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Lang

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[54] **DEVICE FOR THE IMPLEMENTATION OF PROCEDURES FOR THE DECONTAMINATION OF INTERNAL COMBUSTION ENGINE EXHAUST GASES**

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[30] **Foreign Application Priority Data**

Aug. 16, 1971 Germany .... P 21 40 910.9

[52] **U.S. Cl.** .... **261/65**, 261/112, 48/180 R

[51] **Int. Cl.** **F02m 29/14**

[58] **Field of Search** .... 261/65, 112; 48/180 R

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[57] **ABSTRACT**

A device for the implementation of procedures for the decontamination of internal combustion engine exhaust gases by preparation of a flammable and ignitable air-fuel mixture with a variable air ratio figure λ by means of a throttle flap adjustment regulating the fuel jet hydraulic resistance, and which is adjustable such that fuel atomization is performed, using a throttle flap permitting a tolerated air gap all around the circumference in the carburetor duct for the throttle flap position $\alpha = 0°$, which has rims with bores on both sides, and which is followed by a ramjet in the carburetor duct.

15 Claims, 7 Drawing Figures

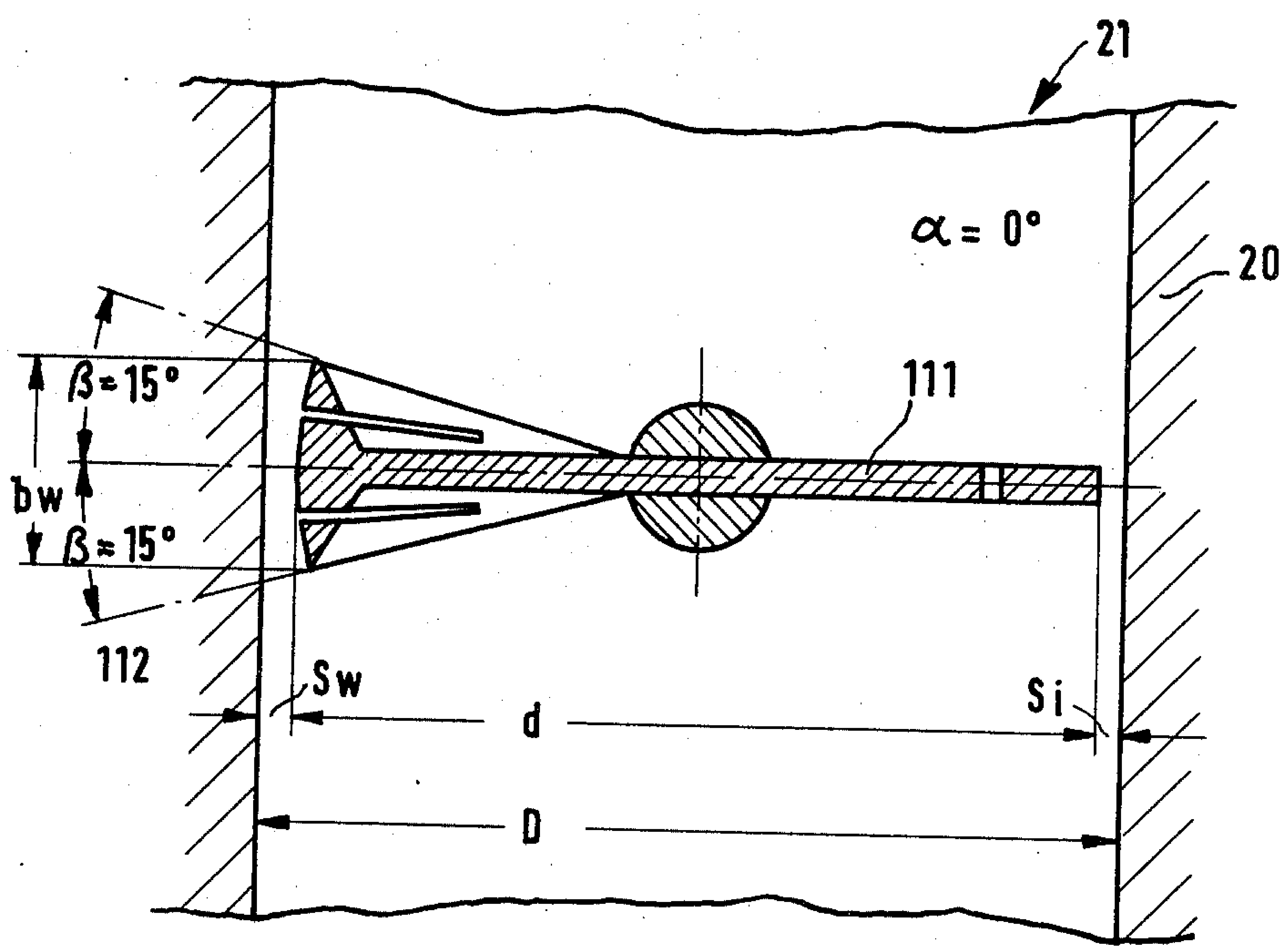
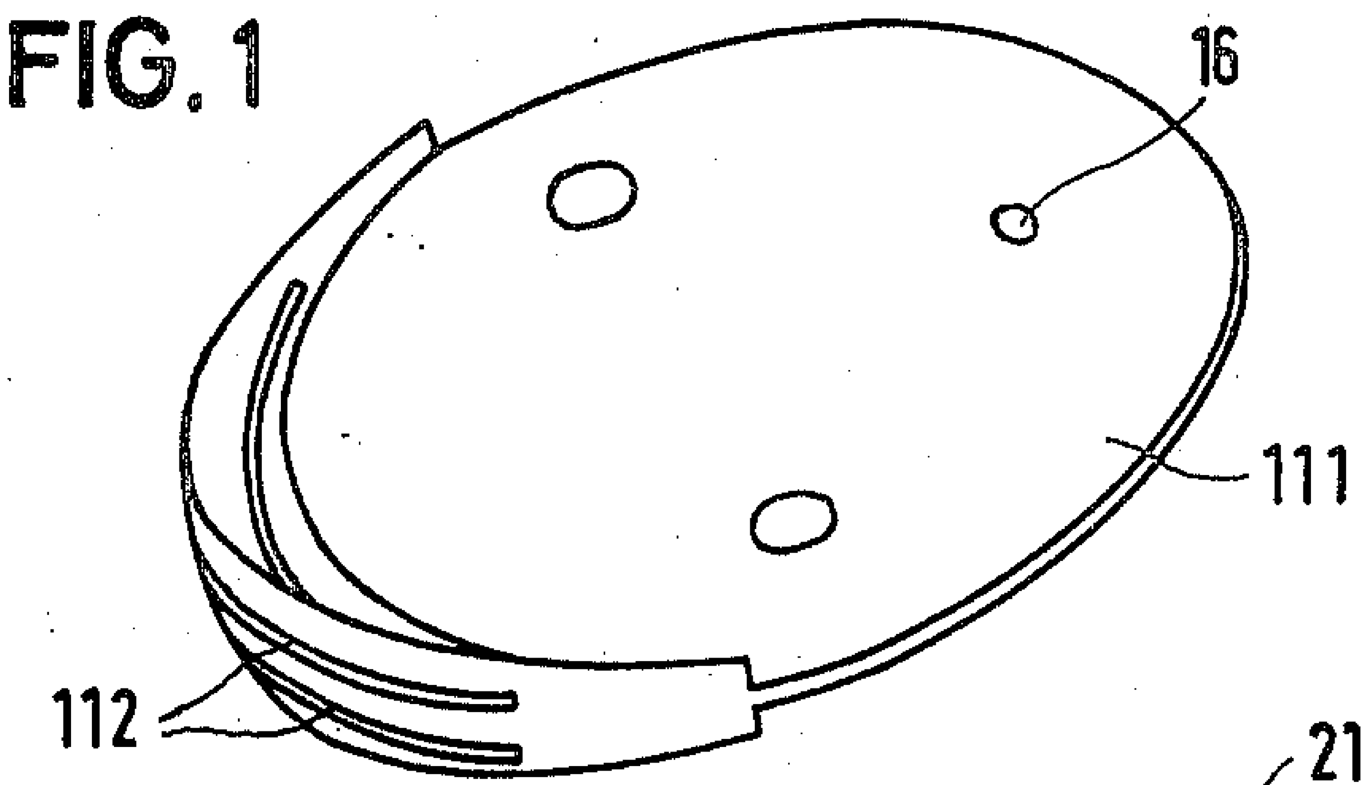


