

(19)



Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11) Publication number:

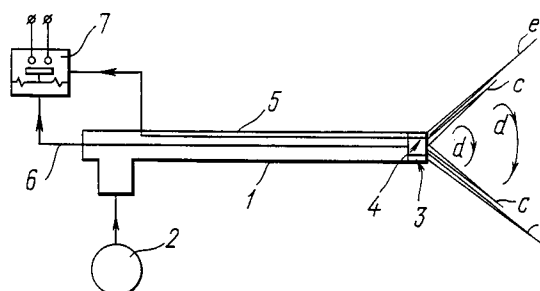
**0 656 509 A1**

(12)

**EUROPEAN PATENT APPLICATION**  
published in accordance with Art.  
158(3) EPC

(21) Application number: **93913672.7**(51) Int. Cl.<sup>6</sup>: **F23N 5/24**(22) Date of filing: **21.05.93**(86) International application number:  
**PCT/RU93/00116**(87) International publication number:  
**WO 94/28356 (08.12.94 94/27)**(43) Date of publication of application:  
**07.06.95 Bulletin 95/23**(84) Designated Contracting States:  
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D-80331 München (DE)**(54) **DEVICE FOR REGULATING A FLAME.**

(57) A device is disclosed for regulating a flame. The said device comprises a housing (1), two pressure bleed-pipes (5, 6) mechanically joined to the housing (1), each of the said bleed-pipes being connected at one end to cavities of the differential pneumatic relay (7); the pipe (6) connects at its other end to the potential flame-zone, while pipe (5) at its other end connects to the region adjacent to the potential flame zone. The device also comprises a source (2) of surplus pressure of the compressible working medium. At the working end of the housing (1) and facing the regulated flame are mounted two coaxially arranged generators (3, 4) for producing involuted streams, namely an outer one (3) and an inner one (4), the pressure bleed-pipe (6) being connected coaxially to the latter.

**FIG.1****EP 0 656 509 A1**

## Field of the Invention

The present invention relates to automatic devices to check furnace devices of various designs, mainly power boiler furnaces, and more specifically, devices for checking flame for presence.

## Description of the Prior Art

Up to now to check principle burners and ignition devices for flame presence, use has been made of electronic and optoelectronic means, such as ionization indicators of burning that employ effects of conductivity variations and the valve effect of a burning zone, the generation of the burning zone radiation, the effects of absorption changes in various sections of the spectrum, luminosity fluctuations and thermoelectromotive forces.

All the means mentioned above display an insufficient reliability. Thus, for instance, ionization devices are equipped with electroinsulated electrodes, inserted into flame. The deposits of soot, dust on the electrodes and insulators, precipitation of moisture on insulators with the ionization currents being specifically small, make the operation of said devices unreliable. The optoelectronic indicators feature a low reliability because of a short service life of emitters and radiation receivers, sensitivity to contamination and low selectivity in flame checking.

The main idea of the present invention is realization of a flame presence checking procedure, based on utilization of gas-dynamic effects, taking place during interaction of streams, flowing into the furnace volume, with the burning zone; as this takes place the stream flow can be either specially formed, or a stream flow of a burner device, like of an ignition nozzle, used. At the base of the invention is, in particular, a static pressure variation effect in the close-to-the-axis part of the twisted stream when it flows into the burning zone, and, namely, disappearance of rarefaction in the close-to-the axis part of the twisted stream during burning.

Known is a device for flame checking, a stream flame detector, at the base of which is the dependence of the pneumatic throttle resistance on the temperature of the working mass with the consumption of said working mass being metered, for instance, by another throttle (SU- A- 1152324).

Said device features a number of advantages over the ionization and optoelectronic devices, and among other things, a high selectivity in flame checking and a zero sensitivity to radiant thermal flows.

The indicated device for flame checking comprises a heat exchanger with an intershroud cavity

and a heat-exchanging pipe, two throttles, one of which is connected to the internal cavity of the combustion chamber (furnace) outside of the burning zone, two auxiliary throttles, a differential converter, a variable volume chamber and an exhaust.

The device described above is provided with a through pneumatic bridge whose shoulders are two throttle reducers, the so-called "hot" and "cold" reducers. One diagonal of the bridge is fed with rarefaction, built up at the exhaust, made up as an ejector, while in the other diagonal an outlet signal is generated in the form of a pressure differential, which is fed to a differential pneumatic relay, closing and opening electric contacts.

Said device operates as follows:

In the mode without burning, pressure in the interthrottle volume of the "cold" reducer is lower than that in the "hot" reducer, the sign of pressure differential between them is such, that the relay membrane is caved in and does not close the contacts. In the course of burning to the inlet of the "hot" reducer high-temperature end products of combustion are supplied, which transfer heat to the walls of the cooling shroud within the interthrottle volume of the reducer. As a result of cooling the end products of combustion at the outlet of the "hot" reducer, a temperature is considerably lower than that at the inlet, which at equal physical rates via the throttle of the reducer results in a considerable difference of the reduced rates via them (the reduced rate is equal to a physical rate, multiplied by a square root of the absolute temperature and divided by a pressure of the working mass). A rise in the reduced rate via the input throttle of the "hot" reducer in comparison with the reduced rate via the output throttle brings about a rise of the input throttle resistance and, in doing so, a drop of pressure in the interthrottle volume. As result, pressure in the interthrottle volume of the "hot" reducer becomes lower than pressure in the "cold" reducer, the pressure differential changes its sign, the relay membrane caves into the opposite direction and closes the contacts.

Said device displays a fair reliability when operating with clean working masses, for instance, with the end products of aviation kerosine combustion, natural gas, propane-butane mixture, combines a relatively simple construction with a sufficiently fast action, possesses a flame checking selectivity. These advantages over the ionization and optoelectronic means make it possible to effectively employ the device in the control systems of the afterburner chambers of aviation gas-turbine engines, pilot burners of the flare devices of the "shelf" sea platforms for exploration of oil and gas-containing layers.

The device indicated above, however, has been successfully used in cases which could have

provided a source of rarefaction and conditions for operation in relatively clean end products of combustion, since the device sucks in a sample of the working mass from the combustion zone and the end products of thermal destruction can lodge in the through part of the device, while sulphur oxides and ash remnants, developing during burning, may cause corrosion and erosive wear of the input throttle of the "hot" reducer as well as when the requirements to the level of the output signal (a pressure differential does not exceed 40% of the rarefaction value) are not strictly observed.

Known is a device to check flame for presence, comprising a through casing, which is connected to a fluid medium source under pressure, located closely to one of its ends and at the opposite end having a fluid medium stream shaping source, a differential pneumatic relay and two pressure bleeding pipes, connected by means of the first ends, each with a respective cavity of the pneumatic relay, and by means of the second ends, one of which having a probable flame zone and the other pipe, with an area outside of said zone (SU-A- 1273693).

In said device the pressure bleeding pipes are provided with four throttles, mounted in pairs and in succession and forming two through pressure reducers with interthrottle cavities between the input and output throttles, the so-called "cold" and "hot" reducers, connected to a differential pneumatic relay, while in the interthrottle cavity of one of the reducers there is mounted a small-sized combustion chamber, an output throttle of said reducer having a form of a nozzle with the fluid medium source (compressible working mass) under an excessive pressure being connected to the input throttles of both reducers.

An advantage of said device over the above-described one consists in the fact that said device does not need any source of rarefaction and it does not suck in a sample of the end products of combustion, but vice versa said products come out of the device.

The aforementioned device operates as follows.

In the mode without burning, pressure in front of the nozzle is below than that in the interthrottle volume of the "cold" reducer (the indicated relation of pressures is ensured by through sections of the throttles and the nozzle). In the course of burning, because of heat generation in the combustion chamber and an increase of temperature in front of the nozzle, the reduced rate through the nozzle sharply rises in comparison with the reduced rate via the input throttle. This is accompanied by an increase of pressure in front of the nozzle and the latter becomes higher than the pressure in the interthrottle volume of the "cold" reducer. The

membrane of the differential relay caves into the opposite direction and closes the contacts.

Said device has a limited service life, because of corrosion and erosion of the nozzle, a low level of the output signal, since a pressure jump, which depends on the relations of hydraulic resistances of the input throttle of the "hot" reducer and of the nozzle as well as on the relation between the temperature of combustion and the temperature of air, has a value less than 30% of the excessive air pressure in front of the device, a possibility to use for burning indication in small-sized combustion chambers, ignition devices, for instance. All these results in a low design reliability and a low operational reliability.

#### Description of the Invention

In the base of the present invention is a task of creating a device to check flame for presence, the design of which makes it possible to reduce the thermal and chemical effects on the components of the device construction, which determine the quality of its operation, increase the adjustment stability, reduce the probability of firing in the through part of the device, increase the level of the output signals up to the values commensurable with the excessive supply pressure or surpassing it, which in the long run can improve the design reliability of the device and its reliability in operation.

The aim is achieved by equipping the design of the flame checking device with a through casing, connected with a fluid medium source under excessive pressure, close to one of the casing ends, and by providing the opposite output end with a fluid medium stream shaping means, a differential pneumatic relay and two pressure bleeding pipes, the first ends of which are connected with an appropriate cavity each of the pneumatic relay, while the second ends of the pipes are connected as follows: one pipe with a zone of probable flame and the other pipe with an area outside the said zone, according to the invention, the fluid medium stream shaping means is made up in a form of two coaxially disposed generators of twisted streams, external and internal ones, mounted coaxially to the casing at its output end, with the end of the first pressure bleeding pipe, located in the casing coaxially to the internal generator of the twisted stream and linked via the internal volume of said generator with the zone of probable flame.

It is suitable to equip the device with a second fluid medium source under an excessive pressure and, in doing so, in the casing of the device and coaxially to it, to install a cylindrical partition which divides the casing into two isolated and coaxially disposed external and internal volumes, the first of which is connected with one pressure source and

the external generator of the twisted stream, while the second one is connected with another source of pressure and the internal generator of the twisted stream.

