

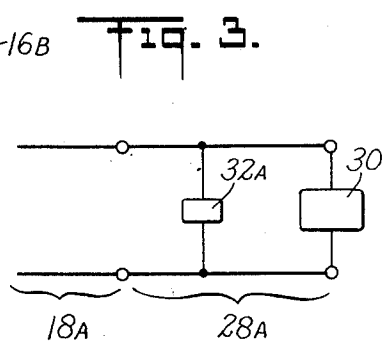
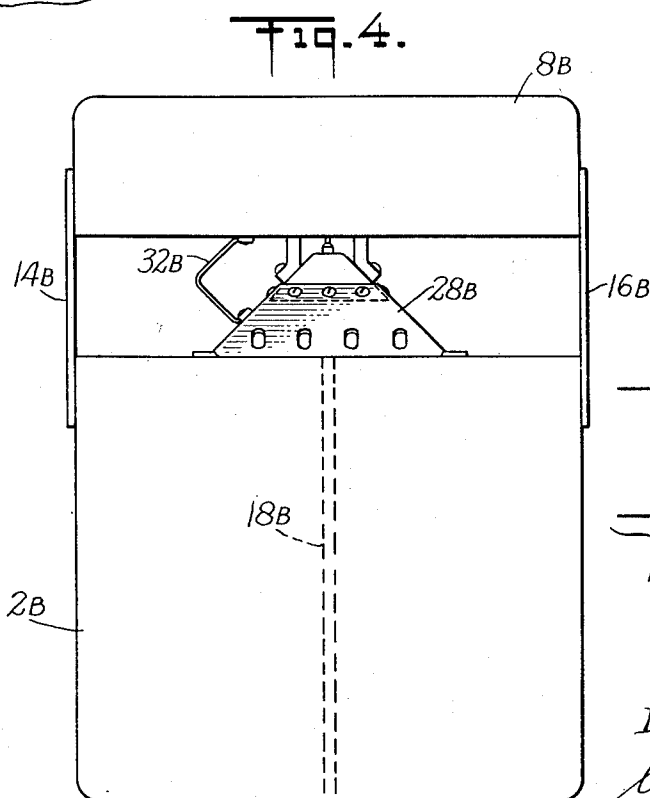
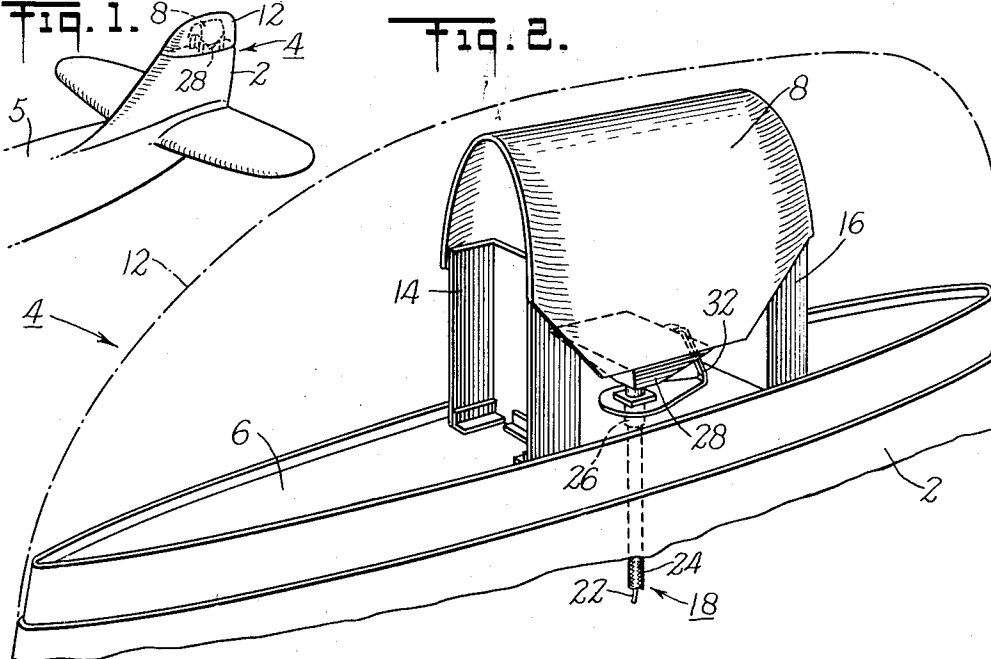
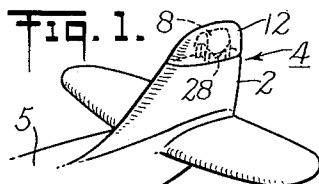
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D. F. BOWMAN
ANTENNA FEED SYSTEM

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2 Sheets-Sheet 1



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Fig. 5.