FIG. 1



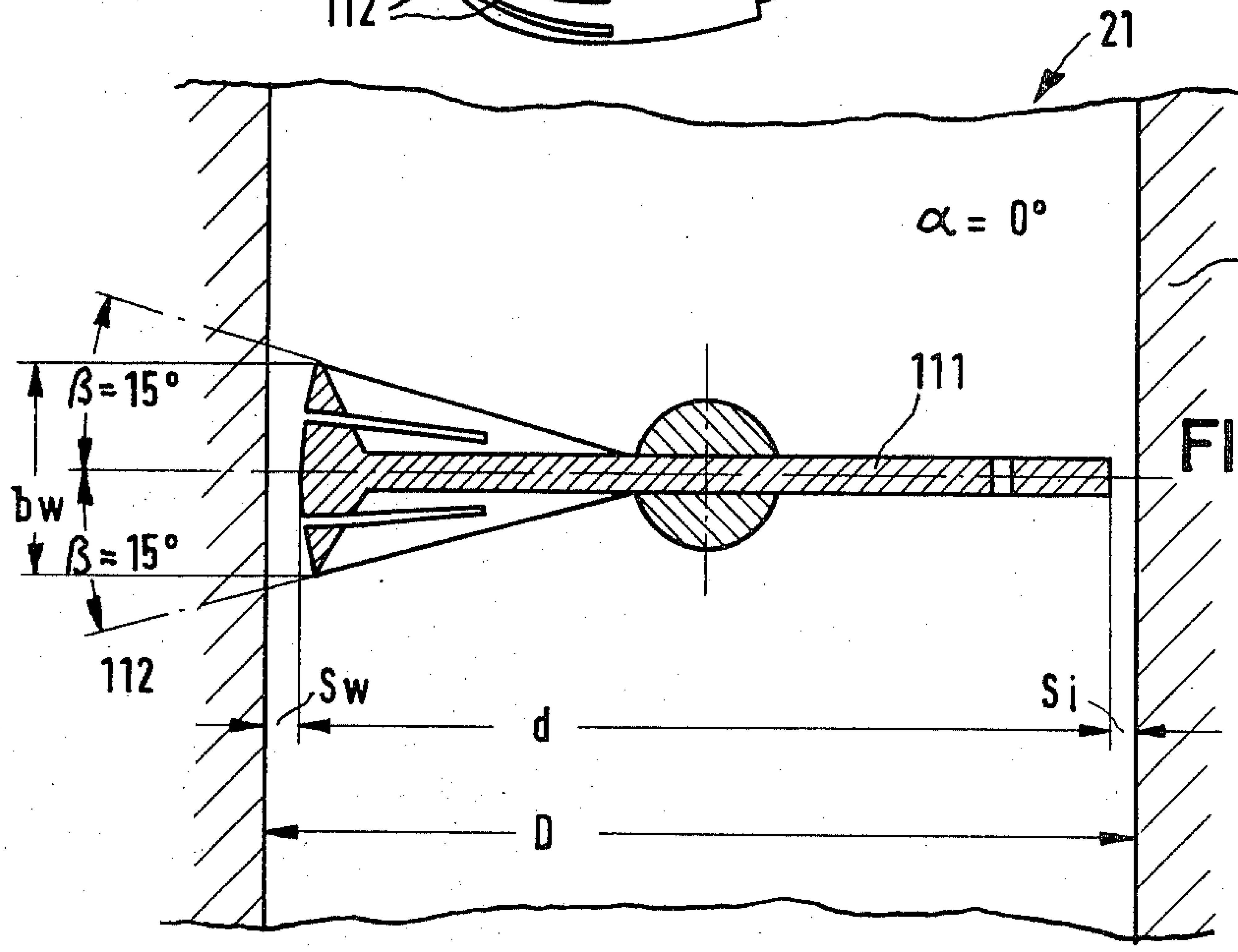


FIG. 2

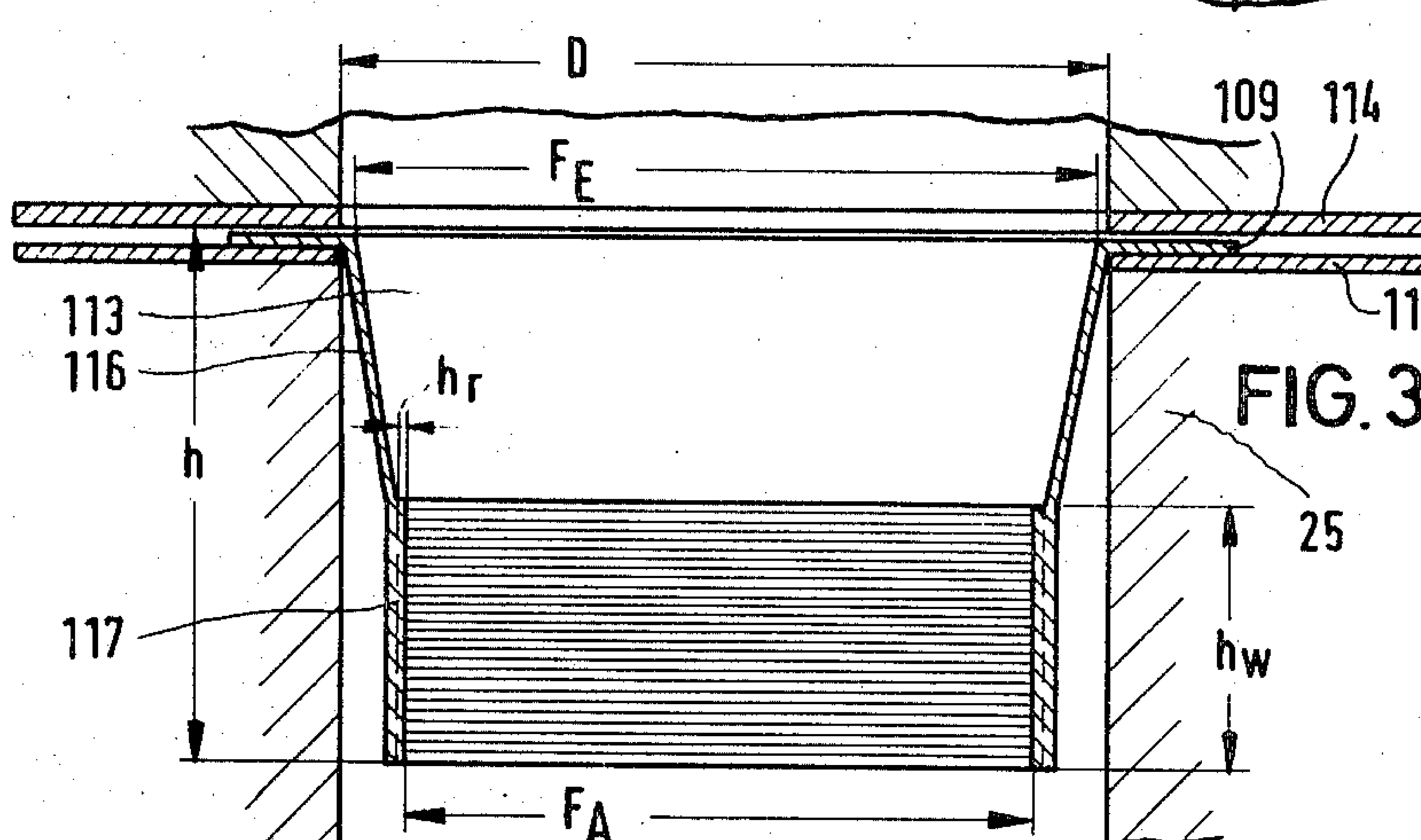


FIG. 3

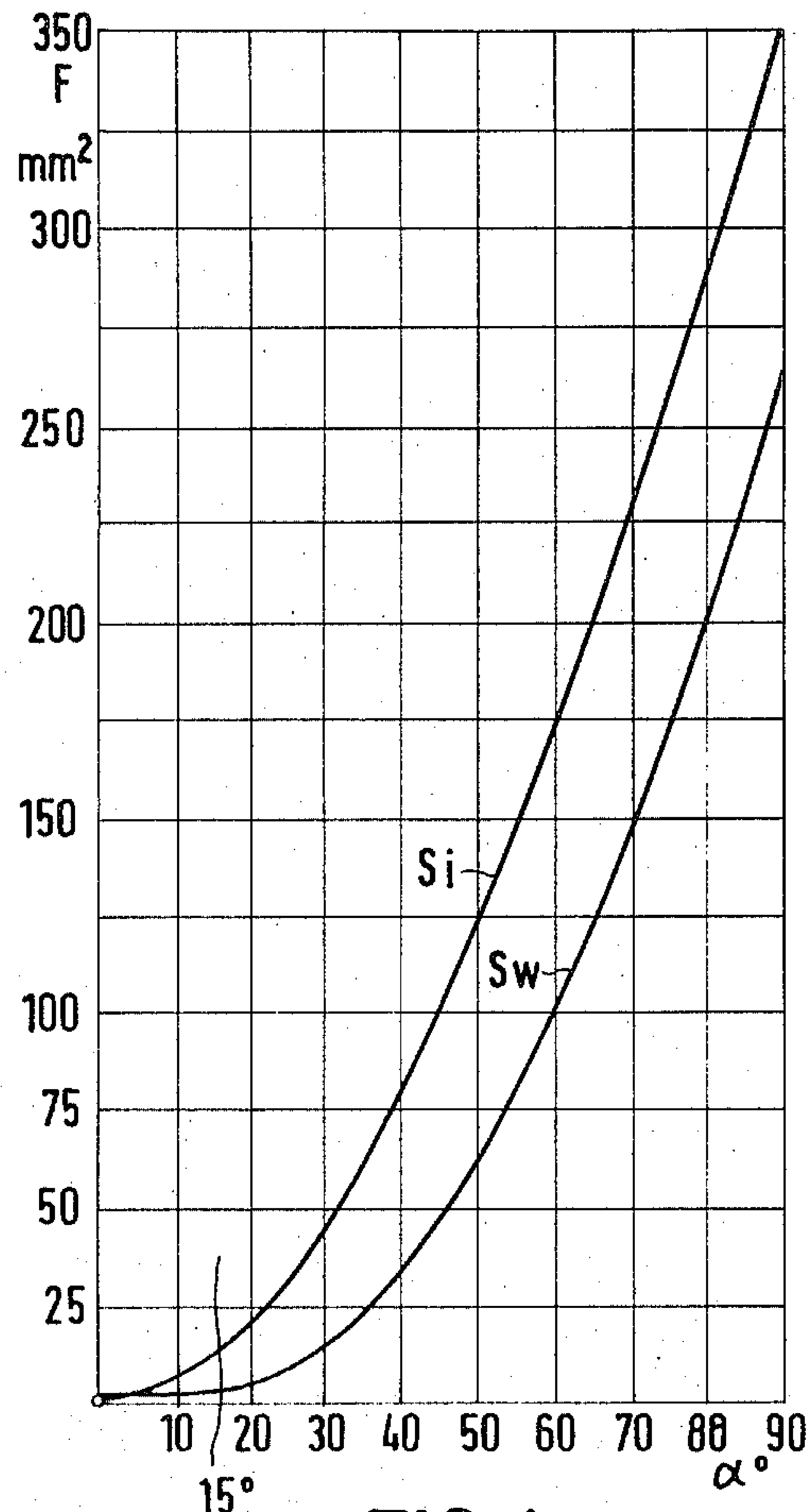


FIG.4

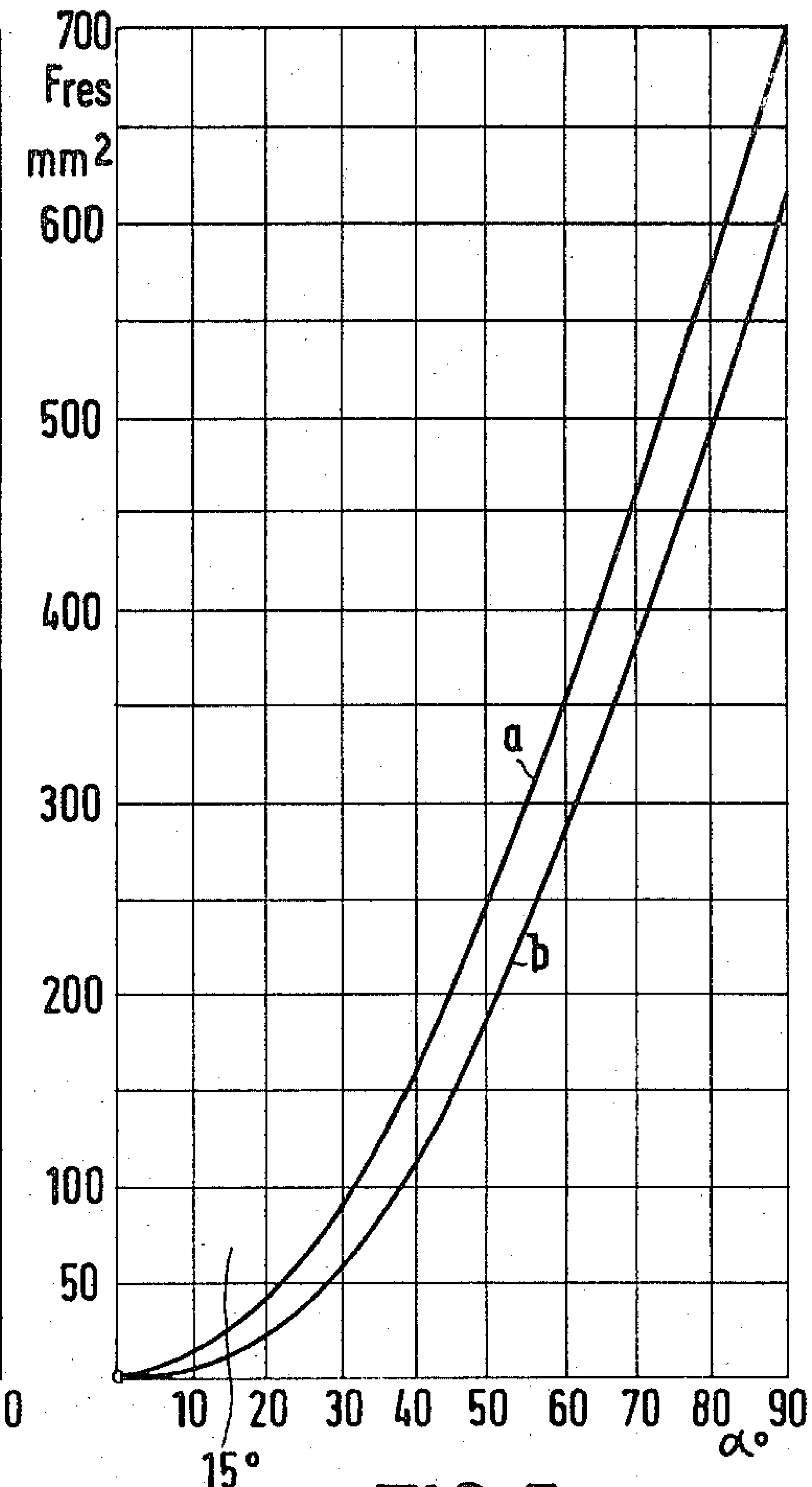


FIG.5

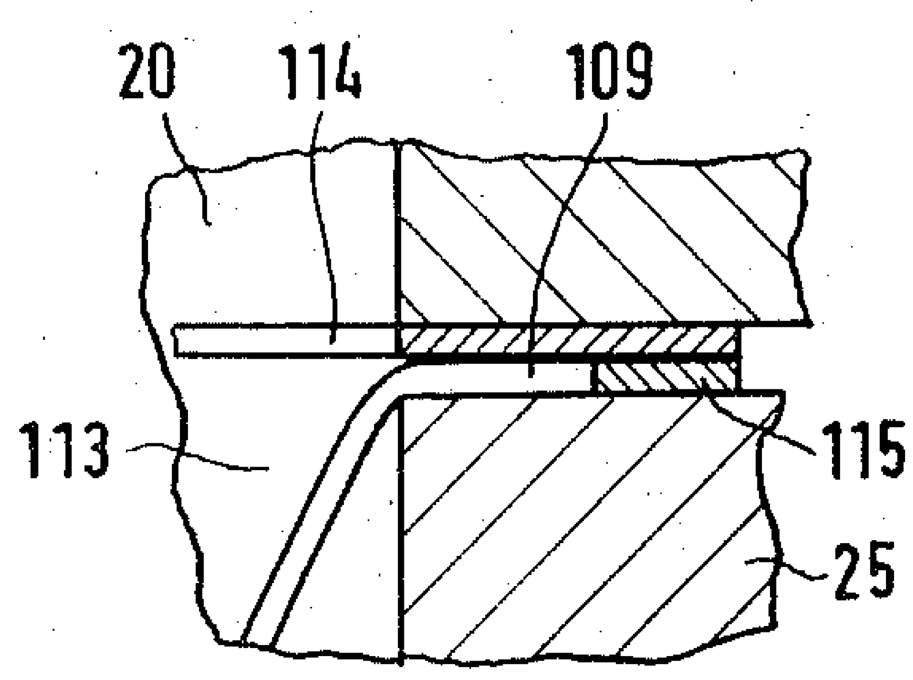


FIG.3a

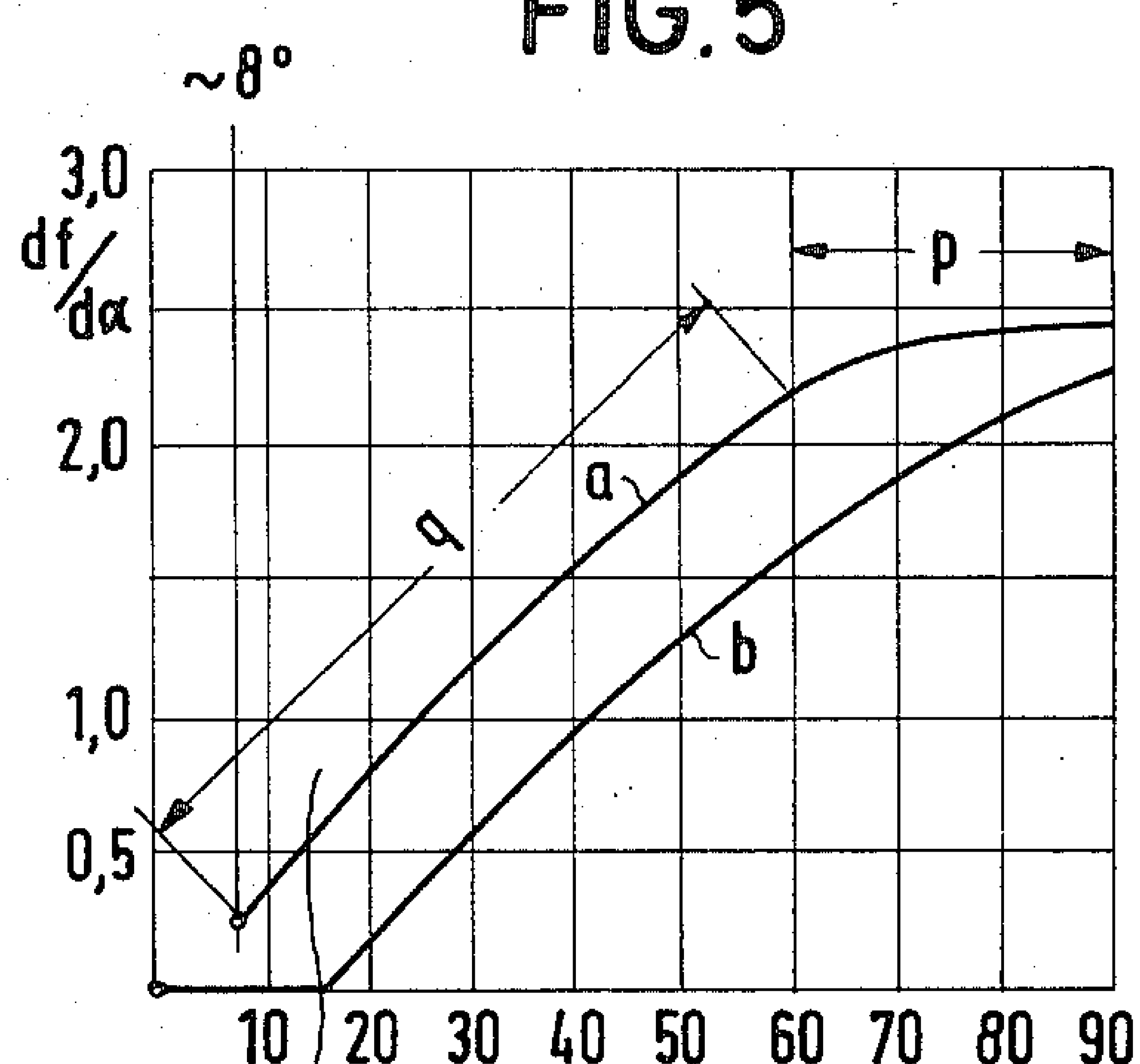


FIG.6

DEVICE FOR THE IMPLEMENTATION OF PROCEDURES FOR THE DECONTAMINATION OF INTERNAL COMBUSTION ENGINE EXHAUST GASES

This invention relates to a device for the implementation of procedures for the decontamination of internal combustion engine exhaust gases by preparation of the flammable and ignitable air-fuel mixture with a variable air ratio figure λ by means of a throttle flap adjustment regulating the fuel jet hydraulic resistance, and which is adjustable such that fuel atomization is performed, using a throttle flap permitting a tolerated air gap all around the circumference in the carburetor duct for the throttle flap position $\alpha = 0°$, which has rims with bores on both sides, and which is followed by a ramjet in the carburetor duct.

Procedures for the decontamination of internal combustion engine exhaust gases and the devices for the implementation of these procedures are based on two process steps:

1. a vertical measure for improving the air/fuel mixture,
2. a horizontal measure for the supply of additional air in the range of an exhaust gas decontamination test, designated λ — variation.

