

SPECIFICATION

Method and Apparatus for Cleaning Exhaust Gas and
Reducing Noise by Using High Voltage Electric Field

5

Technical Field

The present invention relates to a method and an
10 apparatus to clean exhaust gas conveying through the
chamber, by burning up granular particles under plasma
atmosphere, by removing gaseous materials with negative
ions, and by eliminating NOx with ultraviolet rays,
which are induced by high voltage electric field.

15 Specifically, the present invention relates to a method
and an apparatus which can clean exhaust gas and reduce
noise, wherein it comprises the step of burning up the
granular particles with corona discharge after changing
particles into plasma atmosphere, the step of removing
20 gaseous materials with negative ions, the step of
eliminating NOx with ultraviolet rays, and the step of
reducing noise.

The main causes of circumstance pollution are smoke and
25 noise produced by industrial equipments and

automobiles.

Especially, diesel engines are used in popular, since it has high power and cost of diesel is low. By the way, in the event of using diesel engines, there occur
5 some problems that diesel engines push out smoke including granular particles, hydrocarbons, NOx, noise and so on, which must be solved to prevent the circumstance pollution.

In order to solve these problems, intensive studies
10 have been carried about cleaning exhaust gas and reducing noise.

Background of Art

15 Heretofore known methods make use of catalytic filters, electric field and recombustion of exhaust gas.

In DE 3834920, the system has been described, wherein it burns up the deposited carbon particles in ceramic
20 filter with ozone produced by electric field of 20KHz and 20MV.

In WO 9200442, method and device have been described, wherein exhaust gases are taken into a channel of
25 ceramic body where an electric field is generated

across the direction flow, and the soot particles deposited on the walls of the channel are first negatively charged by a discharge electrode and then oxidized by ions adhering to oxygen.

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In DE 3314168, the system has been described, wherein neutral particles are divided into two side streams which are directed over electrodes of large surface area, held at opposite potentials.

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In DE 3711312, the method and apparatus have been described, wherein particles are removed by being ionized with UV rays and by being collected to the plate.

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In US 5074112, an apparatus has been described, wherein a filter disposed within the cavity removes particulate products of combustion from exhaust gases passing the cavity and electromagnetic waves produce heat for incinerating particulate products of combustion.

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As shown in the above, one method can be applied to eliminate only a kind of ingredient, and so the other ingredients including NO_x and noise are pushed out without eliminating.

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Accordingly, the inventors of the present invention invented a method and apparatus for cleaning exhaust gas as well as reducing engine noise.

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SUMMARY OF THE INVENTION

An object of this invention is to provide a method and an apparatus for cleaning exhaust gas pushed out from engines or industrial equipments and reduce engine
10 noises.

Specifically, the object of the present invention is to provide method and apparatus which can clean exhaust gas and reduce engine noise, by partitioning the granular particles and noxious materials in exhaust
15 gas, and then by burning up directly the granular particles under plasma atmosphere, by burning up again the minute particles by means of DC voltage and AC voltage, by removing noxious materials with negative ions, by removing NOx by oxidizing it into NO₂ with
20 ultraviolet rays and ozone, which can be easily solved in water which is produced by Sellen's effect of PN diode in this apparatus, and by cutting off engine noises and electromagnetic interference.

25 The apparatus in the present invention is divided into

seven units in order to enhance productivity and efficiency of after-service, which can be used in combination or in separation.

5 In this invention, partition unit(100) renders exhaust gas to pass through at high speed and burns up particles which has been collected in partition unit(100)

In partition unit(100), to pass exhaust gas at high
10 speed, EHD(electro-hydro dynamics) method and electrostatic method are applied at bottle necked nozzle to accelerate the flow of exhaust gas.

The negatively charged particles accelerate much more by voltage difference between ionpin(110) and attractor
15 electrode(120), and therefore staying or slowing down of exhaust gas in a chamber is prevented.

The negatively charged particles are attracted by electrostatic force on the collector electrode(130) which is made of a metal mesh(211) and particles which
20 can not pass through the collector electrode(130) of a metal mesh(211) drop down into the manhole where one set of discharge pole(140, 140) are disposed to burn up large particles.

In plasma unit(200), particles passed through collector
25 electrode(130) are burned by using corona process,

wherein small particles are burned by streamer corona generated between plasma unit pole(210) and mesh(211).

In order to clean exhaust gas more efficiently, exhaust gas is conveyed to electron unit(300) after passing
5 through plasma unit(200). Electron unit(300) burns up minute particles by means of DC voltage and AC voltage. AC high voltage is applied across pole plate(350) and hole plate(310) in order to generate streamer corona to burn up minute particles.

10 DC high voltage is applied across hole plate(310) and ionpin plate(320) to generate electric wind by ionpin(110) which pushes particles to hole plate(350) in order to enhance the efficiency of corona discharge between hole plate(310) and pole plate(350).

15 By the above-mentioned process, granular ingredients of exhaust gas are nearly cleared.

Also, there are noxious chemical materials including NOx in exhaust gas, which are removed with negative ions generated by ionization unit(400) which generates
20 UV rays between plasma jet and opposite electrode(430), and this UV rays generate lots of negative ions. Noxious materials combine with negative ions and ozones to be changed into other materials.

In order to remove NOx which is not removed in the
25 above-mentioned ionization unit(400), screen unit(600)

is used.

The screen unit(600) comprises ceramic plate A(630), ceramic plate C(650) and ceramic plate B(640) having hexagonal holes(610) in which PN diode(620) are
5 disposed.

By action of 10K voltage applied across plates, UV rays are generated around hexagonal hole(610) in a large amount, and this UV rays let O₂ to be changed into ozone. In addition, PN diodes(620) cause temperature
10 dropping by Sellen's effect to condensate H₂O into water.

During above process, the efficiency of removing NOx will be enhanced by taking air into plates.

This invention can contain a union unit(700), which
15 absorbs engine noises and shields electromagnetic wave to be radiated by high frequency. Union unit is used to meet the regulations of EMI, EMC specification of this inventive apparatus.

According to the above, this invention can clear
20 exhaust gas and can be substituted for a noise absorber.

Brief Description of the Drawings

25 This object, and other objects and advantages of the

present invention, will appear more clearly from the following specification in conjunction with accompanying schematic drawing, in which:

- 5 FIG.1 is an exploded view of the inventive apparatus ;and
- FIG.2(a) is a schematic view showing the working principle of an partition unit ;and
- FIG.2(b) illustrates a brush corona discharge ;and
- 10 FIG.3 is an embodiment of a partition unit ;and
- FIG.4(a) is a schematic view showing the disposition of plasma unit cell and opposite electrode ;and
- FIG.4(b) is illustrates a streamer corona discharge through hemispheric plasma unit pole ;and
- 15 FIG.5(a) is a detailed view of one set in an electron unit ;and
- FIG.5(b) is a schematic view to calculate the distance between a dust collector at soot clean-up space ;and
- 20 FIG.5(c) is a circuit to supply DC voltage ;and
- FIG.5(d) is a circuit to supply DC voltage ;and
- FIG.6 is an embodiment of the plasma jet to generate a negative ion
- FIG.7 is an ionization cell mounted on a cell-plate
- 25 ;and

FIG.8 is a detailed view to show a screen unit ;and
FIG.9(a) is a circuit of high-frequency voltage
generator ;and
FIG.9(b) is voltage multiplier circuit to multiply
5 voltage applied across a thirdly order coil ;and
FIG.10 shows an external view of this invention
apparatus

Detailed Description of the Preferred Embodiment

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In the following, the present invention will be explained in detail referring to the drawings.

Referring to Fig.1, which shows the entire prospect of
15 the present invention, the present invention comprises
a partition unit(100) which renders exhaust gas to pass
through at high speed and burns up large particles
which have been collected in a partition unit(100), a
plasma unit(200) which burns up directly granular
20 particles by making them into plasma state with
streamer corona, electron unit(300) which burns up
minute particles by means of DC voltage and AC voltage,
a ionic polarization unit(400) which eliminates the
noxious materials by generating lots of negative ions,
25 a screen unit(600) which removes NOx by generating

ozone with ultraviolet rays in order to oxidize NO_x into NO₃, which can be easily solved in water which is produced by Sellen's effect of PN diode(620) in screen unit(400), a union unit(700) which reduces engine
5 noises and shields electromagnetic waves irradiated from the above-mentioned unions(100, 200,300, 400, 600), and high voltage generator (not drawn) to supply high voltage to each unit.

10 Each unit will be explained in detail in the followings.

A partition unit(100) is shown in detail in Fig.2 and Fig.3.

15 Referring to Fig.2(a), a partition unit(100) comprises ionpin(110) which induces negative high voltage to ionize air and granular particles in exhaust gas, an attractor electrode(120) in a bottle-necked nozzle which induces negative voltage to accelerate exhaust
20 gas, a meshed collector electrode(130) which partitions granular particles, that is, larger particles drop down into the manhole below the meshed collector electrode(130) and small particles are passed through the collector electrode(130), and discharge poles(140,
25 140) which burns up the dropped materials in manhole.

Fig.2(b) shows a brush corona which is discharged from ionpin(110) to charge the granular particles in exhaust gas.

5 Fig.3 shows one of the embodiments where above elements(110, 120, 130, 140) are mounted in a partition unit(100), wherein a partition unit(100) comprises a partition unit plate(180), a ionpin(110) which ionizes granular particles, an air inlet hole(150) which takes
10 exhaust gas into channel, a partition unit guider(160) where bottle-necked nozzle is mounted, and a partition unit pole(170) which burns up larger particles which is mounted at discharge poles(140, 140) below a collector electrode(130) in front of a ionpin(110).

