that men in the medical profession, as a rule, are not familiar with the use of the engineer's logarithmic slide-rule, but also because of the plurality of separate calculations involved and the necessity of relying upon the memory or upon a plurality of written notations. Another source of uncertainty and error in making the calculations according to this method is the confusion in the published literature with regard to the units in which various quantities in the formula are to be expressed and further confusion as to the names of the different quantities themselves.

All the foregoing uncertainties and sources of error in calculating are largely or completely overcome by means of the present invention, the various novel features and advantages of which will be more clearly understood from the following description of the preferred embodiment of my invention.

In the accompanying drawings, Fig. 1 is a plan of the indicating device or tabular chart illustrating or embodying one form of our invention, and Fig. 2 is a view of one of the slides, and Fig. 3 is a transverse cross-section of the instrument.

A is a slide graduated in units of distance on the left hand side thereof and graduated in corresponding intensities of gamma ray radiations in ordinary air on the right hand side thereof. Slide A also carries appropriate lettering at the top to indicate that it is to be used to assist in calculating the intensities obtained with a radium needle containing 10 mg. of radium enclosed in a 1 mm. brass filter tube or container

The intensity scale a on the right hand side of slide A indicating intensities of gamma ray radiation is identified by appropriate lettering immediately above the zero mark. The distance scale b on the left side of slide A is identified by appropriate lettering in a similar position with respect to the zero mark of the distance scale.

B is a slide carrying two graduated scales c and d. The identifying numerals on scale d indicate the distance in centimeters from the skin (within the tissue) and those on scale c indicate the absorption factor for human tissue expressed in ratios of the intensity of radiation in air to the corresponding intensity in normal human tissue, after traversing the corresponding distances.

C in the particular embodiment illustrated in the drawing is a slide carrying a single graduated scale e in which the numbers identifying the graduations are expressed in cm.

The slide B in the example illustrated corresponds to the second medium exclusive of the filter traversed by the radiation and the two scales carried by this slide B in the drawing may be identified, respectively, by a legend reading "absorption factor in human tissue" alongside the graduated scale c on the left of the slide and by a legend reading "distance from the skin (within tissue)" alongside the scale d on the right of the slide B.

Scale C corresponds to the third medium exclusive of the filter traversed by the radiation and the single scale e carried by this slide C is similarly identified by the legend "distance from surface of diseased tissue."

D in the drawing is a mounting or support provided with three guides or tracks, E, F, G, for the three scales A, B, C, respectively, and adapted to hold the scales in proper position relative to each other and adapted also to permit the slides to be moved relatively to each other in such manner that the zero marking of any distance scale may be brought into correspondence with any distance marking on either of the remaining scales.

In the device illustrated in the drawing the mounting or support D consists of a flattened tube of transparent celluloid and the slides are strips of white celluloid with the graduation marks and identifying numerals and lettering in black ink. The guides or tracks E, F, and G are formed by means of two rows of rivets or eyelets f.

In operating the indicating device or gamma ray tabular chart illustrated in the drawing, the slide B is ordinarily kept in a fixed position and the other two slides A, and C are moved relative to slide B and also relative to each other. The zero mark of the distance scale *e* on the slide C is to be set opposite the number on the scale *d* on the right hand side of slide B which corresponds to the distance of the upper surface of the diseased tissue from the surface of the skin. The slide A, or applicator slide, is raised until the number on the left hand side of the scale corresponding to the distance of the applicator above the surface of the skin is opposite the zero mark of the distance scale *d* on slide B.

After setting the slides as indicated above, the intensity of radiation on or in the tissue is read off from the numbers identifying the markings on scale *a* which lie opposite any selected number on scale *d* on the right of slide B. The absorption factors identifying the graduations on scale *c* on the left hand side of slide B are to be applied to the corresponding intensity numbers identifying the graduations of scale *a* on the right hand side of slide A after the slides A and C have been set to correspond to the distances of the applicator from the surface of the skin and to the distance of the surface of the diseased tissue below the skin, respectively, as described above.

