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2,870,439

MICROWAVE ENERGY ATTENUATING WALL

Filed Dec. 29, 1950

2 Sheets-Sheet 1

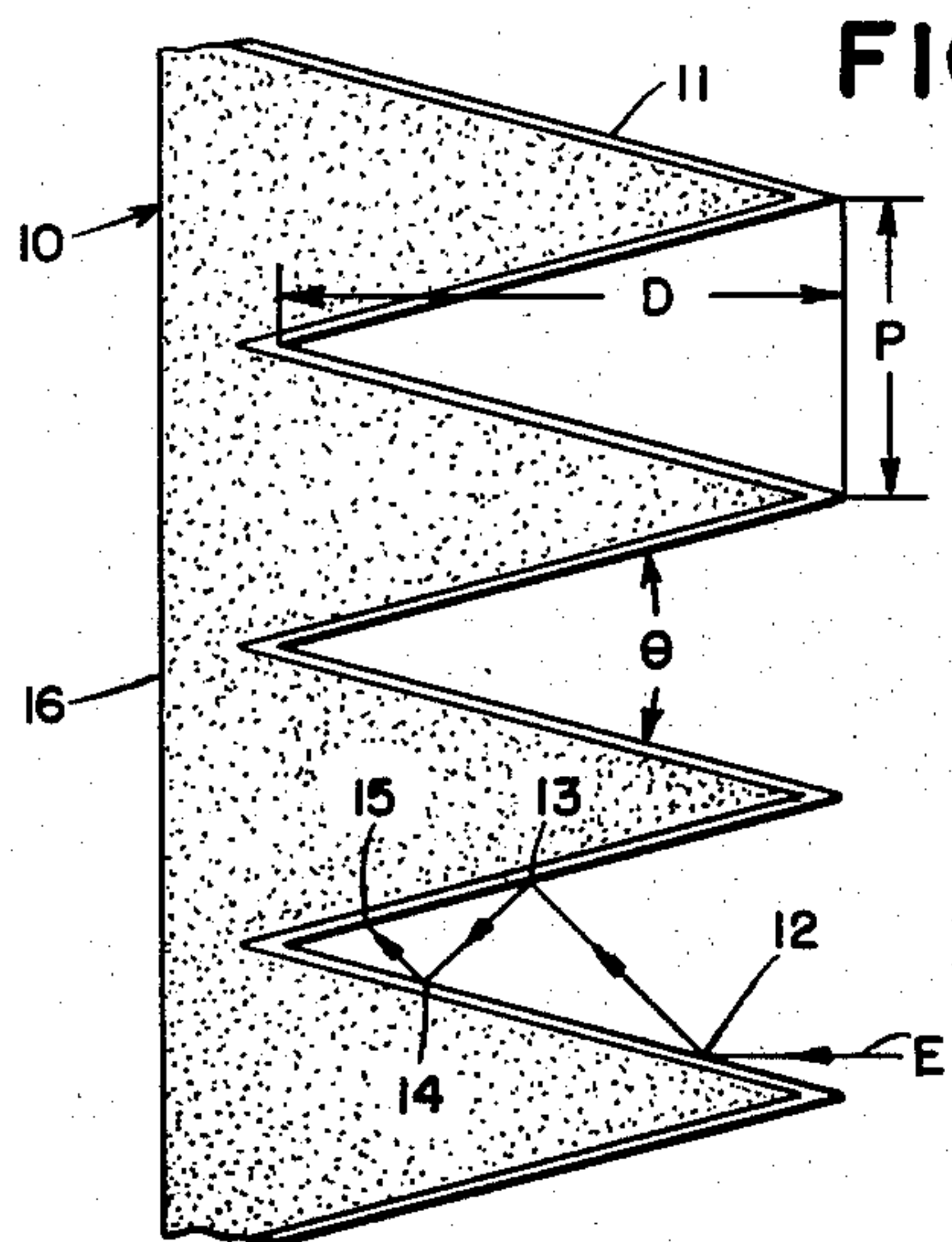