15

Fig.4(a) shows a unit cell(250) of the plasma unit(200) which is composed of several unit cells, wherein a plasma unit cell(250) comprises several plasma unit pole(210) in hemispheric shape which generate streamer
20 corona to burn up the particles passed through the collector electrode(130) of the partition unit(100), several pole hole(220) in which the above plasma unit pole(210) are inserted, meshes [211 ; not shown in Fig.4(a)] which act as a discharge electrode of the
25 plasma unit pole(210) and a ground hole(260) which is

connected to the meshes(211).

Fig.4(b) shows the streamer corona which is generated between the plasma unit pole(210) in the plasma unit
5 cell(250) and meshes(211).

Fig.5(a) shows one set of a electron unit(300) which is composed of several units. One set of the electron unit(300) has a ionpin plate(320), a hole-plate(310)
10 and pole-plate(350), wherein the ionpin plate(320) applied negative high voltage comprises many ionpin(110) which ionize the minute particles and generate electron wind, and many air inlet hole(150) which gas pass through, a hole-plate(310) with many air
15 inlet hole(150) mounted on meshes(211) which act as discharge electrode for streamer corona, and a pole-plate(350) with many air inlet hole(150) and many plasma unit poles(210) which generate streamer corona to burn up the particles.

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Fig.5(b) shows the embodiment that the above plates(310, 320, 350) are disposed in a electron unit(300).

Practically, the efficiency of cleaning exhaust gas
25 depends on size, shape, disposition of the plates(310,

320, 350) and applied voltage and current.

The appropriate area of cleaning exhaust gas in a electron unit(300) is characterized by :

5 $S = WNH$

wherein distance between plates(310, 320, 350) is W, the height of plates(310, 320, 350) is H, the amount of exhaust gas is L, and the cross-sectional area for cleaning exhaust gas is S, if space is composed of n
10 plates.

The space between plates(310, 320, 350) is lane, and the an area of one lane is 2LH so that the total area of cleaning exhaust gas in a electron unit(300) is as the followings.

15 $A = 2NLH$

DC-7KV is applied to each ionpin plate(320) and hole-plate(310) to ionize the minute particles by a ion pin(110) on the ionpin plate(320) and then to deposit
20 the ionized particles on the meshes(211) of the a hole-plate(310) and to cause electron wind between a ionpin plate(320) and a hole-plate(310).

AC 10KV is applied to pole plate(350) to generate streamer corona to burn up the particles collected on
25 meshes(211).

Fig.5(c) is a circuit which supplies DC voltage to an ionpin(110) mounted on an ionpin unit plate(320), comprises a transformer(T) to multiply voltage, a rectifying diode(D1, D2), a filtering resistor(R1, R2) to attenuate ripple signal, resistor (R3) the time constant of this circuit and capacitor(C1) which determine the time constant of this circuit.

FIG.5(d) is another circuit which supplies DC voltage to an ionpin(110) mounted on a ionpin unit plate(320). A circuit comprises a transformer(T) to multiply voltage, a rectifying diode(D3), resistor(R6) and capacitor(C2) which determine the time constant of this circuit when positive voltage is applied, and resistor(R6) and capacitor(C2) which determine the time constant of this circuit when negative voltage is applied.

Here, Electric field(E) generated at a ionpin(110)

$$E = \frac{V}{R(RC/RD)}$$

V : voltage applied at a ionpin(110)]

R : the radius of corona discharge generated at a ionpin(110)

RD : the radius of discharging current generated at

an ionpin(110)

RC : the radius of meshes(211) set up on an air
inlet hole(150).

5 Referring to Fig.6, the ionization unit(400) comprises
many ionization cells(405) composed of an inner
pipe(410) and an outer pipe(420) where gas passes
through at high speed, and an opposite electrode(430)
applied with high voltage. And the point end(406) of
10 each ionization cell(405) is disposed between opposite
electrodes(430).

Referring to Fig.7, the ionization unit(400) comprises
a cell plate(409) on which several ionization cell(405)
15 mounted, and hole-plate(310, shown in Fig.1) which acts
as an opposite electrode(430).

Fig.8 shows one set of screen unit(600) which is
composed of several sets. One set of screen unit has
20 plate A(630), plate B(640), and plate C(650), wherein
it comprises plate A(630) and plate C(640) having
several hexagonal holes(610) which generate UV rays to
render O_2 into ozone and then NO_x into NO_3 , and plate
B(640) having several PN diodes(620) to generate H_2O by
25 dropping down the temperature of exhaust gas resulted

from Sellen's effect.

Fig.9(a) shows a high-frequency voltage generator, wherein it comprises a firstly order coil applied with AC voltage, a transistor(T) to amplify signal, bias resistor(R7) to stabilize operation, a thirdly order coil applied with high voltage according to the turns ratio, a secondly order coil to modulate carrier having 50KHz-100KHz, a voltage multiplier circuit(D5), and capacitor(C5) to charge a thirdly order voltage.

Fig. 9(b) shows a voltage multiplier circuit(D5) in detail shown in Fig.9(a), which comprises a thirdly order coil to induce high voltage according to turns ratio, diode(D10,...,D80) to rectify AC voltage, high voltage is charged across capacitor(C5,...,C70).

And the equivalent circuit of a voltage multiplier circuit(D5) is shown.

Fig.10 shows the entire external form the present invention, which is housed with metal in order to cut off the outer impact and to prevent irradiating engine noise and electromagnetic waves caused by each unit. The outlet of the case is forwarded to the ground.

Finally, a union unit(700) in Fig.1 absorbs noise and shields electromagnetic waves, wherein it comprises a secondly order ferrite core to meet the regulations for noise absorber, EMI and EMC.

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The operation of the apparatus in the present invention will be explained in the followings.

10 Partition unit(100) takes exhaust gas pushed out from an engine and sends it to a plasma unit (200) fluently. In a partition unit(100), EHD(electro-hydro dynamics) method is applied between inhaling site(a-a) and exhaling site(b-b) to accelerate the flow of exhaust
15 gas and electrostatic method of Coulomb's force is used.

Exhaust gas mixed with air is inhaled into a partition unit(100), and the granular particles in exhaust gas are decomposed and ionized into negatively. The
20 negatively charged particles pass through a bottle-necked nozzle, where the speed of the gas accelerates by means of EHD method.

In addition, negatively charged particles accelerates much more by voltage difference between a ionpin(110)
25 and an attractor electrode(120) induced negatively, and

this phenomena prevent exhaust gas from staying or slowing down in the partition unit(100). We call the above process as EHD(electro-hydro dynamics) method.

Exhaust gas after passing through a nozzle is diffused
5 to a collector electrode(130), where the diffusion theory of waveguide is applied. That is, exhaust gas diffused after passing through the narrow space can spread widely without slowing down the speed. The negatively charged particles are attracted by
10 electrostatic force on the collector electrode(130) which is made of metal mesh and larger particles which can not pass through the collector electrode(130) of metal mesh(211) drop down into the manhole where one set of discharge poles(140, 140) are disposed to burn
15 up large particles.

While large particles in exhaust gas are eliminated by burning up in a manhole where small particles may pass through the collector electrode(130). It is preferred that a partition unit pole(170) has a round head in
20 shape to increase ignition energy.

The high speed of exhaust gas is helpful in preventing the collector electrode(130) filled up with small particles.

25 In a plasma unit(200), particles are burned by applying

plasma process, where plasma means that particles are divided into positive and negative particles, of which the amounts are the same, and therefore they show neutral state in total.

- 5 Small particles which can pass through the collector electrode(130) burn up in a plasma unit cell(250) by streamer corona generated between a plasma unit pole(210) applied with + voltage and mesh(211) applied with - voltage.
- 10 In the present invention, the streamer corona is generated by using a hemispheric plasma unit pole(210). By using a hemispheric plasma unit pole, a large amount of streamer corona can be generated.
- 15 When the high voltage is applied for a short time, particles in exhaust gas are charged and burned up by flame discharge which occurs between a plasma unit pole(210) and mesh(211).
- 20 In addition, particles oscillate due to property of attracting each other by electrostatic force and this prevents the meshed net(211) filled up with particles. Further, electrons oscillate in plasma state, and electron's oscillation frequency enhance the particles oscillation.
- 25 Oscillation frequency(f_k) is characterized by;

$$f_k = 8.9 \times 10^3 \sqrt{N}$$

, where N is electron density and oscillation frequency depends on air pressure.

5 In order to clean exhaust gas more efficiently, exhaust gas is conveyed to electron unit(300) after passing through plasma unit(200).

The air inlet hole(150) of hole plate(310) in plate set is composed of metal meshed net[211, not drawn in
10 Fig.5(a)] through which exhaust gas can flow freely, and metal meshed net(211) acts as discharge electrode. AC high voltage is impressed to pole plate(350) and hole plate(310) in order to generate streamer, corona to burn up minute particles. And oscillating AC voltage
15 prevents the metal meshed net[211, not drawn in Fig.5(a)] filled up with particles.

DC high voltage is impressed across hole-plate(310) and ionpin plate(320) to generate electric wind by ionpins(110) on the ionpin plate(320) which pushes
20 particles to hole plate(350) in order to enhance the efficiency of corona discharge between hole plate(310) and pole plate(350).

The above-mentioned process will be explained
25 systematically in the following.

The noxious materials in exhaust gas are nearly cleared by several steps, wherein large particles are first removed in partition unit(100), and then small particles passed through the partition unit(100) are
5 removed in plasma unit(200) by streamer corona, and then minute particles are eliminated in electron unit(300).

There are noxious chemical materials in exhaust gas,
10 and two different methods are used to remove noxious chemical materials in the present invention.

First, noxious materials are removed with negative ions generated by ionization unit(400). Ionization unit(400) which generates ultraviolet rays between
15 outer pipe(420) and opposite electrode(430), and this ultra-violet rays generate lots of negative ions.