It is possible to manufacture a device in which both fluid medium pressure sources use a compressible working medium and both sources are joined into one combined source with one of the coaxially disposed volumes of the casing, coupled with the aggregate source of an excessive pressure through a reducing means.

In this case it is desirable to make up the external generator of the twisted stream as a spiral-type swirler, one of whose channels is provided with a radial hole, through which the second pressure bleeding pipe is communicated with an area, adjoining the zone of probable flame, with the pipe proper, that was mentioned above, disposed in the external circular volume of the casing.

An embodiment of the device is possible in which one source of pressure uses a compressible propulsion mass as a fluid medium, while the second source for a fluid medium uses an incompressible propulsive mass.

This being the case, it is appropriate to connect the external circular volume of the casing with an excessive pressure source of the incompressible propulsion mass, whereas to make the external twisted stream generator use is a shape of the centrifugal injector.

It is preferable to make a twisted stream generator in a form of consecutively connected cylindrical twisting chamber with tangentially disposed nozzles, coupled with the internal volume of the casing, a cylindrical channel and a diffuser, whereas the first pressure bleeding pipe is linked with the internal generator via the central opening, manufactured in the side end wall of the cylindrical twisting chamber and in line with it.

In case the cavity of the casing internal volume is linked with an incompressible propulsive working mass pressure source, whereas the cavity of the casing external volume is linked with an excessive pressure source of the compressible working mass, it is efficient to make the twisted stream internal generator in the shape of a centrifugal injector, whereas to manufacture the external generator of the twisted stream in the form of the following, which are coaxially disposed relative to the casing and in tandem after the nozzle upstream of the working mass and are interconnected: a cylindrical chamber, the diameter of which exceeds the diameter of the centrifugal injector twisting chamber and equipped with tangential channels by means of which the chamber is linked with the external circular volume of the casing, a cylindrical channel and a diffuser, with the first pressure bleeding pipe being connected to the cylindrical chamber by

means of a branch pipe, running through the twisting chamber of the centrifugal injector and in line with the latter.

It is advisable to make slotted nozzles on the external surface of the casing side wall, directed actually along the casing axis toward the output end to create an external jet screen.

Such a device can also be provided with an ejector, disposed outside the casing with the ejector nozzle input being connected to the excessive pressure source output of the compressible propulsive mass to connect the mixing chamber input with the input end of the second pressure bleeding pipe, whereas to dispose the diffuser output end in the space, adjacent to the zone of probable flame existence.

Such an embodiment of the applied flame presence checking device features reliable functioning and a high design reliability, which permits the employment of it in furnace process control systems, to reduce damage, caused by bursts in furnace chambers and destruction of equipment.

#### Brief Description of the Drawings

From now on the invention will be explained by specific descriptions of the embodiments and with references to the drawings, which illustrate the following:

Fig.1. General diagram of the device for checking flame for presence according to the invention.

Fig.2. General diagram of another embodiment of the device according to the invention.

Fig.3. General diagram of one of the embodiments of the device according to Fig.2.

Fig.4. General diagram of another embodiment of the device according to Fig.2.

Fig.5. External twisted stream generator of the device according to Figs. 1 and 2 (axonometry).

Fig.6. General diagram of one of the embodiments of the device according to Fig.2.

Fig.7. External and internal twisted stream generators of the device according to Figs.1,2,6 (longitudinal cross-section).

Fig.8. External and internal twisted stream generators of the device according to Fig.4 (longitudinal cross-section).

Fig. 9. External and internal twisted stream generators of the device according to Fig.3. (longitudinal cross-section).

Fig.10. General diagram of one of the embodiments of the device according to Fig.1.

Fig.11. Diagram of trajectories of flame particles in the nearest zone of the device according to Fig.1.

Fig.12. A chart of the device output signal variations according to Fig. 1 with flame being

present (absent).

Fig. 13. Diagram of trajectories of solid particles in the nearest zone of the device according to Fig.1.

Fig.14 a,b. Charts of output signal variations with flame being present (absent) in the device according to Figs. 1 and 5.

Fig.15. Diagram of trajectories of flame particles and solid particles in the internal zone of twisted stream generator of the device according to Figs. 1,2,6.

#### Preferable Embodiments of the Invention

The flame presence checking device according to the invention comprises a main casing 1 (Fig.1), into the cavity of which a compressible working mass is fed from a source 2 of an excessive pressure relative to the pressure in a furnace, for instance, of an air of a forced-draft fan or a compressor. On the operating side end of the casing 1, facing the flame (furnace) under check, there are two twisted stream generators, an external generator 3 and an internal generator 4, coaxially mounted.

In the casing 1 there are disposed two pressure bleeding pipes 5 and 6, mechanically linked with the casing 1. To the working side end of the casing 1, looking at the flame (furnace) being checked, run is the first pipe 6, connected with the zone of probable flame via the internal volume of the generator 4 to bleed pressure in the furnace, whereas the second pipe 5 is disposed coaxially with the pipe 6 and connected with the area outside of a zone, probably containing flame. By means of the other ends, the pipes 5 and 6 are connected to a differential pneumatic relay 7.

The applied device is designed for checking flame for presence, preferably of burners, operating on gaseous fuel and it is perceived that to ensure a reliable contact of the twisted streams with flame, the casing 1 is dipped into the flame to a small depth.

The main generator according to the diagram is an internal one 4 through which the smallest part of the compressible working mass, taken from the source 2, usually runs. The other part, the greatest one of the compressible working mass, used for cooling the casing 1, runs through the other generator 3 of the twisted stream, the twisting of this part of the stream is necessary to prevent the closing of the stream, coming out of the internal generator 4, that is to exclude an effect of the cooling stream, running through the external generator 3, on the flow pattern within the closest zone inside the twisted stream, running out of the generator 4.

Applied device is reliably cooled by air, flowing over the casing 1 and flowing through the twisted

stream generators 3 and 4, which ensures a great service life and excludes the effect of aggressive mediums (furnace gases) on the construction components.

At the same time the device according to the invention, reliably checks flame, since rarefaction inside the main twisted stream, coming out of the generator 4, depends on the presence or absence of the flame, a change in rarefaction is transferred to the relay 7 via the generator 4 and the pipe 6. Thanks to this fact, the device looks as if it "knows" where the twisted streams goes: to a place with burning or not.

The device according to the invention, as illustrated in Fig.2, is made up similarly to the one, displayed in Fig.1.

A difference consists in the provision of the device, according to Fig.2, with an auxiliary partition 8, manufactured in the form of a tube, mounted in the casing between the twisted stream generators 3 and 4 and in line with the latter so that two isolated volumes are formed: an external volume I and an internal volume II with the volume II communicating with an excessive pressure source 2 of compressible working mass directly, whereas the volume I, via a reducing means.

The provision of the device, according to the invention, with two volumes I and II, divided by a partition 8, makes it possible to separate flows, fed to the generators 3 and 4. This is appropriate to do, since it reveals a possibility to preserve a sufficiently great total pressure in front of the internal generator 4, independently from the velocity of the working mass through the external generator 3, which favourable effects the output signal value (a pressure jump in the course of inflammation).

A device according to the invention, illustrated in Figs. 3 and 4, is made up similarly to the device, displayed in Fig.2.

A difference lies in the fact that said embodiment of the device, according to the invention, is provided with an auxiliary source 9 (Figs 3 and 4) of fuel pressure, connected with the internal volume II (Fig.3), whereas the excessive pressure source 2 of the compressible working mass is connected with the external volume I, or vice versa, the source 9 (Fig.4) of fuel pressure is connected with the external volume I, whereas the excessive pressure source 2 of the compressible working mass is connected with the internal volume II.

In the first case the device according to the invention, as illustrated in Fig.3, is actually a burner or an injector, which is able to check its own flame. In case the fuel pressure source 9 is a source of gaseous fuel pressure, the device, according to the invention, as illustrated in Fig.3, is a gaseous, burner (an ignition device burner, a pilot burner, a main burner). Due to burning that takes place close

to the outlet of the twisted stream out of the generator 4, where it has an influence on the rarefaction value inside the twisted stream, said device possesses an extremely high selectivity of the flame checking, which means that the effect of burning of other burners on the rarefaction value is practically absent.

In case the fuel pressure source 9 constitutes a fluid fuel pressure source, the device according to the invention, as illustrated in Fig.3, is actually an injector with steam-and-mechanical or air atomization of the fuel, in this case the external generator 3 besides stream twisting, required for operation, simultaneously acts as a means of atomization. This being the case, the source 2 operates as a steam pressure or compressed air source.

In the second case with the fuel pressure source 9 (Fig. 4), connected to the external volume I, the device, according to the invention, constitutes actually an injector with mechanical fuel atomization, having an in-built burning indicator, the function of which is performed preferably by the internal twisted stream generator 4, fed from the source 2, in this case from a compressed air pressure source. As in the first case, the device according to the invention, possesses in addition to the above-mentioned advantages, a high selectivity in flame checking thanks also only to the effect of burning of rarefaction inside the twisted stream and connected with this event heat radiation inside its own flare under check.

In said embodiment of the device, according to the invention, as illustrated in Figs.1,2, the external twisted stream generator 3 (Fig.5) is made up in the shape of a spiral swirler 10, in one of whose channels there is a radial hole 11 made by means of which the pipe 5 communicates with the area adjoining the zone of a probable flame to be checked.

The spiral swirler 10 is one of the most popular embodiments of the twisted stream generators. In this case the embodiment is convenient, since the swirler 10 channel constitutes a separate nozzle, in which the flow velocity amounts to a small value. The connecting of the pipe 5, having the radial hole 11, where the pressure is a bit smaller than the pressure in the burner, it becomes possible to form a change of the pressure differential sign in the pipes 5 and 6 during inflammation. This fact brings about an independence of the device operation in flame checking, according to the invention, from the pressure level of the compressible working mass excessive pressure source 2 and from the pressure in the volume where the flame is being checked.

