Oct. 29, 1957 D. B. HAAGENSEN 2,811,624

RADIATION SYSTEMS

Filed Jan. 7, 1954 2 Sheets-Sheet 1

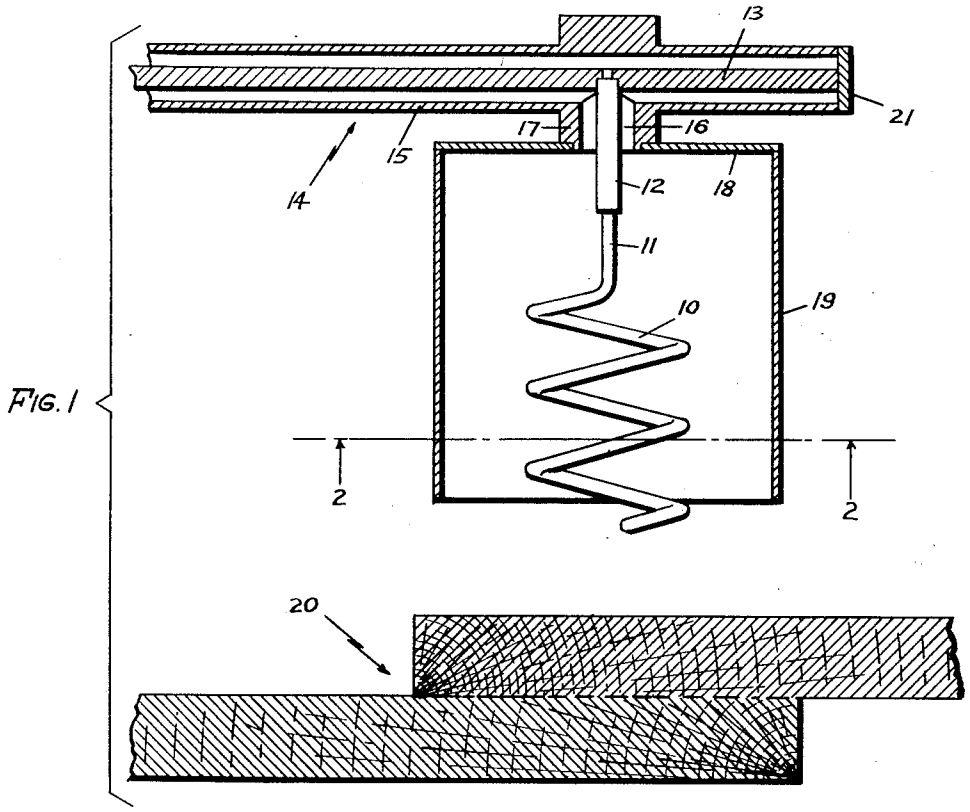


FIG. 1

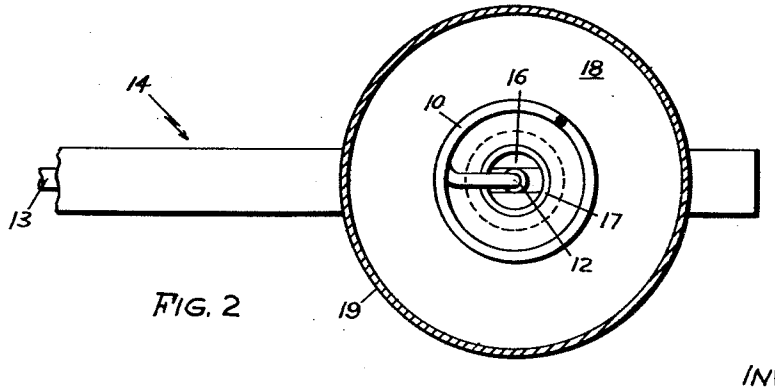


FIG. 2

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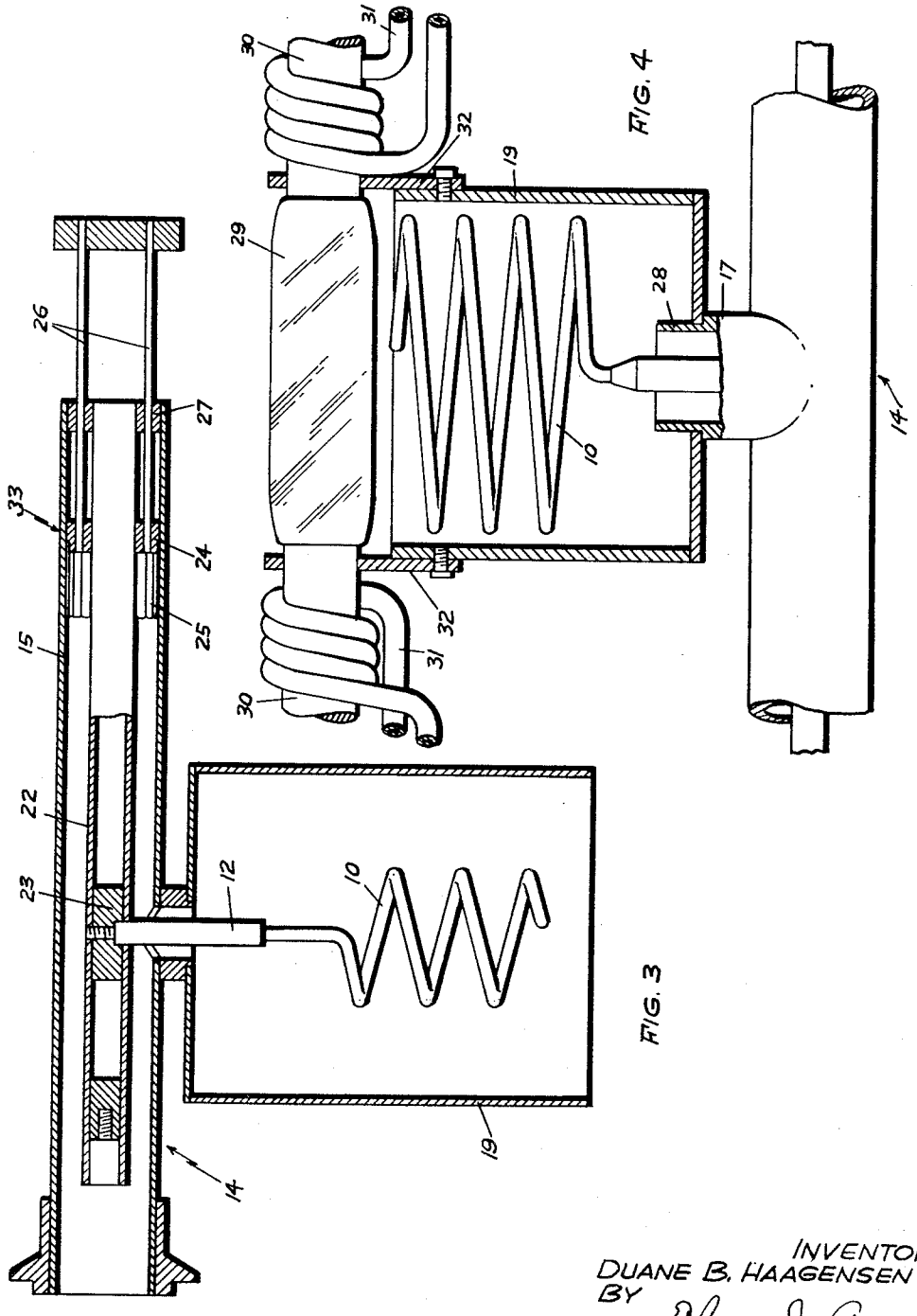


FIG. 4

FIG. 3

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RADIATION SYSTEMS

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6 Claims. (Cl. 219—10.55)

This invention relates to energy radiation systems and more particularly to a specific system found advantageous in directively radiating high frequency energy in a narrow pattern in any desired direction, and which is especially useful in directing energy toward a body to be heated which is positioned closely adjacent the radiation system.

Various types of directive radiating devices are well known in the art and have been used for radiating energy toward objects closely adjacent the radiating device. For example, a quarter wave length radiating probe with a reflecting dish has been used extensively for this purpose. However, such devices are difficult to impedance match over a wide range of frequencies and are susceptible to variation in the standing wave ratio with variation in the type and position of the object to be irradiated.

This invention discloses a device wherein the standing wave ratio may be relatively constant over a wide range of frequencies and for a wide variety of objects irradiated, with the objects being positioned in a relatively large variety of positions with respect to the radiating system. Briefly, the directive radiator comprises a helix surrounded by a conductive shield with one end of the helix being connected to the central conductor of a coaxial line feeding energy to the helix and the other end of the helix being unshielded, thereby radiating energy therefrom in a direction parallel to the axis of the helix in the form of a relatively narrow beam.

Other and further objects and advantages of this invention will become apparent as the description thereof progresses, reference being had to the accompanying drawings, wherein:

Fig. 1 illustrates a longitudinal cross-sectional view of one embodiment of the invention;

Fig. 2 illustrates a transverse cross-sectional view of the device shown in Fig. 1 taken along line 2—2 of Fig. 1;

Fig. 3 illustrates a longitudinal cross-sectional view of a second embodiment of the invention providing for adjustment of the impedance matching characteristic, and

Fig. 4 illustrates a longitudinal cross-sectional view of a further embodiment of the invention showing the use of the device of Figs. 1 or 3 to irradiate a fluid media.