While the general negative-ion generator has a pointed-end in order to produce negative ions, negative ion generator of the present invention has an ionization
20 cell(405) structure which has inner cylindrical wall dividing the space into two routes, that is, inner pipe(410) and outer pipe(420) in addition to the known form. By the above-mentioned ionization cell(405) structure, the negative ion generator of the present
25 invention emits more negative ions several thousand

times than the usual negative ion generator, while the noxious gases passing through at very high speed.

We call this method as plasma jet, where the appropriate distance between outer pipe(420) and
5 opposite electrode(430) should be maintained in order to generate negative ions in a large amount.

Corona is also generated at the pointed end of plasma jet, and its temperature is 800°C-1500°C.

The noxious material molecules are excited by ultra-
10 violet rays and the excited noxious materials combine negative ions and ozones to be changed into other materials. And in this process noxious positive ions are also removed.

15 In order to remove NOx which is not removed in the above-mentioned ionization unit(400), screen unit(600) is used in the present invention.

The screen unit(600) comprises ceramic plate A(630), ceramic plate C(650) and ceramic plate B(640) having
20 hexagonal holes(610) in which PN diodes(620) are disposed.

When 10K voltage is impressed to plates, ultra-violet rays are generated around hexagonal hole(610) in a large amount, and ultra-violet rays let O₂ be changed
25 into ozone.

Ozone is generated in a large amount when thickness of metal is $20\mu\text{m}$ - $30\mu\text{m}$

The impedance matching is important, since the printed metal may be separated from ceramic plate, if higher
5 voltage than 1KV is impressed for a long time.

Also the separation of the printed metal from ceramic plate can be prevented by scratching the ceramic plate.

Such an apparatus has been used for sterilization of
10 food or for generator of ozone, but it has been never used for eliminating of smoke.

In addition, PN diodes(620) mounted in hexagonal holes(610) of plate B(640) cause temperature dropping
15 by Sellen's effect to condense H_2O into water.

Ultra-violet rays are generated in a large amount when high voltage is impressed to the plate A(630) and plate C(650), and this ultra-violet rays make oxygen into ozone which renders NO_x into NO_3 which can be easily
20 solved in water.

During this process, the efficiency of removing NO_x will be enhanced by taking air into plates.

The method of dropping temperature by using PN diodes(620) is called as Sellen's effect and this
25 method has been used for refrigerator, but has never

been used for eliminating smoke.

In the present invention, PN diodes(620) are connected in serial and parallel to induce Sellen's effect.

5 The operating voltage is 0.7V.

Accordingly, the number of diode which is needed, N, is specified as;

$$10 \quad N = \frac{\text{DC voltage (V)}}{0.7V}$$

Most of noxious chemical gas in exhaust gases is removed in an ionization unit(400) and a NOx, which is not filtered in an ionization unit, is removed through
15 a screen unit(600).

Therefore, the granular ingredients and noxious chemical gas of exhaust gases are completely purified.

A high voltage generator with a high frequency
20 comprises by a high frequency oscillator and a high voltage rectifier with transformer.

The high voltage generator with a high frequency of this invention supplies positively and negatively polarized high voltage.

25 A high voltage generator in the present invention is different from the usual one in the point that it has

a special circuit which needs an isolation strength and a feedback circuit to shutdown a firstly order coil voltage, if a secondly order coil is abnormal.

5 This high voltage generator shown in FIG 9(a) comprises a transistor to amplify a modulated signal, a thirdly order coil to induce a high voltage, a secondly order coil to shutdown a firstly order coil voltage, when second orderly coil does not work well, a capacitor(C5)
10 to charge voltage, and a voltage multiplier circuit(D5) to multiply a voltage.

A voltage multiplier circuit(D5) is used to multiply voltage needed for the above-mentioned units(100, 200, 300, 400, 600), wherein E is a charged voltage across
15 a capacitor(C5), 2E is a charged voltage across a capacitor(C10), 3E is a charged voltage across a capacitor(C20), 4E is a charged voltage across a capacitor(C30), 5E is a charged voltage across a capacitor(C40), 6E is a charged voltage across a
20 capacitor(C50), 7E is a charged voltage across a capacitor(C60), 8E is a charged voltage across a capacitor(C70)

A ceramic resistor filter(R100) is used to prevent circuit breakdown, and to avoid dangerous situation
25 which are caused by the remained high voltage across

capacitor(C10,...,C70) in case of a thirdly order coil voltage "OFF".

As modulating a carrier(400KHz) and a signal(50KHz-100Hz) at a secondly order coil, a transistor outputs
5 specially high voltage without excessive current.

To reverse an output voltage polarity, the connection of diode(D10,...,D80) is reversed.

As E is a charged voltage across a capacitor(C5), discharge voltage(Vo)

$$10 \quad V_o = \frac{C_1 E}{C_1 + C_2} \left\{ 1 - e^{-\frac{C_1 + C_2}{C_1 + C_2 R_s}(t)} \right\}$$

15 This invention can contain a union unit(700), which comprises a mechanical-electric filter, to absorb engine noises and to shield electromagnetic waves to be radiated from corona discharge process.

20 Namely, this unit is used to meet the regulations of EMI, EMC specification of this inventive apparatus. By inserting ferrite cores into metal house and by winding wire around ferite cores, this unit(700) shields EMI and EMC.

25 To shield EMI, EMC effectively, a wide range L and C with resonant frequency is recommended.

As above-mentioned, this invention relates to a method

and an apparatus to clean exhaust gas of an internal
combustion engine, an external combustion engine and
anti-pollution equipments an so on. As this invention
can clean exhaust gas and reduce noises, it can be
5 substituted for a noise absorber, for example, the
muffler of automobiles.

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what is claimed is:

1. A method for cleaning exhaust gas by using high voltage field, which comprises:

- 5 (a) step 1, diffusing exhaust gas at high speed by using the bottle-necked attractor electrode(120) and burning up the partitioned large particles with corona discharge;
- 10 (b) step 2, burning minute particles which are not removed through step 1 under plasma atmosphere;
- (c) step 3, burning gaseous particles by using AC voltage and DC voltage;
- (d) step 4, removing noxious gas by using lots of negative ions; and
- 15 (e) step 5, oxidizing NOx with ozone generated by ultraviolet ray and removing NOx by dissolving in H₂O generated from heat exchanging method by PN diodes.

20 2. A method for partitioning exhaust gas by using high voltage field, which comprises;

- (a) ionizing particles and air by using electric discharge;
- (b) diffusing the ionized particles and air to the
- 25 collector electrode(130) at high speed by using



the bottle-necked attractor electrode(120);

(c) partitioning particles, wherein small particles pass through collector electrode(130) and large particles drop down to deposited in the manhole;

5 and

(d) burning up large particles with electric discharge.

3. A method for burning up particles in exhaust gas by using high voltage field, characterized in that
10 particles in the plasma state are burned up by using oscillatory corona discharge;

4. A method for burning up particles as in Claim 3, characterized in that corona discharge is a streamer
15 corona having a large discharging area.

5. A method for burning up minute charged particles in exhaust gas by using high voltage field, which comprises;

20 (a) burning up charged minute particles by using corona discharge generated by AC voltage; and

(b) burning again minute particles which are not burned up in the step(a) by using DC voltage.

25 6. A method for burning up charged particles as in



Claim 5, characterized in that corona discharge is a streamer corona having a large discharging area.

7. A method for neutralizing noxious gas in exhaust gas by using plasma jet which comprises;
(a) generating lots of negative ions; and
(b) decomposing noxious gas by using negative ions.

8. A method for neutralizing noxious gas as in Claim 7, wherein a sharp pointed-end plasma jet generating negative ions comprises a cylindrical inner pipe and a cylindrical outer pipe divided by cylindrical wall.

9. A method for removing NOx in exhaust gas by using high voltage field, which comprises;
(a) generating ultraviolet rays,
(b) oxidizing NOx with ultraviolet rays; and
(c) dissolving oxidized NOx in H₂O which is generate by using heat exchanging method of PN diodes..

10. A method for removing NOx as in Claim 9, wherein a step of generating ultraviolet rays by using a plurality of multi-holed plates comprises;
(a) printing electrode circuit pattern with metal on



the plate;

(b) printing electrode circuit pattern on opposite electrode in the same way; and

(c) supplying high voltage to each electrode for
5 generating ultraviolet rays

11. A method for removing NOx as in Claim 9 wherein each plate has lots of polygonal holes for generating ultraviolet ray effectively.

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12. A method for removing NOx as in Claim 10 or Claim 11, wherein electrode circuit pattern on the plate is printed with metal of which thickness is 10 μ m - 50 μ m.

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13. A method for removing NOx as in Claim 9, wherein heat exchanging method for condensing H₂O is induced by arranging PN diodes in serial or in parallel between plate and plate.

20

14. A method for removing NOx as in Claim 11, wherein ultraviolet rays are generated from hexagonal holes when supplying power to plates.

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15. A method for generating high voltage for



cleaning exhaust gas, wherein a signal is modulated by
a carrier

16. A method for generating high voltage as in
5 Claim 15, wherein a signal is modulated by a carrier of
400KHz-500KHz.

17. Apparatus for cleaning exhaust gas by using
high voltage field, which comprises;

- 10 (a) partition unit(100), which takes exhaust gas into
and then diffuses to the collector electrode(130)
where particles are partitioned, and burns up
large particles with corona discharge; ,
- (b) plasma unit(200), which burns minute particles
15 which pass through partition unit(100) by using
steamer corona;
- (c) electron unit(300), which burns gaseous particles
by using AC voltage and DC voltage
- (d) ionization unit(400), which removes noxious gas by
20 using negative ions; and
- (e) screen unit(600), which oxidizes NOx with ozone
generated by ultraviolet ray and removes NOx by
dissolving in H₂O generated by temperature
dropping induced by PN diodes.



18. Apparatus for cleaning exhaust gas Claim 17,
comprises further union unit(700) in addition to said
units (100, 200, 300, 400, 600), wherein union
unit(700) shields electromagnetic wave and reduces
5 noise.

