

Feb. 20, 1945.

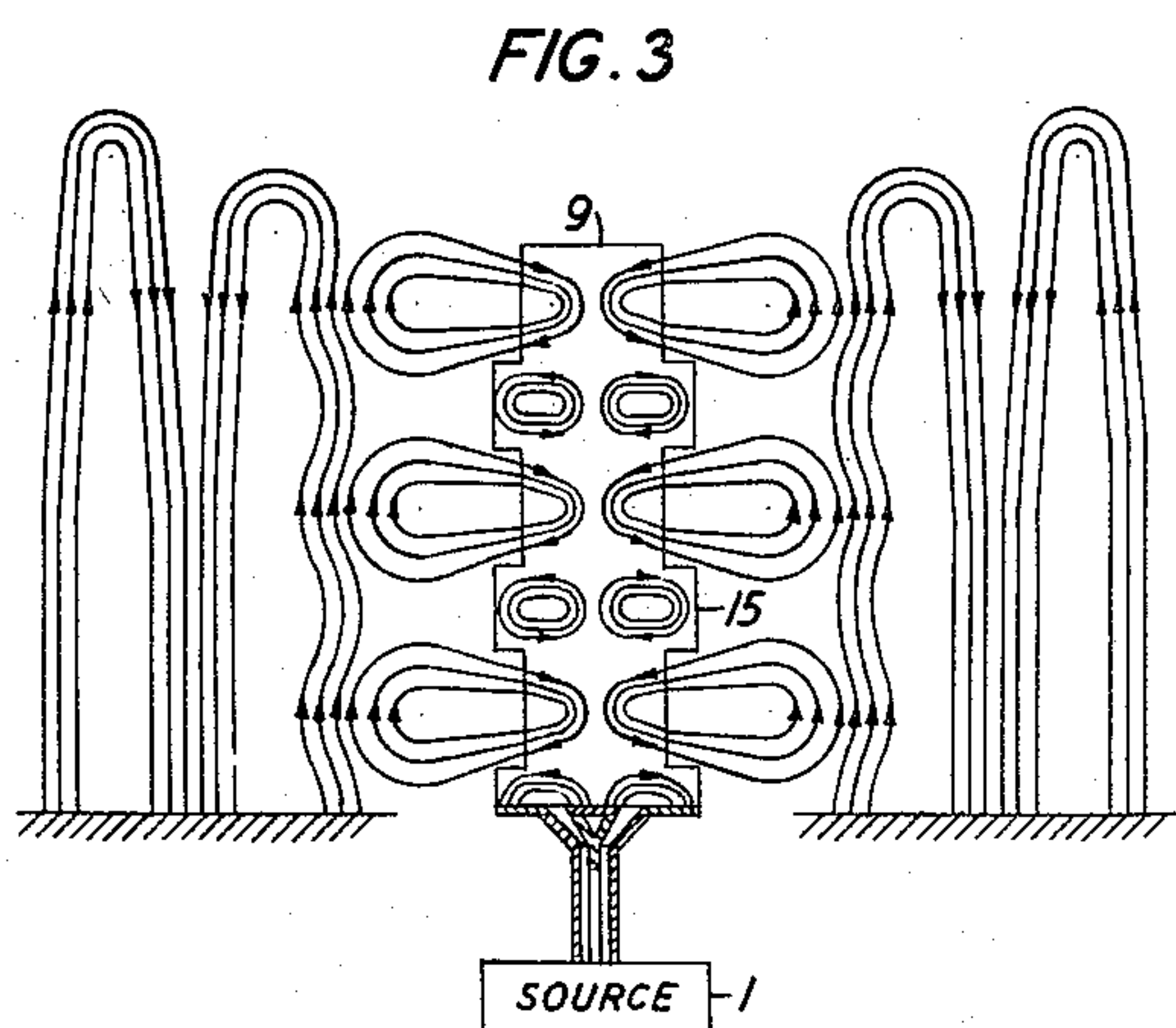
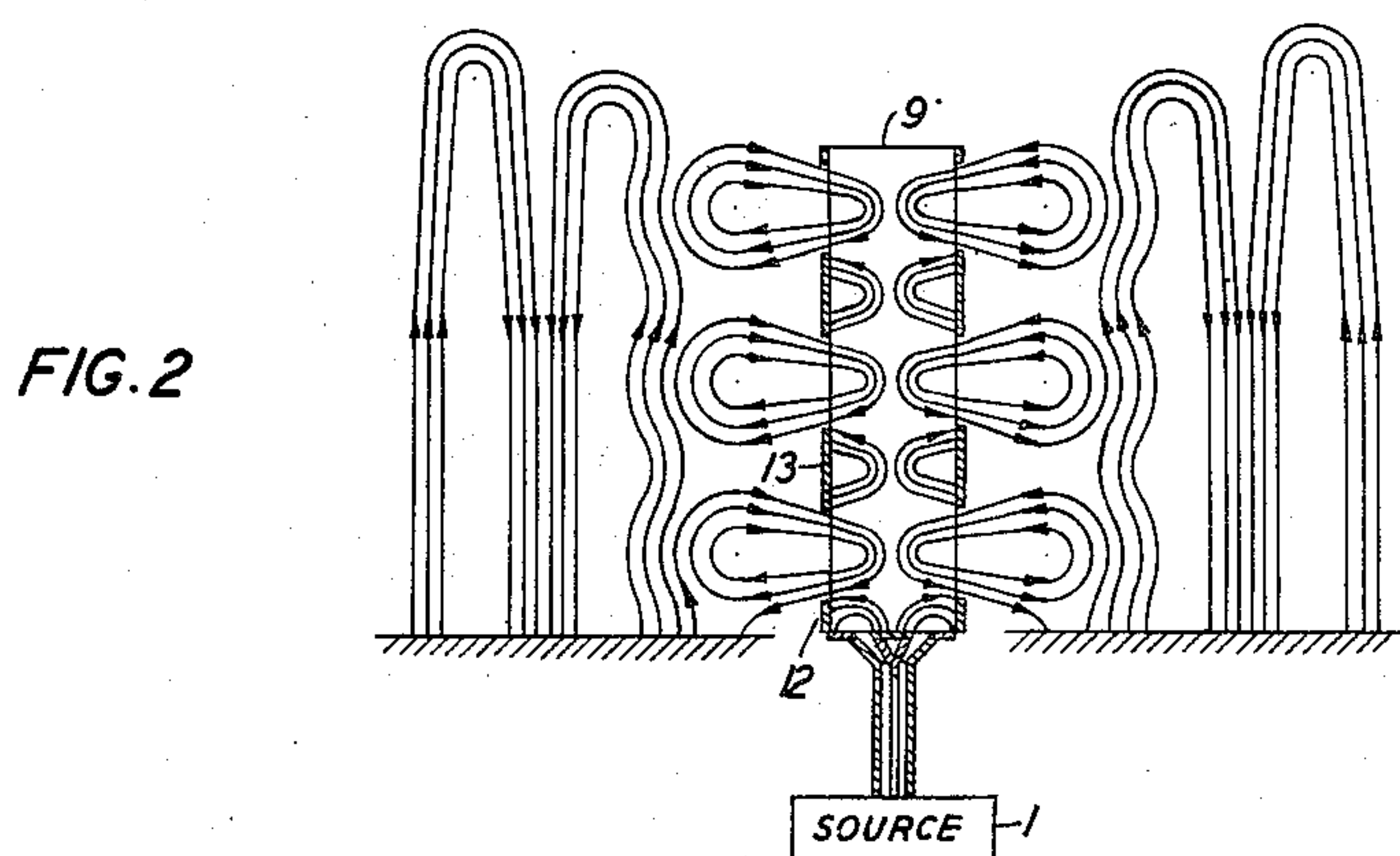
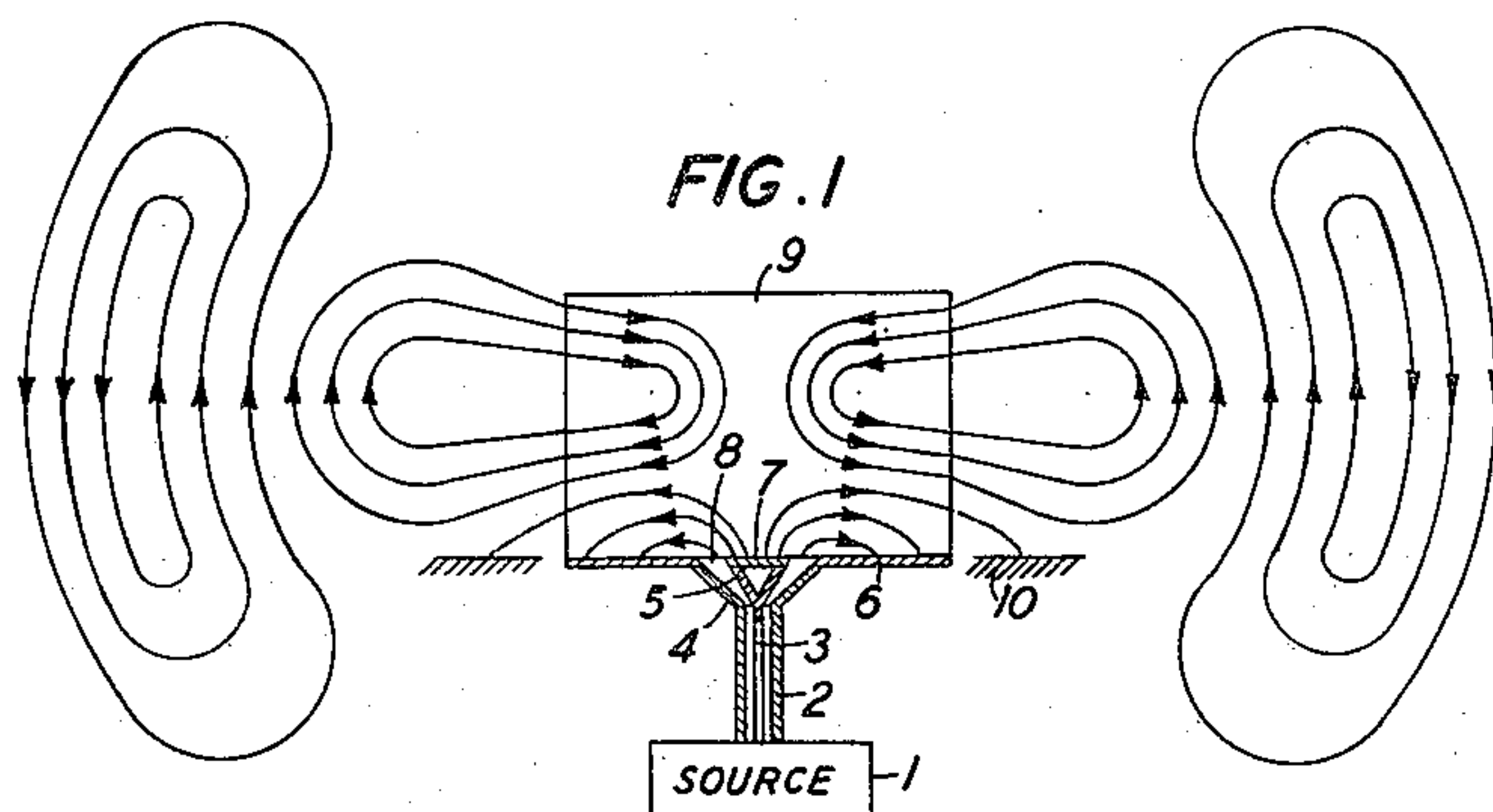
G. C. SOUTHWORTH

