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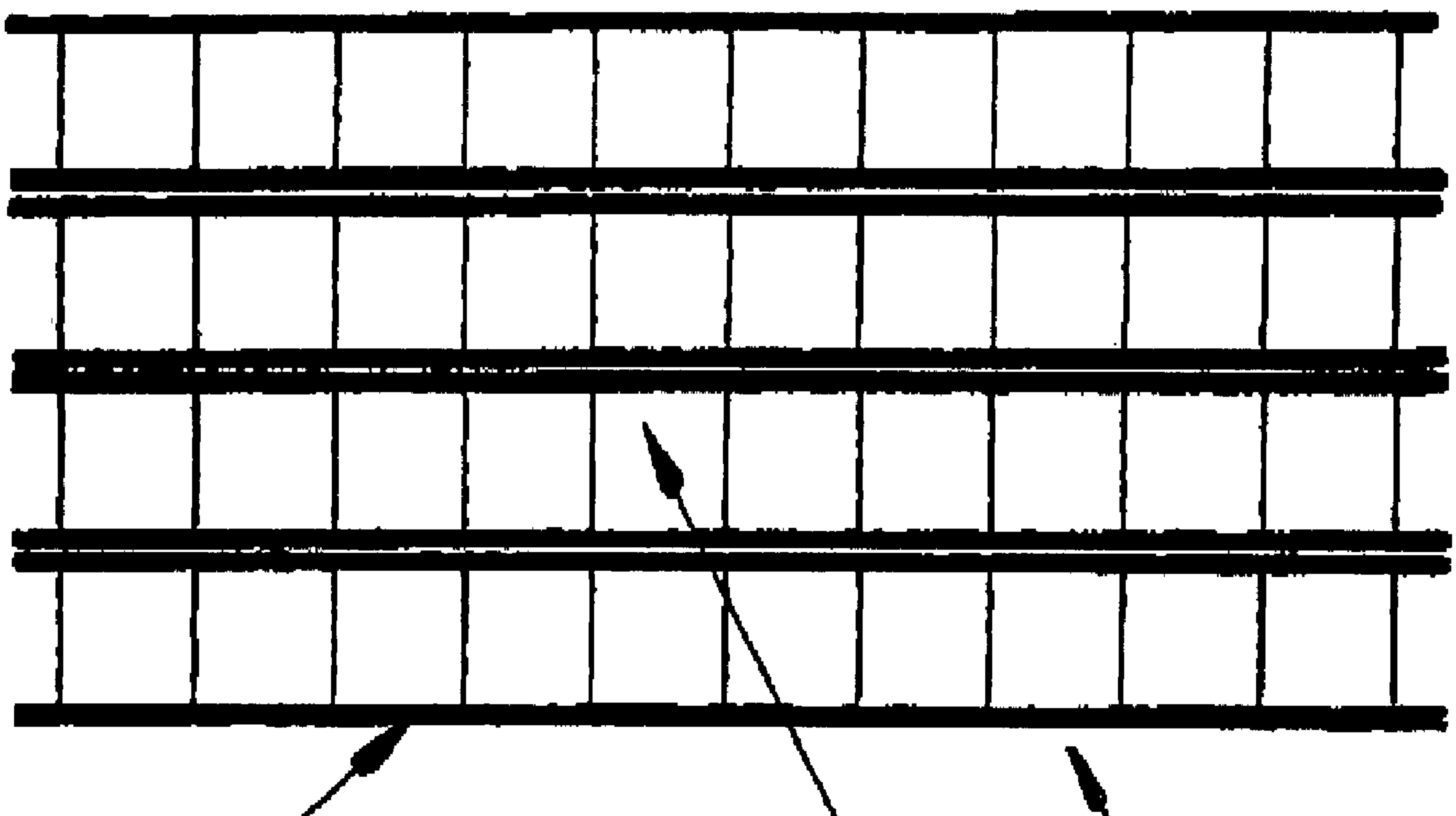
(54) Title: AIR CLEANING DEVICE WITH UNIFORM ELECTRIC FIELD ELECTRET PROPERTIES



(57) Abrégé/Abstract:
A particle precipitation device for removing particles entrained in a gas stream comprises an array (200) of passages (11), through which the gas stream can pass relatively freely, the passage being enclosed by plastics walls having electret properties imparted to the plastics walls after formation of the passages and means for urging the gas stream through the array, whereby particles are collected from the gas stream in the passages.

ABSTRACT OF THE DISCLOSURE

A particle precipitation device for removing particles entrained in a gas stream comprises an array (200) of passages (11), through which the gas stream can pass relatively freely, the passage being enclosed by plastics walls having electret properties imparted to the plastics walls after formation of the passages and means for urging the gas stream through the array, whereby particles are collected from the gas stream in the passages.

AIR CLEANING DEVICE WITH UNIFORM ELECTRIC FIELD ELECTRET PROPERTIES

DESCRIPTION

This application is a divisional of Canadian patent application number 2,369,637 entitled "Electrostatic Air Cleaning Device with Conductive Array".

This invention relates to an air-cleaning device for reducing aerosol concentrations in a confined space such as a factory, shed, greenhouse, hall, shopping mall or room.

High aerosol concentrations can pose a health hazard through breathing the suspended particles.

In farming high aerosol concentrations are found in situations such as poultry sheds and intensive pig rearing sheds etc., and the health of both workers and animals is at risk.

In industry a variety of processes such as welding, grinding, smelting and use of internal combustion engines in confined spaces all produce high polluting aerosol concentrations in enclosed spaces.

In social and domestic situations, aerosol pollution is produced by tobacco smoking. Sneezing can produce aerosols of bacteria and viruses. Allergy producing pollen is found in high concentrations at various times of the year. Dust mite allergen particles are produced when making up beds and enter the air as an aerosol.

Conventional air cleaners remove particles from the air by trapping them either in filters (filtration air cleaners (FAC's)) or by collecting them on plates (electrostatic precipitation air cleaners (ESPAC's)). The filters or plates may then be disposed of, washed or replaced.

US 4234324 discloses an electrostatic air filter comprising closely spaced planar electrodes of conductive material separated by corrugated spacers at edges thereof.

The disadvantages associated with FAC's are:

1. The efficiency of the filter often drops off markedly with time.
2. The pressure drop across the filter is often high and so requires a powerful fan.
3. The powerful fans are often noisy and consume considerable power.
4. The filters need to be regularly replaced.

The advantages associated with ESPAC's are:

1. Lower pressure drop.

2. Low noise and low power.

3. Washable collection plates.

The disadvantages associated with ESPAC's are:

1. Costly shielding of the high voltage metal collecting plates. The user needs to be protected from the possibility of electrical shock from the high voltage power supply (typically several kilovolts). Even when the power supply is switched off, there is danger of shock from stored electrical charge on the plates. The plates need to be removed for cleaning and so a safety interlock is usually provided to automatically discharge the plates before gaining access to them.

2. Loss of efficiency and generation of ozone caused by electrical breakdown and leakage between the metal plates.

3. The plates need to be relatively widely spaced to reduce electrical breakdown in the air between the plates. This reduces efficiency.

An object of the present invention is to provide a practical device for use in removing particles from an air or gas stream substantially without the disadvantages associated with ESPAC's.

One aspect of the present invention provides a particle precipitation device for removing particles entrained in a gas stream comprising an array of passages through which the gas stream can pass relatively freely, the passages being enclosed by plastics walls having electret properties imparted to external ones of said plastics walls after formation of the passages, wherein the passages are provided by fluted plastics sheet material, and wherein the charging of the walls after formation of the passages results in a substantially uniform electric field within passages defined by the flutes, and means for urging the gas stream through the array, whereby particles are collected from the gas stream in the passages.

The passages are preferably provided by fluted plastics sheet preferably having conductive material on opposite external faces thereof. The fluted plastics sheets may, for example, be overlaid one on top of the other, folded in concertina fashion, formed into a spiral, or in a concentric array.

Alternatively, the passages may be provided by plastics tubes arranged side by side. The plastics tubes may be of rectangular cross-section or of circular cross-section.

Yet again the passages may be formed between walls of corrugated plastics sheet or between flat plastics sheets and corrugated conductive material.

The plastics material used in the invention is preferably of polypropylene, polyethylene or a copolymer thereof. Although other plastics materials such as PVC, PET, PTFE and polycarbonate may also be suitable.

Preferred embodiments of the invention further comprise means for electrically charging particles in the gas stream prior to the array of passages. Such means may be corona discharge means or radioative ionisation means.

Devices of preferred embodiments of the invention further comprise means for ionising the gas stream as it leaves the array. The means for ionising the gas stream as it leaves the array preferably comprises a primary corona discharge emitter and a secondary corona discharge emitter at a lower potential to the primary emitter. The primary emitter is preferably connected to high negative potential whilst the secondary emitter is preferably earthed. The primary emitter is preferably a needle having a sharp tip and the secondary emitter is preferably a needle having a relatively blunt tip.

In preferred embodiments of the invention the plastics walls are electrically charged prior to inclusion in the device. The plastics walls may be charged by means of electrodes applied to opposite sides of the walls with a high voltage difference applied thereto. Alternatively, the plastics walls may be charged by applying an electric field at a higher temperature and then cooling to a lower temperature in the presence of the electric field. The plastics walls may also be charged by moving the plastics walls between a high potential corona discharge on one side of an earthed conductive plate on the other side.

