



(11) (21) (C) **2,039,944**
(22) 1991/04/08
(43) 1991/10/12
(45) 2001/01/02

(72) Kolev, Sejko, CH

(72) Koromzay, Tibor, CH

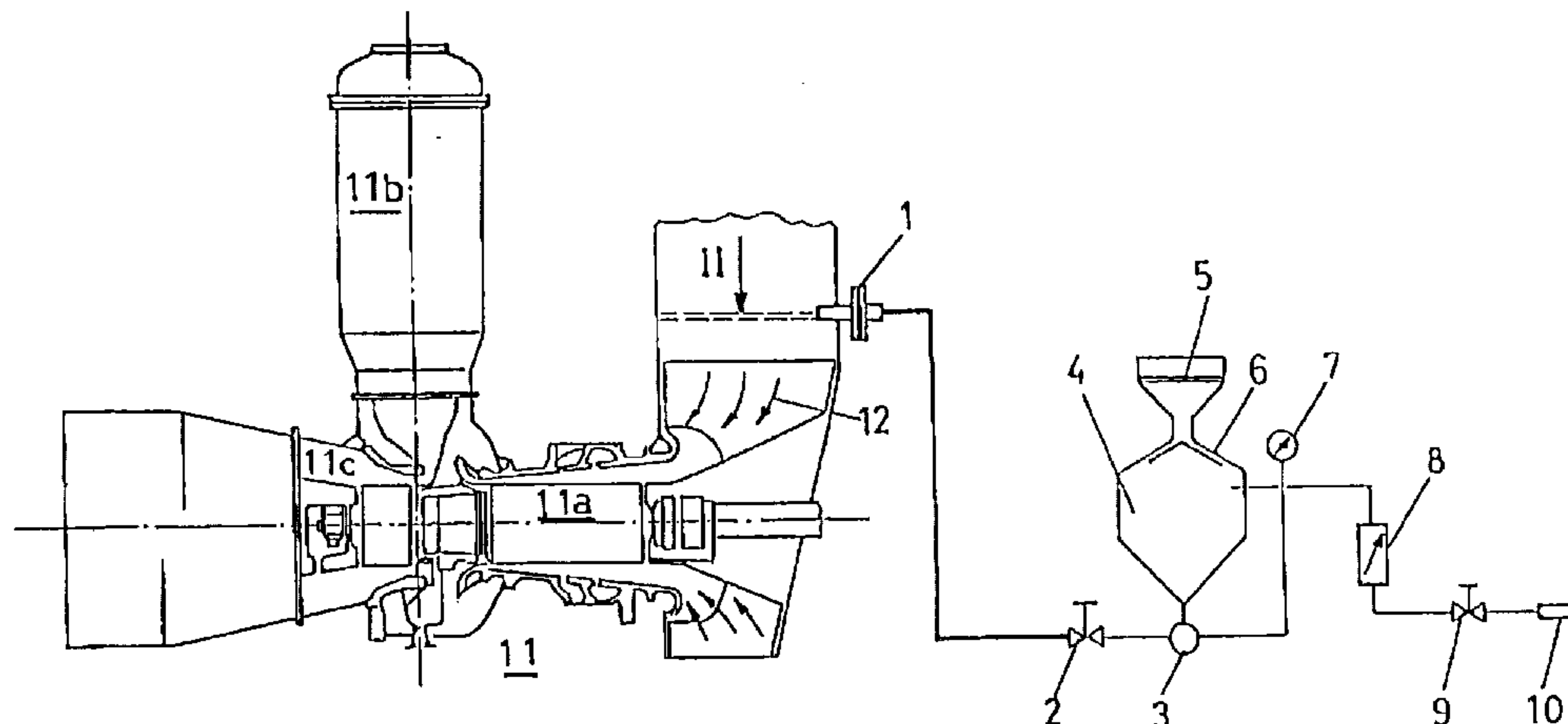
(73) Asea Brown Boveri Ltd., CH

(51) Int.Cl.⁵ C23C 4/02, C23C 4/12

(30) 1990/04/11 (1237/90-0) CH

(54) **PROCEDE DE PROJECTION A GRANDE VITESSE D'UNE
FLAMME AYANT UNE VELOCITE DE PARTICULE D'AU
MOINS 300 m/s**

(54) **HIGH SPEED FLAME SPRAYING PROCESS HAVING
PARTICLE VELOCITY OF AT LEAST 300 m/s**



(57) In a process for coating the blades of a rotating, thermal machine, said blades undergo a first cleaning process in the operating state of the machine, i.e. "on line", the appropriate agent for this, which depends on whether the blades are uncoated or coated, being mixed in with the air stream to the compressor. After switching off the machine and opening the same, the blades undergo in the stationary state, that is to say in the bladed state of the corresponding rotor or stator, a preparation process for the subsequent treatment stage. According to requirements, this preparation process may, for example, consist in the blades being immersed in a vibrating erosive bath. The actual coating of the blades takes place by means of a high-speed flame spraying process, in which the protective coating is sprayed onto the surface of the base material at a particle velocity of at least 300 m/s. Thereafter, the blades also undergo an after-treatment which, according to requirements, serves to reduce the surface roughness and/or is provided to apply a top coating.