The device, according to Fig.6, when fed with fresh air, is designed to check the flame of the principle furnace burners with various functions, but

when it is fed with a gas-and-air mixture, its function is to check the flame of the ignition devices and pilot burners of their own.

The device according to Fig. 6 is manufactured similarly to the device, illustrated in Fig.2.

A difference resides in the fact that on the external surface of the main casing 1 (Fig.6) there are mounted slotted nozzles 12 of the external jet screen, directed essentially along the axis of the casing 1 towards its working side end. The jet screen makes it possible to lower the temperature of the casing 1, which has a beneficial effect on the service life of the device.

In the present embodiment, the device is designed to check flame of the principle burners, operating on a gaseous fuel.

In the embodiments, according to the inventions as illustrated in Figs 1,2 and 6, the internal twisted stream generator 4 (Fig.7) is made in the form of successively connected a cylindrical chamber 13 of twisting with tangential nozzles 14, communicating with the internal volume II of the casing 1, a cylindrical channel 15 and a diffuser 16, while the pressure bleeding pipe 6 being connected with the internal generator 4 via the central hole 17, made up in the wall of the cylindrical chamber 13 of twisting in line with the chamber 13.

The internal generator 4, made up as it is described in the device according to Fig.7, is optimal as a sensitive element of the applied device to check flame for presence and give a chance to build up a pressure jump in the course of inflammation (an original output signal), exceeding the supply pressure 1.2-1.8 times. A high level of the output signal assists in reliability of the device functioning and permits the device supply from a low-pressure forced-draft fan, which extends the application of the device.

The internal generator 4 should be made up as it is described above in the device, intended to check flame for presence in the principle burners (source 2- a low-pressure air source), to check flame for presence in the ignition and pilot burners proper (source 2 - a low-pressure gas-and-air mixture source) as well as in injectors with mechanical atomization of fuel, as an in-built device to check flame of the burning flares of just these injectors (source 2 - a source of low-pressure air).

In the device according to Fig.4, the internal twisted stream generator 4 (Fig.8) is made up as described in the device as illustrated in Figs 1,2, 6, whereas the twisted stream generator 3 is manufactured as a centrifugal injector 18 and constitutes in fact an injector with an inbuilt device to check flame of the burning flare of its nozzle. For normal operation of the device, the twisting of the streams in the internal and external twisted stream generators 3 and 4 should be concurrent (the directions

of twisting should coincide). The device according to Fig.8 features an especially high design reliability, connected with an effective fluid cooling of the casing 1.

In the device according to Fig.3 the internal twisted stream generator 4 (Fig.9) is made up in the form of an centrifugal injector 19, whereas the external twisted stream generator is made up in the form of a disposed coaxially with the casing 1 and in succession along the run of the working mass after the injector 19 and interconnected: a cylindrical chamber 13' of twisting, the diameter of which exceeds the diameter of the injector 19 twisting chamber and equipped with tangential chambers 14, by means of which the chamber 13' is linked with the external circular volume I, the cylindrical channel 15 and the diffuser 16, in the process the pressure bleeding pipe 6 communicates with the cylindrical channel 13', which runs via the twisting chamber of the centrifugal injector 19 and in line with it.

In such an embodiment, the applied device constitutes actually an injector with a steam or air atomization, in which a high-rate twisting of the stream, necessary to organize the working process, creates an external generator 3 - a steam or air atomizer.

The introduction of the branch pipe 20 has been caused by the fact that in spite of a gas eddy flow that takes place inside the injector 19 close to the axis of the latter running in the operating mode, and said flow can be used in principle to transfer a pressure impulse, in the transitional modes (when the fluid fuel supply is cut in and out) the fluid fuel can get into the pipe 6 and a violation of the applied device operation may occur. The branch pipe 20 is introduced into the root part of the external generator 3 stream, with a high angular velocity of eddy movements, due to which fuel particles are thrown to the periphery and clogging of the branch pipe 20 becomes impossible.

The device according to Fig. 10 is made up like the device, illustrated in Fig.1.

A difference consists in the provision of the device according to Fig. 10 with an ejector 21, disposed outside the casing 1, through which the pipe 5 communicates with the volume, adjoining the zone 1, inside of which there is flame to be checked, and an active nozzle 22, which is connected with the compressible working mass excessive pressure source 2. In this case the pipe 5 is disposed outside the casing 1.

Said device, according to the invention, is designed for checking the injector flare of its own, having a stream-mechanical, air, as well as mechanical atomization of the fluid fuel.

The wisdom of the ejector 21 introduction is linked with a necessity to shape a signal in the

form of a pressure differential with its own sign in the pipes 5 and 6, but to do it, it is necessary to have a back pressure a bit lower than the pressure in the volume which accommodates flame under check. This lowered pressure is just built up by the ejector 21. In other words, the ejector 21 in the devices of the injector type performs the same function as the radial hole 11 (Fig.5) in the air and gas and air embodiments of the applied device.

The principle of operation of the applied device involves the following.

From the internal generator 4 (Fig. 1) comes out a twisted stream "c" along of whose axis a sufficiently great rarefaction acts, and the less is a distance to the generator 4, the greater is a rarefaction. Under the effect of said rarefaction, a medium from the volume with the flame being checked, is sucked up by the stream and along the axis of the stream there is a flow coming out of the volume along the arrow "d" towards the device, according to the invention.

Directly close to the active part of the stream, flowing out of the generator 4, the medium, which was prior to it flowing out of the volume with flame under check, is ejected back into the volume, that is, the flow direction is changed to the opposite one as shown in Fig.11. Simultaneously, due to an exchange of impulses with the active part of the stream, the medium, located inside the twisted stream, is caught into the rotational motion, with the distribution of circular (tangential) velocities in this part of the flow being governed by the constant circulation law (a product of a circumferential velocity and a radius is a constant value). Thanks to it and close to the axis where a radius is small, a velocity is high, and, vice versa. Close to the axis, where a velocity is high, a static pressure is low.

In the mode without burning (flame is absent) said rarefaction is transferred to the membrane of the differential pneumatic relay 7 (Fig.1) via the pipe 6, and the membrane opens the contacts. To exclude the effect of pressure in the volume (furnace) under check on the operation of the applied device, the pressure is transferred through the pipe 5 to the same differential pneumatic relay 7, but into the opposite cavity relative to the membrane.

In the mode with burning (flame is present) the twisted stream sucks up hot end products of combustion out of the volume under check, which gets into heat exchange with the working mass, coming out of the twisted stream generator 4, heating it up, with the level of pressures in all points inside the twisted stream being increased and to the greatest extent directly at the generator 4 output. The rarefaction actually disappears and the membrane of the differential pneumatic relay 7 closes the contacts.

Thus, inside the twisted stream a pressure jump is built up in the course of inflammation, which presents an initial signal that characterizes flame (burning).

Should flame disappear due, for instance, to a stop in the fuel supply to the burner being checked or due to other causes, rarefaction is regained inside the twisted stream and the membrane of the pneumatic relay 7 opens the contacts again.

The excessive pressure source 2 is certain to be a source of the compressible working mass excessive pressure, because only in this case heat supply, linked with the suction up of hot end products of combustion, can cause a rise in pressure.

For normal operation the applied device is to have a contact with flame under check or at least it should be disposed in close vicinity to it so as to effect said suction up of hot end products of combustion by the stream.

To do it, the applied device, according to the invention, is provided with a protection facility against heating by radiation and convective thermal flows. Since the flow rate of the compressible working mass, required for the internal generator 4 operation is small and, as a rule, insufficient for cooling the casing 1, the flow rate in the casing 1 is increased by disposing the greatest part of the working mass into the volume, where flame is being checked. This greatest part of the working mass flow is also subject to twisting, and it should be twisted with the same sense as the stream at the output of the generator 4, so as to avoid disturbing the flow pattern close to the device output. These functions are accomplished by the external twisted stream generator 3, from which the twisted stream "e" is flowing out.

In case the generator 3 is not used and instead of it a slotted nozzle is employed to dispose the greatest part of the working mass, utilized as a refrigerant, the disposed flow will screen the twisted stream of the generator 4 and the work of the applied device will be disrupted.

The device, illustrated in Fig.1, when a source of compressed air is employed, can be used to check flame of the principle burners of power boiler furnaces, whereas when a source of a gas-and-air mixture is employed, to check its own flame of the ignition and pilot burners. In the latter case the both streams constitute stream of a combustible mixture, the burning of which aids in the increase of a pressure jump during inflammation.

A typical characteristic of the applied device: the dependence of rarefaction on the supply pressure ( $P_2$  is a pressure in the source, the abscissa axis,  $P_6$  is a pressure in the pipe 6, the axis of ordinates) and a pressure jump "h" (rarefaction) during firing are shown in Fig.12, where a line "n" denotes the mode without burning, and a line "g",

the mode with burning.

An important specific feature of twisted streams that aids in improving the reliability of the applied device for flame checking lies in the fact that dust, products of fuel thermal destruction and particles of fuel that failed to burn up in the axial part of the flow being sucked up, move unsteady; under the effect of centrifugal forces, which are especially great in the stream part that is close to the axis, where the tangential component of the velocity rises in the inverse proportion to the radius, whereas the angular velocity in the inverse proportion to the square of the radius, particles "f" are thrown towards the active flow and are blown back into the volume under check. The nature of the "f" particle trajectory is shown in Fig. 13.

In the flame checking device according to the invention as illustrated in Fig.2, there is introduced an auxiliary partition 8 due to which the working mass flows, delivered to the twisted stream generators 3 and 4, are separated, which also aids in preserving a sufficiently high total pressure upstream of the generator 4 and in the long run results in an increase of the output signal level, since a sufficiently high level of rarefaction is preserved in the mode without burning, when there is no flame, and at the same time a great value of the pressure jump, developing if rarefaction disappears in the mode with burning, when flame is present.