FIG. 1

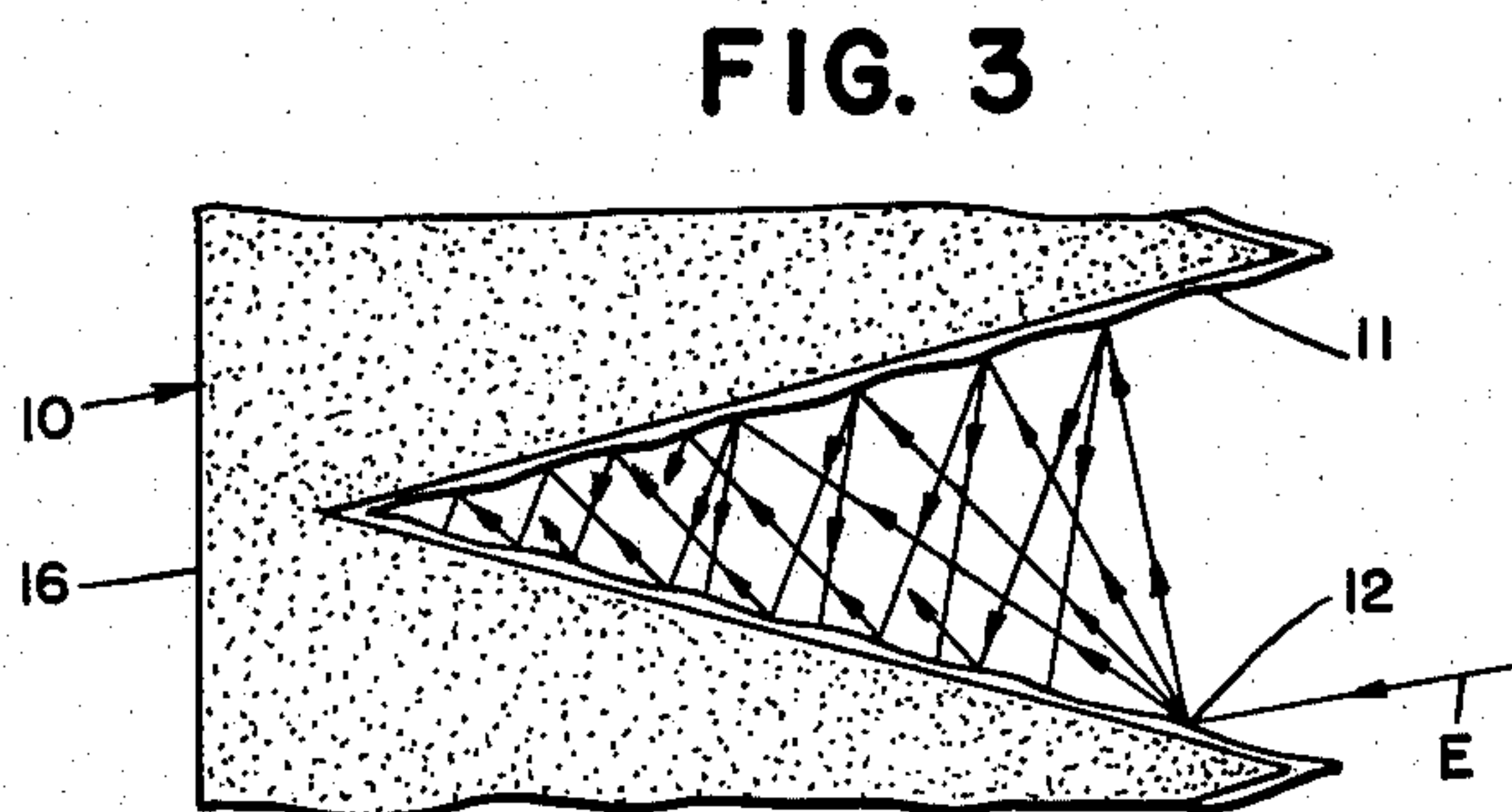
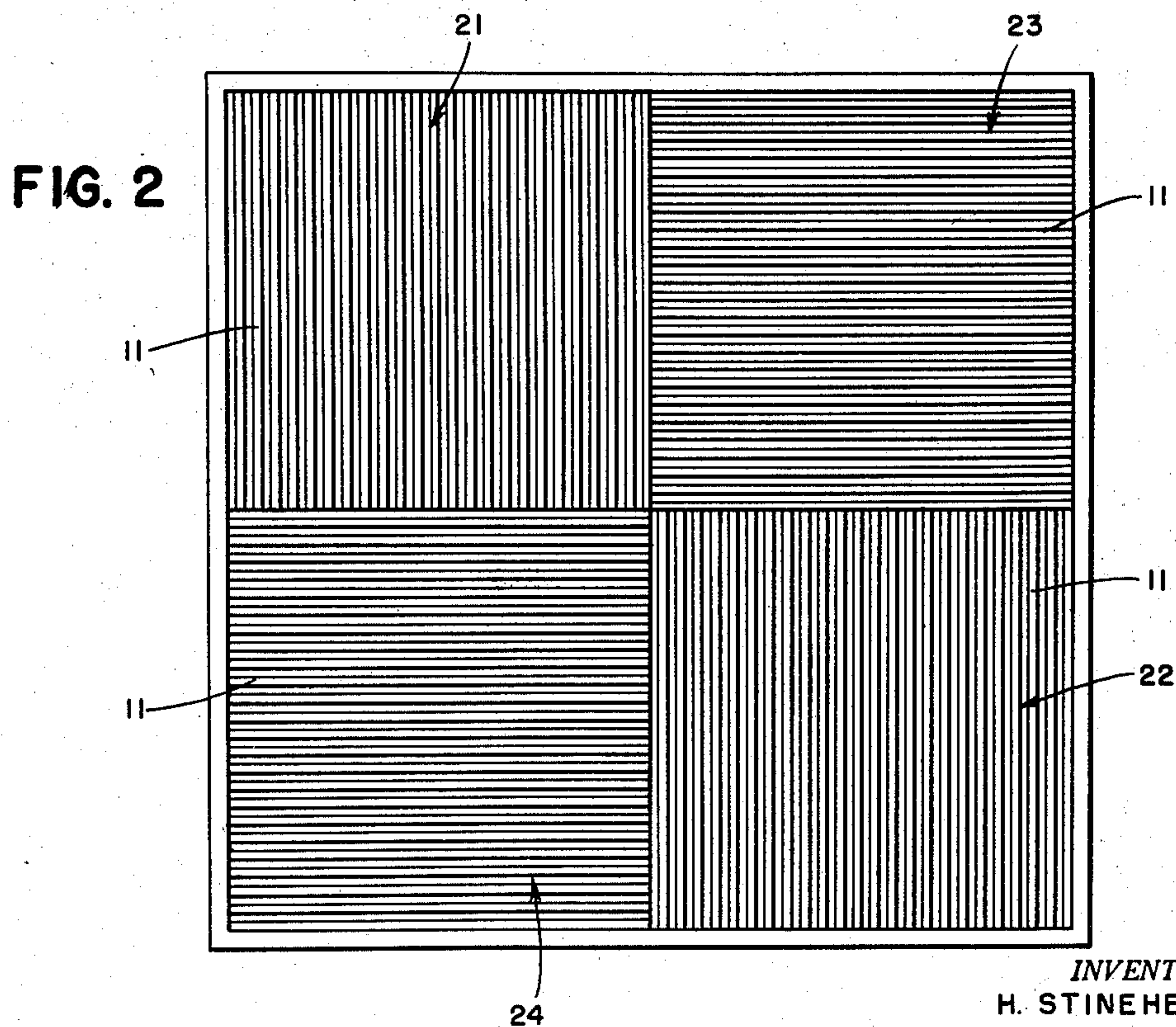