ABSTRACT OF THE DISCLOSURE

In a process for coating the blades of a rotating, thermal machine, said blades undergo a first cleaning process in the operating state of the machine, i.e. "on line", the appropriate agent for this, which depends on whether the blades are uncoated or coated, being mixed in with the air stream to the compressor. After switching off the machine and opening the same, the blades undergo in the stationary state, that is to say in the bladed state of the corresponding rotor or stator, a preparation process for the subsequent treatment stage. According to requirements, this preparation process may, for example, consist in the blades being immersed in a vibrating erosive bath. The actual coating of the blades takes place by means of a high-speed flame spraying process, in which the protective coating is sprayed onto the surface of the base material at a particle velocity of at least 300 m/s. Thereafter, the blades also undergo an after-treatment which, according to requirements, serves to reduce the surface roughness and/or is provided to apply a top coating.

(Fig. 1)

- 1 -

HIGH SPEED FLAME SPRAYING PROCESS HAVING
PARTICLE VELOCITY OF AT LEAST 300 m/s

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a process for coating blades of a rotating thermal machine.

Discussion of Background

For example in the open gas turbine process, the
10 air taken in by the compressor also contains water vapor and solid and gaseous impurities. These have an adverse effect due to erosion, soiling and corrosion. Some of the deposits on the blades have a considerable concentration of corrosively acting constituents such as NaCl and KCl. The
15 salts cause not only high-temperature corrosion on the turbine blading but also increased pitting corrosion in the compressor region and a complex chemical reduction in the strength of the blade material. In the case of high atmospheric humidity, there occurs in the region of the
20 compressor intake a concentration of water vapor, which explains the greater degree to which corrosion attacks the front rows of blades. In order to overcome this problem to a certain extent, blades of rotating thermal machines are often provided with protective coatings. These are used
25 both in the case of steam and gas turbine blades and in the case of compressor blades. Thus, the main objective is to increase the resistance to corrosion and oxidizing attacks as well as to erosion and abrasion (wear). If, in spite of surface treatment, the blades do exhibit damage of a degree
30 which could endanger operational reliability, the next step is to proceed to remove the blades: either they are replaced by new ones or reconditioned and refitted. This removal and fitting entails relatively high costs and time spent. Furthermore, the true condition of the blading is
35 only evident after a relatively long time, i.e. after precleaning, and therefore the decision as to whether

2039944

reconditioning of the blades is feasible or not, or already necessary, can only be taken much later. The disadvantages of this method are the great time losses, the high operating costs of the installation, higher costs for inspections and the uncertainty over the question of the reconditionability of the blades. Therefore, the tendency has been instead to look for ways and means of remedying this situation. In this context, a process has become known by which the entire bladed rotor is lifted out of the stator in order to be reconditioned in a separate installation. The bladed rotors to be coated must be degreased in a suitable way, any organic coatings which may have been applied at an earlier time must be completely removed. Subsequently, the areas to be coated are roughened by dry sand blasting with aluminum oxide and the metallic surface activated. The zones not to be coated must be masked with suitable materials. Thereafter, the undercoats are applied, each having to be fired. This results in a laborious procedure: a sintering process or firing process takes about 55 hours and, on average, has to be carried out four times. This sintering or firing process during coating comprises a heat treatment at about 350° Celsius over a holding time of about 10-12 hours. In addition, in order to carry out the individual process steps, quite large installations of specific geometric design have to be provided, consider for instance that during the sintering process the entire bladed part of the rotor has to be surrounded by a furnace cover.

SUMMARY OF THE INVENTION

Accordingly, one object of this invention is to provide a process of the type mentioned at the beginning with a more efficient method in terms of the times required and costs expended for the reconditioning of the blades. Another object of the invention is to maximize the service life of the coating by suitable processes and protective coatings.

5 The essential advantages of the invention are
to be seen in that the bladed rotor does not have to be
lifted out of its mounting in the stator for the first
process of reconditioning: the cleaning or removal of
protective coating can be carried out before the actual
shutting-down of the machine, i.e. of the compressor,
that is to say during a final phase of operation ("on
line"). As a result, an even exposure of the blades to
be treated is attained, the consequently achieved
10 efficiency of this cleaning process, which ensures
extensive removal of any protective coating there may
be, permitting an immediate decision on the
reconditionability of the blades. This decision can be
made already after shutting down the machine and
15 removing the upper part of the stator. If, after
appropriate analysis of the condition of the blades, it
is decided to recondition them, it is sufficient to
lift the bladed rotor out of the mount and place it on
blocks, where the further process steps of
20 reconditioning can be carried out without the aid of a
sophisticated structure. This leads to low operating
costs (overhauling costs), which means that there is
nothing to prevent this type of treatment being carried
out periodically. Consequently, the operational
25 reliability of the installation is increased.

A further significant advantage of the
invention is to be seen in that, by using a high-speed
flame spraying process, the blades, pretreated in the
fitted state, receive an appropriate protective
30 coating, preferably Si and Al based, just where and
when needed, it being possible for this coating process
to be carried out without lengthy heat treatment and
without the aid of special additional equipment. This
simplifies the entire technical coating procedure,
35 while the costs are lower by about half than in the
case of the known processes. In addition, the service
life of this type of coating is much higher than in the
case of the coatings currently used for this so-called

- 4 -

complete coating. Since the pretreatment of the blades or the after-treatment after spraying on the protective coating is of great significance for the service life of the coating, direct corrective measures can be undertaken specifically, as found to be required. What is obtained after a very short time with low reconditioning costs by means of a process which is very environmentally friendly is blading of top quality which guarantees the operational reliability of the installation over a prolonged period.

