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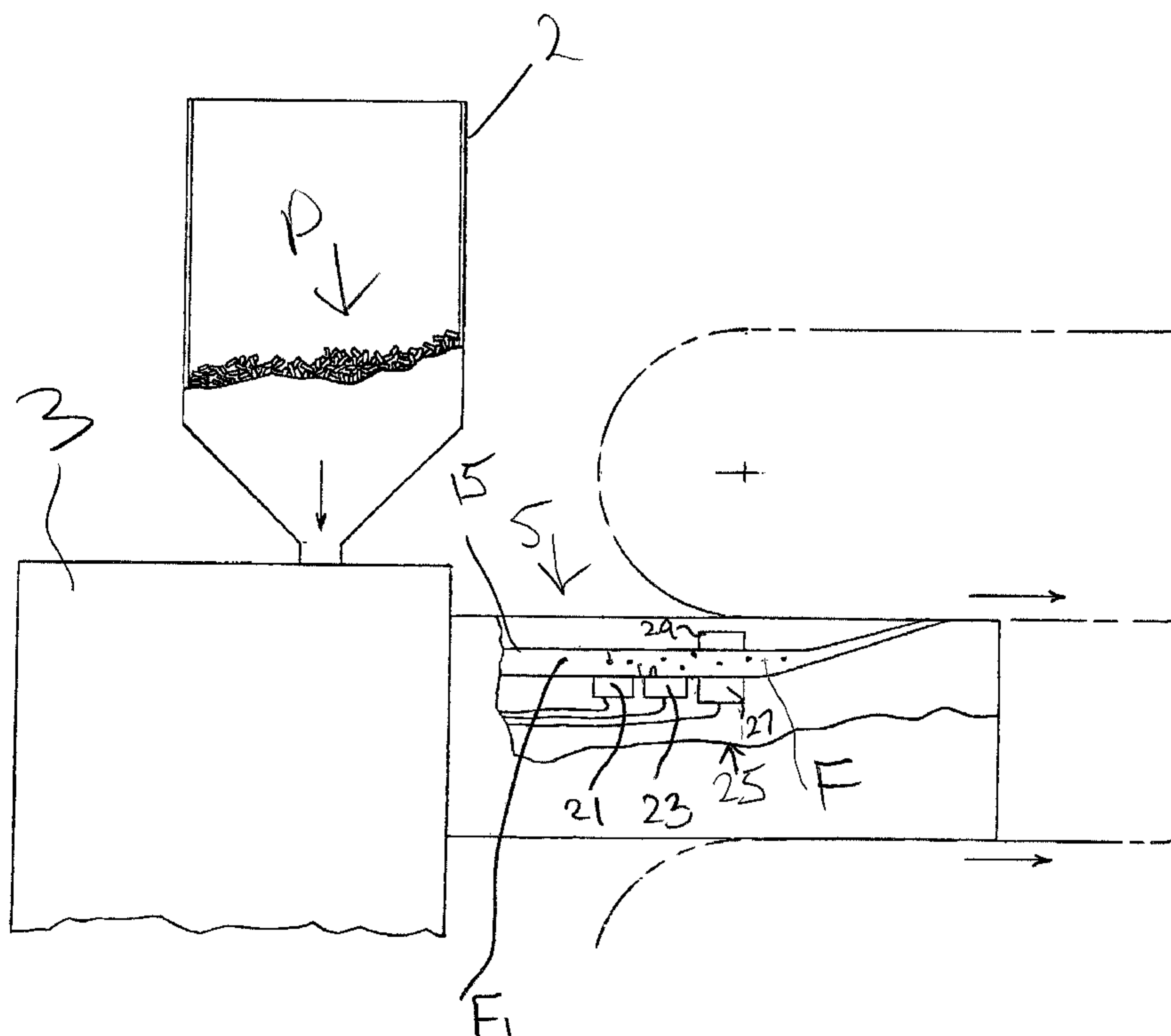
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(54) Titre : APPAREIL DE MOULAGE A OUTILLAGE A MATRICE A CAPTEURS D'ECOULEMENT PLASTIQUE

(54) Title: MOLDING APPARATUS WITH DIE TOOLING HAVING PLASTIC FLOW SENSORS



(57) Abrégé/Abstract:

A molding apparatus includes die tooling having an ultrasound sensor, a temperature sensor and a pressure sensor for sensing different parameters of molten plastic flow from the extruder to the mold region through the die tooling.



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ABSTRACT OF THE DISCLOSURE

A molding apparatus includes die tooling having an ultrasound sensor, a temperature sensor and a pressure
5 sensor for sensing different parameters of molten plastic flow from the extruder to the mold region through the die tooling.

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MOLDING APPARATUS WITH DIE TOOLING HAVING
PLASTIC FLOW SENSORS

FIELD OF THE INVENTION

5 The present invention relates to plastic molding apparatus which is subject to variations in the plastic flow through the die tooling of the molding apparatus.

BACKGROUND OF THE INVENTION

10 A molding apparatus which is used more and more often in the molding of plastic pipe comprises an extruder which feeds molten plastic through die tooling to what is known in the industry as a moving mold tunnel. This moving mold tunnel is formed by mold block sections
15 which travel in a mold closed configuration lengthwise along the mold tunnel. After the mold block sections leave the mold tunnel they open relative to one another to release the pipe from the mold tunnel. The mold block sections then travel in the open positions back to the
20 mold tunnel.

 The above type of traveling molds are particularly useful in forming corrugated pipe. Such corrugated pipe includes belled coupling parts formed directly in the
25 moving mold tunnel. Specifically shaped mold block sections form part of the chain of traveling mold blocks for forming the pipe coupling parts.

 The formation of the coupling parts is
30 particularly critical. If the flow of molten plastic from the extruder is not consistent or uniform this is particularly detrimental to the formation of the belled coupling parts.

35 More specifically, the type of plastic used in the extruder is extremely important. This plastic in its raw

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form comprises small plastic pellets dumped into the extruder hopper. The pellets under both heat and pressure produced by the impeller within the extruder converts the plastic from the solid state to a much more molten state. The plastic in its molten state is then fed from the extruder through die tooling to a mold region. This mold region as earlier described may well be a moving mold tunnel. The pipe including its coupling parts is formed in the moving mold tunnel from the molten plastic.

It is important to be able to measure certain parameters of the plastic flow through the die tooling. Such parameters may relate to the viscosity of plastic flow and they may also relate to the uniformity of the plastic flow. This last parameter provides an indication as to whether or not the plastic flow is homogenous. If it is not homogenous then this can be extremely negative to the pipe particularly in the pipe coupling parts. For instance, if the flow contains weak flow regions the coupling part can well experience blowouts. If on the other hand the plastic flow includes hard regions which will be encountered if the raw material hard pellets are not properly plasticized then the coupling part will be extremely rigid and very ineffective for fitting over and sealing with a mating coupling part.

