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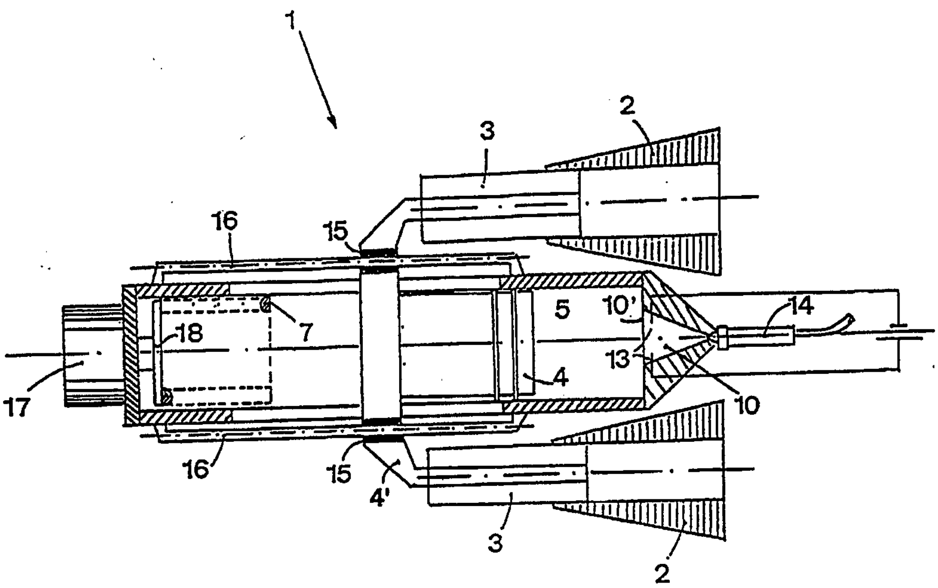

(57) Abstract

In an autogenous generator (1) in which electrical energy is generated by a linkage between fixed windings (2) and permanent magnets which move integrally on the alternating motion of one or more pistons of a two-stroke internal combustion engine, the cylinders (5) coupled to the pistons (4) have a conical precombustion chamber (10) opening towards the cylinders (5), the engine runs with variable compression strokes, and the magnets (3) and windings (2) are designed such that the ratio between the quantities of mechanical energy used to generate electrical energy for two different strokes of the magnets (3) is equal to the ratio between the two compression ratios obtained in the cylinders (5) in relation to the two different strokes performed by the pistons (4) integral with the said magnets (3) multiplied by the ratio between the two overall efficiency values of the engine in relation to the said compression ratios.

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Linear electrical energy generator

This claim concerns the autogenous electrical energy generator sector, and more particularly generators in which the mechanical energy supplied by the alternating movement of pistons in an internal combustion engine without crankshaft is transformed into an electrical current by the interaction of permanent magnets, integral with the aforesaid pistons when moving, with fixed windings which are immersed cyclically when in motion in the magnetic field linked to the said magnets.

This type of generator is obviously suitable for the production of electrical current which can then be used either directly, for example for lighting or heating, as well as indirectly to supply electric motors that can be used for different types of locomotion on land or water or in the air or for other applications.

However the generator is used, it is required to provide good performance in terms of output and adjustment with minimum environmental and noise pollution.

Examples already known of this type of generator have considerable limitations in terms of the requirements mentioned above. A significant example is given in the generator covered by patent application GB 2 219 671A. With this generator as well, the production of electrical energy is achieved by means of the alternating motion of magnets with respect to fixed windings, with magnets integral, when moving, with the pistons of an internal combustion engine without crankshaft, but in terms of arrangement of parts, and the design of these, it differs substantially from that described below: the magnets oscillate when moving with respect to a fixed point which lies essentially on the median transverse section plane of the system comprising the windings, and in addition the fixed windings can also be used alternatively to produce electrical energy that car. be utilised outside the generator or to consume electrical energy to eject the aforesaid magnets to enable the return travel of compression of the pistón. It is clear, therefore, that the dimensions of the device, in line with the energy supplied, is much greater than that needed for a generator as per this invention, in which, as will be seen below, electrical energy is produced both when the magnets enter the windings and when these return in the opposite direction, and in which start-up and regulation of the system can be done simply by modifying the amount of fuel per cycle.

General regulation of the device in the GB patent, however, both in the internal combustion part and the electromagnetic part, is extremely complicated and expensive to achieve as the pressure and amount of air admitted, quantity of fuel, and characteristic values correlated to the current circulating in the windings (impedance, resistance, direction, etc.) have to be controlled electronically, cycle by cycle.

Regulation of the quantity of air admitted, for example, which in the case of petrol combustion has to be calibrated approximately by stoichiometric measurement for both 2 stroke and 4 stroke, should be carried out independently of the above electrical values, acting on the admission of petrol and the air admission shut-off valves. The electrical values in question should then be adjusted in turn, cycle by cycle, in accordance with the effects of the initial adjustment just described. This means that a proper computer facility has to be available to store and interpolate a large volume of data, which makes the equipment both costly and sensitive.

The quantities of electrical energy and the voltage generated in the various cycles, which in fact largely depend on the magnet oscillation frequency, are not directly or automatically proportional to the amount of mechanical energy produced by the engine as the compression stroke changes. This generally means using a sizable battery of accumulators interposed between the internal combustion part, which charges them, and the electric motors which are then supplied by the accumulator batteries.

The functional layout of the I.C. engine, apart from the absence of a crankshaft, is essentially conventional in type, and hence the aim is to achieve good overall efficiency by maximising the energy per cycle to obtain the high temperatures and pressures required.

Whilst this is understandable strictly from the point of view of energy alone, it is not so with regard to pollution in that it is virtually impossible to prevent the formation of toxic compounds such as nitrous oxide and carbon monoxide as the system runs as stated on an essentially stoichiometric mixture at high temperatures inside the cylinder.

Another similar example of a linear generator consists of a Jarrett engine in which, whilst control of the "return" of the piston under compression by means of electric current presents less of a problem, there are all the other aforementioned disadvantages, plus the fact that, in order not to further increase losses that are already high, fresh air for the cycle is admitted into the cylinder by acoustic resonance, which can only be achieved within a restricted cycle frequency range, and which entails this type of engine being started virtually electrically and then used with a largely fixed, very high compression ratio of the order of 26 : 1, which means that it is only really suitable for use with naphtha as a fuel and for operation at very high fixed speeds, with the need to disperse some of the heat by cooling, and problems with particulates, etc.

The inventor of the present invention came to the conclusion that in order to simultaneously resolve the problems of product pollution, design complications, the need to use intermediate accumulator batteries, the poor regulation capability and low efficiency, a generator was needed in which the electromagnetic part and the internal combustion part would together form a functional unit, obviously fully integrated in itself, so that movement with variable piston strokes would result in the quantity of mechanical energy produced by the internal combustion part corresponding exactly to the quantity of energy absorbed by the electromagnetic part to produce electric current, for any stroke, due to the law of thermodynamics, combustion of gases and electromagnetism.

Based on this concept, using one or more precombustion chambers in addition to the actual cylinders, an ultra-simple unit was achieved that could be controlled electronically, primarily by controlling only the quantity of fuel admitted in one cycle and the end of compression position of the piston or pistons. All this was achieved, as will be described in further detail below, at very low maximum, medium and minimum temperatures of the employed thermodynamic cycles (about half that of the usual values for an I.C. engine), and hence virtually zero pollution, and with very high overall efficiency of the internal combustion part at all operation speeds.

Based on the above, the inventor devised the subject of this application for patent, which in fact concerns an autogenous electrical energy generator in which energy generation is achieved by a linkage between fixed windings and one or more permanent magnets which move integrally on the alternating motion of one or more pistons of a two-stroke internal combustion engine, characterised by the fact that the internal combustion engine cylinders coupled to the pistons have at least one precombustion chamber with a base which opens towards the cylinders and in which, under any of the engine's running conditions, at least part of the volume of air contained in it mixes with an approximately stoichiometric quantity of fuel, the engine itself running with variable compression strokes, and the ratio between the two quantities of mechanical energy used to generate electrical energy when stationary corresponding to any two different complete expansion and compression strokes of the said pistons being substantially equal, when the said part of the volume of air is constant, to the ratio between the two compression ratios obtained in the precombustion chambers and relative cylinders due to the effect of the aforesaid two different strokes of the said pistons multiplied by the ratio between the two overall efficiency values of the I.C. engine corresponding to the said compression ratios, each piston completing one expansion stroke due to combustion and expansion in the cylinder, and one compression stroke due to the effect of the action of a component to return mechanical energy.

