March 7, 1944. H. BUCHHOLZ 2,343,531

DIRECTIVE RADIATOR

Filed April 8, 1941 2 Sheets-Sheet 1

Fig. 1

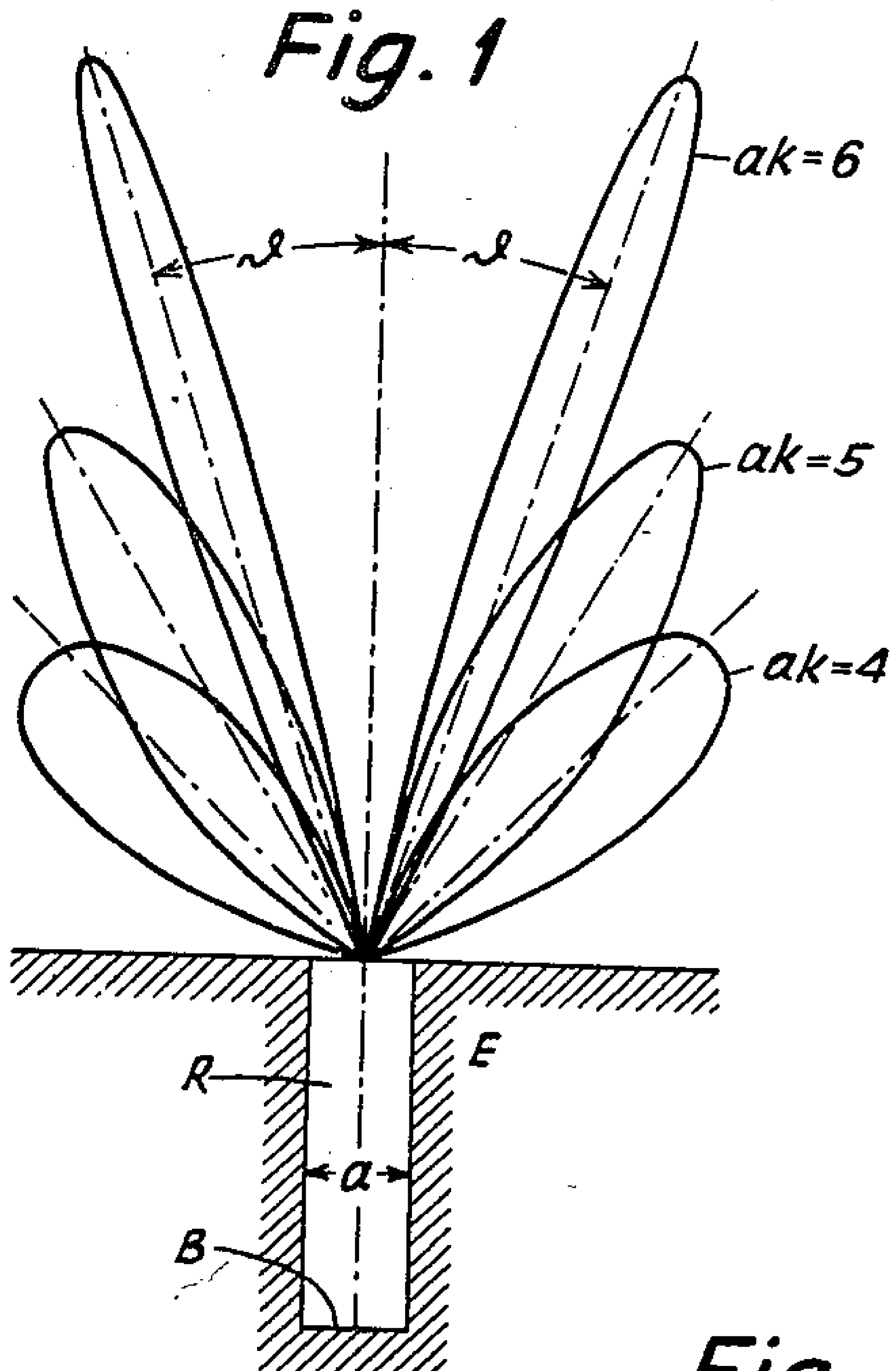



