

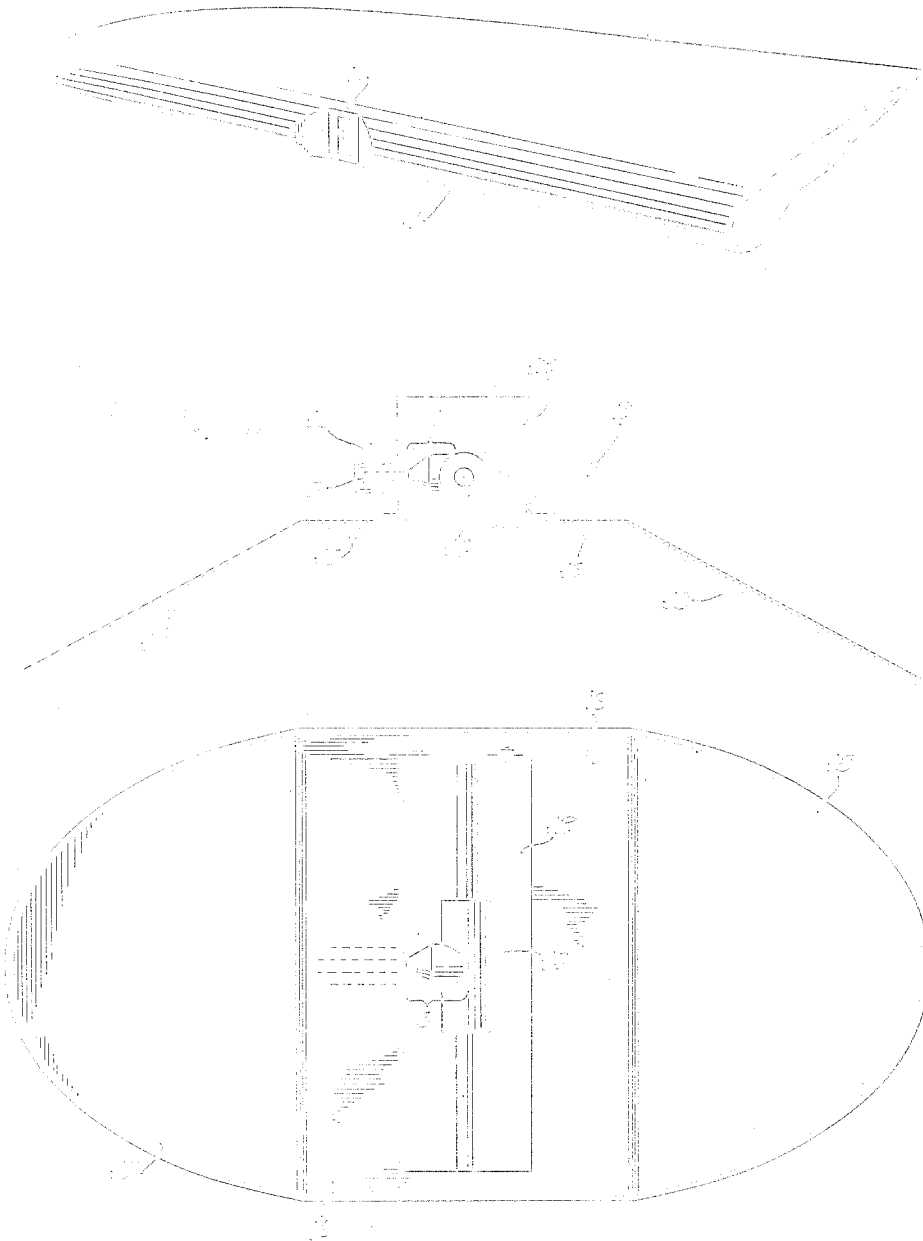
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INVENTOR.
PATENT OFFICE