2,369,808

SHORT-WAVE RADIO TRANSMISSION

Filed June 8, 1940

3 Sheets-Sheet 1



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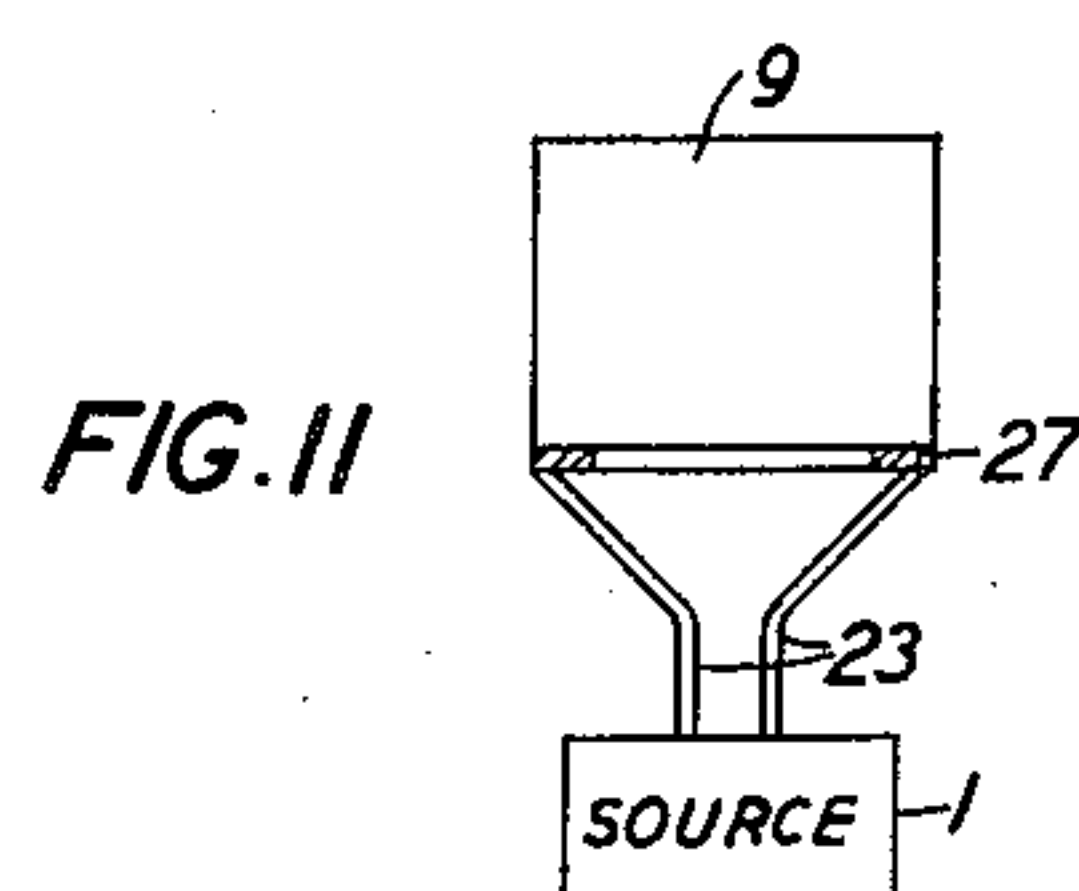
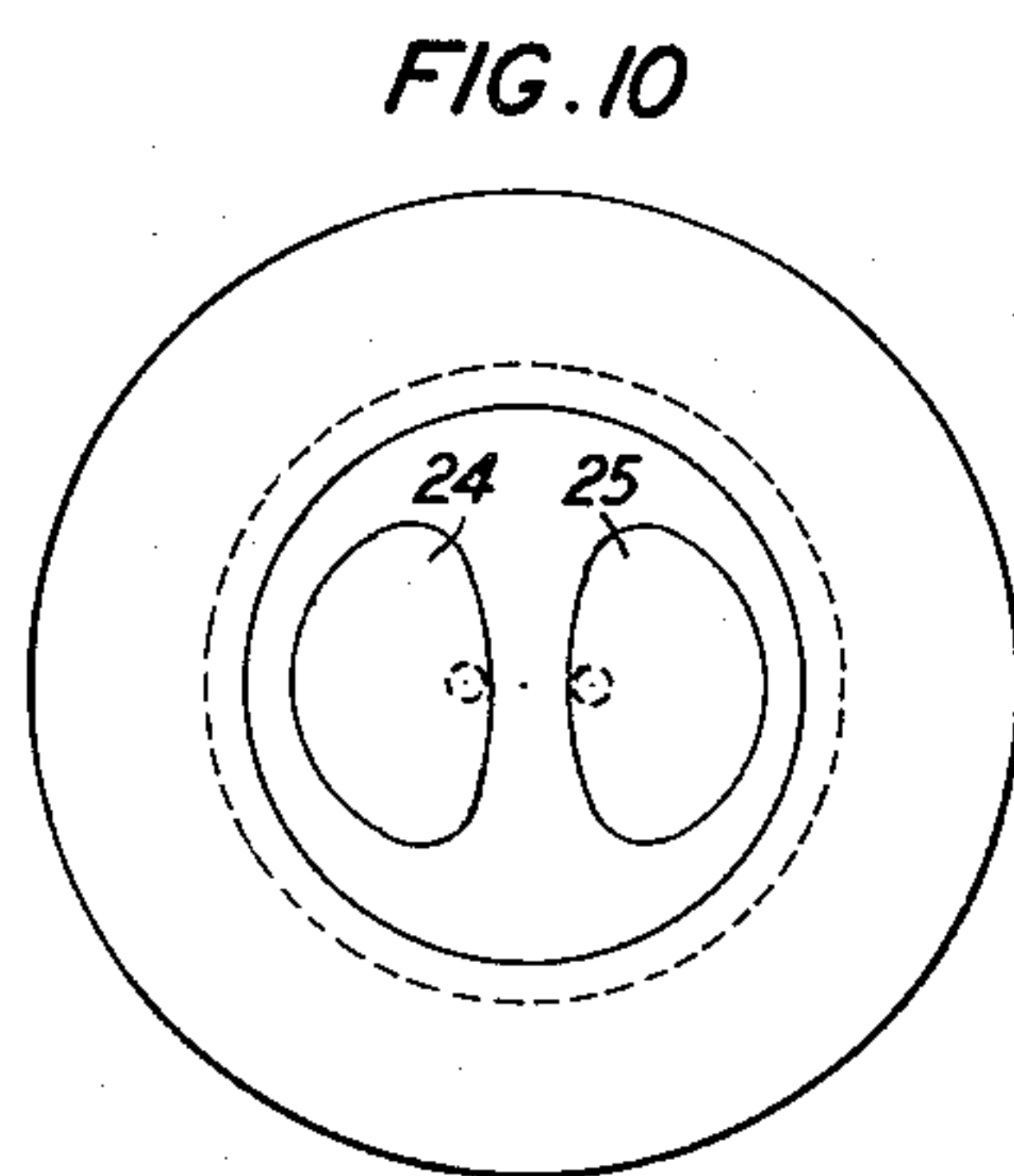
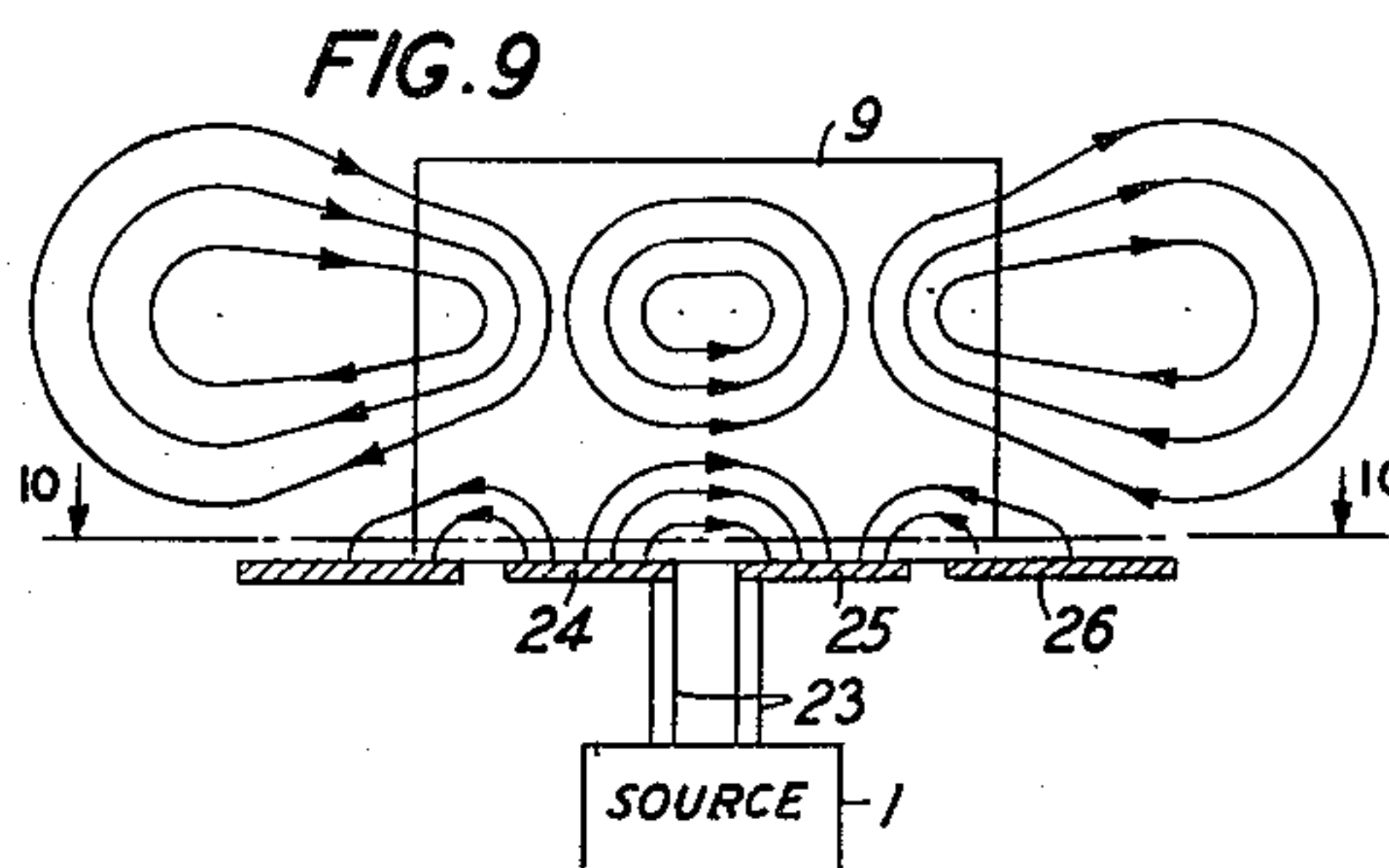