Fig. 2

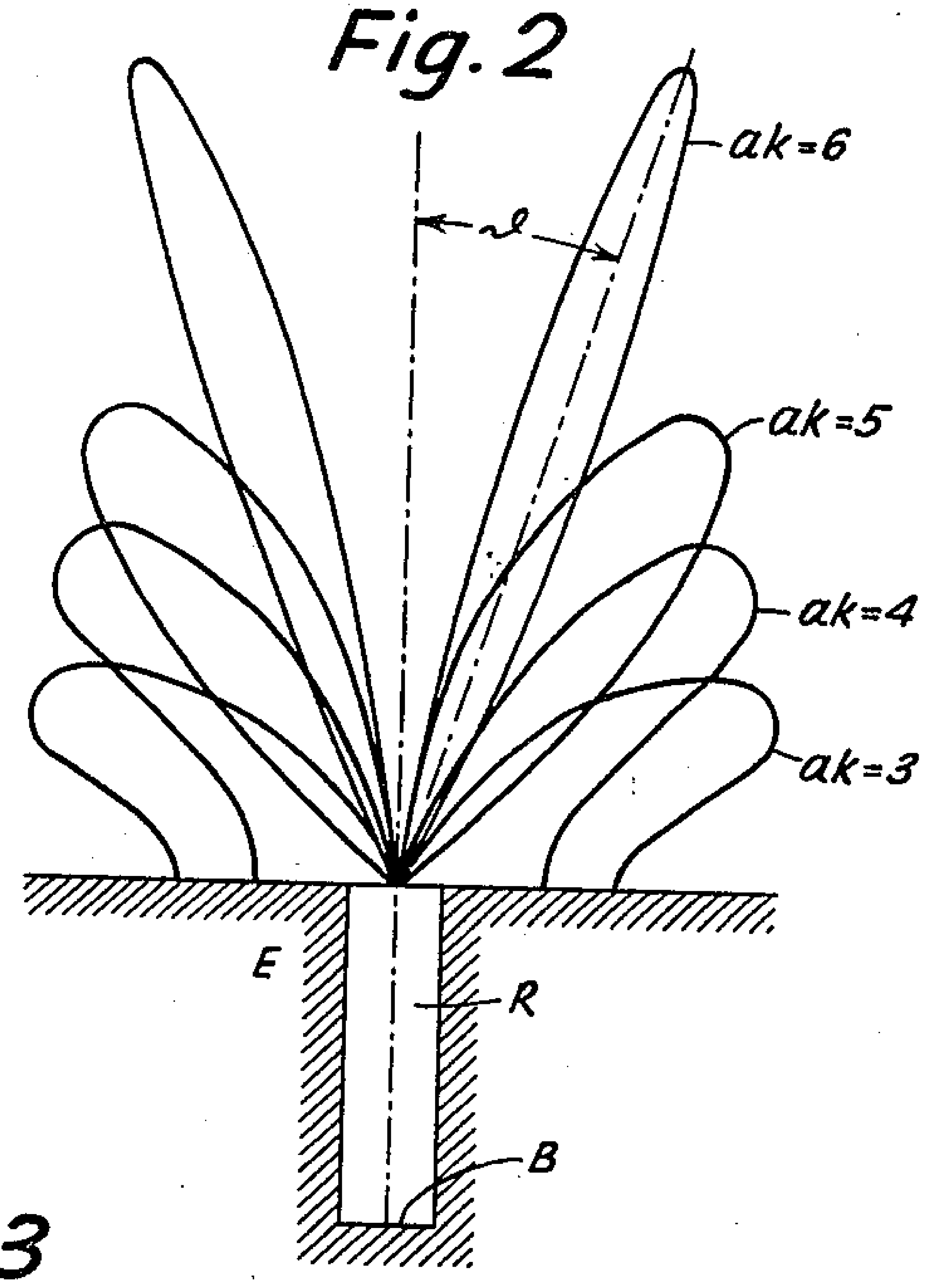



Fig. 3