The vertical measure provides, as compared to the technical state-of-the-art of carburetors with a disc-type throttle flap, an increased mixture preparation by increased vorticity of the air/fuel mixture with maximum possible fuel atomization. In addition, any fuel portions which may have remained liquid, are prepared by a twin jet following the carburetor. The twin jet has a collecting pocket, in which any liquid portions of the fuel accumulate, and are subject to post-atomization by bores in the collecting pocket walls.

The horizontal measure relates to the supply of additional air, synchronously controlled by the throttle flap movement and dependent on the operational steps, over the partial range of an exhaust gas decontamination test, with no additional air being supplied in the case of small throttle flap swivel angles of e.g. up to 15°. For that purpose an air regulating plate is arranged below the carburetor, connected with a roll guide additional air transmitter or a segment-controlled additional air supply. Control of additional air supply in accordance with the operational steps, is, in this case, performed by an envelope curve.

This combined processing technique has resulted in an effective exhaust gas decontamination in the case of internal combustion engines.

Problems may occur in particular if it is necessary to modify Otto carburetor engines or e.g. Wankel engines of the state of the art, considering that many different types of carburetors of all possible makes, in order to install the new devices for the decontamination of exhaust gases. These problems even increase, since it is not possible to standardize the components of these devices for economic production purposes.

A throttle flap having characteristics according to my copending application Ser. 51 163, filed June 30, 1970, requires an arrangement of the throttle flap in a throttle flap shaft, with a grooving down to the depth of half of the shaft diameter.

In most cases however, throttle flap shafts of the state of the art require the arrangement of the throttle flap in a slot. Consequently the throttle flap shafts would have to be exchanged, if a disc-type throttle flap were replaced by a throttle flap with the characteristics of my aforesaid copending application.

The task of the invention is to eliminate any difficulties in the modification of state-of-the-art carburetors, particularly in the vertical provision for improving the air-fuel mixture, which is of special importance in the modification of motor vehicles used in traffic. The parts required for that would have to guarantee a possible interchangeability at any time. These parts shall be limited to a minimum number with the exchange parts being of such a design that they are of maximum effectiveness and cheap in production. This task is solved by the invention of a device for the implementation of procedures for the decontamination of internal combustion engine exhaust gases by preparation of a flammable and ignitable air-fuel mixture with a variable air ratio figure λ by a throttle flap adjustment, regulating the fuel jet hydraulic resistance, and which is adjustable such that fuel atomization is performed, using a throttle flap permitting a tolerated air gap all around the circumference in the carburetor duct for the throttle flap position $\alpha = 0°$, which has rims with bores on both sides, and which is followed by a ramjet in the carburetor duct, similar to my copending application. However, my improvement over my copending application resides in the bores of the rims being formed as oblong holes, and that a ramjet having a smooth entry surface and a subsequent rough surface is arranged between carburetor and suction tube.

The means for solving the task are outlined by drawings showing design examples according to the invention:

FIG. 1 is a perspective view of a throttle flap;

FIG. 2 is a sectional drawing of a throttle flap in a carburetor duct;

FIG. 3 is a longitudinal section of a ramjet following the carburetor;

FIG. 3*a* is an enlarged illustration of a portion of FIG. 3;

FIG. 4 is a diagram of the passage cross sections in the carburator duct, as a function of the throttle flap position, in the case of a rim-free and rim-containing throttle flap half;

FIG. 5 is a diagram of the passage cross sections in the carburetor duct, as a function of the throttle flap position of a disc-type throttle flap 'a' and a throttle flap 'b' partially covered with rims.

FIG. 6 is a diagram of a change in the passage cross section as a function of the throttle flap angle for a rim-containing throttle flap and a disc-type throttle flap without rims.

As can be seen from FIG. 1, the rims **11, 12** on both sides extend over half of the circumference of throttle flap **111**, with the bores being formed as oblong holes **112**. The surface portion of the two oblong holes **112** at the top and at the bottom surface of throttle flap **111** is about 12 – 18 percent of the surface of the whole rim back, with the oblong holes preferably of the same form, having a slot width of preferably 0.8 – 1.0 *mm.*

Moreover, according to FIG. **2**, the width b_w at the widest point of the rim back is determined by an angle $2 \times \beta$ of approximately 30° altogether to the throttle flap shaft axis. The passage gap s_w at the rim-covered throttle flap half, and passage gap s_i at the remaining throttle flap half between carburetor duct **20** is within preferably 0.05 and 0.08 mm.

Ramjet **113** shown in a longitudinal section in FIG. **3**, has a total height *h*, and an upper outer diameter D, which is equal to the diameter of suction duct **25**. The total height *h* of ramjet **113** is within the limits of 0.6 and 0.8 of the upper outer diameter D of ramjet **113**. The conicity of the conical entry of ramjet **113** is determined by a reduction of the exit cross sectional area F_A, in the area of the rough distance h_w of about 10 –20 percent as compared to the entry cross sectional area F_E of ramjet **113**. The rough distance itself shall be about half of the total height *h* of ramjet **113**. Roughness height h_r at this rough distance h_w is 0.5 – 0.8 *mm*, at a carburetor duct diameter D of 28 – 40 *mm*.

The roughness height h_r itself can be made by a fine thread or by knurling. The ramjet **113** below carburetor **21** is, with its flange **109**, between carburetor **21** and suction duct **25** to the engine cylinders sealed to the outside by two preferably standard flange packings with flange **109** of ramjet **113** being arranged between these two flange packings. Good sealing characteristics were obtained in practice by designing the packings according to FIG. **3***a*. The lower packing **115** has a hole of the diameter of the ramjet flange **109**, the upper packing **114** has a hole diameter of the carburetor duct D, i.e., standard-type packing is used in most cases for the upper packing **114**.

The advantage of these types of packings is that ramjet **113** can be rounded off at the entry in the surface F_E, in order to make up for any inaccuracies in the packing bores.