10 According to a broad aspect of the present invention there is provided a process for coating blades of a rotating thermal machine having a compressor. The blades undergo a first cleaning process, in the operating state of the thermal machine, by means of an agent mixed with the air stream to the compressor for a predetermined time through a centrally placed three-jet nozzle which acts in an intake channel of the compressor. The blades undergo a preparation process for the subsequent treatment stage wherein the blades are treated in an erosive bath after opening the machine in a stationary state. The blades are coated in the stationary state with an aluminium-based protective coating by means of a high-speed flame spraying process which sprays protective coating particles onto the surface of a base material at at least a velocity of 300 m/s. The porosity of the protective coating is below 0.5% and the composition of the coating is one of the following: a) 6 to 15% by weight Si, the remainder being aluminium; b) pure aluminium, c) 80% by weight Al, 5 to 15% by weight Si and the remainder being Cu, Mn, Mg, Ni.

30 Advantageous and expedient further developments of the way in which the object is achieved according to the invention are identified in the further claims.

- 4a -

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference
5 to the following detailed description when considered in connection with the accompanying drawings, wherein all elements not required for direct understanding of the invention have been omitted and the direction of flow of the various media is indicated by arrows and wherein:

10 Fig. 1 shows a turbo group with units for a pretreatment stage;

Fig. 2 shows a view of Fig. 1 in the plane II-II;

Fig. 3 shows a cleaning stage or removal of protective coating in a vibrating, erosive bath;

15 Fig. 4 shows a view of the rotor according to Fig. 3 along the plane IV-IV;

Fig. 5 shows a final cleaning process with jet nozzles; and

20 Fig. 6 shows a coating of the blades by a high-speed flame spraying process.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, in Figure 1 a conventional gas turbo group 11 is shown, essentially comprising a compressor part 11a, a combustion chamber 11b and a turbine part 11c. In the pretreatment of the blades, a distinction must be drawn between whether, in the original state, they were uncoated or coated. Irrespective of this precondition, a first cleaning of the blades takes place before shutting down the machine, i.e. the compressor. In the case of coated blades, this cleaning is based preferably on erosion abrasion by soft-blasting granules. Of course, the cleaning of uncoated blades can be performed simply by means of an aqueous solvent, for example trichloroethylene. The cleaning agent (soft-blast granules, aqueous solution etc.) is injected into the air stream to the compressor for a certain time through a centrally placed three-jet nozzle 1 (also see Fig. 2 in this respect), which acts in the intake channel of the compressor. The even and intensive exposure 12 of the compressor blades produces an efficient cleaning process in the case of uncoated blades or an extensive removal of the old protective coating in the case of coated blades. The cleaning process is repeated several times, as required. Since the soft-blasting granules burn at temperatures of about 300 degrees Celsius, there are no problems in this respect with regard to disposal. If an aqueous solution is used, consideration likewise has to be given to these aspects. The control arrangement for the multi-jet nozzle 1 consists of a ball cock 2, which is connected downstream, in the direction of flow of the cleaning agent, of a mixing chamber 3 and serves for controlling the rate of flow. The pressure in this mixing chamber 3 is displayed by a pressure gauge 7. Provided upstream of the mixing chamber 3 is a tank 4, in which for example granules

2039944

are stored, a screen 5 and an inlet valve 6 ensuring that the mixing chamber 3 is supplied with homogeneous material. The required pressure in the tank 4 is provided by means of an air feed line 10, a pressure reducing valve 8 and a main valve 9 in the air line being further auxiliary means of the control arrangement. By corresponding provisions, the turbine blading can be similarly treated.

If necessary, the blades undergo further cleaning or removal of protective coating. As Figs. 3 and 4 show, this takes place by means of a vibrating, erosive bath 14. For this purpose, the bladed rotor 11a and 11c is taken from the stator and placed on blocks 13a and 13b in such a way that a certain part of the blading is immersed in the bath 14. The individual erosive components of the bath 14 are made to vibrate by a vibration generator 15, causing removal of the residual soiling or residual protective coating on the blades. In principle, all types of blades of a rotor of a gas turbo group can be treated in this way.

A final cleaning is carried out according to Fig. 5 with an industrial glass blasting agent 18. This final cleaning is based on erosion removal by said agent, which may consist of glass. A certain part of the blading is covered by a special capsule 16; with simultaneous suction extraction 19 of the injected agent, the cleaning is accomplished by means of one or more jet nozzles 17.

Further process steps can be provided as required:

- Grinding away of the still existing pitting at the most corroded points.
- A crack testing of the blades.
- A dimensional check of the blades, if they have undergone a grinding process.
- Roughening of the surface by sand blasting.

- Before actual coating, it is recommendable to preheat the blades to about 80 degrees Celsius, for example by means of radiator.

5 Fig. 6 shows a possible way in which the high-speed flame spraying process can proceed. For this purpose, a shrouding 16 is provided, which is accessible from the side and encloses a number of prepared blades. By means of a spray nozzle 20, the protective coating is applied to the blades, it being
10 readily possible to perform the guidance of the jet nozzle 20 manually. A suction extraction 19 ensures that excess agent can be removed immediately from the vicinity of the blades.

15 An aftertreatment of the sprayed blades generally comprises the following process steps:

- To reduce the surface roughness, light rubbing over with an emery cloth and/or blasting, for example with glass beads.
- To protect the undercoating and further reduce the
20 surface roughness, a top lacquer coating can be applied with a paint-spray gun. This is on condition that this lacquer does not require a high sustained firing temperature (no furnace construction). A two-component lacquer may be used
25 for this, at least for the first rows of the compressor, where still relatively low temperatures prevail in operation.