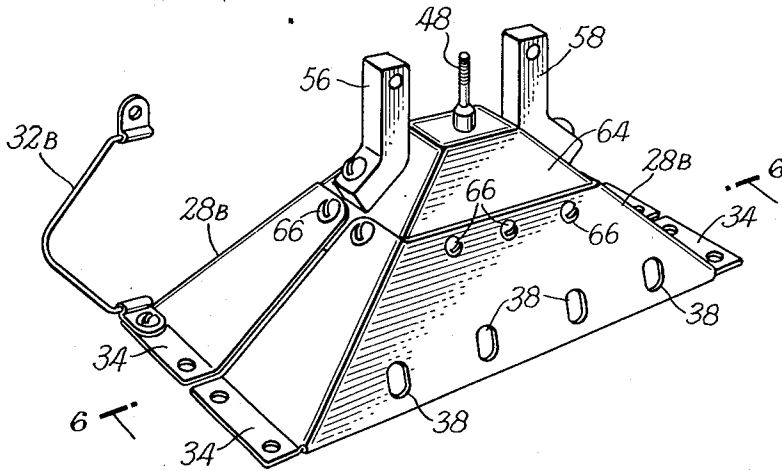
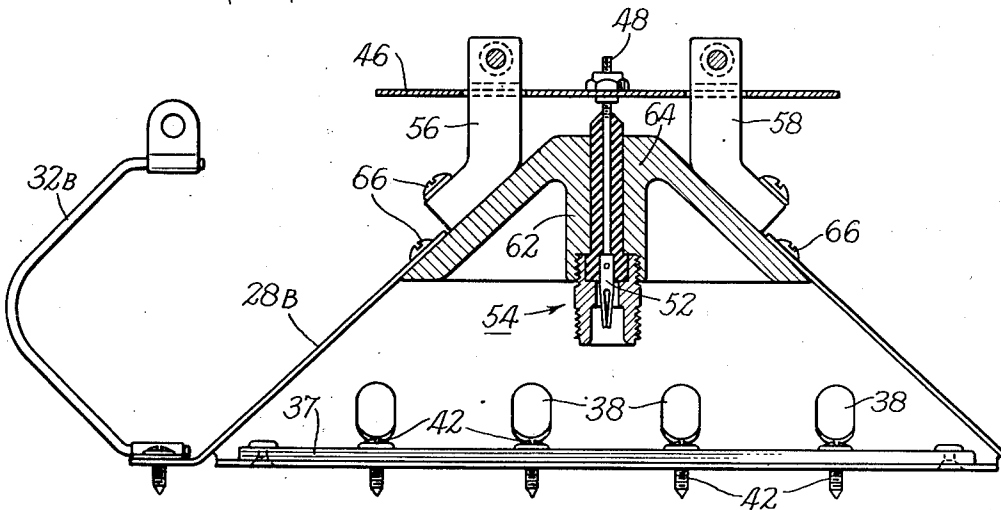


Fig. 6.



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ANTENNA FEED SYSTEM

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5 Claims. (Cl. 250—33)

This invention relates to antenna systems for radiating and receiving radio waves. More particularly it relates to antennas and feeding systems therefor by which efficient operation is obtained throughout a wide frequency band without adjustment of the antenna system.

Such broad-band antennas are useful for many applications, but are of particular importance in connection with aircraft. In aircraft installations, it is preferable, or even essential, that the antennas be "faired-in-to" the body of the aircraft so as not to interfere with the operation of the airfoils, but the space requirements of such "faired-in" antenna systems limits the number of antennas that can be carried by a given aircraft, although the uses for radio antennas, in both military and civilian aircraft, have continued to expand; it is therefore of continually increasing importance that each antenna be capable of functioning efficiently over the widest possible band of frequencies, so that a single antenna can be used for a number of different services. One aspect of the present invention is directed to the improvement of the wide band performance of antenna systems.

