

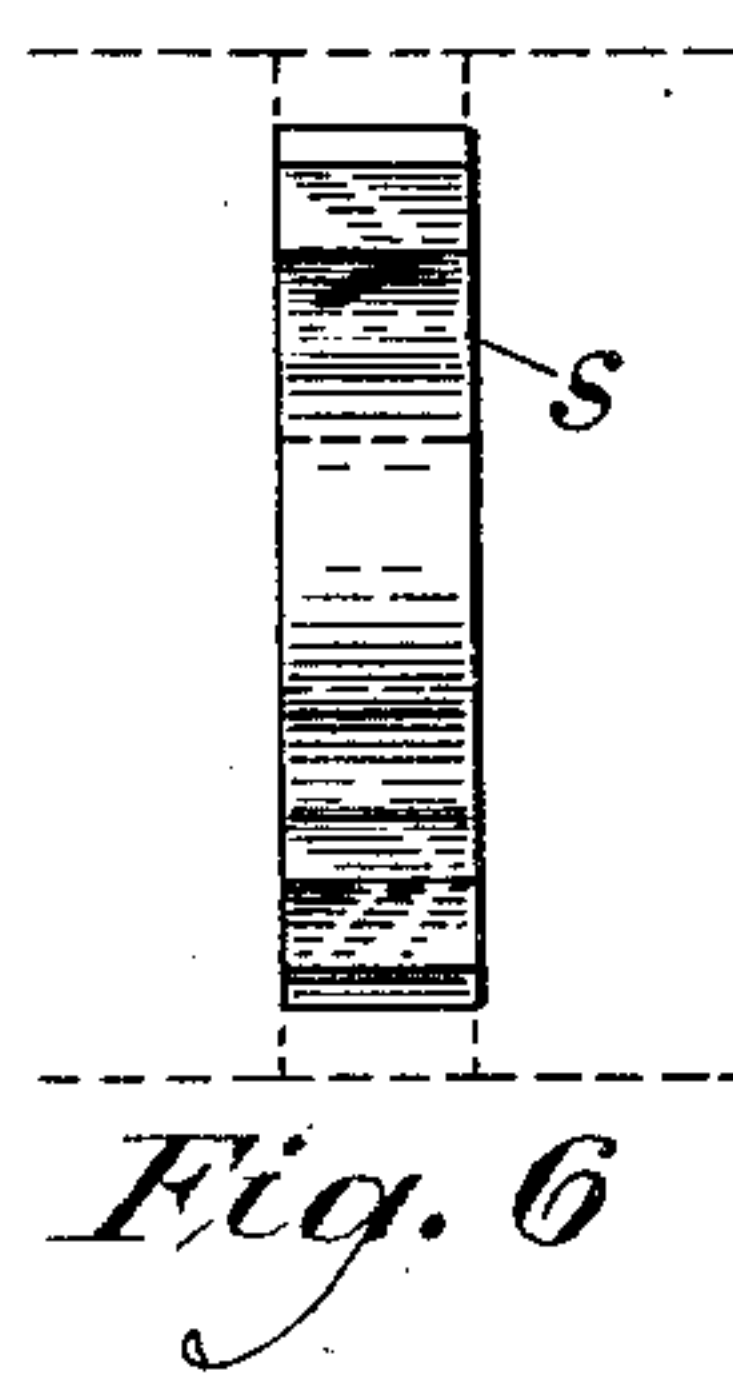
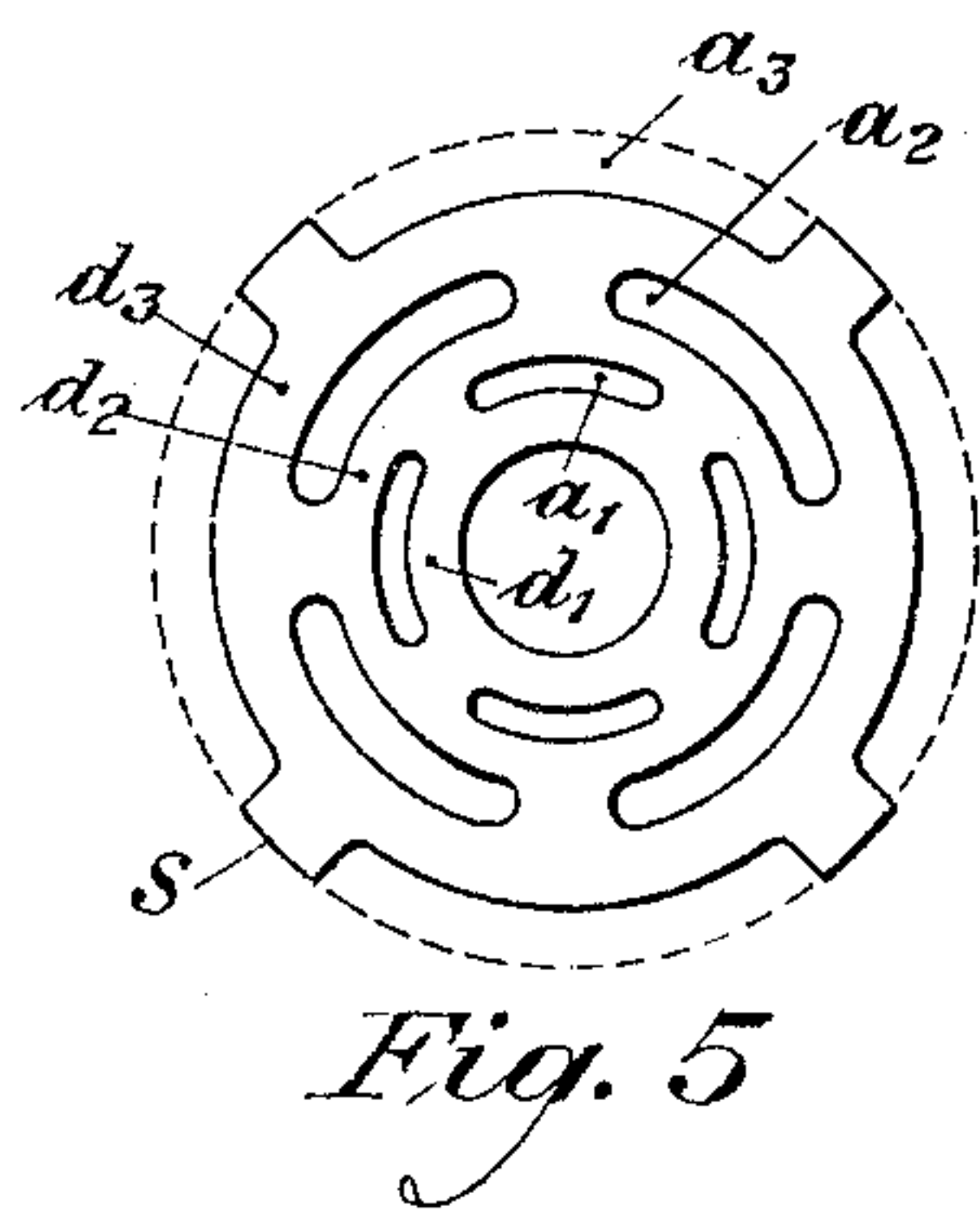