BY *John, Carter & Hayward*

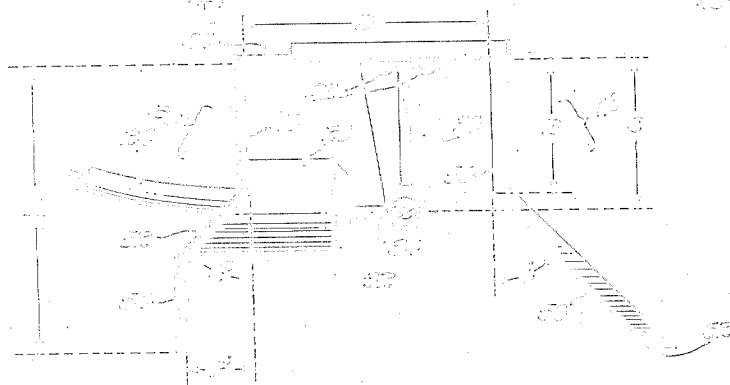
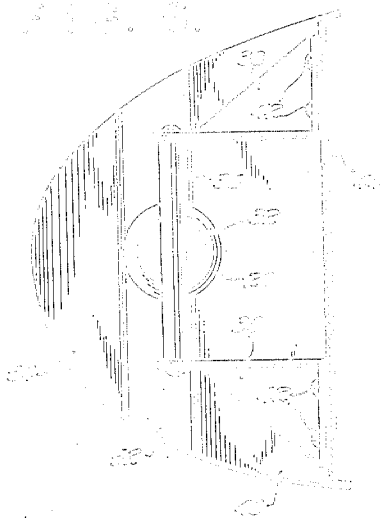
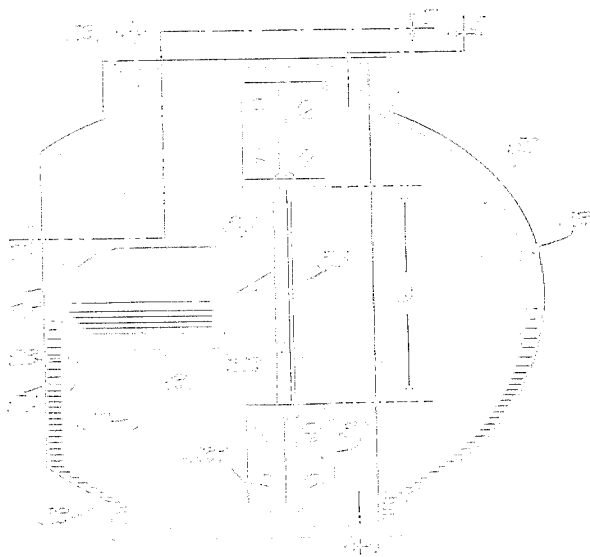
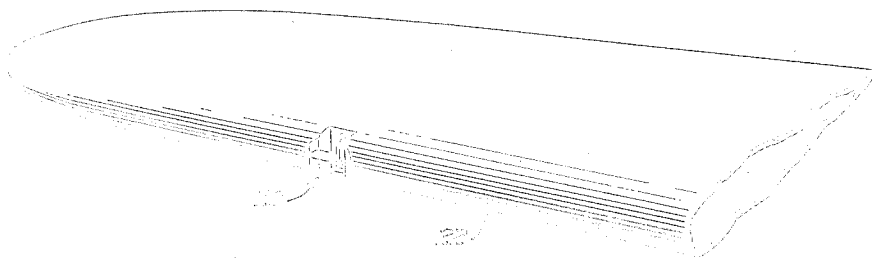
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Abstract The purpose of this study was to determine whether the use of a computerized program designed to teach the basic concepts of epidemiology would increase knowledge about epidemiologic methods among students in a health care program. A pretest-posttest design was used. Students completed a written test before and after completing the course. The mean score increased from 60% to 87%. This suggests that the use of the program may have been effective in increasing knowledge about epidemiologic methods.

the 1990s, the number of people in the world who are illiterate has increased from 400 million to 600 million. The number of illiterate people in the world is expected to increase to 700 million by the year 2015. The number of illiterate people in the world is expected to increase to 800 million by the year 2020. The number of illiterate people in the world is expected to increase to 900 million by the year 2025. The number of illiterate people in the world is expected to increase to 1 billion by the year 2030. The number of illiterate people in the world is expected to increase to 1.1 billion by the year 2035. The number of illiterate people in the world is expected to increase to 1.2 billion by the year 2040. The number of illiterate people in the world is expected to increase to 1.3 billion by the year 2045. The number of illiterate people in the world is expected to increase to 1.4 billion by the year 2050. The number of illiterate people in the world is expected to increase to 1.5 billion by the year 2055. The number of illiterate people in the world is expected to increase to 1.6 billion by the year 2060. The number of illiterate people in the world is expected to increase to 1.7 billion by the year 2065. The number of illiterate people in the world is expected to increase to 1.8 billion by the year 2070. The number of illiterate people in the world is expected to increase to 1.9 billion by the year 2075. The number of illiterate people in the world is expected to increase to 2 billion by the year 2080. The number of illiterate people in the world is expected to increase to 2.1 billion by the year 2085. The number of illiterate people in the world is expected to increase to 2.2 billion by the year 2090. The number of illiterate people in the world is expected to increase to 2.3 billion by the year 2095. The number of illiterate people in the world is expected to increase to 2.4 billion by the year 2100.

