United States Patent

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[54] **METHOD AND APPARATUS FOR INDUCTIVELY CHARGING A FILTER OF COMBINED METAL AND DIELECTRIC MATERIAL FOR COLLECTING NORMALLY CHARGED AIR BORNE PARTICLES**
13 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** **55/2,** 55/131, 55/139, 55/146, 55/149, 55/155, 55/524, 55/525
[51] **Int. Cl.** **B03c 3/00**
[50] **Field of Search** 55/101, 105, 130, 131, 132, 139, 154, 155, 2, 146, 149, 524, 525

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Primary Examiner—Dennis E. Talbert, Jr.
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ABSTRACT: Monocharging a filter consisting of electroconductive and nonconductive collecting surfaces with an inductive field supplied from a low frequency pulsating direct current voltage to attract and collect normally charged particles. This inductive filter charging field permits the use of a metal plate or grid filter or a monocharged filter of highly insulative materials including paper, plastics such as fiber glass, open cell foam or plastic screen. A grid conductor must be employed to charge these nonconductive dielectric materials. Metal plates, wire screens and grids, metal shavings, metal wools inductively charged distribute the monocharge of low voltage low frequency over their own surfaces as well as the insulating or dielectric portions of the filter. This monocharged filter requires no ground or return circuit and merely produces a slight shock if touched but is not harmful.