Referring now to Figs. 1 and 2, there is shown a helical radiator 10 made up of conductive wire wound in the form of a helix. One end of the helix 10 is bent in to the axis thereof and extends outwardly from the helix along the axis thereof to form a lead-in 11. Lead-in 11 is rigidly attached to a support stub 12, which is connected, at right angles, to the inner conductor 13 of a coaxial line 14. The outer conductor 15 of coaxial line 14 has an aperture 16 therein through which support 12 passes, said aperture being joined to a cylindrical support structure 17 surrounding aperture 16 and support member 12, spaced therefrom, to form a portion of a coaxial line branching from coaxial line 14. A circular plate 18 is attached to the free end of support member 17 and has an aperture therein through which support

12 passes. As shown here, plate 18 is planar in form and is positioned at right angles to the axis of helix 10. If desired, plate 18 could be cup-shaped or could be positioned at other angles than at right angles to the axis of helix 10.

Attached to the periphery of plate 18 is a conductive cylinder 19, which is coaxial with helix 10 and extends along the outside of said helix to produce shielding thereof. The other end of cylinder 19 is substantially coextensive with the free end of helix 10. However, helix 10 may, if desired, protrude somewhat from cylinder 19 or may be recessed somewhat inside cylinder 19. As shown here, the diameter of cylinder 19 is substantially twice the diameter of helix 10, and, preferably, this ratio is used to produce relatively low losses in the shielding while still producing good directivity of the beam pattern which radiates from the free end of helix 10 along the axis thereof. In general, if the helix extends somewhat beyond the end of cylinder 19, the beam pattern is somewhat broader than if the helix is recessed inside cylinder 19. For good results, the diameter of the helix 10 should be substantially less than a wave length of the frequency being radiated by helix 10, and, preferably, is less than a half-wave length thereof. It has been found that good impedance matching may be achieved, which has a relatively low standing wave ratio over a wide range of frequencies, if the distance from the beginning of helix 10 along lead-in 11 and support structure 12 to the plate 18 is on the order of one-eighth wave length of the operating frequency.

The spacing between the turns of the helix 10 may be varied considerably while still maintaining satisfactory results. However, it is desirable, for high power applications, that the diameter of the wire of helix 10 be as large as feasible in order to avoid failure thereof either by bending or by overheating. It has been found that a wire diameter on the order of one-tenth inch works well with frequencies in the range from two to three thousand megacycles. In general, the spacing between turns of the helix 10 is substantially greater than the diameter of the wire with larger spacings of the turns being required for devices carrying higher powers to avoid breakdown by arcing between the turns. Good results have been produced with helixes having 2⅞ turns, 3⅞ turns or 5⅞ turns, respectively. Good results may also be obtained with the number of turns differing from the above numbers of turns by integral multiples of one-half turn.

As shown here, the coaxial line 14 is shorted, as shown, at a point spaced from member 12 by a distance somewhat less than a quarter wave length of the desired operating frequency of the device. The shorting is accomplished by means of a plug 21, which also acts as a support for the central conductor 13 of coaxial line 14, and hence is a support through member 12 and lead-in 11 for the helical radiator 10. The exact distance of the shorting plug 21 from the member 12 will vary somewhat dependent on the exact dimensions of the radiating system, but, in general, will be on the order of a quarter wave length.

As shown in Fig. 1, a lossy load to be heated may be positioned closely adjacent the end of helix 10. This load is illustrated at 20 as two pieces of wood overlapped, which are to be bonded by means of glue positioned therebetween. The glue is selected to have a somewhat higher loss factor than the wood, and hence would be heated by energy radiating from the helix 10, thus producing a heat curing of the bond between the wood pieces. This heat curing of the glue may be also accomplished in the presence of pressure, produced by clamps or any other desired means, between the pieces of wood. The coaxial line 14 is fed from any desired source of high

frequency energy, such as a magnetron oscillator, said energy being of any desired frequency, and, if desired, varying cyclically either in frequency or amplitude.