The introduction of the fuel pressure source 9 (Fig. 3, 4) provides for extension of the application sphere.

In case the fluid fuel pressure source 9 (Fig.3) is connected with the internal volume II of the casing 1, whereas the source 2 - a steam pressure or compressed air source is connected with the external volume I of the casing 1, the device operates as an injector with steam-mechanical or air atomization, which checks burning of its own flare. The external generator 3 in this embodiment of the device functions as a main source of the flow twisting and simultaneously as an atomizer, since the rate of a steam or air stream is essentially higher than the rate of fluid stream outflow. Nevertheless, the principle of the applied device operation does not change: heat radiation during fluid fuel burning and adherence-by-suction of inflammable end products of combustion result in a pressure (rarefaction) jump in the axial part of the twisted stream and finally in the operation of the differential pneumatic relay 7.

In case the connections of the sources 2 (Fig.4) and 9 change places, the device, according to the invention in this embodiment, can be used as an injector with a mechanical fuel atomization and as a flame checking device with a low-pressure supply of the internal generator 4. The cooling of the casing 1 with a liquid fuel is effective and the

service life of the device is increased. The source 2 in said embodiment of the device can be of a low-pressure type, since the internal generator 4, which does not perform an additional function of an atomizer, can have an optimal through part from the point of view of building up a deep rarefaction and a pressure jump after the emergence of flame, which will be displayed later.

The manufacture of the external generator 3 (Fig.5) in the form of a spiral swirler 10, provided with a radial hole 11 in one of the channels of the swirler 10, used to connect the pipe 5 with a volume, where flame is being checked, makes it possible to achieve a change in the pressure differential sign at the membrane of the pneumatic relay 7 thanks to a rarefaction, acting in the channel of the swirler 10 which assists in additionally increasing the functional reliability of the applied device operation in general.

A change of sign of the pressure differential  $P_5, P_6$  ( $P$  is the axis of ordinates), supplied to the pneumatic relay 7 by means of the pipes 5 and 6 in this embodiment of the device, takes place when flame appears or disappears irrespective of the supply pressure  $P_2$  (the abscissa axis), as shown in Fig. 14a.

The dependence of the differential  $P = P_5 - P_6$  of pressures (the axis of ordinates) on the supply pressure  $P_2$  is displayed in Fig. 14b.

It is advisable to employ this embodiment of the device when for some reason or other the pressure of the source 2 or a counter pressure in the volume, where flame is being checked, is changed within a wide range, for instance, when the device is fed from a forced-draft boiler fan, loaded by a group of principle burners, through which the air rate is adjusted. In this case a change of pressure source 2 occurs, connected with a change in the leading on the fans, as well as in the furnace pressure, which linked with a change in the thermal loading of the furnace.

It is advisable to supply an embodiment of the device, according to the invention, as illustrated in Fig.6, intended to check flame or a principle burner and fed with air from the excessive pressure source 2, with slotted nozzles 12 so as to create an external jet screen, aimed at additional protection of the casing 1 against the effect of hot end products of combustion.

The air, flowing out of the nozzles 12, flows over along the casing 1, building up protection in a shape of a screen, which is afterwards eroded by the twisted stream, coming out of the generator 3, due to which cold air is prevented from getting inside the twisted stream, flowing out of the generator 4, and the device, according to the invention, is protected against disruption in operation.

Fig.7 display an embodiment of the device whose internal generator 4 of the twisted stream is made up in the from of successively connected: a cylindrical chamber 13 of twisting with tangential nozzles 14, a cylindrical channel 15 and a diffuser 16, whereas the connection of the pipe 6 to the internal generator 4 is carried out via a hole 17 in the wall of a twisting cylindrical chamber 13.

In said embodiment of the device, according to Figs. 1, 2,6, the output signal - rarefaction, is considerably increased in the cylindrical chamber 13 (Fig.7) and a pressure jump (rarefaction) during flame emergence. With the relations of dimensions of the chamber 13, through cross-sections of the tangential nozzles 14 of the chamber 13, the cylindrical diffuser 15 and the conical diffuser 16, being optimal, the value of the pressure jump essentially exceeds the supply pressure value. The essence of the problem is as follows: a twisted stream in the cylindrical chamber 13 and especially in the cylindrical channel 15, possesses much higher angular rates of rotation than the twisted flow in the cone-shaped stream outside the device. Simultaneously increased is the amount of a rarefaction in the mode without burning and a pressure jump (rarefaction) during inflammation. Since the maximum rarefaction acts on the axes of the twisting cylindrical chamber 13, the hole 17 intended for connection of the impulse pipe 6 should be disposed just there, with the diameter of the whole 17 being small, much smaller than the diameter of the cylindrical diffuser 15. Otherwise due to a rise in the static pressure with an increase in distance from the chamber 13 axis, the values of rarefaction and pressure jump during inflammation will noticeably decrease.

The operation of the device in said embodiment differs from the preceding embodiments only by the fact that the end products of combustion are sucked up out of the volume where flame is being checked, not only into the twisted stream, but inside the conical 16 and cylindrical 16 diffusers, simultaneously heating a cold flow close to the walls in the indicated diffusers and increasing (in the mode of burning with flame present) the hydraulic resistance of the diffusers 15, 16, preferably of the diffuser 15, which results in a sharp rise of pressure in the chamber. The conical diffuser 15, mounted after the cylindrical diffuser 15, serves preferably to give a direction to the twisted stream, adhering to the walls of the diffuser 16.

An important specific feature of the twisted stream generator is that the latter displays a clearly defined instability in the motion of dust particles, unburnt fuel, as due to high angular rates of the flow rotation in the diffuser 15, the particles are efficiently thrown by the centrifugal forces towards the walls of the diffuser 15 and without reaching

the walls, they are blown by a high-velocity cold flow close to the walls back out of the device.

Thanks to it the applied device is not contaminated by particles and features a high reliability in functioning in dusty and contaminated medium. The trajectories of particles "f" and the border of particle penetration into the device according to Figs 1,2, 6 are shown in Fig.15.

Fig.8 displays an embodiment of the device according to Fig.4, in which the internal generator 4 comprises a cylindrical chamber 13, and cylindrical 15 and conical 16 diffusors to form a signal of a higher level, while the external generator 3 is an injector with mechanical atomization of the fluid fuel.

A merit of said embodiment of the device is a reliability in functioning as a burning indicator with a low-pressure source 2 of the compressible working mass excessive pressure and a selectivity in flame checking.

Fig.9 shows an embodiment of the device according to Fig.3, in which the internal generator 4 is a centrifugal injector 19. The device is provided with a branch pipe 20, mounted coaxially with the internal generator 4. The branch pipe 20 runs through a gas eddy flow of the injector 19, with no effect on the operational characteristics of said injector, and serves to prevent the fluid fuel from getting into the pipe 6 (Fig.3) during cutting in and cutting out of the source 9.

Said embodiment is designed to check flame for presence in the injector flare with steam-and-mechanical or air atomization. A merit of the indicated embodiment of the device is a simplicity of its design.

Fig.10 shows an embodiment of the device to check flame for presence, which is provided with an ejector 21, an active nozzle 22 of which is connected with the source 2 and the pipe 5, whereas the output is directed towards the volume, where flame is being checked. The ejector 21 is a gas-dynamic appliance, similar to the twisted stream generator 4, and when fed from the excessive pressure source 2, it builds up a rarefaction proportional to the rarefaction in the twisted stream generator 4. A rarefaction in the ejector 21 is selected a bit smaller than that in the generator 4 in the mode without burning, when there is no flame. As a result after ignition, when rarefaction disappears in the twisted stream, a pressure differential at the membrane of the pneumatic relay 7 changes its sign. The application of the ejector 21 is equal to the introduction of the radial channel II in the spiral swirler 10, as illustrated in Fig.5.

It is advisable to employ the device with the ejector 21 to check flame for presence in the injector flares. Therethrough, as is evident from the mentioned above, the applied flame checking de-

vice possesses a high constructional reliability and it is marked by a reliability in functioning.

#### Industrial Applicability

The flame checking device can be employed to generate signals, indicating the presence (absence) of flare burning of principle burners, operating on a gaseous or fluid fuels (water-coal suspensions included), as well as flares of ignition devices in the control systems of furnace processes, the presence (absence) of flame in burner means with various functions in energetics, petrochemistry and metallurgical engineering.

#### Claims

1. A flame checking device, comprising a through casing (1), communicating close to one of its ends with a source (2) of a fluid medium under excessive pressure and having at opposite outlet end a means of shaping a fluid medium stream, a differential pneumatic relay (7) and two pressure bleeding pipes (5, 6), connected by means of the first ends with an appropriate cavity of the pneumatic relay (7) each, and by means of the second ends of the pipe (6) with the zone of probable presence of flame, and the pipe 5, with the area outside said zone, **characterized** in that the means of shaping a fluid medium stream is made up in the form of two coaxially disposed twisted stream generators (3,4), external and internal ones, mounted in line with the casing (1) at its output end, with the end of the pressure bleeding pipe (6) being disposed in the casing (1) coaxially with the internal twisted stream generator (4) and connected with the zone of probable presence of flame via the internal volume of said generator.
2. The device according to Claim 1, **characterized** in that it is supplied by a second source (9) of the fluid medium under excessive pressure, but in this case a cylindrical partition (8) is mounted in the casing (1) and in line with it, which divides the casing (1) into two isolated coaxially disposed volumes: an external volume (I) and an internal volume (II), the first of which is connected with one pressure source and the external generator (3) of the twisted stream, while the second volume, with another source of pressure and the internal twisted stream generator (4).
3. The device according to Claim 2, **characterized** in that both sources use compressible working mass as a fluid medium and both pressure sources are combined into one com-

mon source (2), and in so doing one of the coaxially disposed volumes (I or II) of the casing (1) is connected with the integrated source (2) of the excessive pressure by means of a reducing appliance.