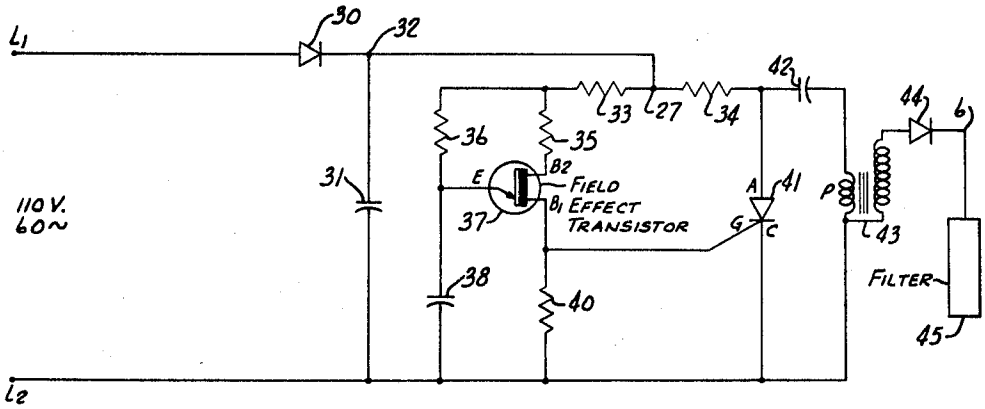

Fig. 1

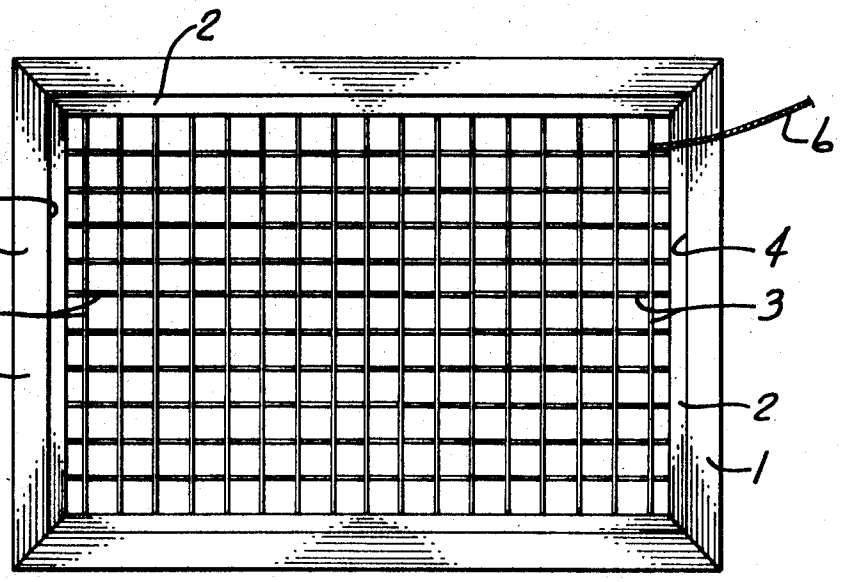

Fig. 2

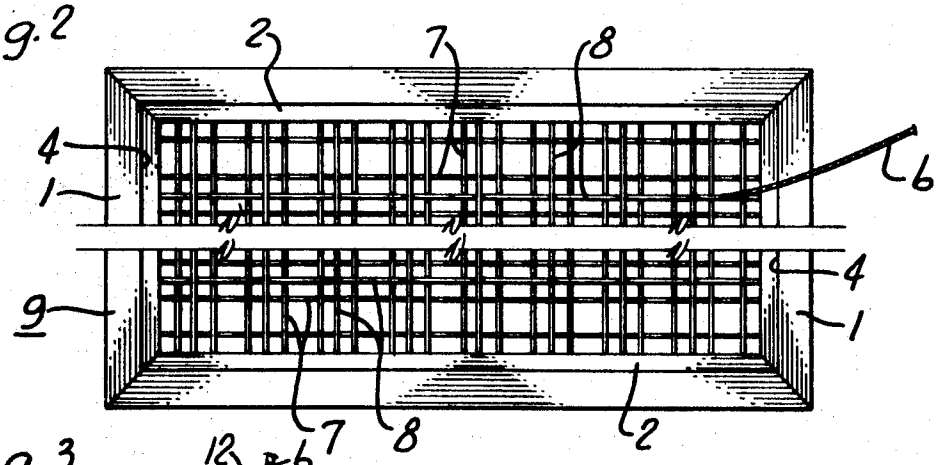

Fig. 3

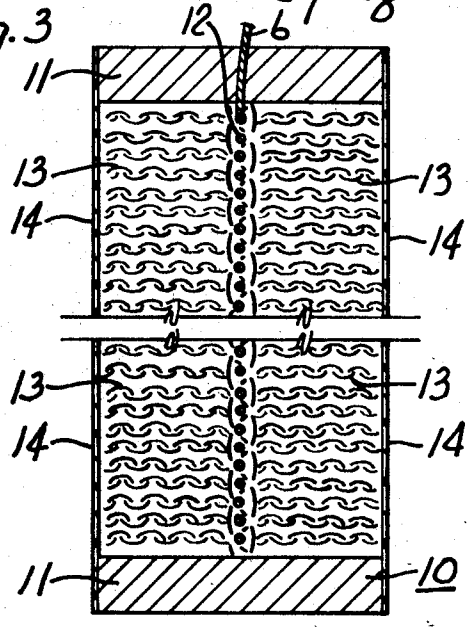

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Fig. 4

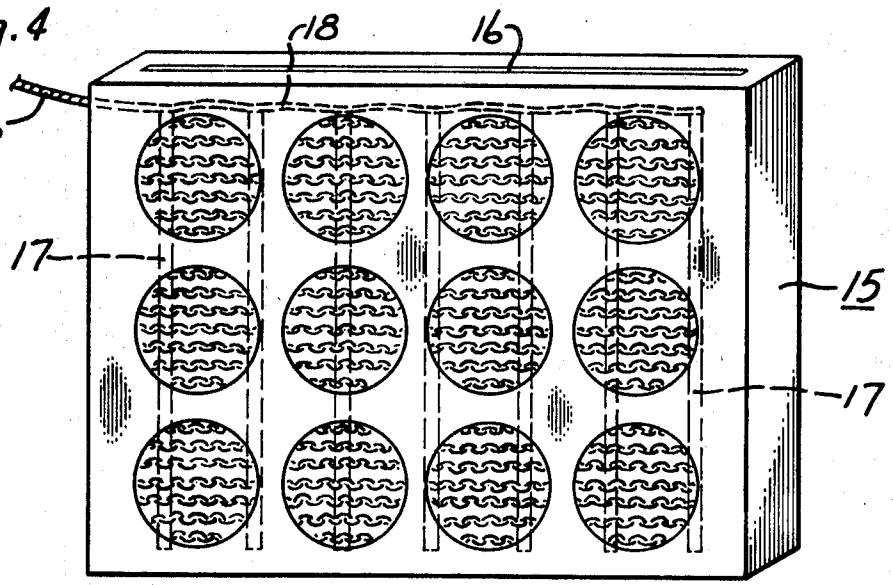


Fig. 5

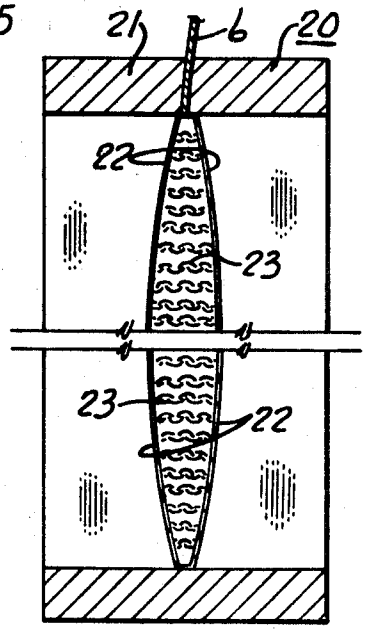
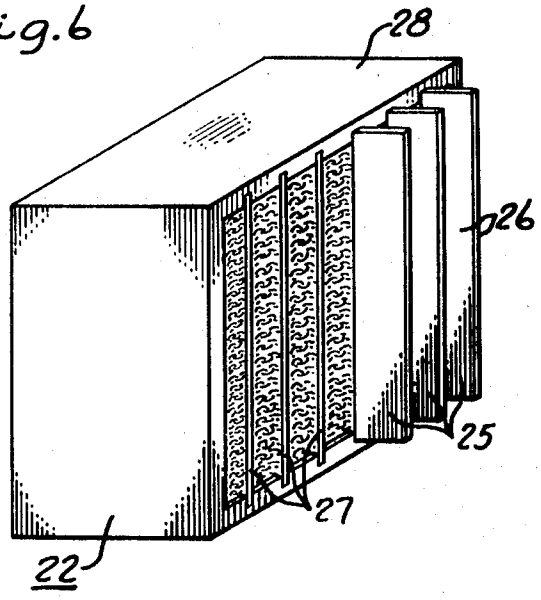