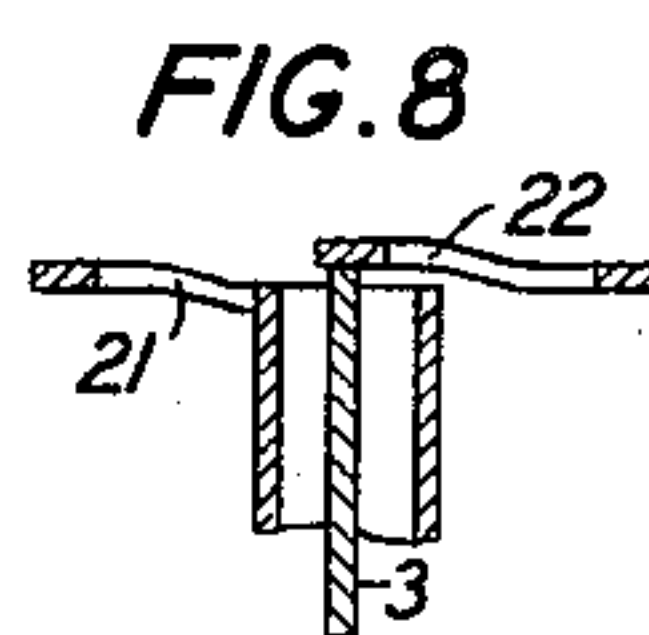
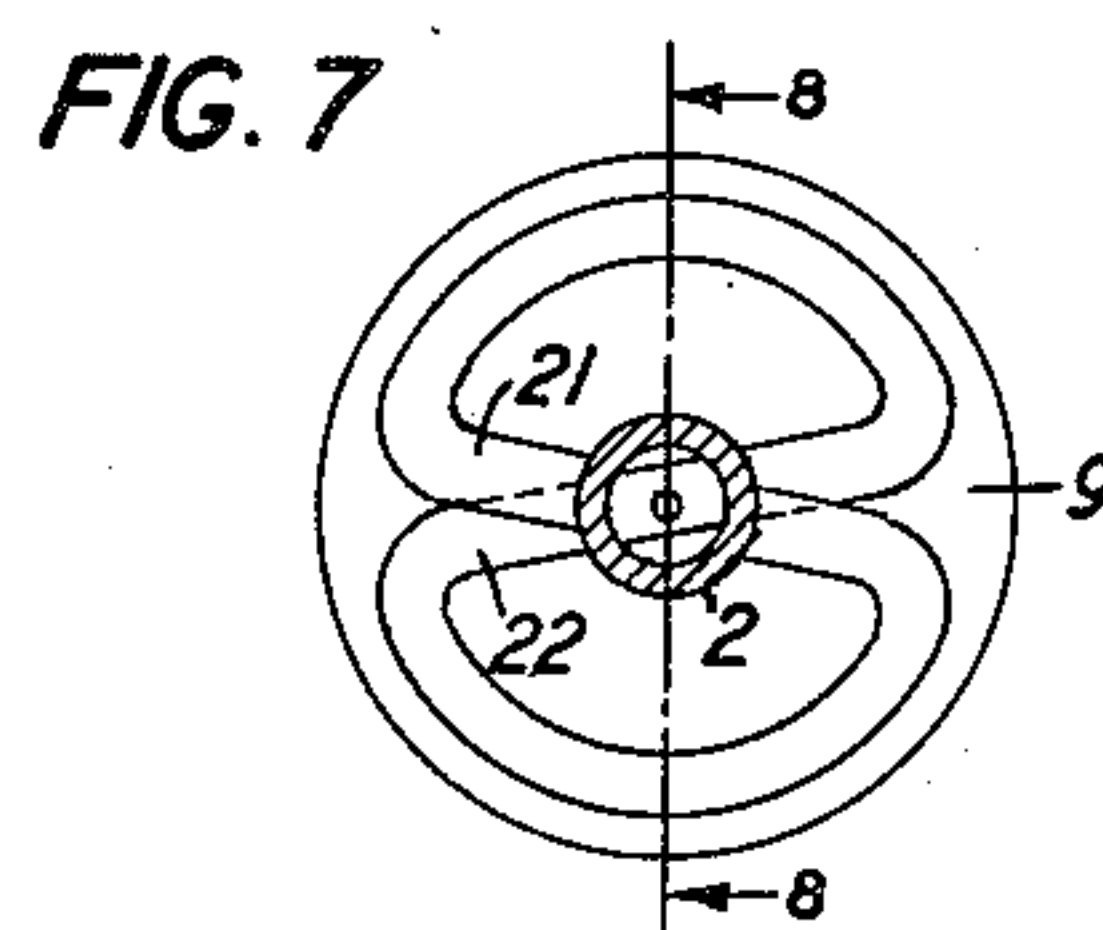
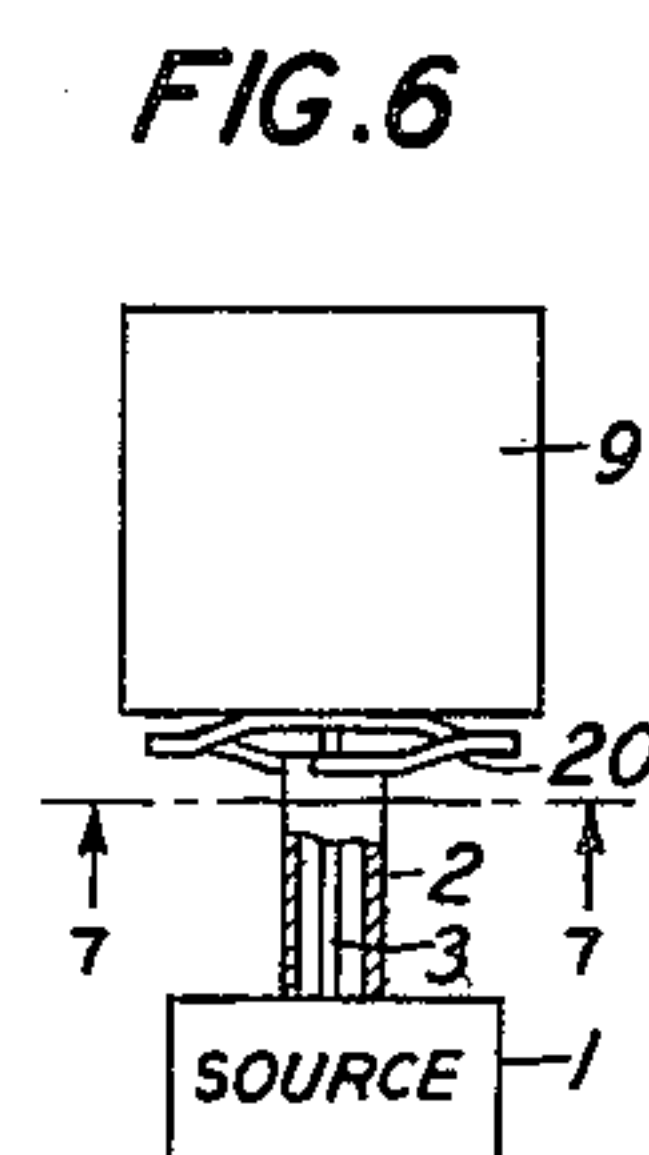
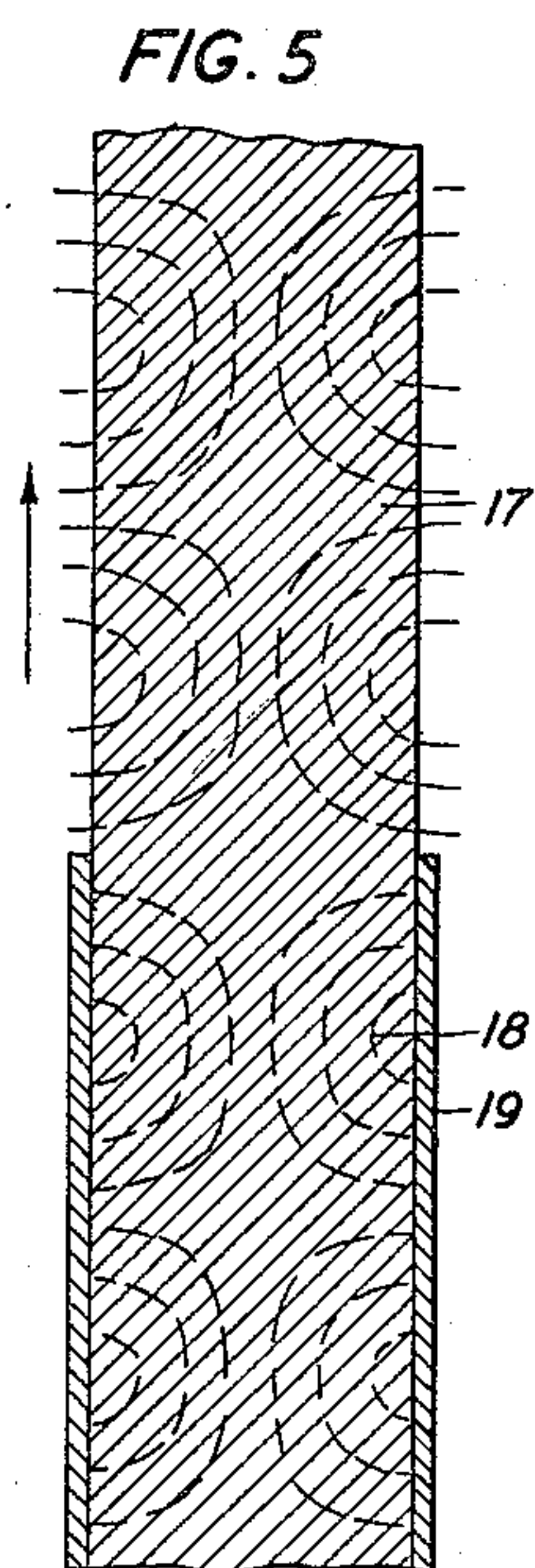
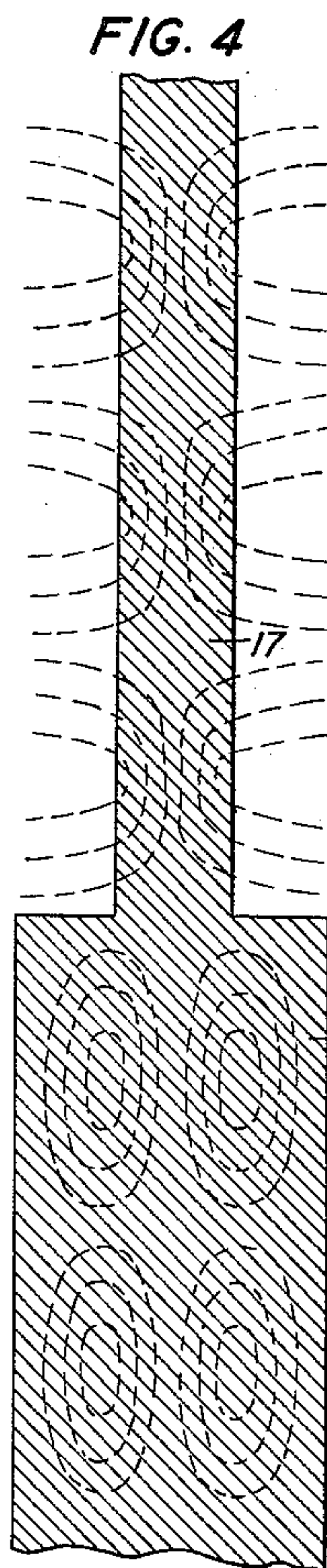
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SHORT-WAVE RADIO TRANSMISSION

