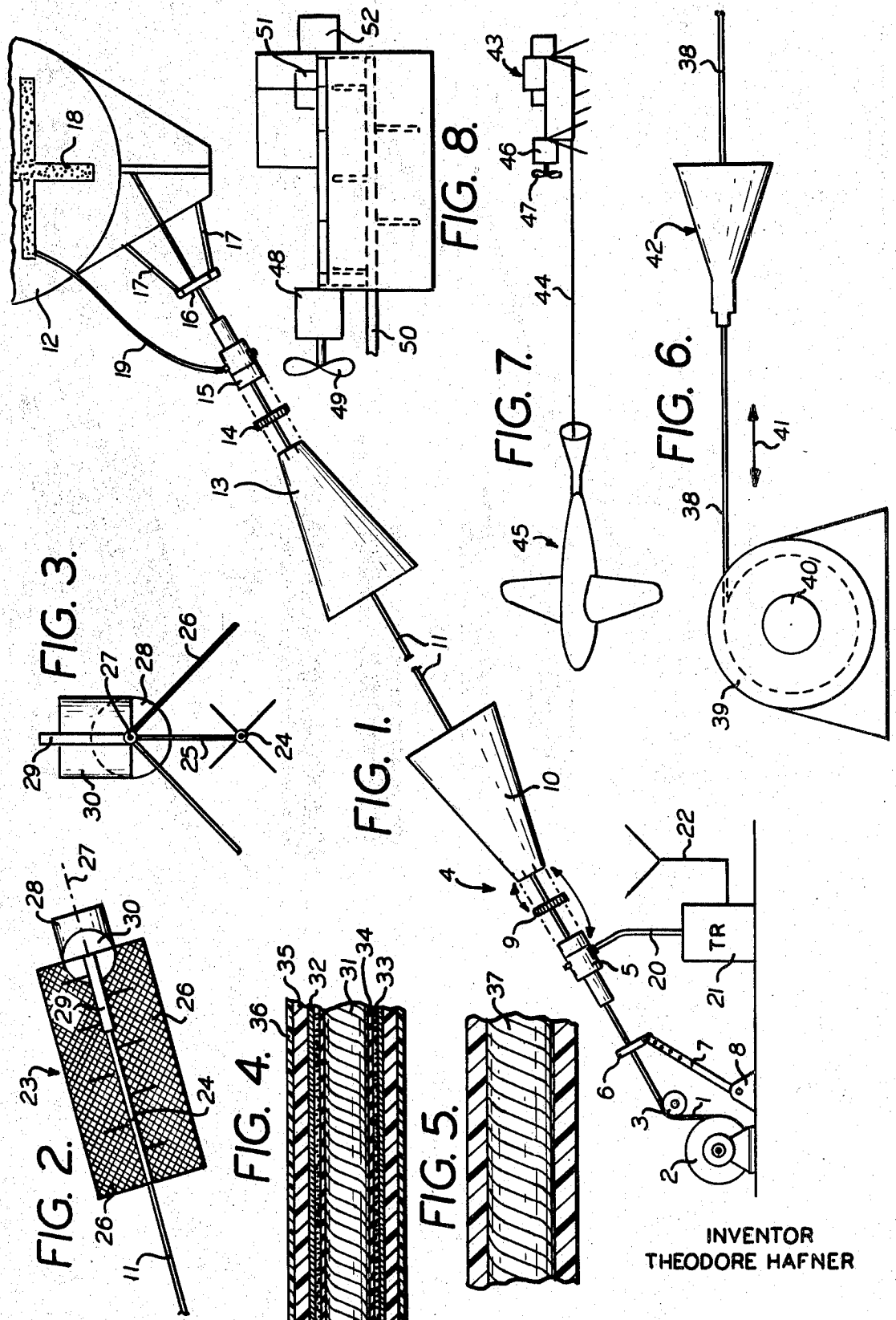
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EXTENSIBLE SURFACE WAVE TRANSMISSION LINE