In another preferred embodiment of the invention the plastics walls may be provided by faces of fluted plastics sheet material and charging may be by means of filling the flutes with a conductive liquid connecting the flute insides to ground potential and outer faces of the sheet material to high negative and positive potentials respectively.

Another means of charging the plastics walls may be by feeding them between rollers of conductive or semi-conductive material maintained at high and low electrical potentials respectively.

It is also preferred that opposed sides of the walls are rendered conductive and electrically connected together. The plastics walls may be rendered conductive by application of a conductive coating or a conductive sheet material.

Particle collection devices of the invention may be based on an electret which is a piece of dielectric material exhibiting a long-lasting electric charge. The electret charge may consist of surface charge layers, charges within the dielectric, polarisation charges or combinations of these.

A thin film electret exhibits an external electrostatic field if its polarisation and space charges do not compensate each other everywhere in the dielectric. This external electrostatic field is utilised in air cleaning filter material manufactured from thin film polymer electret. The thin film polymer is electrically charged to produce a non-woven filter fabric. When air containing suspended particles is passed through the fabric the particles are subjected to strong electrostatic fields as they approach the electret fibres. These forces result in deposition of the particles on the fibres. This fibrous electret polymer filter material has an advantage over conventional fibrous filter media (such as microfine glass fibres) in that high efficiencies can be achieved at relatively low pressure drops.

However, there is a further requirement for a filter medium which can provide high efficiency at even lower pressure drops.

Plastics sheet materials, especially plastics twin-wall fluted plastics sheet material, may be pre-treated to impart, i.e. give it, electret properties, and that material used in an air-cleaning collection device. Plastics materials suitable for the manufacture of the sheet materials include polyethylene (PE), polypropylene (PP), co-polymers of ethylene and propylene, PVC, PET, PTFE, polycarbonate and others. The plastics materials used preferably provide passages through which air passes readily through the flutes and so the pressure drop through such an air-cleaning array is small. Particles in the air stream passing through are subject to strong electric fields within the passages. Charged particles move in the electric field (by a process termed electrophoresis) toward the passage walls where they adhere and are thus captured.

Because the electric field in the passages in non-linear, uncharged or neutral particles also move (by a process termed dielectrophoresis) toward the walls and are captured.

Another aspect of the invention provides an electret structure for a particle precipitation device for removing particles entrained in a gas stream comprising an array of passages through which the gas stream can pass relatively freely, the passages being provided by fluted plastics sheet material having external walls connected by internal walls, the fluted plastics sheet material having electret properties imparted to the external walls thereof after formation of the fluted plastics sheet material so as to produce a substantially uniform electric field within the passages defined by the flutes, and means for urging the gas stream through the array, whereby particles are collected from the gas stream in the passages.

Also provided is an electret structure an electret structure for a particle precipitation device for removing particles entrained in a gas stream, the electret structure comprising an array of passages through which the gas stream can pass relatively freely, the passages being enclosed by plastics walls having electret properties imparted to external ones of said plastics walls after formation of the passages, wherein the passages are provided by fluted plastics sheet material, and wherein the charging of the walls after formation of the passages results in a substantially uniform electric field within passages defined by the flutes.

Whereas most electret air cleaning materials are manufactured to exhibit external electric fields on the surface of polymer films, in this invention care is taken to maximise the electric field strengths inside the air space within the passages of the plastics material.

Embodiments of this invention will now be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows schematically an embodiment of the invention;

Figure 2 shows schematically a system for charging particles in an air stream;

Figure 3 shows another embodiment of the invention;

Figure 4 shows schematically a first means of electret charging of collector plates for devices of the invention;

Figure 5 shows a second means of electret charging of collector plates for devices of the invention;

Figure 6 shows a third means of electret charging of collector plates for devices of the invention;

Figure 7 shows a fourth means of electret charging of collector plates for devices of the invention;

Figure 8 shows schematically a third embodiment of the invention;

Figure 9 shows schematically a fourth embodiment of the invention;

Figure 10 shows schematically a fifth embodiment of the invention;

Figure 11 shows schematically a sixth embodiment of the invention;

Figure 12 shows schematically a charged particle detector according to the invention; and

Figure 13 shows schematically a particle pollution measuring device according to the invention.

In the following description of Figures 1 to 13 of the drawings, like parts have been given the same reference numbers for simplicity and mainly differences between embodiments will be described in detail.

With reference to Figure 1 of the drawings, one preferred embodiment suitable to the electret charging of plastics twin-walled fluted sheet materials 10 is described below.

This comprises an array 11 of insulating plastics twin-wall fluted sheet material 9. In this embodiment there are no high and low potential plates. Instead, each individual sheet 9 is "charged" between high and low voltage electrodes, removed and then stacked to form an array 11. The effectiveness of this array to precipitate particles flowing through it is dependent on the stored electret charge within 9. A large charge may be stored by applying a very high potential difference before removing sheet material 9 and stacking in an array 11.

Removable flat metal or semi-conducting electrodes are applied to the top and bottom of the sheet material 10. A high voltage difference is applied to the two electrodes. After sufficient time for charging the high voltage is then disconnected and the electrodes removed from the newly formed electret sheet material.

As described in parent application 2,369,637 when an initial high potential is applied between the two plates and then the high voltage supply is disconnected, efficiency at particles capture may be expected to drop off, but this is not found to be the case. It appears that the initial high electric field strength generated between the plates causes the fluted plastics sheet material 9 to form an electret material which stores immobilised charge within 9. The electric field strengths generated by this immobilised stored charge are sufficiently strong to precipitate particles on the walls of the flutes of material 9.

The electret sheet material may now be cut up and formed simply by stacking the material into an air-cleaning array 200 (see Figure 1). The electric fields inside the flutes effect the trapping of particles in the air stream flowing through the flutes. No external power supply is required to maintain the electric fields within the flutes because the electret charge within the plastics material is stable with respect to time (Lifetime can be many years).

In the embodiment of Figure 3 of the drawings, it has been found advantageous (after electret charging of the sheet material) to electrically connect together both sides of each sheet 10 (all sides of all sheets in an air-cleaning array). This is done to maximise the electric field strength inside the flutes and therefore maximise the efficiency of filtration.

To electrically connect together both sides of each sheet, all of the plastics sheet surfaces need to be rendered conductive or semi-conductive.

This can be done by applying a conductive paint film or an anti-static coating, or attaching paper or metal film 198 to each side of the sheet.

The conductive surfaces of all of the sheets in an array are then connected together by use of wire 202, conductive tape, semi-conducting tape, conductive coating, semi-conductive or similar means.

When connected together like this the electric field within the flute air space may be maximised and hence the efficiency of capture of particles may be maximised.

The embodiment of Figure 3 will now be further described, by way of the following example.

A sheet of plastics twin-walled fluted sheet material 10 made from a copolymer of ethylene and propylene was selected. The sheet weighed about 300 grams per square metre with a sheet thickness of 2.1 millimetres the flute spacing of 2.7 millimetres and a wall thickness of about 150 microns.

Paper electrodes were placed so as to sandwich the sheet material. One electrode was electrically connected to ground and the other electrode was connected to a potential of minus 33,000 volts for a period of 15 minutes. The electrodes were disconnected, removed and the electret-charged plastics sheet material was cut up and sandwiched in an array as shown in Figure 3.

The electret sheet was cut up to give an airflow transit depth of 70 millimetres. A series of experiments was conducted using an aerosol monitor to determine the efficiency of capture of 0.5 micron salt particles at different air velocities through the array.

The results using uncharged aerosol salt particles at a concentration of about one milligram per cubic metre were as follows:

Air velocity (m/s)	Capture efficiency (%)	Pressure drop (pascals)
1	93	6
2	88	13
3	84	26
4	79	37
5	74	52

The results using negatively charged aerosol salt particles at a concentration of about one milligram per cubic metre were as follows:

Air velocity (m/s)	Capture efficiency (%)	Pressure drop (pascals)
1	99	6
2	99	13
3	99	26
4	98	37
5	96	52

Electret charging of plastics twin-wall fluted sheet material 10 may be achieved by applying an electric field to the material at higher temperature and then cooling to a lower temperature in the presence of the electric field.

Figure 4 illustrates another means of electret charging of plastics twin-wall fluted sheet material using a high-potential corona wire 210 placed above the sheet with an earthed conductive or semi-conductive plate 212 beneath the sheet. The plastic sheet is moved slowly to effect charging along the length of the plastic sheet.

In Figure 5 the electret charging of plastics twin-wall fluted sheet materials 10 is achieved using a high-potential corona point emitter 214 placed above the sheet with an earthed conductive or semi-conductive plate 216 beneath the sheet. The plastic sheet is moved slowly to effect charging along the length of the plastic sheet.

In order to achieve maximum charge storage in an electret material it is usually beneficial to apply a very high potential difference across the electret material. The higher the imposed potential difference, the higher the stored charged available after the imposed potentials are removed. However, the potential difference must be controlled because if it is too high dielectric breakdown takes place with a reduction of electret charge as a result.