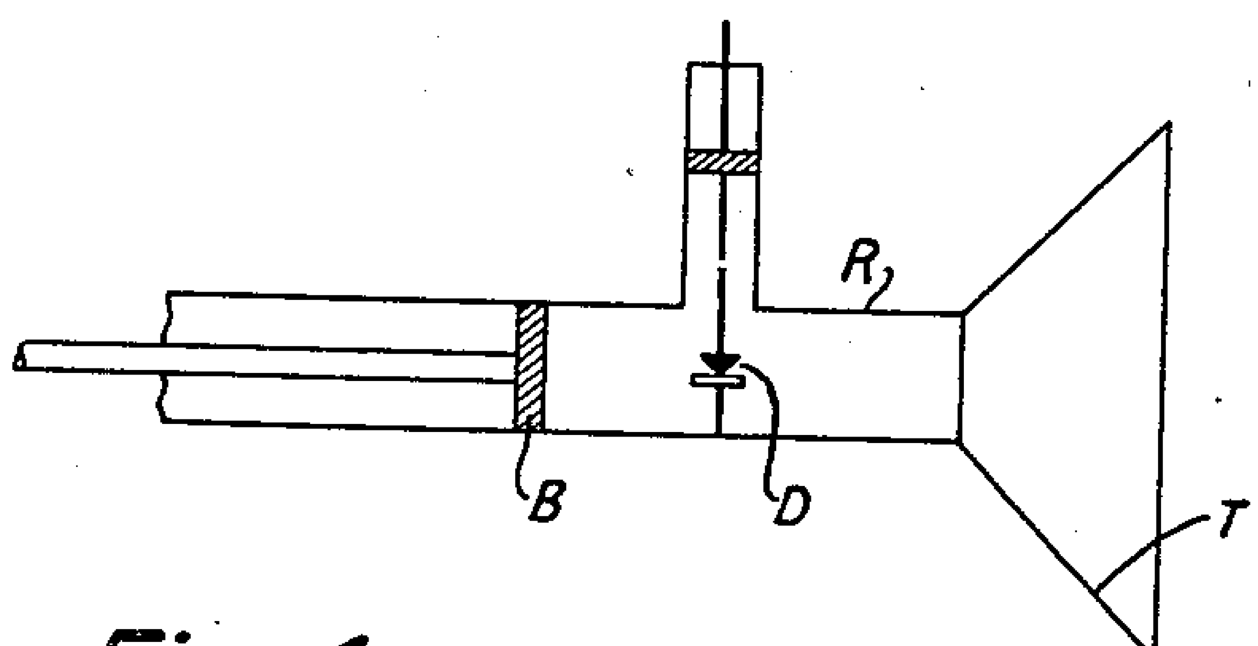



Fig. 4