The advantages mentioned earlier will become evident in the detailed description of the generator given below, with reference to the attached drawings, as follows:

- Fig. 1 is a longitudinal schematic section of one example of construction of a single cylinder two-stroke generator as per the invention.

- Fig. 2 is a longitudinal schematic section of another form of construction with two pistons facing each other and a single communal combustion chamber;

- Fig. 3 shows a schematic plan view of a generator as per the invention equipped with four pistons in pairs integral with two combustion chambers;

- Fig. 4 contains a longitudinal section of a guide construction layout of the magnets and fixed windings;

- Fig. 5 contains a diagram of petrol combustion rate as a function of the air/petrol weight ratio of the mixture;

- Fig. 6 shows a longitudinal section of an example of construction with a single cylinder equipped with auxiliary pistons for scavenging;

- Fig. 7 is a curve of the overall efficiency of the internal combustion engine of a generator as per the invention;

- Fig. 8 is the curve of its specific consumption;

- Fig. 9 shows a type of precombustion chamber of a truncated cone in shape with two injector nozzles.

Figure 1 shows a generator in which the magnets 3 and fixed windings 2 are positioned such that there is a reduction in their linkage as the expansion stroke of piston 4 progresses but an increase as the compression stroke of the said piston 4 progresses. Other constructions are, however, possible in which the parts are assembled such that the opposite occurs, i.e. in which the linkage between the magnets 3 and the windings 2 increases as the expansion stroke progresses and vice versa.

The generator consists of a cylinder 5 in which a piston 4 runs (Fig. 1) with two identical systems of magnets 3 arranged symmetrically with respect to the cylinder axis integral with it by means of a fork 4'. These magnets 3 are immersed in cycles in the compression and expansion strokes performed by the piston 4, this immersion varying in degree depending on the length of the said stroke, within two systems of fixed windings 2, which are likewise identical and symmetrical.
As the compression stroke progresses, as stated, the linkage between the magnets 3 and associated windings 2 increases, and conversely reduces in line with progress of the expansion stroke.

Movement of the piston 4 is caused in one direction by expansion of the compressed gas combined with the effect of fuel combustion, and in the other direction by the action of a system designed to return the mechanical energy, for example one or more torsion springs or another system, including electromagnetic systems of a known type which use electrical energy to return mechanical energy to the piston, with the example of the types of generator already known and referred to above, even if the latter system is more complex and expensive.

The fuel is admitted via an injector nozzle 14, atomised so that it saturates, approximately stoichiometrically, at least part of the volume of air contained in a precombustion chamber 10 that is substantially conical in shape with a base 10' which opens towards the cylinder 5.

The piston/magnet assembly is supported by two rolling (or sliding) friction systems 15, 16 which may be fixed to the body of the said cylinder 5, and which enable it to perform strokes as described above with minimum mechanical losses.

Looking at the same Figure 1, in which the generator concerned 1 with 2-stroke engine is shown in the inactive position, it is easy to describe its operation: to start up, all that is required is to inject a preset quantity of duly atomised fuel into the precombustion chamber 10 and the cylinder 5, and create a spark between the electrodes 13 positioned close to the base 10' of the cone forming the precombustion chamber 10.

The "explosion" of the air/fuel mixture projects the piston/magnet assembly towards the said springs 7, compressing them, and these springs then re-expand to return the same quantity of "absorbed" kinetic energy, so that the piston 4 completes a given return compression stroke.

The extent of this compression stroke depends on the kinetic energy acquired by the piston 4 following the said initial "explosion", from which the quantities of energy that are transformed into electrical energy in the windings 2 in the stroke paths in both directions as well as the various losses are deducted.

The resultant residual kinetic energy of piston 4 then converts into a compression stroke of specific length.

At the end of this compression process, the density, and hence the volume of air contained inside the precombustion chamber 10, will have increased to an extent corresponding to the compression value obtained, and a quantity of petrol equivalent to or slightly more than the corresponding stoichiometric quantity should then be injected by means of injector nozzle 14, and this fuel will then be ignited with the electrodes 13. If the electromagnetic system is designed and constructed in accordance with the invention, i.e. such that, for this compression stroke and for the associated piston speed curve, which increases with compression for obvious physical reasons, the mechanical energy absorbed by the said electromagnetic system to produce electrical energy in the forward and return stroke of the piston 4 will be exactly equal to the energy generated in the combustion cycle (net of output), the piston 4 will complete one expansion stroke plus one return compression stroke stopping at exactly the same point as before with no change in compression ratio.

By injecting the same quantity of fuel for an indefinite number of cycles therefore, operation of the generator in stationary state is obtained.

To increase the electrical energy produced in a cycle, it is only a matter of increasing, by a predetermined amount, the quantity of fuel injected into the precombustion chamber 10.

The increase in energy produced by combustion compared with the last cycle in stationary state is divided between an increase in the quantity of electrical energy produced and an increase in the compression ratio, which establishes at a new value that is again dependent solely on the new position adopted by piston 4 at the end of compression, and the quantity of fuel appropriate to the greater volume of air contained in the precombustion chamber 10 should then be injected to adapt to the new conditions from stationary, and the status will remain stationary under the new conditions, providing that confirmation is again obtained on what is described above, in other words that for this new compression stroke again and for the relative speed curve for the piston 4, the energy absorbed by the electromagnetic system (i.e. the quantity of electrical energy generated in the cycle divided by the electromagnetic efficiency) is exactly the same as the new value of energy supplied by combustion under the new conditions. Obviously the same applies for deceleration and a reduction in piston stroke, although in this case the quantity of petrol per cycle should be reduced instead of increased.

The inventor recommends increasing saturation of air in the precombustion chamber 10, under stationary conditions, by about 20 % compared with the exact stoichiometric value, i.e. an air/petrol weight ratio $\approx$ 12.2.

Under these conditions, swift acceleration and deceleration of the piston 4 can be achieved by increasing or reducing the quantity of fuel, as explained, by up to 14 % compared with the preceding cycle, maintaining the mixture conditions inside the precombustion chamber 10 at all times to enable a combustion velocity that is as close as possible to the optimum (see Fig. 5), with the relative advantages of cycle configuration and its thermodynamic efficiency. If rich mixtures are used in the precombustion chamber 10 when the speed is varied, the effects on a generator as per the invention will be substantially diminished with regard to pollution: combustion does in fact cause immediate, very rapid expansion with relative containment of the temperature of the mixture, which apart from anything else mixes with the very considerable volume of air contained in the cylinder 5 which is at a relatively low temperature under all operating conditions. As a guide, in an experimental prototype with a maximum compression ratio $\rho = 8.5$, for this compression in stationary state, a maximum cycle temperature of approximately 756 °C (1029 °K) and a discharge temperature of about 164 °C (437 °K) are obtained, with $(\lambda_v) = 10$.

An engineer in this field will not have any difficulty in forecasting production of toxic substances from combustion (NO_x, CO) of virtually zero under these conditions.

The combustion procedures described, which are made possible by using precombustion chambers 10, also enable the energy per cycle to be varied, keeping the compression stroke the same, or vice versa, with no other adjustment and, as stated, no negative effects, if the user connected to the generator does not constitute an ohmic type fixed load, in which case regulation of operation is limited to that described before, but a load which may vary depending on the particular characteristic laws, such as, for example, electric motors or magnetic saturation phenomena. In this case, the same procedure can be followed, or the quantity of fuel per cycle on compression varied keeping the stroke the same, or vice versa, to adapt to progress in the load at times when, for example, the instantaneous stall torque deviates swiftly from the motive torque and the load varies in consequence, affecting the quantity of energy to be produced by the generator in one cycle.

It is up to engineers in the field to define the various characteristic operating curves, the geometric dimensions of the engine and parts of the generator, and the type of regulation connected with the type of load, as well as the percentage increase or decrease in the quantity of fuel per cycle to be provided in the various operating situations, with the advantage that in a generator as per this invention, within its sphere of use, as the compression stroke increases, the effective voltage at the winding ends increases along similar curves at a level higher than the first. This also applies to the quantity of energy per cycle in the simplest case in which the load is purely ohmic.
Obviously the abovementioned single phase current produced by the generator can be rectified with diodes or modulated in other ways using a converter, depending on the user's requirements, thus enabling a direct supply to electric

motors in a vehicle without the need for intermediate accumulator batteries.

To regulate operation of the internal combustion engine, all that is needed in the case of a generator 1 as per the invention is to record the position of the end of the compression stroke of the piston 4 and feed this data into a central electronic unit (not shown) which regulates the quantity of fuel admitted in one cycle by the injector nozzle 14 depending precisely on the position reached by the piston 4 in the preceding cycle, as stated, and/or on the load, increasing or reducing this as required, where necessary, by means of an increase or reduction command given, for example, by varying the angular or linear position of an accelerator pedal or another component fulfilling a similar function.