Filed June 8, 1940

3 Sheets-Sheet 2



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SHORT-WAVE RADIO TRANSMISSION

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3 Sheets-Sheet 3

FIG. 12

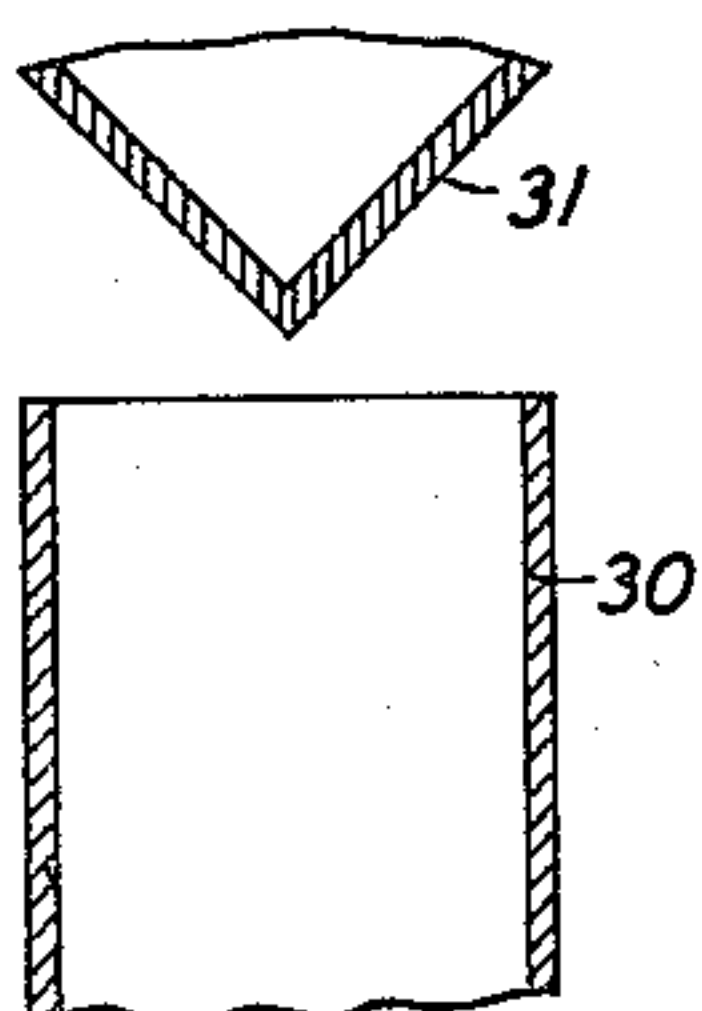


FIG. 13

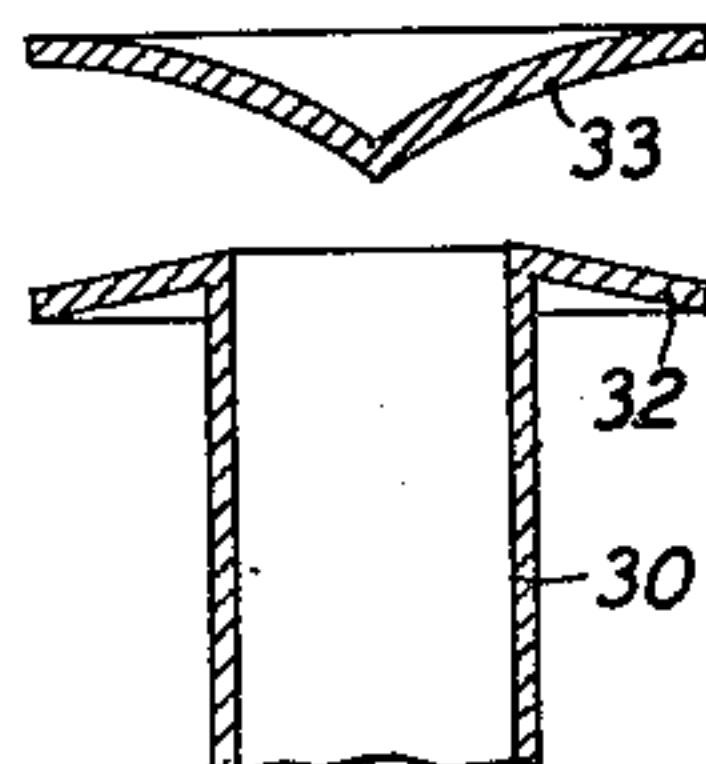


FIG. 14

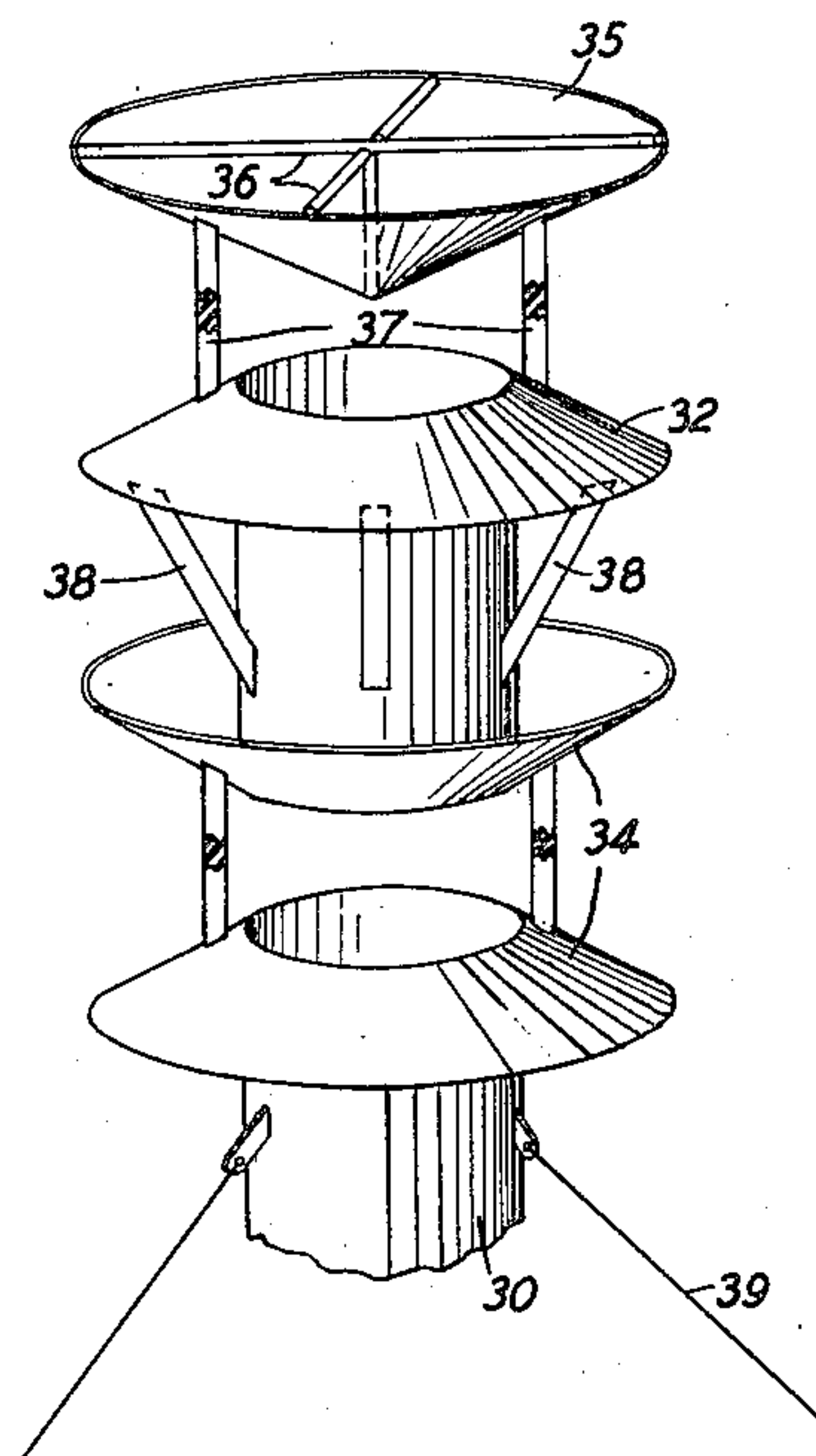


FIG. 15

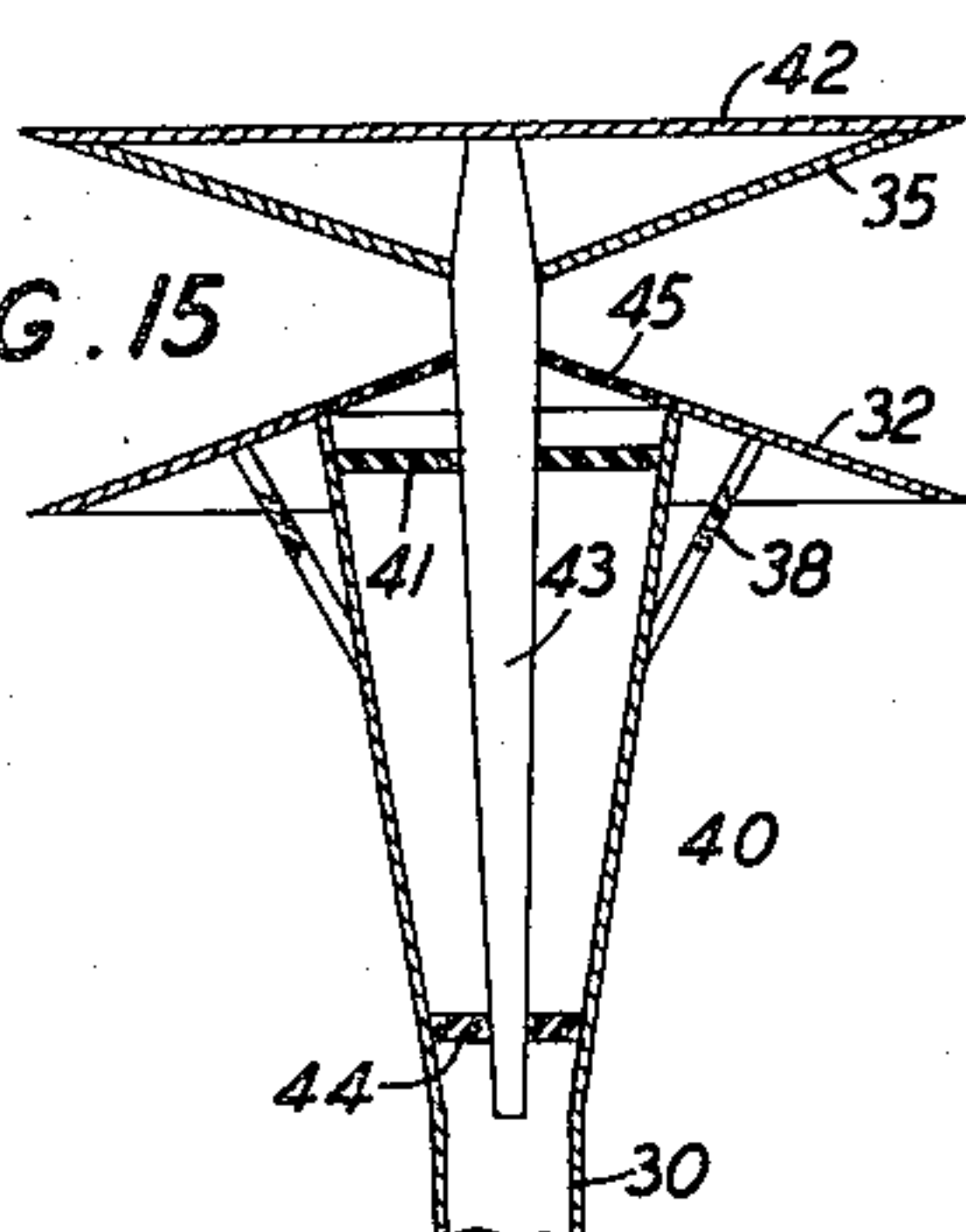


FIG. 16

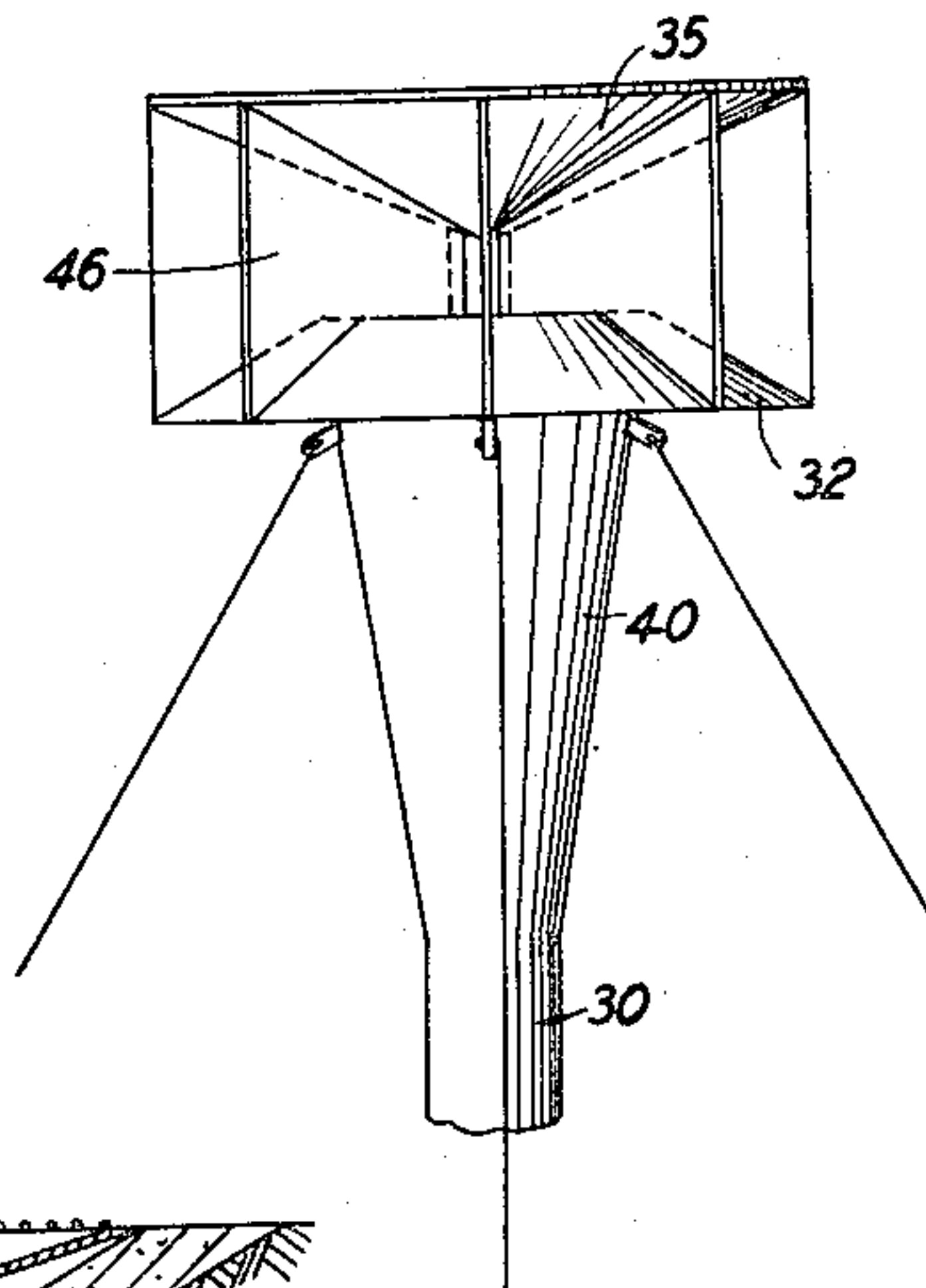


FIG. 17

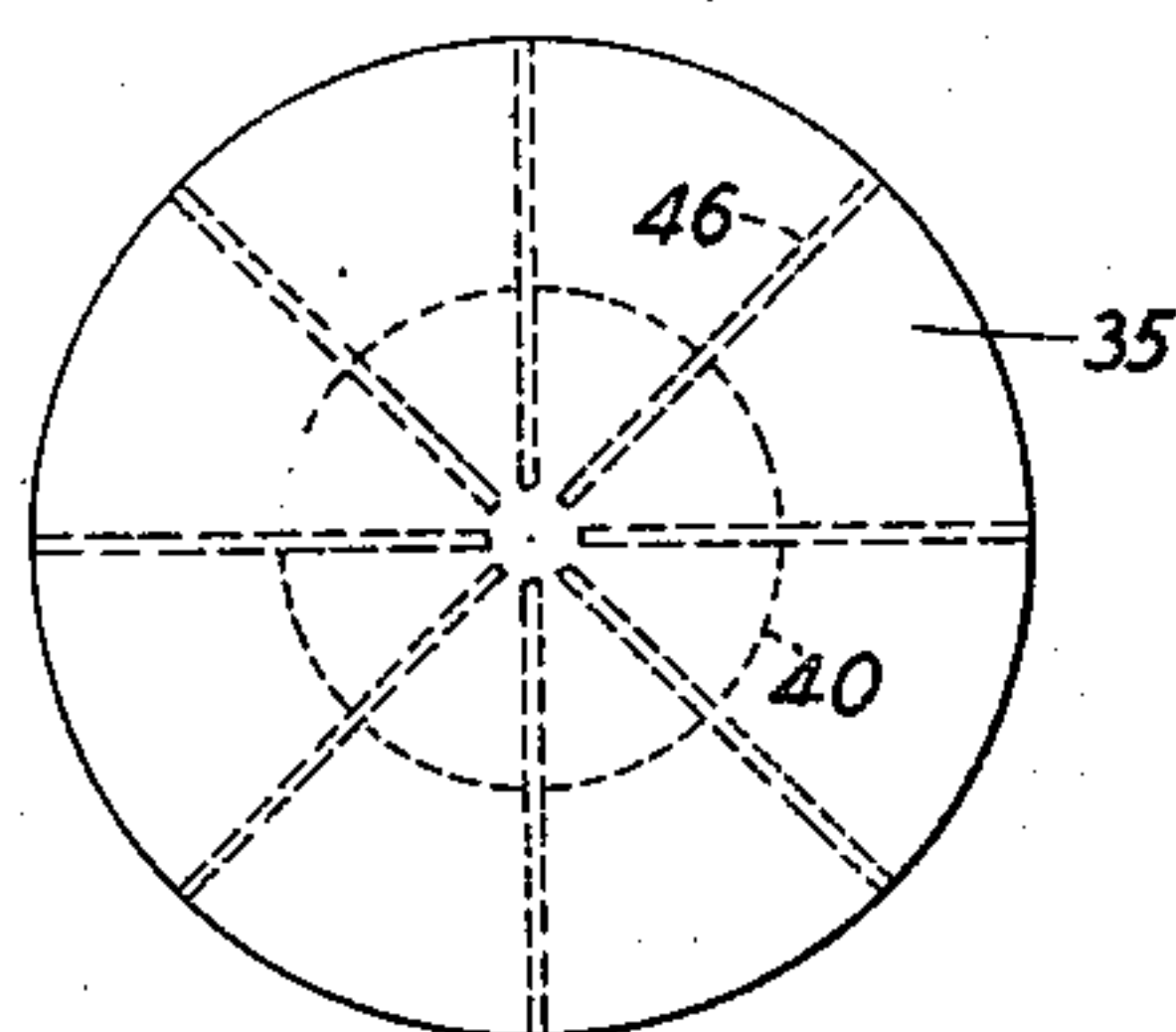
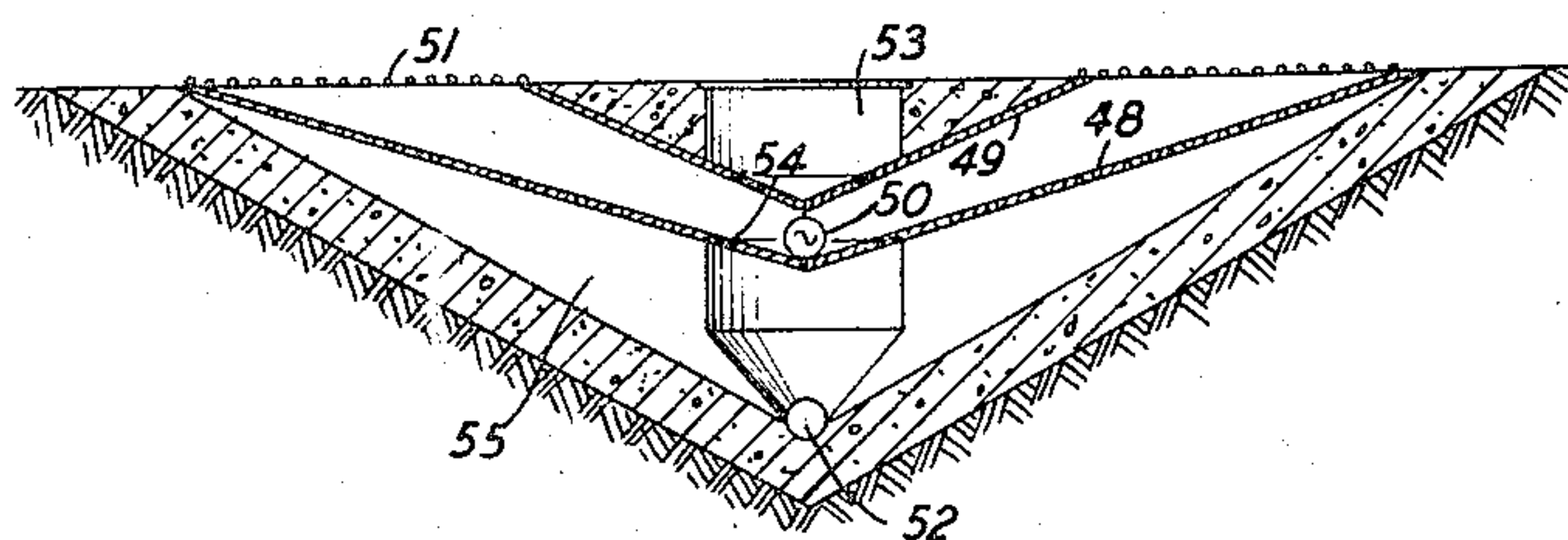


FIG. 18



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UNITED STATES PATENT OFFICE

2,369,808

SHORT-WAVE RADIO TRANSMISSION

George Clark Southworth, Red Bank, N. J., assignor to American Telephone and Telegraph Company, a corporation of New York

Application June 8, 1940, Serial No. 339,559

22 Claims. (Cl. 250—11)

This application is in part a continuation of my application Serial No. 743,753, filed September 12, 1934, which issued on July 9, 1940, as United States Patent No. 2,206,923.

The present invention relates to the radiation and reception of radio waves of ultra-high frequency and more particularly to apparatus and methods for the broadcast or wide angle radiation and reception of such waves. It has for a principal object the production of new and improved apparatus for the radiation and reception of high frequency electromagnetic waves.

In accordance with certain embodiments of the invention, electromagnetic waves are generated in a dielectric guide medium and launched from that medium into space for radiation in all lateral directions. In some embodiments dielectrically guided waves are established in a vertical, hollow metal pipe guide and radiated therefrom in all horizontal directions or in a plurality of preferred horizontal directions. Certain embodiments of the invention are featured by the provision of means for enhancing radiation laterally or radially from the open end of a hollow metal pipe guide. In accordance with certain features of the invention, electromagnetic waves are launched from or received at a point between juxtaposed metallic surfaces defining a radial transmission line or bi-conical structure. In accordance with other features a radiator of the latter kind is excited by means of a hollow pipe guide or other wave guiding transmission structure. The foregoing various embodiments and features are adaptable also to the reception of radio waves. The invention is further featured in certain aspects by the use of dielectrically guided waves of symmetric types as will appear hereinafter.

The nature of the present invention and its various objects, features and advantages including those mentioned hereinabove, will appear more fully on consideration of a limited number of specific embodiments of the invention which have been chosen for presentation in the following specification and accompanying drawings. It will be understood that this disclosure has relation principally to these specific embodiments and that the scope of the invention will be indicated in the appended claims. Referring to the drawings,