FIG. 3



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FIG. 4

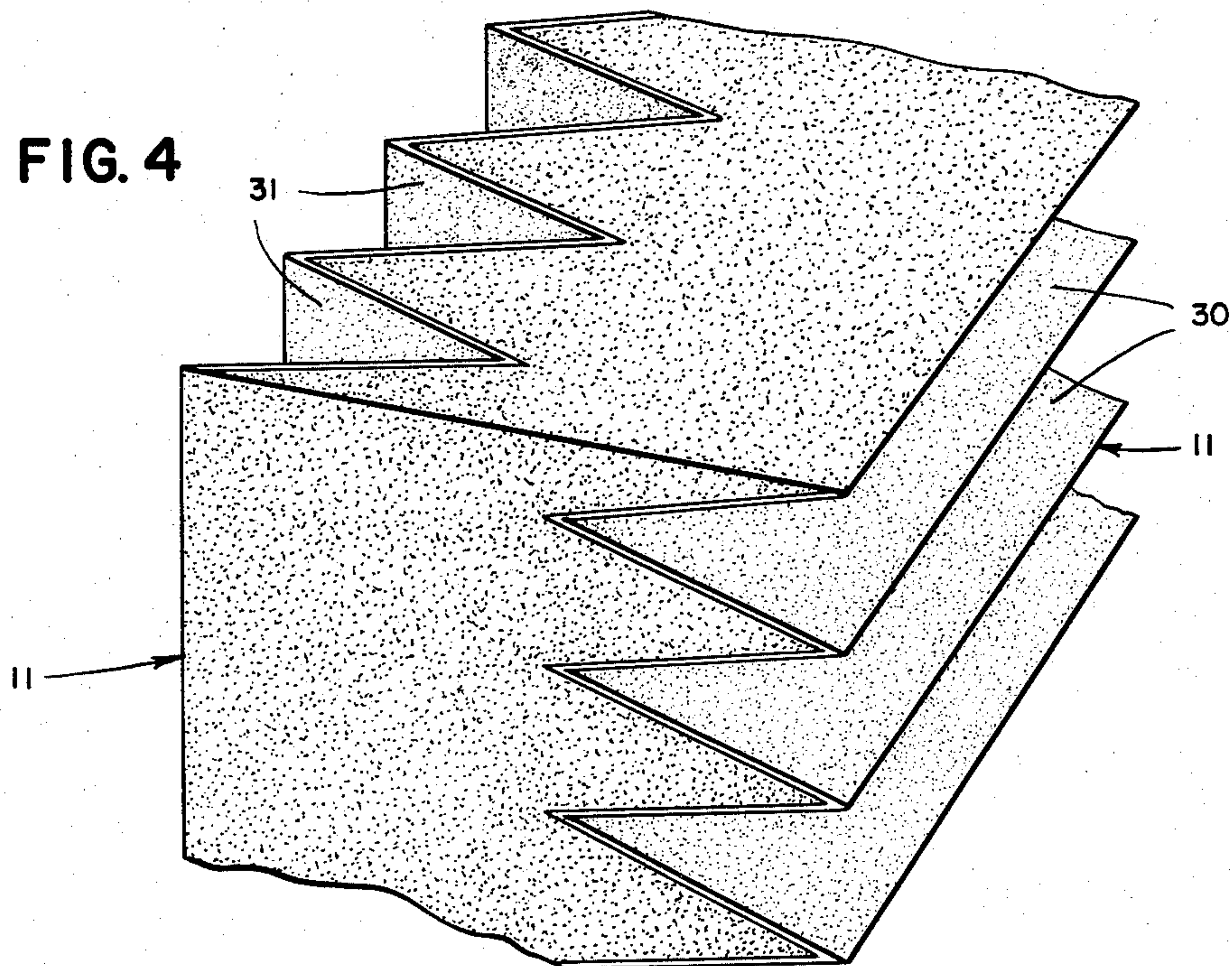