It will be noted that, for an engine of a capacity of around 35 hp constructed with the parameters mentioned and with a variation in the quantity of fuel per cycle equivalent to the aforesaid 14 %, a transition from minimum to maximum power output conditions is achieved in less than 2 seconds.

If the fuel admission is cut off completely, however, the pistons stop, after a very brief residual "inertia" stroke, in the position in which the compression resistance of gas contained in the cylinder 5 is equivalent and opposed to the resulting force of attraction between the moving magnets 3 and the other magnetized parts, or even those that are ferromagnetic only, connected to the fixed winding system 2.

The latter parts are not shown on the drawings, as they may vary considerably in shape and arrangement depending on the designer's wishes, who, as an expert in the field, will have no difficulty in determining the dimensions or positions of these.

It is useful to reiterate that, obviously, to ensure correct operation of the generator, the ratio between the quantities of mechanical energy absorbed by the generator (equivalent to the quantities of electrical energy generated divided by the respective electromagnetic efficiency ratios)for operation with two different compression strokes in an I.C. engine, should be substantially the same as the ratio between the two corresponding compression ratios multiplied by the ratio between the two overall outputs of the engine itself in relation to these compression ratios.

To take a numerical example:

Let us assume that, for two different strokes of a piston (and hence the associated magnets), two compression ratios are obtained equivalent to 8.5 (:1) and 3.6 (:1) and that the overall efficiency values of the I.C. engine are 0.46 and 0.30 respectively for these compression ratios.

To achieve the preset aims, the magnets and windings have to be dimensioned also according to the type of load, the electrical values of which may be controlled, such that the ratio between the quantities of energy consumed by the electromagnetic part of the generator in the two different relative cycles, i.e. during one compression stroke and one expansion stroke of the piston corresponding to the said compression ratios, is equivalent to 8.5/3.6.0.46/0.30=3.6.

In other words, the mechanical energy consumed by the magnets in one cycle of movement corresponding to the compression ratio of 8.5 should be 3.6 times greater than that consumed in a cycle corresponding to the compression ratio 3.6.

This means that the two different quantities of fuel that can be mixed approximately stoichiometrically with two different mass amounts of air contained in the precombustion chamber in relation to the said compression ratios will supply exactly the right amount of energy, net of output, to move the magnets as electrical energy is generated.

If the load between the windings is purely ohmic, this can also be achieved solely by physically dimensioning and shaping the magnets and windings, as explained below, so that this fact occurs automatically for any compression stroke. Otherwise, the quantity of fuel per cycle and/or the electrical values relating to the load can be varied, as explained previously.

The internal efficiency of the actual functional part of the generator then determines the quantity of electrical energy actually generated by the various compression strokes of the I.C. engine.

The above can be achieved physically, for example, by increasing the number of coils in thee windings 2 either in linear mode or following other appropriate curves in the direction of penetration of the magnets 3 inside them (see arrow in Fig. 4), designing the shape of the magnets 3 accordingly and/or varying the electrical values relating to the load.

Other systems are, however, available for an expert in the filed, including the use of several magnets essentially parallelepiped in form and fixed windings (Fig. 4) arranged and dimensioned such that the electrical energy generated in one cycle in their relative movement for different strokes (which is the integral $\int Vi\ dt$ in the cycle time), follows a curve that can be rectified in shape by letting it match with the curve of energy generated in one cycle of the I.C. engine (net of output) by varying, for example, the thickness of the magnets, their width and or the air gap (T in Fig. 4) in the direction of travel.

These variations do not necessarily have to be implemented: the designer may also decide to use magnets that are parallelepiped in shape, varying the part of the volume of air mixed in the precombustion chamber and/or the quantity of fuel used to saturate it such that the quantity of energy generated by the engine at any speed is the same as that used by the generator to produce electrical energy.

This is particularly easy if the load is taken as purely ohmic and of constant value (Fig. 4).

The type of combustion obtainable with one precombustion chamber 10 operating as described, or preferably two precombustion chambers placed diamectrically opposite and facing 110 (see Fig. 9), is more similar to that obtained with a burner rather than the conventional combustion with an I.C. engine, and as stated, affords very low temperatures inside the cylinder, which together with the abundance of oxygen for completion of combustion, largely guarantees freedom from toxic products such as CO,HC and NO_x.

The precombustion chambers shown in Figs. 1, 2 and 6 are conical in shape with just one injector nozzle 14 provided on the apex, but it may sometimes be useful to use precombustion chambers that are, for example, sub-cylindrical or truncated cones in shape with an injector nozzle 111 set in a predetermined position perpendicular to the precombustion chamber axis (Fig. 9). If the cylinder 9 is connected by means of appropriate ducts 112 to the closed base 113 opposite that facing the said cylinder 9, it is possible to saturate to the required extent just part of the total volume of air contained in the precombustion chamber.

A second injector nozzle 14 fitted to the said closed base 113 can be used for the initial starting cycle only. With this latter arrangement and the precombustion chambers facing, it is possible to completely eliminate any residual HC due to the very high turbulence generated by collision of the two volumes of mixture during their expansion and combustion. Other arrangements with one or more injectors are also possible.

The process described so far concerns cases in which the I.C. engine is supplied with fuels with low ignition temperatures, such as petrol, alcohols or gaseous fuels, but diesel or similar fuels can also be used; for this, provide two injector nozzles in a single precombustion chamber (as in Fig. 9), with the first injecting petrol, for example, with appropriate timing, just for the transitory engine starting period until an adequate compression ratio is reached for self-ignition of the diesel, which is then injected by the second nozzle.

This solution may be recommended in the case of high capacity static generators, in which the maximum output may predominate in importance with regard to the problem of particulate emission (which can in fact be limited by partially recycling exhaust gases, as described below).

With this type of operation again, very low temperature can be maintained compared with similar conventional type engines.

It has already been mentioned how the piston/magnet assembly can be supported in motion by, for example, two or more rolling friction bushings 15 which slide along the guide pins 16 (Fig. 1) or similar devices, to minimise friction and in this case there is no need to provide for lubrication of any of the moving parts, in view of the low temperatures reached. No cooling system is required either, and it is in fact expedient to insulate the I.C. engine so that its operation is adiabatic.

As the I.C. engine is 2-stroke type, as we have seen, for each cycle, air needs to be introduced to refill and scavenge the cylinder or cylinders. One solution proposed by the inventor is to achieve this by the movement of an auxiliary scavenging piston 19 in fig. 6 which, when moving, i sintergal with the piston 4 of the engine, and which, during the compression stroke of the piston, draws in air inside the cylinder 20 which holds it by means of a one-way valve 21, whilst during the expansion phase of the above piston 4 it compresses this air up to the moment when a second one-way valve 22 lets it enter the precombustion chamber 10 and relative cylinder 5, due to the drop in pressure occurring in the interim in the cylinder 5 of the engine.

With this system, scavenging efficiency values of a value approaching 0.90 can be achieved without any problem, and what is more important, these are essentially constant for any compression stroke and hence any quantity of fuel per cycle.
The same result can be achieved with an auxiliary piston 19' in Fig. 9, which is integral with piston 6 and uses part of the said cylinder 9 of the engine as an auxiliary cylinder 20', in accordance with the well-known method in the field of 2-stroke engines with intrinsic scavenging.
This solution is shown in Figure 9 in the case of opposite pistons, as explained below.

As the effective expansion stroke of a piston 4, 6 of the engine is equivalent only to the corresponding length of the cylinder 5, 9 whereas the compression stroke of the auxiliary piston 19, 19' is equal to the sum of this length plus the compression stroke of the springs, by taking action at the design stage, a diameter can be chosen for the auxiliary piston 19, 19' larger, the same or smaller than that of the engine piston depending on whether total or just partial scavenging of the combustion gases is required for a given speed range. For example, in the prototype mentioned above, with an auxiliary piston 19, Fig. 6, with the same diameter of engine piston 4, total scavenging takes place until there is a compression stroke corresponding to a compression ratio equivalent to 3.5 : 1, and partial scavenging with a decreasing quantity of air admitted in lower strokes, until scavenging is obtained equivalent to just 50 % of the volume of the cylinder at the compression ratio taken as the minimum used, equivalent to 1.6 : 1. Partial recycling of combustion gases at the lower compression ratios serves, as found to an increasing extent as the latter reduce, to keep the temperatures and hence the duration of combustion high enough to avoid the formation of HC in the exhaust gases in the transitory status of low compression on start-up of the generator 1.

For optimum operation, a cylinder temperature sensor and pressure measuring probe will be useful, the first of these being used to slightly vary the quantity of fuel admitted when the engine is cold (starter), and the second, again depending on the position of the piston at the end of compression, to change the predominance of the fuel injection pump in order to achieve efficient injection calibrated for all the operating statuses.