19. Apparatus for partitioning exhaust gas by
using high voltage field, which comprises;
(a) ionpin(110) ionizing particles with high voltage to
10 remove particles;
(b) partition unit guide(160) to make the smooth flow
of exhaust gas;
(c) partition unit plate(180) mounted a plurality of
air inlet holes(150) to make the smooth flow of
15 air;
(d) attractor electrode(120) to supply voltage to the
bottle-necked nozzle where the flow of exhaust gas
accelerates;
(e) collector electrode(130) filtering particles; and
20 (f) partition unit pole(170) mounted with discharge
electrodes (140, 140) to burn up large particles
dropped in the manhole.

20. Apparatus for partitioning exhaust gas as in
25 Claim 19, wherein nozzle part acts as electrode in



whole tube.

21. Apparatus for partitioning exhaust gas as in
Claim 19, wherein said partition union pole(170) is in
5 the shape of sphere to enhance ignition of particles.

22. Apparatus for burning up particles in exhaust
gas composed of plasma unit(200) which contains a
plurality of plasma unit cells(250), wherein a plasma
10 unit cell comprises

(a) plasma unit pole(210) to generate streamer corona;
and

(b) meshed net(211) to act as discharge electrode.

15 23. Apparatus for burning up particles as in Claim
22, wherein streamer corona occurs between said plasma
unit pole(210) and said meshed net(211).

24. Apparatus for burning up particle as in Claim
20 22 or Claim 23, said plasma unit pole(210) is formed in
hemisphere which one side is flat to cause streamer
corona.

25. Apparatus for burning up particles as in Claim
25 22 or Claim 23, electron density between plasma poles



is $10^3 - 10^5/\text{cm}^3$.

26. Apparatus for burning up particle as in Claim 22, or Claim 23, the number of oscillation across
5 plasma poles is 10MHz.

27. Apparatus for burning up charged particles composed of electron unit(300) which contains a plurality of sets, wherein one set comprises
10 (a) ionpin plate(320) having air inlet hole(150) having mounted with ionpins(110) to generate electric wind;
(b) hole plate(310) having air inlet hole(150) mounted with meshed net(211) which acts as opposite
15 electrode; and
(c) pole plate(350) mounted with plasma unit poles(210) generating streamer corona

28. Apparatus for burning up charged particles as
20 in Claim 27, wherein said ion pin plate(320) is as matrix structure which comprises;
(a) ion pin(110) to generate electric wind; and
(b) air inlet hole(150) for smooth air flow.

25 29. Apparatus for burning up charged particles as



in Claim 27, said hole plate(310) is formed with a number of air inlet holes(150) in which have meshed net for smooth air flow.

5 30. Apparatus for neutralizing noxious gas in exhaust gas composed of ionization unit, which comprises ionization unit cells(405) generating negative ions and ultraviolet rays by plasma jet formed as cylindrical outer pipe(420) and cylindrical inner
10 pipe(410) with a sharp pointed-end.

 31. Apparatus for neutralizing noxious gas as in Claim 30, said ionization unit(400) comprises;
 (a) cell plate(409) mounted ionization cell(405) as
15 matrix form; and
 (b) hole plate(310) having air inlet hole(150) in which meshed net is cross-sectionally mounted.

 32. Apparatus for removing NOx, wherein plate
20 B(640) arranged with PN diodes(620) to drop temperature are mounted between plate A(630) and plate C(650).

 33. Apparatus for removing NOx as in Claim 32, wherein said plate A(630) and plate C(650) used as an
25 electrode have a lot of hexagonal holes(610).



34. Apparatus for removing NOx as in Claim 32, wherein said PN diodes(620) are connected in a serial or parallel to induce temperature dropping called as Sellen's effect

5

35. Apparatus for generating high voltage to supply high voltage to said partition unit(100), plasma unit(200), electron unit(300), ionization unit(400) and screen unit(600)

- 10 (a) transistor(TR) to amplify signal;
(b) a firstly order coil supplied with high voltage;
(c) a thirdly order coil generating high voltage according to turn ratio;
(d) ceramic resistant filter(R100) to discharge the
15 remained voltage at a thirdly order coil when the switch is off.
(e) feedback circuit connecting a secondly order coil and the base of transistor.

- 20 36. Apparatus for generating high voltage as in Claim 35, wherein said high voltage generator comprises further voltage multiplier circuit(D5) to multiply a thirdly order voltage and capacitor(C5) to charge a thirdly order voltage

25



37. Apparatus for removing noise and electromagnetic wave composed of union unit(700), wherein the outer part is formed as ferrite core for shielding electromagnetic wave and electric field in the air.

38. Apparatus for removing noise and electromagnetic wave as in Claim 37, wherein said ferrite core is connected in 2 stages serially, the first stage is operated in positive magnetic field and the second stage is operated in negative magnetic field.

39. Apparatus for absorbing noise by using high voltage field, which comprises;

- (a) partition unit(100), which takes exhaust gas into and then diffuses to the collector electrode(130) where particles are partitioned, and burns up large particles with corona discharge;
- (b) plasma unit(200), which burns minute particles which pass through partition unit(100) by using steamer corona;
- (c) electron unit(300), which burns gaseous particles by using AC voltage and DC voltage
- (d) ionization unit(400), which removes noxious gas by



using negative ions; and

(e) screen unit(600), which oxidizes NOx with ozone generated by ultraviolet ray and removes NOx by dissolving in H₂O generated by temperature dropping induced by PN diodes.

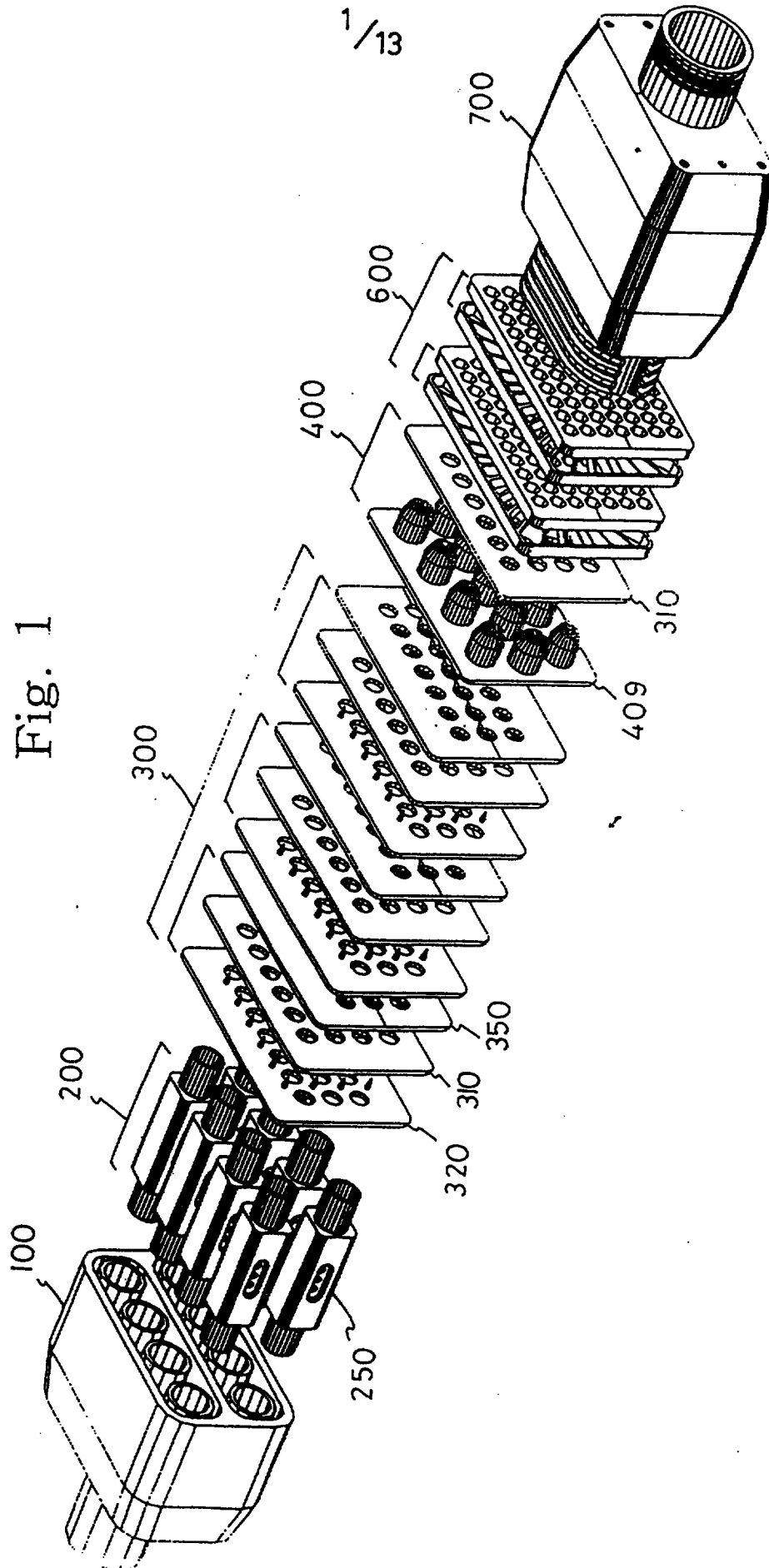
(f) union unit(700) which shields electromagnetic waves and reduces noise.