FIG. 5

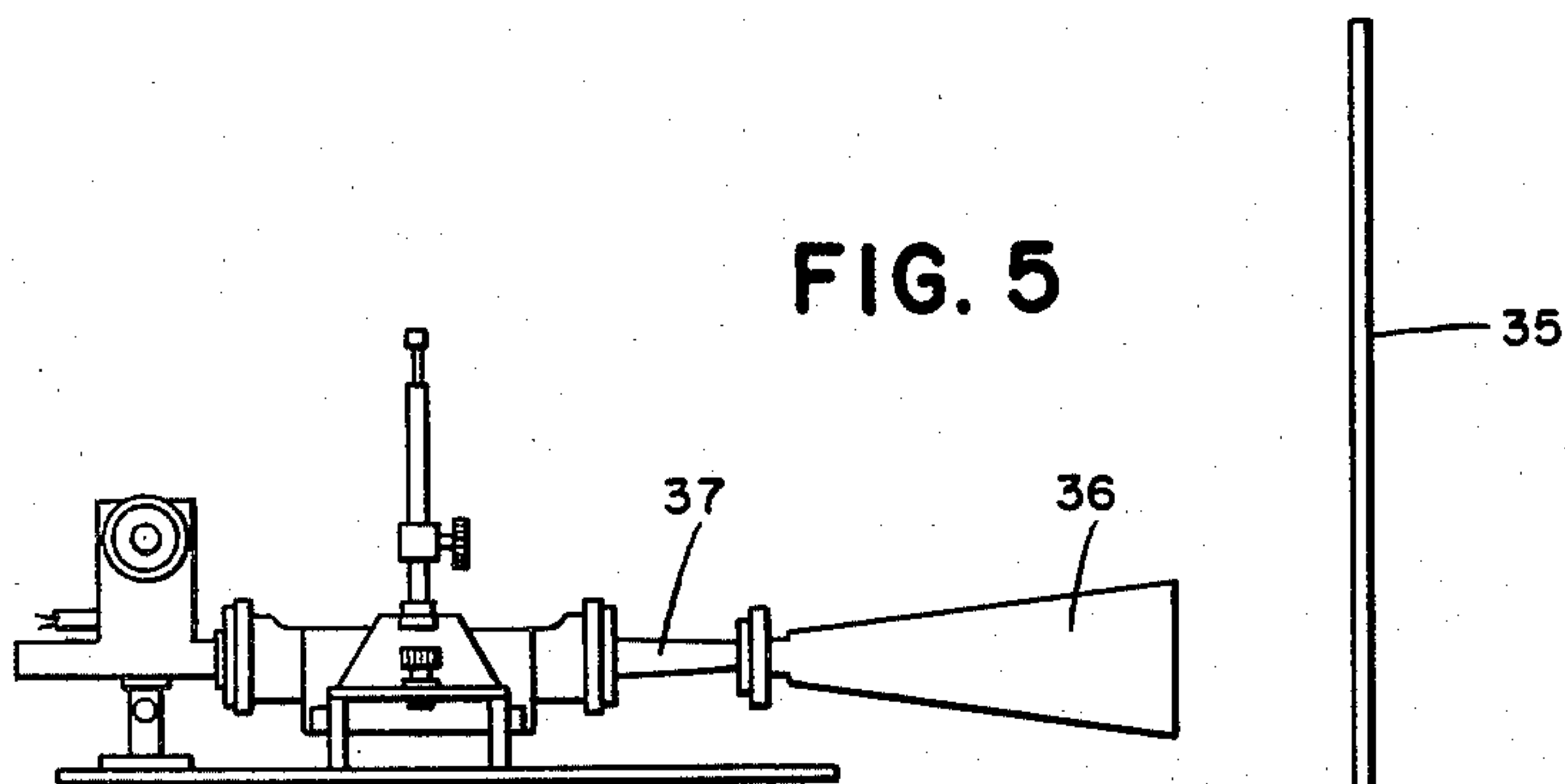
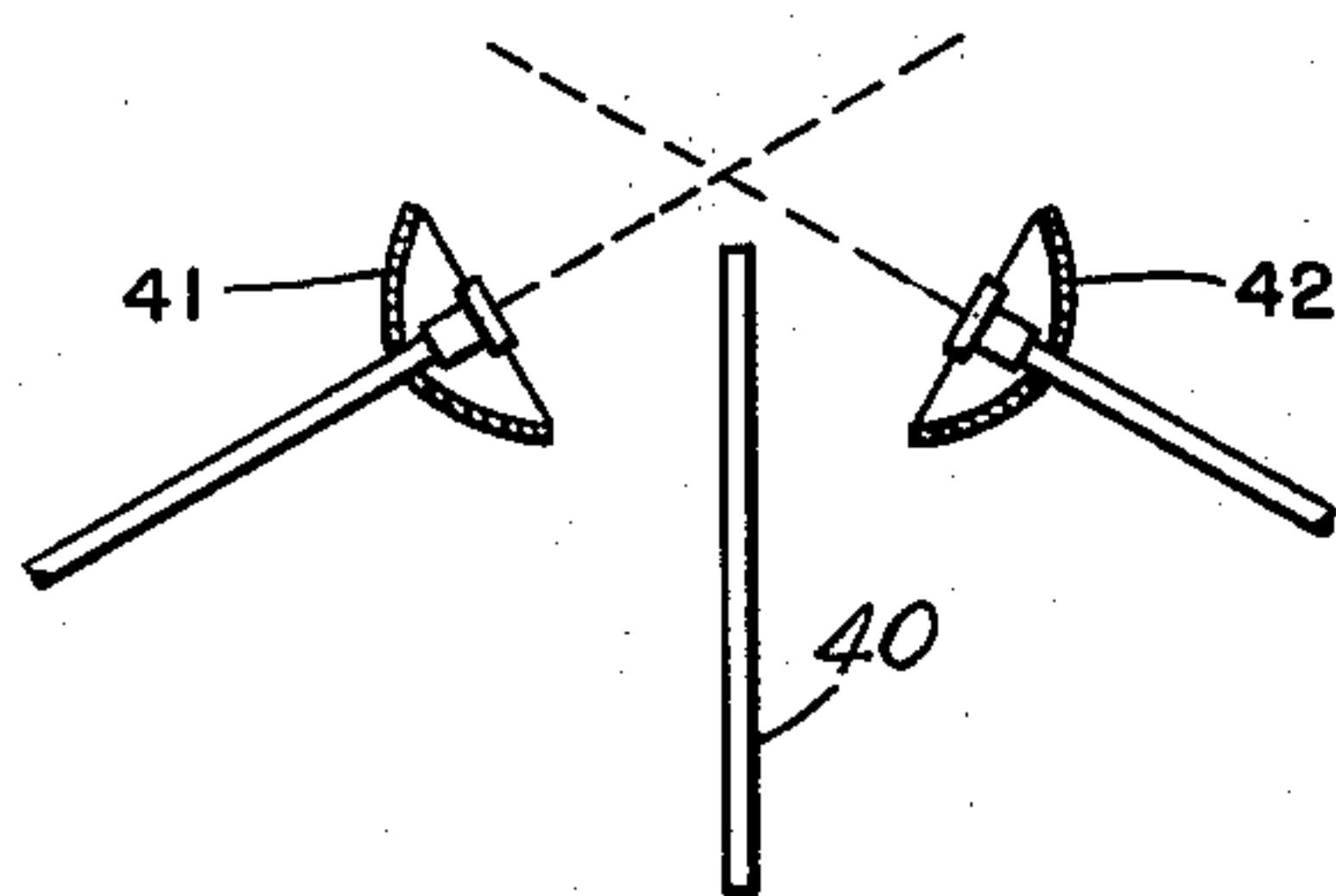