The fluted structure of plastics twin-wall sheet material 10 lends itself to electret charging by an alternative preferred means as shown in Figure 6. The insides of the flutes are washed through or filled with water or other liquid 220, which has been made suitably conductive. The insides of the flutes, which are now temporarily conductive, are connected to ground potential and the top and bottom surfaces of the plastics sheet are covered with conductive or semi-conductive electrodes 222, 224. The top electrode 222 is connected to a suitably high negative potential. The bottom electrode 224 is connected to a suitably high positive potential. In this manner electret charge is formed in the dielectric of the top and bottom surfaces of the sheet material.

After a suitable time the electrodes are disconnected, the conductive liquid is drained from the flutes and the flutes are air-dried. A very high electric field strength in the airspace inside the flutes is achieved in this manner.

This newly formed electret flute material can now be cut up and arranged into an air-cleaning array as shown previously.

As shown in Figure 7 of the drawings, electret charging of plastics twin-wall fluted sheet material 10 is achieved by feeding of the sheet material slowly through rollers 230, 232 made of conductive or semi-conductive materials. The rollers are maintained at suitable high and low electrical potentials respectively. The rollers may be wet or treated with a suitable conducting liquid in order to enhance charge transfer.

The electret charging of plastics twin-wall fluted sheet material may be achieved in a manner similar to that mentioned with respect to Figure 1, except that one of or both of the removable electrodes are wet or treated with a suitable conducting liquid in order to enhance charge transfer.

Materials other than plastics fluted sheet material may be advantageously electret charged and then used to construct air-cleaning arrays of the invention. Figure 8 illustrates this. Rectangular section tubing 300 is electret charged by two planar electrodes 302, 304 as shown. The electret charging can be achieved using a batch process or preferably continuously.

Alternatively as shown in Figure 9 the rectangular section plastics tubing 300 is electret charged by two L-section shaped electrodes 306.

Figure 10 shows that circular or elliptical-section plastics tubing 310 may be electret charged by two suitably shaped electrodes 312, 314.

Once electret charged the rectangular 300 or circular 310 plastics tubes may be cut up and assembled into air cleaning arrays as shown respectively in Figure 11.

Figure 12 of the drawings shows an electret charged fluted array (similar to the array shown in Figure 3) is used not as an air-cleaning device but as a charged particle detector. Charged particles entering the flutes 10 are subject to the electric field across the flutes. The particles move to the walls where they adhere and give up their charge. The charge migrates to the electrodes 198. Positively charged particles or ions move to one side of the flutes and negatively charged particles or ions move to the other side.

By ensuring correct orientation of polarised electret charged sheets and by connecting together alternate electrodes, it is possible to measure two currents, one attributable to collected positive charges (A1) and one attributable to collected negative charges (A2).

The charged particle collection capabilities of such an array can be utilised to construct a sensitive particle pollution-measuring device 400 (see Figure 13). A brief description of such a device follows. A conductive tube 402 has an inlet grill 404 and leads to an electret array 406 of the type shown in Figure 3. The conductive tube 402 is connected to earth. Within the tube 402 is a corona emitter needle 408. Beyond the array 406 is a fan 410 and an outlet grill 412. The array 406 is connected earth via an ammeter A to measure current resulting from charge collected on the array from captured particles.

Air is drawn into the device by the fan 410. All of the air stream is subject to mono-polar corona charging (technically termed field-charging). As the particles pass through the corona charger all particles are charged. If the corona charge is negative then all particles will be charged negative regardless of the state of charge of the particles entering, i.e. positive, neutral and negative particles entering of the corona charger will exit with negative charge.

If all of these negative particles are then captured in the electret charged array 406, the current flowing from the array is proportional to the density of particles entering the device and proportional to the air flow through the device.

Such a device has a number of advantages over other particle pollution measuring devices, including high sensitivity (low pressure drop allows high air flow rate), a stable zero state (no particles, no electrical current), no leakage or interference problems (collecting array is not connected to any high voltages).

The embodiment of Figure 13 will now be further described, by way of the following example:

A smoke aerosol was generated in the room and was drawn into a circular section conductive tube of 100 mm diameter. (Air velocity 1.5 metres per sec.). The aerosol was passed over a centrally located insulated needle held at a potential of about minus 6,000 volts. Corona discharge from the needle produced an ion current of 4.5 microamperes to electrically charge the incoming particles. All of the highly mobile excess negative ions were captured by the surrounding conductive tube. The charged particles by virtue of their low mobility were carried along in the air stream into a square electret charged array of 70 millimitre depth. The negative particles in the stream were captured in the array and gave rise to a current measured by an ammeter.

The results of an experiment are as follows:

Aerosol concentration (micrograms/cubic metre)	Current from array (nano-amperes)
1000	6.2
800	5.0
600	3.7
400	2.5
200	1.3
0	0.0

The figures demonstrate a linear relationship between aerosol concentration and current collected by the array.

In embodiments of the invention, it may be desirable to pre-charge particles before they enter the filter array. This may be achieved by means of two ion emitters 36, 38 placed in a plastics airflow exit duct of an air filter of the invention. One of the emitters 36 has a sharp point, typically having a radius of curvature of tip of less than 0.1

mm, at a high negative potential and is positioned a distance z from ion emitter 38 having a blunt tip (radius of curvature of the tip being typically 0.5mm to 2.0mm).

As a result of the high electric field strength between the emitters, both emitters go into corona emissions. The sharp emitter 36 emits negative ions in abundance. The blunt emitter 38 emits positive ions in smaller quantities. The negative ion stream essentially neutralises the positive ion stream. The net effect of blowing air across both emitters resulting in a departing cloud of negative ions.

These ions exit the air-cleaning machine and go towards diffusion charging of the particles in the room. Air ions produced by virtue of the ion emitters are blown into the room where by diffusion charging they impart a small amount of electrical charge to the particles in the room. As the charged particles are drawn into the air-cleaning machine they are captured by the electrostatic fields within the flutes of the sheet materials. It is desirable to place the ion emitters inside the air-cleaning machine to reduce both local deposition and to reduce the possibility of electrostatic shock. External ion emitters produce local dirt deposition in the vicinity of the emitters and can also pose an electrostatic nuisance to the users of the air cleaner. This contrasts with the use of two sharp emitters. If two sharp emitters are used there is more abundance of positive ions. Positive ions in the exit air stream will effectively neutralise negatively charged particles and thus reduce the efficiency of particle capture in the flutes. Optimisation of negative ionisation (and hence mono-polar charging) is achieved by adjusting emitter potentials, radius of curvatures of emitter tips, distance z and airflow direction and velocity.

CLAIMS

1. A particle precipitation device for removing particles entrained in a gas stream comprising an array of passages through which the gas stream can pass relatively freely, the passages being enclosed by plastics walls having electret properties imparted to external ones of said plastics walls after formation of the passages, wherein the passages are provided by fluted plastics sheet material, and wherein the charging of the walls after formation of the passages results in a substantially uniform electric field within passages defined by the flutes, and means for urging the gas stream through the array, whereby particles are collected from the gas stream in the passages.

2. A device as claimed in claim 1, wherein sheets of the fluted plastics sheet material are overlaid one on top of the other.

3. A device as claimed in claim 1, wherein the fluted plastics sheet material is folded in concertina fashion.

4. A device as claimed in claim 1, wherein fluted plastics sheet material is formed into a spiral.

5. A device as claimed in claim 1, wherein the passages are provided by plastics tubes arranged side by side.

6. A device as claimed in claim 5, wherein the plastics tubes are of rectangular cross-section.

7. A device as claimed in claim 5, wherein the plastics tubes are of circular cross-section.

8. A device as claimed in any one of claims 1 to 7, wherein the plastics material is selected from a group consisting of polypropylene, polyethylene or a copolymer thereof, polyvinyl chloride, PET, PTFE and polycarbonate.

9. A device as claimed in any one of claims 1 to 7, further comprising means for electrically charging particles in the gas stream prior to the array of passages.

10. A device as claimed in claim 1 or 9, comprising corona discharge means for electrically charging the particles in the gas stream.

11. A device as claimed in claim 1 or 9, comprising radioactive ionisation means for electrically charging the particles in the gas stream.

12. A device as claimed in any one of claims 1 to 11, further comprising means for ionizing the gas stream as it leaves the array.

13. A device as claimed in claim 12, wherein the means for ionising the gas stream as it leaves the array comprises a primary corona discharge emitter and a secondary corona discharge emitter at a lower potential to the primary emitter.

14. A device as claimed in claim 13, wherein the primary emitter is connected to high negative potential and the secondary emitter is earthed.

15. A device as claimed in claim 13 or 14, wherein the primary emitter is a needle having a sharp tip with a radius of curvature of less than approximately 0.1 mm and the secondary emitter is a needle having a relatively blunt tip with a radius of curvature of approximately 0.5 to 2.0 mm.

16. A device as claimed in any one of claims 1 to 15, wherein the plastics walls are charged by means of electrodes applied to opposite sides of the walls with a high voltage difference applied thereto.

17. A device as claimed in any one of claims 1 to 15, wherein the plastics walls are charged by applying an electric field at a higher temperature and then cooling to a lower temperature in the presence of the electric field.