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Fig. 2(a)

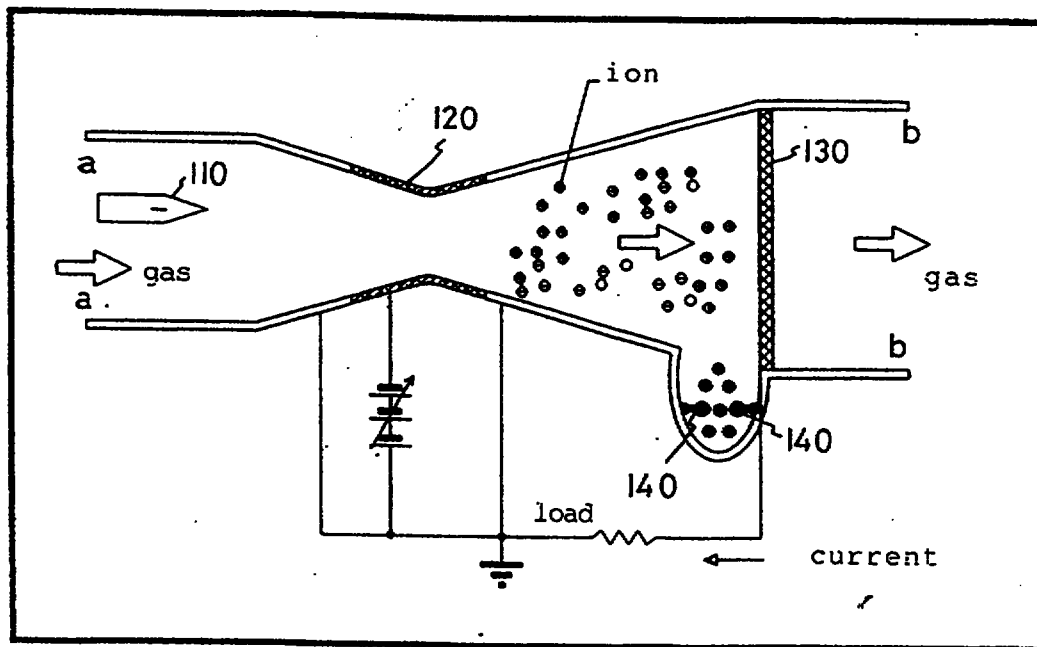


Fig. 2(b)

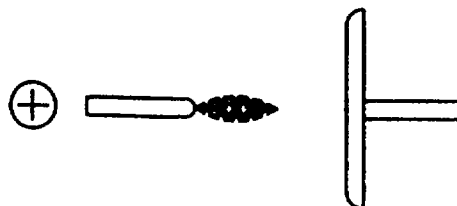
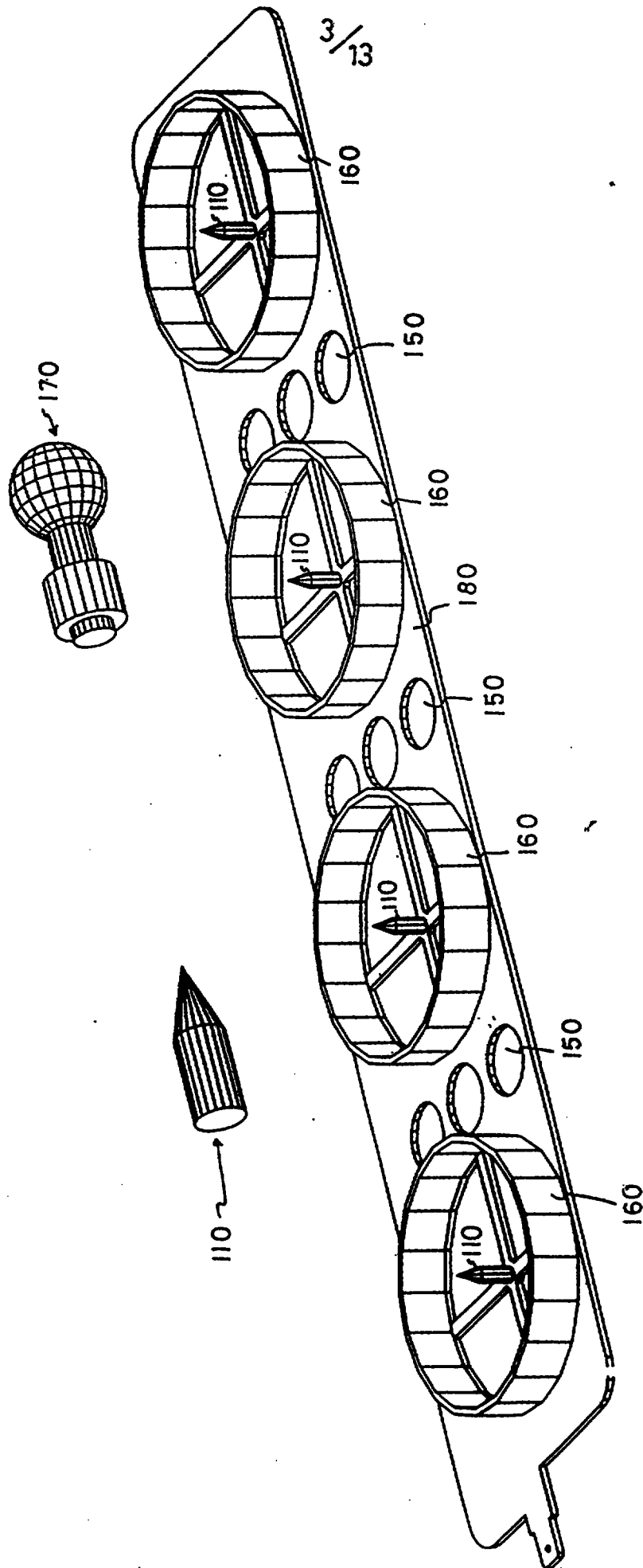
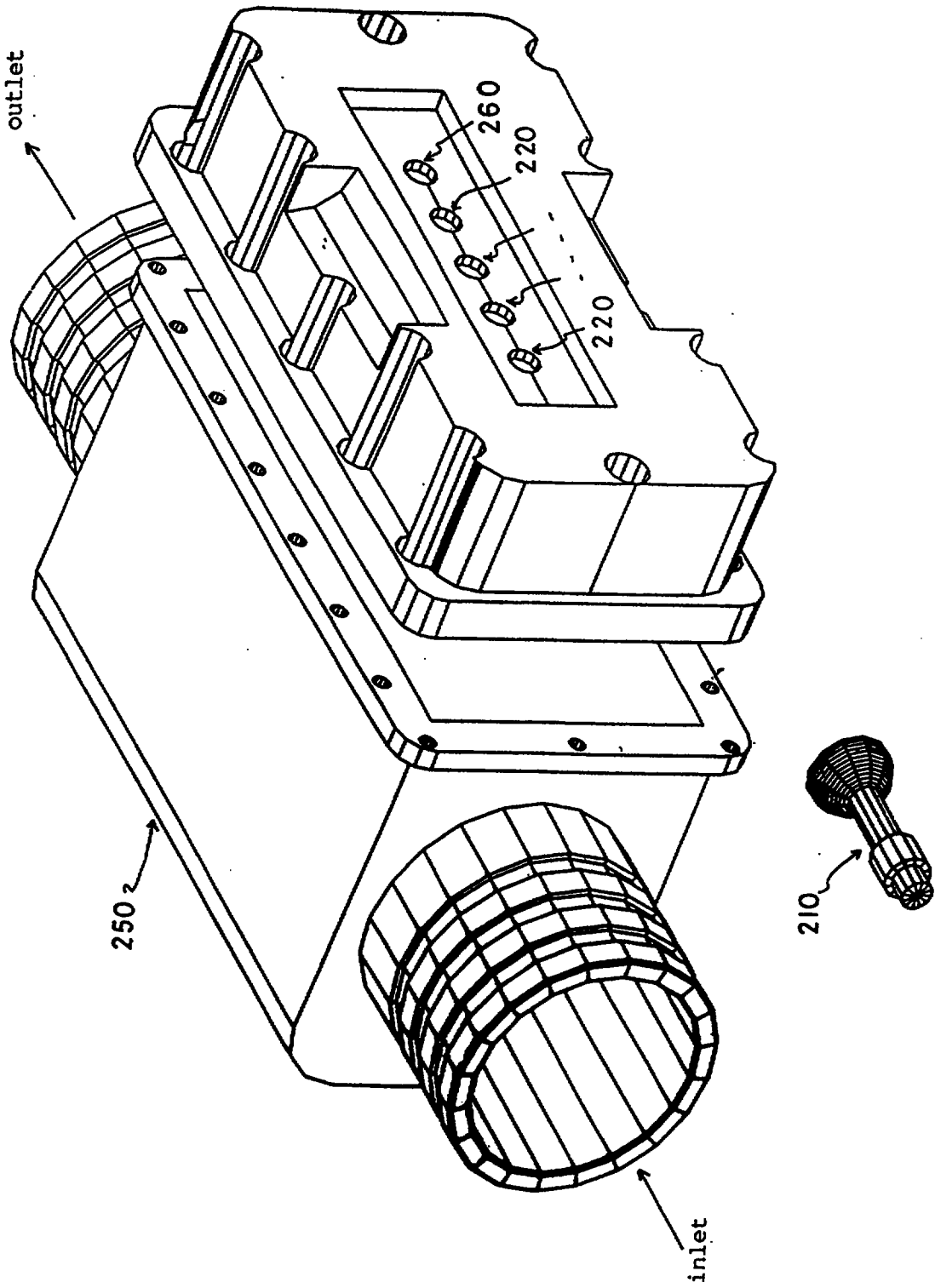


Fig. 3



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Fig. 4(a)



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Fig. 4(b)