These components are not shown on the drawings as they are known and easily implemented by an expert in the field.

Notwithstanding all the above, to further simplify the construction of an autogenous generator as per the invention, and to eliminate restricting reactions and/or vibrations at the same time, it is expedient to use one or more pairs of pistons 6, 6' facing each other, preferably with a single communal detonation chamber 9 (fig. 2). In this case it is possible to have just one precombustion chamber 10 (or two precombustion chambers 111 facing each other as in Fig. 9) arranged centrally and with the longitudinal axis h perpendicular to the axis k of pistons 6, 6'. To ensure perfect synchronisation between several pairs of pistons when they are operative, where necessary the inventor proposes to make pistons 6, 6' integral by means of connecting devices 8, 8' (Fig. 3), these pistons operating in the same direction at a given moment in the cycle(practically one half of the pistons).

If components are then incorporated to return mechanical energy, i.e. the springs 7 in the case described, so that their position is adjustable in the direction of axis K of the movement of the pistons coupled to them, different amounts of electrical energy can be generated per cycle without varying the required frequency, or the frequency can be varied using the same cycle corresponding to optimum efficiency, varying the length of stroke of the pistons and hence varying the time taken by these to do this. Implementation of continuous monitoring of the velocity and synchronisation of the pistons also means that the piston stroke can be varied micrometrically so that it can be maintained constant and perfectly synchronized. It is obvious that, to achieve this last result, it is sufficient for just the position of the springs coupled to one half of the pistons to be adjustable, i.e. those pistons which are connected integrally by means of the connection device 8 shown in Figure 3.

Apparatus suitable for making the above adjustment can be in the form, for example, of a stepping motor or DC electric motor 17 connected by a system of screws and female threads acting as a linear repeater for a component 18 integral with the relative spring 7.

The inventor has also provided for a further means of preventing vibration due to momentary lack of synchronisation between two facing pistons. In fact, by connecting the mechanical parts of the generator which act as a support and locator for the springs 7 (in the drawing in Fig. 2 these parts just consist of the body 11 which forms the housing for cylinders 5 and 5') to earth or to a component supporting the generator by a connector 12 of predetermined limited elasticity in the direction of movement of pistons 6, 6', there is no elastic yield in the connector 12, if the pistons are perfectly synchronised, as the forces acting in opposite directions on two springs 7 connected to two facing pistons are equal with each other at all times. If, however, one of the two pistons moves in advance of the other, this will first exert force on the relative spring and then on the elastic connectors 12, which will extract part of the kinetic energy that should be stored by the spring and then return the relative piston, under the effects of elastic hysteresis due to compression of the springs.

This entails a deceleration in the piston return stroke and its gradual synchronisation with the other (delayed) facing it. Obviously this correction of synchronisation entails losses, albeit slight, in the overall energy balance, and it is thus advisable to use an electronic procedure as mentioned above, modifying the spring return position in order to ensure perfect initial synchronisation.

In conclusion to this description, the reader is invited to look at the overall efficiency diagrams (Fig. 7) of an I.C engine, the generator as per the invention and its specific consumption (Fig. 8). It is not felt that any special detailed comments are warranted, as these are easy for a specialist in the field to interpret. Overall efficiency does in fact have a value of about double that of a conventional engine at any speed.

All the component parts, their design and positioning and the regulation systems can be modified and improved in line with the know-how of a specialist in the field.

For example, instead of being supported by a fork 4', the magnets 2 in Figures 1 and 2 can be fixed to a cylindrical support provided on the same axis of the piston and integral with it, with parts arranged in a similar way to that already described for the Jarrett engine. This case is not shown in the drawings.

Different constructions fall within the scope of protection provided by this application of patent where these are attributable to the concepts expressed in the attached claims.
The constructions described and illustrated are therefore deemed to be preferred examples that are neither limitative nor binding.

Claims

1. Autogenous electrical energy generator (1) in which energy generation is achieved by a linkage between fixed windings (2) and one or more permanent magnets (3) which move integrally on the alternating motion of one or more pistons (4) of a two-stroke internal combustion engine, characterised by the fact that the internal combustion engine cylinders (5) coupled to the pistons (4) have at least one precombustion chamber (10) with a base (10') which opens towards the cylinders and in which, under any of the engine's running conditions, at least part of the volume of air contained in it mixes with an approximately stoichiometric quantity of fuel, the engine itself being apt to run also with variable compression strokes, and the ratio between the two quantities of mechanical energy used to generate electrical energy when stationary corresponding to any two different complete expansion and compression strokes of the said pistons (4) being substantially equal, when the said part of the volume of air is constant, to the ratio between the two compression ratios obtained in the precombustion chambers (10) and relative cylinders (5) due to the effect of the aforesaid two different strokes of the said pistons (4) multiplied by the ratio between the two overall efficiency values of the I.C. engine corresponding to the said compression ratios, each piston (4) completing one expansion stroke due to combustion and expansion in the cylinder (5), and one compression stroke due to the effect of the action of a device (7) to return mechanical energy.

2. Autogenous generator as per claim 1, in which the magnets (3) and fixed windings (2) are positioned such that there is a reduction in their linkage as the expansion stroke of the pistons (4) progresses but an increase as the compression stroke of the said pistons (4) progresses.

3. Autogenous generator as per one of claims 1 and 2, in which the magnets (3) and fixed windings are shaped, arranged and dimensioned such that, when an ohmic load of constant value is applied between the ends of the windings, the ratio between the two quantities of mechanical energy used to produce electrical energy in relation to two different complete expansion and compression strokes of the said pistons (4) one cycle is automatically equal to the ratio between the two compression ratios obtained in the precombustion chambers (10) and the relative cylinders (5) due to the two different strokes performed by the said pistons (4) multiplied by the ratio between the two overall efficiency values of he I.C. engine in relation to the said compression ratios.

4. Autogenous generator as per claim 3, in which the said magnets (3) are essentially parallelepiped in form, these and the fixed windings (2) being arranged and dimensioned such that the mechanical energy used to produce the electrical energy in their relative movement in one cycle follows a curve, in line with variation in the compression stroke of the said piston or pistons (4), that can be rendered as substantially coincident with the curve of energy generated in one cycle

of the I.C. engine in accordance with this same compression stroke by varying the thickness of the magnets (3), their width and or the air gap (T) in the direction of travel.

5. Autogenous generator as per any of the above claims in which at least one precombustion chamber (10) is substantially conical in shape, with an injector nozzle (14) on its apex.

6. Autogenous generator as per any of claims 1 to 4, in which the at least one precombustion chamber (110) is substantially a truncated cone in shape, and its closed base (113) opposite that facing the cylinder (9) is connected to the said cylinder (9) by means of one or more ducts (112), an injector nozzle (114), positioned axially on the said closed base, and a second injector nozzle (111) positioned perpendicular to the axis of the precombustion chamber in a predetermined position.

7. Autogenous generator as per any of the above claims in which, in order to eliminate vibrations and restricting reactions, there are one or more pairs of pistons (6, 6') facing each other.

8. Autogenous generator as per claim 7, in which the pistons (6, 6') are an entire multiple of two and are made integral with each other by means of connecting devices 8, 8' (Fig. 3), these pistons (6, 6') operating in the same direction at any moment in the cycle.

9. Autogenous generator as per either of claims 7 or 8 in which two cylinders opposite each other (6, 6') have a common combustion chamber (9) into which leads at least one precombustion chamber (10) with its longitudinal axis (h) perpendicular to that (K) of the two cylinders (6, 6').

10. Autogenous generator as per claim 9, in which there are two precombustion chambers (110) for each pair of facing cylinders (6, 6') situated diametrically opposite each other and facing.

11. Autogenous generator as per one of claims 7 to 10 in which the position of at least part of the said components (7) designed to return mechanical energy is adjustable in the direction of the axis of movement of the pistons coupled to these components.

12. Autogenous generator as per claim 11 in which only the position of the return energy component coupled to the half of the pistons (6 Fig. 2) is adjustable, which moves in a given direction at a given moment in the cycle.

13. Autogenous generator as per any of the above claims characterised by the fact that the part (11) which acts as a support and locator for the abovementioned return mechanisms (7) is connected to earth or to the element supporting the generator (1) by means of connectors (12) of predetermined elasticity in the direction of movement of the pistons (6, 6' Fig. 2).

14. Autogenous generator as per any of the above claims in which air for scavenging and refilling the cylinders (5) is introduced by the precombustion chamber(s) (10) by one or more auxiliary scavenging pistons (19) integral with the pistons (4) of the I.C. engine, these auxiliary pistons (19) drawing in air in the compression phase of the pistons (4) by means of primary single-way valves (21) fixed to the associated auxiliary cylinders and forcing this into the said precombustion chambers (10) by means of secondary single-way valves (22) situated near the said precombustion chambers (10) during the expansion phase of these pistons (4).