FIG. 6



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MICROWAVE ENERGY ATTENUATING WALL

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7 Claims. (Cl. 343-18)

The present invention relates to the absorption of radio waves and more particularly to suppressing transmission of radio waves lying within the microwave region.

For many purposes, such as the testing of antennas and radiating elements and for shielding, it is desirable to provide a wall or other barrier having power absorption characteristics approximating those of free space. Such a wall or barrier may be termed a free space wall.

The principal object of the invention is to provide a finite medium having microwave absorption characteristics approximating those of free space.

More particularly, it is an object of the invention to provide a finite medium that will absorb substantially all the microwave energy incident thereon.

Another object of the invention is to provide a free space wall upon which microwave energy may be directed substantially without reflection back to the source.

A further object of the invention is to provide a free space wall which will substantially completely prevent transmission of microwave energy in a given direction or directions substantially without reflection back to the source.

Another object of the invention is to provide a free space wall which will substantially completely prevent the transfer of microwave energy from a transmitting antenna to an adjacent antenna.

Still another object of the invention is to provide a free space wall having absorption characteristics substantially independent of frequency over a wide frequency range.

Further objects of the invention will appear from the following description.

In accordance with the invention, these objects are achieved by providing a free space wall composed of such a material and given such a configuration that substantially no microwave energy incident thereon is reflected back to the source. In other words, the wall will provide, for incident microwave energy, an impedance comparable to that of free space. It is to be understood that the term microwave refers to radio waves lying within the range of approximately 300 megacycles to 300,000 megacycles.

Free space may be considered as a medium having infinite dimensions and an intrinsic impedance of approximately 377 ohms. The intrinsic impedance η of wave transmission mediums in general is given by the relationship:

$$\eta = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\epsilon}}$$

where σ represents the conductivity in mhos per meter, μ is the permeability, ϵ is the permittivity and ω is the angular frequency. Since the permeability of all relatively pure dielectric mediums is approximately unity, and since there are no known dielectrics having permittivities materially less than that of free space, the in-

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trinsic impedance of free space represents the maximum attainable value for known dielectric materials. In order to provide a wall that will have absorption characteristics approaching those of free space, that is, a wall which will not reflect incident microwave energy back towards the source, it will be necessary to cause the incident energy to impinge on the wall more than once, so that sufficient energy will be dissipated in the multiple reflections. This is achieved by giving the wall such a configuration that incident energy will be reflected from one surface of the wall to another surface thereof, energy being absorbed in the wall at each reflection, so that the total loss after multiple reflections will attenuate the energy to a sufficiently low value without causing reflection of energy back towards to source.

The invention will now be described in greater detail with reference to the appended drawing in which:

Fig. 1 illustrates a cross sectional area of a portion of a free space wall in accordance with the invention;

Fig. 2 shows a free space wall according to the invention;

Fig. 3 is an enlarged view of a portion of Fig. 1;

Fig. 4 illustrates a portion of a double free space wall in accordance with the invention;

Fig. 5 shows a free space wall arranged to absorb energy from a microwave horn antenna; and

Fig. 6 shows a free space wall arranged to prevent transfer of energy between a pair of microwave antennas.

Referring now to the drawing and more particularly to Fig. 1, there is shown a cross sectional area of a portion of a free space wall comprising a backing 10 having a plurality of substantially parallel V-shaped serrations cut into an outer surface thereof, the serrations having a pitch P and a depth D. The walls of the serrations are substantially plane surfaces arranged to meet at an angle θ .

The surfaces of the serrations are coated with an electrically resistive film 11 to provide attenuation of incident microwave energy. Backing 10, which serves to provide structural support for the resistive film, may be composed of any insulating material having impedance characteristics similar to those of air. Examples of such materials are foamed polystyrene and cellular cellulose acetate.

To insure sufficient attenuation of a wave entering the surface of resistive film 11, the film should have a thickness greater than the depth of penetration. The term "depth of penetration" is to be understood as meaning that depth at which the power of a wave entering the surface of resistive film 11 is attenuated one neper, that is to the value of 36.8% of the power of the wave at the surface. The thickness of film 11 should not be made too great, as a reduction in surface resistivity with a consequent reduction in efficiency will result. To insure penetration of the surface, resistive film 11 should have a reflection factor much greater than zero but less than one. The term "reflection factor" is to be understood as meaning the ratio of the power of a reflected wave to the power of an incident wave at the reflecting surface. A reflection factor of 0.6 would mean that 60% of the energy would be reflected and 40% transmitted into the film. It has been found that reflection factors lying within the range of approximately 0.5 to 0.75 produce the most satisfactory results.

A suitable material for resistive film 11 is a colloidal solution of graphite in alcohol or water, which may be sprayed in layers on a foamed polystyrene or other backing. Addition of substances such as carbontetrachloride and benzol to the colloidal solution of graphite will cause the film to adhere more firmly to the backing. The examples given for resistive film 11 and backing 10 should

be considered as illustrative only, as many other materials might be employed.

The angle θ between adjacent serration walls should be chosen so that a wave incident on one wall will be reflected to an adjacent wall and not back towards the source. The serration pitch P and depth D are preferably chosen as fractional parts of a wavelength of the incident wave so that maximum efficiency and minimum reflection toward the source will be achieved.

In a preferred embodiment of the invention, angle θ is given a value of 30° , dimension P is substantially a quarter wavelength at a frequency in the middle of the range with which the wall is to be used, and dimension D is approximately a half wavelength at this frequency. A given wall constructed according to the above specifications may be used over a wide frequency range, such as 300 to 10,000 megacycles.