18. A device as claimed in any one of claims 1 to 15, wherein the plastics walls are charged by moving the plastics walls between a high potential corona discharge on one side, and an earthed conductive plate on the other side.

19. A device as claimed in any one claims 1 to 15, wherein the plastics walls are provided by faces of fluted plastics sheet material and charging is achieved by means of

filling the flutes with a conductive liquid connecting the flute insides to ground potential and outer faces of the sheet material to high negative and positive potentials respectively.

20. A device as claimed in any one of claims 1 to 15, wherein the plastics walls are charged by feeding them between rollers of conductive or semi-conductive material maintained at high and low potentials respectively.

21. A device as claimed in any one of claims 16 to 20, wherein the opposite sides of the walls are rendered conductive and electrically connected.

22. A device as claimed in claim 21, wherein the opposite sides of the walls are connected to ground.

23. A device as claimed in claim 21 or 22, wherein the plastics walls are rendered conductive by application of a conductive coating or a conductive sheet material.

24. A device as claimed in any one of claims 1 to 23, in the form of a pollution monitor, wherein the plastics walls are electrically connected to earth via an ammeter for measuring current resulting from collected particles.

25. An electret structure for a particle precipitation device for removing particles entrained in a gas stream, the structure comprising an array of passages through which the gas stream can pass relatively freely, the passages being provided by fluted plastics sheet material having external walls connected by internal walls, the fluted plastics sheet material having electret properties imparted to the external walls thereof after formation of the fluted plastics sheet material so as to produce a substantially uniform electric field within the passages defined by the flutes

26. An electret structure for a particle precipitation device according to claim 25 wherein the electric field is substantially orthogonal to both external walls.

27. An electret structure for a particle precipitation device according to claim 25 formed by a process comprising the steps of forming the fluted plastics sheet material with opposing external walls connected to each other by the internal walls, the internal walls defining the passages; applying opposite charges to the external walls so as to

produce the substantially uniform electric field within the passages defined by the flutes, the electric field being substantially orthogonal to both external walls.

28. An electret structure for a particle precipitation device for removing particles entrained in a gas stream, the electret structure comprising an array of passages through which the gas stream can pass relatively freely, the passages being enclosed by plastics walls having electret properties imparted to external ones of said plastics walls after formation of the passages, wherein the passages are provided by fluted plastics sheet material, and wherein the charging of the walls after formation of the passages results in a substantially uniform electric field within passages defined by the flutes.

29. A particle precipitation device comprising an electret structure as defined in claim 25, and means for urging the gas stream through the array, whereby particles are collected from the gas stream in the passages.