15. Autogenous generator as per any of the above claims in which, at any stationary operating status, at least part of the air contained in the precombustion chamber(s) (10) of the I.C. engine is mixed with a quantity of fuel equivalent to 120 % of the stoichiometric quantity.

AMENDED CLAIMS

[received by the International Bureau on 20 October 1995 (20.10.95); original claim 1 amended; remaining claims unchanged (1 page)]

1. Autogenous electrical energy generator (1) in which energy generation is achieved by an electromagnetic system comprising fixed windings (2) linked to one or more permanent magnets (3) which move integrally on the alternating motion of one or more pistons (4) of a two-stroke internal combustion engine, characterised by the fact that the internal combustion engine cylinders (5) coupled to the pistons (4) have at least one precombustion chamber (10) with a base (10') which opens towards the cylinders and in which, under any of the engine's running conditions, at least part of the volume of air contained in it mixes with an approximately stoichiometric quantity of fuel, the engine itself being apt to run also with variable compression strokes, and the ratio between the two quantities of mechanical energy used by said elecromagnetic system to generate electrical energy when stationary corresponding to any two different complete expansion and compression strokes of the said pistons (4) being substantially equal, when the said part of the volume of air is constant, to the ratio between the two compression ratios obtained in the precombustion chambers (10) and relative cylinders (5) due to the effect of the aforesaid two different strokes of the said pistons (4) multiplied by the ratio between the two overall efficiency values of the I.C. engine corresponding to the said compression ratios, each piston (4) completing one expansion stroke due to combustion and expansion in the cylinder (5), and one compression stroke due to the effect of the action of a device (7) to return mechanical energy.