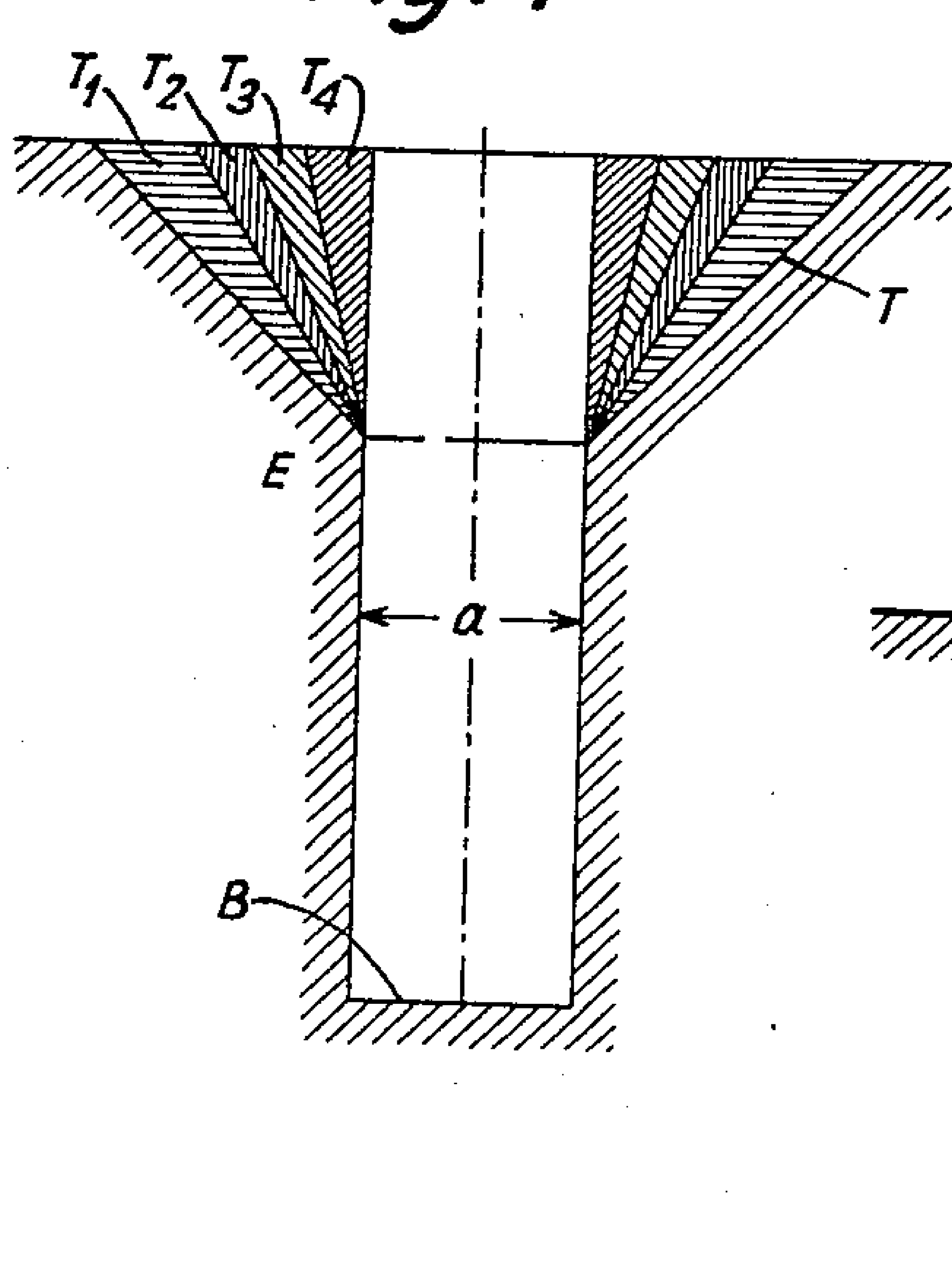
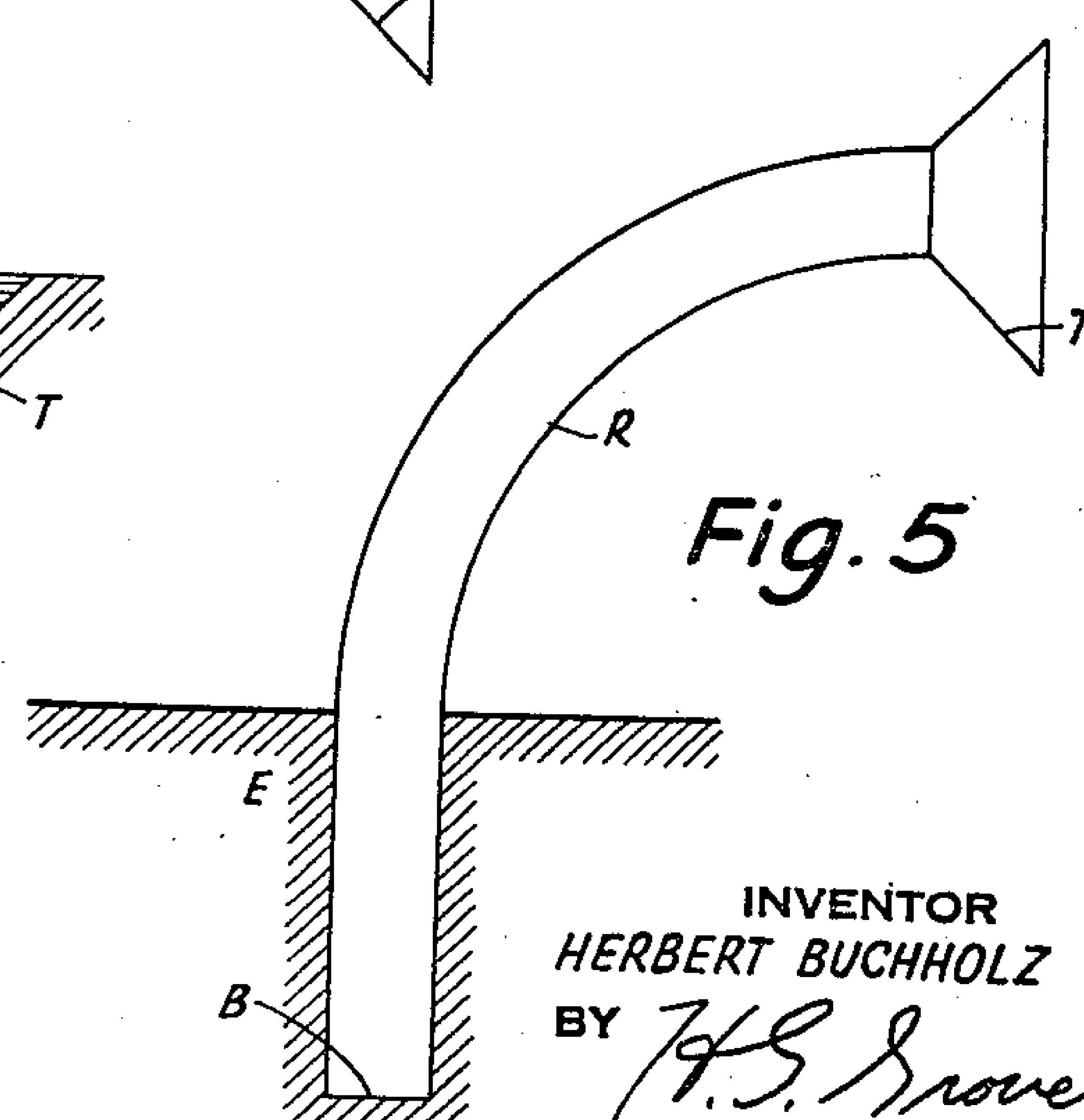



