Jan. 14, 1930. J. M. CAGE 1,743,526

LIGHTNING PROTECTION

Filed Dec. 27, 1926 3 Sheets-Sheet 1

Fig. 1.

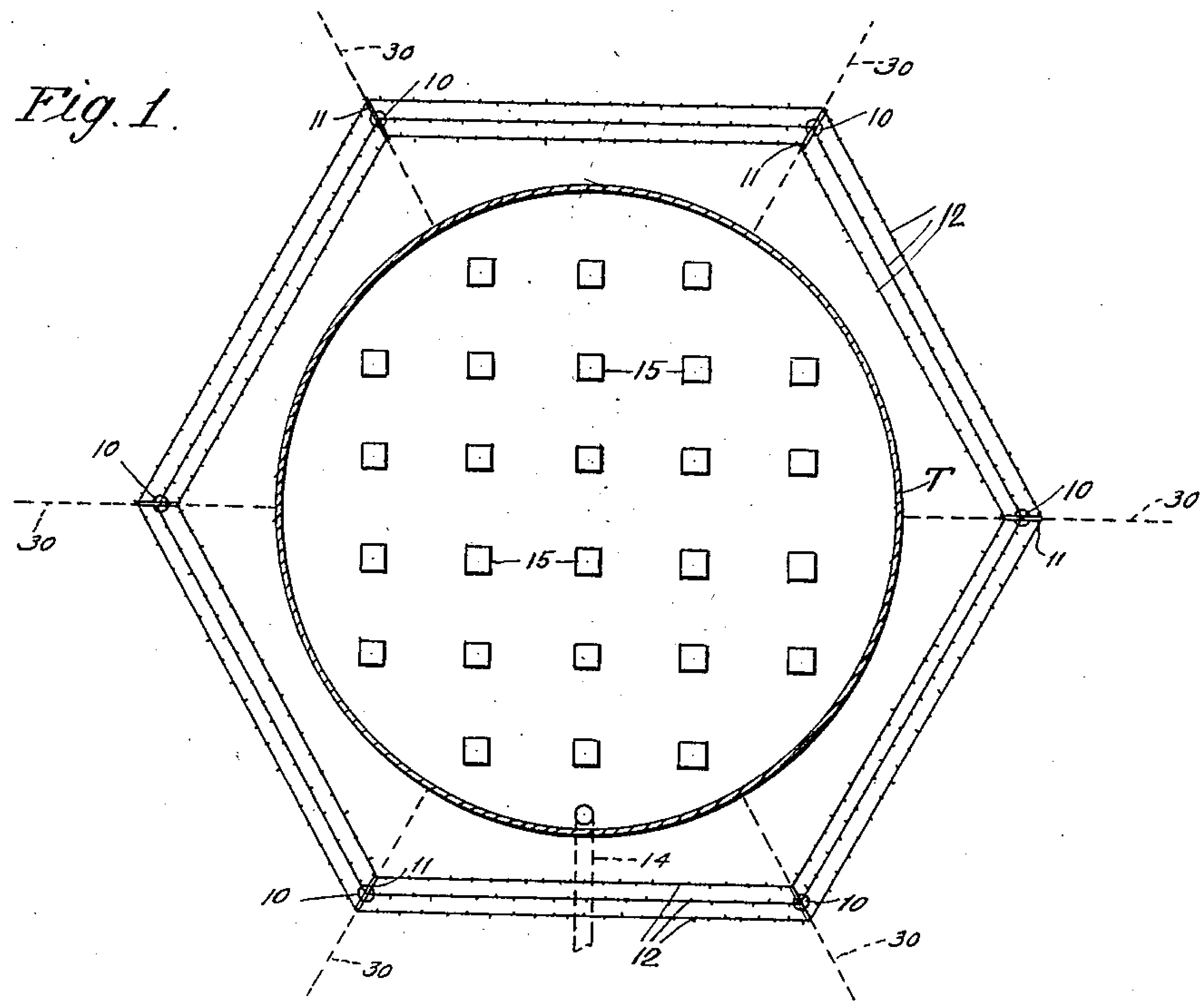
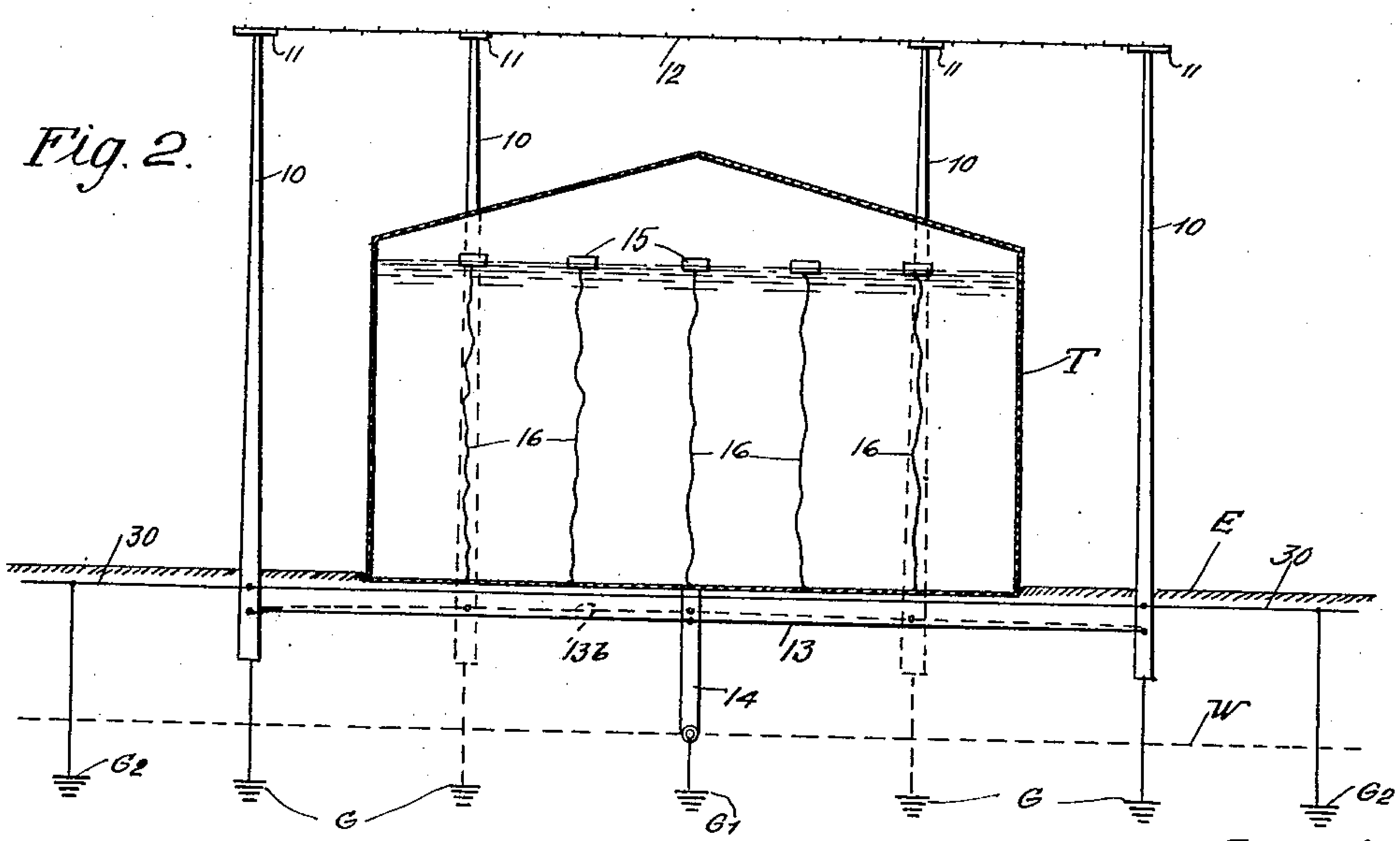