According to the literature referenced under 1 and 2 below, a carburetor is considered an atomizer, which works on the principle of the velocity atomizers; i.e., a cohesive mass of liquid is disrupted by the inertia, surface and viscosity forces, as a result of the relative speed between the liquid and the airstream surrounding it. This literature additionally points out the calculation of the degree of fuel atomization which can be obtained. From that it can be seen that the maximum smallest drop size depends, apart from the substance constant, very much on the air/fuel relative speed. The higher it is, the finer will be the fuel atomization. In addition to the increased vorticity as a result of the influence by the sharp-edged rimback surfaces relative to the disc-type throttle flap, the asymmetry of the flow speeds at the rim-covered side of the throttle flap relative to the side which forms crescent-shaped areas exercises a homogenizing influence on the carburetor duct cross section. Intended cross-currents occur due to vacuum fluctuations below the throttle flap, caused by the asymmetry of the current field, which intensify the mixing of the air/fuel mixture.

FIG. 4 shows the difference between surfaces on the rim-covered side and the rim-free side. The difference is particularly obvious in small throttle flap swivel angles of e.g. up to 15°. S_l means the gap on the rim-free side and S_w means the gap on the rim-covered side. If the throttle flap is swivelled through 15°, the closely tolerated gap of the horizontal throttle flap position $\alpha = 0°$ is maintained at the rim-covered side of the throttle flap, whereas a crescent-shaped surface has already been formed at the rim-free side. This results in maintaining the maximum relative speed air to fuel at the side of the idling jet and bypass bores. Thus a maximum possible mixture preparation is reached at the lower engine operating range, resulting in a trouble-free and efficient engine operation.

FIG. **5** shows that the resulting flow surface in the carburetor duct is smaller in case of a throttle flap according to FIG. **1** than in case of a disc-type throttle flap. Curve 'a' is for a disc-type throttle flap, curve 'b' is for a rim-covered throttle flap.

Increased vorticity in the flow in the area of the throttle flap according to FIG. **1** has a braking influence on the flow, which is roughly compensated by a flow acceleration due to the reduced flow surface.

FIG. **6** shows the surface variation as a function of the swivel angle α of the throttle flap.

The differential curves $dF/d\alpha$ for the disc-type throttle flap, and a throttle flap according to FIG. **1** provide information about a change in the flow. Flow processes are largely not clarified, particularly under the influence of additional air (correction air in the carburetor), so that mathematical aspects of the flow are not given. FIG. **6** shows the areas in which the speeds are largely constant, this is actually the case if $dF/d\alpha$ is approximately 0.

A crescent-shaped throttle flap has a position already at idle engine r.p.m. which varies with the idling speed to be adjusted. In the example according to FIG. **6**, a basic adjustment of the disc-type throttle flap of approximately 8° was assumed. It can be concluded from the surface influence of the increasing crescent surfaces on both sides of the throttle flap shaft, that a nearly constant delay in the flow is effective over the area q of curve a, whereas the delay is less rapid from about 60° onwards, in order to turn into a constant flow depending on the cross section along, in the subsonic range. Therefore, calculations can be performed in range *p* by using simple gas dynamic equations; the simple Bernouille equation for incompressible media and the continuity law. This is not possible in portion *q* of curve *a*. As in portion *q* the speeds, in case of reducing throttle flap position angles, approach the transsonic range to sonic speed, the pressure function $P = /dp/s$ in compressible flows becomes effective.

The pulsating-turbulent flow permanently existing already in the carburetor throat receives an increase in pulsation in the throttle flap area, which is indicated e.g. by a rocking motion of the fuel film at the wall of the carburetor duct.

A throttle flap according to FIG. **1** has a different flow path in case of throttle flap swivel angles of $\alpha = 0°$ to 90°. The gap surface at the rim side, with gap width s_w has a constant value to swivel angles of up to e.g. 15°; i.e. $dF/d\alpha = 0$.

Only from 15° on there is a delay in the speed characteristics, approaching the value of the disc-type throttle flap at $\alpha = 90°$. Carburetor measurements have shown that there are no changes in the fuel flow rate over a swivel range of 0° to 90° in case of a throttle flap according to FIG. **1**, relative to a disc-type throttle flap. This is of particular importance when passing the throttle flap in the area of the bypass bores. Whereas the influence of the throttle flap position on the mixture ratio when passing the bypass bores is relatively great in the case of state-of-the-art carburetors, and also presents problems in manufacture, a throttle flap according to FIG. **1** shows insensibility of the swivel angle position towards the bypass bores. The relative speed air/fuel remains constantly high, i.e., at the rim-side of the flap a highest possible fuel atomization is maintained.

At the rim-side of a throttle flap according to FIG. **1**, the flow of air is increased by the upper slot **112**, that "over-riching" of the forming mixture under the influence of the bypass bores cannot take place.

This is also important in thrust-operation, in which case the throttle flap rapidly returns to the zero position. A carburetor measurement was also performed in the full throttle position $\alpha = 90°$, in order to have the possibility of a flow resistance comparison with a disc-type throttle flap. It showed that the rate of air flow *kg/h* is the same in both types of throttle flaps. Thus it was clarified that the functions in a state-of-the-art carburetor, above the throttle flap, are not changed by the installation of the devices according to the invention.

The literature referenced under **1** below reports that the advantage of a fine atomization of the fuel with the disc-type throttle flap being largely closed is impaired by the fact that the flow is near the wall, resulting in a large wall deposit. On the other hand the fuel largely evaporates even in the form of a wall deposit, due to the high vacuum in the suction tube. The wall deposit presents the greatest problem on the way towards a uniform mixture distribution, as the liquid film, which is pulled here and there in individual flows, can be directed only with great difficulty. Consequently there are close limits as to possibilities of improving atomization in the carburetor. The disadvantage of high flow speeds is high filling losses, apart from the fact that it is not possible to perform such a fine atomization by very high flow speeds that wall deposits are largely eliminated. This is the information of the state-of-the-art, as outlined in the literature listed **1.**

The throttle flap according to FIG. **1** enables fine fuel atomization to the maximum and acts against the formation of deposits on the wall. The wall deposit consists of the reluctantly evaporating portions in the fuel, i.e., of portions with high boiling points. The invention uses this possibility of a preparation of liquid fuel portions by applying the known flow processes in rough tubes. A pulsating tubulent flow has, in the boundary layer at the wall, a fine and very thin laminar underflow, which is the carrier of those fuel portions that remain liquid.