A plastic-based polyurethane reaction lacquer may be an example of such a top coating.

30 Regarding the quality of the protective coating, it should be said that conventional compressor coatings very often exhibit low erosion resistance. Since such galvanic protective coatings are only effective if they are present in the metal-coating-electrolyte system, a locally eroded coating is reduced
35 in its protective effect.

The aluminum-based protective coating employed here is an active corrosion-protected coating, the composition of which is preferably as follows:

1. One protective coating consists of 6 to 15% by weight Si, the remainder aluminum;
2. Another protective coating consists of pure aluminum;
3. Another protective coating consists of 80% by weight Al, 5 to 15% by weight Si, the remainder Cu, Mn, Mg, Ni.

The chemical structure of the abovementioned protective coatings and the application process likewise described above (high-speed flame spraying process) provide a less erosion-sensitive "sacrificial anode" coating, which actively protects the base material against corrosion. The application process, which is a high-energy coating process, provides erosion-resistant protective coatings which have good adhesion and the desired electrical connection to the base material without further protective coating-specific aftertreatment. The proposed protective coatings may be additionally provided with a top coating. This dirt-repelling top coating may, for example, be black. Such a dirt-repelling top coating makes it easier to detect icing on the blades by means of ice detectors. The high-speed flame spraying process, which operates at a particle velocity of at least 300 m/s, represents an optimum bonding of the coating to the base material of the blades. Even in the case of a relatively thick protective coating, it is ensured that the coating does not peel off. The explanation for this is that, upon impact of the powder particles, the high kinetic energy produces residual compressive stresses in the coating respectively sprayed before. The maximized resistance against corrosion is attributable to the fact that the coatings used here have a very high hardness. The process proposed here has the effect that the oxide content of

2039944

the coating is lower than in the case of protective coatings sprayed in air. That means that the coating is more pure, for which reason it oxidizes less quickly, any oxidation there may be occurring only on the surface. Due to the fact that the protective coatings are very dense, their porosity is below 0.5%. There is virtually no chance of them being destroyed by corrosion: in the salt spray test specified in DIN 50021, a commercially available ceramic aluminum coating was compared with a protective coating according to the above composition and with the above process. The results have fully confirmed the above statement. In a fatigue process, an analogous comparison was carried out: it was found that the loading until the first fatigue crack in the blade was 20% higher in the case of blades coated according to the above composition and the above process than in the case of the comparison blades. This means that the immunity of the blading to fatigue failure could be increased.

On the basis of the stated advantages and the results after several thousand operating hours in a compressor of a coastal installation, an improvement in the service life of the active protective coating of 50% resulted.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

CLAIMS,

1. A process for coating blades of a rotating thermal machine having a compressor, said blades undergoing a first cleaning process, in the operating state of the thermal machine, by means of an agent mixed in with the air stream to the compressor for a predetermined time through a centrally placed three-jet nozzle which acts in an intake channel of said compressor; and said blades undergoing a preparation process for the subsequent treatment stage wherein said blades are treated in an erosive bath after opening said machine in a stationary state, said blades being coated in said stationary state with an aluminium-based protective coating by means of a high-speed flame spraying process which sprays protective coating particles onto the surface of a base material at at least a velocity of 300 m/s, wherein the porosity of the protective coating is below 0.5% and the composition of the coating is one of the following:

- a) 6 to 15% by weight Si, the remainder being aluminium
- b) aluminium,
- c) 80% by weight Al, 5 to 15% by weight Si, the remainder being Cu, Mn, Mg, Ni.

2. The process as claimed in claim 1, wherein said blades when in said stationary state, after the application of said protective coating, undergo an after-treatment to reduce the surface roughness and to apply a top coating.

3. The process as claimed in claim 1, wherein said blades when in said stationary state, after the application of said protective coating, undergo an after-treatment to reduce the surface roughness or to apply a top coating.

4. The process as claimed in claim 1, wherein said agent mixed in with the air stream for cleaning the blades consists of soft-blasting granules.

5. The process as claimed in claim 2 or 3, wherein said top coating consists of a plastic-based polyurethane reaction lacquer.