Fig. 2.



Inventor.
John M. Gage.

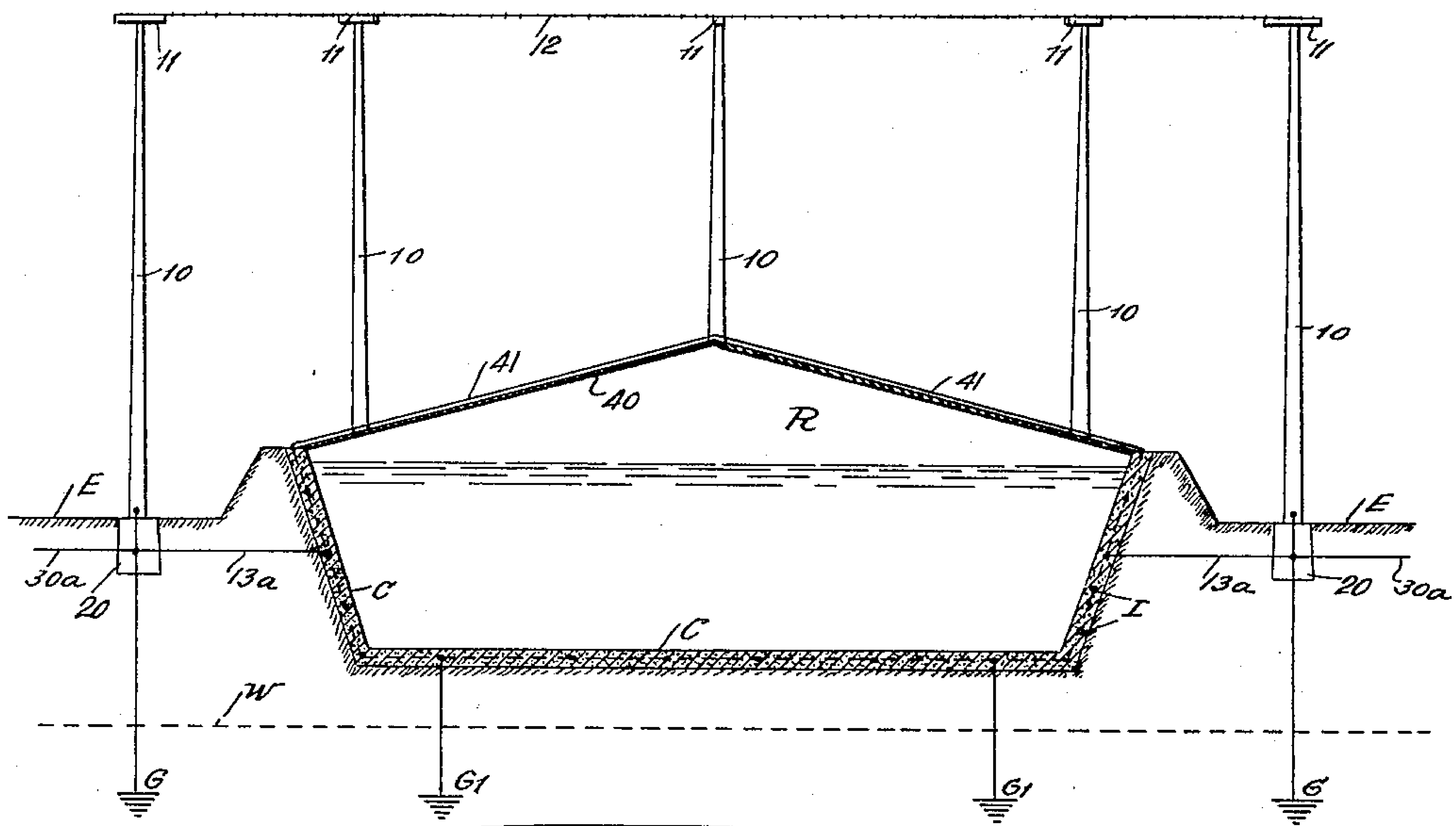
Attorney.