Figure 1. The effect of the concentration of the *Agaricus bisporus* spores on the growth of *Agaricus bisporus* and *Agaricus bisporus* spores. The concentration of the spores was 10⁶ spores/ml (a), 10⁷ spores/ml (b), 10⁸ spores/ml (c), 10⁹ spores/ml (d), 10¹⁰ spores/ml (e), 10¹¹ spores/ml (f), 10¹² spores/ml (g), 10¹³ spores/ml (h), 10¹⁴ spores/ml (i), 10¹⁵ spores/ml (j), 10¹⁶ spores/ml (k), 10¹⁷ spores/ml (l), 10¹⁸ spores/ml (m), 10¹⁹ spores/ml (n), 10²⁰ spores/ml (o), 10²¹ spores/ml (p), 10²² spores/ml (q), 10²³ spores/ml (r), 10²⁴ spores/ml (s), 10²⁵ spores/ml (t), 10²⁶ spores/ml (u), 10²⁷ spores/ml (v), 10²⁸ spores/ml (w), 10²⁹ spores/ml (x), 10³⁰ spores/ml (y), 10³¹ spores/ml (z), 10³² spores/ml (aa), 10³³ spores/ml (ab), 10³⁴ spores/ml (ac), 10³⁵ spores/ml (ad), 10³⁶ spores/ml (ae), 10³⁷ spores/ml (af), 10³⁸ spores/ml (ag), 10³⁹ spores/ml (ah), 10⁴⁰ spores/ml (ai), 10⁴¹ spores/ml (aj), 10⁴² spores/ml (ak), 10⁴³ spores/ml (al), 10⁴⁴ spores/ml (am), 10⁴⁵ spores/ml (an), 10⁴⁶ spores/ml (ao), 10⁴⁷ spores/ml (ap), 10⁴⁸ spores/ml (aq), 10⁴⁹ spores/ml (ar), 10⁵⁰ spores/ml (as), 10⁵¹ spores/ml (at), 10⁵² spores/ml (au), 10⁵³ spores/ml (av), 10⁵⁴ spores/ml (aw), 10⁵⁵ spores/ml (ax), 10⁵⁶ spores/ml (ay), 10⁵⁷ spores/ml (az), 10⁵⁸ spores/ml (ba), 10⁵⁹ spores/ml (bb), 10⁶⁰ spores/ml (bc), 10⁶¹ spores/ml (bd), 10⁶² spores/ml (be), 10⁶³ spores/ml (bf), 10⁶⁴ spores/ml (bg), 10⁶⁵ spores/ml (bh), 10⁶⁶ spores/ml (bi), 10⁶⁷ spores/ml (bj), 10⁶⁸ spores/ml (bk), 10⁶⁹ spores/ml (bl), 10⁷⁰ spores/ml (bm), 10⁷¹ spores/ml (bn), 10⁷² spores/ml (bo), 10⁷³ spores/ml (bp), 10⁷⁴ spores/ml (bq), 10⁷⁵ spores/ml (br), 10⁷⁶ spores/ml (bs), 10⁷⁷ spores/ml (bt), 10⁷⁸ spores/ml (bu), 10⁷⁹ spores/ml (bv), 10⁸⁰ spores/ml (bw), 10⁸¹ spores/ml (bx), 10⁸² spores/ml (by), 10⁸³ spores/ml (bz), 10⁸⁴ spores/ml (ca), 10⁸⁵ spores/ml (cb), 10⁸⁶ spores/ml (cc), 10⁸⁷ spores/ml (cd), 10⁸⁸ spores/ml (ce), 10⁸⁹ spores/ml (cf), 10⁹⁰ spores/ml (cg), 10⁹¹ spores/ml (ch), 10⁹² spores/ml (ci), 10⁹³ spores/ml (cj), 10⁹⁴ spores/ml (ck), 10⁹⁵ spores/ml (cl), 10⁹⁶ spores/ml (cm), 10⁹⁷ spores/ml (cn), 10⁹⁸ spores/ml (co), 10⁹⁹ spores/ml (cp), 10¹⁰⁰ spores/ml (cq), 10¹⁰¹ spores/ml (cr), 10¹⁰² spores/ml (cs), 10¹⁰³ spores/ml (ct), 10¹⁰⁴ spores/ml (cu), 10¹⁰⁵ spores/ml (cv), 10¹⁰⁶ spores/ml (cw), 10¹⁰⁷ spores/ml (cx), 10¹⁰⁸ spores/ml (cy), 10¹⁰⁹ spores/ml (cz), 10¹¹⁰ spores/ml (da), 10¹¹¹ spores/ml (db), 10¹¹² spores/ml (dc), 10¹¹³ spores/ml (dd), 10¹¹⁴ spores/ml (de), 10¹¹⁵ spores/ml (df), 10¹¹⁶ spores/ml (dg), 10¹¹⁷ spores/ml (dh), 10¹¹⁸ spores/ml (di), 10¹¹⁹ spores/ml (dj), 10¹²⁰ spores/ml (dk), 10¹²¹ spores/ml (dl), 10¹²² spores/ml (dm), 10¹²³ spores/ml (dn), 10¹²⁴ spores/ml (do), 10¹²⁵ spores/ml (dp), 10¹²⁶ spores/ml (dq), 10¹²⁷ spores/ml (dr), 10¹²⁸ spores/ml (ds), 10¹²⁹ spores/ml (dt), 10¹³⁰ spores/ml (du), 10¹³¹ spores/ml (dv), 10¹³² spores/ml (dw), 10¹³³ spores/ml (dx), 10¹³⁴ spores/ml (dy), 10¹³⁵ spores/ml (dz), 10¹³⁶ spores/ml (ea), 10¹³⁷ spores/ml (eb), 10¹³⁸ spores/ml (ec), 10¹³⁹ spores/ml (ed), 10¹⁴⁰ spores/ml (ee), 10¹⁴¹ spores/ml (ef), 10¹⁴² spores/ml (eg), 10¹⁴³ spores/ml (eh), 10¹⁴⁴ spores/ml (ei), 10¹⁴⁵ spores/ml (ej), 10¹⁴⁶ spores/ml (ek), 10¹⁴⁷ spores/ml (el), 10¹⁴⁸ spores/ml (em), 10¹⁴⁹ spores/ml (en), 10¹⁵⁰ spores/ml (eo), 10¹⁵¹ spores/ml (ep), 10¹⁵² spores/ml (eq), 10¹⁵³ spores/ml (er), 10¹⁵⁴ spores/ml (es), 10¹⁵⁵ spores/ml (et), 10¹⁵⁶ spores/ml (eu), 10¹⁵⁷ spores/ml (ev), 10¹⁵⁸ spores/ml (ew), 10¹⁵⁹ spores/ml (ex), 10¹⁶⁰ spores/ml (ey), 10¹⁶¹ spores/ml (ez), 10¹⁶² spores/ml (fa), 10¹⁶³ spores/ml (fb), 10¹⁶⁴ spores/ml (fc), 10¹⁶⁵ spores/ml (fd), 10¹⁶⁶ spores/ml (fe), 10¹⁶⁷ spores/ml (ff), 10¹⁶⁸ spores/ml (fg), 10¹⁶⁹ spores/ml (fh), 10¹⁷⁰ spores/ml (fi), 10¹⁷¹ spores/ml (fj), 10¹⁷² spores/ml (fk), 10¹⁷³ spores/ml (fl), 10¹⁷⁴ spores/ml (fm), 10¹⁷⁵ spores/ml (fn), 10¹⁷⁶ spores/ml (fo), 10¹⁷⁷ spores/ml (fp), 10¹⁷⁸ spores/ml (fq), 10¹⁷⁹ spores/ml (fr), 10¹⁸⁰ spores/ml (fs), 10¹⁸¹ spores/ml (ft), 10¹⁸² spores/ml (fu), 10¹⁸³ spores/ml (fv), 10¹⁸⁴ spores/ml (fw), 10¹⁸⁵ spores/ml (fx), 10¹⁸⁶ spores/ml (fy), 10¹⁸⁷ spores/ml (fz), 10¹⁸⁸ spores/ml (ga), 10¹⁸⁹ spores/ml (gb), 10¹⁹⁰ spores/ml (gc), 10¹⁹¹ spores/ml (gd), 10¹⁹² spores/ml (ge), 10¹⁹³ spores/ml (gf), 10¹⁹⁴ spores/ml (gg), 10¹⁹⁵ spores/ml (gh), 10¹⁹⁶ spores/ml (gi), 10¹⁹⁷ spores/ml (gj), 10¹⁹⁸ spores/ml (gk), 10¹⁹⁹ spores/ml (gl), 10²⁰⁰ spores/ml (gm), 10²⁰¹ spores/ml (gn), 10²⁰² spores/ml (go), 10²⁰³ spores/ml (gp), 10²⁰⁴ spores/ml (gq), 10²⁰⁵ spores/ml (gr), 10²⁰⁶ spores/ml (gs), 10²⁰⁷ spores/ml (gt), 10²⁰⁸ spores/ml (gu), 10²⁰⁹ spores/ml (gv), 10²¹⁰ spores/ml (gw), 10²¹¹ spores/ml (gx), 10²¹² spores/ml (gy), 10²¹³ spores/ml (gz), 10²¹⁴ spores/ml (ha), 10²¹⁵ spores/ml (hb), 10²¹⁶ spores/ml (hc), 10²¹⁷ spores/ml (hd), 10²¹⁸ spores/ml (he), 10²¹⁹ spores/ml (hf), 10²²⁰ spores/ml (hg), 10²²¹ spores/ml (hh), 10²²² spores/ml (hi), 10²²³ spores/ml (hj), 10²²⁴ spores/ml (hk), 10²²⁵ spores/ml (hl), 10²²⁶ spores/ml (hm), 10²²⁷ spores/ml (hn), 10²²⁸ spores/ml (ho), 10²²⁹ spores/ml (hp), 10²³⁰ spores/ml (hq), 10²³¹ spores/ml (hr), 10²³² spores/ml (hs), 10²³³ spores/ml (ht), 10²³⁴ spores/ml (hu),