Because of the many varied sizes and shapes of the different types of aircraft, each aircraft antenna, with its associated feeding and impedance matching structures, usually has been designed for one particular type of aircraft; and if the antenna is to be used with a different type of aircraft, the antenna and its feed arrangement ordinarily must be re-designed in accordance with its new environment. One aspect of the present invention deals with the standardization of components for use with various aircraft antenna arrangements. Thus, the present invention provides a feeding system incorporating a constant impedance transition element which may be in the nature of a stock item of standard design, which may be readily incorporated in antenna systems of widely different designs, and is constructed so as to permit easy computation of the correct reactance and position of the necessary impedance compensating elements, and which permits convenient installation of these impedance compensating elements.

Accordingly, a preferred embodiment of the present invention includes two spaced radiating portions and a feeding system which includes a transition element of standard design that, in conjunction with a plane surface of one of the radiating portions, forms a transmission line of constant characteristic impedance, which is arranged to be coupled to a feed-line of substantially equal characteristic impedance. One aspect of the invention relates to a system for feeding energy to an antenna capable of efficient operation over a wide band of frequencies. Still another aspect relates to a system for the simplification of the design procedure in connection with the design or development of broad-band antennas. Still another aspect of the invention relates to impedance modifying or compensating elements in conjunction with a constant impedance transition element for compensating the reactance of the antenna.

These and other aspects, objects, and advantages of the present invention will be apparent from a consideration of the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 shows a portion of an aircraft having an antenna system embodying the invention;

Fig. 2 shows an enlarged view, in perspective, of a portion of the antenna system shown in Fig. 1;

Fig. 3 shows, diagrammatically, an equivalent circuit for the antenna shown in Fig. 1;

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Fig. 4 shows another embodiment of the invention; Fig. 5 is a perspective view of a conical transition element suitable for feeding energy to the antenna structure of Fig. 4; and

Fig. 6 is a sectional view taken along line 6—6 of Fig. 5.

The characteristics of a given antenna are the same, if properly interpreted, irrespective of whether that antenna is used for transmitting or receiving. Although the discussion herein refers for the most part to transmitting antennas, the interpretation of the present disclosure is not to be so limited. The term radiating portion, therefore, is to be construed, not as an element necessarily used for radiating, but rather one which is capable of radiating and, therefore, suitable for receiving. Other terms used herein, with relation to the radiation and reception of electro-magnetic energy, are to be similarly interpreted.

The antenna shown in Figures 1 and 2 utilizes the outer conductive surface of the lower portion 2 of a vertical stabilizer, generally indicated at 4, of an aircraft 5 as one of its radiating elements. The top of this stabilizer portion 2 is closed by a deck-plate 6 of conductive material on which is mounted a second radiating portion 8, which is adapted to be enclosed within a suitably shaped housing 12 of impregnated fiberglass or other suitable material, which completes the streamline surface of the vertical stabilizer, as indicated in Figure 2 by the broken line.

This second radiating portion 8 is supported by channel-shaped members 14 and 16 of insulating material, which are secured to opposite ends of the radiating portion 8 and to the upper surface of plate 6. In this example, the radiating portion 8 is constructed of sheet metal formed into a tube-like configuration having a flattened undersurface.

In order to conduct radio frequency energy to or from the antenna structure, a coaxial feed-line, generally indicated at 18 having an inner conductor 22 and an outer conductor 24, extends from the transmitting or receiving equipment (not shown), upwardly within the first radiating portion 2, and joins a coaxial type connector 26 which is secured to and extends downwardly from the plate 6. By means of this connector, the outer conductor 24 of feed-line 18 is connected to plate 6, and the inner conductor 22 is connected to the apex of a four-sided conical transition element 28, the base of which is secured to the flattened undersurface of the second radiator portion 8. The transition element 28, which is constructed, for example, of sheet metal, is supported by radiator portion 8 so that the apex of the cone, if it were fully completed, would be substantially in the plane of the deck-plate 6. The cone formed by the transition element 28 is slightly truncated for mechanical reasons, and the word conical as used herein is intended to include such substantially conic structures.