Referring now to Fig. 3, there is shown a further embodiment of the invention wherein the helix **10** is recessed slightly inside the cylinder **19**. As shown here, the helix is recessed inside the cylinder **19** and has 2⅞ turns. However, any desired number of turns could be used. In general, the greater number of turns, the sharper being the beam radiated from the end of the helix. The elements of Fig. 3 are substantially the same as those of Fig. 1, except that the central conductor **13** of Fig. 1 is illustrated herein as a hollow conductor **22** with a plug **33** therein at the point of connection of member **12** to central conductor **22**. In addition, a movable shorting assembly **23** has been substituted for the short **21**. The shorting assembly **23** consists of a plunger **24** positioned inside the outer conductor **15** and having resilient fingers **25** attached thereto which resiliently contact outer conductor **15** according to well-known practice. Plunger **24** is slidable in conductor **15** and is moved by means of rods **26** rigidly attached to plunger **24** and extending outwardly beyond the end of conductor **15** through a fixed plug **27** at the end of conductor **15**. By this arrangement, the distance from the short produced by plunger **24** to the point of connection of the member **12** to inner conductor **22** may be adjusted to accommodate widely different operating frequencies with optimum impedance matches and to match the radiating device **10** to a variety of different impedance high frequency sources feeding the coaxial line **14**.

It should be clearly understood that any desired impedance matching structure could be substituted for the shorting structures **21** or **23**, and, if desired, the helical radiator could be connected directly to the end of the coaxial line **14** with the desired impedance matching stubs being connected to line **14** as branch lines. In addition, the helical radiator **10** could, if desired, be fed from a wave guide or directly from the output of a magnetron oscillator.

Referring now to Fig. 4, there is shown the application of the devices of Figs. 1 through 3 to the irradiation of fluids. In Fig. 4 the helical radiator is of the same general type illustrated in Figs. 1 and 3, but occupies substantially the entire interior of cylinder **19**. While the losses in cylinder **19** are increased by positioning the helical director relatively close thereto, the directivity of the device is improved. Also, the support member **17** has an extension **28** thereof which extends somewhat into the cylinder **19** and has been found useful in improving the impedance match of the device. Positioned adjacent the open end of cylinder **19** is a tube **29** of material, which is transparent to the radiated energy from helix **10**, and may be, for example, glass or quartz. The axis of tube **29** is positioned substantially perpendicular to the axis of helix **10**, but any desired configuration of tube **29** or positioning with respect to helix **10** may be used. As illustrated herein, the ends of glass tube **29** are connected to metal pipes **30** by means of which a fluid to be irradiated may be circulated through tube **29**. As illustrated here, tubes **30** are cooled by means of cooling coils **31** surrounding tubes **30** and through which any desired coolant, such as water, may be passed. Tubes **30** are shown here as being supported with respect to cylinder **19** by means of support tabs **32** attached to cylinder **19**. The device so far described can be used, for example, to ionize gaseous media for spectrum analysis with the gaseous media passing through the glass tube **29** at any desired pressure.

This completes the description of the particular embodiments of the invention illustrated herein. However, many modifications thereof will be apparent to persons skilled in the art without departing from the spirit and scope of this invention. For example, the helical radiator could be used for directively radiating energy toward remote points, rather than those closely adjacent the radiator. The helix need not be circular, but could be wound in an oval, square, or rectangular shape, or with any other desired cross-sectional shape and the shield **19**, while preferably conforming to the cross-sectional shape of the helix, need not necessarily conform thereto, but could be rectangular or triangular while using a circular cross section helix. Accordingly, it is desired that this invention be not limited by the particular details of the embodiments disclosed herein, except as defined by the appended claims.

What is claimed is:

1. An energy radiation system comprising a helical radiator, a shield substantially surrounding substantially the entire length of said radiator, said radiator having an end which is free from shielding, and a body to be heated positioned adjacent said unshielded end of said radiator.

2. An energy radiation system comprising a helical radiator, a cylindrical shield substantially surrounding substantially the entire length of said radiator, said radiator having an end which is free from shielding, and a body to be heated positioned adjacent said unshielded end of said radiator.

3. An energy radiation system comprising a helical radiator, a coaxial line connected to said radiator, a shield substantially surrounding substantially the entire length of said radiator, said radiator having an end which is free from shielding, and a body to be heated positioned adjacent said unshielded end of said radiator.

4. An energy radiation system comprising a helical radiator, a coaxial line connected to said radiator at one end thereof, a shield substantially surrounding substantially the entire length of said radiator, the other end of said radiator being free from shielding, and a body to be heated positioned adjacent said unshielded end of said radiator.

5. An energy radiation system comprising a helical radiator, a coaxial line having its central conductor connected to said radiator, a shield substantially surrounding substantially the entire length of said radiator, an end of said helical radiator being free from shielding, and a body to be heated positioned adjacent said unshielded end of said radiator.

6. An energy radiation system comprising a helical radiator, a coaxial line having its central conductor connected to one end of said helical radiator, a shield substantially surrounding substantially the entire length of said radiator, the other end of said radiator from that connected to said central conductor being free from shielding, and a body to be heated positioned adjacent said unshielded end of said radiator.

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