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1. INFORMATION
 2. RECEIVED FROM
 3. DATE

$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

Glenn L. Gandy

1997年12月15日
 1997年12月15日

1918, 1919

INVENTION
AIRCRAFT ANTENNA

1918, 1919

WASCO No. 2, 1918, 1919

5 (Sheet-Sheet 5)

FIG. 1.

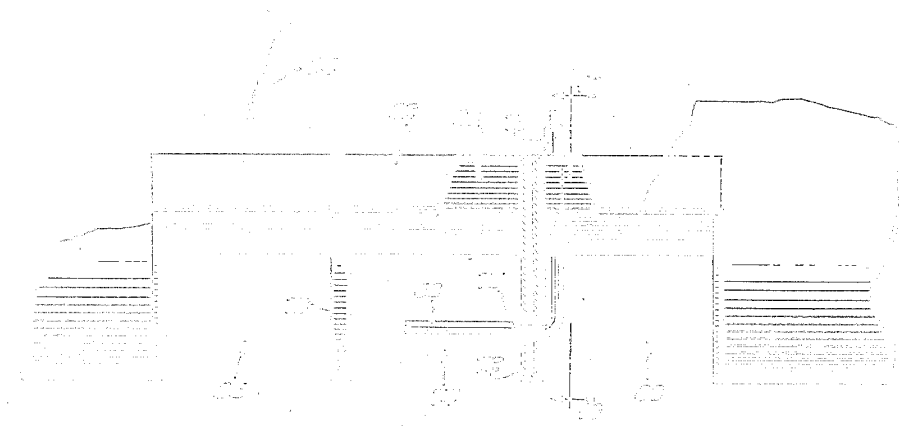
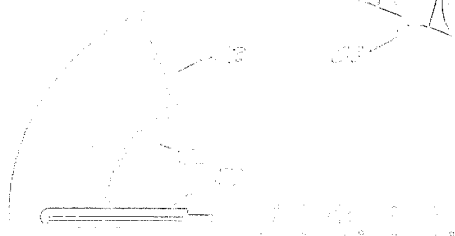
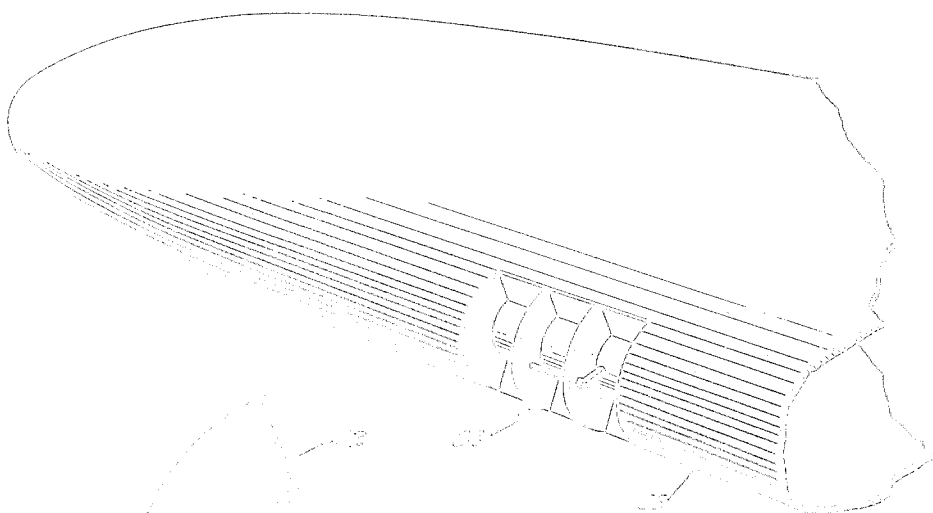


FIG. 4.