The exterior surfaces of the conical transition element 28 form, in conjunction with the upper surface of plate 6, a substantially radial transmission line, which has a constant characteristic impedance throughout the length of the conical element. This impedance is controlled by the angle or angles at the apex of the cone, as is well known to those familiar with this art. This angle usually is selected which will produce a characteristic impedance substantially equal to the characteristic impedance of feed-line 18.

Figure 3 shows a simplified equivalent circuit of the antenna system in which the feed-line 18 is represented at 18A, and the transmission line formed by the conical transition element is represented, diagrammatically, at 28A. An impedance 30 terminates the transition line 28A, and represents the impedance of the antenna. If the characteristic impedance of the line 28A varied along its length, such as would be caused by the use of an exponentially tapered, or other irregularly-shaped, junction in place of the conical transition element, it would be difficult or impossible to compute the proper position and magnitude of the compensating impedance element which would be required to compensate for the reactive characteristics of the antenna over a desired frequency range, even though the reactance characteristics of the

antenna were known. However, in accordance with the present invention, the transition element 28 acts as an extension of the feed-line 18, with a minimum discontinuity at the junction, and it becomes a relatively simple matter to determine the position which should be occupied by the compensating element, and the reactance which this element should present, in order to render the antenna efficient over the desired range of frequencies. In most cases this compensation, for antennas operating in the V. H. F. and U. H. F. regions, can be accomplished by a conductive strap connected across the conical transition line and which is dimensioned and positioned so that the inductive reactance of the strap will compensate the capacitive reactance of the antenna, and thus materially extend the range of frequencies within which the antenna will function.

In the embodiment shown in Figures 1 and 2, this compensation is achieved by a metal strap 32, which is secured to the second radiating portion substantially at the base of the conical transition element 28 and extends to a point on the deck-plate 6, which is selected in accordance with the impedance of the antenna system and the frequency range over which the antenna is to be used. The impedance of this compensating strap is represented at 32A in Figure 3. An additional advantage of using such a strap as an impedance compensation element is that the second radiating element 8 is grounded with respect to low frequency currents, thus reducing the danger of corona or lightning discharges.

Figure 4 shows another embodiment of the invention in which a conical transition element 28B is inverted from the position shown in Figures 1 and 2. A first radiating portion 2B, having a conductive external surface, is supported in any desired manner, and a second radiating portion 8B is spaced from and supported by the first radiating portion 2B, for example, by two strips 14B and 16B of insulating material, suitably secured to the two radiating portions. The feed-line 18B extends upwardly through the first radiating portion 2B into the conical transition element 28B, and the outer conductor is connected to the surface of the conical transition element near the apex thereof, but the inner conductor passes through and is insulated from the transition element 28B, and is connected to the underside of the second radiating portion 8B. It is to be understood that the radiating portions 2B and 8B are relatively thick in order to provide sufficient surface for cooperating with the transition element 28B, and to provide the desired broad-band radiation characteristics, and that the surface of radiating portion 8B that faces the transition element 28B is substantially plane so that the resulting radial transmission line will have a constant characteristic impedance.

The outer surface of the transition element 28B may define the surface of a right-circular cone, or it may be in the form of a pyramid having any number of sides. The use of right-circular cone simplifies the calculations, but is not always suitable because of the shape of the radiating portions. For example, in the embodiment shown in Figure 4, the transition element 28B has a trapezoidal horizontal cross-section, which has the advantage that a larger cone can be used when the thickness of the radiating portion is not sufficient to permit the use of a right-circular cone; such a condition often exists when the vertical stabilizer of an aircraft is used as a radiating element, as in the embodiment shown in Figure 1.

Figures 5 and 6 illustrate, in more detail, the construction of the transition element 28B shown in Figure 4 and which may be readily adapted for operation with various antenna structures. The lower portion of the transition element 28B is constructed in two halves, of sheet metal formed to the desired figuration, and is provided at each end with outwardly extending flanges 34 which provide a portion of the means for securing the transition element to one of the radiating portions.

Reinforcement of the conical structure is provided by two metal strips 37 which are secured, as by riveting, to inwardly extending flanges of the element 28B. Suitable openings 38 are provided along the sides of the conical transition element 28 to permit access to captive screws 42 by which, in conjunction with screws through the flanges 34, the transition element will be secured to one of the radiating portions.