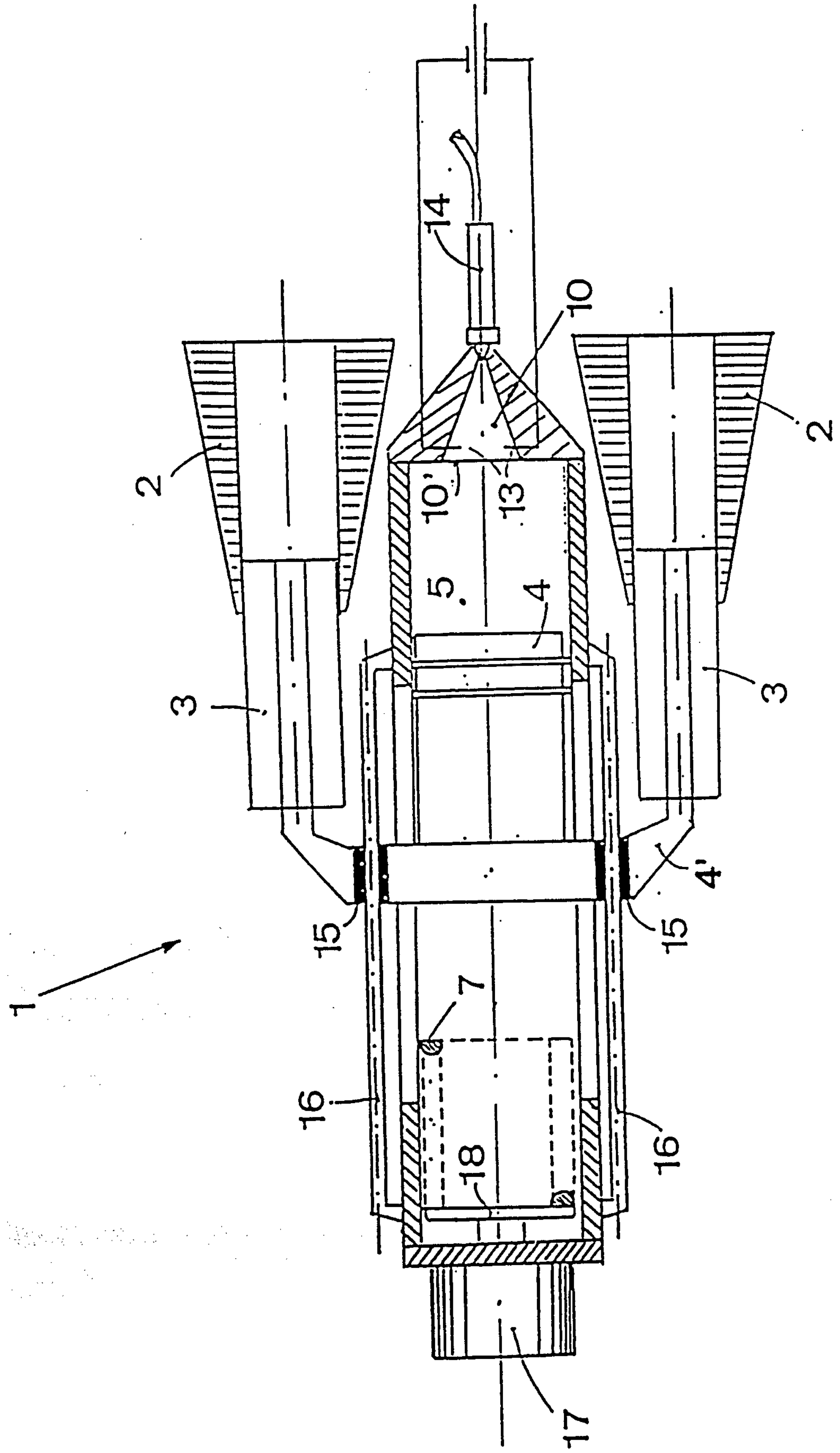


FIG.1

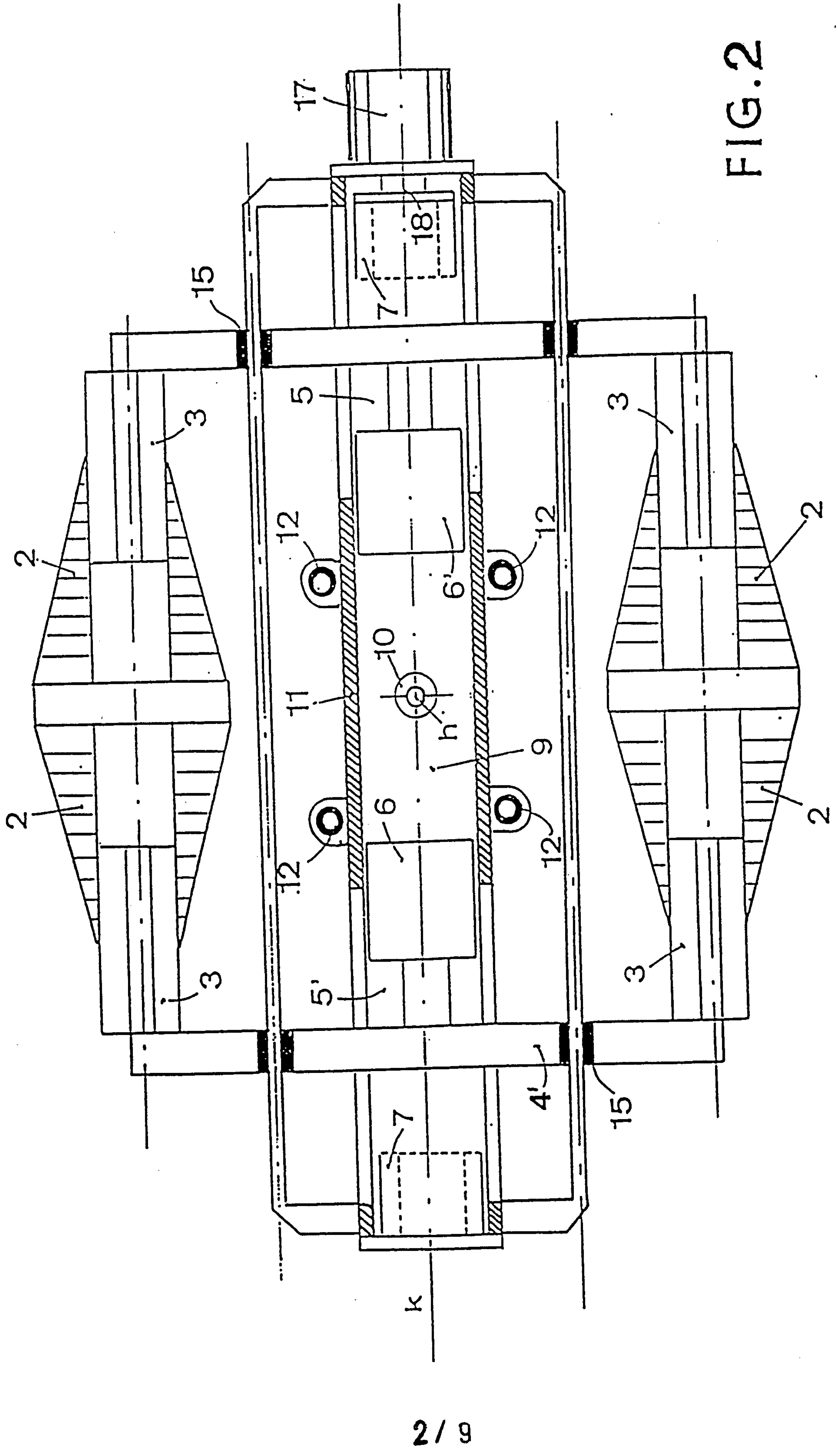


FIG. 2

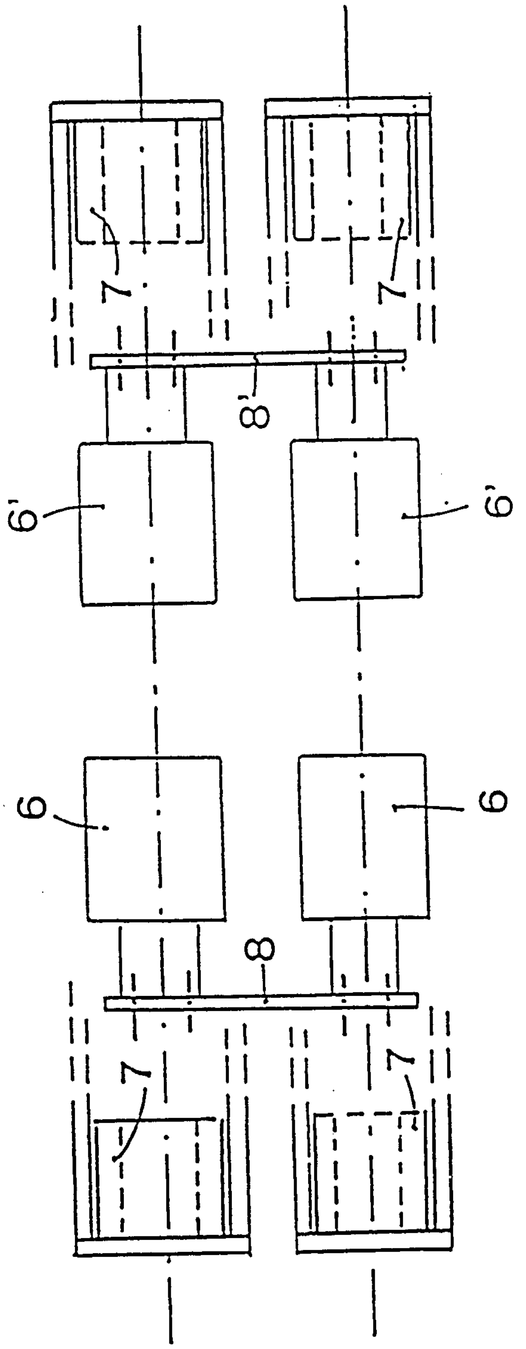


FIG.3