INVENTOR.
ANTHONY DODGE

BY *John, Arthur & Rogers*

ATTORNEYS.

UNITED STATES PATENT OFFICE

2,835,087

AIRCRAFT ANTENNA

William D. Bann, Pleasant, N. H., assignor to Air-
craft Instruments Laboratory, Inc., Concord,
N.H.

Application September 11, 1939, Serial No. 778,453

11 Claims (Cl. 361-28.5)

This invention relates to radio antennas for receiving and radiating electromagnetic energy; and more particularly to directional antennas which are recessed into curved conducting surfaces. In one aspect the invention is concerned with the production of electromagnetic fields having field intensity patterns substantially independent of the configuration of conducting surfaces near the radiating element.

A non-directional antenna, i. e. one which radiates (or receives) radio waves equally well in all directions, has maximum utility only in those systems where it is desired to transmit (or receive) signals in all directions. For many applications, particularly at higher frequencies, it is more desirable to use a directional antenna, i. e. one that radiates (or receives) a stronger signal in one direction than in another. Thus, if a directional transmitting antenna is adjusted to radiate the strongest signal toward the receiver, a lower power transmitter or lower sensitivity receiver may be used to achieve the same results in that direction, as would be achieved by a higher power transmitter or higher sensitivity receiver with a non-directional antenna. The development of both receiving and transmitting antennas with desired directional characteristics is, therefore, of utmost importance.

The directivity of an antenna may be represented graphically by plotting the intensity of the electromagnetic field produced by the antenna in different directions at a fixed distance on polar-coordinate paper with the radiating element located at the center of the graph. The outline so formed represents the "field pattern" of the antenna in a given plane. The effectiveness of the antenna in any direction may be readily ascertained by examination of a series of such graphs, or field patterns, representing different angular planes relative to the antenna.

The shape of the field pattern of an antenna, and thus its directivity, usually depends not only upon the size and shape of the radiating element itself, but upon the configuration and dimensions of conducting surfaces and materials near the radiating element. Thus, a simple cylindrical radiating element of uniform diameter would produce a given pattern when operating in an isolated position; however, if a flat conducting surface is placed near the radiating element the field pattern will be changed, even though the conducting surface is not connected electrically to the antenna. Such flat surfaces, are often utilized to secure a desired field pattern. Another type of directional antenna utilizes a radi-

ating element mounted near the focal point of a parabolically-shaped conducting surface. This reflecting surface affects the radiation of the radio frequency waves in much the same way that the reflector of a search light concentrates the light into a beam.

It is often desirable to locate such directional antennas near conducting surfaces that have configurations which would cause undesirable distortion of the field pattern. In accordance with the present invention, the effects of such surfaces on the field pattern are reduced materially.

For particular applications it is desirable to construct the directional antenna so that no portion of the antenna extends beyond the surrounding surfaces. For example, such "faired-in" or "aperture type" antennas have been developed for use on modern high speed aircraft where projecting structures would interfere with operation of the aircraft and would themselves be subject to icing and other conditions which might interfere with the electrical performance of the antenna.

The field patterns of antennas of this type are affected by the configuration and position of adjacent conducting surfaces of the aircraft. In order to secure desirable radiation patterns, these antennas usually are mounted so that the adjacent surfaces of the aircraft are relatively flat and generally perpendicular to the direction of propagation of the radio waves. The field patterns of these antennas are also affected by the shape of portions of the aircraft at a considerable distance from the antennas, e. g. the configuration of the fuselage or engine nacelles may have a controlling influence on the shape of the field pattern of an antenna mounted some distance away.

In certain instances it is desirable to locate such "faired-in" antennas in sharply curved or irregular surfaces. For example, it is structurally convenient to mount such antennas in the leading edges of aircraft wings to radiate electromagnetic energy in a generally forward direction. The field pattern, however, is subject to distortion by these curved surfaces and may have several major radiation lobes separated by deep intervening nulls, i. e. regions of very low field intensity, thus making the antenna ineffective for many applications.

In accordance with the present invention, methods and apparatus are provided for reducing or eliminating radio frequency currents in these curved surfaces and for preventing or re-

ducing the secondary radiation therefrom, to radiate an electro-magnetic field which is substantially independent of the configurations of these adjacent surfaces and which may be adapted to produce an essentially single-lobe field pattern.

It is, accordingly, an object of this invention to provide methods and apparatus for producing an electromagnetic field having a pattern substantially independent of conducting surfaces adjacent the radiating structure which produces the field.

It is a further object to provide methods and apparatus producing a desired radiation field pattern from an antenna located adjacent non-planar, or converging or diverging planar, conducting surfaces.

It is a further object to provide methods and apparatus for producing a substantially single-lobe radiation field pattern from an antenna located near curved conducting surfaces.

In one aspect of the invention, it is an object to eliminate radio frequency currents from curved surfaces near the radiating structure.

In another aspect of the invention is an object to prevent secondary radiation from conducting surfaces adjacent an antenna.

It is another object to provide an aperture type radiator in conjunction with a metallic surface for producing a field pattern substantially independent of the configuration of that surface.

It is a further object to provide such an antenna which has a substantially single-lobe pattern, occupies minimum space, may be fitted conveniently into aircraft structures, and which operates successfully over wide ranges of frequency.

A more specific object is to provide such a wide-band radiator which is suitable for use in the curved leading edges of aircraft wings.