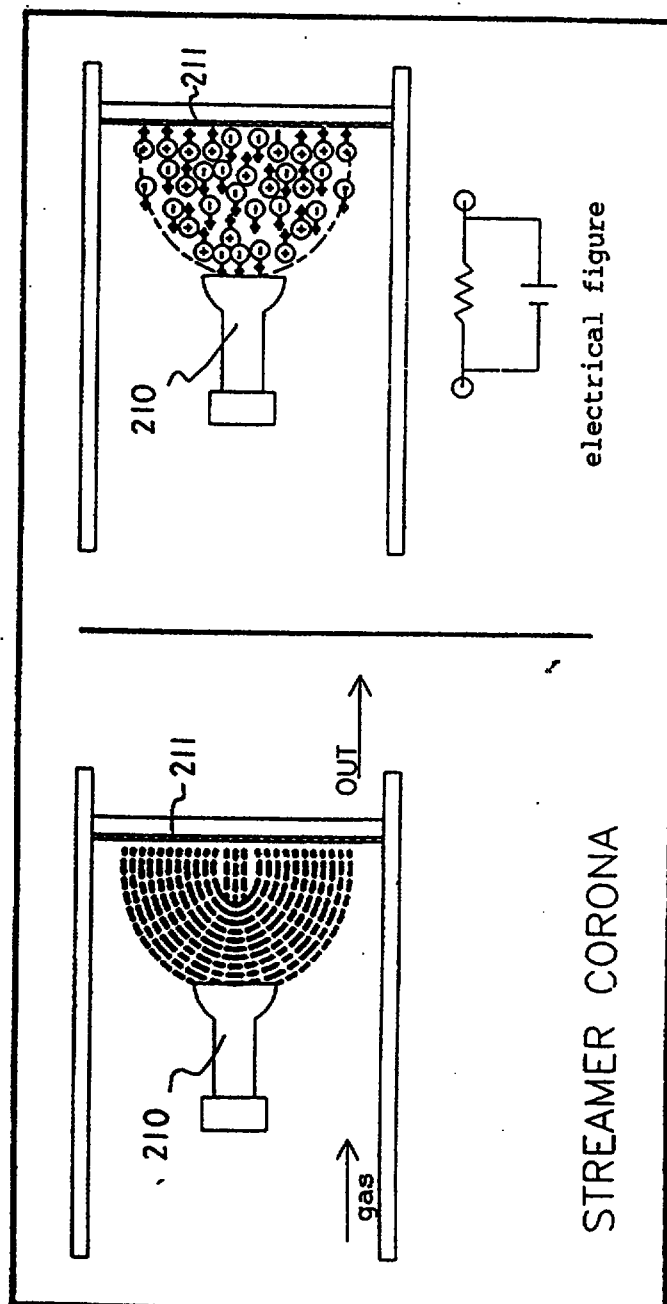
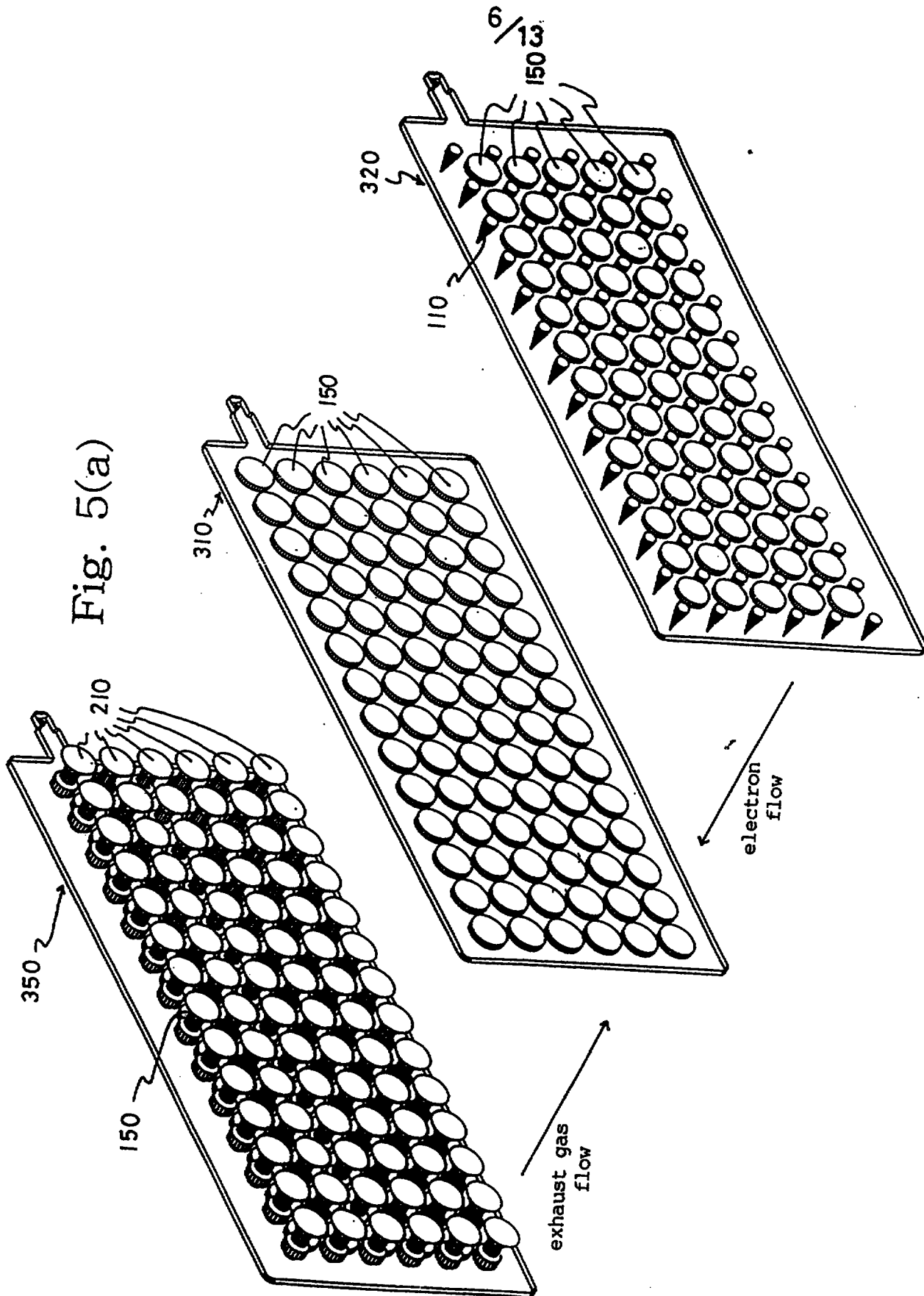


Fig. 5(a)



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Fig. 5(b)

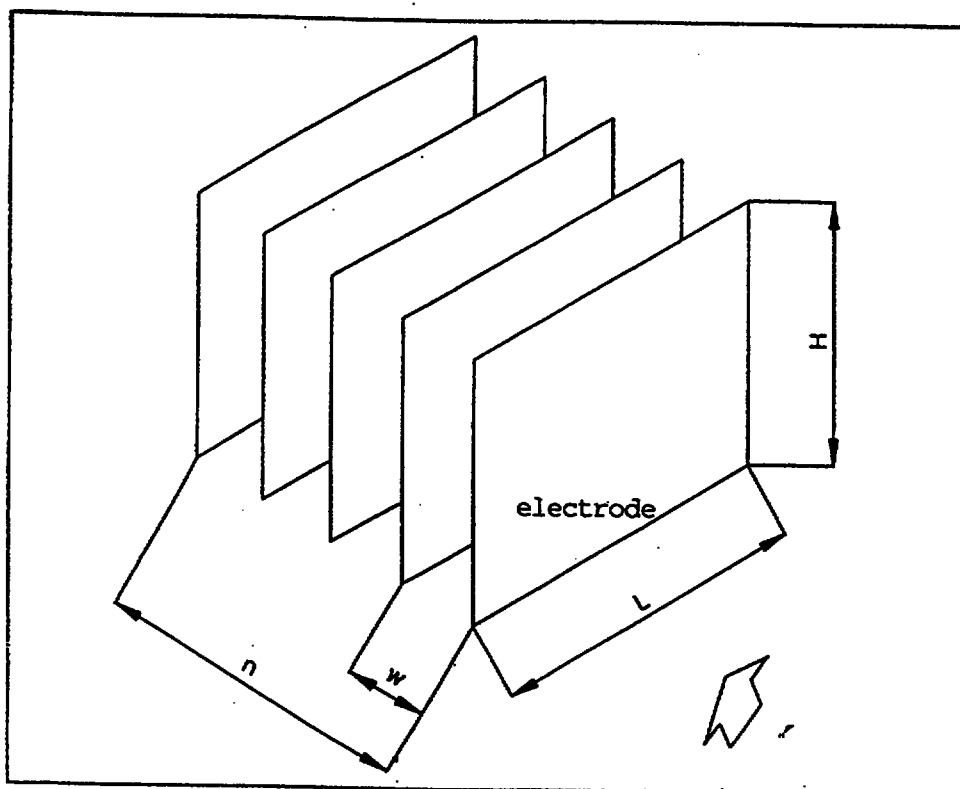
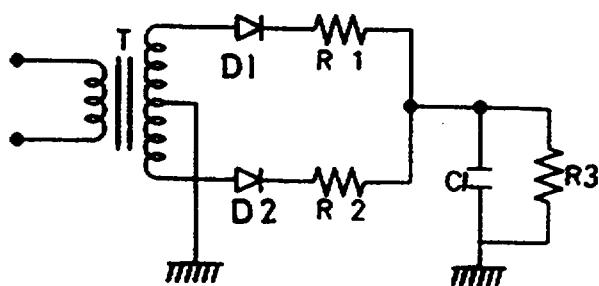


Fig. 5(c)



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Fig. 5(d)