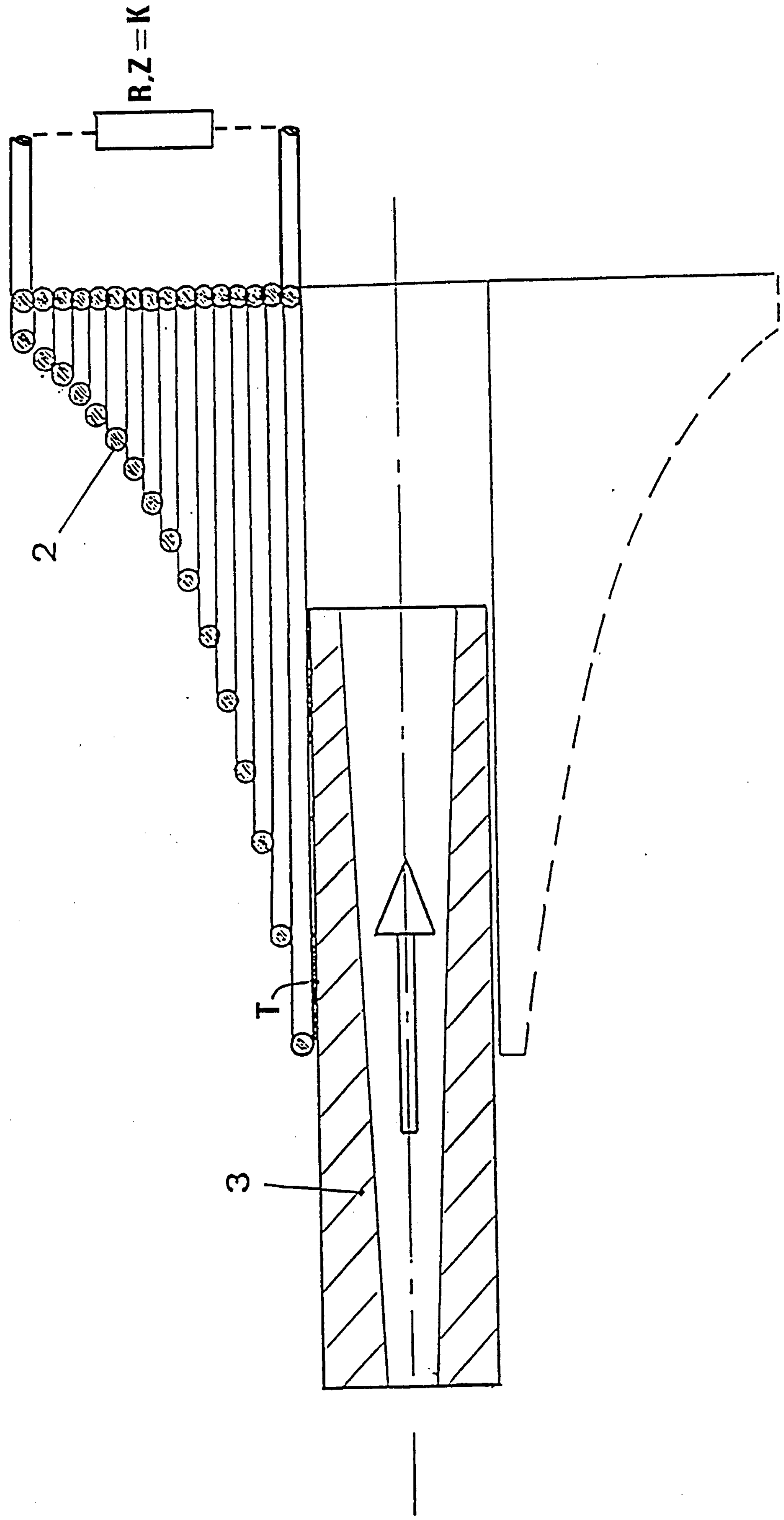


FIG.4

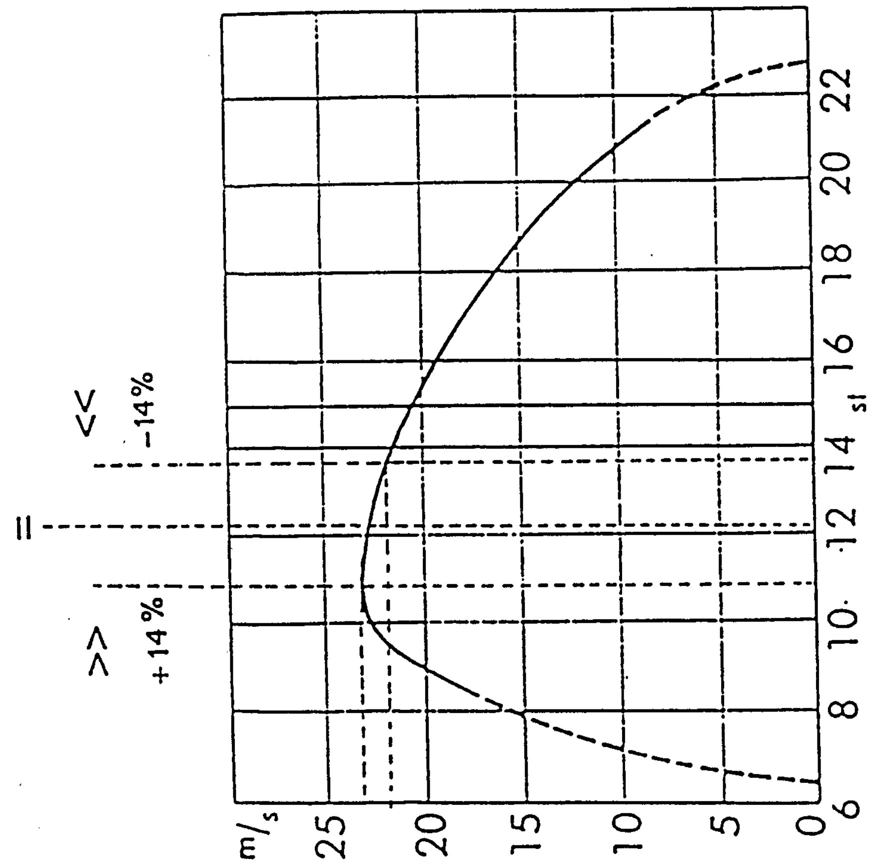


FIG.5

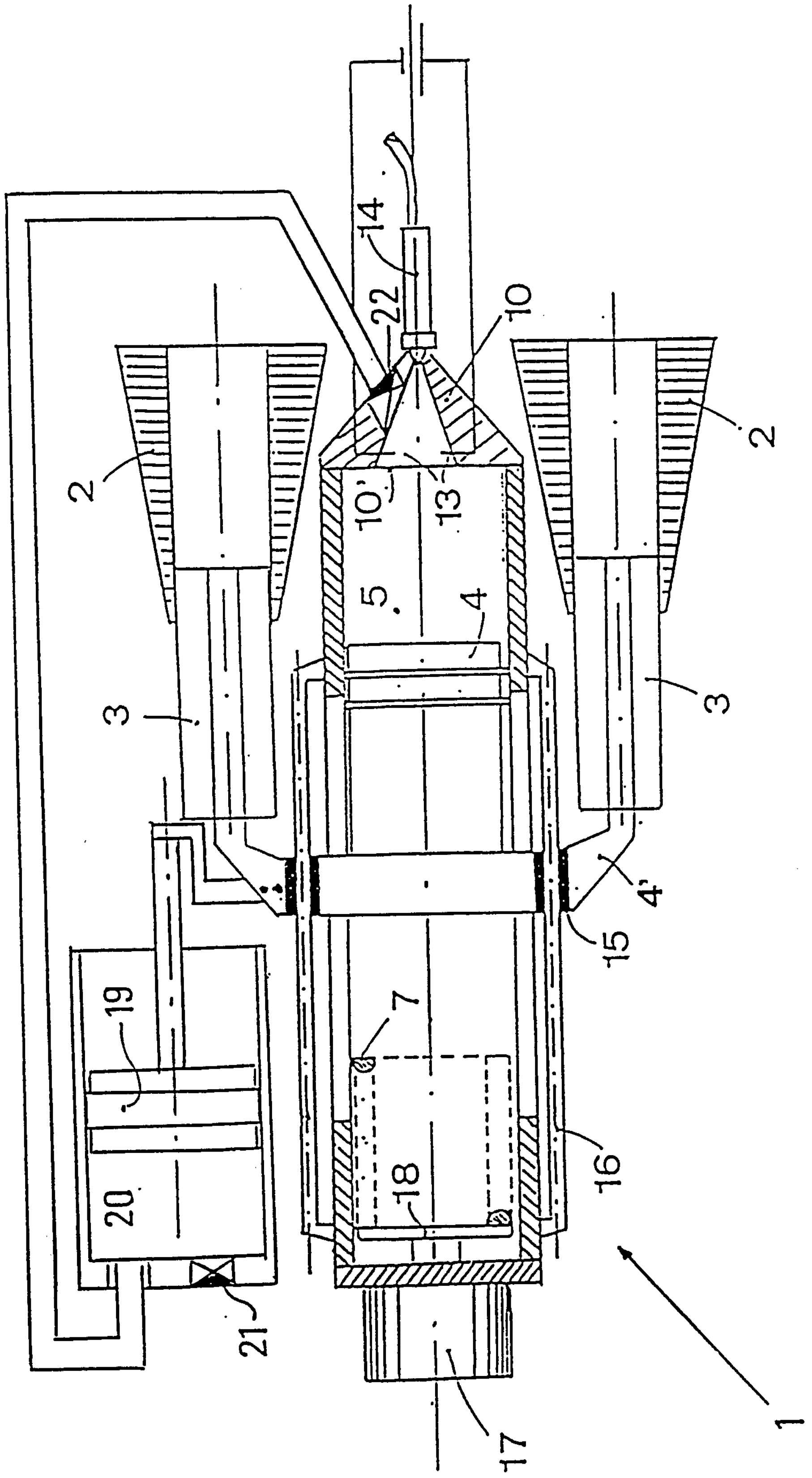
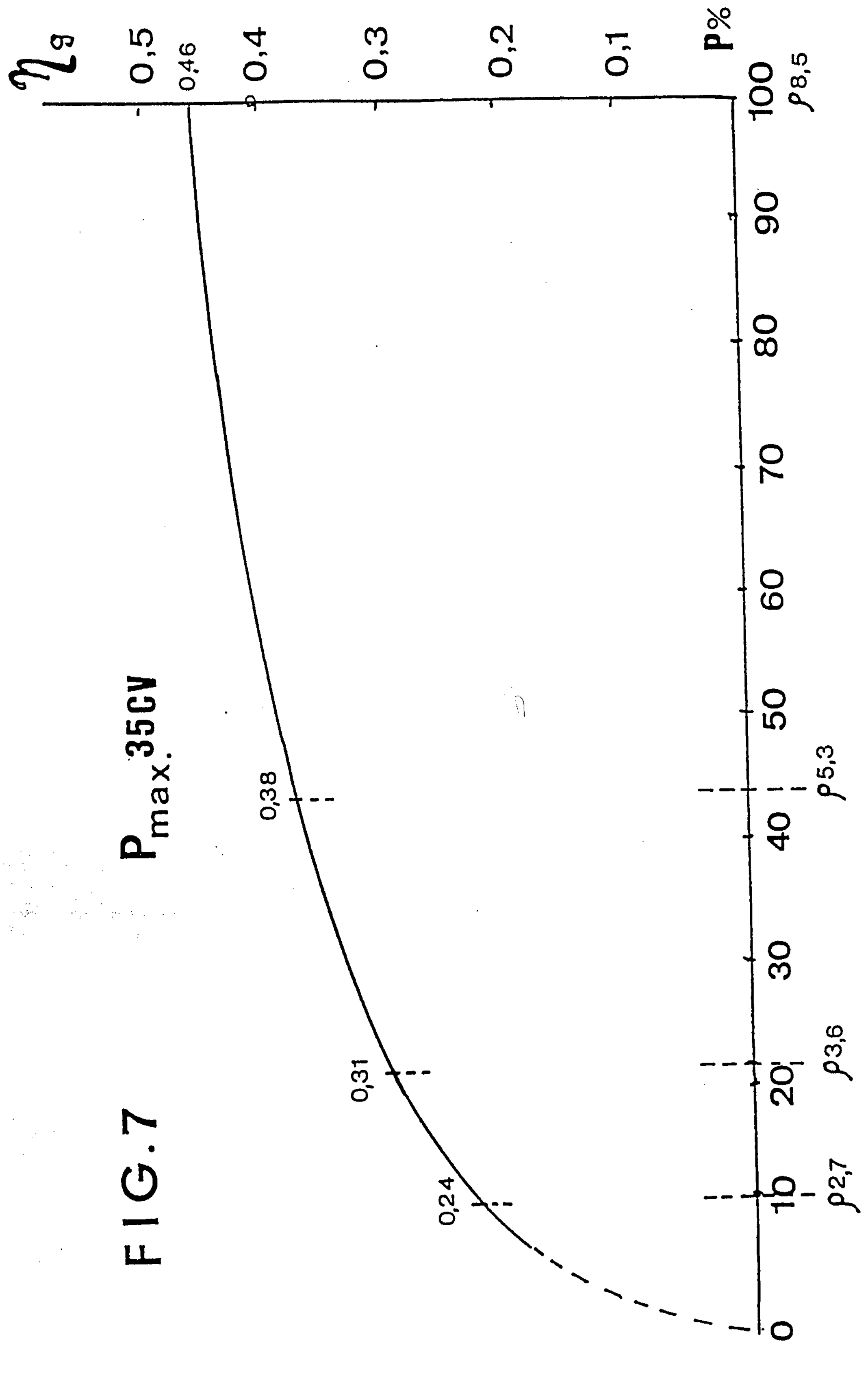