It is a further object to provide a radiator in the leading edge of an aircraft wing and which produces a field pattern substantially independent of the shape of the wing surface.

A further object is to provide a wide-band "faired-in" antenna capable of successful operation adjacent sharply curved or irregular surfaces.

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

Fig. 1 is a perspective view of an aperture type antenna embodying the invention and incorporated in the leading edge of an aircraft wing;

Fig. 2 is a plan view of the antenna structure shown in Fig. 1;

Fig. 3 is an elevational view of the same antenna structure;

Fig. 4 shows another aperture type antenna embodying the invention and mounted in an aircraft wing;

Fig. 5 is an elevational view of the antenna structure shown in Fig. 4;

Fig. 6 is a sectional view taken on line 6-6 of Fig. 5;

Fig. 7 is a view taken on line 7-7 of Fig. 5;

Fig. 8 shows still another antenna structure and the manner in which it is mounted in an aircraft wing;

Fig. 9 is a plan view of the antenna shown in Fig. 8; and

Fig. 10 is a cross-sectional view taken on line 10-10 of Fig. 9.

The characteristics of a given antenna are the same, if properly interpreted, regardless of whether that antenna is used for transmitting or

receiving. This equivalence follows the reciprocity law which is an extension of the well-known reciprocity theorem found in electrical circuits. 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 element, 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 electromagnetic energy, are to be similarly interpreted.

In the embodiment of the invention shown in Figs. 1 to 3, an antenna structure, generally indicated at 2, is recessed into the leading edge of a metal-covered aircraft wing 4.

A radiating element 6, consisting of a tapered thickened extension of the inner conductor 8 of a coaxial feed line 10, extends horizontally within a cavity 12, constructed of sheet copper or other suitable conductive material and is secured, as by solder, to the enlarged center portion of a terminating element 14. The ends of element 14 are secured suitably, as by screws (not shown), to opposite ends of the cavity 12. This element 14 forms a substantially non-radiating termination for the radiating element 6 and modifies the input impedance characteristics of the antenna so that it may be driven efficiently over the desired frequency range by the coaxial feed line 10.

In this example the forward edges around the open face of cavity 12 are secured by soldering, or other suitable means, to a sheet metal conducting surface 16 which extends outwardly from and parallel to the open face of the cavity. This surface 16 is substantially parallel to, but mounted back of, an imaginary vertical plane tangent to the forward edge of the aircraft wing. The upper and lower edges of the surface 16 are secured by flanges, or other suitable means (not shown), to the skin of the aircraft wing 4. The surface 16 extends laterally outwardly on either side of the cavity and then is bent forward to form two sloping metal surfaces 18, the edges of which are contoured to join throughout their length with the aircraft skin.

Thus, the primary radiating element 6 is mounted within the rectangular cavity 12, which is recessed within the aircraft wing 4 and connected to the skin of the aircraft by outwardly extending, generally V-shaped, sloping cavity-wall extensions 18.

The entire antenna structure is covered preferably by a curved sheet of plastic, or other suitable insulating material, which follows the contour of the wing surface; the entire antenna structure, thus, being mounted so that the aerodynamic characteristics of the wing remain unchanged.

The primary radiating element 6 in conjunction with the cavity 12 transmits radio frequency energy outwardly through the open side of the cavity 12. In order to prevent undesirable secondary radiation of the electromagnetic energy from the adjacent curved surfaces of the wing, such as would be caused by direct coupling at the open face of the cavity, this energy is radiated into a space defined by the surface 16 and the sloping surfaces 18. Thus, the energy is propagated through a transitional region adjacent the face of the cavity which prevents excitation of radio frequency currents on the surfaces of the wings and produces, in this example, an essentially single-lobe field pattern.

Thus, the radiation from the antenna system is

of the antenna structure and surface the configuration of which is entirely within the control of the antenna designer and radiation from surfaces the configurations of which are dictated by aerodynamic or other considerations is suppressed. The antenna produces a horizontally polarized field.

Another antenna structure, generally indicated at 21, for producing horizontal polarization, is shown in Fig. 4, located in the leading edge of an aircraft wing 22; the details of this structure being shown in Figs. 5, 6, and 7.

As in the previous example, radio frequency energy is supplied to the antenna through a coaxial feed line 23. This feed line enters the antenna cavity through a sidewall, generally indicated at 24, and extends longitudinally through an end-loaded sleeve-type radiating element 25. This radiating element, supported by the cavity wall 26, extends horizontally into the cavity and is connected at its inner end, through an annular tapered portion 27, to the outer conductor of the coaxial line 23.

The inner conductor of line 23 extends inwardly beyond the radiating element 25 and is connected by a tapered section of conductor 28, to an end-loading element 29, which in this example is in the form of a bar. The loading element 29 is supported, by means of insulating brackets 30 and screws 31, from the rear wall 32 of the radiation cavity.

The generally U-shaped open-end radiation cavity is defined by the plane rear wall 32 and two forwardly extending side walls, generally indicated at 33 and 34, respectively.

The wall 33 has an inner portion 35 perpendicular to the rear wall 32 to which it is connected, a center, outwardly flared, portion 36, and an outer portion 37 parallel to portion 35.

The opposite cavity wall 34 is provided with an inner portion 38, perpendicular to the rear wall 32 to which it is connected, and an outwardly flared portion 39. The edges of walls 33 and 34, are shaped to conform with the adjacent edges of the skin of the aircraft and, together with the upper and lower edges of the rear wall 32 are provided with a ridge 40 extending completely around the radiation cavity and which is secured thereto to the wing surface.

As in the previous example, the antenna structure is covered with sheet plastic or other similar material (not shown) to provide a smooth external surface.

