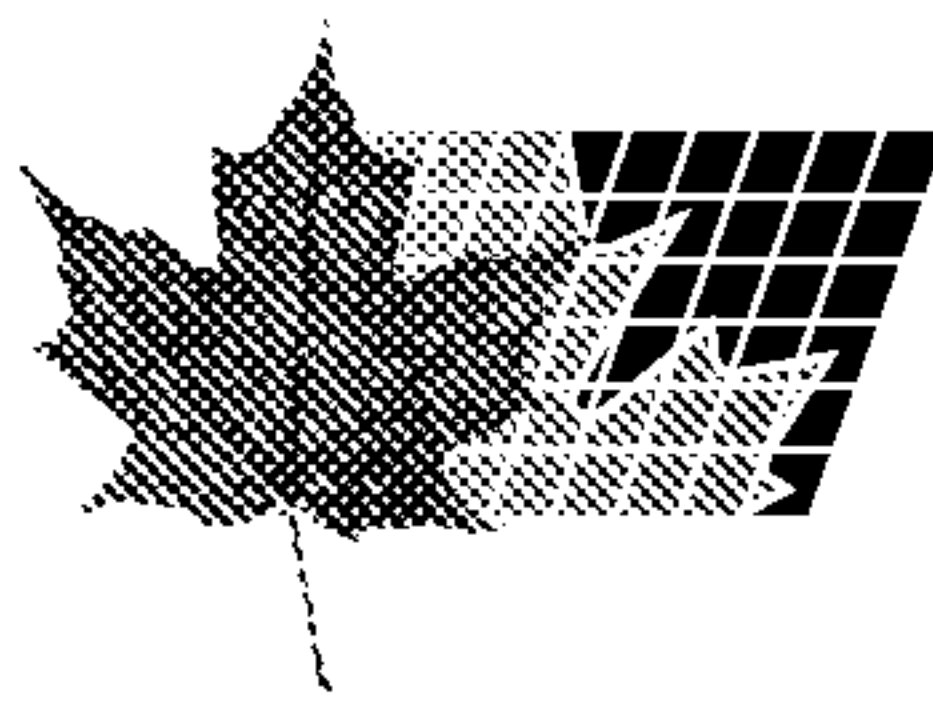




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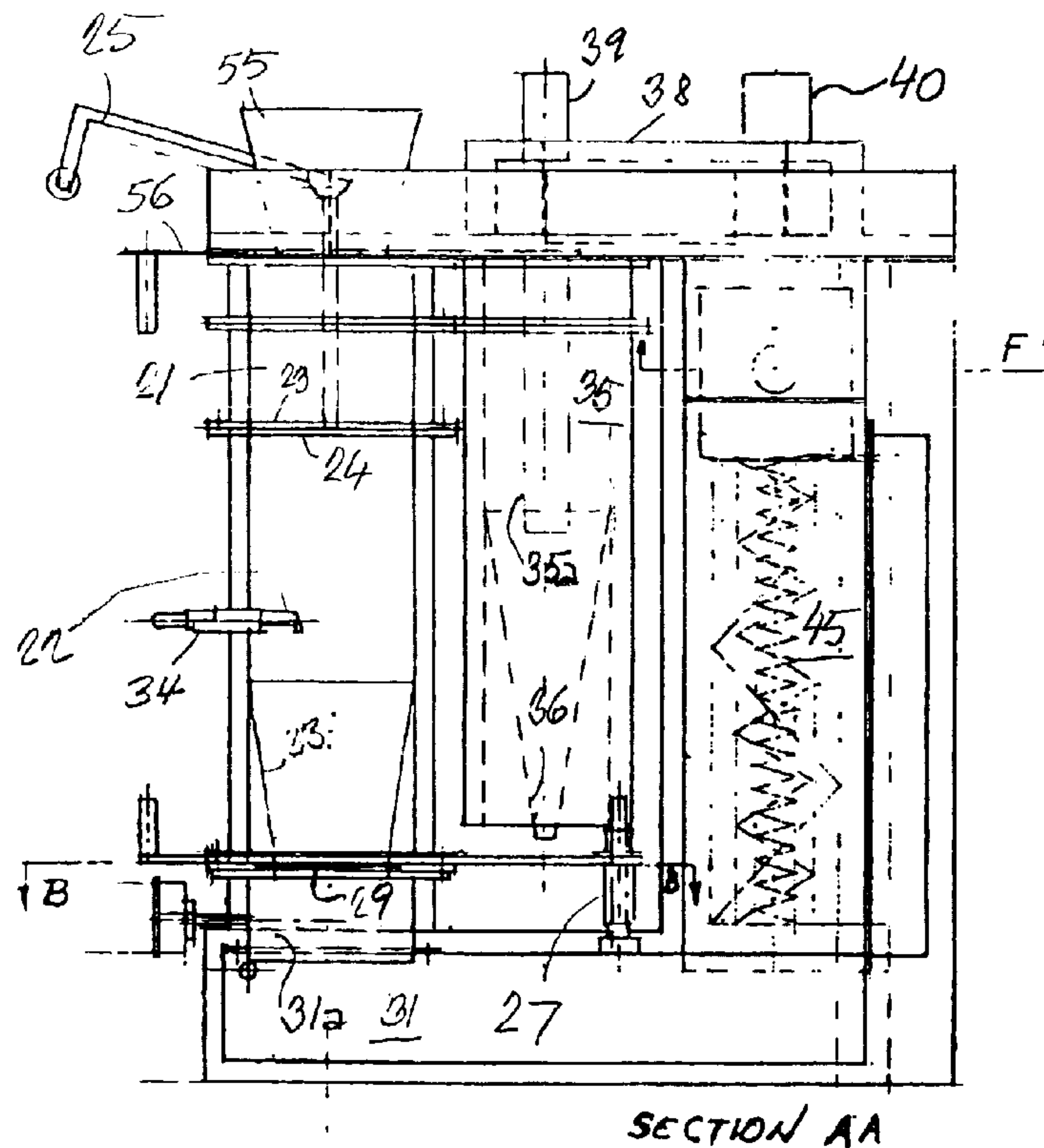
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(54) **METHODE DE TORREFACTION DU CAFE ET
TORREFACTEUR**

(54) **METHOD AND APPARATUS FOR ROASTING COFFEE**



(57) Control of the roasting fluidized bed of coffee. It is governed by sensing the cracking sound pattern generated by the coffee being roasted. The sound pattern signifies when the pyrolysis of the roasted batch is at its peak. The roasting is then stopped after a predetermined period of time. The following of the sound at the peak of pyrolysis accurately and uniformly determines the starting period for the timing of the stoppage of the process to obtain uniform roasting result. The process is not vulnerable to variations in roasting such as moisture, temperature of the roasting air etc. Air circulation control conduit is provided with a vent port for gases and an inlet port for fresh air, the two ports can be simultaneously opened or closed while the control conduit is simultaneously closed or opened, respectively.

Abstract of the Disclosure

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Control of the roasting fluidized bed of coffee. It is governed by sensing the cracking sound pattern generated by the coffee being roasted. The sound pattern signifies when the pyrolysis of the roasted batch is at its peak. The roasting is then stopped after a predetermined period of time. The following of the sound at the peak of pyrolysis accurately and uniformly determines the starting period for the timing of the stoppage of the process to obtain uniform roasting result. The process is not vulnerable to variations in roasting such as moisture, temperature of the roasting air etc. Air circulation control conduit is provided with a vent port for gases and an inlet port for fresh air, the two ports can be simultaneously opened or closed while the control conduit is simultaneously closed or opened, respectively.

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METHOD AND APPARATUS FOR ROASTING COFFEE

The present invention relates to a method and apparatus for roasting coffee.

Three operations are needed to convert the green coffee beans into consumable beverage: (1) roasting, (2) grinding and (3) brewing. The characteristic flavour and aroma of coffee is developed only by roasting.