4. The device according to Claim 2, **characterized** in that a compressible working mass is used as a fluid medium in the pressure source (2), whereas an incompressible propulsive working mass in the fluid medium source (9).

5. The device according to Claim 3, **characterized** in that the external twisted stream generator (3) is made up in the form of a spiral swirler (10) in one of whose channels there is provided a radial hole (11) through which a pressure bleeding pipe (5) communicates with the region adjoining the zone of probable presence of flame, with the pipe (5) proper being disposed in the external circular volume (I).

6. The device according to Claim 4, **characterized** in that in case the external circular volume (I) of the casing (1) is connected a source (9) of the incompressible working mass excessive pressure, the external generator (3) of the twisted stream is made up in the form of a centrifugal injector.

7. The device according to Claims 5 and 6, **characterized** in that the internal twisted stream generator (4) is made up in the shape of successively connected: a cylindrical chamber (13) of twisting with tangential nozzles (14), connected with the internal volume (II) of the casing (1), a cylindrical channel (15) and a diffusor (16), while the pressure bleeding pipe (16) is linked with the internal generator (4) through a central hole (17), manufactured in a side end wall of the twisting cylindrical chamber (13) and in line with it.

8. The device according to Claim 4, **characterized** in that the cavity of the internal volume (II) is connected with the pressure source (9) of the incompressible working mass, whereas the cavity of the external volume (I) is connected with the excessive pressure source of the compressible working mass, the internal twisted stream generator (4) is made up in the form of a centrifugal injector (19), whereas the external twisted stream generator (3) is made up as coaxially disposed relative to the casing and in succession along the run of the working mass behind the injector (19) and connected with each other, a cylindrical chamber (13'), the diameter of which exceeds the diameter of the

twisting chamber of a centrifugal injector (19) and equipped with tangential channels (14) through which the chamber (13') is linked with an external circular volume (I), of the cylindrical channel (15) and a diffusor (16), with the pressure bleeding pipe (6) being connected with the cylindrical chamber (13') by means of a branch pipe (20), passing through a chamber of twisting of the centrifugal injector (19) in line with the latter.

9. The device according to Claim 1, **characterized** in that on the external surface of the side wall of the casing (1) there are slotted nozzles (12), directed actually along the axis of the casing (1) towards its outlet end to create an external jet screen.

10. The device according to Claim 1, **characterized** in that the device comprises an ejector (21), disposed outside the casing (1), with the inlet of the nozzle (22) of the ejector (21) being connected to the output of an excessive pressure source of the compressible working mass, the inlet of the ejector (21) is connected with the input end of the pressure bleeding pipe (5), whereas the output end of the ejector (21) diffusor is disposed in an area adjoining the zone of probable presence of flame.