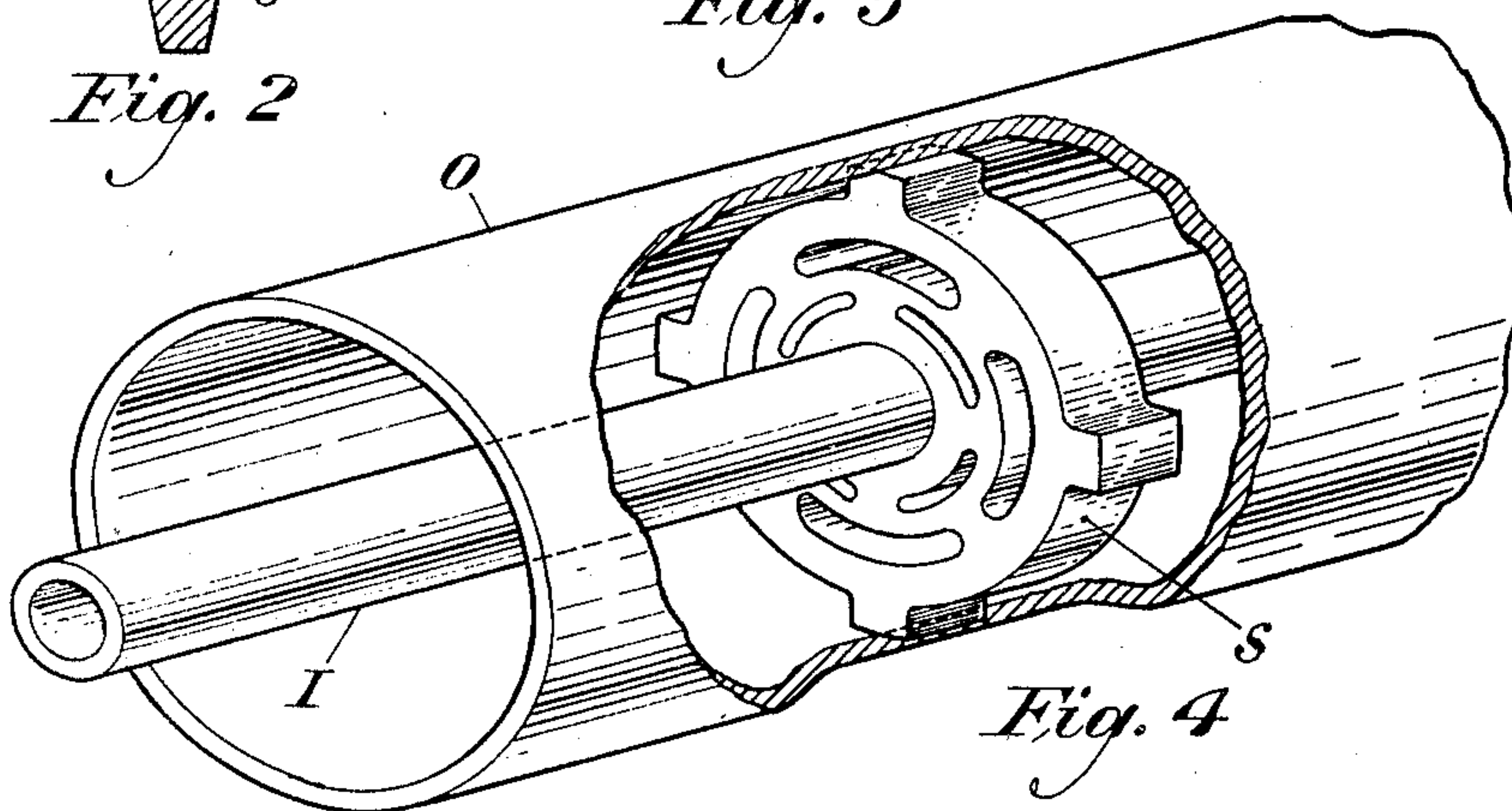