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EXTENSIBLE SURFACE WAVE TRANSMISSION LINE

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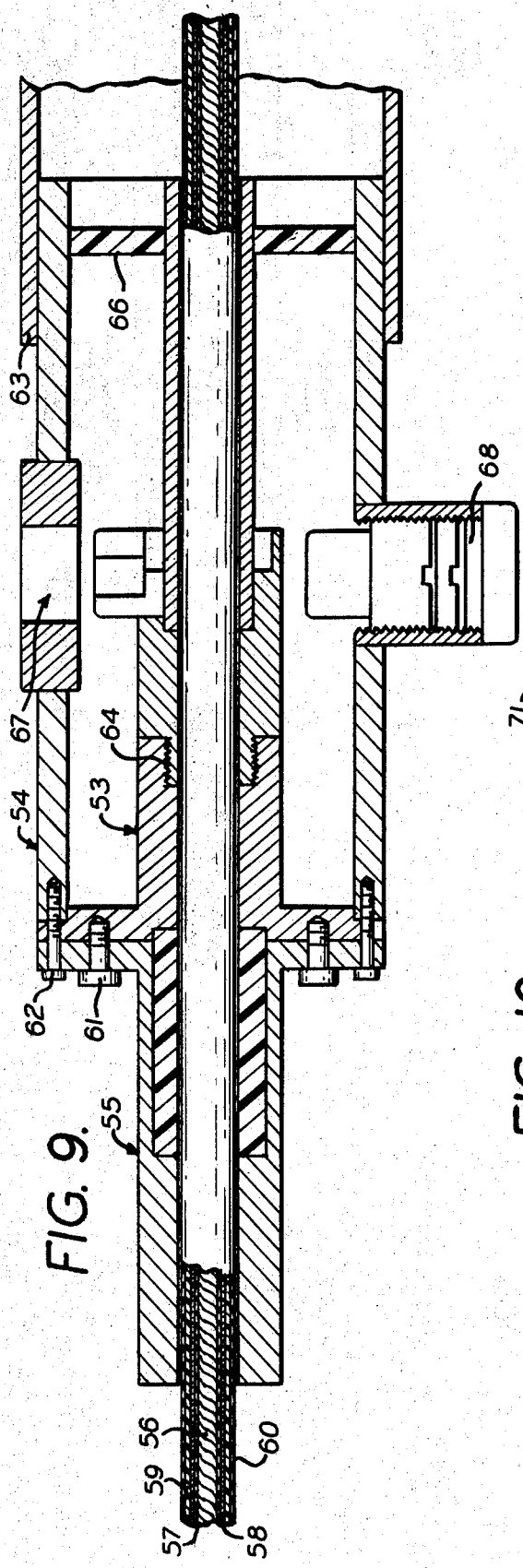


FIG. 9.