SUMMARY OF THE PRESENT INVENTION

The present invention provides sensing means capable of sensing different characteristics of a molten plastic flow in die tooling of a plastic molding apparatus. Through the use of these sensing means an operator of the die tooling is able to determine causes of potential problems and therefore can make the appropriate corrections.

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More specifically, the present invention relates to molding apparatus with an extruder which receives plastic material that is converted by heat and pressure within the extruder to a molten form of the plastic material. The plastic material in its molten form is fed from the extruder through die tooling of the apparatus to a mold region of the apparatus.

The die tooling of the apparatus is provided with sensing means in the form of an ultrasound sensor, a temperature sensor and a pressure sensor. These sensors all sense the plastic flow through the die tooling and allow the operator of the equipment to determine potential causes of undesired variations in that plastic flow.

BRIEF DESCRIPTION OF THE DRAWINGS

The above as well as other advantages and features of the present invention will be described in greater detail according to the preferred embodiments of the present invention in which;

Figure 1 is a schematic view of a pipe molding apparatus according to a preferred embodiment of the present invention;

Figure 2 is an enlarged schematic view of the molding region of the apparatus of Figure 1;

Figure 3 is an enlarged schematic view of the upstream region of the apparatus of Figure 1;

Figure 4 is an enlarged view of the interior of the die tooling of the apparatus shown in Figure 3;

Figure 5 is a cross-sectional view of die tooling

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of a further pipe molding apparatus according to another preferred embodiment of the present invention;

Figure 6 is a view of the die tooling of Figure 5 when rotated at 90 degrees from the Figure 5 position;

Figure 7 is a cross-sectional view along the lines 7-7 of Figure 6;

Figures 8 and 9 are graphs produced with an ultrasound sensor fitted to a plastic molding apparatus according to a preferred embodiment of the invention/

DETAILED DESCRIPTION ACCORDING TO THE PREFERRED EMBODIMENTS OF THE PRESENT INVENTION IN WHICH:

Figure 1 shows a molding apparatus generally indicated at 1. This apparatus includes an extruder 3 which feeds through die tooling 5 to a mold region generally indicated at 7. Plastic pipe 9 emerges from the downstream end of the mold region.

The mold region itself is formed from an upper endless chain of mold block sections 11 and a lower chain of mold block sections 13. The mold block section 11 and 13 close with one another in a moving mold tunnel 14.

As is known in the art when making profiled double walled pipe, the bulk of the mold block sections 11 and 13 will have interior mold cavities defined by alternating troughs and crests on the faces of the mold blocks. These troughs and crests are used to shape a corrugated profiled exterior pipe surface.

Some of the mold block sections will not have this same interior shape. More specifically, at spaced apart locations within each of the chains of mold block

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sections there will be mold block sections having a larger diameter bell shaped interior surface. These particular mold block sections are used to form pipe coupling parts within the length of continuous pipe 9 produced by molding apparatus 1. Such a coupling part is indicated at 10 on pipe 9 shown in both Figures 1 and 2 of the drawings.

It is important that the plastic flow to be described later in detail through the apparatus be consistent or homogenous in its makeup. The inclusion of weak or hard spots in the plastic flow may be very detrimental to the pipe particularly at the coupling region 10.

Figure 3 of the drawings shows more details of the extruder and the die tooling of apparatus 1. This extruder is fed pellets P of raw plastic material through a hopper 2 down into the extruder. The extruder itself includes an extruder screw which in combination with heat internally of the extruder converts the solid plastic pellets to a molten flow of plastic. This molten flow indicated at F in Figure 4 of the drawings is fed under pressure from the extruder through the die tooling 5 to the mold region 7.

In the formation of circular plastic pipe the die tooling includes at least one circular flow passage through which the plastic flow F moves from the extruder to the mold region. In the formation of double walled pipe there are two of these flow passages one being located outwardly around the other.

In accordance with the present invention sensing means are provided at least one of the above described flow passages. In Figure 3 of the drawings these sensing

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means are in the form of sensors 21, 23 and 25 to sense the flow of molten plastic F through passage 15.

Sensor 21 is a temperature sensor. This sensor senses the melt temperature of the plastic flow. Sensor 23 is a pressure sensor. This sensor measures the melt pressure i.e., the pressure required to force the molten flow of plastic through the die tooling.

Sensor 25 comprises an ultrasound sensor. This sensor includes a emitter 27 and a receiver 29.

In the case of ultrasound sensor 25, emitter 27 emits sound waves that move through the plastic flow to the receiver 29. The way that this sensor performs its sensing operation is to determine the speed with which the wave passes through the plastic flow and the amount of deflection of the wave as it passes through the plastic flow.

Among other things, sensor 25 senses the viscosity of the plastic flow. The more viscose the flow the faster the waves travel through. Also the less viscose the flow the less deflection of the waves.

Changes or variations in the plastic flow can be produced from a number of different factors. These factors can relate for example to extruder impeller wear, alignment of the die tooling temperature of the extruder and changes in the source of material fed into the extruder hopper. The ultrasound sensor on its own may not be able to indicate which one of these factors is producing measured flow changes. This is where the temperature sensor and the pressure sensor when used in combination with the ultrasound sensor became extremely useful.

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More specifically, if the apparatus is producing pipe at a constant output and either one of these sensors 21 or 23 senses that there is an increase in the melt temperature or the melt pressure than this is a good indication that the changes in the flow characteristic as measured by the ultrasound sensor 25 may well be caused by problems associated with the raw material P fed to hopper 2. For example, Figure 4 shows that the plastic flow F contains solid particles F1. These particles from the plastic pellets P or whatever other source of material is used have not been broken down to a completely molten state as they leave the extruder. As these flow particles F1 move by the ultrasound sensor they will slow the speed of the ultrasound wave passing between the emitter and the receiver. They will also cause a substantial attenuation or deflection of the waves. Therefore, the ultrasound sensor will detect that there is a change in the flow characteristic.

20

Either one or both of the pressure and the temperature sensors will also sense a change in the pressure and/or temperature of flow F. For example, the impeller of the extruder must work harder in order to both break down harder starting material and to push that harder material through flow passage 15. As a result when anomalies such as particles F1 are in the flow F either the pressure and/or the temperature sensed by sensors 21 and 23 will be elevated. This elevation in temperature and/or pressure typically indicates that there is a problem with the starting raw material rather than the equipment itself.

All three of the sensors can equally as well be used to indicate weak spots in the flow F. These weak spots are also generally caused as a result of poor or

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inconsistent raw starting material. When encountering a weak spot in the flow the ultrasound waves will typically move more quickly through and have less attenuation at those weak spots. Furthermore, typically the temperature and pressure required to move weaker spots through the passage will be less than that required for normal plastic flow.

As will be appreciated from the description above the temperature and pressure sensors are used as fine tuning devices to fine tune the results produced by the ultrasound sensor.

In the above description the three sensors 21, 23 and 25 are all located at different longitudinal locations in the die tooling. Figures 5 through 7 show a further preferred embodiment of the invention in which all of the sensors are located at a common longitudinal location within the die tooling. With this set up each one of the sensors is sensing or measuring the plastic flow at the same place in the flow.