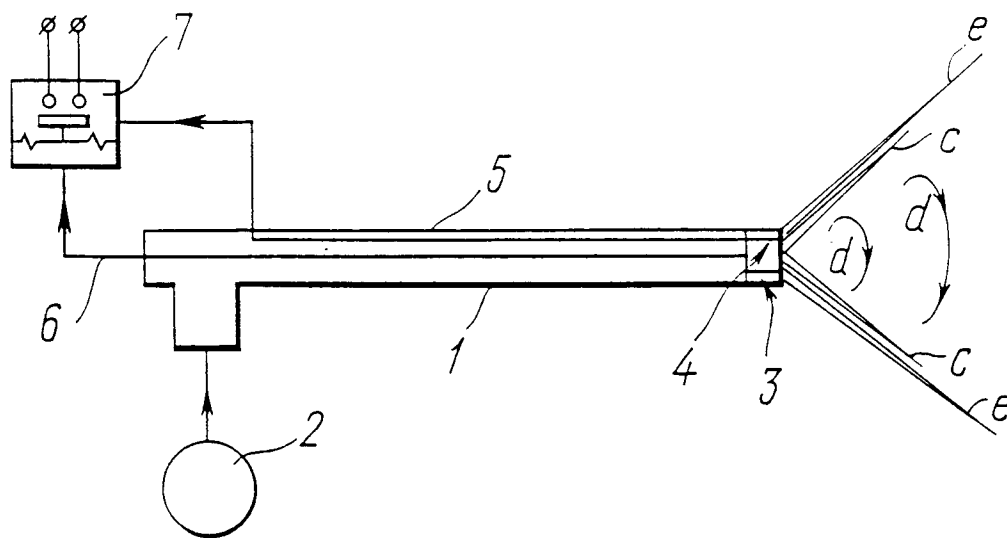


FIG.1

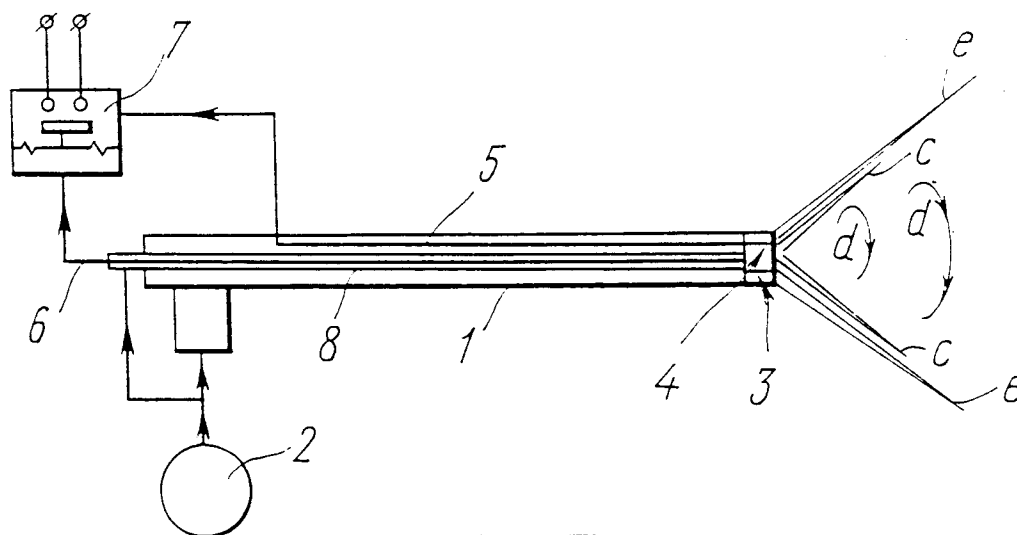


FIG.2

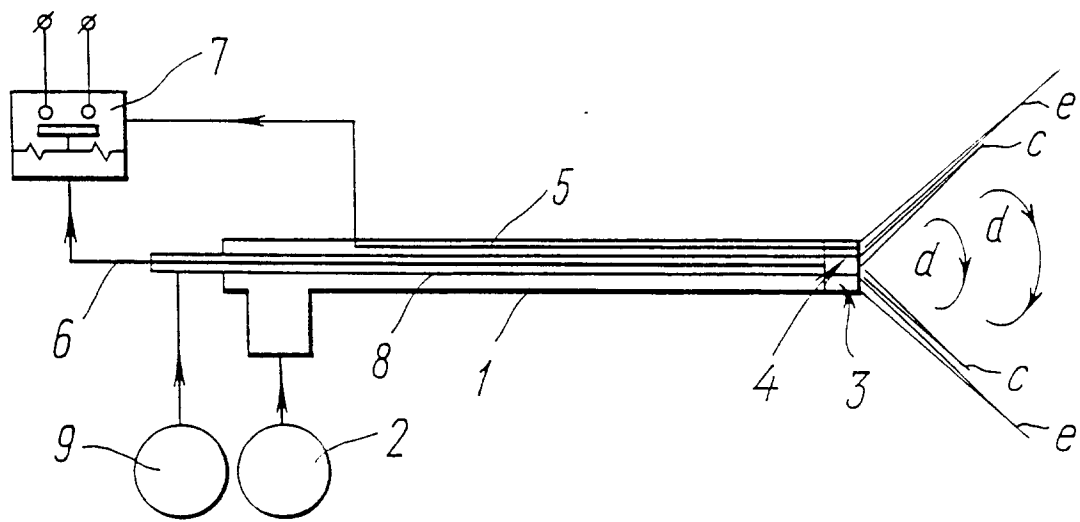


FIG. 3

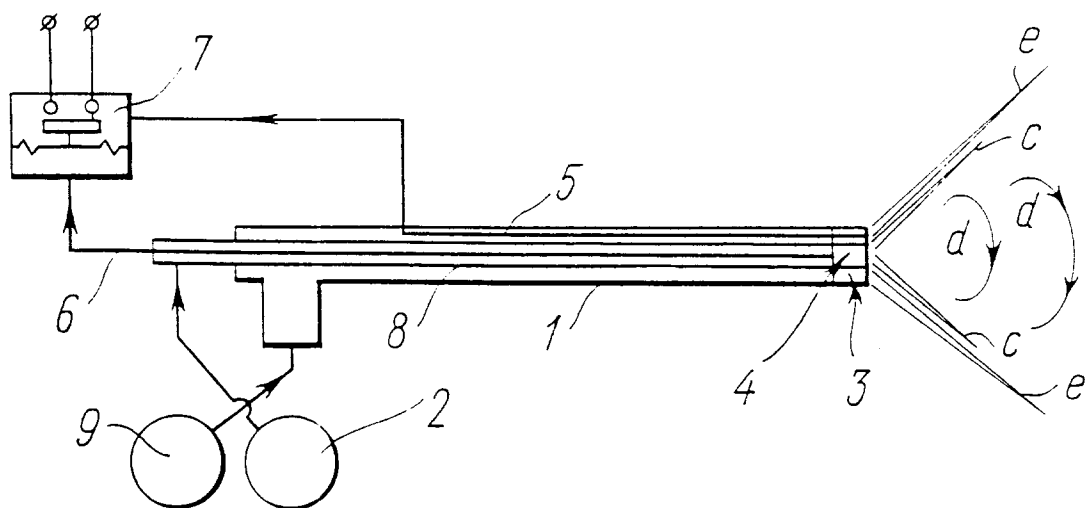
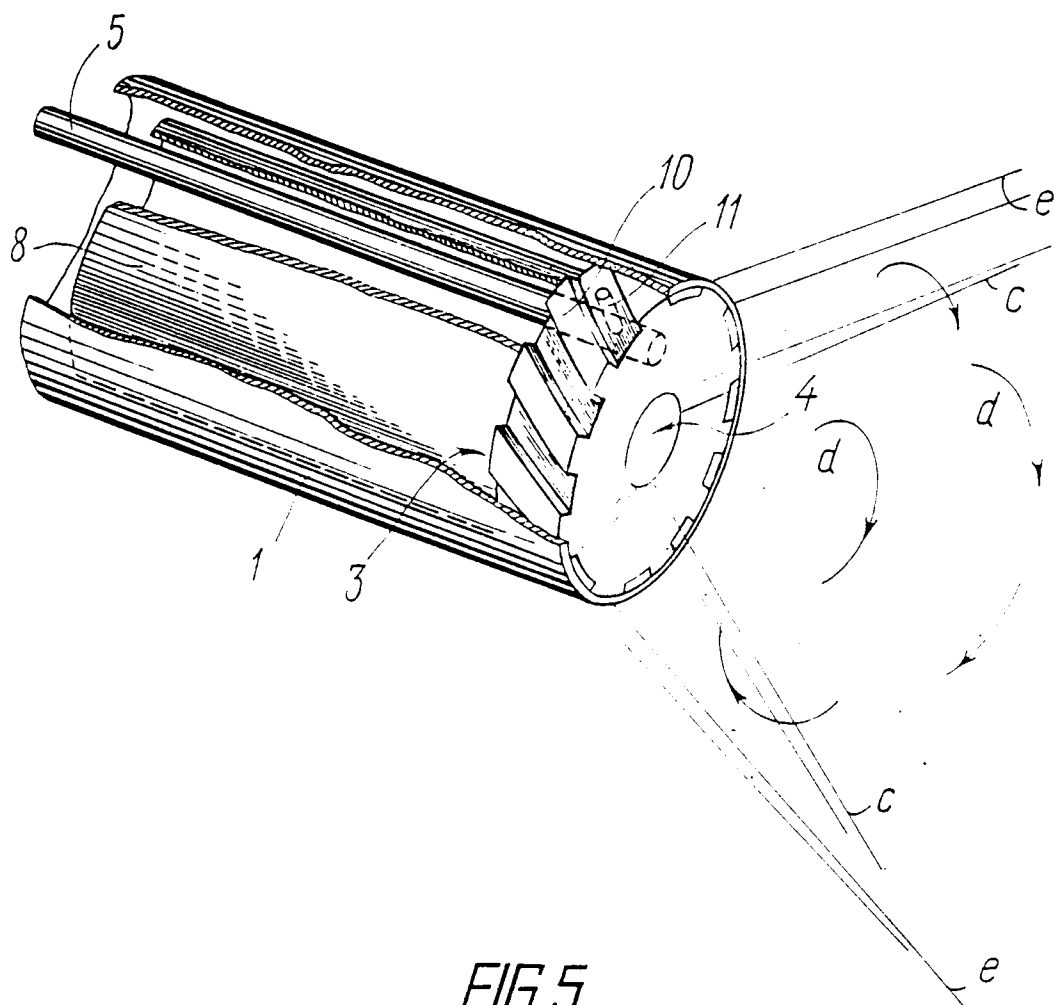