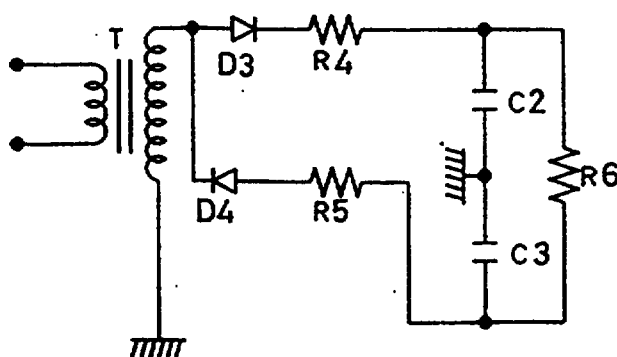
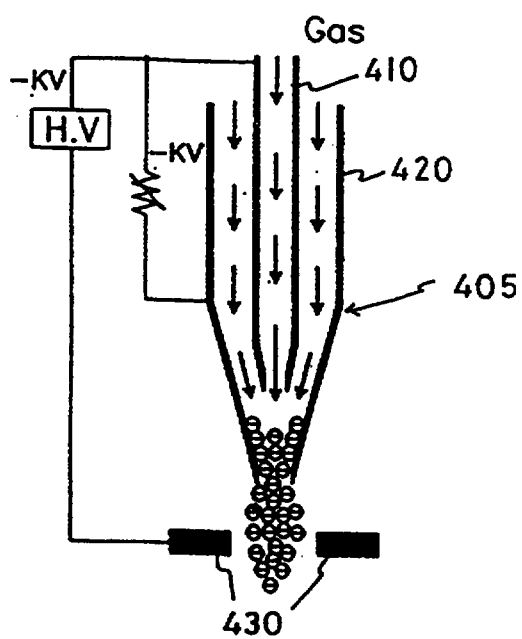
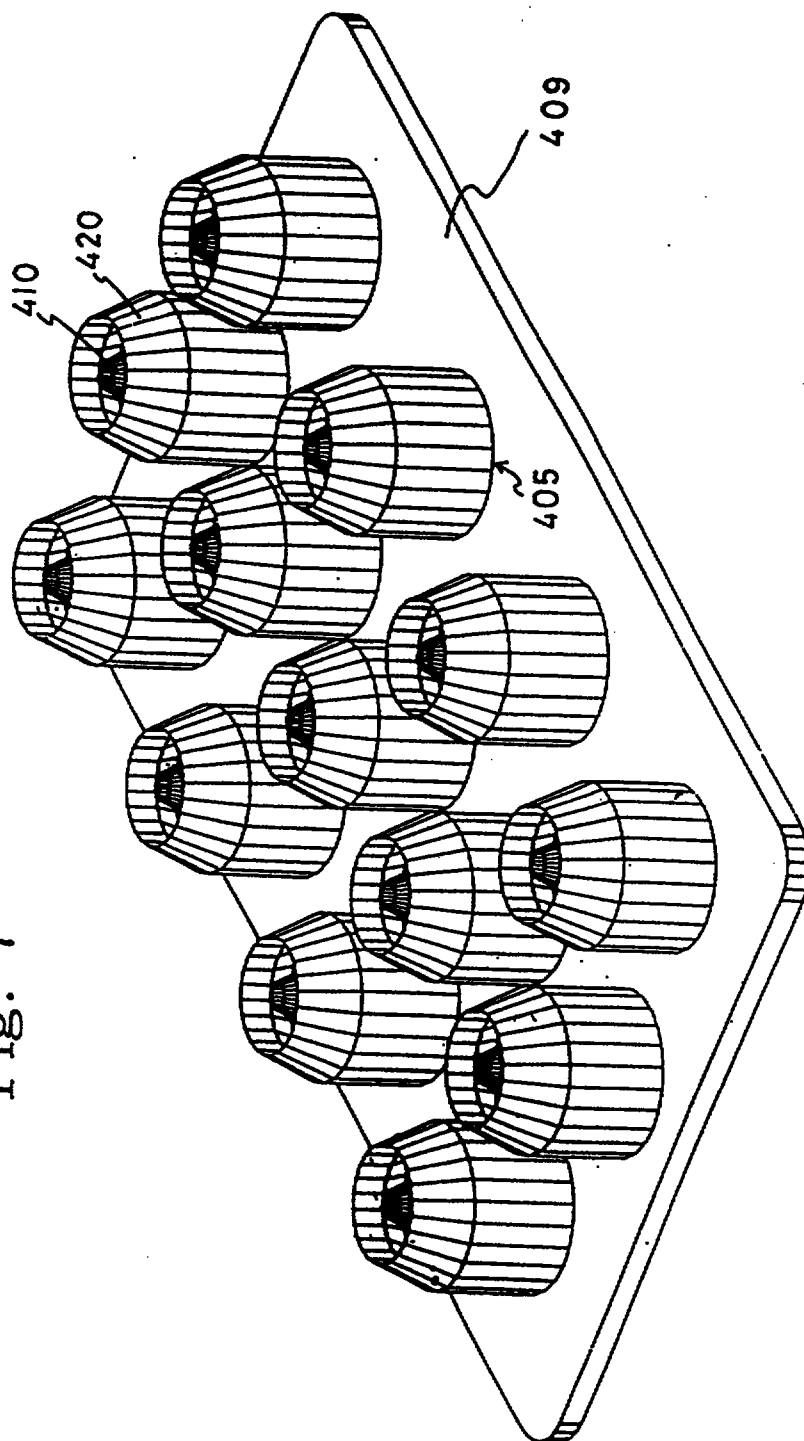


Fig. 6



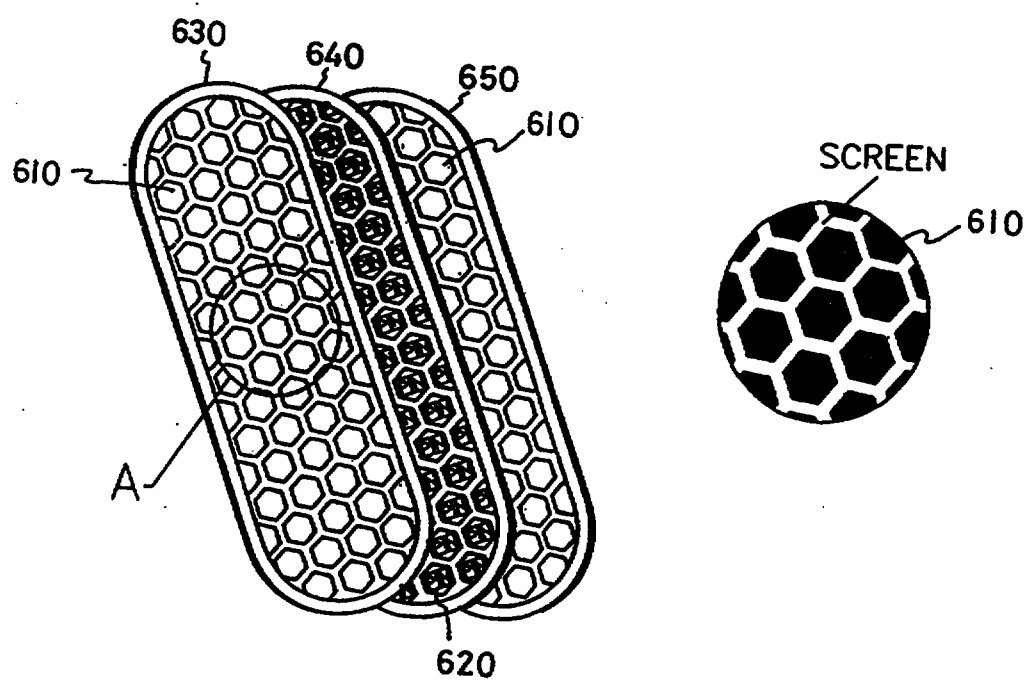
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Fig. 7



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Fig. 8



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Fig. 9(a)