Jan. 14, 1930. J. M. CAGE 1,743,526

LIGHTNING PROTECTION

Filed Dec. 27, 1926 3 Sheets-Sheet 2

Fig. 3.



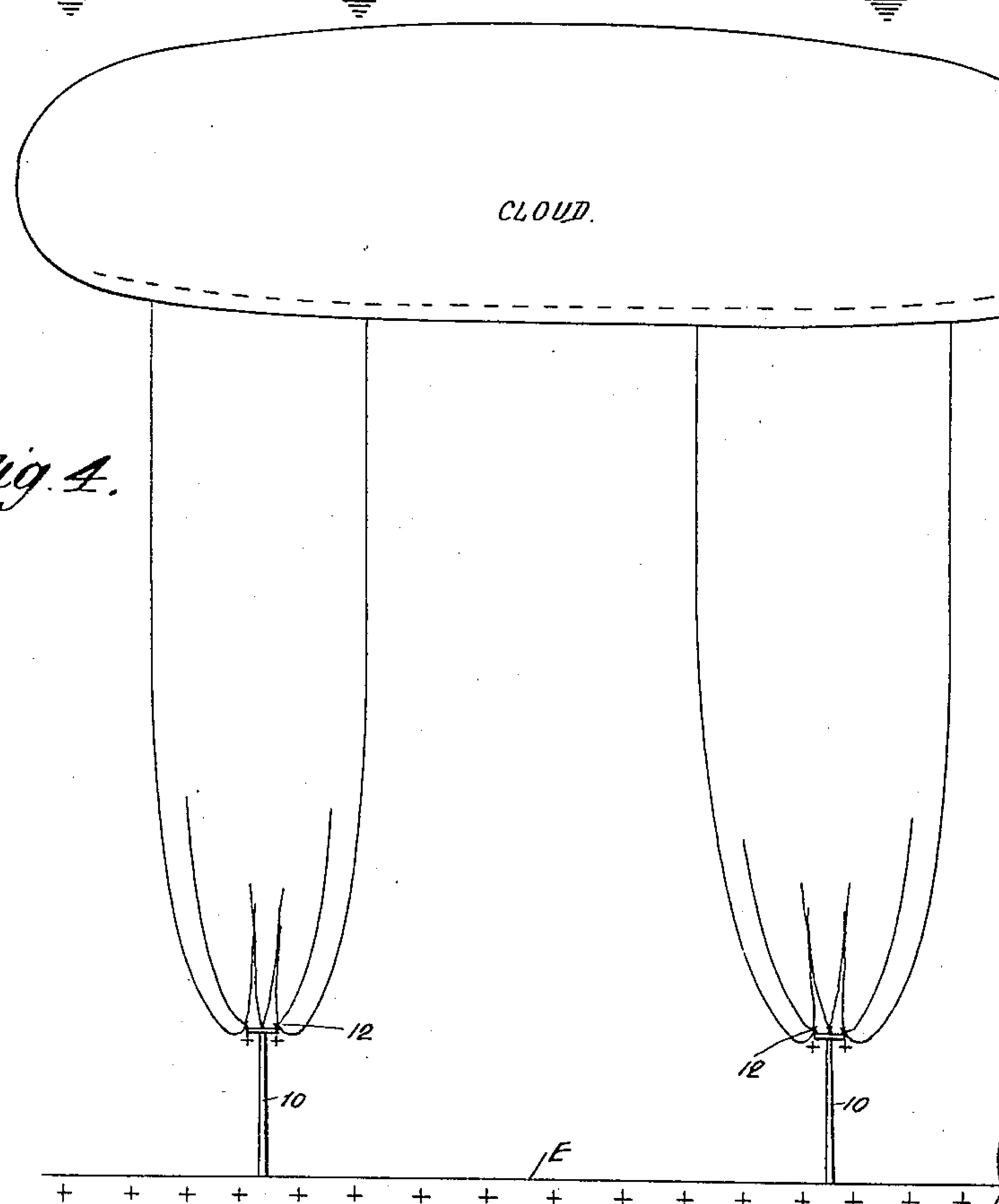


Fig. 4.

Inventor.
John M. Cage.

Attorney.

Jan. 14, 1930.

J. M. CAGE

1,743,526

LIGHTNING PROTECTION

Filed Dec. 27, 1926

3 Sheets-Sheet 3

Fig. 5.