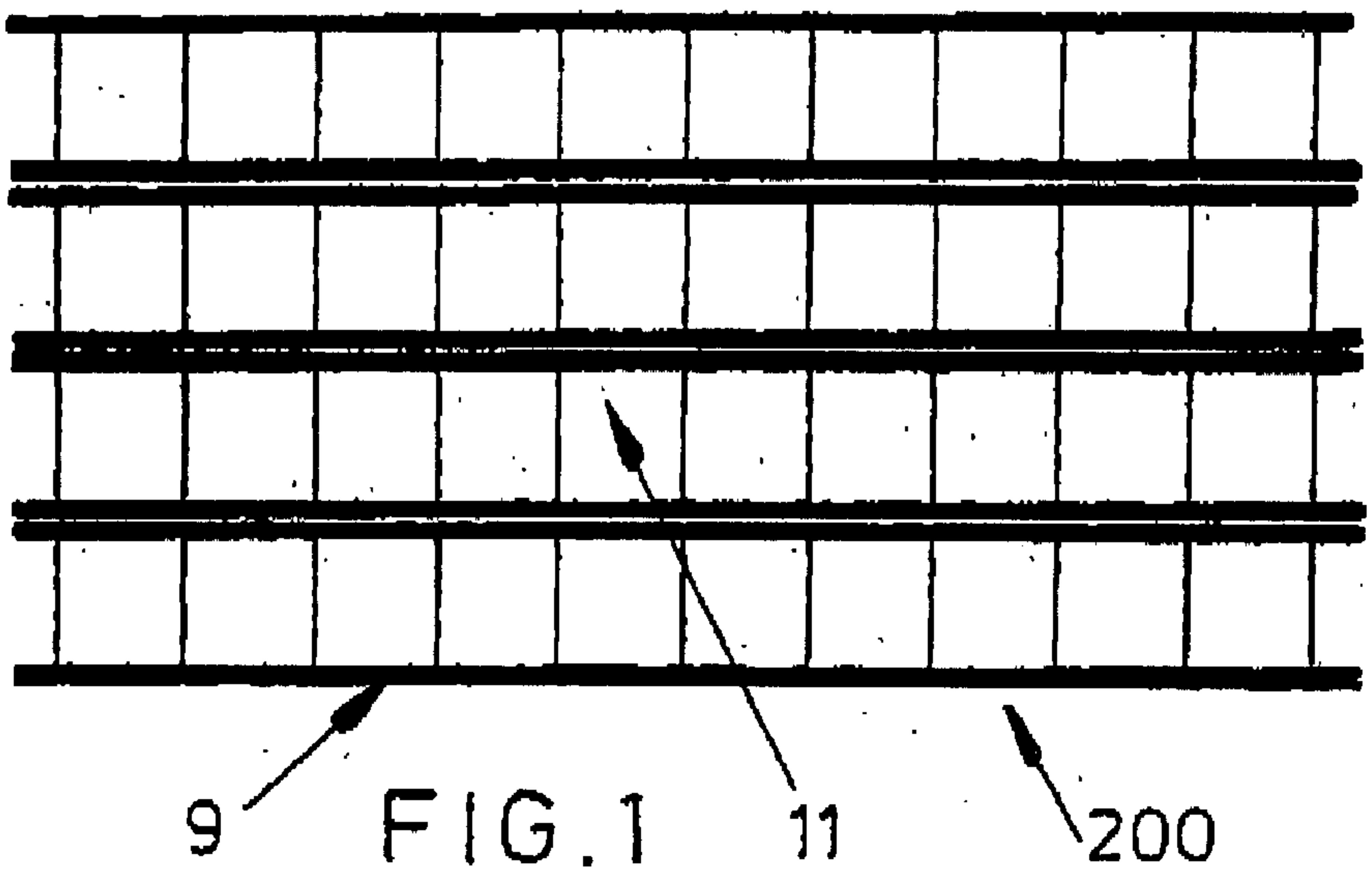


FIG.1

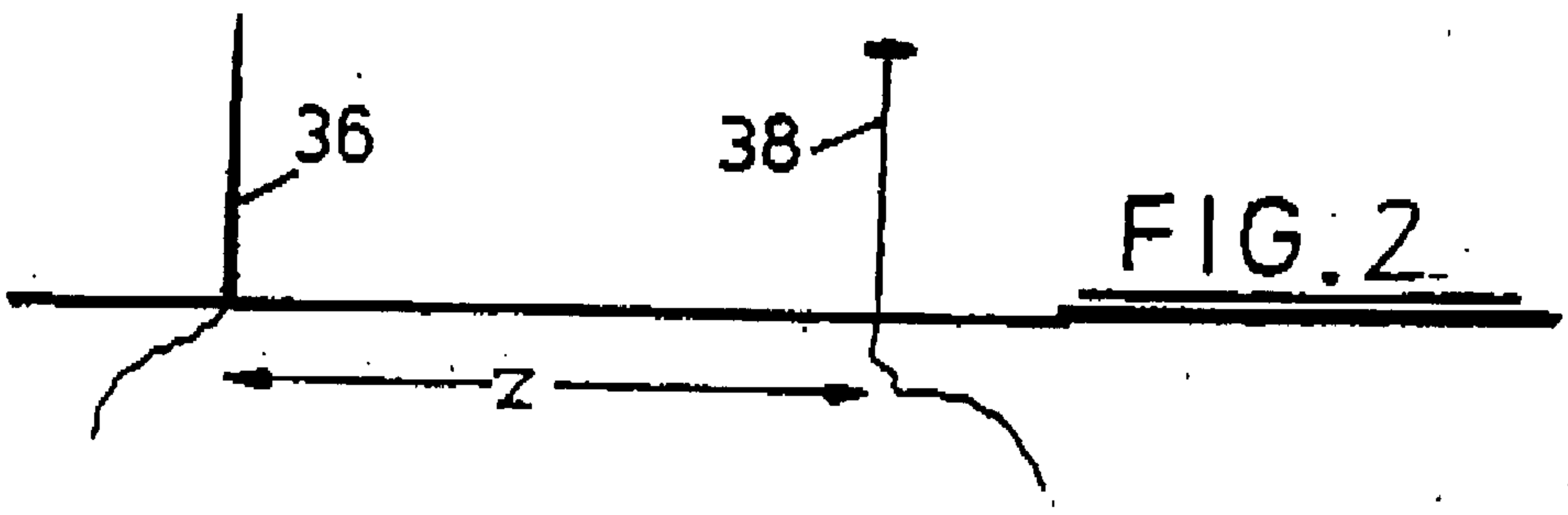


FIG.2

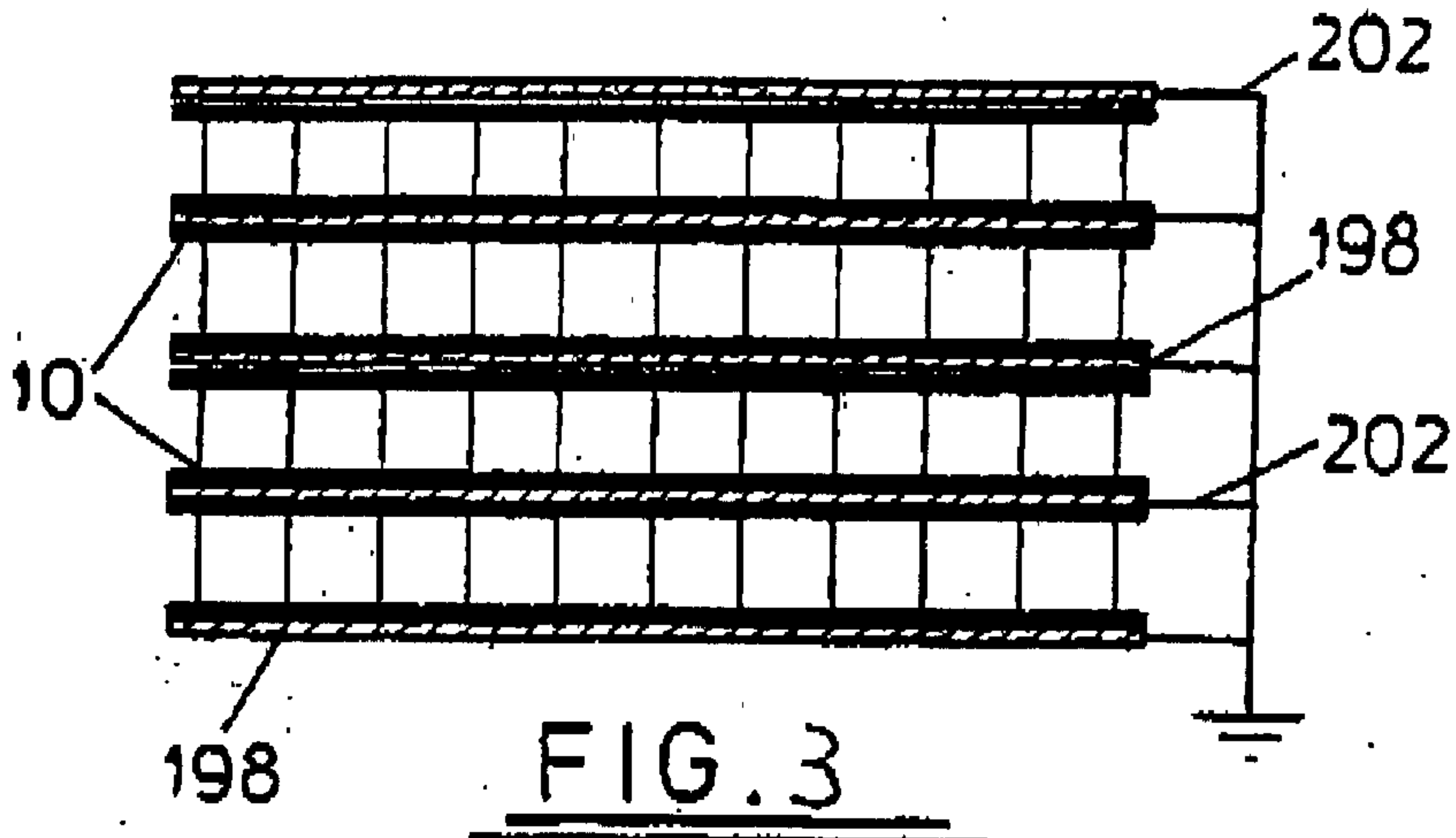


FIG.3

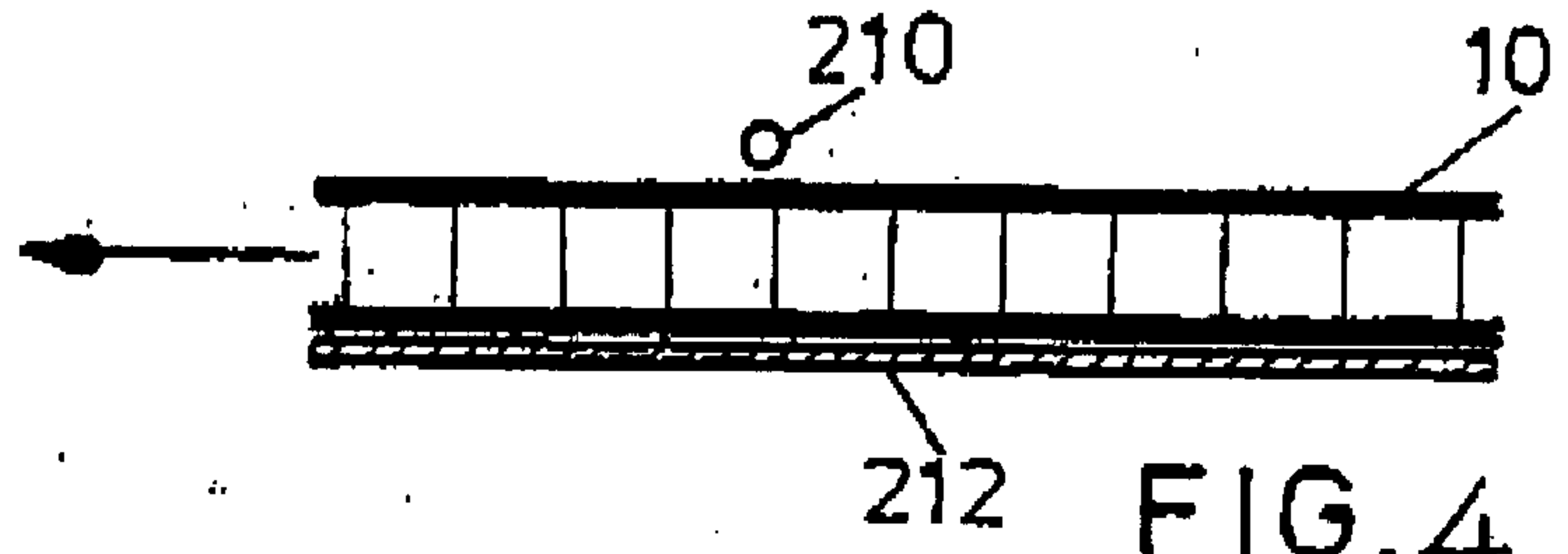


FIG.4