Figure 5 of the drawings shows die tooling 31 having an interior flow passage 33. An ultrasound sensor comprising an emitter 35 and a receiver 37 are positioned diametrically opposite one another around the circular flow passage within the die tooling.

Figure 6 of the drawings shows die tooling 31 rotated 90 degrees from the Figure 5 position. Here it will be seen that a temperature sensor 39 and a pressure sensor 41 are located at the same longitudinal position of tooling 31 as the ultrasound sensor. Sensors 39 and 41 are also located on diametric opposite sides of circular flow passage 31. The receiver and emitter of the ultrasound sensor are located between the two sensors

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39 and 41.

The above described arrangement as clearly shown in Figure 7 of the drawings provides a very balanced
5 sensing of the plastic flow through the die tooling.

Figures 8 and 9 of the drawings show graphically measurements which are particularly useful as sensed by the ultrasound of the present invention.

10

As earlier noted, the extruder contains an impeller or extruder screw which converts the starting plastic material to the molten flow of material. This extruder screw can be run at different extruder speeds.
15 The ultrasound sensor will provide an indication as to the most appropriate extruder speed to be used with a specific starting material. Figure 8 shows the relative attenuation of the ultrasound waves passing through the plastic flow in the die tooling at different extruder
20 screws speeds. Figure 9 on the other hand shows the speed with which the ultrasound waves pass through the plastic flow at different extruder screw speeds.

Figures 8 and 9 show graphically that when the
25 extruder screw is operated at speeds of up to 25RPM both the wave attenuation and the sound speed are relatively consistent. This indicates good productivity and a good marrying of the extruder speed with the starting material.

30

Figures 8 and 9 also indicate that at extruder speeds over 35RPM there is a substantial increase in the relative attenuation of the ultrasound waves and large spikes in the sound speed graph. This indicates
35 relatively poor productivity of the apparatus. When seeing these kinds of results at over 35RPM there is an

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indication to the operator of the apparatus to either adjust the extruder screw or to replace the raw material or to do both if the apparatus is to be run with extruder screw speeds in excess of 35RPM.

5

As per the earlier discussion, the pressure and temperature sensors are extremely helpful in determining which particular adjustment should be made to the apparatus.

10

Although various preferred embodiments of the present invention have been described in detail, it will be appreciated by those skilled in the art that variations may be made without departing from the spirit
15 of the invention or the scope of the appended claims.

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**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. Molding apparatus including an extruder which
5 receives plastic which is converted pressure to a molten
form by heat and pressure within the extruder, said
apparatus further including die tooling between said
extruder and a mold region of said molding apparatus, the
plastic in its molten form being fed from the extruder as
10 a plastic flow through the die tooling to the mold
region, the die tooling including sensing means which
senses different characteristics of the plastic flow,
said sensing means including an ultrasound sensor which
transmits sound waves across the plastic flow and which
15 measures different parameters of the sound waves, a
temperature sensor which measures temperature of the
plastic flow and a pressure sensor which measures
pressure of the plastic flow within the die tooling.
- 20 2. Molding apparatus as claimed in Claim 1 wherein
said ultrasound sensor senses plastic flow changes within
the die tooling, said temperature and pressure sensors
providing more specific information as to potential
sources of the plastic flow changes.
- 25 3. Molding apparatus as claimed in Claim 1 wherein
said die tooling has a circular cross-section, said
ultrasound sensor having an emitter and a receiver
positioned at diametric opposite sides of said die
30 tooling, said temperature sensor and said pressure sensor
being located proximate said ultrasound sensor.
4. Molding apparatus as claimed in Claim 3 wherein
said ultrasound sensor is located at a fixed longitudinal
35 location along said die tooling, said temperature sensor
and said pressure sensor also being located at said

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longitudinal location of said die tooling.

5. Molding apparatus as claimed in Claim 4 wherein
said pressure sensor is located between said emitter and
5 said receiver of said ultrasound sensor at a first
circumferential location around said die tooling, said
pressure sensor being located at a second circumferential
location around said die tooling separated from said
temperature sensor by both said emitter and said receiver
10 of said ultrasound sensor.

6. Molding apparatus as claimed in Claim 5 wherein
said temperature sensor and said pressure sensor are
located diametrically opposite one another on said die
15 tooling.

7. Molding apparatus as claimed in Claim 2 wherein
said ultrasound sensor measures viscosity of the plastic
flow, said temperature sensor and said pressure sensor
20 sensing uniformity of the plastic flow.

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FIG. 1.