Fig. 6



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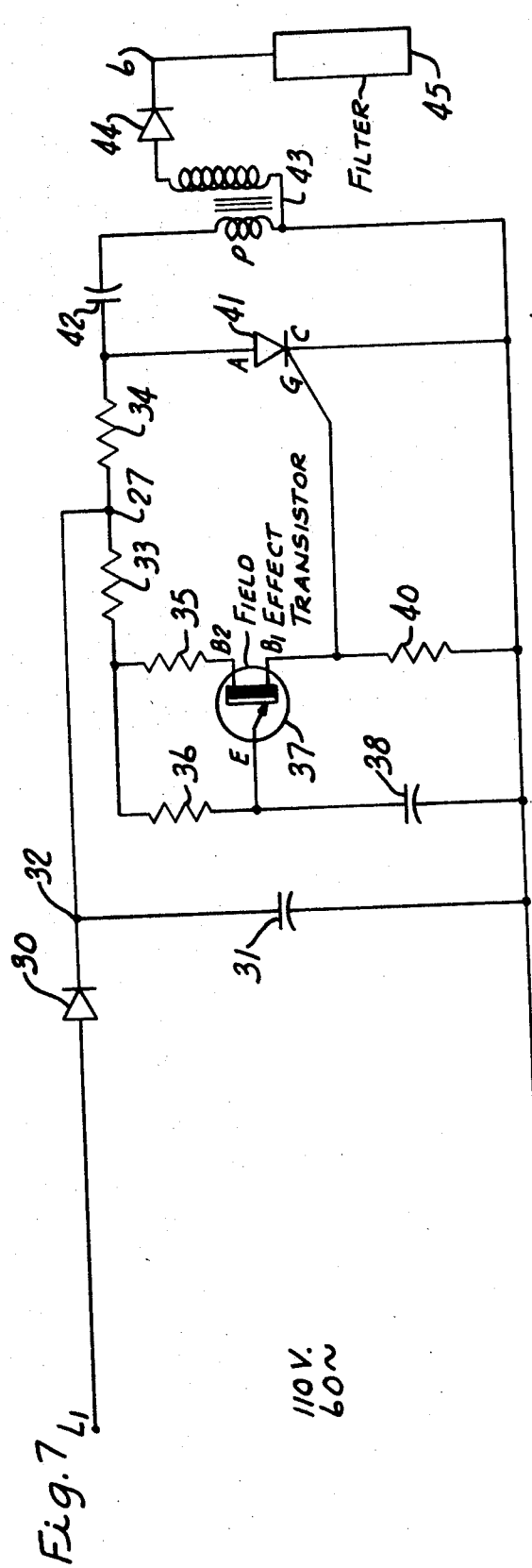