In this example the radiating element 25 and the sloping wall portions 36 and 39 are unsymmetrically constructed. In this instance such unsymmetrical construction is necessary, if a substantially symmetrical field pattern is desired, because of the particular arrangement of the radiating and loading elements 25 and 29 within the radiating cavity.

The above antennas are adapted particularly for wide-band operation, the antenna shown in Fig. 4 providing satisfactory operation over the frequency range between 500 and 1,000 megacycles. The following dimensions, indicated in Figs. 5 to 7, are typical of an antenna useful for operation of this frequency range:

The total depth of the antenna as indicated by dimension A is 5 1/2 inches; the depth of the cavity portion of the antenna as indicated by dimension B is 3 1/2 inches; the distance from the loading element to the base of the cavity as indicated by dimension C is 2 3/4 inches; the horizontal width of the cavity as indicated by dimension

D is 4 1/2 inches; the angle between the direction of the inner portion 35 of the cavity wall 33 and the direction of the outer flared portion 36 as indicated at E is 45 degrees; the lateral distance between the outer cavity wall portion 36 and the cavity wall portion 35 as indicated by dimension F is 1 1/2 inches; and the length of the loading element 29 as indicated by dimension G is 4 inches.

In Fig. 8 is shown another antenna structure, generally indicated at 39, mounted in the leading edge of an aircraft wing 40. Details of this antenna structure are shown in Figs. 9 and 10. A horizontal radiating element 41, supplied with radio frequency energy through a coaxial cable 42, is secured to a wall 43 of an open-face cavity, generally indicated at 44, by an insulating bushing 45 through which the inner conductor of cable 42 passes. The cavity 44 is generally curved; the side walls 46 and 47, formed of copper or similar conducting material, have arcuately shaped forward and rear edges. These walls are joined at the back by a curved sheet-metal plate 48, which forms the back surface of the cavity, and at their ends by planar walls 49 and 50. As in the previous examples, the forward side of the generally curved cavity 44 is open to permit the radiation of electromagnetic energy.

In order to prevent the flow of radio frequency currents in the curved surfaces horizontally adjacent the antenna and, thus, prevent secondary radiation of electromagnetic energy therefrom, two additional cavities, generally indicated at 51 and 52, are provided on either side of radiating cavity 44. The construction and dimensions of these cavities are generally similar to that of cavity 44. These cavities act as radio frequency chokes and present a high impedance to the flow of radio currents within the frequency range over which the antenna is to be used.

The cavities may be constructed, if desired, by dividing a large cavity into the corresponding individual cavity portions so that the entire assembly may be considered as a single cavity having baffle plates, substantially perpendicular to the rear wall, dividing it into three or more portions.

Generally speaking, the antenna construction having flared walls is preferable for wide band applications and for use at higher frequencies where the minimum radius of curvatures of the wing surface is relatively large in terms of wavelengths. At lower frequencies, such that the minimum radius of curvature is small in terms of wavelengths, the multiple cavity structure with parallel dividing walls is preferred because its physical size can be much smaller and still provide effective decoupling of the radiated waves. For certain applications, particularly over intermediate frequency ranges, it is advantageous to combine the two structures to provide a flared cavity with one or more parallel-wall cavities on each side thereof. With this construction, an antenna may be provided that is capable of satisfactory operation over an extremely wide band of frequencies; the parallel-wall cavities being most effective to prevent undesirable secondary radiation in the lower portion of the frequency range and the flared cavity most effective in the upper portion of the frequency range.

Although antennas constructed in accordance with the present invention are particularly well adapted for use near sharply curved surfaces, they have obvious advantages when used adjacent any irregular conducting surface. By an

Irregular surface is meant a surface which is not substantially in a single plane, and which in conjunction with a simple quarter wave stub antenna would not, at the frequency of operation, produce an essentially single-lobe field pattern. Thus, the term irregular surface would include surfaces having curved, concave or convex, or planar diverging or converging portions.

It is apparent that the present invention may be embodied in a wide number of physical forms, each adapted to perform best its particular functions under the particular conditions of use. It is apparent furthermore that the invention is not to be limited to the production of symmetrical field patterns as it is obvious that by suitable modifications of the flare and cavity structures desirable asymmetrical patterns may be obtained. The illustrations and embodiments of the invention therefore are to be construed in an explanatory and not in a limiting sense.

I claim:

1. A forwardly-directed faired-in antenna system for use in aircraft having metal wing surfaces comprising an aircraft wing having an electrically-conductive surface, the surface of the leading edge of said wing defining a sharply-curved air foil, an electromagnetic aperture type radiation structure recessed in the leading edge of said wing for radiating radio waves in a generally forward direction, and forwardly-extending outwardly-flared auxiliary conducting surfaces interposed between said radiation structure and said sharply-curved air foil and electrically connected along their forwardmost edges to said air foil and along their rearward edges to said radiation structure, said conductive surfaces being positioned to form an abrupt angular discontinuity between said conductive surfaces and said air foil at the junction therebetween, thereby to offer a high impedance at the frequency of operation to the transverse flow of electromagnetic currents therebetween, whereby secondary radiation from the curved wing surfaces is minimized and a desirable single-lobe field pattern is produced.

2. A forwardly-directed faired-in antenna system for use in aircraft having metal wing surfaces comprising an aircraft wing having an electrically-conductive curved air foil surface, an electromagnetic aperture type radiation structure recessed in the leading edge of said wing for radiating radio waves in a generally forward direction, said structure having a rear wall and forwardly extending walls electrically connected to said rear wall, the forward edges of said walls defining a radiation aperture, auxiliary conducting surfaces electrically connected to and interposed between said air foil and said aperture defining edges of said walls, said auxiliary surfaces being positioned to form an abrupt angular discontinuity between said auxiliary surfaces and said air foil at the junction therebetween, and an excitation element positioned in said radiation structure and back of said radiation aperture, said radiation aperture being positioned a substantial distance back of said air foil where it joins said auxiliary surfaces.