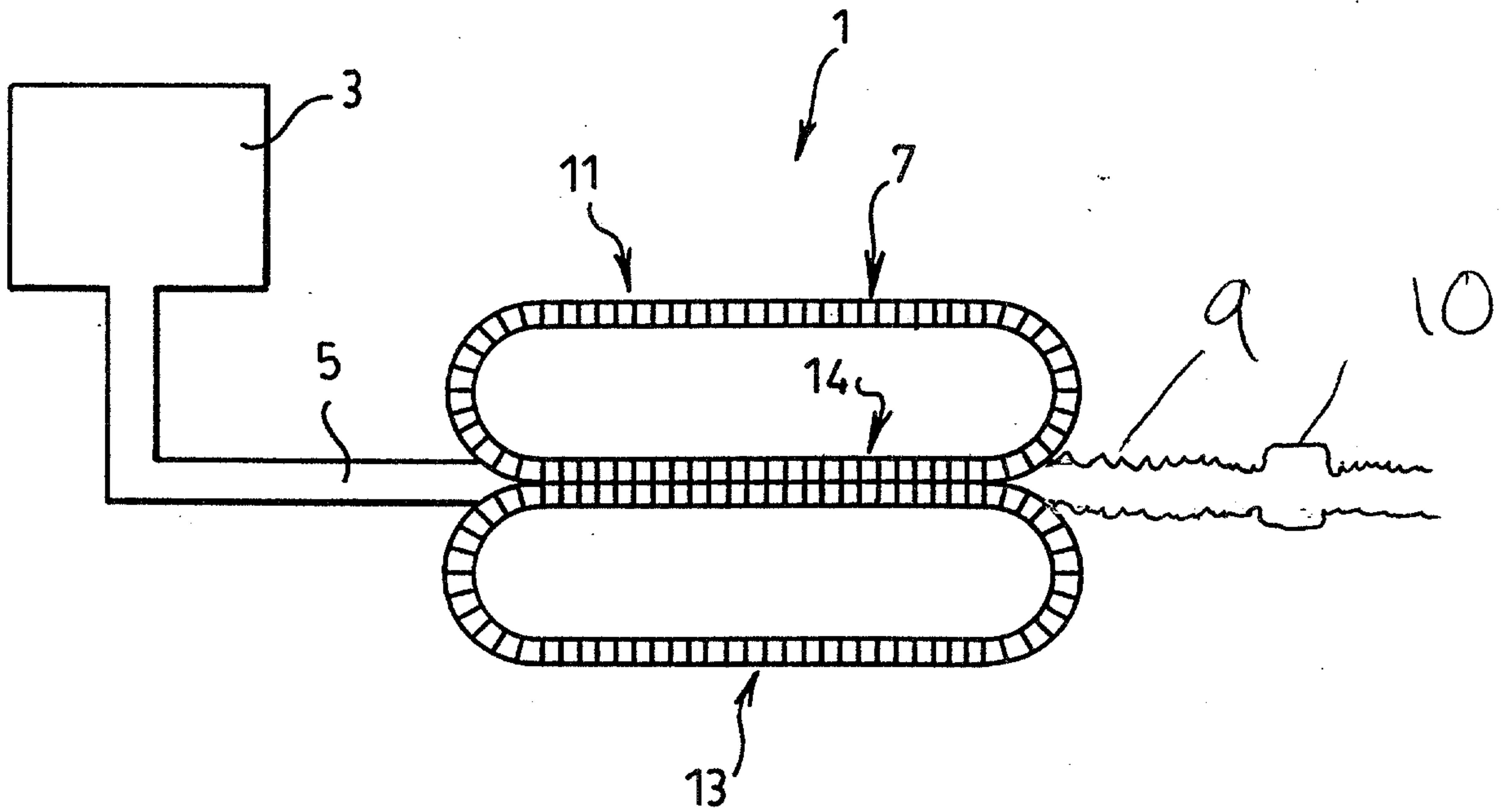


FIG. 2.