Fig. 5



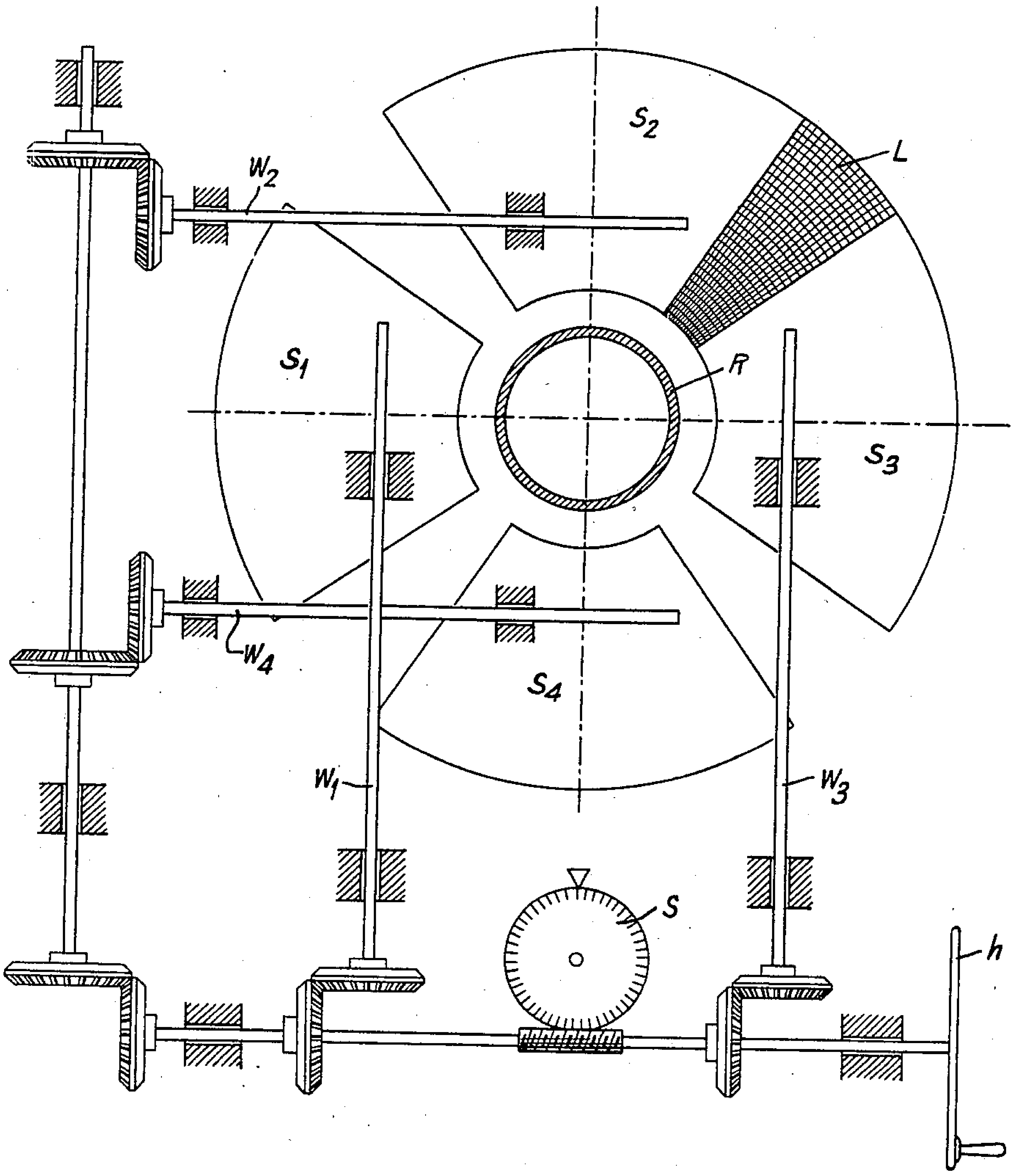

INVENTOR
HERBERT BUCHHOLZ
BY H. S. Grover
ATTORNEY

March 7, 1944. H. BUCHHOLZ 2,343,531

DIRECTIVE RADIATOR

Filed April 8, 1941 2 Sheets-Sheet 2

Fig. 6




INVENTOR
HERBERT BUCHHOLZ
BY H. S. Grover
ATTORNEY

Patented Mar. 7, 1944

2,343,531

# UNITED STATES PATENT OFFICE

2,343,531

## DIRECTIVE RADIATOR

Herbert Buchholz, Berlin, Germany, assignor to General Electric Company, a corporation of New York

Application April 8, 1941, Serial No. 387,512
In Germany January 1, 1940

7 Claims. (Cl. 250—11)

The problem on which the present invention is based consists in providing a directional wireless transmitter arrangement, in which the acuteness of the angles within which the electromagnetic radiation occurs is changeable, and in which with simple means the characteristic of the radiation diagram can be influenced. For instance, by a simple manipulation, the radiation diagram may be made either as steep as possible in upward direction or bearing as flat as possible against the ground or bunched in radiation angles between these two forms.

With this object in view an arrangement for transmitting short electromagnetic oscillations is proposed according to the invention comprising a funnel antenna connected with a dielectric space, which is limited by perfect conductors, this funnel antenna being characterized in that the flank-steepness or the included angle between the walls of the funnel antenna may be altered according to the degree of concentration desired.

It has been known for a considerable time, that electromagnetic waves can be propagated by tubes. The arrangement used for such propagation consists of a metal tube of desired length and of a few centimeters in diameter, the interior of which tube is uniformly filled by a dielectric such as air, water and the like. In the hollow space enclosed within metallic walls, electromagnetic resonance conditions may be established. The resonance wave length or frequency is determined by the dimensions of the hollow space. Such tubular conductors are often called dielectric conductors or hollow-space conductors. The most favorable attenuation values are attained and the dimensions being of the order of the wave length, the employment of such hollow spaces as resonators is especially suitable for ultra-short waves.