Fig. 7

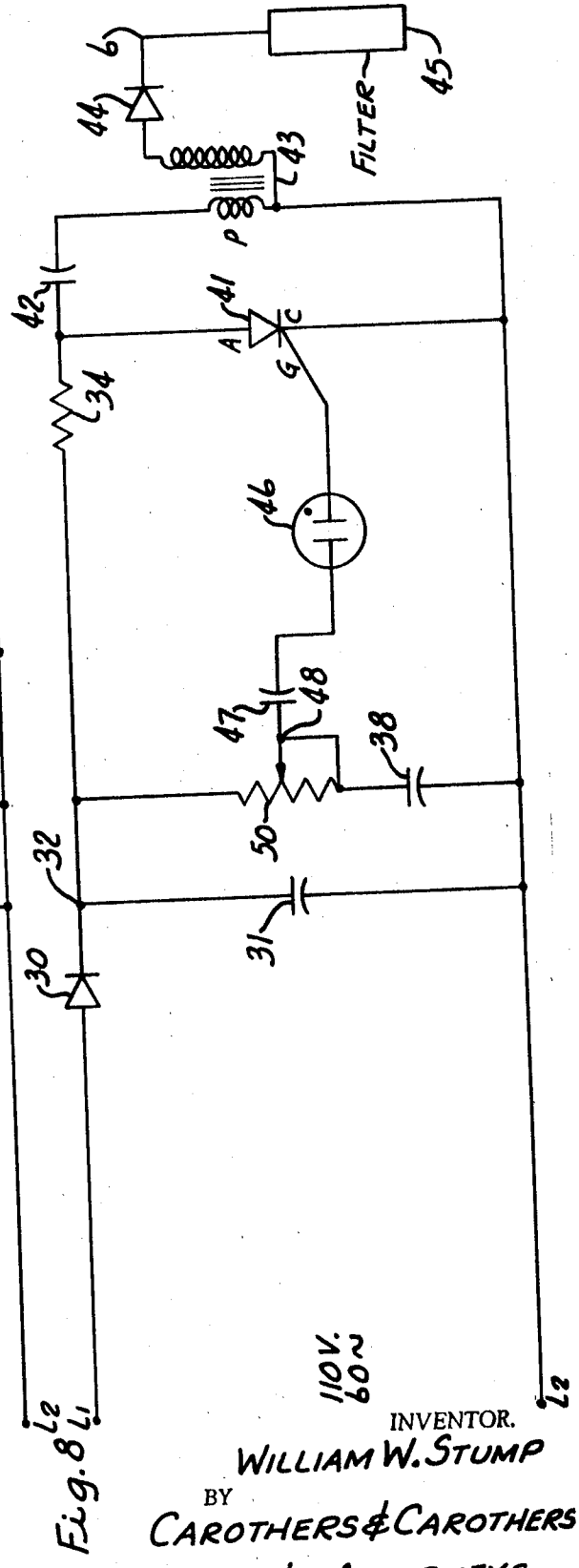

Fig. 8

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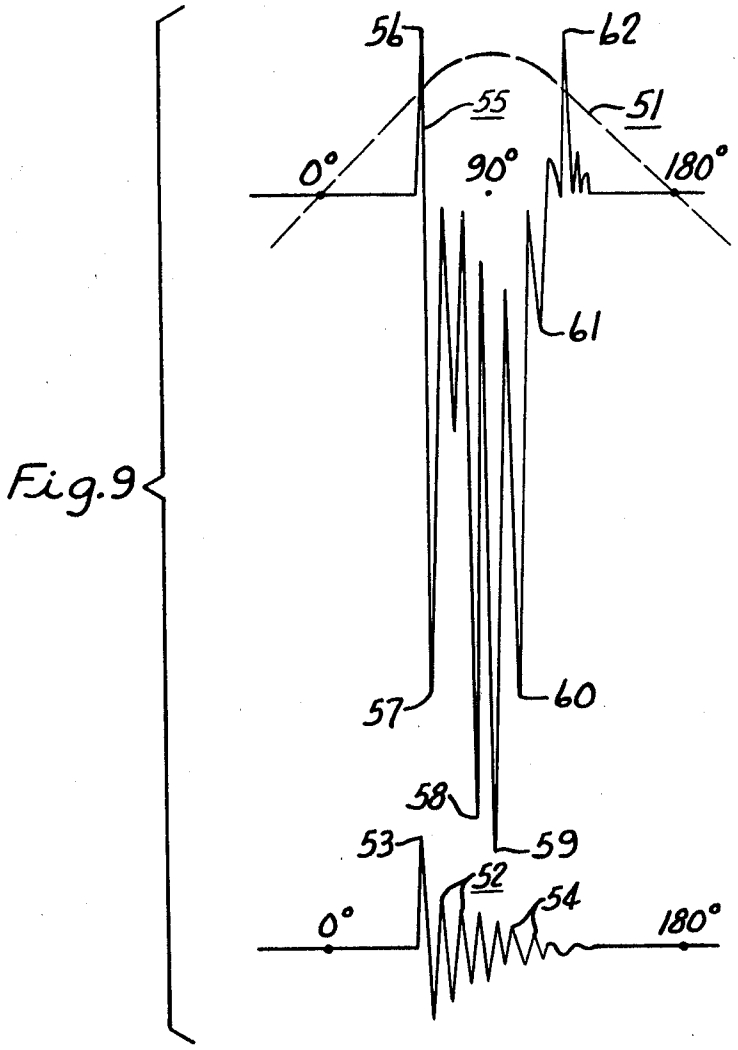

Fig. 9

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METHOD AND APPARATUS FOR INDUCTIVELY CHARGING A FILTER OF COMBINED METAL AND DIELECTRIC MATERIAL FOR COLLECTING NORMALLY CHARGED AIR BORNE PARTICLES

BACKGROUND OF THE INVENTION

U.S. Pat. No. 3,040,497 of Class 55, Subclass 112, is directed to Electrostatic Gas Filters wherein an electrostatic charge is applied to each of two filters of glass floss or fiber in combination with vertical rod grids to increase the effectiveness of filtering out dust passing therethrough. The two filters are insulated from ground and extend across the duct opening but are spaced from each other, being placed 2 inches in tandem for the flow to pass therethrough. A high voltage high frequency AC supply is charged on one filter and a 30,000 volt pulsating DC voltage charge is charged to the other filter. These two charges on the two filters create an ionizer in one and a collector in the other and electrostatic charges surround the grids of each filter and they combine to charge the area between the filters to form an ionizer and a dense electrostatic barrier to dust particles. In this respect their circuits depend upon the common grounds of each circuit to provide interelectrical cooperation between the two spaced filters with a definite limitation upon their spacing.