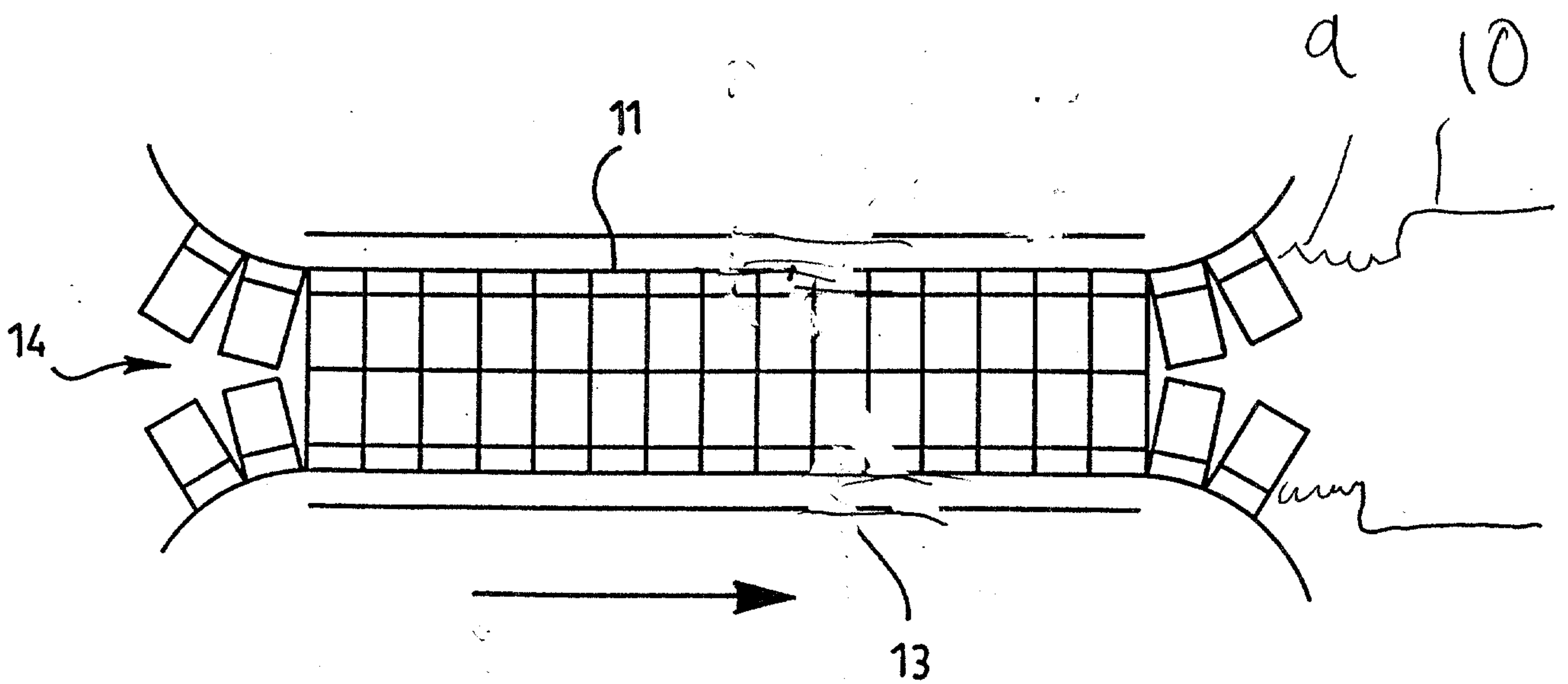
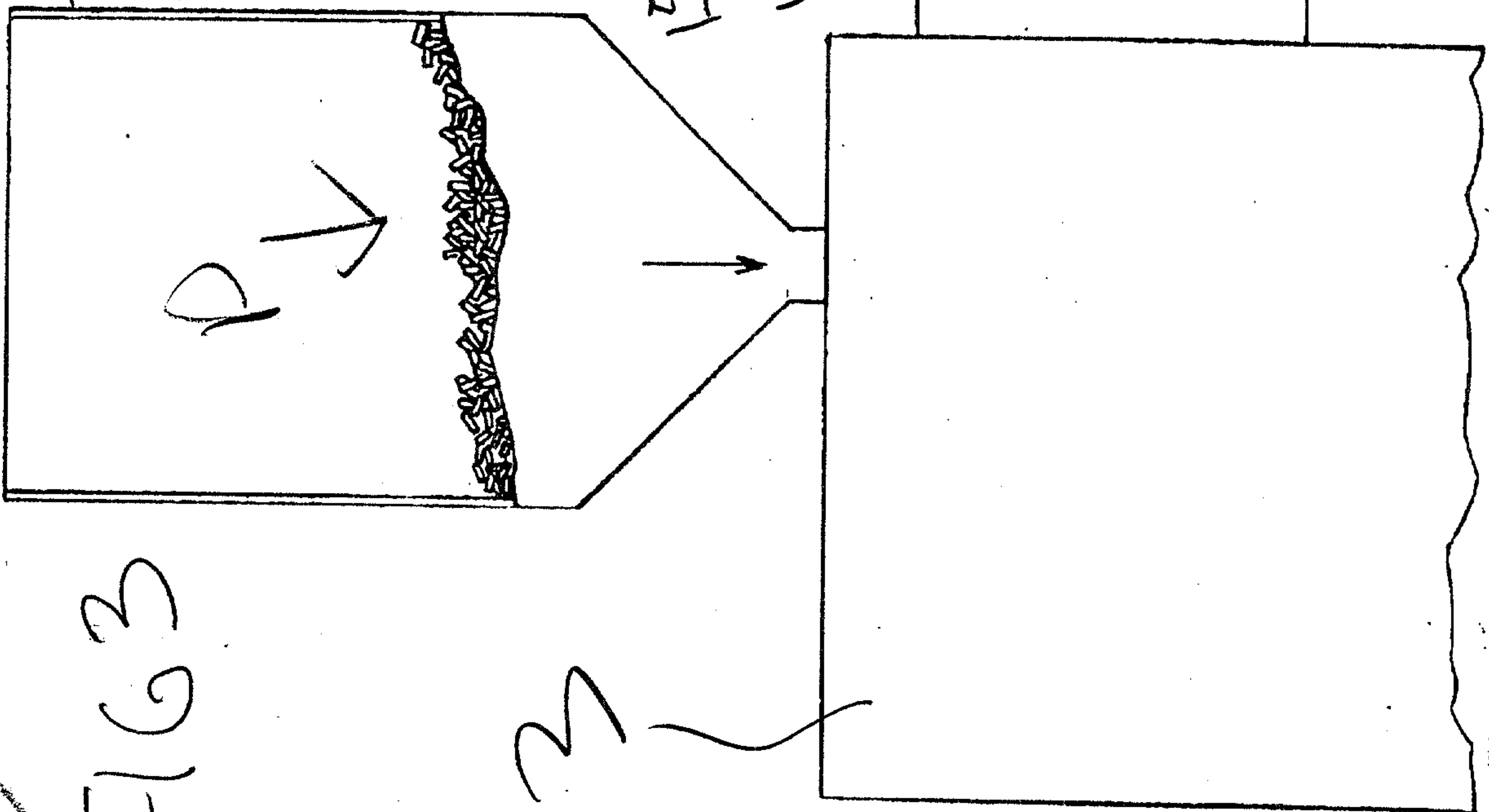