1/3

FIG.1

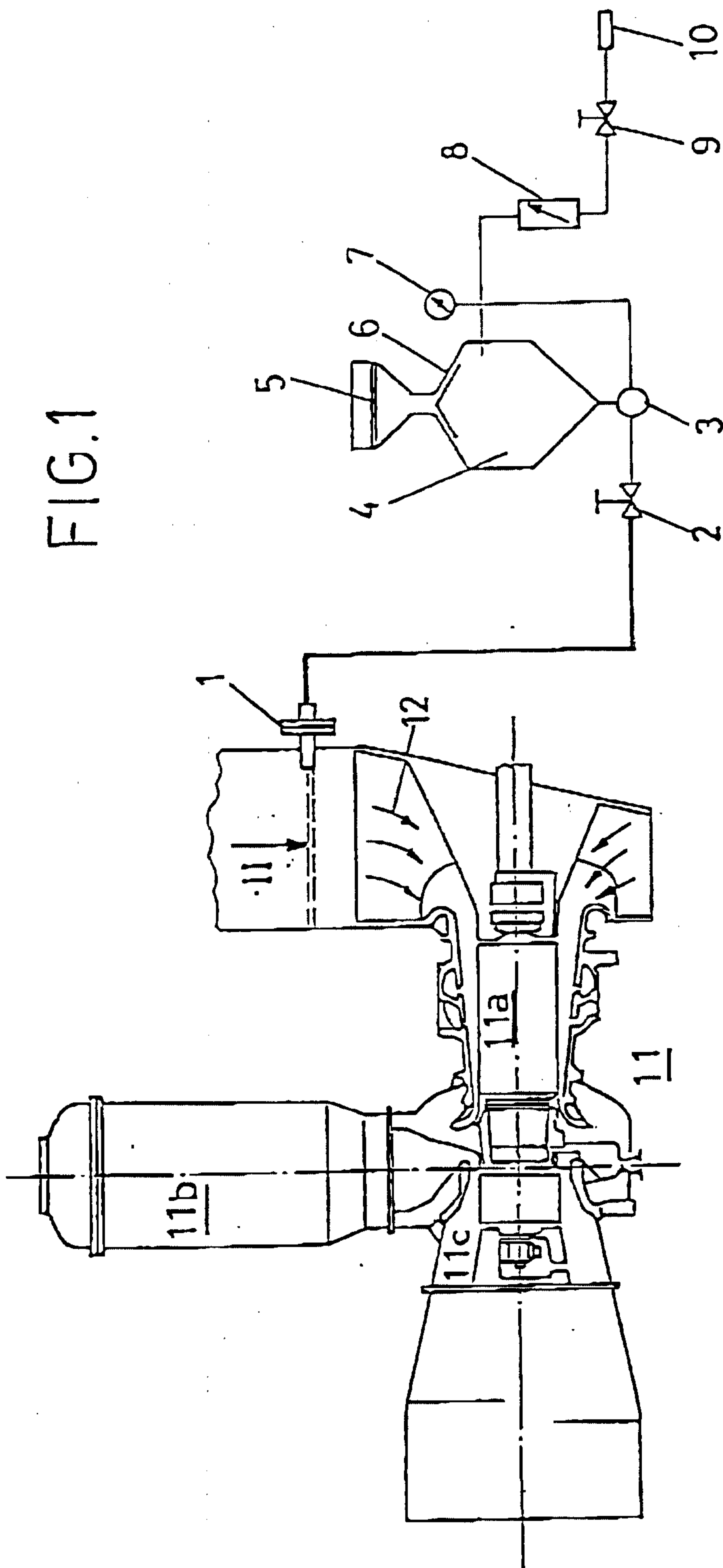


FIG.2