FIG. 4



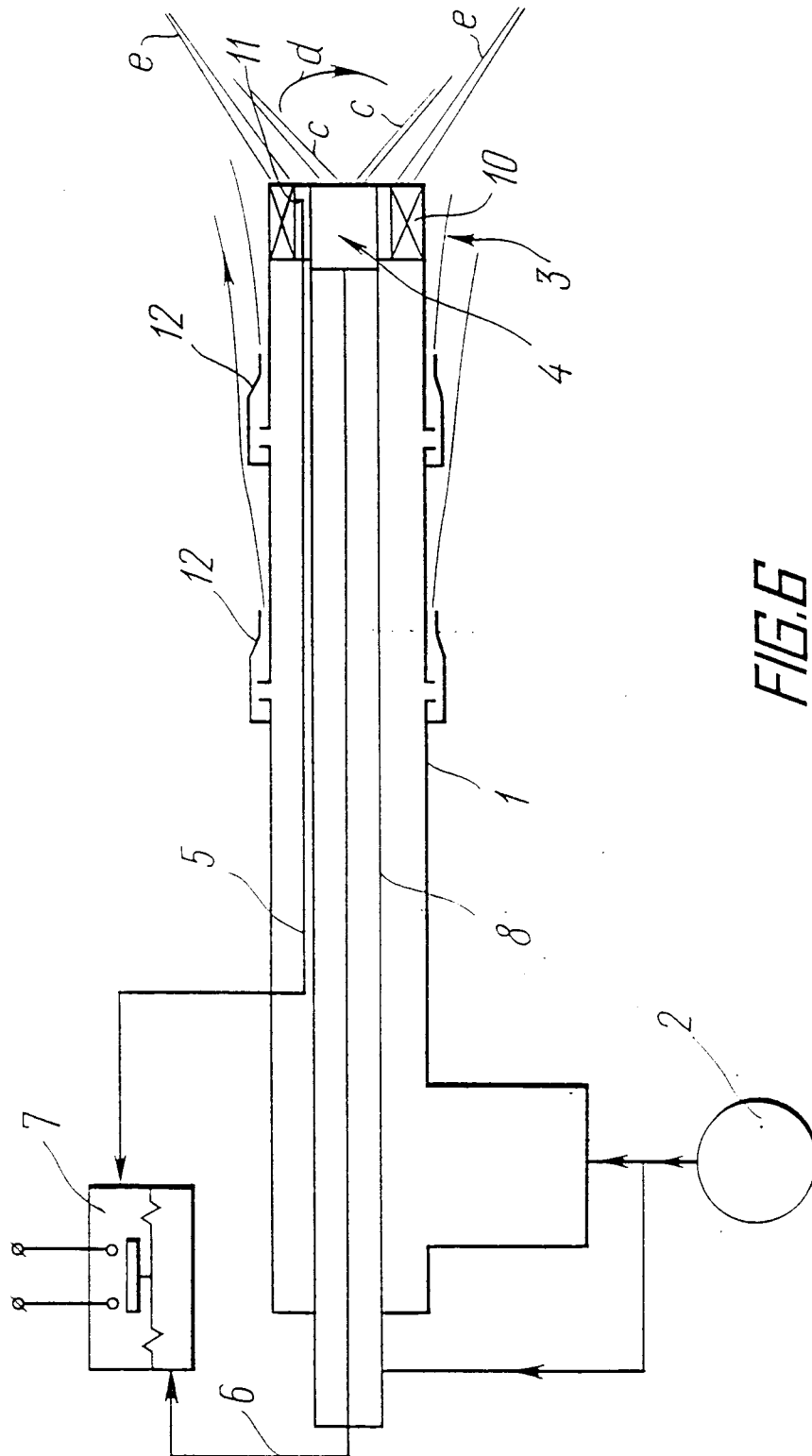


FIG. 6

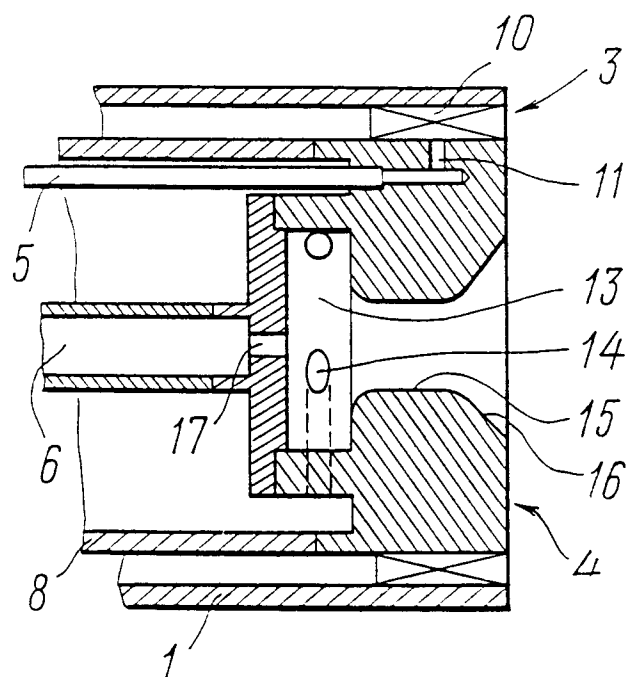


FIG. 7

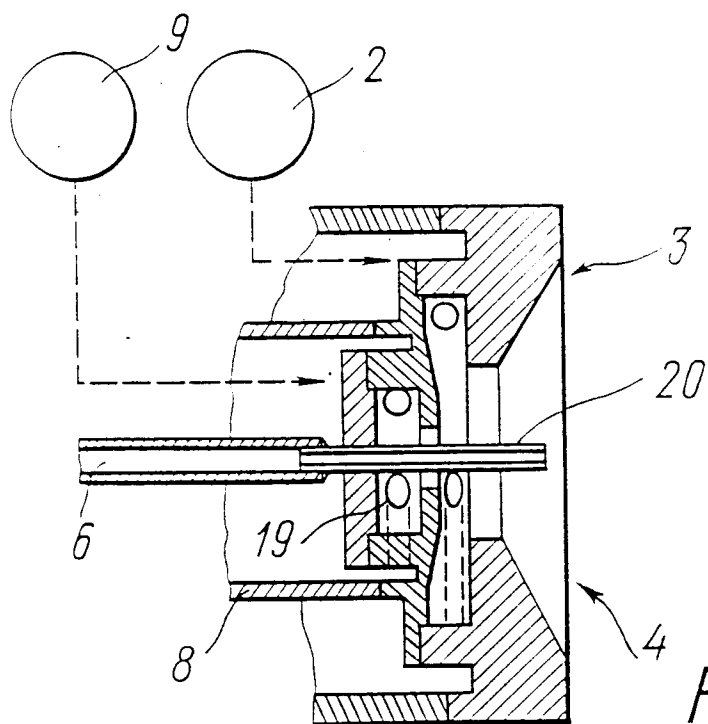
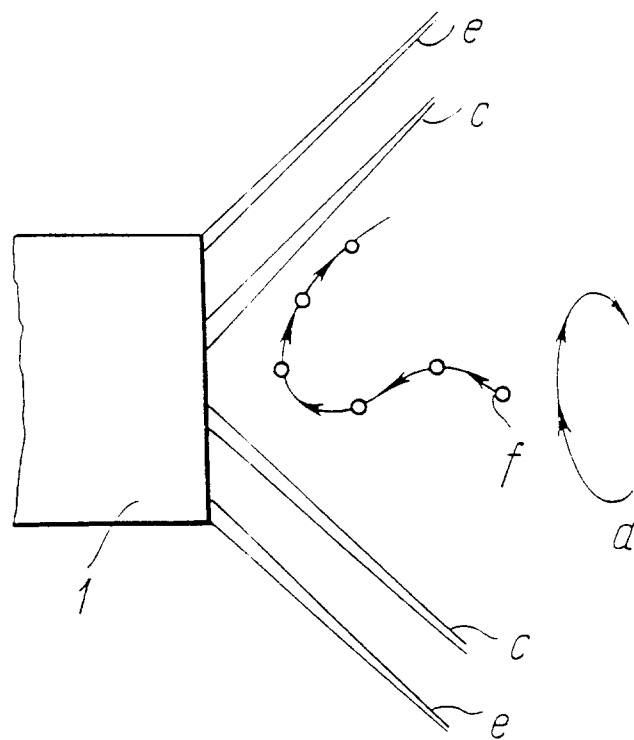
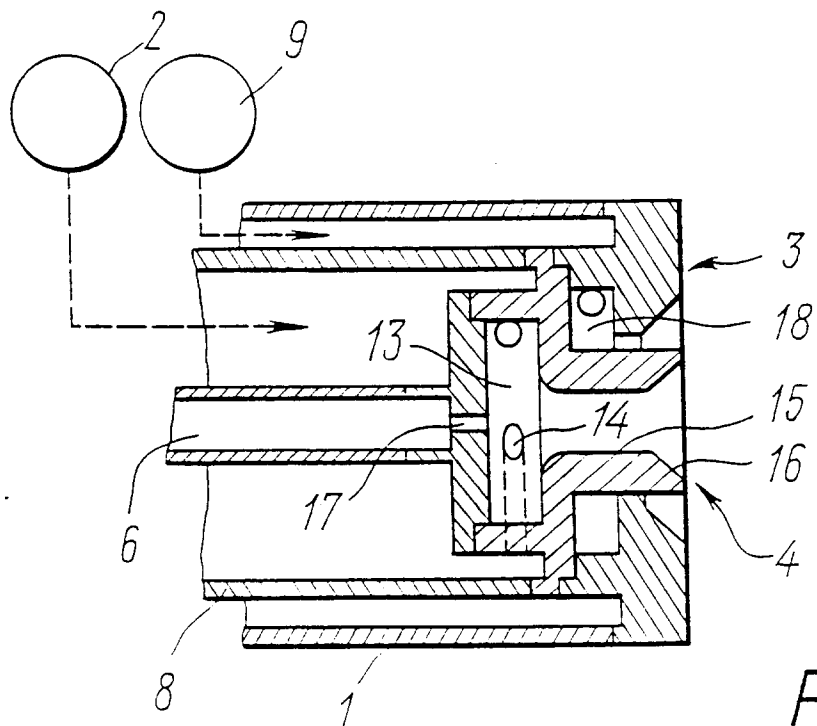
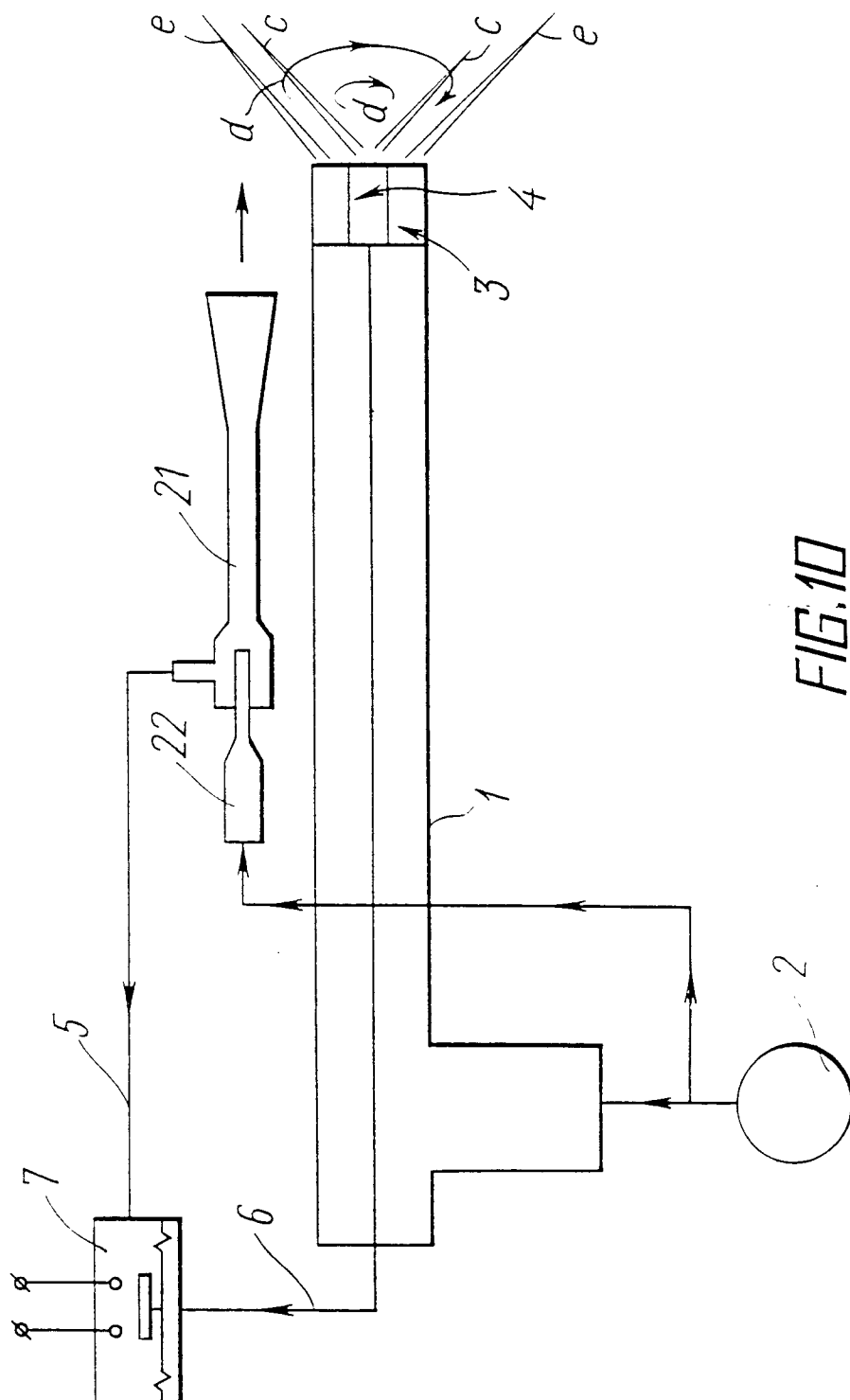