SUMMARY OF THE INVENTION

The principal object of this invention is the provision of method and apparatus of filtering normally charged air borne particles on metallic filters as well as combined metallic and dielectric materials by a novel method and circuit of charging the filter with an inductive field induced by a low frequency pulsating direct current voltage.

Any type of well-known metal filter may be employed with the method comprising this invention. A dielectric filter when properly charged functions equally well. A wire mesh screen, grid, or hardware cloth of a sheathed wire with or without plastic fibers or mesh will properly function as a collecting medium. They may be readily washed or disposed of by replacing the plastic, glass fibers, paper tissues ro other dielectric material. The charging grid may then be vacuumed and new dielectric material applied. Any dielectric material can be used for the dielectric filter if the material can be inductively charged. Thus, the dielectric materials are not limited to those examples mentioned above or elsewhere in the application.

Another object of this invention is the provision of a air permeable filter of dielectric material and of metallic material of a combination of both. Although such filters are old for use without charging, their use with a monocharge of low frequency pulsating direct current voltage having the characteristic of a spike discharge of narrow width and short duration provides a highly efficient dust collector. This inductive charging system is safe for several reasons. The short spike pulse for 1 millisecond cannot burn or cause muscles to freeze to the charged element. The current capacity is in the nature of 1 microampere which cannot be destructive.

The circuit itself is novel and provides a pulse initiating circuit means which includes a silicon controlled rectifier operating a parallel or loop circuit characterized as a high voltage low impedance discharge circuit and including a condenser and autotransformer primary of the spark coil type, which delivers a spike discharge of a very narrow width and short duration. The condenser charges and fires the transformer through a diode to produce a monocharging inductive field on the filter. This output distributed by a metal screen or grid charges paper or fiber glass which filters and collects charged particles such as dust and lint from 1 to 200 microns at an efficiency of from 86 percent to 92 percent.

The gate controlled rectifier is supplied by AC through a half wave diode boosted by a condenser and through a load resistor and is preferably pulsated by a field effect transistor, all which are included in the pulse initiating circuit means and is the preferred form of obtaining low frequency DC pulsations. Another mode of producing gate pulsations is by the use of a neon lamp operated by a pulsing circuit. The SCR feeds the loop circuit including the primary of the spark coil type autotransformer in series with a condenser which also stops the firing of the SCR after each spike type voltage discharge from the autotransformer in each circuit.

Other objects and advantages appear hereinafter in the following description and claims.

The accompanying drawings show, for the purpose of exemplification without limiting the invention or the claims thereto, certain practical embodiments illustrating the principles of this invention wherein:

FIG. 1 is a plan view of a filter frame of insulating material with a single 20 mesh metal wire screen.

FIG. 2 is a plan view of a filter frame of insulating material with a plastic screen of approximately 20 or 30 mesh and having a charging wire grid attached thereto.

FIG. 3 is a sectional view of a filter insulating frame having 10 mesh metal hardware cloth flanked by open cell foam covering the mesh and held in place by large mesh plastic retaining grids.

FIG. 4 is a perspective view of an ordinary fiber glass filter found in open market with an inserted rod charging grid.

FIG. 5 is a sectional view of a filter constructed of a metal wool enclosed in a plastic screen secured to a frame of insulating material.

FIG. 6 is a perspective view of a filter constructed of parallel plates aligned in a frame of insulated material and constructed of metal hardware cloth having paper tissue attached to each side to be aligned in the airstream.

FIG. 7 is a circuit diagram of a preferred form for generating a low frequency pulsating direct current voltage to inductively charge a filter of combined metal and dielectric.

FIG. 8 is a modified circuit diagram for generating a low frequency pulsating direct current voltage to inductively charge a filter of combined metal and dielectric.

FIG. 9 is a reproduction of the spike waveform that occurs at the filter for either circuit disclosed.

Referring to FIG. 1 of the drawings, the insulating frame 1 of this filter may be made of wood or plastic of either thermal plastic or thermal setting type. It should have fair nonmoisture absorption characteristics and be capable of supporting parts such as filtering material and have wire or plastic screens fastened thereto. For this purpose an offset shoulder 2 is formed in the frame opening at the center of the frame 1 to receive a filter body such as the twenty mesh wire screen 3 or grid shown in place in FIG. 1. The edges of this screen or grid fits on the surrounding surfaces 4 which is disposed at right angles to the shoulder 2 and extend around the frame 1. This completes this filter 5 of FIG. 1. It is nothing but a wire screen in an insulated frame. The edges of the screen are nailed, cemented or glued to the frame shoulder 2.

This filter 5 is for insertion in the airflow conduit transverse of the flow of air or gas to be cleaned which passes therethrough. A covered and shielded conductor 6 is connected to this metallic screen 3 and is lead off through the frame 1 at the most convenient place for connection to the circuit. The control box carrying the circuit of FIg. 7 or 8 is small and is mounted conveniently on the air duct through which the air travels and is connected by a plug which may be withdrawn to open the circuit and remove the filter from the duct.