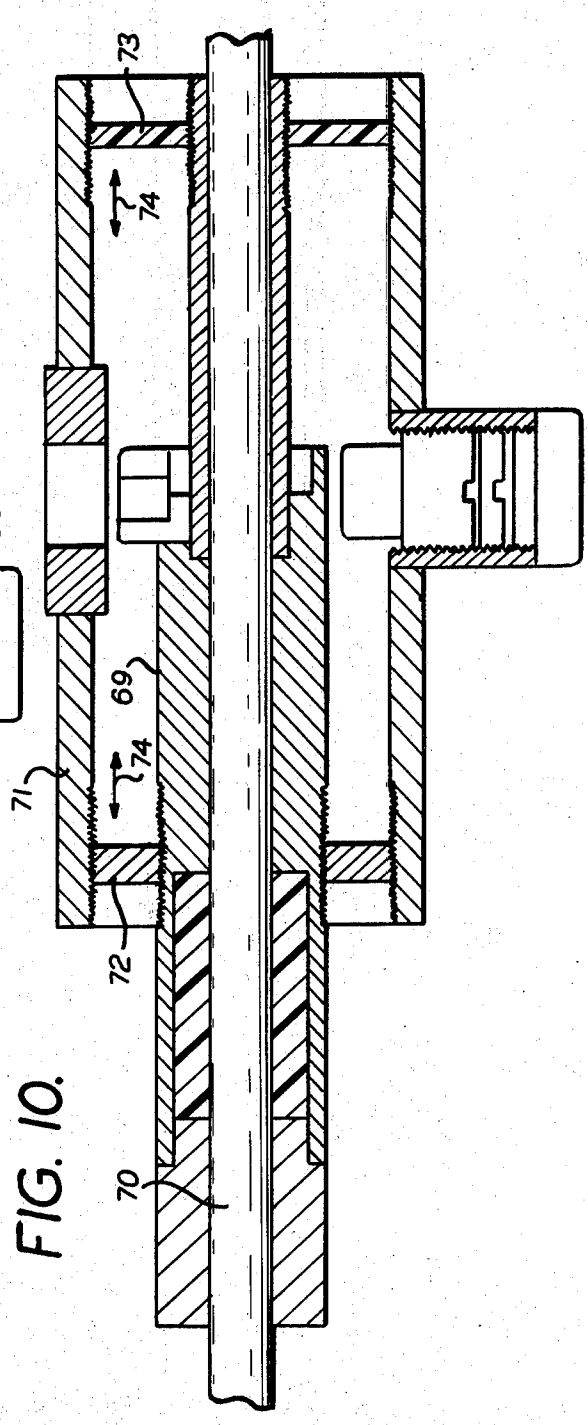


FIG. 10.

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FIG. 12.

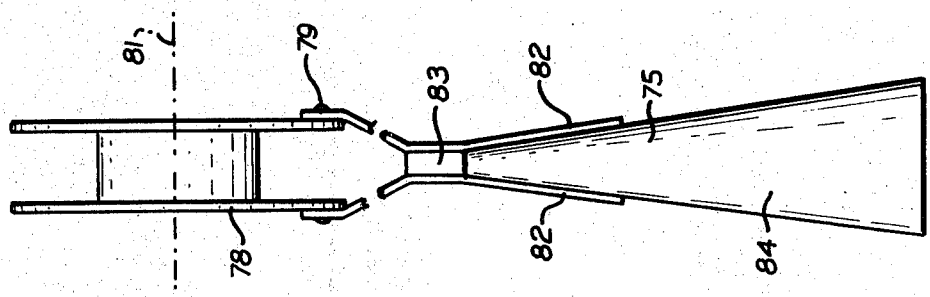
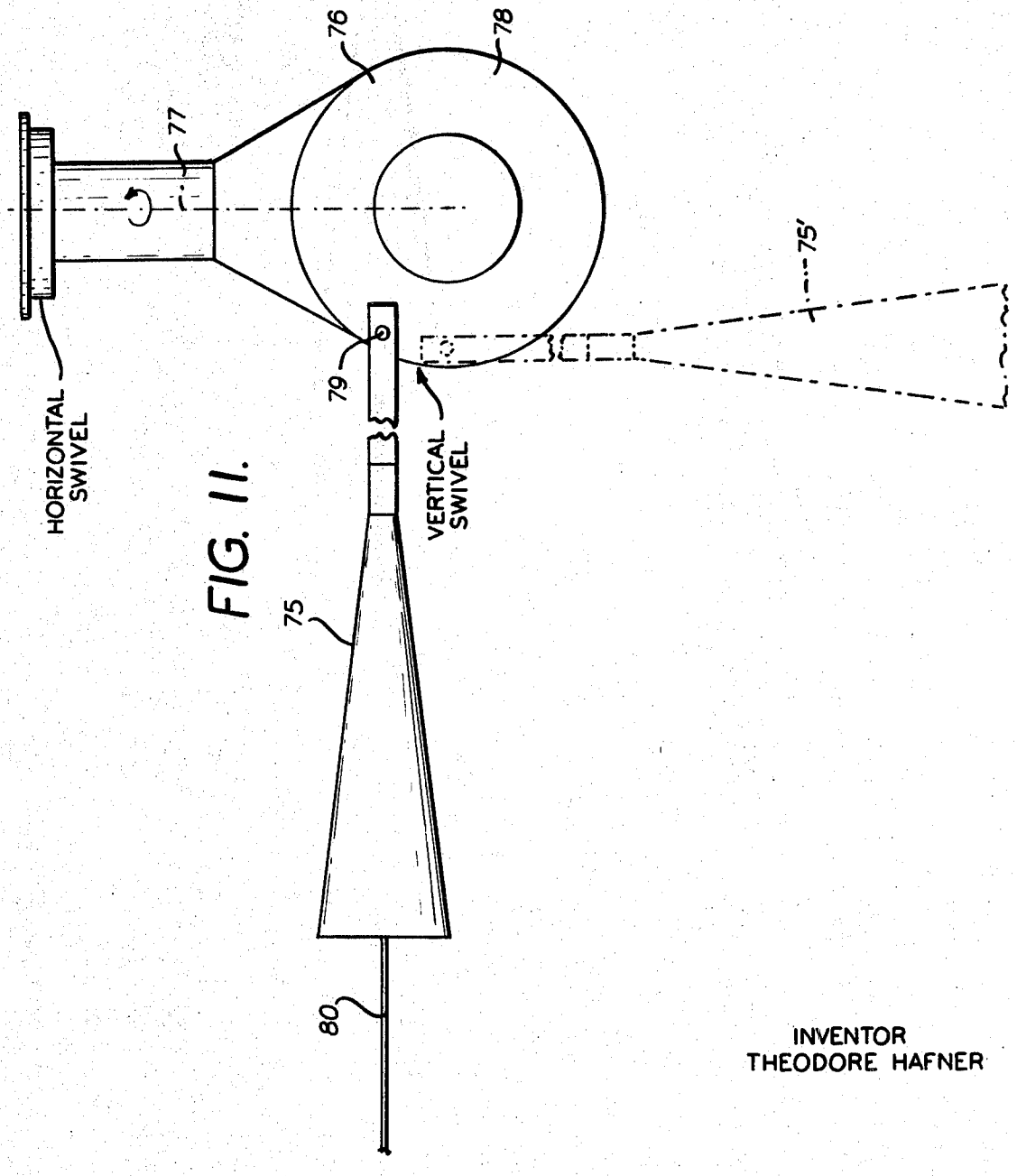