Figure 1 is a diagrammatic vertical section of a radiator having a directivity pattern that extends principally in all the directions of a horizontal plane;

Fig. 2 is a diagrammatic vertical section like

Fig. 1 but showing radiation from several sources arranged vertically one above another;

Fig. 3 is a diagrammatic vertical section like Fig. 2 but with variations of diameter of the guide instead of the use of metallic bands as in Fig. 2;

Fig. 4 shows a dielectric rod with radiation from an end portion of reduced diameter;

Fig. 5 shows a modification of Fig. 4 in which the non-radiating portion of the guide has a metallic sheath;

Fig. 6 is a diagrammatic vertical section of a radiator excited with symmetric magnetic waves; and Figs. 7 and 8 show details thereof;

Fig. 9 is a diagrammatic vertical section of a radiator excited with asymmetric electric waves; and Fig. 10 shows details thereof;

Fig. 11 is a diagrammatic vertical section of a radiator excited with asymmetric magnetic waves;

Fig. 12 is a vertical section showing a dielectric guide radiating vertically in combination with a conical reflector to enhance radiation in all substantially horizontal directions;

Fig. 13 shows a modification of Fig. 12 incorporating a bi-conical radiator fed from a metal pipe guide;

Fig. 14 is a modification of Fig. 13 showing details for the mechanical support of the elements;

Fig. 15 shows a modification of Fig. 14 and it is illustrative also of a manner of coupling a coaxial conductor line to the bi-conical radiator;

Figs. 16 and 17 show a further modification of Fig. 14 that is especially adapted for the use of waves of H_0 or symmetric magnetic type; and

Fig. 18 shows another form of bi-conical structure especially adapted as a radio aid to the blind landing of aircraft.

In my application, supra, in my U. S. Patents 2,129,711 and 2,129,712, both issued September 13, 1938, and elsewhere, it has been shown that electromagnetic waves can be propagated through dielectric rods and hollow metal pipes under certain circumstances of wave frequency, dielectric constant and electromagnetic field configuration. It has been shown and explained that there are various types of waves susceptible of propagation in the so-called dielectrically guided form, each type being identified by the characteristic spacial distribution of its component electric and magnetic fields. Certain types have been classified as magnetic, others as electric, and there has been a further subdivision of type into symmetric and asymmetric. Thus we shall have occasion hereinafter, as in the patents identified above, to