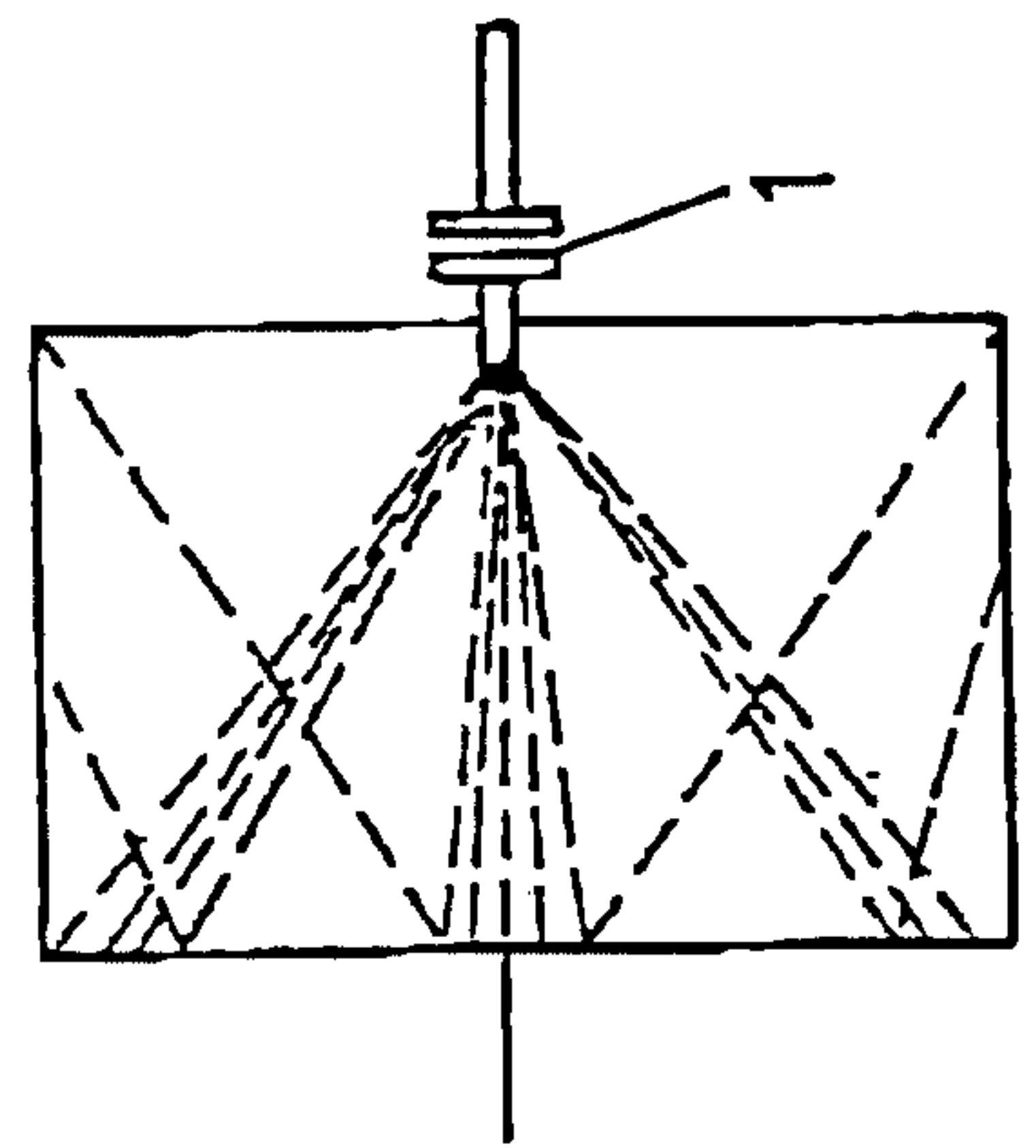


FIG. 3