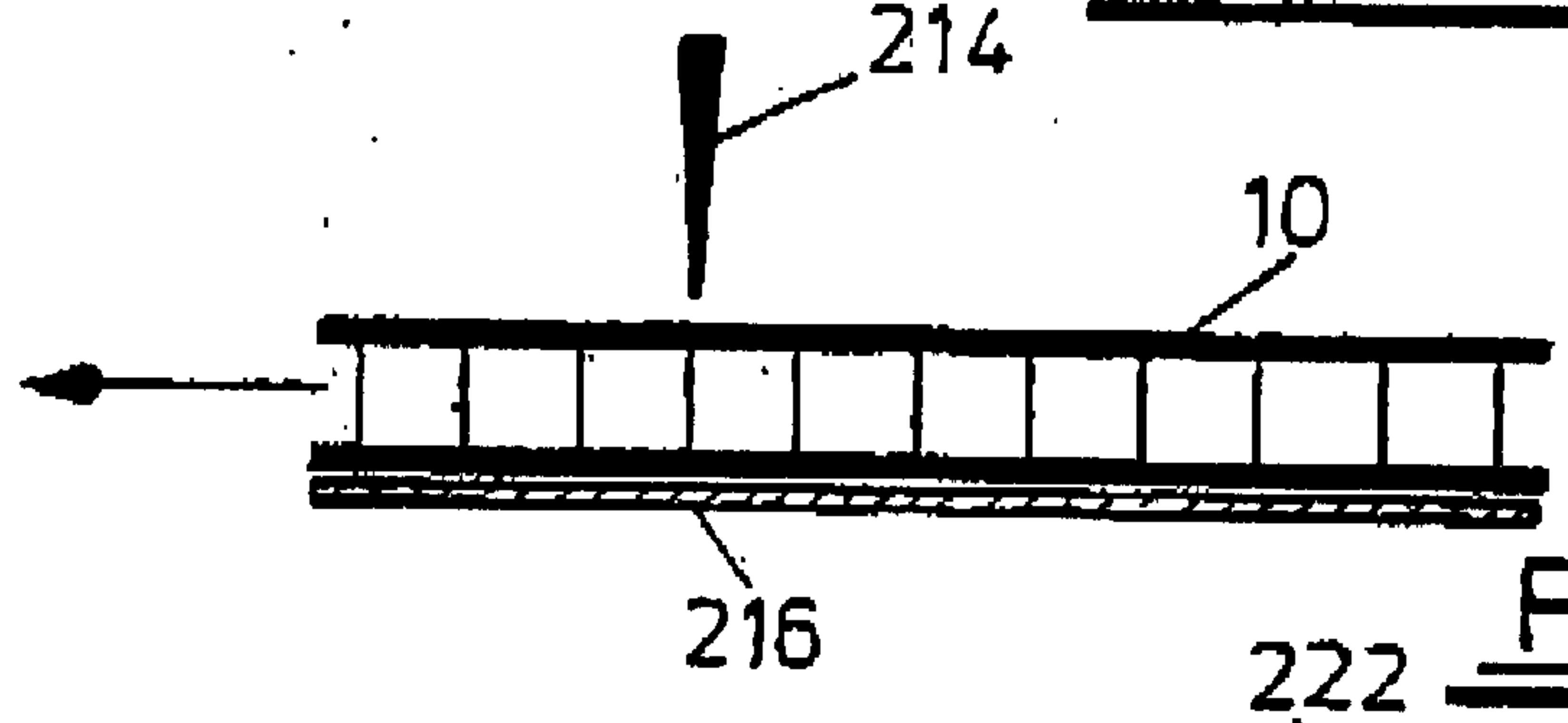


FIG.5

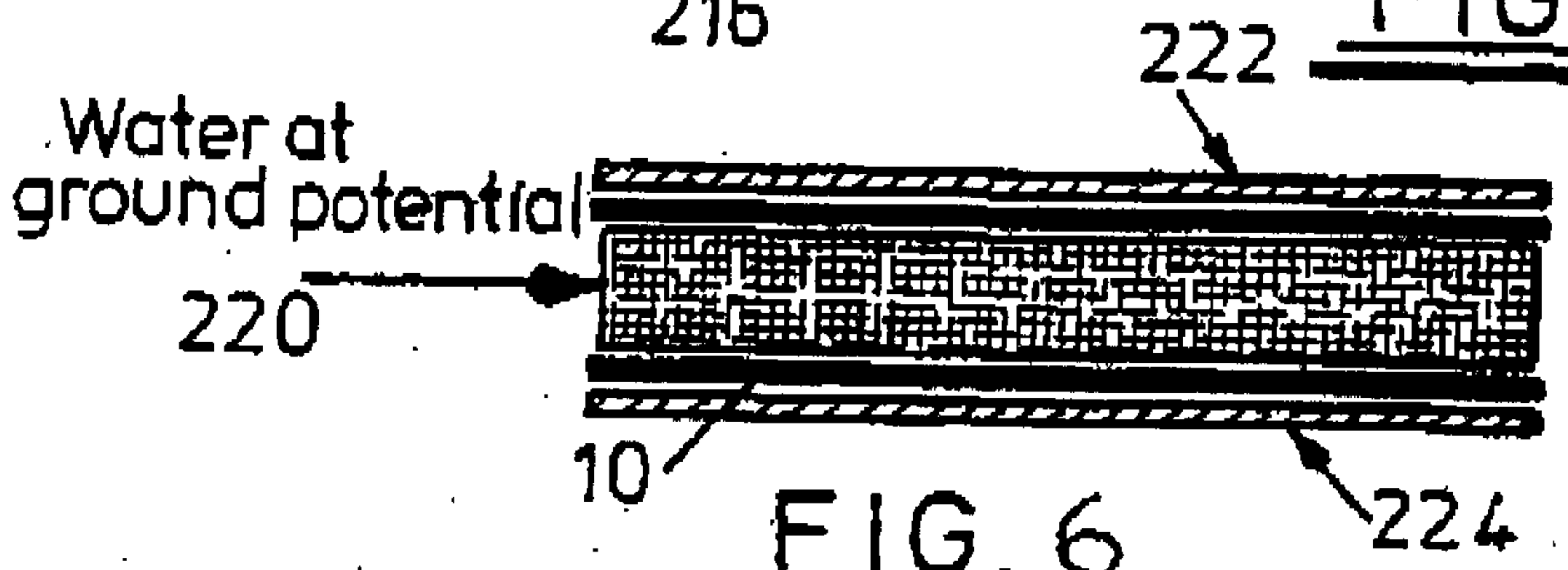


FIG.6

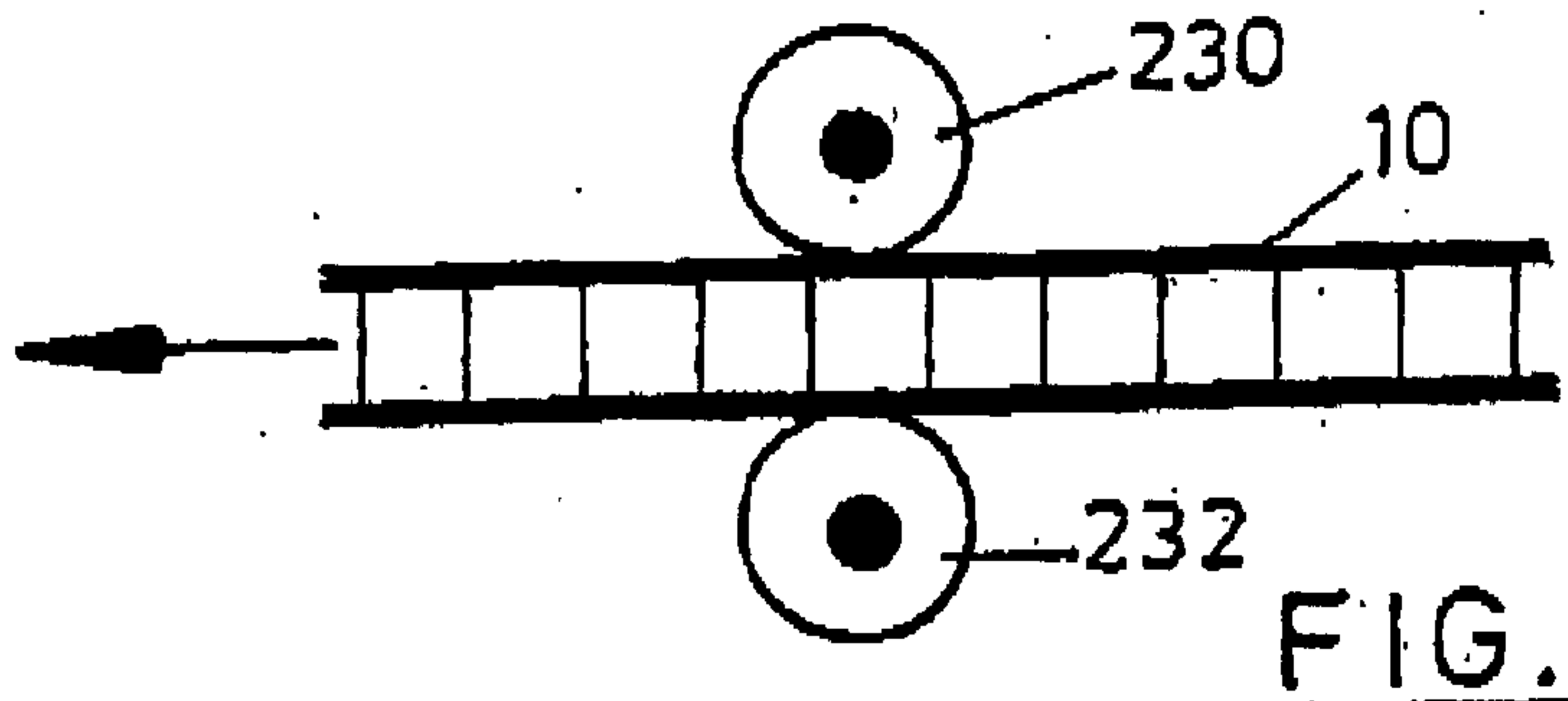


FIG. 7

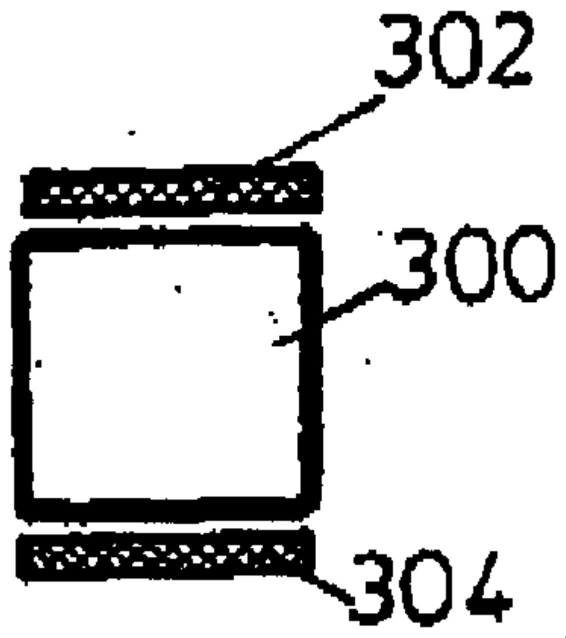


FIG. 8