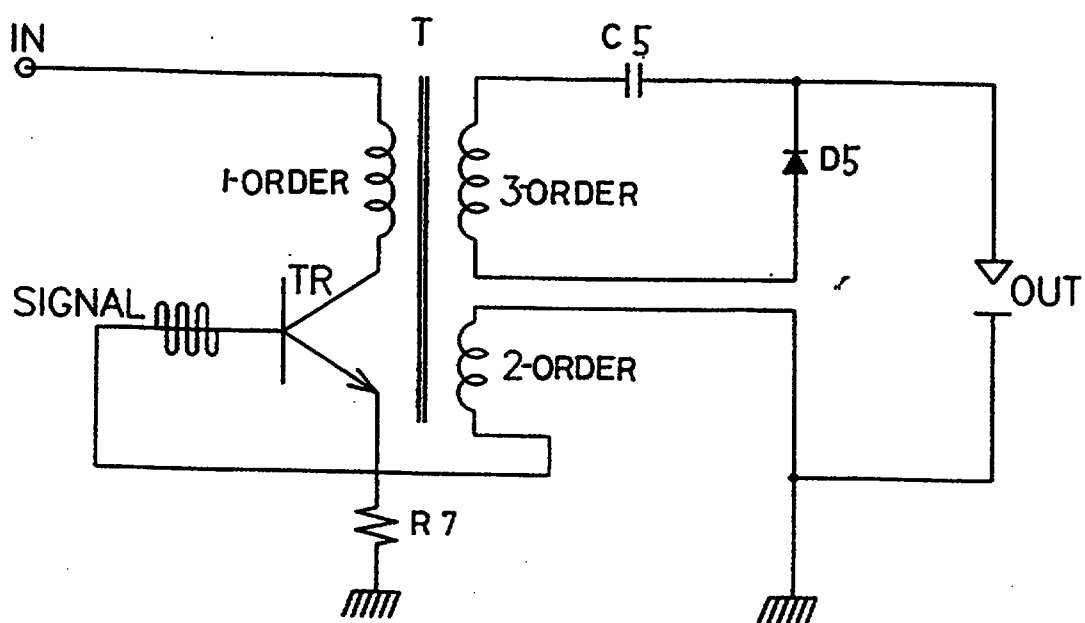
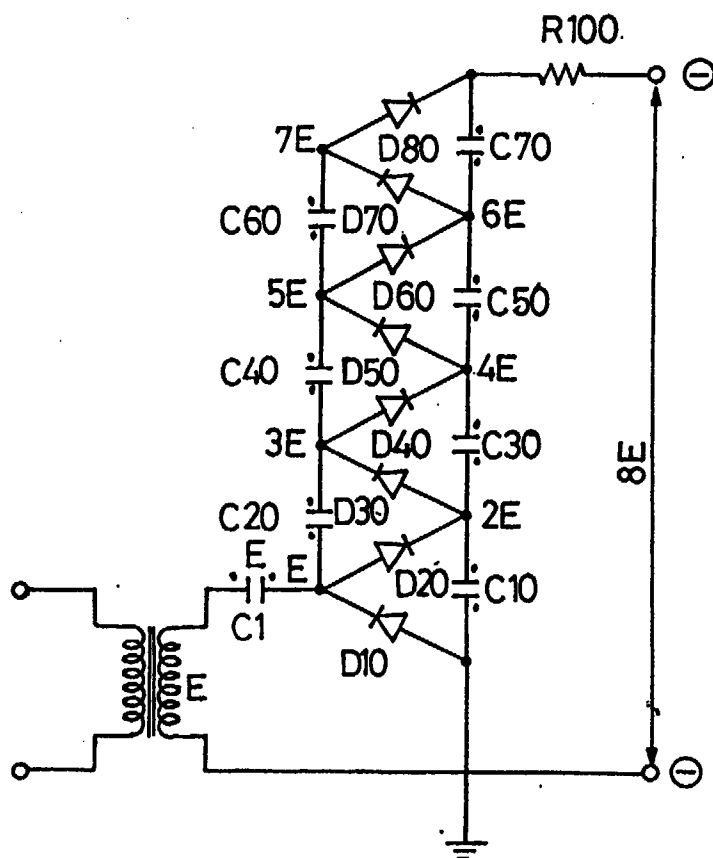
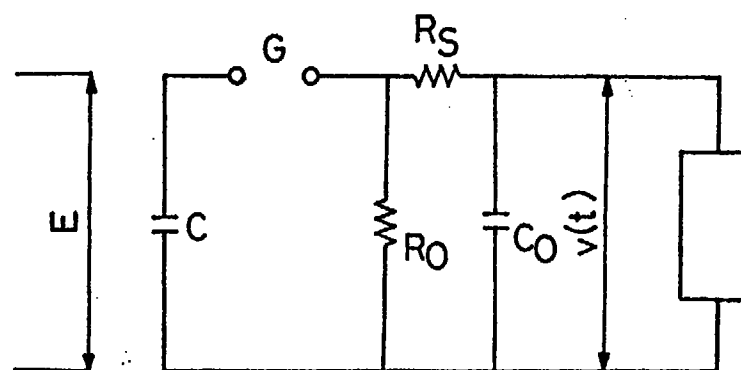


Fig. 9(b)



voltage multiplier circuit

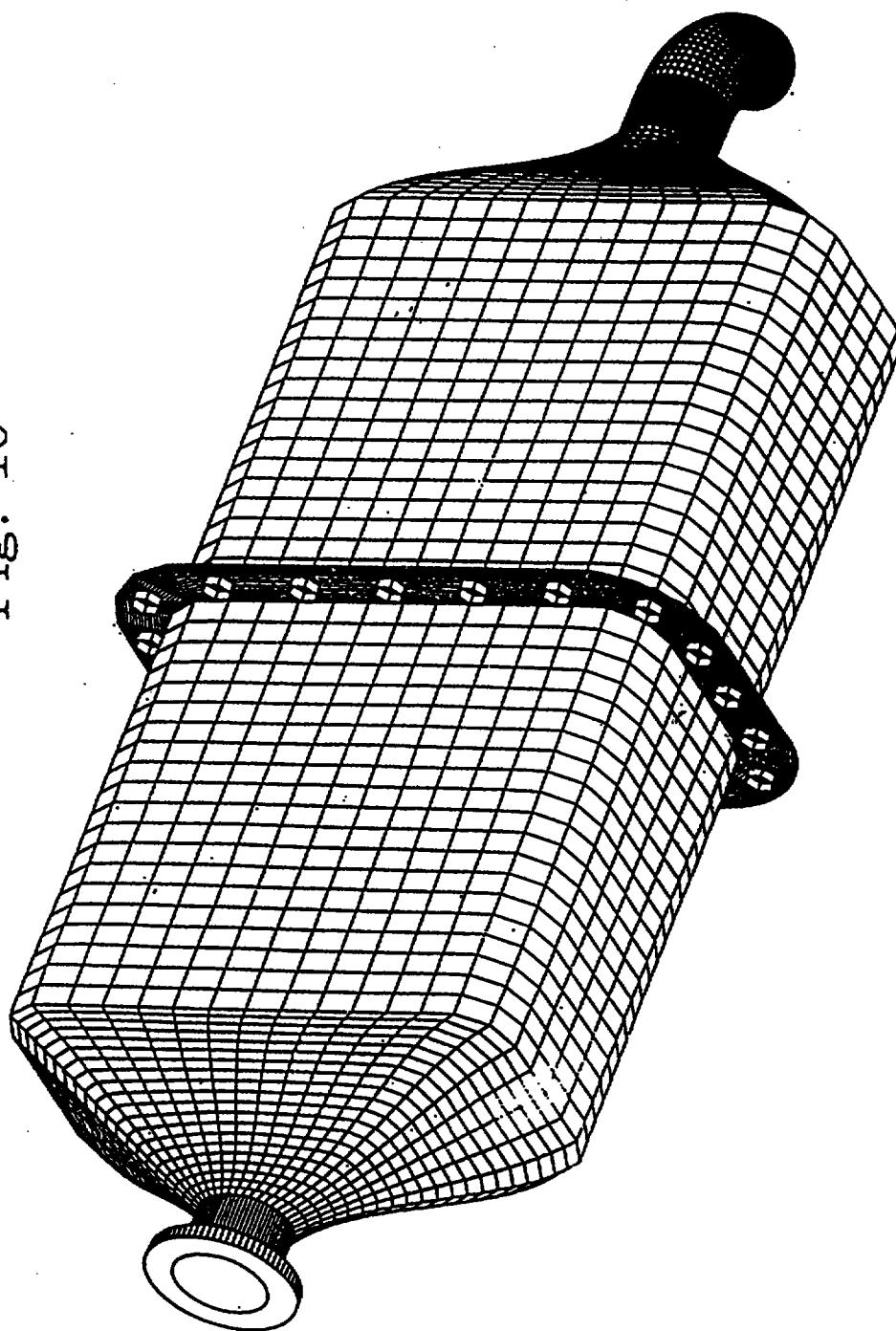


equivalent circuit

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Fig. 10





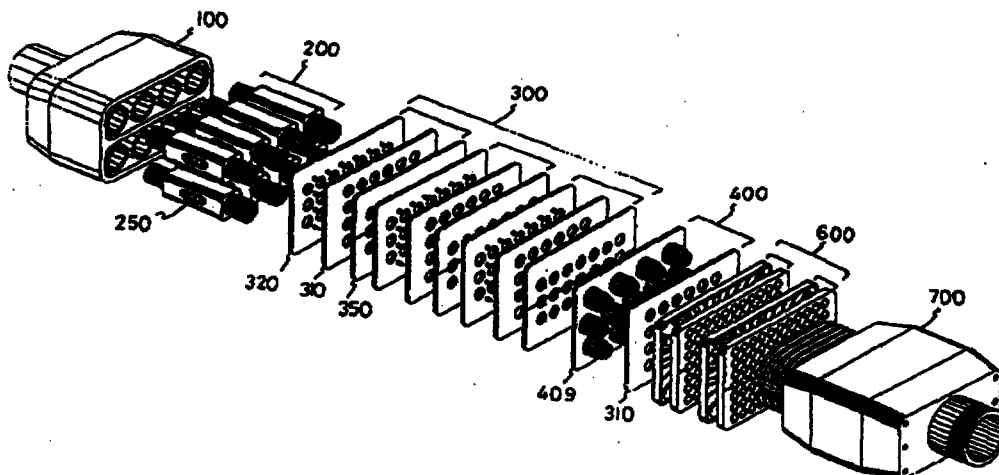
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/KR96/00007 (22) International Filing Date: 19 January 1996 (19.01.96) (30) Priority Data: 1995/61243 28 December 1995 (28.12.95) KR (71) Applicants (for all designated States except US): HYUNDAI PRECISION & IND. CO., LTD. [KR/KR]; 140-2, Gye-dong, Chongro-ku, Seoul 110-270 (KR). SEONDO ELECTRIC CO., LTD. [KR/KR]; 734 Wonsi-dong, Ansan-si, Kyungki-do 425-020 (KR). (72) Inventors; and (75) Inventors/Applicants (for US only): PARK, Chan, Ho [KR/KR]; 268-20 Sukchon-dong, Songpa-ku, Seoul 138-190 (KR). LEE, Yong, Hee [KR/KR]; 206-509, Dong-myung Apartment, Sunbu-dong, Ansan-si, Kungki-do 425-140 (KR). (74) Agent: LEE, Won, Hee; Chunwoo Building, 5th floor, 736, Yoksam-dong, Kangnam-ku, Seoul 135-080 (KR).	(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AZ, BY, KG, KZ, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published With international search report.	

(54) Title: METHOD AND APPARATUS FOR CLEANING EXHAUST GAS AND REDUCING NOISE BY USING HIGH VOLTAGE ELECTRIC FIELD



(57) Abstract

A method and an apparatus for cleaning smoke and reducing noises of an internal combustion engine or external combustion engine by using high voltage field. The present invention relates to a method and an apparatus which can clean exhaust gases and reduce noises, wherein it comprises the step of burning up the granular particles with corona discharge after changing particles into plasma state, the step of removing gaseous materials with negative ions, the step of eliminating NO_x with ultraviolet rays and the step of reducing noises.