FIG. 9





**FIG. 10**

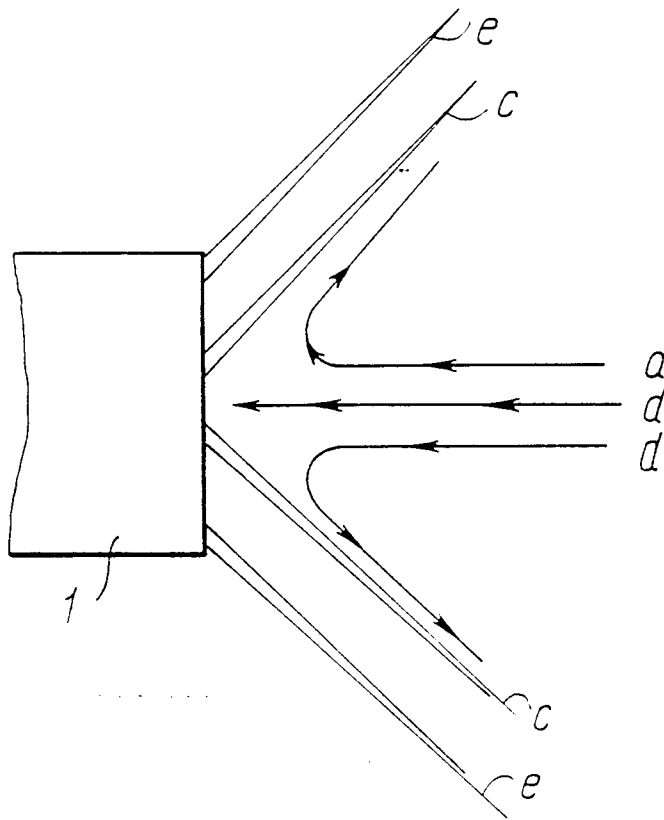


FIG.11

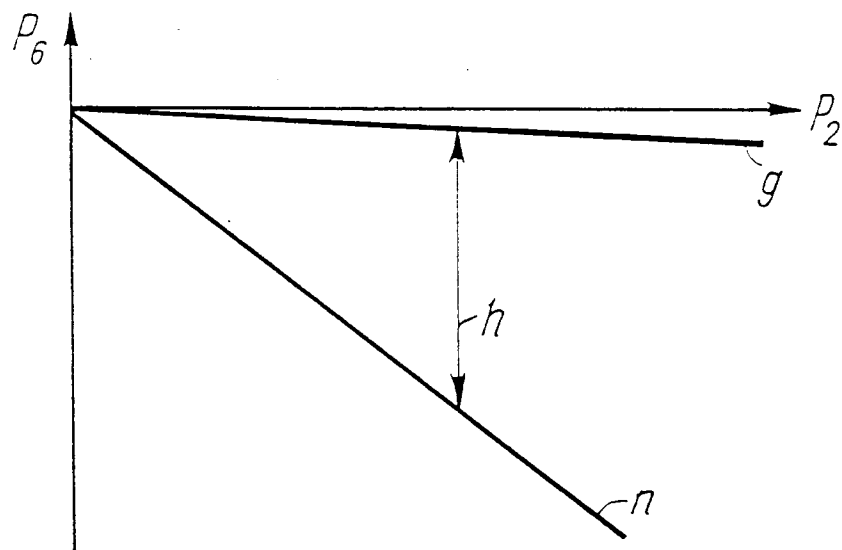


FIG.12

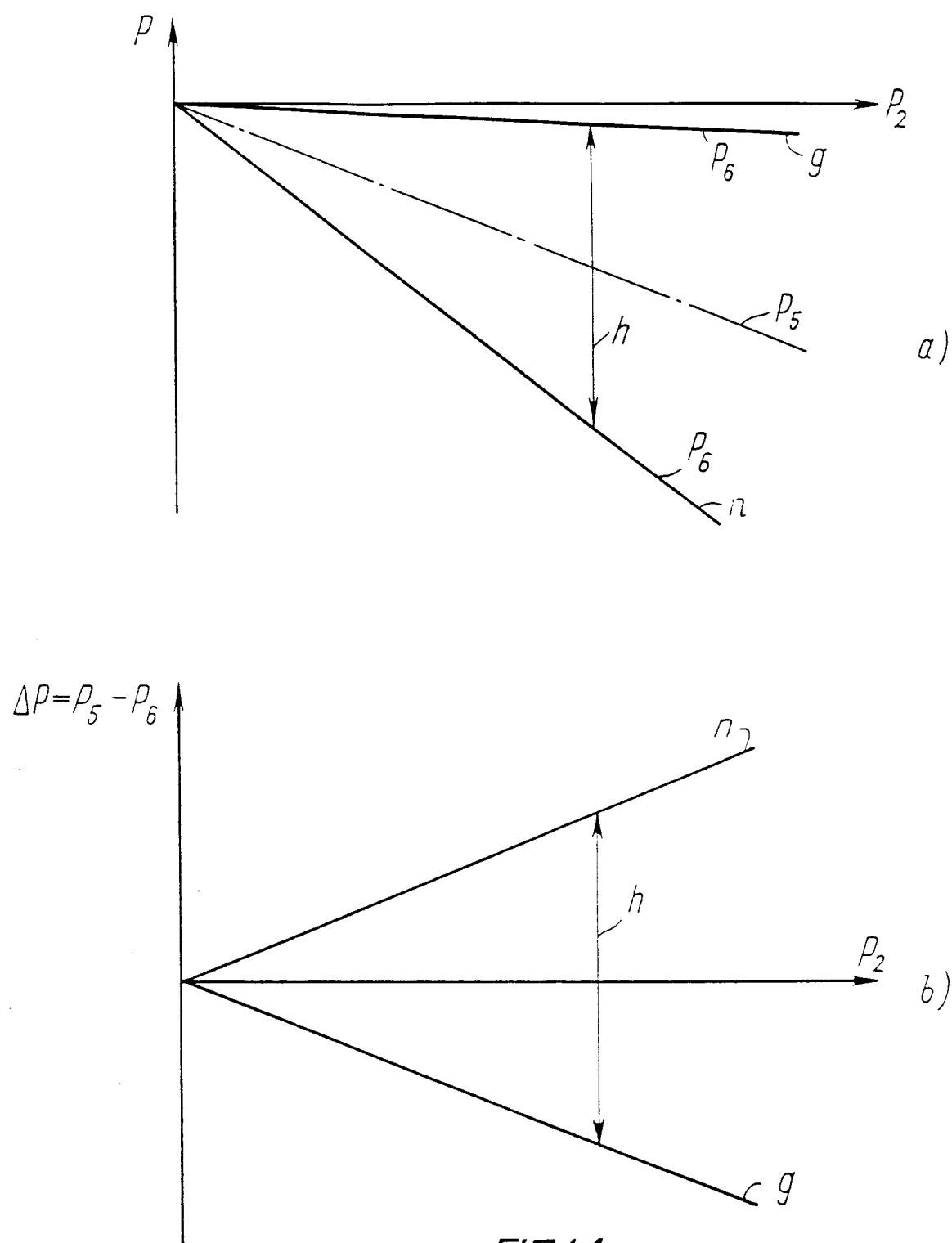
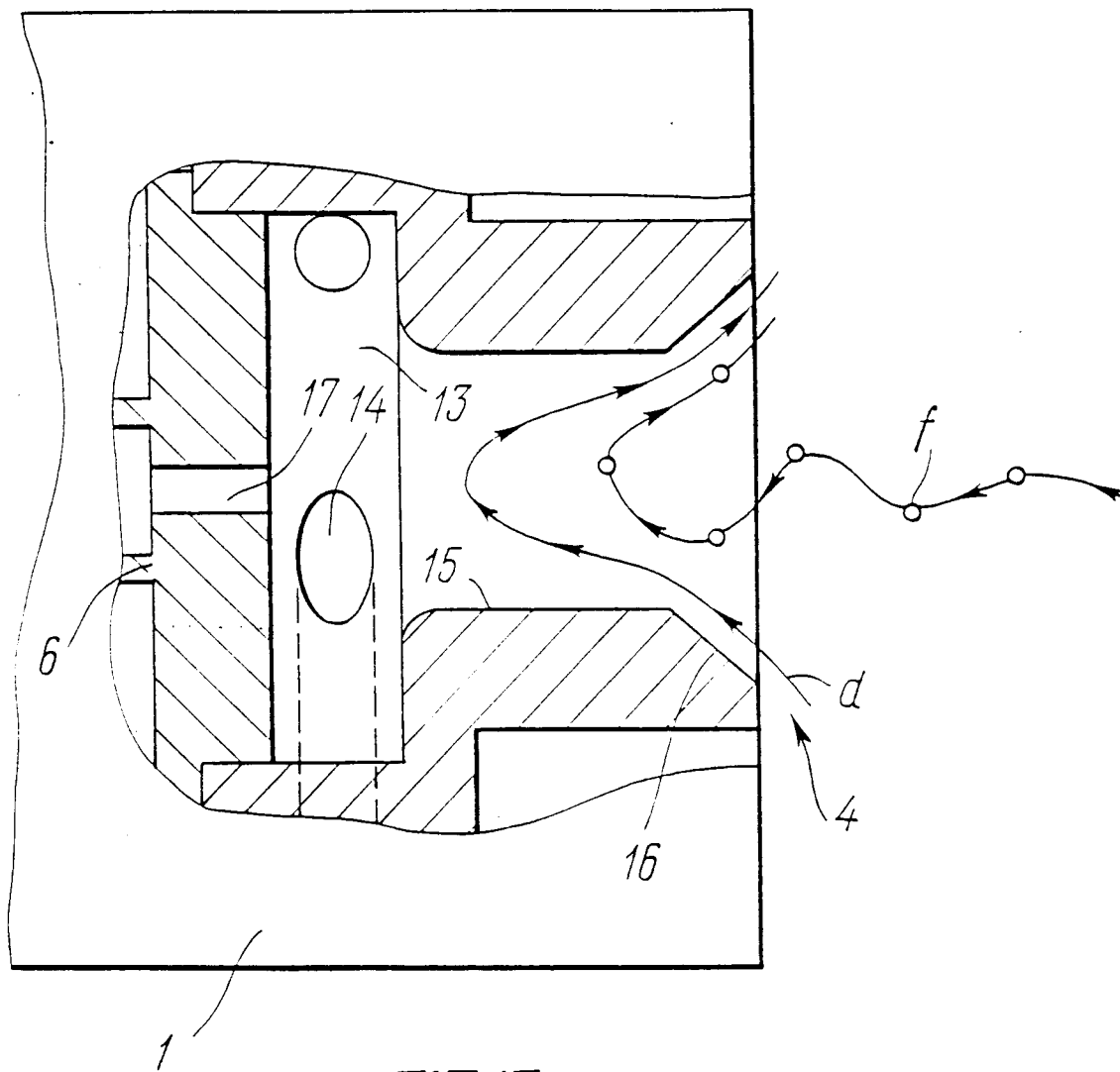


FIG.14



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/RU93/116

## A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.5 F23N5/24

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)

Int. Cl.5 F23N 5/24, F23N 1/00

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 practicable, 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         | US, A, 3467502 (J.E. DAVIS),<br>16 Septembre 1969 (16.09.69)                                                     | 1,2                   |
| A         | DE, A, 1227183 (SCHMITZ & APELT),<br>20 Octobre 1966 (20.10.66)                                                  | 10                    |
| A         | SU, A1, 1071882 (Gosudarstvenny Proektny Institut<br>"Kharkovskii Santekhproekt"),<br>7 February 1984 (07.02.84) | 1,2,4                 |
| A         | SU, A1, 1326842 (Ju.S. Dvukhzhilov et al),<br>30 July 1987 (30.07.87)                                            | 1                     |

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

## \* Special categories of cited documents:

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"&amp;" document member of the same patent family

Date of the actual completion of the international search

21 December 1993 (21.12.93)

Date of mailing of the international search report

14 January 1994 (14.01.94)

Name and mailing address of the ISA/RU

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