In Fig. 1, a wave E striking resistive film 11 at point 12 will be subjected to multiple reflections and absorptions at points 12, 13, 14 and 15 before passing through the wall and will be partially attenuated at each of these points. The wave passing through rear surface 16 of the wall will be sharply attenuated, the degree of attenuation depending on the surface resistance and thickness of the resistive film 11 and the number of reflections to which the wave has been subjected. The number of reflections will be dependent primarily upon the angle of incidence of the wave front and the angle θ . Irregularities in the surface of resistive film 11 will vary the number of reflections depending upon the point of incidence of the wave front. While the wave E in Fig. 1 is shown as being reflected at points 12, 13, 14 and 15 as a single beam, in practice the reflection phenomenon will be more complicated because of the irregular nature of the surface of resistive film 11. Fig. 3 shows an enlarged view of a single pair of serration walls onto one of which is directed a wave E . Wave E represents a small portion of a wave front which will be incident on the wall. Because of the irregular nature of the wall coating, that portion of the wave front which is reflected from point 12 will comprise many components reflected in different directions. Each of these reflected components is again broken up into additional components upon striking the opposite wall. In this way many more reflections of the incident wave are achieved than would be expected from the illustration of Fig. 1. Since a wave front may be considered as made up of a large number of waves such as wave E , it is apparent that the polarization of the wave front will be substantially destroyed because of the action of the resistive film 11 on the wave front. The additional reflections resulting from the irregular nature of the surface of resistive film 11 are desirable in that attenuation is produced at each reflection. Maximizing the number of reflections will maximize the attenuation achieved. The energy absorbed at each point of reflection is dissipated in the form of heat.

If a portion of the energy of an incident wave penetrating film 11 of a serration wall were not absorbed therein but were to pass through into backing 10, reflections of such energy between the penetrated wall and the adjacent serration wall would occur, so that proper attenuation would still be achieved.

Fig. 2 shows one face of a free space wall. The face illustrated comprises four quadrants, two of which, 21 and 22, have vertically cut serrations and the other two of which, 23 and 24, have horizontally cut serrations. The reverse face of the wall, which is not shown in the figure, would be identical with the illustrated face with the exception that the quadrants on the reverse face having vertically cut serrations would be opposite quadrants 23 and 24, while those having horizontally cut serrations would be opposite quadrants 21 and 22. A complete free space wall might comprise one wall as shown in Fig. 2 or a plurality of such walls, depending on the degree of

attenuation desired. A plurality of free space walls, such as the one shown in Fig. 2, might be used as the sides, top and bottom of a box or room to provide a space substantially free of microwave energy or to prevent microwave energy from leaving the box or room.

In Fig. 1, the serrations are shown as being cut horizontally. The wall will therefore tend to be slightly more effective for attenuating vertically polarized waves than for horizontally polarized waves.

Fig. 4 shows a free space wall in which attenuation for different polarizations is substantially equal and in which the attenuation is increased. Reference now to Fig. 4, a first section 30 is identical to the wall shown in Fig. 1. A second section 31, however, comprises serrations cut in a vertical direction. In other respects section 31 is identical with section 30. The wall of Fig. 4 may be considered as a portion of the wall illustrated in Fig. 2.

Addition of section 31 behind section 30 approximately doubles the number of reflections achieved and hence greatly increases the attenuation secured. As the serrations of section 31 are perpendicular with respect to those of section 30, the total attenuation provided for a horizontally polarized wave will be substantially equal to that provided for a vertically polarized wave.

If the wave E , after passing through sections 30 and 31, were to be reflected back toward the source, as by reflecting it from a metal surface, additional attenuation would occur as the wave again passed through sections 31 and 30. By providing additional sections, similar to sections 30 and 31, the attenuation can be increased to any desired amount. In a preferred embodiment of the invention, a wall having a section 30 and a section 31 provided an attenuation of 12 decibels.

For testing an antenna in a relatively low power transmission system, one free space wall, such as the wall shown in Fig. 2, may provide adequate suppression of incident microwave energy. For testing antennas in higher power transmission systems, more wall sections may be required to provide adequate suppression. Such additional wall sections may be placed directly behind and contiguous the free space wall shown in Fig. 2, or they may be spaced therefrom. For purposes such as separation of receiving from transmitting antennas, the number of wall sections necessary for effective isolation will depend, in large measure, on the relative orientation of the antennas and the relative power of the transmitted and received signals.

In Fig. 5, which illustrates the use of a free space wall for suppressing the transmission of energy from a microwave antenna, a free space wall 35, which may be similar to the wall shown in Fig. 2, is interposed in the path of microwave energy from a radiating horn 36 coupled to the output of a wave guide system 37.

In Fig. 6, which illustrates the use of a free space wall for suppressing the transfer of energy from one antenna system to another, a free space wall 40, which may be similar to the wall shown in Fig. 2, is interposed between two parabolic antenna systems 41 and 42.

While the wall illustrated in Fig. 2 has a rectangular surface, walls having other shapes could be constructed for various purposes. For instance, a free space wall could be constructed in a cylindrical or spherical shape for surrounding a radiating element. Since the dimensions of the serrations are not critical, a given free space wall is useful over a relatively wide frequency range.