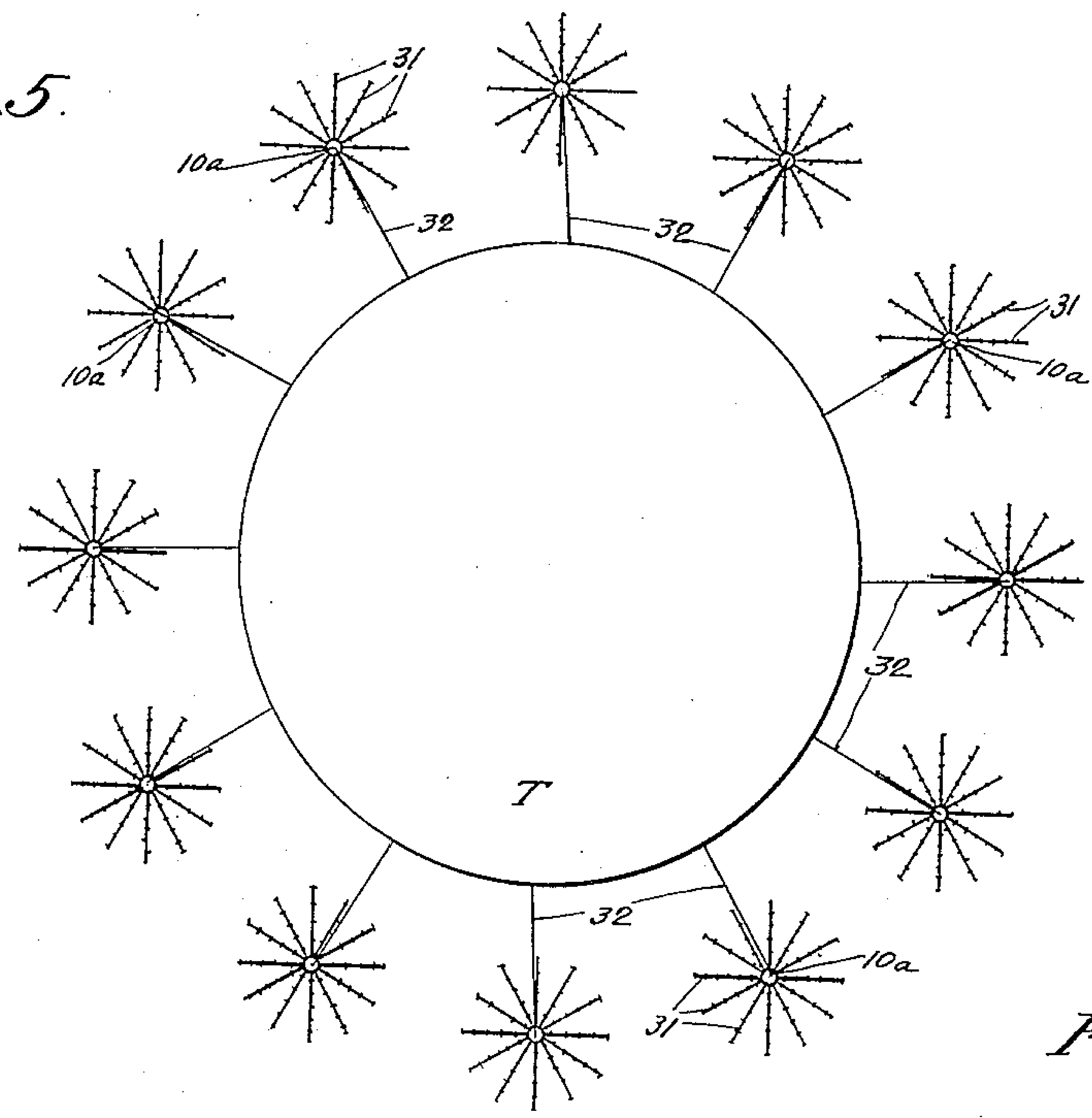
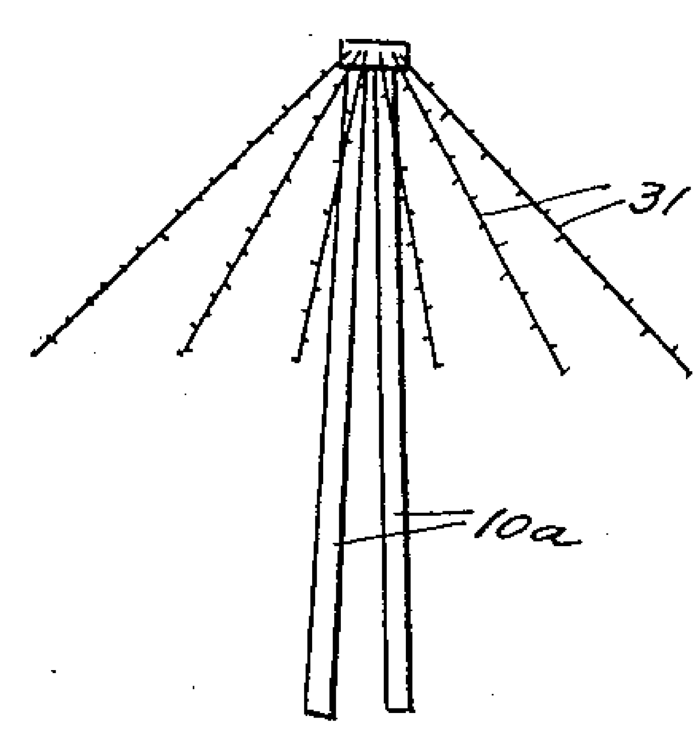


Fig. 6.



Inventor.
John M. Cage.

James T. Barkelew

Attorney.

Patented Jan. 14, 1930 1,743,526

UNITED STATES PATENT OFFICE

JOHN M. CAGE, OF LOS ANGELES, CALIFORNIA, ASSIGNOR OF ONE-HALF TO OLIVER O. HOWARD, OF ROCKPORT, MASSACHUSETTS

LIGHTNING PROTECTION

Application filed December 27, 1926. Serial No. 157,056.

This invention has to do with the protection against lightning of earth areas, and bodies, structures or objects of any description, whether or not they may be upon or in connection with the ground, at sea, in the air, etc. The invention characteristically contemplates, as will be understood from what follows, the protection of any such area or body by lightning prevention in a novel manner based upon dissipation or transfer of the flash-causing charge; but at the same time, it contemplates and affords protection also in manners that are old and well known.

The theory of lightning rod protection has long been understood to be two-fold; that a lightning rod has two functions. One of these functions is the dissipation of charge energy to atmosphere, thus somewhat to decrease the liability of the potential gradient between the cloud and rod building up to the discharge point; the other function is to attract and carry to ground any lightning flash that may occur within the immediate neighborhood of the rod. However, lightning rods have been practically ineffectual for the dissipation or transfer of the flash-causing charge, for reasons that I will hereinafter point out, and have perhaps been more successful in their function of catching lightning discharges than they have in their function of preventing discharge. And if lightning rod protection does successfully take a lightning discharge and carry it to ground, there is no provision in such lightning rod systems for taking care of what is known as the "secondary effect" on surrounding objects.