FIG. 11.



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EXTENSIBLE SURFACE WAVE TRANSMISSION LINE

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Int. Cl. H01p 3/12; H01q 1/28
U.S. Cl. 333—95 10 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to a surface wave transmission system, in which the closed end of the surface wave launcher is formed as a coaxial line having an inner conductor through which a surface wave conductor is movable, and an outer conductor conductively supported on one end, and dielectrically supported on the inner conductor on the other end of the coaxial line; and capacitively coupled to the inner conductor at an intermediate point of the coaxial line so as to permit tuning from the outside.

This invention relates to an assembly of a surface wave transmission line with a winding mechanism in which a surface wave transmission line, after passing the closed end of a surface wave launcher, is fed unto a winding mechanism to be wound on and wound off with a radius as not to produce a definite deformation of the line so that the line will straighten itself out automatically after being unwound and passing the launcher at its open end.

In a more specific embodiment, the invention consists of a flying body comprising an antenna structure, means for propelling said structure, means for controlling the position of said structure, a ground station and a tethering line connecting said structure to said ground station, said ground station comprising means for transmitting to, and receiving signals from said flying body; and said tethering line being in the form of a surface wave transmissing line of a predetermined frequency range, including a core of sufficient mechanical strength to serve as a tethering line, a conducting layer surrounding said core and a dielectric coating surrounding said foil of a thickness sufficient to maintain surface waves of said frequency range along said line, means on said ground station to transmit said surface waves, and means on said structure to receive said surface waves, said transmitting means including launching means, permitting slidable passage of said surface wave transmission line from its open end to its closed end, and means for selectively winding on and off said line when emerging from said launching means at said ground station.

These and other objects of the invention will be more fully apparent from the drawings annexed herein, in which FIG. 1 represents an extensible transmission line attached between a flying antenna structure and a ground station.

FIG. 2 shows a flying antenna structure in side elevation.

FIG. 3 represents a cross section through an antenna struction.

FIG. 4 shows a tethering line in accordance with the invention.

FIG. 5 shows a modification of FIG. 4.

FIG. 6 illustrates the specific structure of the tethering line in operation.

FIG. 7 shows a tethering connection between an airplane and a flying antenna structure.

FIG. 8 shows a specific flying antenna structure.

FIG. 9 shows one of the parts of FIG. 1, especially the balun in greater details.

FIG. 10 represents a modification of FIG. 9.

FIGS. 11 and 12 show in front and side elevations respectively, a specific winding mechanism for a surface wave transmission line such as illustrated in FIGS. 1 to 10.

As apparent from FIG. 1, a surface wave transmission line such as illustrated in greater details in FIG. 4 or 5 is shown at **1**, emerging from a motor-operated drum **2** and passing over rollers **3** to a surface wave launcher (or receiver) **4** which is shown in an exploded view.