FIG 3



F1 FIG 4

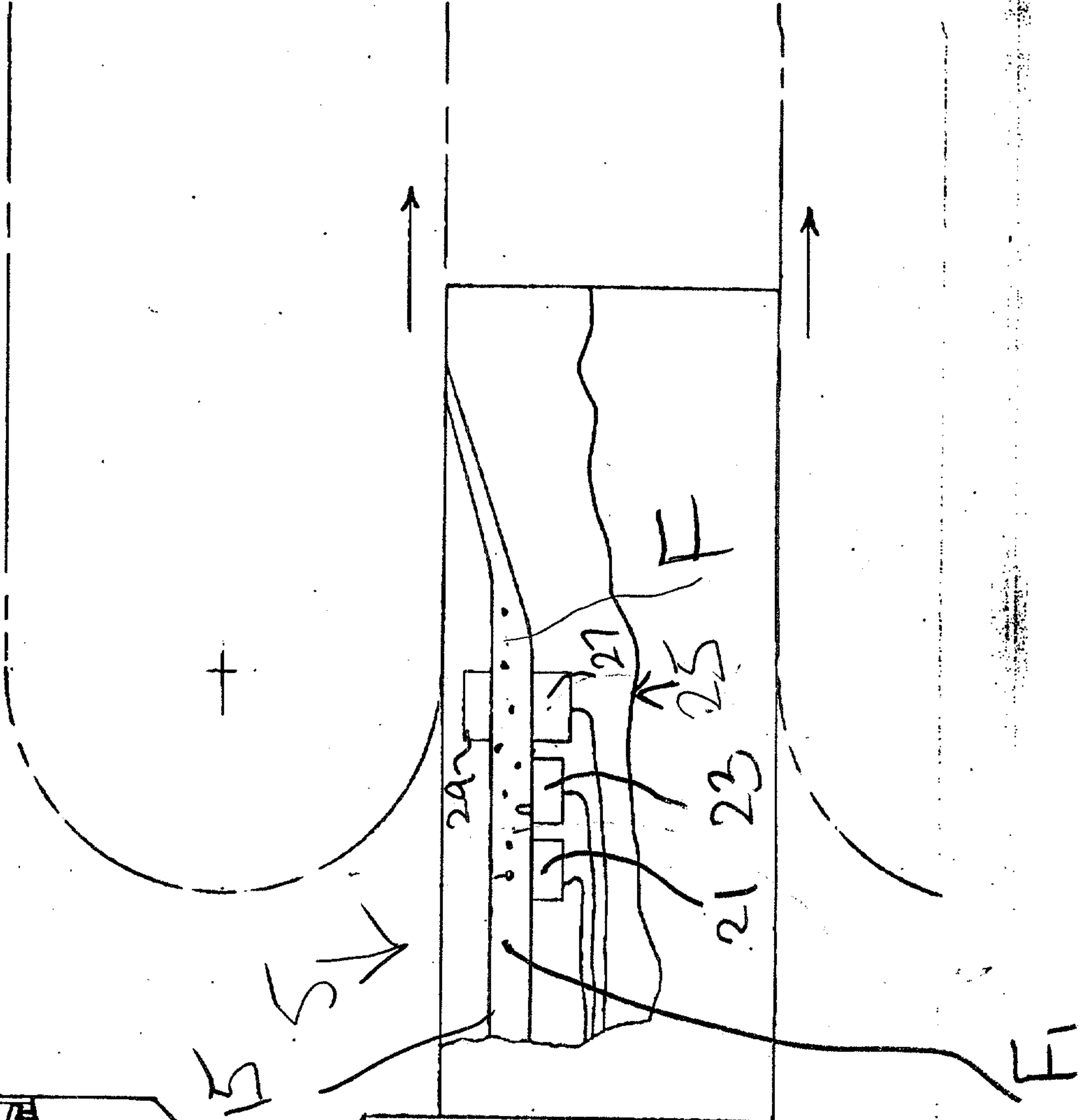
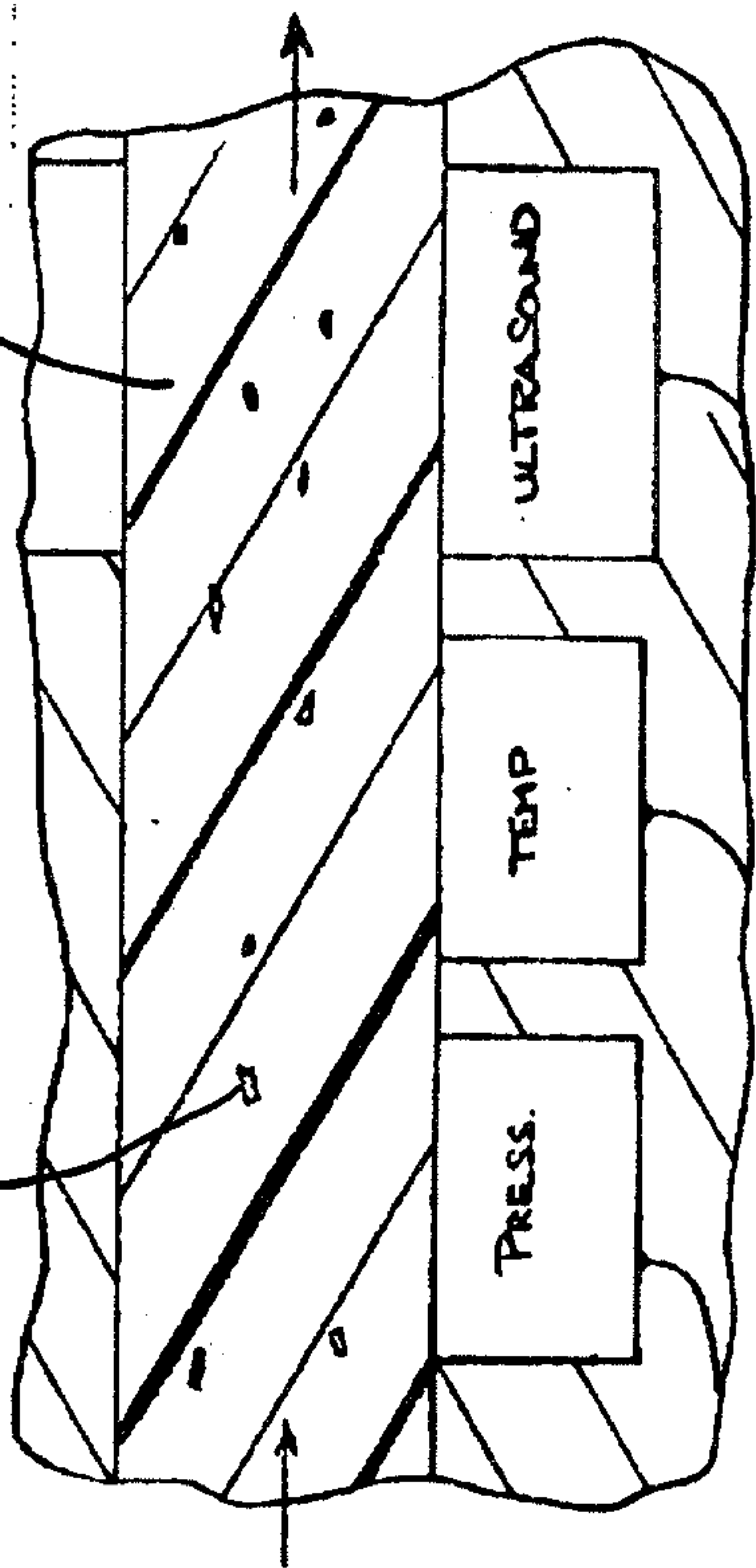