The exact cause or agency that initiates and builds up the potential difference between two clouds or earth and cloud, and thus ultimately causes the lightning flash, is of no fundamental importance so far as my invention is concerned. It is generally understood that potential differences between cloud and earth, for instance, may be the result of causes in which induction or influence, cloud and atmospheric friction, and transfer by rain may play a part; but, whatever the initial cause, the important fact upon which my invention is based—the condition which my invention is aimed to relieve or obliterate—is that the immediate cause of lightning flashes resides in the building up of opposite electrical charges in cloud and earth, or cloud and other objects, the potential difference in proportion to the distance—the potential gradient—electric stress or electric field intensity—finally becoming high enough to break down air resistance and cause the flash. The primary object of my invention is to remove, or reduce below the danger point, the immediate cause of both the lightning flash and the "secondary effect".

When a flash occurs the potential difference at the points at opposite ends of the flash is almost instantaneously substantially equalized at those points, the flash forming a path of low resistance between cloud and earth. There is consequently an immediate flow of charge from surrounding areas or points to the point of discharge. Surrounding points on an earth area, for instance, have a charge density perhaps nearly as high as that at the point where the discharge occurred. Consequently, at all such surrounding points there is immediate release, so to speak, of the charge previously bound by the cloud charge; and that release constitutes the secondary effect which often-times causes disastrous results. The action of this secondary effect on oil tanks, for instance, is well known from experience; the current flow set up in different parts of an oil tank or reservoir or body of oil may be sufficient, even though the lightning stroke be at a considerable distance, to cause ignition of gases if there happens to be any slight gap in the path of flow. It has therefore been proposed to protect oil storage by means of some electro-static shielding system that would be adequate to prevent the storage from taking a charge and also permit a ready flow of the charge from or through the shielding systems; but such shielding system must necessarily take the charge and therefore does not reduce the liability of a lightning flash occurring. Thus, such a system deals with conditions occurring during or after a lightning flash, and with conditions caused by such flash, whereas the present invention deals with conditions precedent to the flash for the purpose of preventing the flash itself.

Thus, in a typical instance of protecting oil storage tanks and reservoirs against the influences of lightning, it has been proposed to set up tall towers, or other structures, primarily for the purpose of taking a lightning flash; or to provide a series or net work of conductors over a tank or reservoir, to protect in some degree against the secondary effect. Neither of these means, however, prevent the occurrence of lightning flashes or remove the cause of the secondary effect; in fact, the mere provision of what amounts to lightning rods may have the effect under certain circumstances of causing a lightning discharge to take place close to the tank; and although lightning rods or towers may effectually carry the discharge to ground, the secondary effect may cause damage. And if adequate shielding provision can be made to take care of the secondary effect, there is always a chance that the lightning discharge may strike the tank or reservoir itself, instead of the rods or towers; because, as I have said, neither the shielding system nor the rod system will prevent lightning strokes.

My invention is aimed primarily at the prevention of lightning flashes and secondary effects by way of removing their causes; by way of removing or neutralizing the charges which ultimately cause the lightning flash, or the secondary effect, and removing those charges before the potential gradient becomes dangerous. Although I shall explain my invention as applied particularly to the protection of an oil tank or reservoir, and the immediately surrounding earth area, it will be understood from what I say in the following detailed description, that my system is applicable as well to the protection of other bodies or structures which do not stand upon or are not connected to the earth's surface, or ground; as for instance, ships, airplanes and dirigibles. However, the invention perhaps can be best understood from a description of an application directed primarily to oil reservoirs and tanks; the following description is therefore drawn along those specific lines, but without thereby limiting the invention to such specific application. In the drawings accompanying this description:

Fig. 1 is a plan showing diagrammatically the application of my system to an oil tank;

Fig. 2 is a diagrammatic sectional elevation of the same;

Fig. 3 is a diagrammatic elevational section showing the application of the system to an oil reservoir;

Fig. 4 is a diagrammatic elevation showing the relation between a cloud and a protected area;

Fig. 5 is a diagrammatic plan showing a variant form of charge dissipating element, as it may be arranged about the object to be protected;

Fig. 6 is a detail elevation showing the charge dissipating element of Fig. 5.

Generally speaking, my invention characteristically resides in the provision of a charge dissipating or charge transferring element of some horizontal extent, preferably elevated well above the level of the area or object being protected and connected into that object or area in such a manner that the change of the object or area is freely transferable to the dissipating or transfer element as fast as the element transfers or dissipates the charge. The dissipating or transferring element is characteristically one of such relative size, form and location as to cause concentration of the lines of force and thus to cause localized increase of the potential gradient, electric stress—or electric field; and further of such formation, that it will, in that localized field of increased potential gradient, act to dissipate or transfer the charge at a total rate sufficient to keep the charge on the protected area or object from building up to the danger point. This last mentioned formation, for dissipation or transfer, may be attained by using wires preferably of small diameter (short radius of curvature) or, better practically, by using wire for concentration and equipping that wire with sharp points for dissipation.

For reasons that I hereinafter touch upon it may be preferred, wherever the nature of the situation permits, to arrange the dissipating and transferring element above and peripherally around the immediate object or area to be protected; but this is not necessarily the case, as will hereinafter appear.

The particular manner in which the elevated charge transferring element is connected into the body or area is variable to suit particular circumstances. Such connections, for instance, may be effected through ground connections of both area or body and the elevated element; or may be effected by direct conductor connections between the area or body and the charge-transferring element; or by both. In any case, these connections are so made that they are effective to pass the charge from the whole of the area or body to the charge-transferring element at a rate at least equal to the rate of dissipation or transfer which is designed to be great enough, at a comparatively low potential gradient, to pass off the charge at least as fast as it tends to build up, so as to prevent a charge from reaching any dangerous intensity. In cases where the body or area to be protected is of a dielectric or poorly conducting nature, the connections may be so made into it at different points as to be effective in carrying away its whole charge, or substantially its whole charge, to the charge dissipating or transferring element.

From what I have said, it will be seen that the invention is applicable in various manners to the protection of various specific things, and in the following detailed description, in connection with the accompanying drawings, I shall attempt to set forth a few typical instances, without, however, limiting the invention or its application or use, to such specific or mentioned instances.