In this view, a balun **5** or transducer is indicated attached at **1** and it is adjustably connected through a clamp **6** and adjustable brackets **7** to a ground support at **8**. The other end of balun **5** is attached by another clamp **9** to horn **10** from which the surface wave conductor emerges at **11** to extend over the desired distance to a flying antenna structure which in this case may be part of a balloon, helicopter or airplane, schematically indicated at **12**.

At the top end, the surface wave conductor **11** enters a receiving horn **13** which, when assembled, forms, together with clamp **14**, balun **15** and clamp **16**, a surface wave receiving structure which is substantially identical with the launching structure described above.

While both surface wave launching and receiving structures are substantially supported, riding only on the surface wave conductor **11**, which passes through them, the bottom launcher is also held back by link structure **7**, and the receiver at the top by one or more steel ropes **17**, all this, of course, without impeding the winding on and off of line **11** by motor-operated drum **2**.

Balloon **12** may have printed thereon a cross-shaped antenna pattern, schematically indicated at **13** and connected by coaxial cable or any other transmission line indicated at **19**, to the top balun **15**.

Similarly, at the other or bottom end of line **11**, the bottom balun **5** is connected through a coaxial cable **20** or any other transmission line, to a receiver or a transmitter, or a transmitter-receiver unit, indicated at **21**, in case the antenna pattern **18** at the top is to serve as a receiver, transmitter antenna or as both, transmitter and receiver antennas respectively.

If required, ground station **21** may be controlled by, or may be used to control, other equipment over a ground antenna schematically indicated at **22**.

FIG. 2 illustrated a specific flying antenna structure in which the surface wave transmission line **11** is terminated at the top, not in a horn type surface wave receiver which has to be connected to a flying antenna, such as **18** in FIG. 1, but line **11** is connected directly to a turnstile antenna structure which is attached to line **11** and/or an extension of line **11**, and which is schematically shown at **23** (see also the cross-section shown in FIG. 3) which has been so designed that the surface wave field of transmission line **11** is matched with the wave field of turnstile antenna **23**.

In order predeterminedly to direct the generally omnidirectional radiation pattern of such a turnstile antenna **23**, the supporting stem **24** of the turnstile antenna **23** supports on insulating stub **25** the metal screen **26** which also forms the wings of the flying antenna structure **23**, which are movably hinged to each other at **27**, thereby insuring a desired directivity of turnstile antenna **23**.

Control of the movements of these wings **26**, around their common axis **27**, is effected by a motor **28** and by signals derived from the ground station **21** over line **11** which, as indicated above, not only serves as a mechanical tethering line but also as a high frequency transmission line for surface waves which have a considerable bandwidth or channel-carrying capacity.

In order to further, and predeterminedly, stabilize the flying antenna structure an adjustable horizontal flap is attached at **29** to the wings **26**. Flap **29** is controlled by a motor **30** which is also controlled by signals derived from transmission line **11**.

Flap 29 and wings 26 and their controls, may be effectively realized in any desired manner and, if necessary, as in any airplane, be formed as parts only of wing and flap surface which are made adjustable and thereby controllable, all this without departing from the scope of this invention.

FIG. 4 shows a specific surface wave conductor, consisting of a stranded steel rope 31 of sufficient mechanical strength to support the wind velocity and other stresses encountered in its operation as a tethering line.

In order to act as a surface wave conductor, steel rope 31 is surrounded by a conducting layer 32 which may be either a copper foil, or the like highly flexible conducting layer, or a sodium coating, and as schematically indicated in the drawing, separated if necessary from the steel rope 31 by an adhesive layer 33 which may also be conductive to increase the consistency of conduction, especially at the high frequency under consideration, characteristic of surface wave transmission.

Another layer or coating which may be insulating in character as indicated at 34, may serve to insulate the conducting layer or layers 32, 33 from steel rope 31, thereby permitting additional direct or alternating currents to be fed through the cable to provide energy to motors or other equipment on the flying antenna structure, and/or heat the surface wave conductor sufficiently to prevent excessive ice or sleet formation which would impair operation, or at least increase the loss of surface wave propagation. The pure polyethylene, 35, which maintains the surface wave, is protected by a black polyethylene skin 36.

On top of conducting layer or layers 32, 33 is arranged an insulating coating 35 of low-loss plastic such as pure polyethylene or Teflon to concentrate the surface wave to a radial distance corresponding to that of the surface wave field radius, or the radial dimensions of the launching and receiving structure, which are generally of the order of one wavelength of the operating frequency range.