The roughness height required in order to dissolve a laminar flow is known from resistance measurements performed on rough tubes, as outlined in the literature listed under **3** below. Reynold's numbers of 2×10^4 to 2×10^5 occur in the suction tubes of carburetors. The critical Reynold's number for the change of a laminar flow into a turbulent one is at 2300 in the case of circular tubes. It can be seen from the diagram for the resistance number in the case of rough tubes, in the literature referenced in **3** below, that a roughness height of 0.5 to 0.8 is required for the existing Reynold's Nos., at suction tube diameters of state-of-the-art carburetors, in order to dissolve the laminar underflow at the wall of a carburetor suction tube. The liquid film of reluctantly evaporating portions of the fuel is torn when flowing over the rough passage of the jet-type insert according to FIG. **3.**

A ram collar effect occurs, which directs the torn liquid portions into the main flow and pulls them away with the overall flow. The preferably conical entry passage of the insert according to FIG. **3** accelerates the main flow and actually compensates for the braking vorticity losses of the dissolving wall stream.

From production aspects, the simplest method would be to roughen the jet-type insert according to FIG. **3** by the arrangement of a fine thread, having a thread pitch h_r, of a suitable profile.

The advantage of the conical form of the insert according to FIG. **3** is that no assembly difficulties can occur.

The task of the invention is fulfilled, in particular as far as the modification of operating motor vehicles is concerned, if the standard disc-type throttle flap of a carburetor of the state-of-the-art, is replaced by a throttle flap according to FIGS. **1** and **2,** and if a ram jet according to FIG. **3** is installed below the carburetor, to the suction duct to the cylinders. Installation and maintenance of both devices presents no problem to workshop and customer. No adjustments can be performed on the devices, so that the effect of these devices is independent of the motor vehicle running time. Both devices are independent of the motor vehicle make, and also of the carburetor manufacturers.

Only the carburetor duct diameter must be known, and the manufacturing tolerances to be expected. This uncomplicated solution provides for economic production, and thus results in a price which is acceptable to the holder in order to perform a decontamination of engine exhaust gases.

If the throttle flap **111** is made from permeable i.e., porous material, a selectable filter effect can be reached, depending on the degree of porosity, so that, as the case may be, bore **16** in the throttle flap may no more be required. A porous throttle flat from sintered metal can then be easily fabricated, particularly in mass production.

Literature taken into consideration:

"Vergaser fuer Kraftfahrzeug-Motoren" von Prof. Dr. Ing. e.h. Alfred Pierburg VDI-Verlag GmbH, Dusseldorf.

2. "Uber die Grundlagen der Zersteubung und ihre Anwendung bei Vergasern von Otto-Motoren" von Dr. sc. techn. Dipl, Ing. Hans Peter Lenz Kaarst-Neusse, VDI-Fortschritt-Berichte, Reihe **6** Nr. **14.**

3. "Fuehrer durch die Stromungslehre" von Prof. Dr. Ing. Ludwig Prandtl Verlag Friedrich Vieweg & Sohn, Braunschweig

I claim:

1. In a device for the implementation of a procedure for the decontamination of internal combustion engine exhaust gases by preparation of a flammable and ignitable air-fuel mixture with a variable air ratio figure λ by a throttle flap adjustment regulating the hydraulic resistance in the fuel jets, and which is adjustable such that fuel atomization is performed, by using a throttle flap permitting a tolerated air gap all around the circumference in the carburetor duct for the throttle flap position $\alpha = 0$, which has rims with bores on both sides, and which is followed by a ramjet in the carburetor duct, the improvement comprising bores in the rims formed as oblong holes and ramjet means having a smooth entry surface and a subsequent rough surface arranged between a carburetor and a suction duct (**25**).

2. The improvement according to claim **1,** wherein the maximum rim width of the rim back (b_w) is given by an angle (2β) of 30° altogether, to the throttle flap shaft axis.

3. The improvement according to claim **1,** wherein the cross sectional area portion of both oblong holes at the top and bottom side of the throttle flap is 12 – 18 percent of the surface of the total rim back, and, that the preferably uniformly shaped oblong holes have a slot width of preferably 0.8 to 1.0 mm.

4. The improvement according to claim **1,** wherein a flow gap (s) exists between the throttle flap and the carburetor duct and is within the limits of preferably 0.05 – 0.08 mm.

5. The improvement according to claim **1,** wherein the upper outer diameter (D) of the ramjet means is equal to the diameter (D) of said suction duct.

6. The improvement according to claim **1,** wherein the total height (h) of said ramjet means is within the limits of 0.6 – 0.8 of the upper outer diameter (D) of said ramjet means.

7. The improvement according to claim **1,** wherein the conicity of the conical entry of said ramjet means is given by the reduction of the exit cross sectional area (F_A) by about 10 – 20 percent approximately, as compared to the entry cross sectional area (F_E).

8. The improvement according to claim **1,** wherein said rough passage (h_w) is half of the total height (h) of said ramjet means.

9. The improvement according to claim **7,** wherein the roughness height (h_r) is 0.5 – 0.8 mm, at a carburetor duct diameter (D) of 28 – 40 mm.

10. The improvement according to claim **9,** wherein said roughness height (h_r) is made by a fine thread with preferably sharp-edged thread profile.

11. The improvement according to claim **9,** wherein the roughness height (h_r) is made by knurling.

12. The improvement according to claim **1,** wherein said ramjet means is arranged below the carburetor, with its flange between the carburetor and the suction duct to the engine cylinders, is sealed to the outside by two preferably standard uniform flange packings, said flange of said ramjet means being arranged between these two flange packings.

13. The improvement according to claim **1,** wherein said ramjet means is arranged below the carburetor with its flange between the carburetor and the suction duct to the engine cylinders and is sealed by a lower packing which has a hole equal in diameter to the flange diameter and an upper packing which has a hole equal in diameter to the carburetor duct, said ramjet means being rounded at the entry of surface (F_E).

14. The improvement according to claim **1,** wherein said throttle flap is made of porous permeable material.

15. The improvement according to claim **14,** wherein said throttle flap is made of sintered metal.

* * * * *