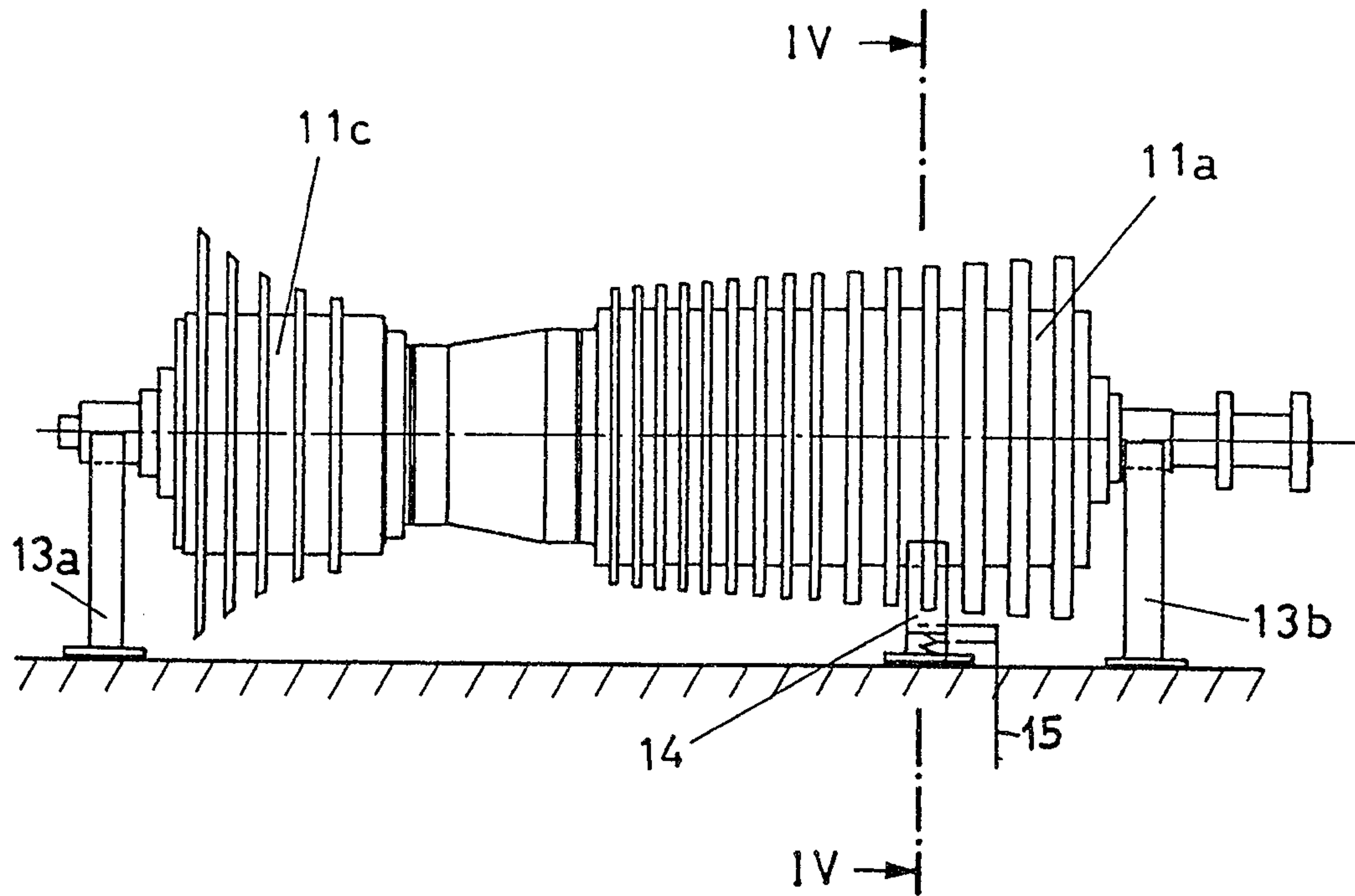
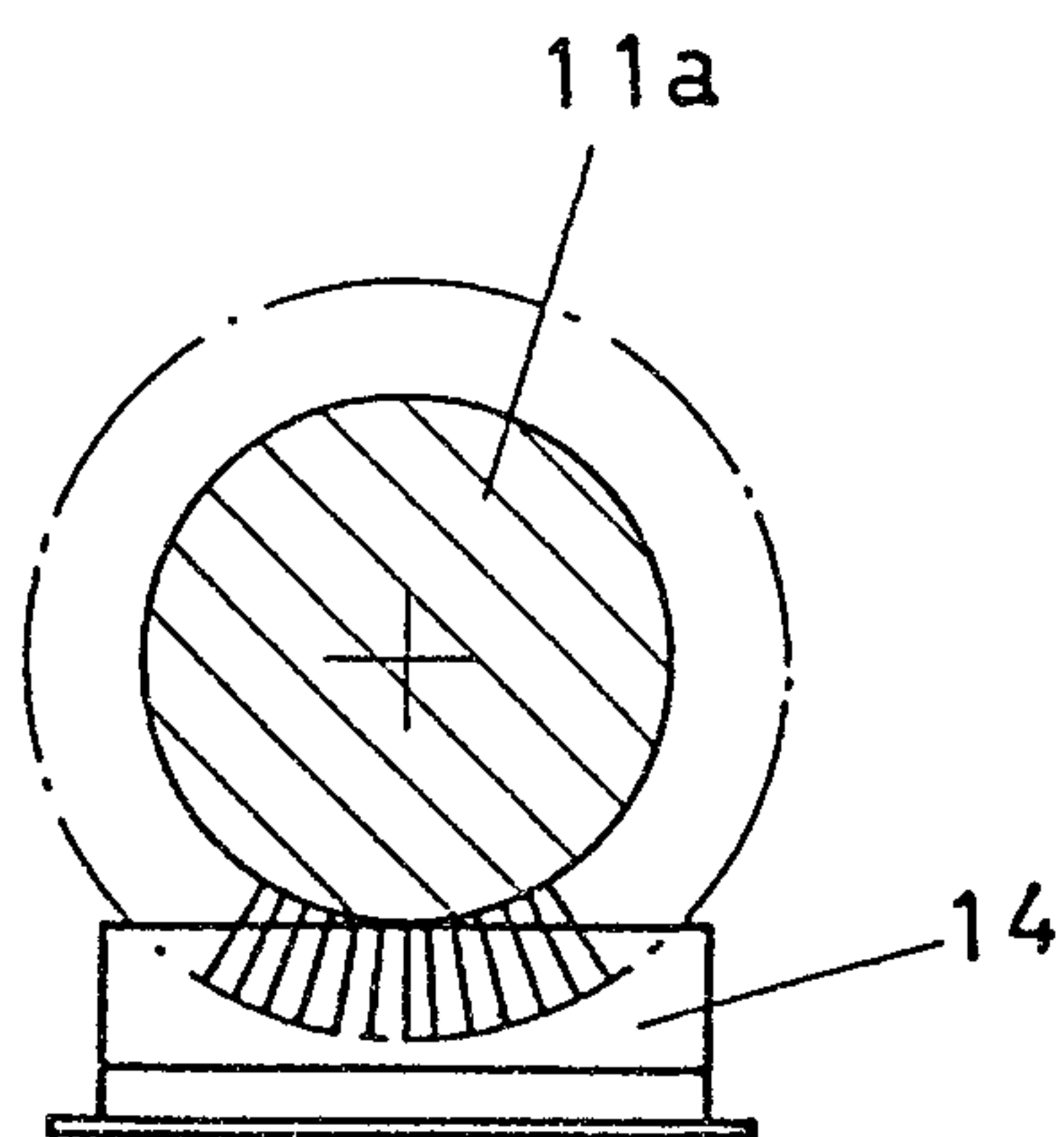