FIG 5

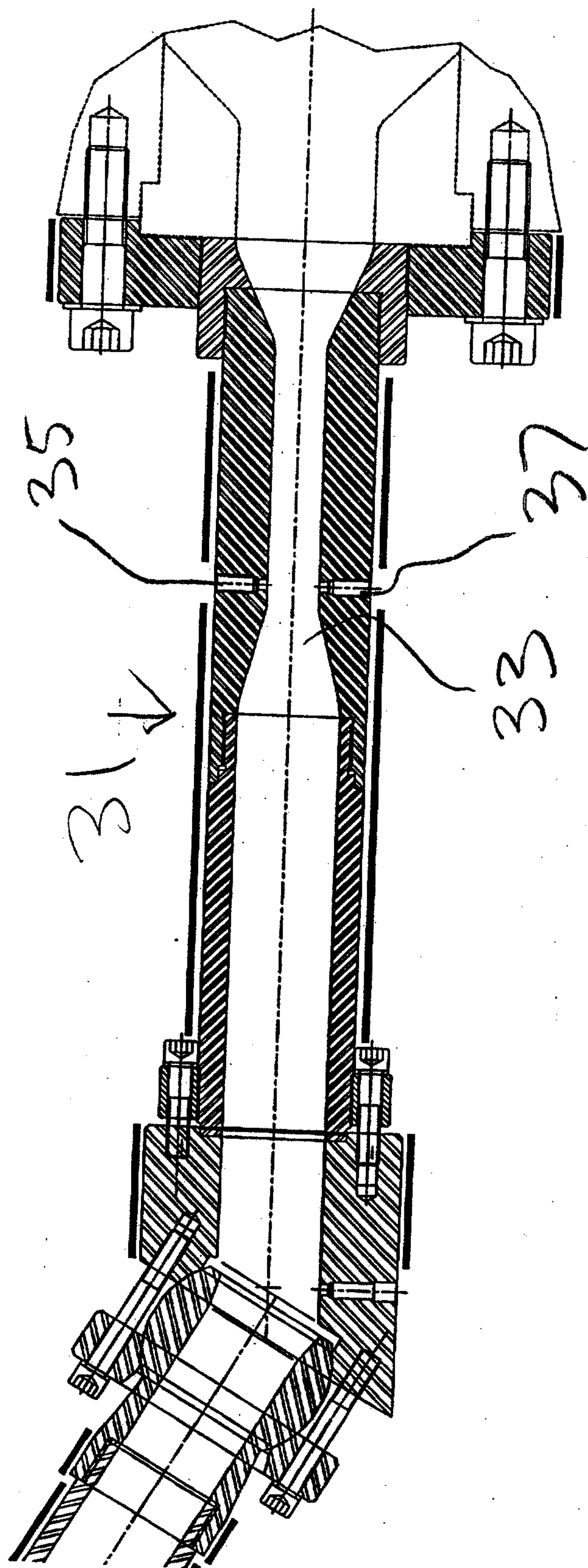


FIG 6

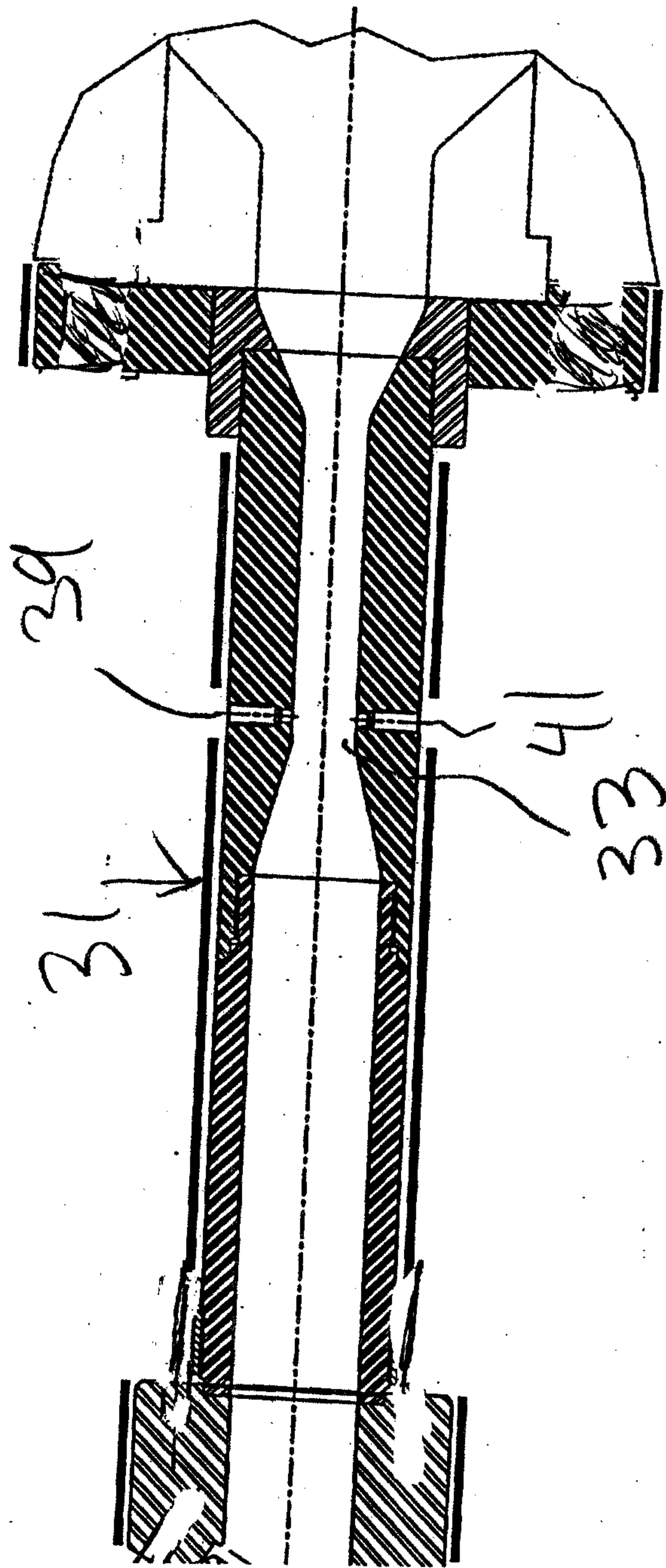
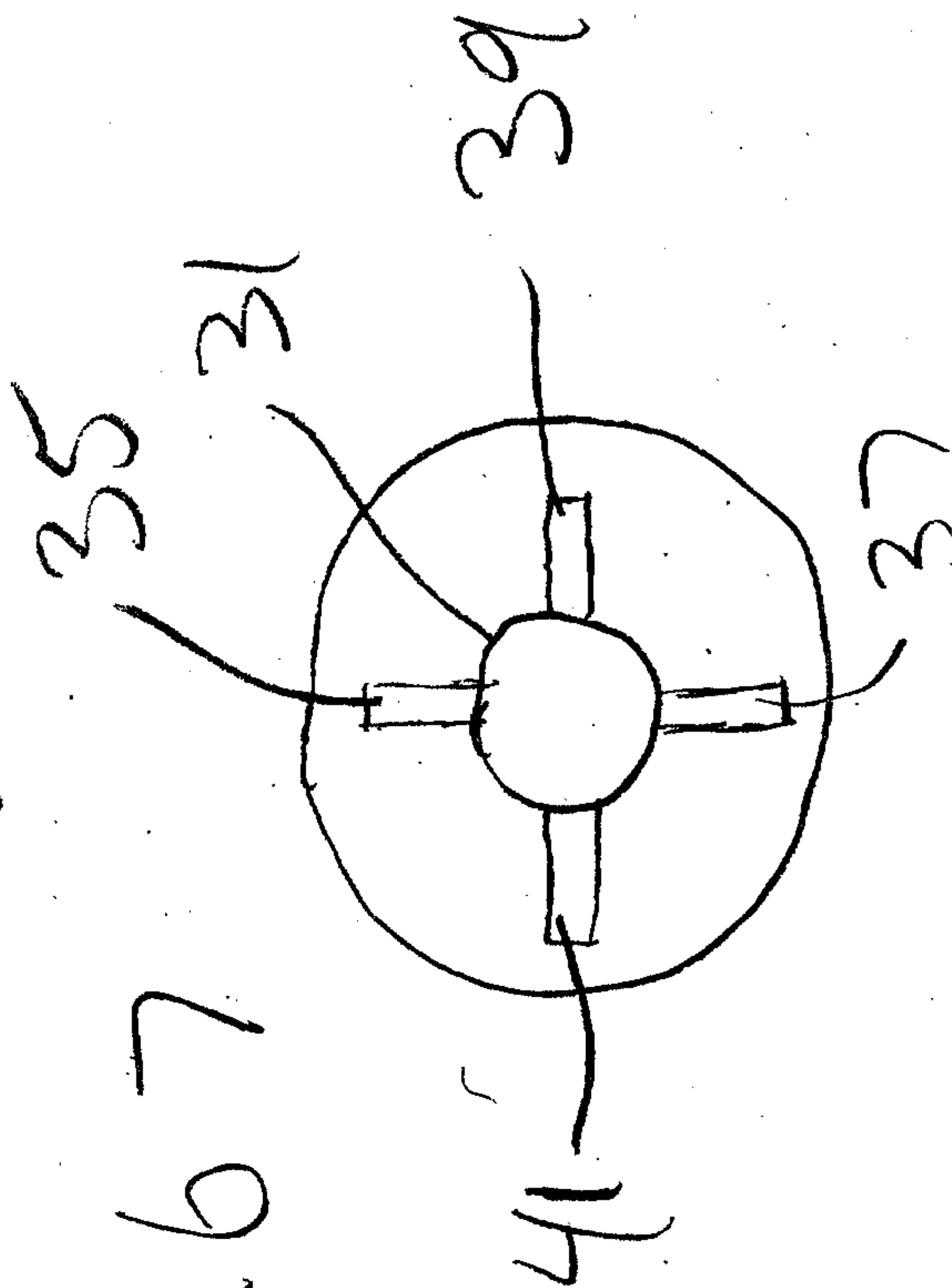