In Figs. 1 and 2 I show, for instance, an oil tank T, of usual typical form, resting upon the earth's surface E. In applying my invention to the protection of such a tank, I will usually erect a suitable number of poles or towers 10 spaced around the tank. In case it is desired to string more than one charge transferring and dissipating wire, these poles may be provided with cross arms 11, and a plurality of wires 12 may be strung upon them in encircling or peripheral formation about the tank, and at a suitable distance from it. For the purposes of my system I have found that ordinary barbed wire such as used for fencing, will do the work very well, although heavier wire such as used for trench entanglements may be used. The only requisite is that the wire or other charge transferring or dissipating element shall be of such form (small diameter or radius of curvature) as to cause concentration of the lines of force, thus causing ionic discharge to readily take place. This ionic discharge may be greatly accelerated and increased by the placing of frequent properly distributed points along the length of the charge transferring wire or element. As to the number and spacing of points and the spacing of the wires, when more than one is used, I shall speak later.

An important thing in connection with the charge transferring element is that it is suitably and adequately connected into the protected area or body or object; and this may be done in a variety of manners. In addition to being connected into the protected area or object, it is of course always adviasable that the elevated charge transferring element will also be grounded to take advantage of ground water conductivity. In some installations the grounding and the connection into the protected area or body or object may be, in practice, one and the same thing; it may be that the connection into such area, body or object may be by way of ground connections; but it is well to keep in mind the two possible distinct functions of such ground connections, as the system is capable of application in some situations where there is no ground connection at all, and it is also capable of functioning for charge transfer without a ground connection. However, in many cases where protected objects or structures are upon the earth's surface, the connections will involve ground connections—will involve connections to the earth's surface, and to ground below the surface, to protect the earth area as well as the structure or body, to remove the lightning causing charge built up in the earth area as well as in the body or structure.

Thus, in the typical instance of protecting an oil body, the poles or towers 10 may all be thoroughly grounded, as by providing them with grounds G placed below the water level W where the ground connection is highly effective. The tank itself may also be similarly grounded, as at G^1; and thus through the several grounds the tank and poles will not only be grounded but will be interconnected. The poles or towers may typically be of metal, and wire or wires 12 may be simply strung upon them in electrical connection with them; or they may be of wood or any other suitable material, and conductors may be strung up the poles to provide the connections.

In addition to, or in substitution for, the grounded interconnections, the poles and tank may be interconnected by suitable metallic conductors as indicated at 13^b and 13. The conductors 13 may run to the tank itself, or may, for instance, run to a pipe 14 that contacts with the tank. The pipe 14, are the several such pipes which usually communicate with the tank, may themselves form the ground connection for the tank, particularly if they are deep enough or extended enough to make good grounds. In situations where the earth is relatively moist or the water level W is close to the surface, the connections to ground also form adequate connections into the earth surface or area, the water level being a comparatively good conductor. However, where the earth is dry, or the water level rather deep, it is well to provide conductors at or near the surface to carry off the surface charge. Thus there may be radiating conductors 30 laid near the surface E. These may extend outwardly to any desired extent to connect in the earth surface in any desired areas; and they may be occasionally grounded as at G^2 to take advantage of the water level conductivity in gathering in the earth surface charge. Pipes leading from the tank, on or near the surface, may constitute in part, or wholly, the conductors 30. Such conductors 30, whatever their nature, typify a surface conducting system so spread upon or near the surface as to feed in the earth surface charge from substantially the whole of the area being protected; so that the charge is fed in even though the surface be a relatively poor conductor.

It will be seen from what has now been described, that the charge transferring or dissipating element is connected into the earth area desired to be protected, and also connected into the tank itself. If the substance contained in the tank is of such dielectric strength that it will hold a charge and prevent that charge passing sufficiently rapidly to the tank and thus to the dissipating element, then connections may also be made into the body of liquid in the tank in such a manner as to connect intimately into that body of liquid at various points and thus take off its charge. For instance, spaced floats 15 may rest at the surface of the oil and they may support conductors 16 which are connected to the bottom of the tank in any suitable manner; or are connected in any suitable manner to any conductor going to the dissipating element or to ground, or both. These conductors may preferably be bare wire or rods and the floats themselves may also be conductors. However, any conductive system that is in more or less intimate contact with the body of oil or other substance may be used. For instance, a screen may be floated on the liquid surface or screens may be placed at spaced levels in the tank. It is not positively known at present whether such conductors to the oil itself are necessary for the protection of the oil. Petroleum oils have a certain dielectric strength; but my experimental data seems to indicate that most petroleum oils are sufficiently mobile under the charges and time intervals involved, to pass the charge off from the oil at a sufficient rate to keep the oil fully protected. However with particularly viscous oil such conductors may accelerate removal of the charge. Thus, the question as to whether it is necessary or desirable to use such intimate connections with an oil body depends upon how fast it is necessary to pass the charge off from the oil; and that of course depends upon how fast a lightning causing charge will, under any circumstances, build up in the oil. However, and whether or not such connections are necessary or desirable for the protection of oil, such connections are again illustrative of the general proposition involved in my invention that wherever a body or substance to be protected is of a nature that can be regarded as di-electric or poorly conductive, that body or substance may be intimately electrically connected by conductors with the dissipation element.

In Fig. 3 I show a typical application of the system to the protection of an oil reservoir R. Such reservoirs may be simply earth reservoirs, with or without a roof 40; or they may have concrete bottom and side walls, as shown at C, usually reinforced as indicated at I. The connections to grounds G^1 may thus run directly to the reinforcement and the concrete, as may also the connections 13^a that go to the towers or poles 10. However, if a reservoir has not such a reinforced concrete lining, a net work of conductors, or spaced conductors, may be placed upon the walls and floor to be the conductive equivalent of the reinforced concrete lining.

The poles or towers 10 in this case are shown set on concrete bases 20. There may be connections to the ground G and conductors 13^a may be connected from the reservoir to the towers. Conductors 13^a may be placed close to the surface and may be, if desired, extended as at 30^a to perform the same service as before described. The roof 40, if it be not in its own structure well connected to parts connected to the wires 12, may be especially so connected; and if the roof is not of metal conductor wires 41 may be laid across and in contact with it and connected into the charge transferring system at any convenient point.