Referring now to FIG. 2, the frame 1 in this instance is the same as that illustrated in FIG. 1 and is provided with a plastic screen in place of a wire screen as illustrated in FIG. 1. This plastic screen is indicated at 7 and may be constructed of a 20 or 30 mesh. This plastic screen is provided with a metal grid 8 which may be made of either bare or coated wire which is woven or otherwise secured in a pattern to the plastic screen 7. As illustrated in FIG. 2, the dimensions of wire grid is considerably larger than the mesh of the plastic screen 7 but it covers substantially all of the plastic screen and it may extend to the frame 1 as shown in FIG. 1. Again the grid may be spaced from the frame 1 depending upon the need for the distribution of the induced field on the plastic screen.

When a grid of this character substantially covers the whole of the plastic screen, thus the plastic screen is provided with the same charge and will be equally effective in attracting any charged particles that pass through this filter **9**. This filter is also provided with a shielded and properly insulated conductor **6** for attaching the same by means of a plug to the box containing the circuit as shown in FIGS. **7** and **8**.

The filter structure **10** illustrated in FIG. **3** is provided with the frame **11** which may preferably be from 2 or 3 inches thick and the center of the frame is provided with a wire of 10 mesh metal hardware cloth screen **12** having attached thereto in suitable manner the shielded and insulated conductor **6** for securing this filter to the circuit. Both of the outer faces of the screen are covered with a foamed, open cell flexible polyester structure **13** held in place by a large open mesh outer grid **14** of plastic. This character of open cell foam is very porous. One can see through it but it provides a maze of intricate deviations through the openings created by the open plastic structure. Thus the plastic grids **14** hold the open cell foam plastic mesh on each side of the electrode grid connected to the wire or cable **6**.

When the grid **12** and its lead connection **6** is energized it also energizes the open cell plastic **13** together with the plastic outer grids **14** that retain the same in the frame **11**. This construction makes a very fine filter even though the majority of the materials of the filter are made of plastic or some form of dielectric material such as fiber glass, spun wools of different character of plastics.

Referring to FIG. **4**, the filter **15** is an ordinary fiber glass filter that can be purchased in the open market at almost any hardware store. This filter is made of cardboard and is filled with the fiber glass and applicant can readily change this into a more effective filter by cutting a slit **16** in the cardboard across the top of the filter and inserting therein a grid **17** in the form of a series of copper rods or wires which extend substantially the full depth of the filter and are connected together at the top by the lead wire **18**. The wire **18** connects each of the rods of the grid **17** and is in turn connected by the insulated lead **6** which extends to the circuit control box as described with reference to each of the foregoing figures.

This fiber glass filter thus becomes a charged filter similar to each of the other filter structures and the fiber glass becomes charged and will attract any charged particle passing therethrough. Thus by adding the charged grid of this invention to a filter that is made of material that cannot conduct electricity it is nevertheless capable of accepting an inductive field from the circuit disclosed and is effective to increase its ability to remove the dirt as a filter many times more efficiently than that without this inductive charge. This type of a filter **15** is referred to as a throw away type. Thus by retaining the grid **17** in the form of the rods one may purchase the filter of fiber glass in a paper container as illustrated and insert the grid **17** and when the filter is ready to be discarded merely remove the grid **17** wash the same and insert it in a new filter structure. This could not be possible if it were not for the inductive field of low frequency pulsating direct current impressed on this insulating material and effective for it to function in turn to draw and hold the charged particles passing through the filter. This is an improved advancement and is an important object of this invention.

Referring now to FIG. **5**, the filter **20** is provided with an insulating frame **21** and retains a pillowlike structure covered on both sides with plastic screen **22** of suitable mesh containing aluminum wool **23** or the like. The aluminum wool **23** is quite light and when stuffed in the pillow-shaped plastic screen mesh **22** it functions as a very good screen that may be readily cleaned either by a vacuum cleaner or if the dirt becomes too greasy it may be readily washed.

In all instances where a plastic screen is employed as the only member or an outer covering for any other material, it may be best to vacuum both sides of the plastic filter before washing the same. A considerable portion of the dirt may be removed by the vacuum cleaner from the outer surfaces of the filter and those surfaces within the filter if not properly cleansed by this force of vacuum cleaner, may be readily removed by washing with a detergent or other means and then blowing the air through the filter in order to dry the same.

It is obvious that since the contents **23** within the plastic screen such as aluminum, copper of iron wool is electrically conductive there is no question about the fact that the whole screen is provided with an inductive field by the attachment of the lead in wire **6** as previously described.

Referring now to FIG. **6**, the filter **24** depicts a filter with parallel plates that would be of the character included in a Cottrell type system where ionization is provided by an ionization grid before the air passes between parallel plates which are oppositely polarized.