FIG.6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$\rho_{2,7}$

FIG.7

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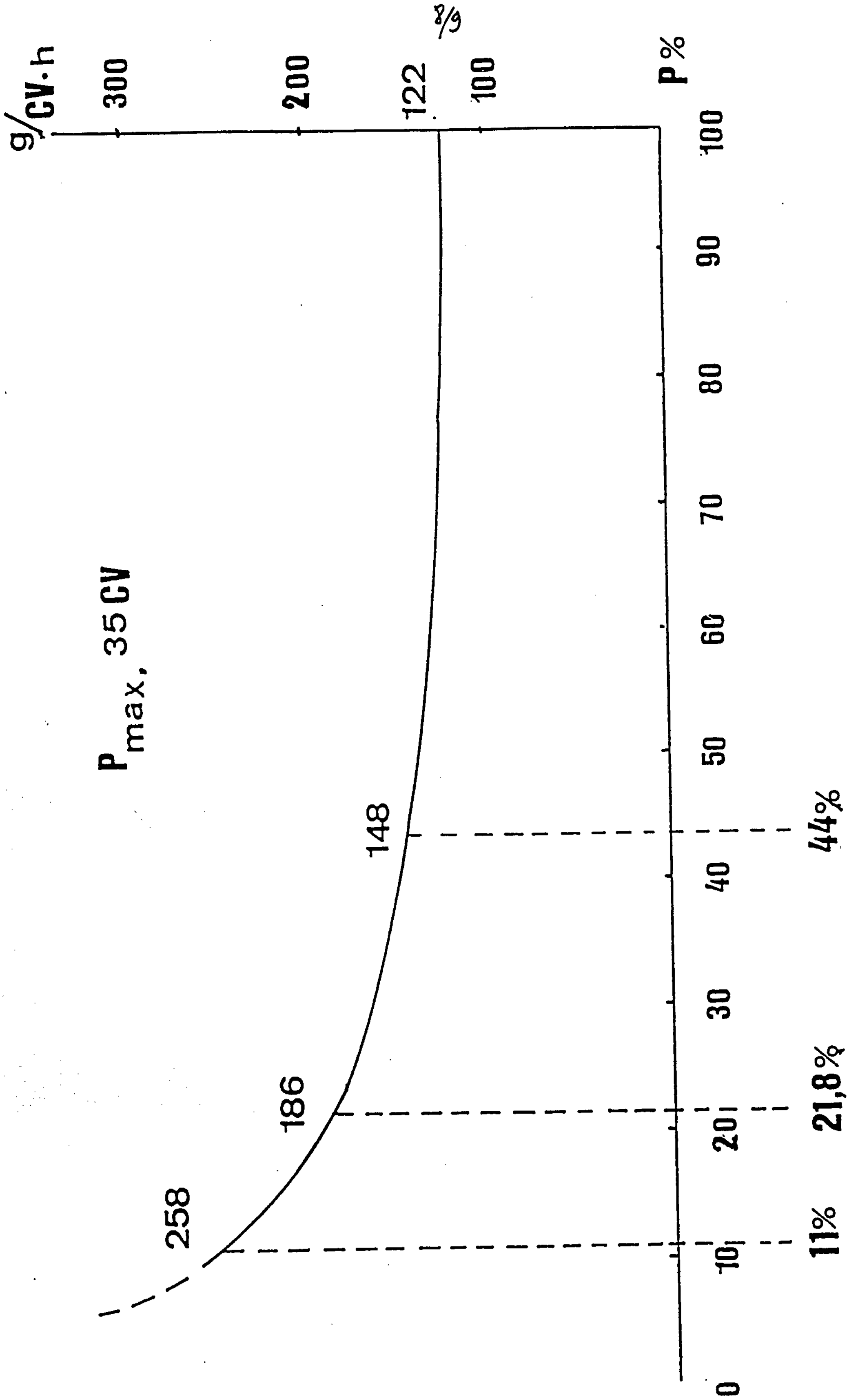
F I G. 8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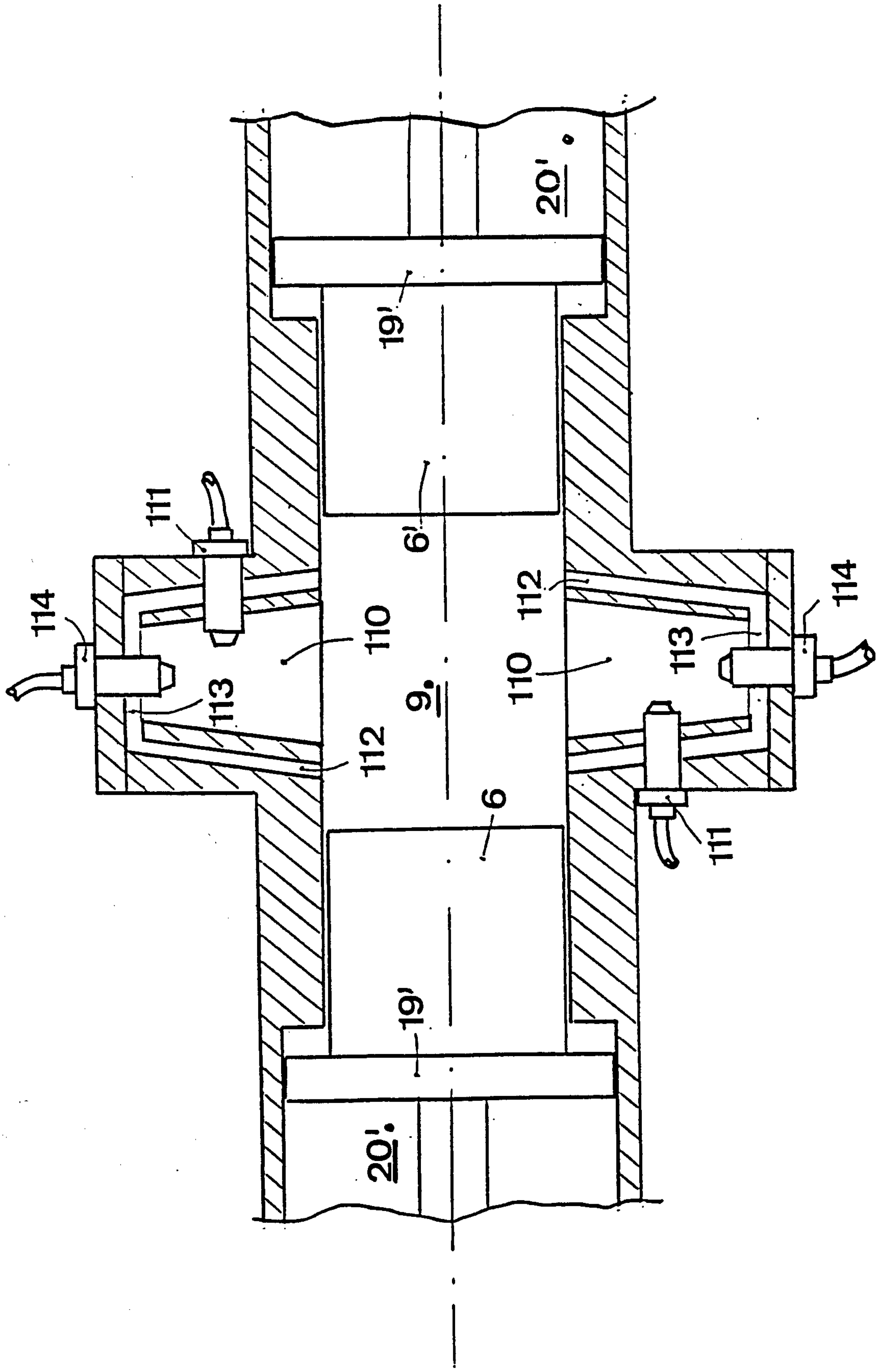

FIG.9

INTERNATIONAL SEARCH REPORT

Interr Application No
PCT/EP 95/02054

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F02B71/04 H02K35/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F02B H02H H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP-A-0 063 514 (VALLON) 27 October 1982 see page 7, line 11 - page 11, line 16; figure 1	1,2
A	US-A-4 154 200 (JARRET) 15 May 1979 see abstract; figure 1	1
A	DE-B-10 81 558 (STAHL) 12 May 1960 see column 1, line 1 - line 52; figure 1	2
A	FR-A-1 291 635 (SPIT) 19 March 1962 see page 2, paragraph 10 - paragraph 5; figure 4	2

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
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- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 August 1995	06.10.95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Wassenaar, G

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INTERNATIONAL SEARCH REPORT

...mation on patent family members

Interr Application No
PCT/EP 95/02054

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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		JP-A-	57173366	25-10-82
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		DE-A-	2217194	02-11-72
		GB-A-	1392827	30-04-75
DE-B-1081558		NONE		
FR-A-1291635	21-09-62	NONE		