In the accompanying drawings Figures 1 and 2 are radiation diagrams for explaining the principles of the present invention, while Figure 3 illustrates a form of receiver for short waves as used in practicing the present invention, while Figure 4 is an embodiment of the invention and Figures 5 and 6, modifications thereof.

In dielectric conductors two main oscillation forms are distinguished, namely the electric and the magnetic wave type.

On the basis of calculations which will not here be gone into but the results of which are diagrammatically illustrated in Figures 1 and 2, respectively, for the electric and magnetic wave types it has been found that a hollow-space conductor, perpendicularly inserted in the ground, its open end being flush with the surface of the ground, has a radiation diagram in which the maximum is situated on the surface of a cone with its point on the axis of the hollow-space conductor. The opening angle $\theta$ of this cone is dependent on the ratio of the operating wave length to the diameter $a$ of the hollow-space conductor R which is used. By alteration of these two values the radiation diagram may be made as steep as possible in upward direction or bearing on the ground as flatly as possible.

Funnel-shaped structures may be connected to the open ends of a hollow-space conductor arrangement of the above described type. A transmitter of very short wave length is disposed within the interior of the hollow-space conductor. The hollow-space conductor with a funnel extending from the same serves for emitting a bunched radiation. A receiver arrangement as shown in Fig. 3 within a metal funnel T may be used as antenna for tube waves. The receiver consists of a tube R, on which the metal funnel T is placed. The detector D may be shifted along a slit in the tube together with the concentric tuning system placed on the same. A bridge B serves for tuning the receiver. This arrangement will sustain horizontally and vertically polarized oscillations.

The present invention includes the following considerations: Placing a funnel on a hollow-space conductor brings chiefly the advantage, of increasing the value of $a$ in the radiation cross-section and thereby, as can be seen from the Figures 1 and 2, causing the direction of the maximal energy radiation to become steeper, without the necessity of, at the same time, increasing the diameter of the dielectric conductor. If therefore the funnel antenna is constructed according to the invention whereby its flank-steepness may be regulated while in operation, it is possible to adjust as desired the direction of the maximal energy radiation.

In the form of construction shown in Fig. 4 the flank-steepness of the funnel connected with tube R is varied as desired by putting onto the main outer funnel of the hollow-space conductor R in the ground E conical additional funnels $T_1$, $T_2$, $T_3$, $T_4$ and so on having different opening angles. The funnel T while shown flush with the surface of ground E may alternatively project from the ground or if desired it may even be fully outside the ground. The funnel T or the additional funnels $T_1$ to $T_4$ are preferably of conical or pyramid-shape.

Another form of construction is that shown in Fig. 5, in which the additional funnels $T_1$ to $T_4$ of Figure 4 may be placed on a hollow-space conductor R which is constructed like a trombone. The conductor may be filled with a suitable dielectric of specific inductive capacity such as for instance water, or the like.

In all forms of construction, a doubling of the radiation may be attained if the ground-piece B has a highly reflective surface. For avoiding obstruction and prejudicial reflections within conductor R it is advantageous for the radius of curvature of the hollow space conductor R to be at least 4 to 5 times as great as the diameter of the tube. Instead of a cylindrical tube the present invention may employ a tube with rectangular cross-section it is thereby possible to produce a polarized wave in a very simple manner. In this instance the radiation diagram is much wider in one direction than in the other direction.

Another form of construction for the alteration of the flank angle is shown in Fig. 6. With the aid of the device shown in Fig. 6 it is possible, to continually regulate the direction of the maximal energy radiation. A single conical, parabolic or pyramid-shaped funnel T is then used, which is subdivided into several, for instance four sectors $S_1$ to $S_4$. These sectors are rigidly connected with the shafts $w_1$ to $w_4$, which may be simultaneously operated by means of intermediate shafts and gear means from a hand wheel *h*. By the rotation of hand wheel *h*, the amount of which may be read on a scale disc *s*, the funnel sectors $S_1$ to $S_4$ may be folded together more or less and in this manner the opening angle can be continuously altered. The different sectors of the metal funnel are preferably connected together by elastic metallic plaitings such as strands or the like for filling the gaps between the intermediate spaces as indicated at one point at L. The width of the sectors of the funnel must preferably be adapted to cover an adjusting range from 10 to 40° for the opening angle. They may be so arranged that the gaps between the sectors are closed at a middle flank angle and overlap at smaller angles. If desired the sectors may be so arranged as to join one with the other without gaps at greater angles of adjustment.