Solid parallel plates may be employed with the present invention but the plates **25** shown, are made of hardware wire screen of 10 mesh or more. The screen or grid plates **25** are preferably dipped in a readily soluble liquid glue and tissue such as a cleaning or facial tissue paper is then placed on each side of the wire mesh as indicated at **26**. Each of the plates or screen grids **25** are carried in an insulating slotted frame or tube section **27** of the filter **28** and when the filter **28** is removed form the system the plates or grids **25** may be withdrawn and washed to remove the paper with the dirt. The grid is then dried and redipped in a soluble glue substance to again retain a layer or two of the facial tissues on each side of the grid and reinserted in the filter and thence into the duct in service.

Each of the plates or grids **25** may be connected together in the single filter **28** by a single lead **6** to connect the series to the control box and thereby energize each of the grids with the same inductive field.

Paper may be employed on a filter that requires the air to pass through the paper tissue however such a filter restricts the flow of air somewhat and is not desirable for gravity or low force circulating type heating systems although it is quite effective in the filter such as illustrated in FIG. **6**.

One thing about the use of an inductive field as employed in filters of this invention on electroconductive as well as insulated material is that a moderately low voltage is employed for the filtering charge which may be from 3 to 6,000 volts with a current capacity of one tenth of a milliamp which potential is not to ground and produces merely an inductive type of potential. Whether or not a person is grounded they can receive a shock from the charged filter. However, the filter functions without any need for a ground connection and in this respect the inductive field is charged to the dielectric filter as a monocharge voltage.

Another important object and advantage of this application is the simplicity of the circuit for effecting a monocharge for inducing a field on conductive as well as nonconductive materials for the purpose of precipitating or drawing out of the air any particles which normally carry a charge. In its simplicity, it is also less expensive and not harmful. It can be applied to gravity as well as circulating systems.

Referring to FIG. **7**, the circuit is supplied with 110 alternating current through the lines L1 and L2, L1 being considered the voltage line whereas L2 is considered to be a ground connection. L1 is connected to the anode of the diode **30** the cathode of which is connected to one side of the condenser **31** and also connected by the line **32** to one end of each of the resistors **33** and **34**. The other end of resistor **33** is connected to one end of each of the resistors **35** and **36**. The resistor **35** is connected to the base B2 of the field effect transistor **37**. The emitter E of the field effect transistor **37** is connected to the other end of the resistance **36** and to one end of the condenser **38**. The B1 of the field effect transistor **37** is connected to one end of the resistance **40** and to the gate G of the silicon controlled rectifier **41** the anode of which is connected to the other end of resistor **34** and to one end of the condenser **42**. The other end of condenser **42** is connected to one end of the primary P of the autotap transformer **43**.

Line **2** is connected to the other end of each of the condenser **31**, the condenser **38**, the resistance **40**, the cathode C

of the silicon controlled diode 41 and the other end of the primary winding P of the autotap transformer 43.

This completes the pulse initiating circuit means which includes a means to rectify the alternating current together with the field effect transistor which supplies a pulsating charge to the gate of the silicon controlled rectifier 41 which is loaded by the resistance 34. The controlled rectifier supplies a current flow through the charging condenser 42 to the primary of the autotap transformer 43 of the discharge circuit. The condenser 42 also shuts off the SCR and also charges the transformer primary to produce a spike type voltage discharge through the diode 44 of the discharge circuit to the filter or collection unit as indicated at 45 in FIG. 7. As previously pointed out this circuit needs no return because it is a monocharge filter producing an inductive field not dependent upon a return circuit.

Thus, the circuit described will produce an inductive charge on the filter when provided with the proper grid containing a voltage of from 3 to 6,000 volts DC but has a very low current capacity. The field effect transistor provides a pulsation of the direct current voltage in the nature of 60 to 70 cycles per second which is an extremely low frequency for a pulsating direct current voltage. This is the principal reason why this inductive field charging apparatus is ideal for domestic application in gravity as well as circulating forced air furnaces. It will effectively remove any air borne particles that are provided with a charge and could not in any way be serious or harmful to persons who come in contact with the charged field.

Referring to FIG. 8, wherein a more simplified and alternate circuit is shown connected to the 110 volt 60 cycle lines L1 and L2 is the diode 30 the cathode of which is connected to one side of the condenser 31 the other side being connected to line 2. The cathode of the diode 30 is likewise connected to one end of the silicon controlled rectifier load resistance 34, the other end of which is connected directly to the anode of the SCR and to the nonpolarized condenser 42 the other side of which is connected to the primary P of the autotransformer 43. The other side of the primary P of the autotap transformer 43 as well as the cathode of the silicon controlled rectifier are connected directly to line 2 as in the previous circuit and the diode 44 is connected directly to the line 6 to the filter 45 as in the previous circuit.

The pulse initiating circuit means in FIG. 8 is maintained by the neon tube 46 one side of which is connected to the gate G of the silicon controlled rectifier 41 and the other element of the neon tube 46 is connected directly to one side of the condenser 47 the other side of which is connected by the line 48 to the movable arm of the potentiometer 50 one end of which is connected directly to the cathode of the diode 30 and the opposite end is connected to one side of the condenser 38 the other side of which is connected to line 2. This circuit means provides substantially the same low frequency in pulsating direct current voltage and is not capable of delivering much more than one tenth of a milliamp. Thus both circuits are very safe yet are very effective in inducing a field to a current carrying a grid as well as a plastic or insulating material for the purpose of collecting any charged particles such as dust as previously described.