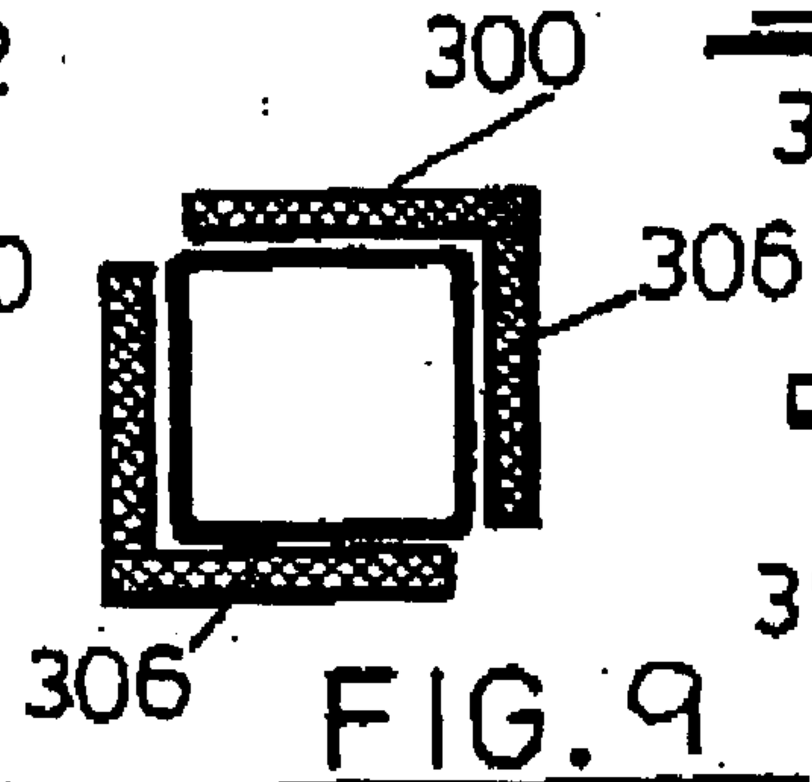


FIG. 9

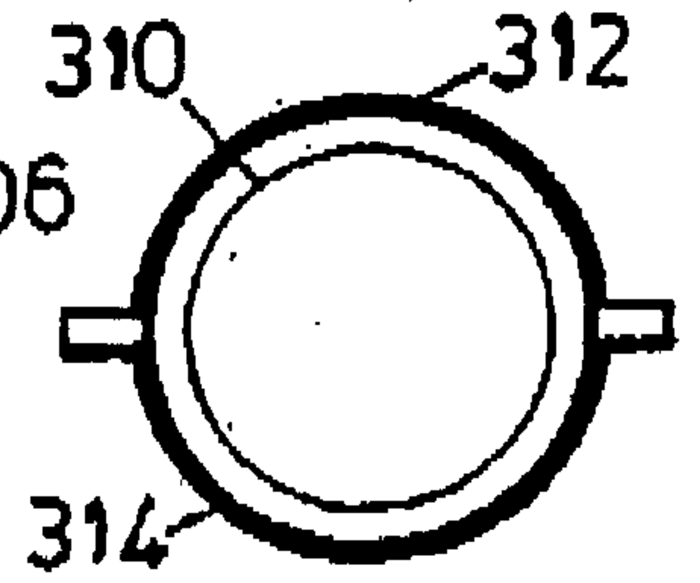


FIG. 10

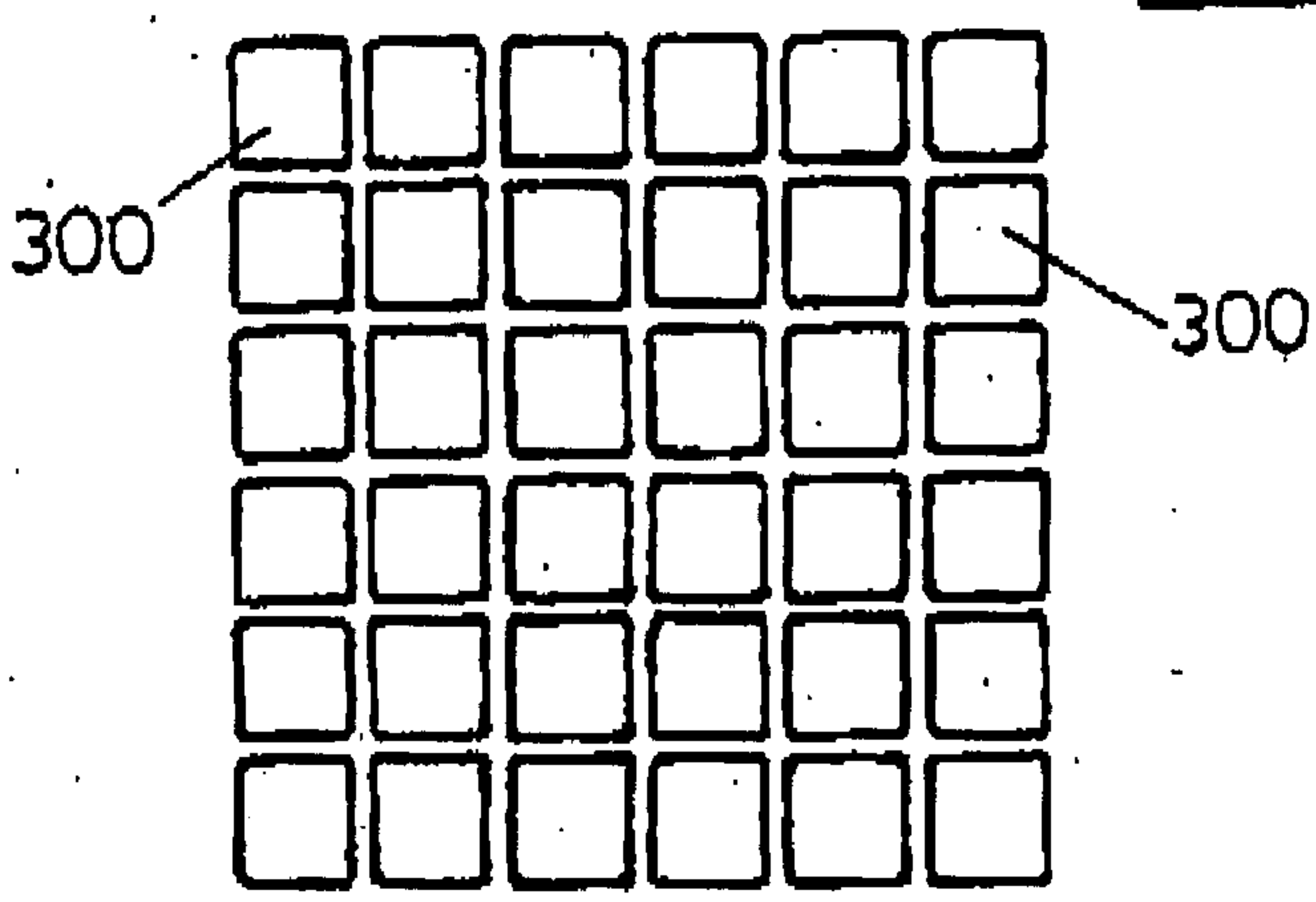


FIG. 11

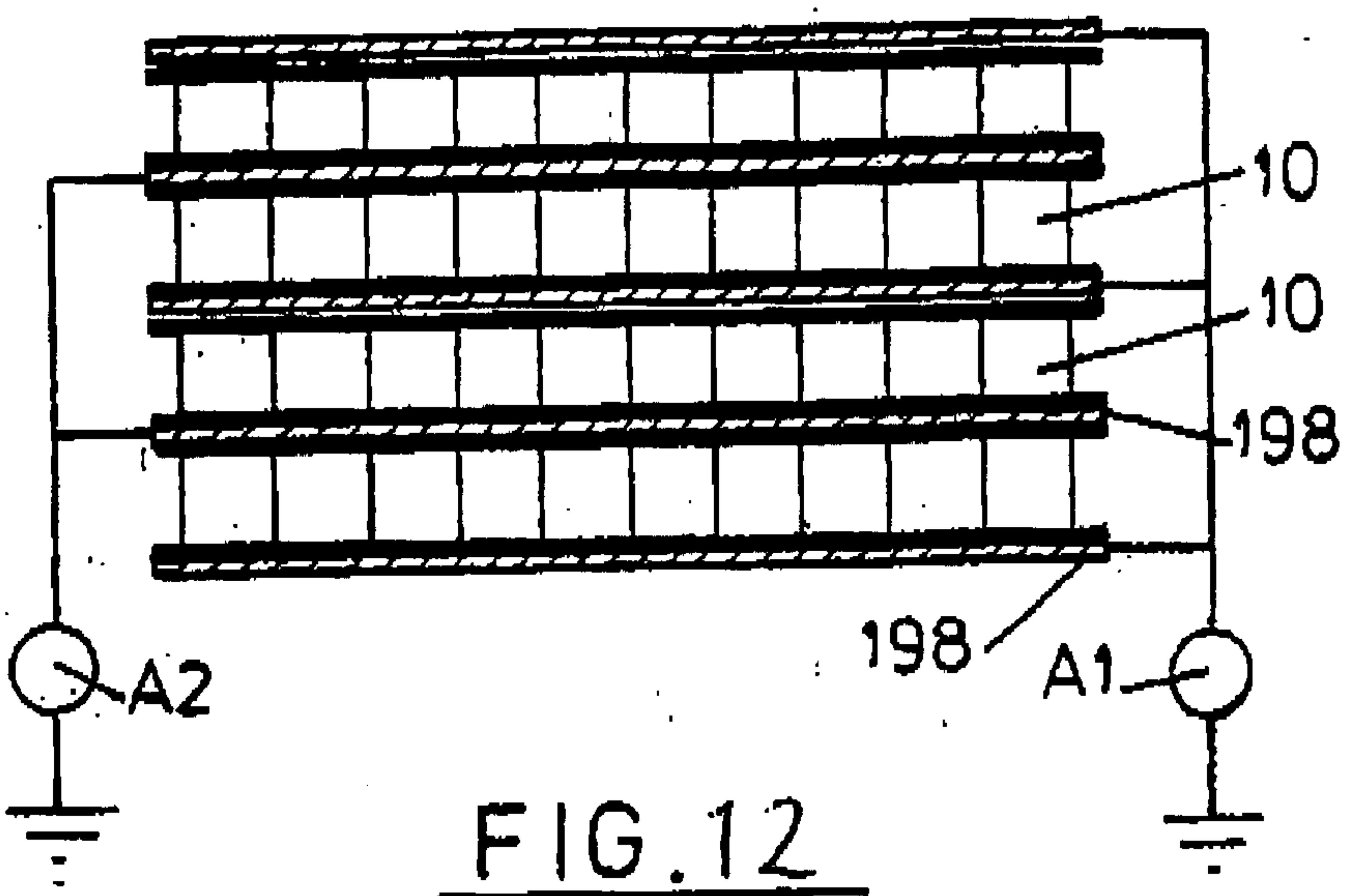


FIG.12