refer to dielectrically guided waves of symmetric magnetic type, for example, which may be alternatively designated mathematically as H_0 . Inasmuch as those skilled in the art are now familiar with the nature and characteristics of dielectrically guided waves and of the several wave types in particular, and of means for launching and receiving each type of wave, such matters will not be treated in detail herein but reference may be had to the literature of the art and to my prior application and patents. For the purposes of the present application the phrase "dielectrically guided waves" appearing in the appended claims may be understood as denoting wave transmission of the kind described, characterized in that the guiding structure presents to the waves the transmission characteristics of a high-pass filter the cut-off frequency of which is functionally related to a transverse dimension of the guiding structure.

Referring now to Fig. 1 there is represented an ultra-high frequency wave source 1 that is connected to the lower extremity of a coaxial conductor transmission line comprising a cylindrical outer conductor 2 and an inner axial conductor 3. At the upper extremity of the coaxial conductor line the inner conductor 3 is expanded into a cone 5 and the cylindrical outer conductor 2 is expanded into a corresponding funnel 4, the cone 5 and the funnel 4 being spaced apart and this space being a continued expansion upward of the space between the conductors 2 and 3. In a horizontal section at any height a constant ratio is maintained between the radius of the outer surface of member 5 and the radius of the inner surface of member 4.

The cone 5 has a flat metallic base 7 on top, and in the same plane therewith it is surrounded by a flat annulus 6, the central portion 7 and the flat annulus 6 being spaced by an annular gap 8. It will readily be seen that the lines of force which extend radially between the conductors 2 and 3 will pass up between the flaring members 4 and 5 and will arch across between the plates 6 and 7, as indicated in Fig. 1. All of the lines shown in Fig. 1 are electric lines of force; generally the magnetic lines are circles around the vertical axis of the coaxial conductor system 2-3.

Standing on the plates or electrodes 6 and 7 is a cylinder 9 of dielectric material. This may be regarded as a short section of cylindrical dielectric guide with vertical axis. Surrounding the base of the dielectric guide 9 is a conductive platform 10.

The waves in the dielectric guide 9 represented by the lines of electric force are broken off in loops and progress upwardly therein. These waves will be recognized as being of the symmetric electric type: electric, inasmuch as there is a component of electric force in the direction of propagation, and symmetric inasmuch as the field is uniform in all horizontal directions around the axis of propagation. These lines of electric force extend out into the space surrounding the guide 9 and form completely closed loops. The latter move out horizontally as well as upwardly and are detached as electromagnetic waves and radiated into space. It should be understood that the field represented by the lines of force in Fig. 1 is symmetric about the axis of the guide 9.