Roasting is a time-temperature dependent process, where chemical and a physical changes are caused in the green coffee beans accompanied by loss of dry matter primarily such as gaseous carbon dioxide and water and other volatile products of the pyrolysis. Roasting is normally carried out under atmospheric conditions with hot gases and excess air as primary heating agents. Heat also may be provided by contact with hot metal surfaces, solely in more primitive methods, but more generally as supplement to convection from the hot gases. The degree of roast plays a major part in determining the flavour characteristic of extracts eventually brewed from roasted coffee, whatever the type.

In general, roasters have been designed and are available based on different mechanical principles as summarized below.

- Horizontal rotating drum - solid or perforated wall
- Vertical static drum with blades
- Vertical rotating bowl
- Fluidized bed roaster
- Pressure roaster

All roasters must also provide a cooling facility to bring the roasted coffee after the desired level of roast to ambient temperature, usually by contact with cold air.

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The known roasters use either "once through" flow of hot air or they recirculate the hot gases developed by roasting. The disadvantage of the first type is a high energy consumption since the incoming air has to be constantly heated to the required temperature. The second type is

5 disadvantageous as it is difficult to properly control the roasting cycle. Another disadvantage of the circulated flow of air is in the danger of tar deposits formation on the roasted beans impairing the quality of the final product. The known roasters utilize the clocking of the roast time from the beginning of the process to its end. This is disadvantageous as when only

10 one of many variables of the roasting process or conditions changes, the result is not uniform even for the same type. The changes in variables governing the roasting are inevitable. Every batch of green beans, even of the same type, is slightly different from another because of its temperature, moisture, condition of roaster, variation in energy supply, to mention just a

15 few.

It is an object of the present invention to improve the roasting methods and apparatuses such as to avoid or at least reduce the above disadvantages and to provide an improved uniformity of the coffee roasting process.

20 In general terms, the invention provides, in one aspect thereof, a method of controlling the roasting of a batch of a type of coffee in a roasting chamber of a roasting device, comprising the steps of:

(a) charging a batch of nonroasted coffee beans to the roasting chamber;

(b) 25 subjecting the batch to the flow of air having the temperature required for bringing the beans of the batch to the pyrolysis;

(c) sensing at least one of variables of the pattern of the cracking sound generated by the beans of the batch as the batch is heated to the point of pyrolysis, said variables including (i) the rapidity of the cracking sound; (ii) the frequency of the cracking sound; (iii) the

30 volume of the cracking sound;

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- (d) using said sensing to determine three stages of said pattern: (1) a first crack at which the respective variable/variables is/are measurably above zero; (2) an interim period following the period of said first crack sound, at which interim period the respective variable/variables is/are virtually zero; and (3) a second crack sound, following said interim period at which the respective variable/variables is/are measurably above zero;
- (e) when the pattern reaches said second crack sound, initiating the operation of clocking means preset to a predetermined time length;
- (f) upon expiry of said predetermined time length generating an output signal for stopping the roasting operation and discharging roasted coffee from said roasting chamber.

In another aspect, apparatus is provided for roasting a batch of a type of coffee comprising:

- (a) a roasting chamber having a bottom portion and a top portion and operatively associated with heated air supply flowing in a direction from said bottom portion to said top portion;
- (b) a sound probe mounted in said chamber for sensing characteristics of sound generated by the batch in said chamber as it is being roasted;
- (c) said sound probe being operatively connected to an activating device adapted to become actuated when the sound acquires predetermined parameters.

The invention will now be described with reference to the enclosed informal drawings and photograph reproductions. In the drawings:

- Figure 1 is a diagrammatic side view of the roasting apparatus with certain parts omitted;
- Figure 2 is sectional view along the section line B-B of Fig. 1;
- Figure 3 is a front view taken from the left of Fig. 1;
- Figure 4 is a perspective view of the apparatus showing the roasting chamber in a discharge mode;
- Figure 5 is a perspective view of the apparatus showing the roasting chamber in a closed mode;

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- Figure 6 is a partial perspective view of a lower portion of the environs of the roasting chamber in an open state;
- Figure 7 is a perspective view of a lower portion of the apparatus showing the discharge of chaff from the cyclone separator of the apparatus of the present invention;
- Figure 8 is a diagrammatic representation, in a side view, of the upper portion of the roasting chamber with certain parts omitted;
- Figure 9 is a partial side view showing the preferred embodiment of air circulation control of the apparatus; and
- Figure 10 is a block diagram of the arrangement of a preferred embodiment of the sound analyzing system of the apparatus of the present invention.