Suppose now that for whatever reason it may be, opposite charges tend to build up in a cloud overhead and in the earth area in which the tank or reservoir is located, and therefore tend to build up in the tank or reservoir. The charge in the cloud is usually negative and the earth charge positive, although frequently these signs will be reversed. For the purpose of this illustration the cloud will be assumed negative, but the argument will be equally strong and identical in terms with the cloud positive. A stress exists between the two opposite charges, and the lines of force are comparatively highly concentrated on the elevated wire or wires of the dissipating system, the surface charge density on that wire or those wires being substantially higher than is the charge density elsewhere. Correspondingly, the potential gradient or electric field in the immediate vicinity of the wire or wires is substantially increased. The charge on the cloud is more or less uniformly distributed. This condition is indicated in the drawings in Fig. 4. The sharp points on the wire or wires are located in what may be termed a zone of concentration of the lines of force, i. e., a high electric field, or a zone of comparatively increased potential gradient; and the silent discharge activity—the ionization activity at each point, is thus comparatively enhanced and increased. It is a characteristic feature of my system that the change carrying element on which the points are mounted, or with which they are associated, is of such a nature (for instance, a comparatively small wire rather than a broad sheet of metal) that the lines of force are so concentrated and the potential gradient locally so increased as to cause effective ionization discharge from the associated points when the average potential difference between the cloud and earth, or to protected body, is well below the flash-over point, typically less than say half the flash over gradient; and that the number of points so associated with such concentrating element is sufficient, at such potential gradients, to dissipate and transfer by ionization the total charge at least as fast as that charge tends to build up.

The typical utility of having the points mounted on comparatively small wires, with the points spaced apart far enough to get little or no interference between them, and with the wires spaced far enough apart so as to get little or no intereefernce between their concentrated effects on the lines of force, will now become apparent; and so also the utility of having the dissipating system elevated and comparatively wide-spread horizontally and thoroughly connected into the object or body being protected and also, in most cases, thoroughly connected into a comparatively widely extending earth surface area. The charges built up on cloud and earth respectively are usually spread over a considerable extent—areas of the order of a circular mile. The feeder system which feeds the earth charge to the dissipating system as fast as dissipation takes place; and the wide spread of the dissipating system (as for instance, extending completely around an earth area, or around a large reservoir) makes that dissipating system, so to speak, more effectually "cover" the charged cloud area. Thus, the ionization current, which is dissipated from the dissipating system is most readily transferred through atmosphere as a return flow current to the under surface of the cloud, the return current being more effectively distributed over the under surface of the cloud, causing effectual discharge of the cloud as well as discharge of the earth. It is apprehended that the cloud (that area of cloud that is concerned in a single charge formation) must be discharged as well as the earth area or object. Consequently it is of importance that my dissipating system be so spread as to effectually "cover" a charged cloud area with the ionic stream that is dissipated from the points and that flows back to the cloud along the lines of force. The peripheral, encircling arrangement has certain advantages. With that kind of arrangement it is relatively easy to have, along any one side of a protected body, enough points to take care of the total necessary dissipation; so that a cloud drifting over a protected area from any direction will begin to be discharged immediately it begins to approach, carrying its earth charge along with it, so to speak. And also there is, in a peripheral arrangement, an action of concentration of charge from a surrounded area much as a static charge on a disk tends to go to its periphery. The concentration of charge, and the ionic action of the points, on a peripheral wire is found to be much higher than on points and wires not so arranged.

Generally speaking, any operation which would transfer this earth charge back to the charged cloud will prevent a lightning stroke. The theory of lightning causation generally accepted is that electrical energy is transferred from cloud to earth mainly by falling rain. Any means or any operation which will effectually afford a path for a return current to the cloud will equalize, or substantially equalize, the potentials of cloud and earth or body and prevent a lightning flash. Thus any means of conductance between the earth or body and cloud will have the desired effect. For instance, a conductor cable suspended to cloud height by a balloon may have that effect; but there seems to be practical difficulties in the way of such mode of protection. For instance, wind conditions may make such a means impracticable; and there would always be the liability of a charged cloud at another elevation discharging through a flashover into the suspended balloon, much as flashes take place from cloud to cloud or to rods.

My invention fundamentally makes use of the atmosphere as the dissipating or transferring path and dissipation or transfer by that path is substantially unaffected by weather conditions. In transferring through the atmosphere as a path the current flow may be looked upon as caused by atmospheric ionization caused by the relatively high potential gradient set up at the zone of concentration of the charge. The ionization, however, may be caused in other manners; or the ionization at the discharging points may be assisted by other means. For instance, it is of course well known that air ionization may be set up by flame and chemical action, splashing, etc. Thus the requisite ionization, and the consequent establishment of a path for dissipation and transfer of the charge may be set up by ionization by any suitable means, and data to the present time seem to indicate that the discharge from the sharp points of barbed wire, for instance, takes place at a sufficiently high rate at comparatively low potential, hence no such help seems at the present time to be necessary. While the rate of discharge per point increases as the potential difference between earth and cloud increases—increases as the ionization increases—there seems to be sufficient ionization and therefore sufficient dissipation and transfer at comparatively low potentials. However, if it be desired to increase the dissipation and transfer at the lower potentials, ionization may be started or augmented at such lower potentials by some suitable means.

In the practical use of my system there are certain controlling factors that are taken into account. Without going into a large amount of detail I may say that the most reliable figures (G. C. Simpsons, Proc. Roy. Soc. 1909-1910; Phil. Mag. 30, 1, 1915), as to the rate of electrical energy transfer from cloud to earth seem to indicate that in heavy thunderstorms the transfer is at the rate of 12 microamperes per acre of earth area, and the maximum observed, so far as I am aware, has been 40 microamperes per acre. Thus, for instance, from a cloud area say one mile in diameter, or approximately 500 acres, the maximum observed energy transfer would be at the rate of about 20,000 microamperes. On the assumption that all of that energy transfer might under circumstances be more or less concentrated in a small earth area or in a single body or structure, the dissipation or retransfer rate should be at least as high as the last figure and preferably, for safety, should be substantially higher.