FIG. 4



PATENT AGENTS

Swabe & Gilroy Kenault

90/027

FIG. 5

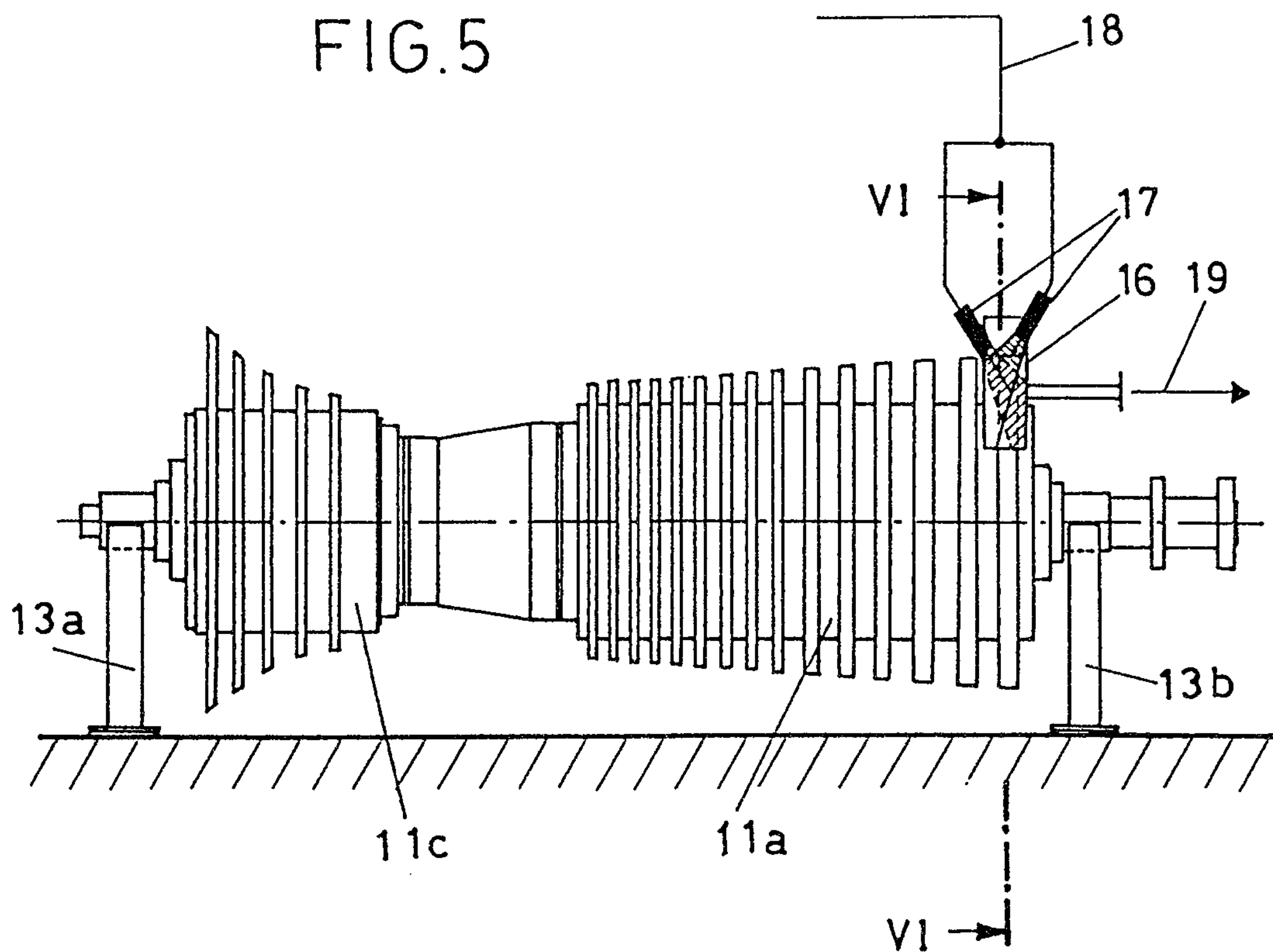
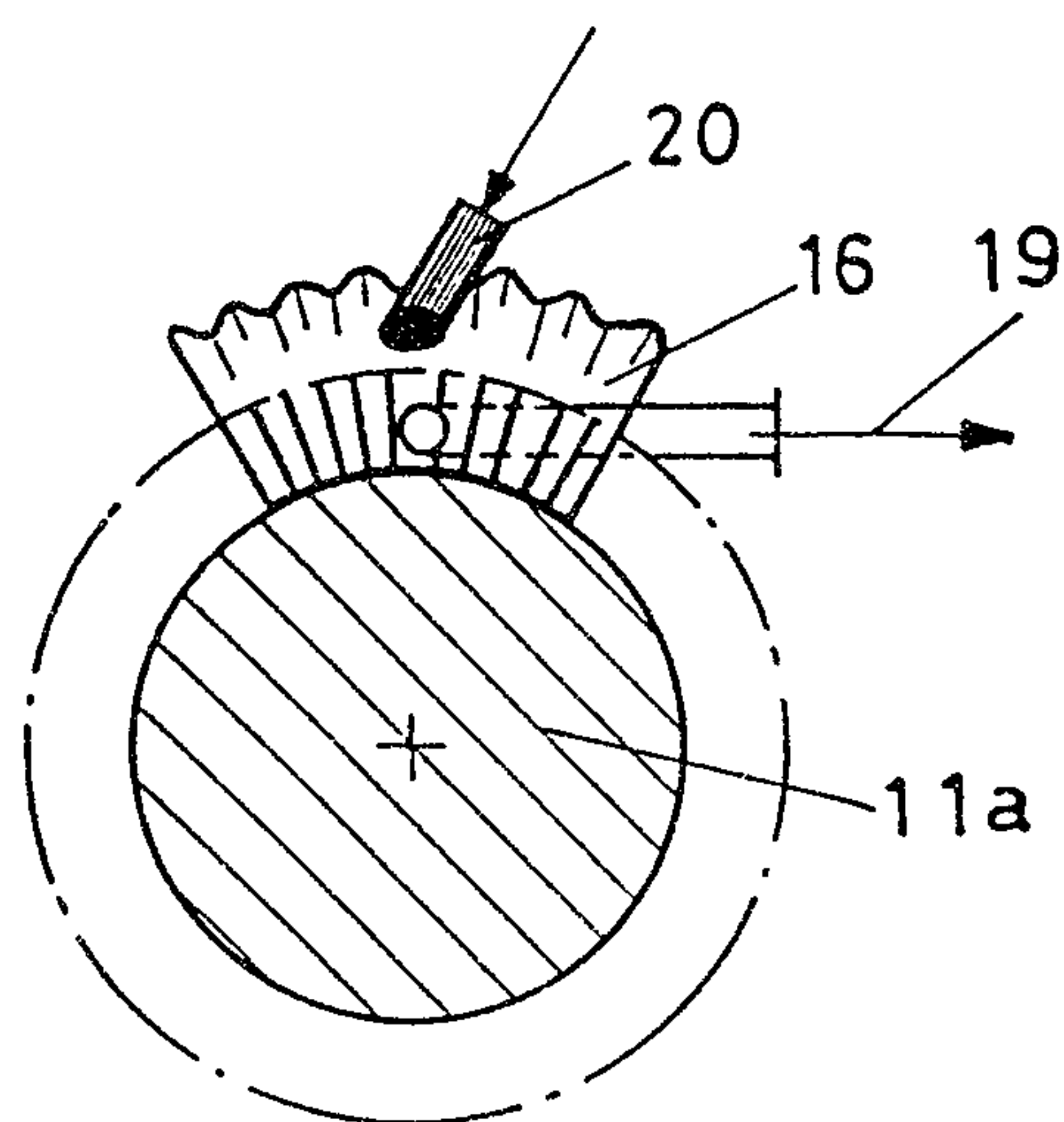


FIG. 6



PATENT AGENTS

Swabe & Ogilvy Renault

90/027