3. A faired-in antenna system for use in irregular surfaces comprising a supporting structure having an irregular, exposed, electrically-conductive surface, an electromagnetic cavity type radiator recessed in said structure for radiating radio waves, said structure having a rear wall and forwardly-extending side walls electrically connected to said rear wall, and out-

wardly-flared forwardly-extending auxiliary conducting surfaces electrically connected to said side walls and extending forwardly and outwardly therefrom, the forward edges of said auxiliary surfaces being connected to and forming an abrupt angular discontinuity with said irregular surface, the lines of juncture of said auxiliary surfaces and said irregular surface being entirely outside the limits of and forwardly of the forwardmost portions of said side walls.

4. A forwardly-directed faired-in antenna system for use in aircraft having metal wing surfaces comprising an aircraft wing having an electrically-conductive surface, an electromagnetic aperture type radiation structure recessed in the leading edge of said wing for radiating radio waves in a generally forward direction, said structure having a rear wall and forwardly extending walls electrically connected to said rear wall, the forward edges of said walls defining a radiation aperture, and auxiliary conducting surfaces electrically connected to and interposed between said air foil and the forward edges of said aperture defining edges of said radiation structure, said conductive surfaces being substantially planar and positioned to form an abrupt angular discontinuity between said conductive surfaces and said air foil at the junction therebetween.

5. A faired-in antenna system for use in irregular surfaces comprising a supporting structure having an irregular, exposed, electrically-conductive surface, an open-faced box having conductive rear and side walls and an excitation element mounted within said box, cavity type antenna structure including said box being recessed in said supporting structure, and at least one substantially planar, outwardly-flared, auxiliary conducting surface electrically connected to one of said side walls and extending forwardly and outwardly therefrom, said auxiliary surface being connected to said irregular surface along a line of juncture positioned forwardly of the forwardmost portion of said box.

6. An aperture type antenna system for the directional radiation and reception of electromagnetic energy over a wide range of frequencies comprising an irregular electrically conductive surface, a cavity structure recessed in said irregular surface and having an open face on its forward side, a radiating element positioned within said cavity structure, a transmission system for coupling electromagnetic energy to said element, and auxiliary electrically-conductive surfaces connected to opposite sides of said cavity structure, at least one of said surfaces forming a sloping wall extending outwardly and forwardly from said cavity structure and being connected along its forwardmost edge to said conductive surface and defining therewith along the line of juncture exposed angles on the forward side substantially greater than 180 degrees and significantly less than 270 degrees.

7. An aperture type antenna system for directional radiation and reception of electromagnetic energy over a wide range of frequencies comprising an electrically conductive surface, a cavity-type radiation structure recessed in said surface and including first and second forwardly-extending electrically-conductive walls, said first wall including an outwardly-flaring portion connected along its forwardmost edge to said conductive surface, each point along the line of juncture between said first wall and said conductive surface forming the vertex of an exposed angle defined by said conductive surface and the forward sur-

face of the outwardly-flaring portion of said first wall, said angle being greater than 180 degrees and significantly less than 370 degrees, and a radiating element positioned within said radiation structure and including an excitation portion supported by and extending inwardly from said second wall.

8. A broadband directional aperture type radiation system for the radiation of electromagnetic energy from a curved conducting surface comprising a curved electrically-conductive surface having an opening therein, and an aperture type antenna recessed in said surface and including opposed conductive walls having spaced substantially parallel rear portions and outwardly-flaring forwardly-extending portions joined along their forward ends to said curved surface along the edge of said opening and forming with said surface a curved line of abrupt change in direction.

9. For use in metal-covered aircraft, a broadband faired-in antenna structure for minimizing the effects of an adjacent irregular surface comprising an irregular electrically-conductive surface forming part of the air-fol skin of said aircraft and having an opening therein, a cavity-type structure recessed in the opening in said surface and having rear and forwardly-extending side walls, the forward edges of said walls defining at least a portion of a radiating aperture, two oppositely-disposed auxiliary surfaces connected to the forward edges of said walls and extending forwardly and outwardly therefrom, the forwardmost edges of said auxiliary surfaces being connected to said irregular surface along the edges of said opening, the lines of juncture of said auxiliary surfaces and said irregular surface forming an abrupt directional discontinuity, an excitation element positioned within said cavity structure between said walls and back of the junction of said side walls and said auxiliary surfaces.

10. A broadband directional antenna system for the radiation of electromagnetic energy comprising a curved electrically-conductive surface having an opening therein a cavity-type radiator

structure recessed in said opening and having rear and side walls and a forwardly-directed open face, at least one of said side walls having a forwardly-extending outwardly-flaring portion, the forward edges of each of said side walls being connected to said conductive surface along lines of juncture forming abrupt surface discontinuities, said lines of juncture having a radius of curvature along their lengths less than one wavelength at the lowest frequency of operation.

11. A directional aperture type antenna system for the radiation or reception of electromagnetic energy comprising a curved electrically-conductive surface, a first cavity-type radiator recessed in said curved surface, a transmission system for delivering electromagnetic energy to said first cavity type radiator, and second and third auxiliary cavity-type radiators recessed in said conductive surface on opposite sides of said first cavity-type radiator, said second and third cavity-type radiators being energized solely by energy from said first cavity-type radiator, each of said cavity-type radiators including rear and side walls and having a forward electrically-open aperture for the radiation of electromagnetic energy.

ARTHUR MORANE.

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