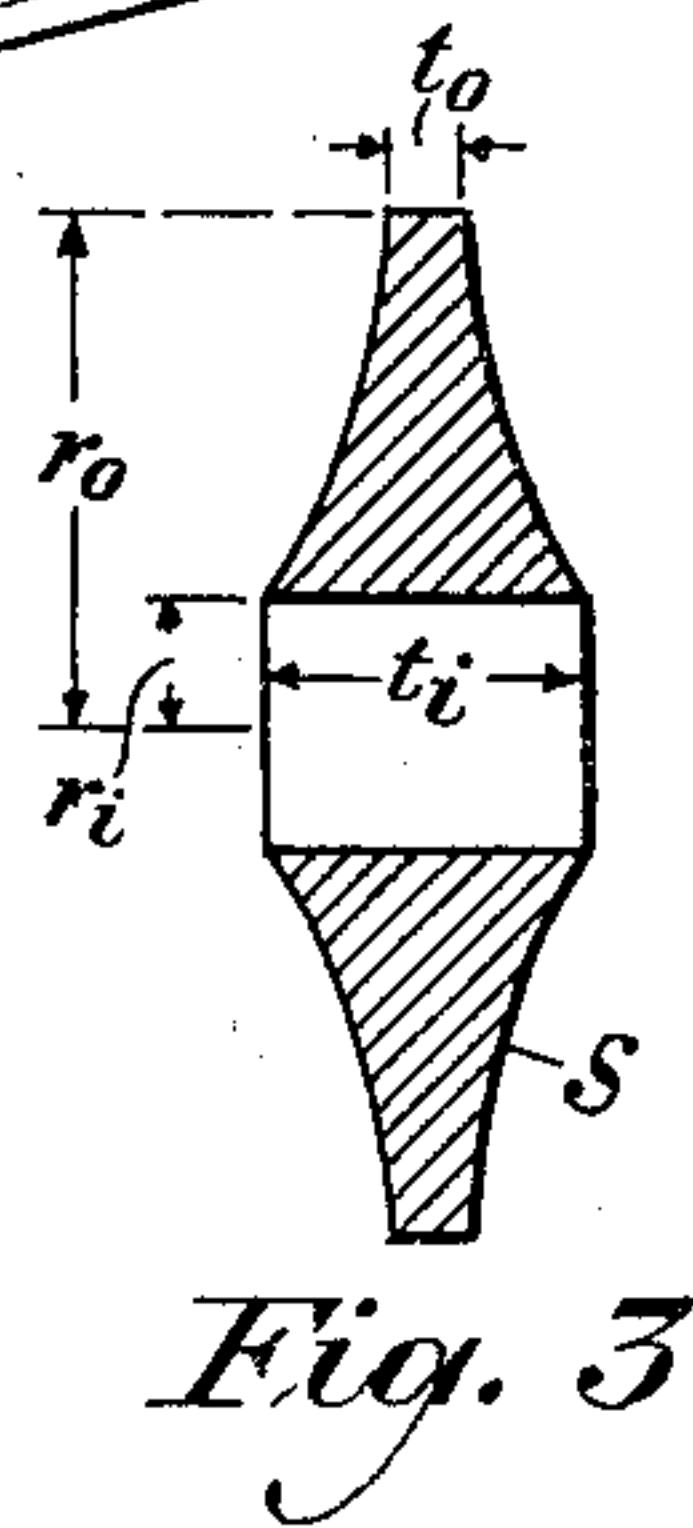
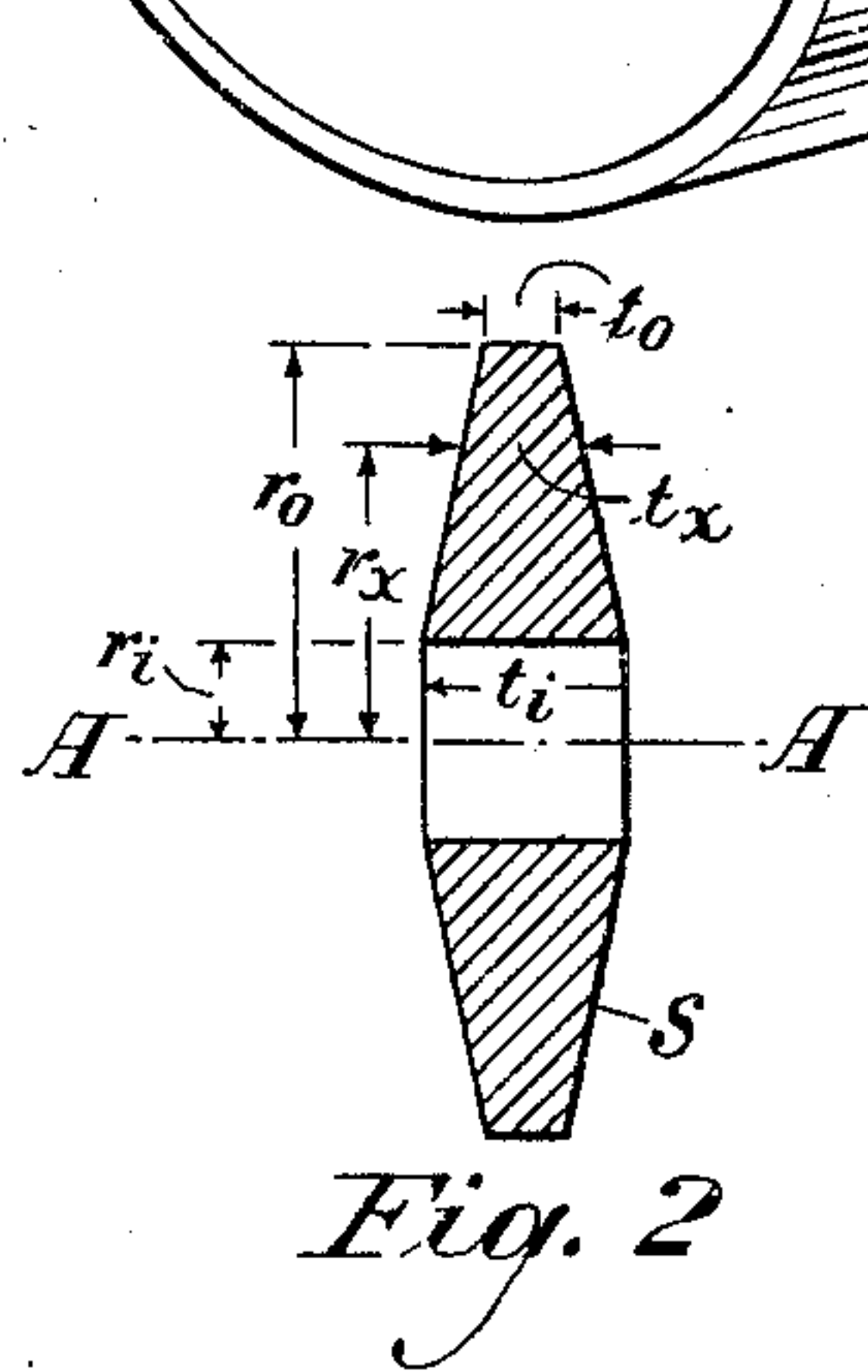