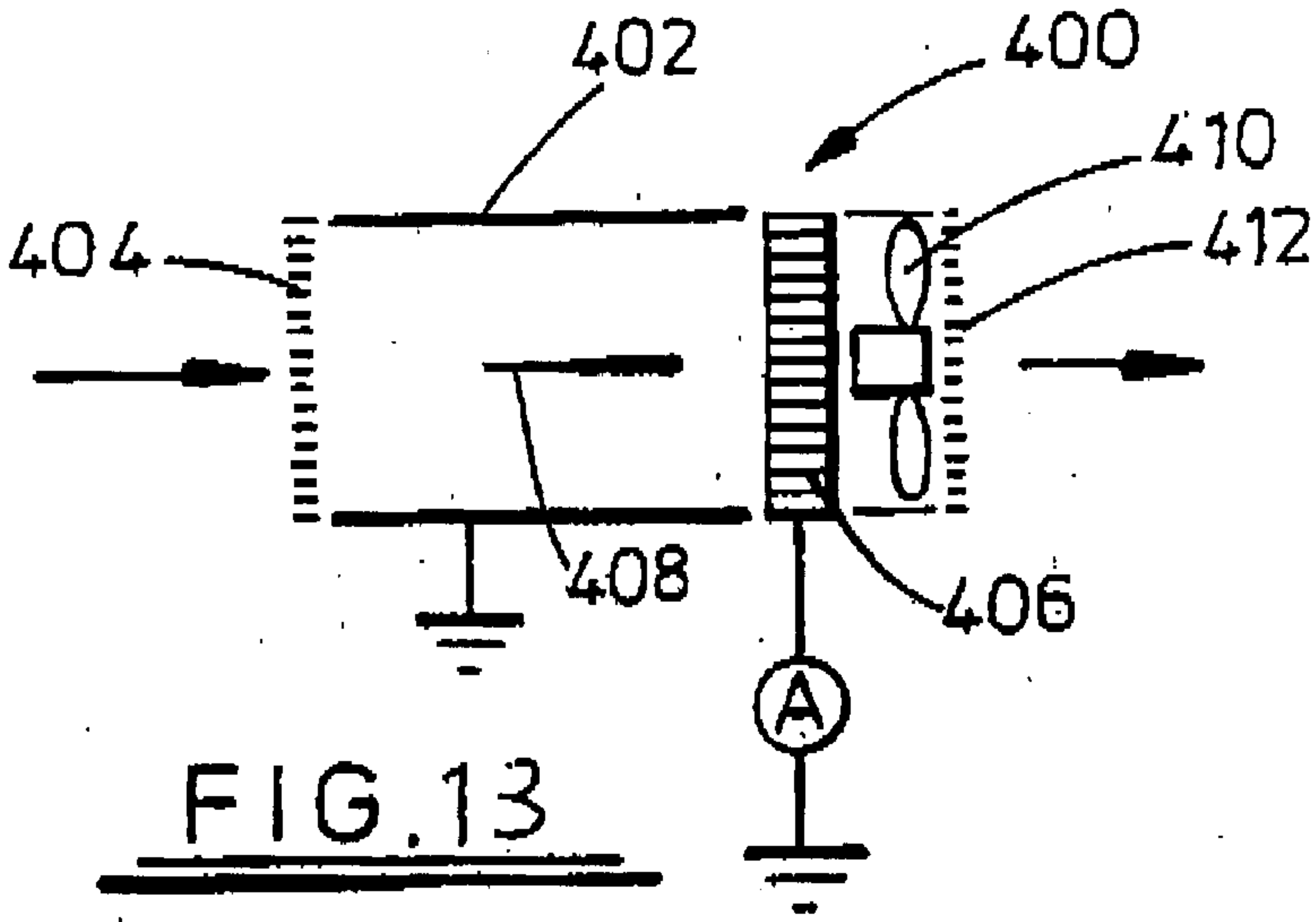
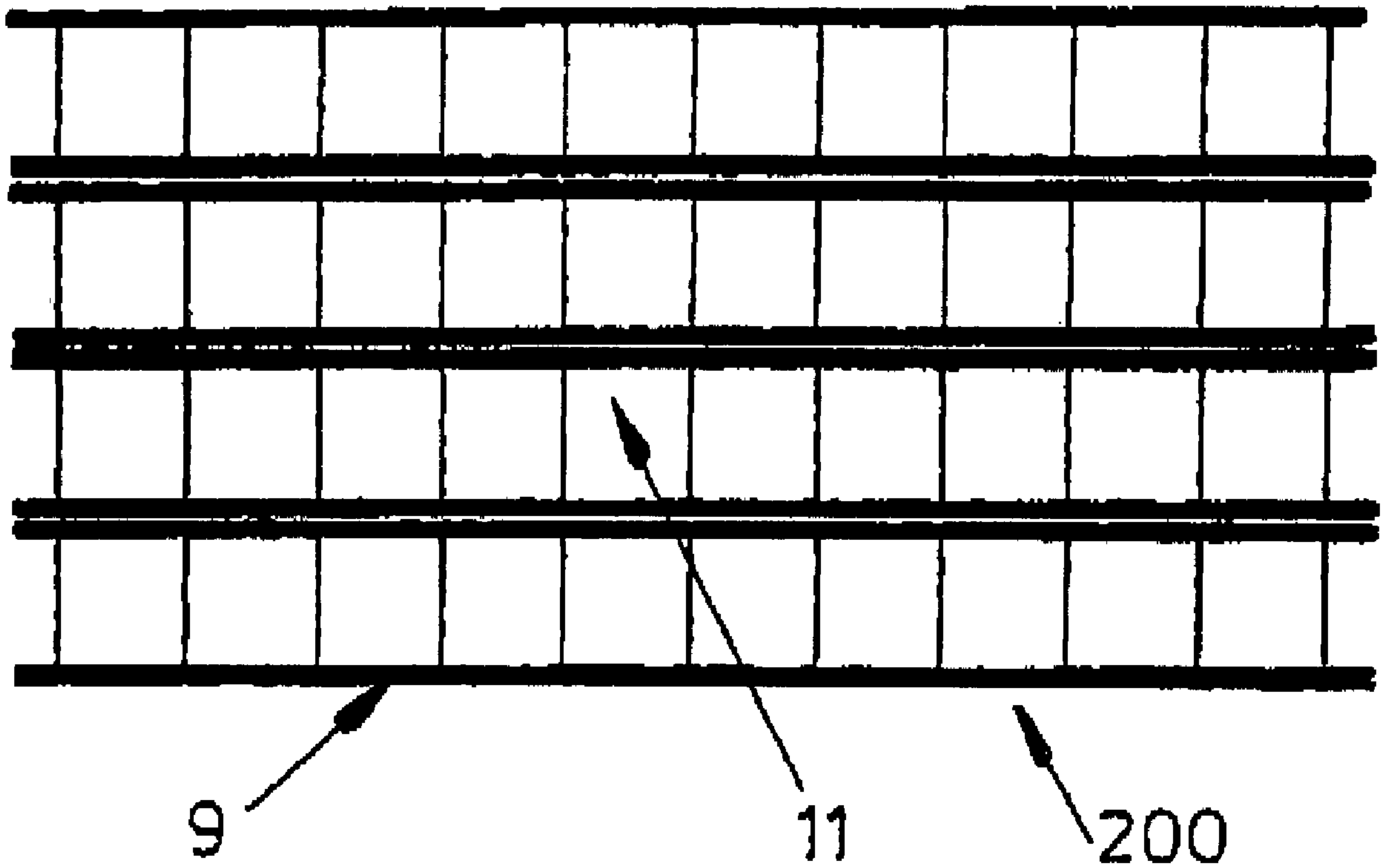


FIG.13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11
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