The operation of the indicating device may be further illustrated by means of a specific example as follows:

If a radium needle applicator containing 10 mg. of radium with a 1 mm. brass filter (corresponding to the slide A illustrated in the drawing) is placed 1 cm. above the surface of the skin and if further the surface of the diseased tissue is 2 cm. below the surface of the skin the procedure in operating the device and taking the readings would be as follows:

Set numeral 1 of the left hand scale *b* of the slide A (marked "Radium Needle 10 mg. filter; 1 mm. Brass") opposite the zero mark of the right hand scale *d* of slide B. Set the zero mark of the scale *e* on slide C opposite the numeral 2 of the right hand scale *d* of slide B. Having thus set the slides for the given set of conditions, the intensities in milli-eves at various points upon and within the sound and diseased tissue are read off as follows:

At the surface of the skin or upper surface of the sound tissue, the intensity of radiation is read off from the number on the graduated scale *a* which lies opposite the zero mark of the graduated scale *d* on the right of the slide B. and is seen to be 8.97. At 1 cm. below the surface of the skin and within the sound tissue, the intensity is read off from the number on the scale *a* which lies opposite the numeral 1 of the scale *d* and from the corresponding absorption factor on scale *c* and is seen to be 2.3 multiplied by .93=2.14. At the surface of the diseased tissue, the intensity is read off from the numbers on scales *a* and *c* lying opposite the zero mark on scale *e* on the slide C and is seen to be 1.03 multiplied by .86=0.89 approximately. At 2 cm. below the surface of the diseased tissue and within the same, the intensity is read off from the numbers on scales *a* and *c* lying opposite the numeral 2 of the graduated scale *e* on the slide C and is seen to be .371 multiplied by .74=0.27 approximately.

It will be understood that the invention is not limited to the particular arrangement of slides or to the particular graduation scales and identifying numbers shown in the drawing, but various other arrangements of slides and different graduated scales and identification numbers may be used without departing from the scope of the invention. These variations and modifications will be understood by one skilled in the art of constructing indicating devices of the general type to which the invention belongs. Thus the values of the graduations on the different graduated scales may be expressed in units other than those illustrated. Also other graduated scales may be added to certain of the slides to correspond to different types of tissue or media. Thus a graduation scale of absorption factors on the right hand side of the slide C may be added expressing these absorption factors as ratios of the transmitted intensity in the diseased tissue to the corresponding transmitted intensities in the sound tissue at corresponding distances. In this instance, the absorption factors for the diseased tissue would be applied to the intensity values obtained as explained in the example described above. Also, the absorption factors may be expressed in an inverse ratio in which instance they would have to be placed on a different slide from the one illustrated in the drawing.

We claim:

1. An adjustable tabular chart comprising a slide having a scale and also a series of indicated values bearing a definite fixed relation with respect to the indications on the scale, a second scale with respect to which the first scale is relatively movable, a second series of indicated values bearing a predetermined fixed relation with respect to the indications on the second scale, said scales and series of values cooperating so that when the first scale is set to the second scale a result may be obtained by using the two values identified by a chosen point on the second scale.

2. An adjustable tabular chart comprising a slide having a scale and also a series of indicated values bearing a predetermined fixed relation with respect to the indications on the scale, a second scale with respect to which the first scale is relatively movable,

a second series of indicated values bearing a predetermined fixed relation with respect to the indications on the second scale, and an additional slide having a scale thereon, all of said scales and series of values cooperating so that when the scale of the first named slide is set to the second scale a result may be obtained by using the two values identified by a chosen point on the second scale and so that when said additional slide is set to the second scale a result may be obtained by using the two values identified by a chosen point on the scale of said additional slide.

3. An adjustable tabular chart comprising a first strip carrying a distance scale and carrying also a scale of corresponding intensity values, a second strip carrying a like distance scale and a scale of corresponding absorption factor ratios and a third strip carrying a distance scale, the first and third strips being adjustable with respect to each other and also with respect to the second strip, the said scales being adapted to cooperate with each other in such manner that after setting the distance scale on the first strip to the distance scale on the second strip and after also setting the distance scale on the third strip to the distance scale on the second strip, a result on the scale of intensity values on the first strip may be obtained from the scale of absorption factor ratios on the second strip and also so that a result may be obtained on the scale of intensity values on the first strip from the distance scale on the third strip and the scale of absorption factor ratios on the second strip.

In testimony whereof we affix our signatures.

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VICTOR FRANCIS HESS.