The roaster includes a cylindric roasting chamber 20 comprised with an upper chamber 21 and a lower chamber 22. There are flanges 23, 24 with a heat resistant seal (not shown) secured to one of the flanges 23, 24 to sealingly engage the opposed flange when the upper and lower chambers are aligned such as shown in Fig. 1 or Fig. 5. A locking lever 25 is operatively associated with the upper chamber 21 to sealingly secure the two flanges 23, 24 to each other. The upper chamber 21 communicates, via a tangential inlet 26 with a cyclone separator to be described later. The top of the upper chamber 21 is provided with a hopper 55 provided with a manually operated knife valve 56.

The lower end of the lower chamber 22 is pivotably secured to a pivot 27 which permits the lower chamber 22 to assume the position of Fig. 1, i.e. coaxial with the upper chamber 21, and that of Fig. 4, by pivoting same over an arc of about 40°.

The lower end of the chamber 22 sealingly slides on a support plate which has two circular passages therein. The first passage 29 is provided with a pattern of perforations allowing passage of air through same but being smaller in size than a coffee bean. The second, discharge passage 30 has a diameter similar to that of the first passage 29 but is of the type of

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plain bore. The first passage 29 is located on top of a pressure air chamber 31a at the downstream end of a lower duct 31 while the discharge passage is located above a discharge container 32. The bottom portion of the interior of the lower chamber 22 is provided with a truncated cone 33 the lower end of which has the diameter corresponding to the diameter of the passages 29, 30. Accordingly, when the upper and lower chambers 21, 22 are aligned, pressurized air may flow into the chamber 20 through the perforated first passage 29, and when it is pivoted about the pin 27 to a discharge position, the contents of the chamber fall through the cone 33 into the discharge container 32.

A sampler 34 located in the wall of the lower chamber 22 serves the purpose of visual checkup of the coffee beans treated in the chamber 22. In principle, it is just a spoon-like element which is normally disposed inside, but can be pulled temporarily outside of the chamber 22. The sampler is adapted to prevent hot air and unscooped beans from escaping from the chamber 20 as the sample of the beans is taken out of the chamber and examined, to be later returned back into the chamber 20 by simply pushing the sampler back to its initial, closed position.

As already mentioned, there is a tangential inlet 26 communicating the upper chamber 21 with a cyclone separator 35. The cyclone separator 35 is of a known design and operating principle. Briefly, it separates chaff from the flow of air coming from the roasting chamber 20. The chaff falls down through the tip of a cone 36 and through a discharge tube best shown in Fig. 7, into a chaff collecting container 28. The air cleaned of chaff exits at a top outlet 37 communicating with the circulation control box 38 (Fig. 9).

The circulation control box 38 has an air vent port 39 and a fresh air inlet port 40. A lever system 41 simultaneously operates a vent flap 42 and a fresh air control flap 43. Both flaps 42, 43 can assume a position where they control their respective ports. Thus, in a position shown in Fig. 9, the flap 42 closes the circulation box 38 permitting chaff free gases from the

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cyclone 35 to be discharged through the outlet 37 and vent port 39 into the atmosphere. In an opposite extreme, the flap 42 closes the vent port 39, forcing air coming from the cyclone 35 to flow into the control box 38. The flap 43 of fresh air is moved simultaneously with the flap 42. In the mode
5 of Fig. 9, it closes the box 38 permitting flow of air through the port 40 and into an inlet 44 of an air heater 45 having heating elements and adapted to heat the incoming air to a predetermined temperature. Circulation fans 46, indicated only diagrammatically, aid in force the circulation through the entire system. It can be observed that two extreme modes can be assumed
10 by the flaps 42, 43. The circulation closed mode where the flap 42 closes the circulation and opens the vent 39, while the flap 43 closes the circulation box 38 and opens fresh air inlet 40, or the circulation mode where the flap 42 closes the vent 39 opening the circulation box 38 while the flap 43 closes the fresh air port 40 opening the box 38 to permit
15 circulation of gases coming from the separator 35 to pass again through the air heater 35.