The scale disc *s* may be calibrated, if required, so that the direction of the maximal energy current can be directly read. By means of a suitable transmission between the hand wheel for the flank adjusting and the oscillatable sectors, the direction of the bunches of rays may be regulated extremely accurately. In the arrangement shown in Fig. 6, the funnel T is to be considered as being viewed from the rear side. The hollow-space conductor R has to be considered as arranged perpendicularly to the plane of the drawings. The upper bordering edge of the tube R coincides approximately with the inner funnel edge.

Instead of a conical or parabolic funnel evidently a pyramid-shaped funnel may be used also utilizing the form of construction shown in Fig. 6, but having instead a rectangular cross-section. In the latter instance it is possible to simultaneously adjust the flank-steepness of all of the side faces of the funnel with the use of the means as shown in Fig. 6 or, if desired, each flank or pair of opposite flanks may be separately adjusted. Thus if the sides are of different width the flank steepness of the narrow side may be adjusted independently of the flank steepness of the wide side.

The funnels used according to the invention may be fully metallic or made from wire plaitings.

The present invention is specially suited for a direction radiator or for navigation. It may also be used for assisting the blind-landing of airplanes. If required, the present invention may be arranged to radiate or receive horizontally and vertically polarized waves. The invention may be further employed as transmitter as well as a receiver of electromagnetic oscillation.

I claim:

1. A funnel arrangement adapted to be associated with a dielectric wave guide including a plurality of separate wall sectors arranged with their small ends around the end of said guide and means for varying the angle included between opposing ones of said sectors whereby the directivity of said arrangement is altered.

2. A funnel arrangement adapted to be associated with a dielectric wave guide including a plurality of separate wall sectors arranged with their small ends around the end of said guide, means for varying the angle included between opposing ones of said sectors whereby the directivity of said arrangement is altered and means for establishing electrical continuity between said wall sectors.

3. A funnel arrangement adapted to be associated with a dielectric wave guide including a plurality of separate wall sectors arranged with their small ends around the end of said guide, means for varying the angle included between opposing ones of said sectors whereby the directivity of said arrangement is altered and means for establishing electrical continuity between said wall sectors comprising elastic metal plaitings connecting adjacent edges of said sectors.

4. A funnel arrangement adapted to be associated with a dielectric wave guide including a plurality of separate wall sectors arranged with their small ends around the end of said guide, said sectors being rotatable about a transverse axis located in an intermediate position between their inner and outer ends whereby the angle included between opposing ones of said sectors may be varied.

5. A funnel arrangement adapted to be associated with a dielectric wave guide including a plurality of separate wall sectors arranged with their small ends around the end of said guide, said sectors being rotatable about a transverse axis located in an intermediate position between their inner and outer ends whereby the angle included between opposing ones of said sectors may be varied and so arranged that their longitudinal edges are substantially in alignment at the midpoint of their rotation.

6. A funnel arrangement adapted to be associated with a dielectric wave guide including a plurality of separate wall sectors arranged with their small ends around the end of said guide, said sectors being rotatable about a transverse axis located in an intermediate position between their inner and outer ends whereby the angle included between opposing ones of said sectors may be varied and so arranged that their longitudinal edges are substantially in alignment at the midpoint of their rotation and means for establishing electrical continuity between said sectors comprising elastic metal plaitings connecting adjacent edges of said sectors.

7. A funnel arrangement adapted to be associated with a dielectric wave guide including a plurality of separate wall sectors arranged with their small ends around the end of said guide, said sectors being rotatable about a transverse axis located in an intermediate position between their inner and outer ends whereby the angle included between opposing ones of said sectors may be varied and so arranged that their longitudinal edges are substantially in alignment at the midpoint of their rotation, means for establishing electrical continuity between said sectors comprising elastic metal plaitings connecting adjacent edges of said sectors and gear means coupling said sectors together for simultaneous rotation.

HERBERT BUCHHOLZ.