Experimental results and data indicate that the dissipation and transfer rate from a single point, such as the sharp point of a wire barb, elevated and isolated from bodies or structures that would interfere with its action, can be as high as 40 microamperes at a potential or potential gradient substantially less than that corresponding to the flash-over point. Thus 500 points would, on that basis, take care of the maximum observed rate of transfer from a circular mile of cloud. But it is desirable to have what may be called a factor of safety; to provide a sufficient number of points to take care of even an exceptional transfer requirement at a potential gradient always much less than that of the flash-over point, say at less than half the flash over gradient; consequently in a practical installation the number of points will be much larger than the comparative figures given above. For instance, in protecting an oil reservoir where the encircling wire system is one-half mile in circumference, ordinary barbed wire may be used. Provision of an excess of the discharge points does not hurt the system as a whole, even though the discharge points may be so close together that the discharge or transfer from each individual point may be somewhat less than if the points were spaced further apart. For instance, within the potential gradients observed by me the spacing between points would seem to be about six inches for maximum efficiency at all points; and if a number of parallel wires with points are used, the spacing, for maximum efficiency, between the parallel wires should be somewhat larger. However that has only to do with the individual efficiency of each point; although the individual efficiency at each point in ordinary barbed wire where the barbs are spaced at about four inches may be lower than the maximum attainable point efficiency, the presence of the excess points raises the total efficiency of the system. As to the question of the number of parallel wires forming the peripheral or encircling concentration and discharge system, however, other factors may come into play. For instance, in some cases, it may be desirable to employ only a single barbed wire, as the potential and therefore the transfer rate of the charge concentrated in and discharging from a single wire may be greater than if the concentration were spread on numbers of parallel wires. However, for mechanical reasons, and because a single wire might by accident or deterioration fail, it will usually be wise to use two or more such wires.

The results of investigations indicate that the rate of transfer from the concentrating and transferring system depends among other things upon the height of the system above the area or object being protected. The greater the elevation of the system, the higher the rate of dissipation and transfer, other things being equal. Consequently, the protective system will ordinarily be placed upon towers, or otherwise suitably supported at a considerable elevation, or as high as is practicable above, the uppermost parts of the protected object or area so as to increase correspondingly the potential gradient in the zone of concentration at the dissipating points. Also, to equalize the field concentration and flux, the outer wires, or outer parts of the wire system, might be relatively lower than the inner or central wires or parts; or if desired, the outer wire or wires, or any of the wires, might be arranged elevated above the others to get an earlier discharge from the higher wires.

In Figs. 5 and 6 I show a physical modification of the system wherein, instead of using continuous encircling wire or wires, I may arrange a series of towers 10^a each having a concentrating and dispersive system of wires and points at its top, as shown at 31. Such towers may be electrically connected as hereinbefore described, and of course electrically connected to the tank T in some one of the manners hereinbefore described. In Fig. 5 conductors 32 are shown running from the towers to the tank. The towers will be so placed and spaced that they form a wide spread system that covers the cloud area and from which the earth charge will be dissipated and transferred as before explained.

From what has been said it will now be readily gathered that my system involves characteristically the transfer or neutralization of lightning-causing charges, causing the energy of such charges to be dissipated or spread over comparatively large space and long time period. The actual amount of electrical energy in a lightning flash is not large; high concentration in time and space is its destructive characteristic. The potential energy of such a flash is spread out both as to area and as to time; and the energy is dissipated in frictional resistance of the air to ionic movement between earth and cloud.

From what has now been said it will be seen that my system of protection is essentially different from whatever protection may have been afforded by lightning rods and the like. Although it has been recognized that dissipation of charge takes place from the point or points of a lightning rod, such rods have not been capable, on account of their small superficial area presented to the cloud, of taking advantage of any practical amount of concentration of the lines of force or materially increasing the potential gradient. The horizontally extending wire system, isolated by elevation above the body from which it takes its charge, has greater capacity than a small vertical rod—it collects more lines of force; and the dissipating points, or other formation, then acting in the zone of concentration of the wire, further increases the concentration locally. Furthermore, with a given amount of ionic flow between earth and cloud, a spreading of that ionic flow apparently increases the effective flash-over gradient. And neither is my system to be compared to the action that may be supposed to take place in a forest or area surrounded by trees, which is not self-protective, as has been observed in large numbers of instances. The trees themselves are not sufficiently good conductors to take and transfer the energy of the charge.

In the following claims the word "body" is used in a broad and inclusive sense except where otherwise indicated, to include the body of the protected earth area as well as a body such as an oil tank or other structure upon an earth area, or a body not supported upon the earth's surface.

I claim:

1. A lightning prevention system, embodying substantially exclusively an elevated conductor encircling the earth area to be protected and connected into that area to receive its charge, the size of the encircled area being such relative to the dissipating capacity of the elevated conductor as to keep the earth charge within that area from building up to the danger point as that charge passes into the encircling conductor, the conductor being at a substantially uniform elevation throughout its length and provided with charge dissipating points of substantially uniform elevation spaced along the length of the conductor at spacings substantially far enough apart to avoid dissipation interference with each other.

2. A lightning prevention system, embodying substantially exclusively an elevated conductor encircling the earth area to be protected and connected into that area to receive its charge, the horizontal spread of said encircling conductor being proportioned to the dissipating capacity of the elevated conductor for limiting the earth charge within that area to a safe maximum, the conductor being at a substantially uniform elevation throughout its length and provided with charge dissipating points of substantially uniform elevation spaced along the length of the conductor at spacings substantially far enough apart to avoid dissipation interference with each other.

In witness that I claim the foregoing I have hereunto subscribed my name this 17th day of December 1926.

JOHN M. CAGE.