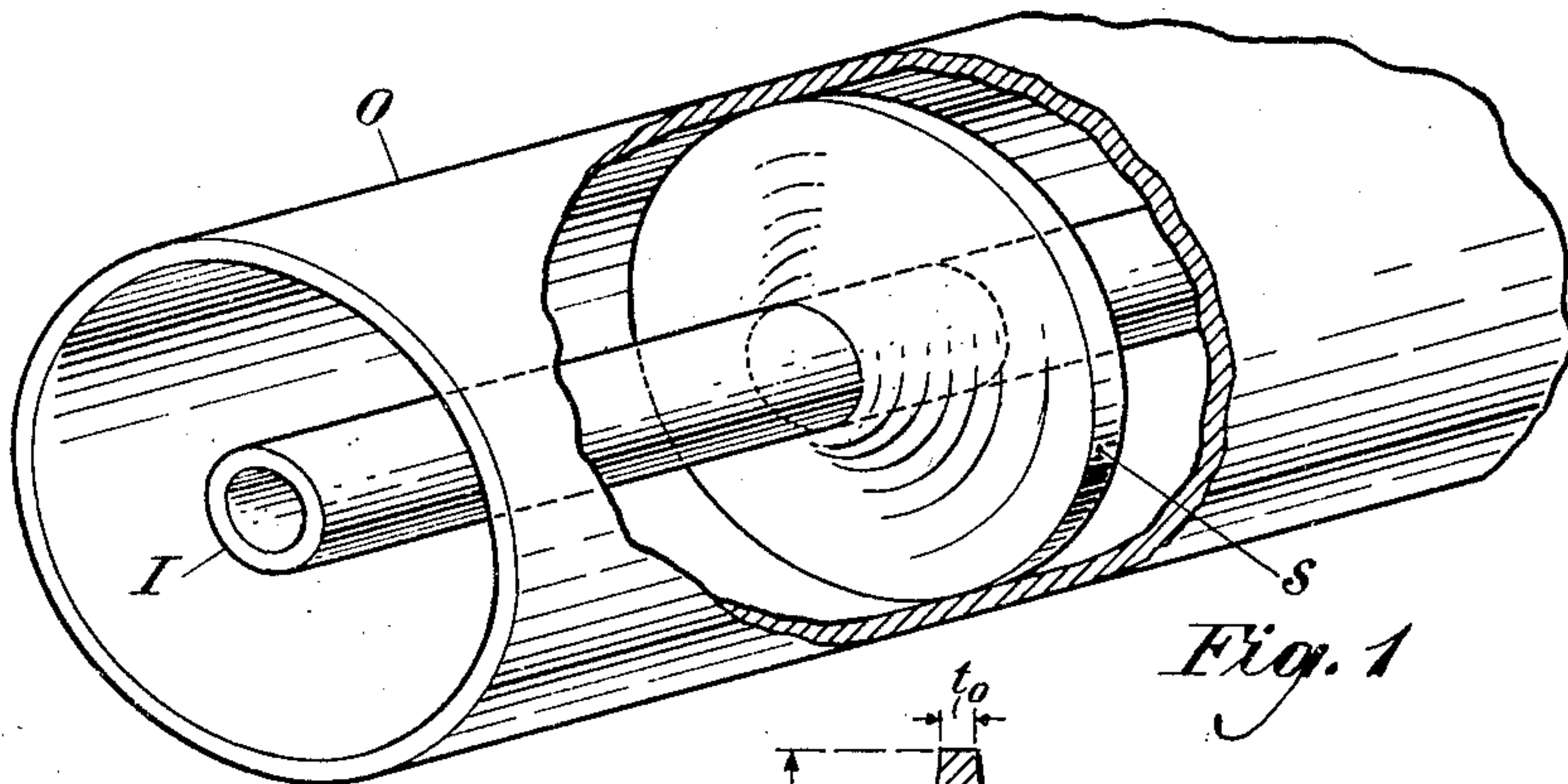
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INSULATOR FOR COAXIAL CONDUCTORS