The autotap transformer shown both in FIGS. 7 and 8 at 43 is preferably of the spark coil type as used in automobiles or other internal combustion engines. This type of an autotype transformer has very little iron merely being provided with an iron core with a limited return. Most of the flux must travel through the air from one end of the core to the other. This type of autotransformer provides a very sharp spike discharge. It is very narrow and in a way approaches infinity but it is not infinite but really high in comparison with other form of the transients produced on the wave passing through the transformer primary.

As shown in FIG. 9 is a reproduction of the character of spike wave provided showing the transients.

FIG. 9 shows the spike waveform produced by each of these tow circuits. The frequency of this pulse if from 60 to 70 times per second. The curve shown at 51 is a tracing of the 60 cycle voltage to indicate the time. The curve 52 shows the waveform at the end of the coaxial shielded lead 6 with no load thereon. The spike is evident at 53 and it dampens to zero with little or no action as indicated at 54.

The curve 55 is a result of attaching the lead 6 to the filter. With this filter load, this monocharging spike voltage produces a terrific series of reflected surges between the filter and the charging condenser 42. The first charging spike 56 is reflected back by the second negative peak 57 followed by the surges 58, 59, 60 and 61 and the lower dampening peak 62 which is a high positive kick that is believed to shut off the SCR. It is believed that these active portions of the spike pulses produce the 85 percent efficiency in collecting charge carrying particles without the use of a return circuit.

It should be noted that after the high peak surges there appears a dampening configuration. This circuit produces a spherical field around the filter which when in open air is very strong. Without a pickup coil a neon light has strong intensity at 10 feet. With a pickup coil it will indicate this charge many feet away.

When the charged screen is placed in a duct of a furnace, the shielding of the metal is effective in confining this field, yet it may be measured inside of the furnace indicating that the field is extensive in a grounded ductwork.

I claim:

1. The method of inducing precipitation of normally charged airborne particles from an air medium passing through a collector consisting of a grid contained filter medium of essentially dielectric material, comprising the steps of;
gating a controlled semiconductor rectifier with low frequency pulses to produce low frequency direct current charging pulses,
charging a loop circuit including a condenser and the primary of an autotransformer to induce low frequency spike type high voltage pulses of short duration from the autotransformer secondary,
and discharging the low frequency direct spike type high voltage pulses through a diode to the grid contained filter medium of dielectric material to produce thereon an inductive field.

2. The method of claim 1 characterized by the step of;
providing an iron core in said autotransformer to induce low impedance to generate a spike type high voltage discharge having a sharp peak voltage of narrow width and short duration.

3. The method of claim 1 characterized by the step of;
controlling the rate of discharge of said condenser into said autotransformer primary coil to control the spike type voltage pulses characterized by having a sharp peak of low frequency thereby providing a physically non-hazardous collector.

4. An inductive field charging apparatus for inductively charging a filter medium for collecting normally charged airborne particles passing through said filter medium comprising pulse initiating circuit means to supply a low frequency DC pulse and including a gate controlled rectifier having its gate connected to said pulse initiating circuit means, a high voltage low impedance discharge circuit connected across the anode and cathode of said gate controlled rectifier and including a charging condenser and an autotap transformer, said autotransformer connected through a high voltage rectifier to said filter medium to inductively provide a monocharge thereto.

5. The inductive field charging apparatus of claim 4 characterized in that said autotransformer has a primary coil connected in series with said charging condenser and a secondary coil connected through said high voltage rectifier to said filter medium to inductively provide a monocharge thereto.

6. The inductive field charging apparatus of claim 4 characterized by an autotransformer of the spark coil type to form the low impedance spike discharge through said high voltage rectifier.

7. The inductive field charging apparatus of claim 4 characterized in that said pulse initiating circuit means includes a field effect transistor having one base connected to said controlled rectifier gate, and a diode connected through load resistance to said controlled rectifier anode and to the other base of said field effect transistor.

8. The inductive field charging apparatus of claim 4 characterized in that said pulse initiating circuit means includes a diode connected through load resistance to said controlled rectifier anode and to a coupling condenser connected to a neon tube the end of which is connected to said controlled rectifier gate.

9. The inductive field charging apparatus of claim 4 characterized in that said filter medium includes an air permeable dielectric filamentary material.

10. The inductive field charging apparatus of claim 9 characterized by a metallic grid embedded in said dielectric filamentary material.

11. The inductive field charging apparatus of claim 9 characterized in that said dielectric filamentary material is cellular foam of polyethylene ester.

12. The inductive field charging apparatus of claim 4 characterized in that said filter medium includes an air permeable metallic filamentary material.

13. The inductive field charging apparatus of claim 4 characterized in that said filter medium includes a combination of air permeable dielectric and metallic filamentary materials.