While the invention has been described in specific embodiments and in specific uses thereof, it is not desired that it be limited thereto, for obvious modifications thereof will occur to those skilled in the art without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. A device for attenuating microwave energy, comprising a body member composed of insulated material

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and having a pair of opposite generally plane surfaces each of said surfaces being divided into a like plurality of generally rectangular segments, each of said segments having a lateral edge abutting a lateral edge of another segment, each of said segments comprising a plurality of generally V-shaped substantially parallel serrations, the abutting sides of adjacent serrations meeting at an angle lying within the range of about 20 to 30 degrees and an electrically resistive film coated on the sides of said serrations so that multiple reflections of said microwave from one to the other of the abutting sides of said adjacent serrations will be produced when the device is disposed in the path of said microwave energy, said electrically resistive film having the properties of reflecting and absorbing substantial portions of incident microwave energy, the substantially parallel serrations of each of said segments of each of said surfaces being arranged in a substantially perpendicular direction to the parallel serrations of a segment having a lateral edge abutting the lateral edge thereof, each of said segments of one of said surfaces being arranged opposite a corresponding segment of the other of said surfaces, the parallel serrations of said corresponding segments being arranged in substantially perpendicular directions.

2. A device for attenuating microwave energy, comprising a body member composed of insulating material and having a pair of opposite generally plane surfaces each of said surfaces being divided into a like plurality of generally rectangular segments, each of said segments having a lateral edge abutting a lateral edge of another segment, each of said segments comprising a plurality of generally V-shaped substantially parallel serrations, the abutting sides of adjacent serrations meeting at an angle lying within the range of about 20 to 30 degrees and an electrically resistive film coated on the sides of said serrations so that multiple reflections of said microwave from one to the other of the abutting sides of said adjacent serrations will be produced when the device is disposed in the path of said microwave energy, said electrically resistive film having the properties of reflecting and absorbing substantial portions of incident microwave energy, the substantially parallel serrations of each of said segments of each of said surfaces being arranged in a substantially perpendicular direction to the parallel serrations of a segment having a lateral edge abutting the lateral edge thereof, each of said segments of one of said surfaces being arranged opposite a corresponding segment of the other of said surfaces.

3. The device of claim 2 wherein the said electrically resistive film comprises graphite.

4. The device of claim 2 wherein the said insulating material comprises polystyrene foam.

5. The device of claim 2 wherein the said electrically resistive film comprises graphite and the said insulating material comprises polystyrene foam.

6. A wave attenuation system for continuous microwave energy comprising a source of microwave energy, means to direct said microwave energy along a given path and in said given path a device for attenuating microwave energy, comprising a body member composed of insulating material and having a pair of opposite generally plane surfaces each of said surfaces being divided into a like plurality of generally rectangular segments, each of said segments having a lateral edge abutting a lateral edge of another segment, each of said segments

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comprising a plurality of generally V-shaped substantially parallel serrations, the abutting sides of adjacent serrations meeting at an angle lying within the range of about 20 to 30 degrees and an electrically resistive film coated on the sides of said serrations so that multiple reflections of said microwave from one to the other of the abutting sides of said adjacent serrations will be produced when the device is disposed in the path of said microwave energy, said electrically resistive film having the properties of reflecting and absorbing substantial portions of incident microwave energy, the substantially parallel serrations of each of said segments of each of said surfaces being arranged in a substantially perpendicular direction to the parallel serrations of a segment having a lateral edge abutting the lateral edge thereof, each of said segments of one of said surfaces being arranged opposite a corresponding segment of the other of said surfaces.

7. A microwave antenna isolating arrangement, comprising first antenna means for transmitting continuous microwave energy, second antenna means arranged in the vicinity of the first antenna means, and means in the path between said first and second antenna means for substantially preventing transfer of microwave energy from one to the other of said antenna means consisting of a device for attenuating microwave energy, comprising a body member composed of insulating material and having a pair of opposite generally plane surfaces each of said surfaces being divided into a like plurality of generally rectangular segments, each of said segments having a lateral edge abutting a lateral edge of another segment, each of said segments comprising a plurality of generally V-shaped substantially parallel serrations, the abutting sides of adjacent serrations meeting at an angle lying within the range of about 20 to 30 degrees and an electrically resistive film coated on the sides of said serrations so that multiple reflections of said microwave from one to the other of the abutting sides of said adjacent serrations will be produced when the device is disposed in the path of said microwave energy, said electrically resistive film having the properties of reflecting and absorbing substantial portions of incident microwave energy, the substantially parallel serrations of each of said segments of each of said surfaces being arranged in a substantially perpendicular direction to the parallel serrations of a segment having a lateral edge abutting the lateral edge thereof, each of said segments of one of said surfaces being arranged opposite a corresponding segment of the other of said surfaces.

References Cited in the file of this patent

UNITED STATES PATENTS

2,441,615	Brown	May 18, 1948
2,464,006	Tiley	Mar. 8, 1949
2,507,746	Wright	May 16, 1950
2,579,324	Kock	Dec. 18, 1951
2,594,971	Moullin	Apr. 29, 1952
2,599,944	Salisbury	June 10, 1952
2,610,250	Wheeler	Sept. 9, 1952
2,656,535	Neher	Oct. 20, 1953

OTHER REFERENCES

Principles of Radar, M. I. T. Radar School Staff, second edition, McGraw-Hill Book Co., Inc., New York, pages 8-3 to 8-5 relied on.