An impedance compensating strap 32B, of bendable

material, is secured to the base of the transition element 28B for providing an inductive reactance for compensating the capacitive reactance of the antenna. When the transition element is installed, the free end of the strap is connected to a point, on the plane surface of the radiating portion opposing the transition element, selected in accordance with the particular impedance characteristics of the antenna. Although the strap 32B, as provided, is suitable for many installations, it is to be understood that both the position and size of the strap may have to be altered in accordance with the impedance characteristics of the antenna structure over the desired frequency range. Moreover, the impedance compensating effect can be adjusted to a considerable extent by bending the strap 32B so as to advantageously modify the impedance or its effective position on the line. It is also to be understood that a number of compensating elements or straps can be employed when the particular impedance characteristics make this desirable.

A mounting plate 46 is secured, by means of a threaded extension 48 to the inner conductor 52 of a co-axial connector 54, and is supported by two brackets 56 and 58, of insulating material, which are secured to the surface of the transition element 28B. This plate 46 is provided for securing the transition element to one of the radiating portions.

The coaxial connector 54 is supported within the transition element 28B by means of an upper metal cone portion 62 having an inner tubular fitting and an outwardly-extending funnel-shaped flange 64, which is secured by machine screws 66 to the inner surface of the lower portion of the transition element 28B. Access is obtained to the coaxial connector 54 by removing the appropriate screws 42 and 66 to release one of the sheet-metal sides of the transition element 28B, thus eliminating any need for a service door to be provided in one of the radiating portions.

From the foregoing it will be observed that the antenna and feed-system embodying my invention is well adapted to attain the ends and objects hereinbefore set forth and be economically manufactured since the separate features are well suited to common production methods and are subject to a variety of modifications as may be desirable in adapting the invention to different applications. For example, in the embodiments shown herein emphasis has been placed on compensating the antenna for low frequency operation, because of space limitations for the structure, by the use of an inductive strap, but it is apparent that other reactive compensation elements will be employed when the particular antenna characteristics or operation make this desirable. It is furthermore apparent that although the transition element shown herein is adapted to cooperate with a plane conductive surface in order to produce a radial transmission line having a constant characteristic impedance equal to the characteristic impedance of the feed-line, that a non-planar surface can be employed to cooperate with the conical surface so long as the resulting transmission line maintains a substantially constant characteristic impedance throughout its length.

I claim:

1. An antenna system comprising first and second spaced radiating portions, an intervening transition element having a conical outer surface for coupling energy to said radiating portions, said transition element being connected at one end to said first radiating portion and having its opposite end positioned adjacent said second radiating portion, an inductive impedance compensating element having connections at each end and electrically connected between said transition element and said second radiating portion for compensating the reactance of said first and second radiators to permit efficient operation over a wide band of frequencies, and radio frequency energy transmission means coupled to said transition element.

2. An antenna system comprising first and second spaced radiating portions, an intervening transition element having a conical outer surface for coupling energy to said radiating portions, said transition element being connected at its base to said first radiating portion and having its opposite end positioned adjacent said second radiating portion, an impedance compensating element comprising a metallic conducting strap having connections at each end and connected electrically between said transition element and said second radiating portion for com-

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compensating the reactance of said first and second radiators to permit efficient operation over a wide band of frequencies, and radio frequency energy transmission means coupled to said transition element.

3. An antenna system comprising first and second spaced radiating portions, an intervening transition element having a conical outer surface with its base secured to said first radiating portion and its apex positioned adjacent said second radiating portion for coupling energy to said radiating portions, a coaxial connector positioned within said transition element and having a first conductor connected to said transition element and a second conductor connected to said second radiating element, and an impedance compensating element having connections at each end and connected electrically between said transition element and said second radiating portion for compensating the reactance of said first and second radiators to permit efficient operation over a wide band of frequencies.

4. An antenna system as claimed in claim 1 wherein said transition element is in the shape of a cone having a trapezoidal cross-section in a plane perpendicular to the longitudinal axis of said cone.

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5. An antenna system as claimed in claim 1 wherein said compensating element comprises a strip of conductive bendable material.

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