Generally the velocity of propagation in the material of the guide 9 will be less than in air or empty space. By a proper choice of diameter and dielectric material, this velocity may advance

tageously be made about one-half that of ordinary light. This means that the wave-length in the guide is one half that in the surrounding medium. A specific set of data giving satisfactory results is to employ an operating frequency of 1750 megacycles per second and to make the guide 9 of an insulating material having a dielectric constant of about 10 and hence an index of refraction of about 3.16. The wave-length in the guide depends upon both the diameter and the index of refraction. The diameter of the guide 9 is chosen at 6.54 centimeters so that the wave-length in the radiator shall be about one half that in the surrounding medium. The length or height of the cylinder 9 is about 4.5 centimeters which is slightly more than one half the wave-length in the dielectric.

The apparatus of Fig. 2 differs from that of Fig. 1 principally in that the cylindrical dielectric guide 9 with vertical axis has been much extended in a vertical direction and surrounded with a metallic band 12 at its base and other metallic bands 13 equally spaced along its height. As the waves represented by the lines of force within the guide 9 progress upwardly therein, part of their energy is radiated into the surrounding space between successive metal bands 12 and 13 as indicated in Fig. 2. The waves then move up to a position where the ends of the lines of force rest entirely on a metallic band such as 13 and in this stage there is no radiation in the immediately surrounding space. Then at the next stage higher up between the next two successive metallic bands 13, there is more radiation, and so on. Outside of the guide the lines of force become detached and link end to end to form the wave front, which presently straightens out vertically and moves radially outward from the guide. As in Fig. 1 the radiation is uniform in all horizontal directions from the guide 9.

Assuming that the material and the dimensions are so chosen in Fig. 2 that the wave-length in the guide is half that in the surrounding medium, then the radiating portions between the metal bands 13 will be spaced at intervals equal to the wave-length in the guide. Thus they will oscillate in the same phase as indicated by the arrows in Fig. 2. The dielectric material within the guide 9 may be gaseous instead of solid if suitable means are provided for supporting the metal bands 13. Appropriate supporting means are described hereinafter with reference to Figs. 14, 16 and 17.

Instead of suppressing radiation at points along the height of the guide 9 by means of metal bands 13 as shown in Fig. 3, this effect may be attained as shown in Fig. 3 by spaced enlargements of the guide. Within each enlarged part 15, the lines of force are closed within the guide, but within each reduced part they break out into the surrounding space and break off and link together end to end to give the radiated wave configuration indicated by the lines of electric force.

Where the diameter is increased as at 15, this has the effect of reducing the speed of propagation along the guide which requires the radiating parts of the guide to be brought nearer together.

In the modification of the invention shown in Fig. 4 a dielectric rod 16 is provided to convey the wave to the radiating portion 17. The rod 16 is of such diameter that the wave energy is largely confined within it, while the radiator portion 17 is also a dielectric rod, constituting an

axial extension of the guide 16, having reduced transverse dimensions such that the waves are radiated therefrom in the manner described with reference to Fig. 1, for example. The radiator portion 17 may be modified in the manner described with reference to Figs. 2 and 3 to enhance horizontal directivity. The waves launched into the guide 16 at its lower extremity may be symmetric electric waves or of any other desired type.

Fig. 5 shows a modification of Fig. 4 in which the dielectric rod 16 is replaced by a dielectric rod 18 having a metallic sheath 19. Because of the presence of the sheath 19 the diameter of the guide portion 18 may be reduced relative to that of guide 16 in Fig. 4 and as illustrated it is of the same diameter as the radiator extension portion 17.

Whereas the combination shown in Fig. 1 is designed for the use of symmetric electric waves, the combination shown in Fig. 6 is adapted for use with symmetric magnetic waves. The principal difference in structure lies in the coupling element 20 that is interposed between the end of the coaxial conductor line 2—3 and the dielectric radiating rod 9. Details of one form which the coupling element 20 may take are shown in Figs. 7 and 8. As will appear from the latter figures the coupling element comprises a strip-like conductor arranged roughly in a figure 8 and substantially coplanar, with the upper crossing branch 22 of the figure 8 connected to the projecting end of the inner conductor 3 of the coaxial line and with the other crossing branch 21 interrupted by and connected to the end of the outer conductor 2. The structure provides virtually a circular conducting path for the uni-phase flow of the exciting current. The radiating element 9 of Fig. 6 is about 60 per cent larger than the corresponding element of Fig. 1 for the same dielectric material and the same wave frequency.

It will be understood that the waves traveling up the coaxial conductor system 2—3 of Fig. 6, with the lines of electric force radially directed, are reshaped by the coupling member 20 and enter the dielectric guide 9 with the lines of electric force in the form of horizontal circles. From the guide 9 the waves are radiated out laterally into space with substantially uniform intensity in all horizontal directions.

For the radiation of waves of asymmetric electric or E_{11} type, two parallel conductor rods 23 are extended vertically upward from the source 1 as shown in Fig. 9. A high frequency alternating current is impressed across these conductors at their lower ends. At their upper ends they are terminated by the two plates or electrodes 24 and 25 having the shape shown in Fig. 10. The lines of electric force extend between these plates and some lines also extend across from each electrode 24, 25 to the annular base plate 26. The lines of force become detached and progress upwardly and expand laterally and spread out horizontally with the usual velocity of light in free space. The configuration of the electromagnetic field within the dielectric rod 9 is such as to suggest an analogy to the case of two ordinary linear antenna elements standing vertically at the two plates 24, 25 spaced one half wave-length apart and oscillating in opposite phase.

The horizontal intensity diagram for the system of Figs. 9 and 10 shows two maxima of in-

tensity in two opposite horizontal directions in the plane of the conductors 23 with null intensity at right-angles thereto. The same radiation of power measured in watts will give much more intensity in a preferred direction and its opposite than when the same power is distributed uniformly in all horizontal directions. If the same power is radiated in both cases, the gain in the preferred direction with the characteristic described is about three decibels. This means that one watt of power is as effective in the preferred direction as two watts would be when radiated uniformly in all directions. The antenna of Figs. 9 and 10 is very useful when it is desired to avoid interference with stations in lateral directions by suppressing radiation in those directions. The units of Figs. 9 and 10 can be combined in arrays, in the light of the analogy noted, to give enhanced directional selectivity.

Radiation of waves of asymmetric magnetic or H_{11} type may be effected by the system shown in Fig. 11. Here the source 1 puts a high frequency alternating current across the two parallel conductor rods 23 which diverge at their upper ends and are connected to two diametrically opposite points of the horizontal conductor annulus 27. The lines of electric force extend substantially parallel with the diameter of the annulus that connects the upper ends of the two conductors 23. These lines of force are propagated upwardly in the dielectric guide 9 and outwardly therefrom with a wave directivity pattern substantially the same as that obtaining with the Fig. 9 system. It should be noted that Fig. 11, like Figs. 6 and 9, represent unitary radiators and that they may be incorporated in multiple structure in the manner illustrated in Figs. 2 and 3.

Where a dielectric guide comprises a metallic sheath, I have found that dielectrically guided waves advancing through the pipe toward the open end are radiated therefrom with reasonable efficiency and that the directivity or field intensity pattern produced depends on the type of guided wave employed. I have found too that the directional effect can be substantially modified and the wave power largely confined to preferred directions of radiation by providing appropriate means at the open end of the pipe. For broadcast systems, that is, for radiation uniformly in all horizontal directions, I have found guided waves of symmetric type to be especially well suited. One example of practice in accordance with this phase of my invention will be described with reference to Fig. 12.

In Fig. 12 there is shown a vertical dielectric guide comprising a metal pipe 30 of circular cross-section containing only an air dielectric. At the lower extremity of the pipe 30, means (not shown) are provided for launching therein dielectrically guided waves of symmetric type, such for preferred example as symmetric magnetic (H_{01}) or symmetric electric (E_{01}), which advance upwardly through the pipe to the open end shown. Axially aligned with the pipe 30 and inverted above it is a conical metallic member 31. At the open end of the pipe 30 the guided waves are radiated outwardly with the wave power largely concentrated in the horizontal plane or approximately so. The directional pattern depends in part on the directional characteristic of the open-ended pipe 30 and in part on the reflection effect arising at the conical member 31, hence the pattern depends also on the shape and relative position of the member 31. The direction

of polarization of the radiated field depends on the type of guided wave employed, but in any case it is well known that the distant radio wave receiver should be so oriented with reference to the wave as to yield a maximum received signal.

A preferred embodiment of the invention, closely related to Fig. 12, is shown in simplified form in Fig. 13. This embodiment is, or may be, the same as that described with Fig. 12 with reference to the following modifications. First, the upper extremity of the pipe guide 30 is terminated in a downwardly extending frusto-conical flange 32; second, the strictly conical element 31 of Fig. 12 has been replaced by a semi-conical member 33 that is flatter and that is somewhat concave so as to better cooperate with the flange 32 to enhance the desired lateral directivity of the combination.

It will be seen that the members 32 and 33 of Fig. 13 form an outwardly directed horn having circular symmetry about the axis of the pipe guide 30 and that the horn so formed is excited approximately at its center by means of the pipe guide 30. In one aspect therefore, Fig. 13 may be understood as showing a substantially bi-conical horn having circular symmetry as described and a specific kind of exciter for transferring wave energy to and from the horn. Again, the proportions and spacing of the members 32 and 33 may be varied within wide limits to yield the precise directivity pattern desired.

Mechanical details appropriate for the support of the various elements of the combination in Fig. 13 are depicted in Fig. 14. Thus, internal bracing rods 36 are provided for the upper conical member 35 and insulating supporting rods or strips 37 are provided to support it. Bracing members 38, either metallic or of insulating material, are desirable if the material of the conical member 32 is not self-supporting or in any case where the radial extent of the member 32 is great enough to require additional structural strength. Guy wires 39 may be attached to the pipe 30 as shown.

In accordance with a further feature of the invention as illustrated also in Fig. 14, the wave guiding structure 30 may have one or more peripheral gaps spaced apart in the manner and for the purposes described with reference to Fig. 2. Each such gap may be provided with a pair of conical flanges 34 forming a bi-conical horn. Greater vertical directivity is obtainable by increasing the number of radiating orifices in the array, and it is therefore possible in any case to avoid the use of horns having a high degree of directivity but dimensions so great as to present serious difficulties in providing adequate mechanical support.

Another means of supporting the upper conical member 35 of Fig. 14 is shown in Fig. 15. In this case the upper end of the metallic pipe guide 30 is terminated in a slightly flaring portion 40 which at its upper extremity carries the lower conical member 32. At the upper end of the flaring portion 40 there is wedged an insulating disc or washer 41, and in the central aperture thereof is wedged the vertical tapering metallic rod 43. The upper portion of rod 43 extends through the vertex of the conical member 35 and its end abuts a metallic cover plate 42 that closes the otherwise exposed top of member 35. Additional anchorage for the supporting member 43 may be provided in the form of an insulator disc 44 near the lower extremity of rod 43. Rain and snow are excluded from the wave guiding system by means

of a dielectric cover 45 surrounding the rod 43 and covering the upper end of flaring portion 40.