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INSULATOR FOR COAXIAL CONDUCTORS

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3 Claims. (Cl. 173—265)

This invention relates to coaxial conductor systems and more particularly to insulating spacers to be used in separating the coaxial conductors.

Various forms of spacers, including a simple cylinder or disk and modified designs having parts of the dielectric cut out, have been proposed from time to time for separating the conductors of a concentric conductor system. With these constructions, however, the disk being of the same thickness throughout, the flux density increases in passing from the outer conductor to the inner conductor due to the fact that the cylindrical area of the dielectric must obviously decrease with decreasing diameter. It is known that the absorption losses in the dielectric are proportional to the square of the flux density. This makes it important to obtain uniform flux density as the flux passes from one conductor to another. In accordance with the present invention, changes are made in either the shape or the material of the insulating spacer in order to approximate the condition of uniform flux density throughout the material of the spacer.

The invention will now be more fully understood from the following description, when read in connection with the accompanying drawing, Figure 1 of which shows a section of a concentric conductor system employing one type of insulating spacer in accordance with the invention; Figs. 2 and 3 show cross-sections taken through two forms of insulating spacers which may be used in the conductor system of Fig. 1; Fig. 4 shows a section of concentric conductor system employing a different form of insulating spacer in accordance with the present invention; Fig. 5 and Fig. 6 showing, respectively, side and edge views of the insulating spacer employed in Fig. 4.

In a typical concentric conductor system, an outer cylinder O of conductive material (see Fig. 1) surrounds an inner cylinder I of conductive material, the two cylinders being concentrically arranged and one connected as a return for the other. In such a system the attenuation will be a minimum if the space between the conductors be of some gaseous dielectric such as air, which has a dielectric constant of unity. For mechanical reasons, however, it is necessary to provide spacers of solid dielectric materials between the conductors at intervals. Such a spacer is shown at S in Fig. 1.

The most obvious and simple form of spacer is a right circular cylinder to fit the inside of the outer conductor and having a hole through its center to take the inner conductor. Let us now consider the requirements for low leakage

conductance in such a spacer of some given material.

First, let us assume that the leakage conductance is due entirely to dielectric absorption in the solid dielectric and that this absorption is proportional to the square of the flux density. This latter assumption is based on general experimental results with a large number of solid dielectrics.

The dielectric absorption then is similar to the I^2R loss in a conducting medium. In the case of the I^2R loss, it is well known that the resistance is a minimum for a given current when that current is uniformly distributed throughout the medium. Similarly, it is reasonable to suppose that the dielectric absorption in an insulating material will be a minimum when the flux density is uniform throughout the dielectric.

Now, if a spacer is to contain a certain amount of dielectric, determined, say, by mechanical considerations, the losses in that volume of dielectric should be a minimum if the shape of the dielectric is such as to give as nearly uniform flux density as possible.

In the particular case of a concentric or coaxial conductor system in which a homogeneous dielectric of uniform thickness is interposed between the inner and outer conductor, the flux leaves a relatively large area of the outside conductor and enters a relatively small area of the inner conductor. Thus, the flux density increases in going from the outer to the inner conductor. To obtain more uniform flux density, it is therefore proposed, in accordance with one form of the present invention, to increase the cylindrical cross-sectional path of the flux as it approaches the inner conductor.