In case polyethylene is used for surface wave concentration, the pure polyethylene sheeting is covered with a thin skin of black polyethylene which assures weather resistivity without substantially increasing propagation losses.

Conductive layer or layers 32, 33 may be replaced by a single copper foil embedded or sandwiched in a plastic medium such as polyamid which is highly flexible, thereby supporting the conducting layer in the various winding operations imposed on the cable. If necessary, the plastic may also be provided on one or both sides of the sandwich with an adhesive to increase the overall stability and especially the flexing strength of the structure.

In a modification of the surface wave conductor shown in FIG. 5, the steel rope and its conductive coating is replaced by finely stranded steel wire in which each strand is individually copper-coated or -plated in the form of a Teflon (trademark) coated Copperweld (trademark) or Copperply (trademark) wire 37 which, by the number of strands, can be adjusted to the desired high tensile strength and elasticity, say 4000 lbs. breaking strength, without losing its elasticity and flexibility so that it can be continuously wound on and off a relatively small drum which, for example, may have a diameter of 15" for an overall cable diameter of ¼", or generally with a ratio of cable diameter to drum diameter of the order of at least 1:50.

FIG. 6 explains the function of a surface wave cable such as illustrated in FIGS. 4 and 5, in which cable 38 under control of a drum 39 operated by motor 40 is arranged to travel in either directions 41, passing a launching or receiving structure as schematically indicated at 42. While conductor 37 is wound on drum 39 it is elastically and not permanently deformed. As it is wound off drum 39 and as it passes the launching or receiving

structure 42, cable 37, under control of its own elasticity, will automatically become straight, thereby transmitting the surface wave with a minimum of loss.

As apparent from FIG. 7 a flying antenna structure 43 such as illustrated in FIGS. 2 and 3, is tethered through a surface wave conductor 44 from an airplane schematically indicated at 45.

In addition to wing and flap controls effected through surface wave conductor 44 in the manner described with respect to FIGS. 2 and 3, the antenna structure 43 may be propulsed itself by a motor 46 fed through line 44 (see two conductor arrangements 31, 32, FIG. 4) and driving a propeller 47, and also controlled by command signals derived from airplane 45 through the tethering surface wave conductor 44.

In an alternative arrangement, shown in FIG. 8, motor 46 may be formed as a generator 48 which is driven by propeller 49 under control of the motion asserted by line 50, and the current of generator 48 may be used to energize the flap and wing control motors indicated at 51 and 52 respectively.

FIG. 9 shows in side elevation and in cross-section one of the coaxial transducers or baluns shown in the exploded views of FIG. 1.

As apparent from FIG. 9, the transducer consists essentially of three portions: a central portion 53, a front portion 54, and a rear portion or filter portion 55, which are all screwed together to form a solid unit and therefore, if necessary, can be replaced by the same or other parts fitting different frequency range requirements.

Passing through portions 53–55 is a surface wave conductor consisting of a stranded steel rope 56 surrounded by a thin dielectric layer 57, a copperfoil 58, preferably attached by an adhesive (not shown) to layer 57, and surrounded by the field concentrating dielectric 59 proper, which consists of pure polyethylene schematically indicated at 59 which, if necessary, may be further protected by a thin black outer polyethylene layer 60.

If necessary, copperfoil 57 may also be attached by an adhesive to layer 59. Layers 58, 59 may be replaced by a Teflon or equivalent coating to produce minimum loss with maximum weather resistivity and optimum abrasive characteristics.

The elastic flexibility of rope 56 combined with layers 57 and 60 may be such as to produce the desired alternative straightening out and curving required in accordance with the invention, during the different winding and unwinding operations.

Portion 55 has a Teflon cylindrical sleeve insert which operates as a filter and the entire part 54, of course, can be replaced in accordance with the mechanical requirements of wear and tear, but also depending on the particular operating spectrum required of the surface wave conductor.

Center portion 53 is attached to end portion 55 by screws 61 and is further attached by other screws 62 which also connect the outer or filter portion 55 to center portion 54 to which at its other end the horn 63 is connected. The inner conductor of the entire balun structure is connected at one end to 53 by a screw connection 64 and at the other end is spaced from portion 54 by a dielectric window 66 of plexiglass or the like. Portion 54 also supports at 67 the coaxial connection of the balun to the outside and a diametrical position 68 an adjustment probe for correcting the operating frequency range or bandwidth within certain limits.