The combination shown in Fig. 15 as above described is especially adapted for dielectrically guided waves of the symmetric electric type, for the transition of dielectrically guided waves of such type in the guide 30 to the coaxial extension thereof formed by members 40 and 43 is an easy and efficient one. The supporting rod 43 may be made of a dielectric material rather than of metal, if desired, in which case symmetric magnetic guided waves may be used, although even with this type of wave the rod may be of metal if it does not occupy too much of the total diameter. Where the support is of metal and symmetric electric waves are employed as described, they are converted at the lower end of rod 43 into coaxial conductor waves and as such they are transmitted to the horn members 32 and 35. These waves are then conveyed radially outward, with the members 32 and 35 constituting virtually a flaring radial transmission line, and they are radiated uniformly in all horizontal directions from the periphery of the line so formed.

Whereas all of the devices herein described are adaptable to use as radio wave receivers on substitution of an appropriate receiver for the source 1, it is especially evident in the case of Fig. 15 that a vertically polarized wave impinging from any direction on the periphery of members 32 and 35 will establish coaxial conductor waves between members 43 and 40 which will then be converted into symmetric electric waves at the lower end thereof for transmission to the receiving apparatus at the base of the pipe 30.

In lieu of the supporting structures shown in Figs. 14 and 15, the arrangement shown in Figs. 16 and 17 may be employed. The latter is especially adapted for the use of guided waves of symmetric magnetic type. In Fig. 16 the conical members 32 and 35 are separated and the upper one supported by a plurality of vertical, radially-directed metallic vanes or partitions 46, which extend from the periphery of members 32 and 35, horizontally over the top of the flaring guide portion 40, to a point just short of the axis. Where symmetric magnetic waves are transmitted through the guide 30, the electric field between the members 32 and 35 is horizontally polarized and symmetric about the axis so that the partitions 46 lie in equipotential regions and therefore do not disturb the outward progress of the waves. If symmetric electric waves are used on the other hand, the partitions 46 lie parallel to the electric field of the issuing waves, but a substantially uniform radiation pattern can be obtained nevertheless in this case by treating each of the compartments bounded by adjacent members 46 and the conical members 32 and 35 as a metallic horn and proportioning the parameters of each such horn to give the desired distribution of field intensity over a given fraction of the angular range to be covered. In view of the foregoing it will be evident that the vanes 46 can be used in the same manner in connection with the bi-conical horns of Fig. 14 and the spaced metal bands 13 of Fig. 2.

It is important to note with regard to Fig. 16 that the flaring extension 40 of the pipe guide 30 functions not only as a feeder but also as a horn. It introduces an initial gradual expansion of the electromagnetic field comprising the guided waves and the further expansion is effected in the bi-conical structure which is arranged as a hori-

zonally directed continuation of the vertical horn portion. Accordingly, for a given degree of field expansion a smaller bi-conical horn structure is required where a horn-like feeder is employed.

Another form which the radial transmission line or bi-conical horn may take is shown in Fig. 18 in its application to the blind landing of aircraft. Buried in the landing area, so that its upper extremity is flush with the ground level, is a first inverted conical metallic member 48, and above it and axially aligned therewith is a second similar member 49 of lesser conical angle, the two members 48 and 49 thus defining a bi-conical horn. Between the vertices of the two cones is connected a high frequency electromagnetic wave source 50 the waves from which are guided out to the periphery of the horn and radiated into space at a predetermined angle relative to the horizon. Covering the mouth of the horn is a grating 51 made up of metallic rods that are coaxial with the horn. These rods are at right-angles to the electric field emanating from the horn and hence do not interfere with propagation and radiation of the waves. To support the grating 51 and the material above the member 49, radial supporting rods or beams not shown may be provided just below ground level. Alternatively metallic vanes 46 as in Fig. 16 may be inserted between members 48 and 49 to provide the necessary mechanical support.

The lower conical member 48 may be perforated to allow rain water and snow to fall into the drainage space 55 below it for discharge through the drain 52. Above the drain is indicated a manhole 53 through which the central portion of the conical members within the annular overlapping joints 54 may be removed when servicing of the source 50 is necessary. It will be understood that the combination described radiates a wave having no lateral directivity but substantial vertical directivity so that a plane arriving from any direction and provided of course with suitable guiding equipment can glide down the radiated wave to a safe landing. It will be further understood that where horizontal directivity is required or desired, space between the cones may be divided by vertical septa into a plurality of horn-like portions only some of which are operative, or that individual sources and individual horns differently oriented may be substituted. As in all of the embodiments hereinbefore described, signals may be impressed on the waves generated by the source either for communication of intelligence or merely to distinguish the combination from other radio transmitters within the receiving range of the plane apparatus.

It is to be understood further that the embodiments herein disclosed are preferred illustrative embodiments and that the invention is susceptible of application in other and varied forms within the spirit and scope of the appended claims.

What is claimed is:

1. A radio antenna system comprising means defining a pair of conductive expanses juxtaposed and shaped to form between them a wave guiding passage that extends from an inner end in all azimuthal planes to an outer end that is open to free space for the radiation or interception of radio waves, one of said conductive expanses having an opening near the said inner end of the passage, and translating means coupled through

said opening in radio wave energy transfer relation with said passage.

2. A radio antenna system including means defining a pair of conductive surfaces spaced apart and forming between them a wave guiding passage that extends in all azimuthal planes from an inner end to a peripheral outer end open to free space for the radiation or interception of radio waves, one of said surfaces having an opening therein at the inner end of said passage, and radio wave translating means coupled to said passage through said opening.

3. In combination, a radial transmission line for electromagnetic waves comprising means defining a pair of juxtaposed conductive expanses each with substantial symmetry about a common axis, said transmission line flaring outwardly from the axial end thereof, one of said conductive expanses having an aperture at the axial end of said line, and translating means coupled to said line through said aperture for exciting said line or for receiving radio waves intercepted thereby.

4. A radio antenna system comprising means defining a pair of conductive expanses juxtaposed and shaped to form between them a wave guiding passage that extends from an inner end in all azimuthal planes to an outer end that is open to free space for the radiation or interception of radio waves, and a transmission line coupled to said passage and comprising a tubular conductor for the transmission of waves through the interior thereof, said tubular conductor opening into said passage near the said inner end thereof.

5. A system in accordance with claim 4 in which said conductive expanses lie wholly on opposite sides of a plane passing between them.

6. A system in accordance with claim 4 in which said transmission line is a uniconductor wave guide.

7. In combination, a pair of juxtaposed conductive surface members each defining an at least approximately conic surface, said members being spaced apart with said surfaces in axial alignment to form an electromagnetic wave guiding passage between them, one of said members having an opening therein at the axial end of said passage, a shielded transmission line coupled to the axial end of said passage for launching electromagnetic waves therein for radiation from the other end of said passage or for receiving radio waves entering said other end, said line comprising a tubular conductor the interior of which is connected through said opening in communicating relation with said passage.

8. A radio antenna system comprising a conductively sheathed dielectric guide with vertical axis and open upper end, a source or receiver of radio frequency electromagnetic waves coupled to said guide, an outwardly extending flange around said open end and an at least approximately conical reflector inverted above said open end whereby the radiation pattern of said antenna system is principally directed in a substantially horizontal plane.

9. In combination, a hollow pipe guide for ultra-high frequency electromagnetic waves, said guide having one end open for the radiation or reception of radio waves, conductive means defining a transmission line that extends outwardly from said guide on all sides thereof and that is mounted at the said open end for guiding said waves between said open end and the outer extremity of said transmission line, and translating means removed from said open end in energy transfer relation with the waves in said guide.

10. A combination in accordance with claim 9 in which said transmission line is flared.

11. In combination, a radial transmission line for electromagnetic waves comprising means defining a pair of juxtaposed conductive expanses each with substantial symmetry about a common axis, electromagnetic wave translating means at the axial end of said line for exciting said line or for receiving radio waves intercepted thereby, said transmission line having a flare substantially from said axial end to the peripheral end thereof, and said translating means comprising a tubular conductive wave guide.

12. In combination, a vertical hollow pipe guide the upper end of which is flared as a vertically directed horn, and a substantially bi-conical horn surmounting the said vertically directed horn for the radiation or reception of radio waves in substantially the horizontal plane, the length of said vertically directed horn being at least several times the wave length of said waves.

13. In an ultra-high frequency broadcast antenna system, a wave guide comprising a conductive pipe enclosing a dielectric medium, electromagnetic wave translating means for launching into said pipe or receiving therefrom dielectrically guided waves of symmetric type having a frequency above the cutoff frequency of the guide, said pipe being open-ended, and means at the open end for modifying the radiation pattern of the open-ended pipe.

14. A broadcast antenna system in accordance with claim 13 in which said modifying means comprises a conductive horn.

15. In combination, a hollow pipe guide one end of which is open; means removed from said open end for launching in said guide or receiving therefrom dielectrically guided electromagnetic waves of symmetric type, and means defining an approximately conical conductive surface inverted over and spaced from said open end for enhancing the directivity.

16. A combination in accordance with claim 15 comprising an external conductive flange surmounting the said guide at its open end.

17. In combination, a vertical hollow pipe guide the upper end of which is electrically open, means removed from said open end for launching into said guide ultra-high frequency electromagnetic waves of symmetric type for transmission to said open end, and means providing a conductive surface over said open end and spaced therefrom for impeding radiation of said waves in a vertical direction, whereby radiation in the horizontal plane is enhanced.

18. A combination in accordance with claim 17 comprising in addition an external conductive flange surmounting the said upper end of said pipe guide, said flange and said conductive surface constituting a transmission line for guiding said waves outwardly from said pipe guide.

19. In combination, a tubular uniconductor wave guide, and translating means for launching or receiving dielectrically guided waves therein, said tubular guide having a plurality of openings longitudinally spaced apart for the interception or radiation of electromagnetic waves, each of said openings being substantially continuous circumferentially of said guide and said openings being spaced in such relation to the length of such waves as to enhance the directivity.

20. A combination in accordance with claim 19 in which said guide is open-ended.

21. A combination in accordance with claim 19 including a bi-conical horn at each of said openings.

22. A vertical hollow uniconductor guide for the transmission of dielectrically guided waves therein, a substantially bi-conical horn surmounting the upper end of said guide for the radiation or reception of radio waves in the horizontal plane, and means supporting the upper member of said bi-conical horn comprising a rod anchored within said guide and extending axially through said upper end.

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