For simplicity, consider a spacer of the shape shown in cross-section in Fig. 2, this spacer extending between an outer conductor O (see Fig. 1) and an inner conductor I, the concentric axis of the two conductors being as shown at A—A, the spacer being surrounded by a medium of zero dielectric constant. A simple calculation shows that when

$$t_x = \frac{r_o}{r_x} t_o$$

or

$$t_i = \frac{r_o}{r_i} t_o$$

where these symbols have the significance shown in Fig. 2, the cylindrical cross-sectional area at any radial distance from the axis A—A will be the

same as that for any other radial distance. Hence, the flux density will be uniform at all points in passing from the outer to the inner conductor.

5 With this arrangement, it will be obvious that as the solid dielectric is of uniform dielectric constant throughout, and the cylindrical cross-sectional area at any radial distance from the axis is the same, the product of the dielectric
10 constant by the volume of a thin cylindrical layer of dielectric at any radial distance from the axis will be constant.

In actual practice, the medium surrounding the spacer will have a finite dielectric constant (about
15 unity) and some of the flux leaving the outer conductor through this gaseous medium may enter the solid dielectric and continue to the inner conductor. It is therefore desirable to increase the axial thickness more rapidly as the inner
20 conductor is approached than would be indicated by the above inverse linear relation. The general shape of the spacer would be somewhat as shown in Fig. 3 where

$$25 \quad t_i > \frac{r_o}{r_i} t_o$$

The exact shape will depend on the relative dielectric constants of the spacer material and the surrounding medium, the smaller the ratio the
30 greater the curvature. It may be quite impossible to obtain absolutely uniform flux density in the solid dielectric but the general shape shown in Fig. 3 should give more uniform flux distribution than could be obtained by a homogeneous
35 spacer having the same axial thickness throughout.

If, for mechanical reasons, such as ease of manufacture, it is desired to keep the axial thickness of the spacer uniform, then the insulation
40 may be "graded" somewhat as is general in high voltage cables. In this arrangement the material of highest dielectric constant is employed next to the inner conductor, and then the next highest, and so on, with the material of minimum
45 dielectric constant adjacent the outside conductor. Figs. 4, 5 and 6 show one form of insulator which approximates the desired graded condition, the insulator being shown applied to the concentric conductors in Fig. 4.

50 In this case the spacing insulator S assumes the form of alternate rings of solid dielectric and air dielectric, as shown in Fig. 5. The solid rings are indicated at d_1 , d_2 and d_3 and the successive rings of gaseous dielectric at a_1 , a_2 and a_3 . For
55 mechanical reasons it is obviously necessary to interrupt the rings or layers of air dielectric in order to join the successive rings of solid dielectric as shown, but in any event, each successive outer

ring of air dielectric is made of greater thickness with respect to the corresponding solid ring as we pass from the inner conductor to the outer conductor.

With this arrangement, the cylindrical cross-sectional area decreases as we approach the axis but the effective dielectric constant increases (if we consider the average dielectric constant of two adjacent layers of different dielectric material). Hence, the product of the volume of a cylindrical
85 layer of limited thickness, but including two dielectrics, by the average or effective dielectric constant of that volume of material, may be made approximately the same at any radial distance from the axis.

Other forms of spacer involving the principles hereinbefore discussed will readily suggest themselves. In general it appears desirable that the surfaces of dielectric in contact with the conductors be smooth and close-fitting in order to
95 obtain a more uniform flux distribution. Intimacy of contact between the inner conductor and the dielectric is particularly desirable because of the relatively small area of contact at the inner conductor.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims. 100

What is claimed is:

1. In a concentric conductor system, a disk-like spacer between the inner and outer conductors, said spacer being so shaped and being composed of such dielectric materials that the product of
110 the volume of a limited cylindrical ring of the spacer multiplied by the average dielectric constant of the material of the ring will be substantially the same at any radial distance from the concentric axis of the system.

2. In a concentric conductor system, a disk-like spacer between the inner and outer conductors, the linear thickness of said spacer being so related to the dielectric constant and to the circumferential dimension at each radial distance
120 from the concentric axis that the flux density will be substantially the same at any radial distance from the concentric axis of the system.

3. In a concentric conductor system, a disk-like spacer between the inner and outer conductors, said spacer having its linear thickness along the concentric axis increased as the axis is approached in accordance with the dielectric constant and the circumferential dimension at each radial distance from the concentric axis, so that
130 the flux density will be substantially the same at any radial distance from the axis.

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