FIG. 10 shows balun continuously adjustable for a variable frequency range. In this case, the inner conductor 68, supporting a surface wave conductor 70 proper is provided with a very fine outer thread. Similarly, the outer conductor 71 of the balun is provided with a fine inner thread. These threads permit the end plates of the balun, namely the conducting end plate 72 and the dielectric end plate 73, to be adjusted in directions indicated by arrows 74 and thereby adjust to operating frequency range of the balun in a predetermined manner.

FIGS. 11 and 12 show a launching or receiver unit **75** attached to a reel **76** of otherwise well-known construction, which is arranged rotatable or swiveling around a vertical axis **77**. Launching unit **75** itself is attached to drum **78** rotatable about a horizontal axis schematically indicated at **79**. In that way, launcher unit **75** under control of the drag exerted by the surface wave conductor **80** emerging from launcher unit **75** may assume any position between the horizontal position shown in FIG. 11 at **75** in full line, and the vertical position **75'** shown in dotted line, thus reducing strain on the entire structure as well as its individual parts to a minimum.

FIG. 12 shows in somewhat greater detail how the launcher unit **75** is attached to the walls **78** which in turn must be rotatable about drum axis **81** by means of a pair of brackets **83** connecting the outer walls **78** of drum **76** over the balun **83** to the horn **84** of the launcher unit **75**. At axis **79** brackets **82** are mounted rotatably so as to permit the self-adjustment of the position of launcher unit **75** in accordance with the principles set forth above, to be affording electric connection of the surface wave conductor and continuous transmission of the surface wave from launcher to receiver and conversely, during the winding and unwinding operations with a minimum of strain.

While the invention has been described and illustrated with certain arrangements of conductors, insulators, launchers, receivers, antennas, terminal and control equipment, it is not limited thereto but may be applied in any appropriate form or manner whatsoever without departing from the scope of this invention.

What is claimed is:

1. In a surface wave transmission line assembly, a surface wave launcher, a surface wave transmission line passing through said launcher, from its open to its closed end; the closed end being formed as a coaxial line having an inner conductor permitting said surface wave transmission line to freely move through said inner conductor; and an outer conductor conductively supported on said inner conductor at one end, and dielectrically supported on said inner conductor on the other end of said coaxial line, and capacitively coupled to said inner conductor at an intermediate point of said coaxial line so as to permit tuning from the outside, of the energy fed through said coaxial line from and to said surface wave transmission line, substantially without being affected by the movement of said surface wave transmission line through said inner conductor; means for selectively winding on and off said surface wave transmission line after having passed through said launcher at its closed end; said surface wave transmission line being wound with such a radius as not to produce a definite deformation of said line so that said line will straighten itself out automatically after being unwound and passing through said launcher at its open end.

2. Assembly according to claim **1** wherein said surface wave transmission line consists of a flexible elastic steel rope surrounded by a copper foil and a dielectric coating surrounding said copper foil.

3. Assembly according to claim **1** wherein said surface wave transmission line consists of stranded copper coated steel wire, whereby the stranding occurs substantially on the surface of the rope, said rope being surrounded by dielectric coating.

4. Assembly according to claim **2** wherein said dielectric coating consists of Teflon.

5. Assembly according to claim **2** wherein there is provided an additional insulation between the copper foil and the steel rope.

6. Assembly according to claim **2** wherein said launching means are arranged to swivel with respect to said winding means so as to permit said launching means to follow the movement of the line during winding and unwinding operations.

7. Assembly according to claim **2** wherein said winding means are arranged to swivel with respect to their support so as to permit said winding means to follow the movement of the line during winding and unwinding operations.

8. Assembly according to claim **2** wherein said winding and launching means are rigidly attached to each other to form a solid unit, said unit being arranged to swivel so as to permit it to follow the movement of said line emerging from said launching means at its open end.

9. Assembly according to claim **2** wherein said winding and launching means are flexibly coupled to each other so as to permit said launching means to follow the movement of said line during winding and unwinding operations.

10. Assembly according to claim **2** wherein said launching means, at its open end, has a horn portion to which feet guiding means are attached by means of radial strings.

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