FIG 7



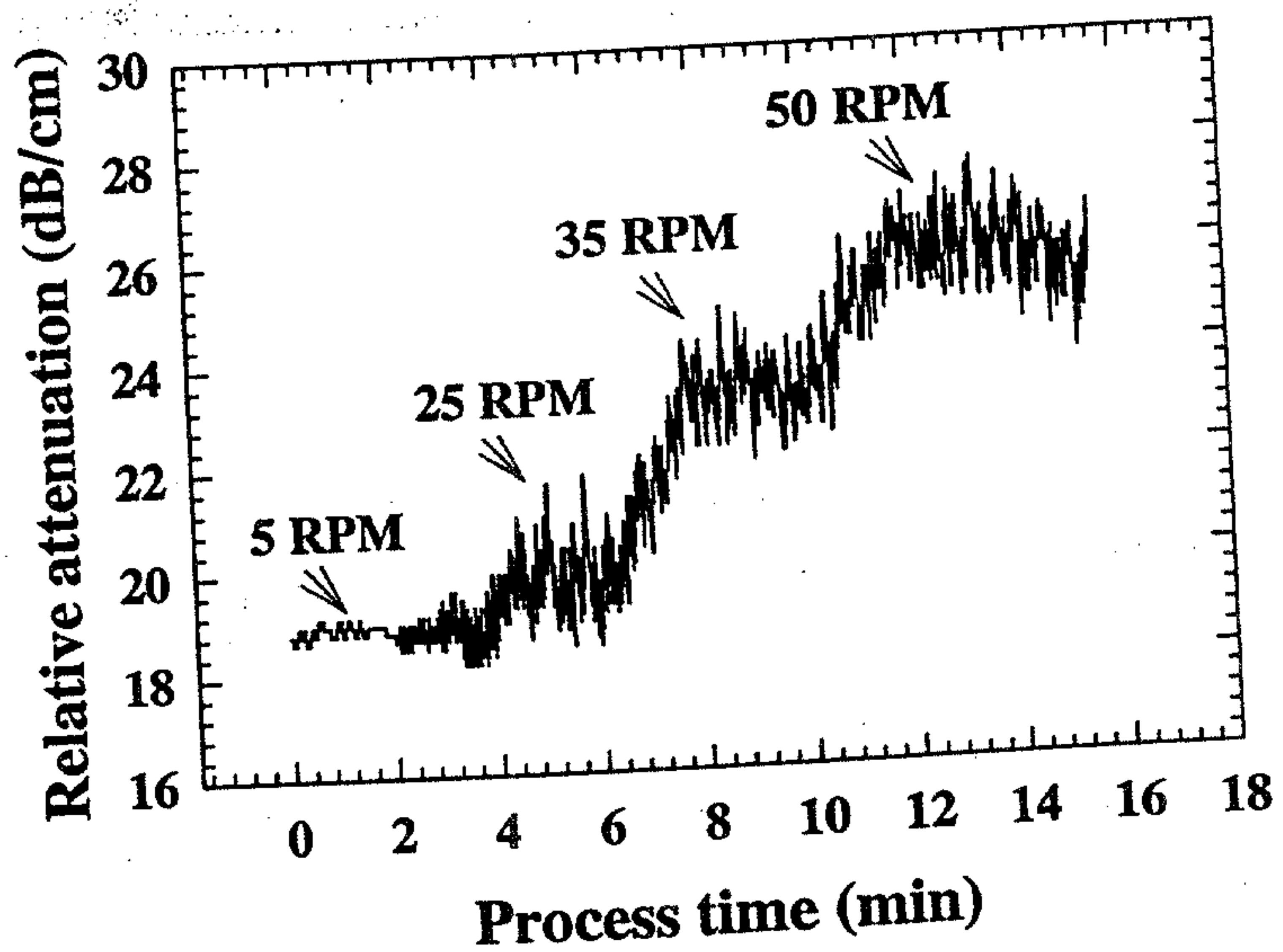


FIG 8

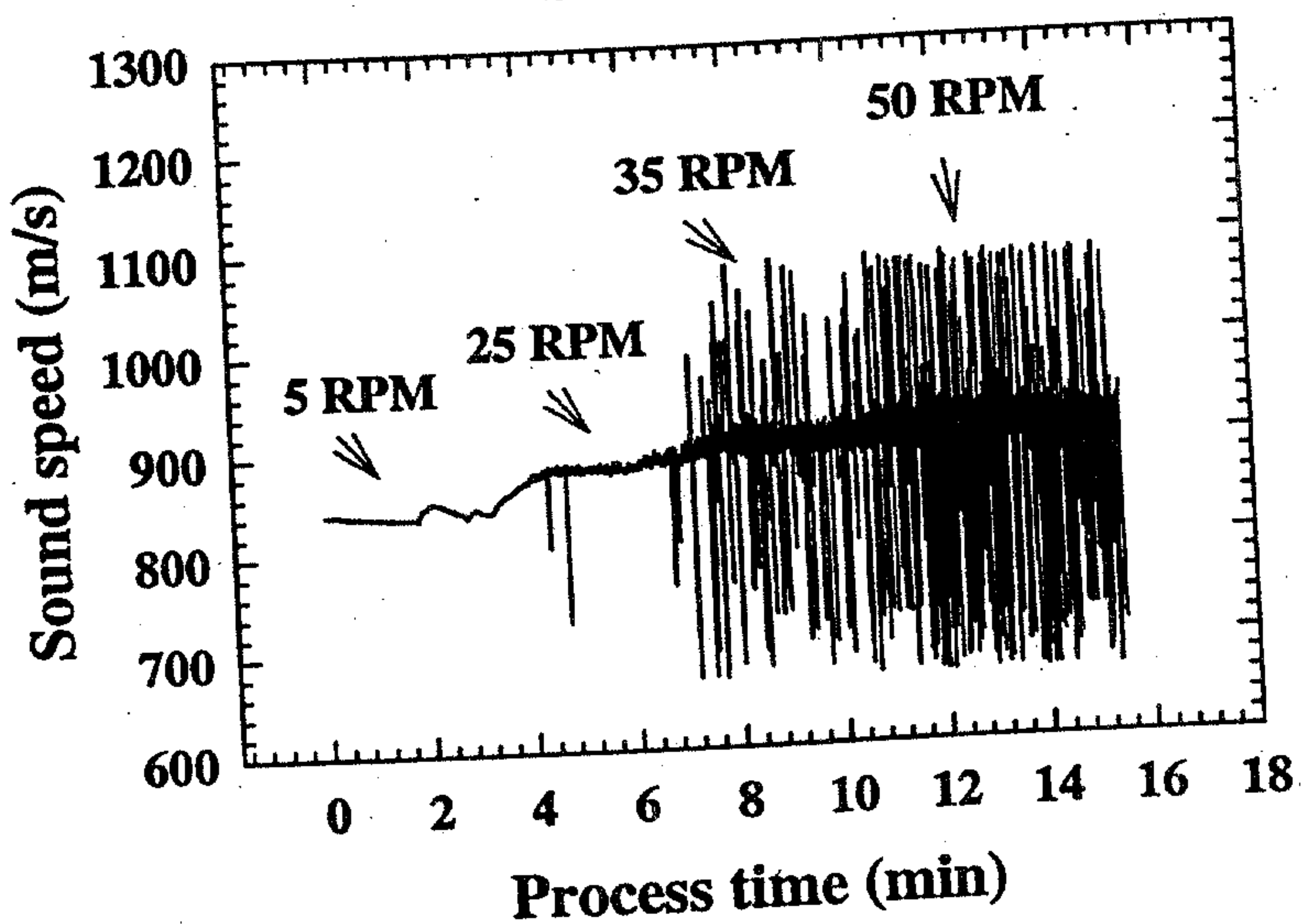


FIG 9