The fresh or hot air is thus forced to flow down through the heater 35, into the pressure air chamber 31a and into the roasting chamber 20, generating the fluidization effect on the coffee bean charge in the chamber
20 20 simultaneously with the roasting thereof.

Turning now to Figure 8, a check tube 47 is shown as reaching into the interior of the upper chamber 21. The tube is operatively associated with a sound analyzing device which is indicated diagrammatically in Fig. 10. Briefly, the system 48 comprises a microphone 49 connected, via an
25 amplifier 49a, to a three-stage band-pass filter 50, full wave rectifier 51, low pass filter 52, a comparator 53 and an output relay 54. Other known systems can be applied for the same purpose but the arrangement shown is preferred.

30 The output relay 54 is adapted to cause the control of air circulation depending on the condition of the roasted coffee as will be described. It will be appreciated, however, that different parts or a number of various

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sections of the roaster can be automatically operated utilizing the output of the device shown in Fig. 10.

In operation, the blowers of the air heater 45 draw in air from the inlet 40 (the flap 43 closes the circulation control box 38) and discharge it in to heating chamber 45 where is heated to a thermostat controlled temperature from about 250°C to about 270°C. The heated air then flows through the lower duct 31 into the pressure air chamber 31a the pressure air chamber 31 and through the perforations of the first passage 29.

The hot air passes through the coffee beans batch in the roasting chamber bringing the batch into the state of a fluidized bed. The air which has passed through the fluidized bed and through the upper chamber 21 with chaff from the roasted beans passes through the tangential inlet 26 into the cyclone 35 for chaff removal. The chaff is collected at the container 28 and the chaff free air exits through the central tube 35a through the outlet 37 at the top of the cyclone body 35. Since at this stage the flap 42 closes the vent port 39 and the flap 43 closes the inlet port 40, the air is then drawn through the circulation control chamber 38 back into the air heater 45 and circulated to the roasting chamber 20 as described.

Near the end of the roasting operation using the recirculated air, heavy smoke may develop. This may result in undesired deposits of tar on the roasted beans which negatively influence the final quality of the product. If heavy smoke develops, the operator interrupts the circulation by activating the lever system 41 such as to move the flap 42 to open the vent 39 and close the passage in the circulation control chamber 38 while also opening the inlet 40 to draw fresh air into air heater 45 and hence into the roasting system. The hot air with smoke is vented at 39 to the atmosphere while fresh air is drawn through the inlet port 40 and into the system. The described system of control of the recirculation of course also permits a partial venting and a partial circulation with likewise partial intake of fresh air.

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The operator is guided by electronically developed activation or signals, it being understood that the activation or signals may also be used to operate one or more elements of the roasting circuit, for instance the recirculation of hot air, temperature control at the heater 45 etc. The
5 present invention provides such activation utilizing a phenomenon which occurs during the roasting of coffee, as will now be described.

In a coffee roasting operation, the original moisture present in green coffee beans takes place. Then the roasting itself starts at a temperature of about 200°C after which through exothermic reactions, escalation of the
10 roasting process occurs which requires considerable control of the roasting for a given degree of roast. Reaction in green arabica coffee may start as low as 160°C. The reaction peaks at about 210°C and falls off at about 250°C.

The most obvious physical change to occur is the external color
15 which ranges from light brown to almost black. This change is accompanied by exudation of oil to the surface with increased severity of roasts. Swelling of beans also progressively occurs.

The invention utilizes the phenomenon of the roasting of coffee being accompanied by the popping or cracking of the beans leading to a
20 considerable decrease of density as a function of the degree of roast but also of the speed of roasting. While different types of coffee beans behave in a different fashion during the roast, the cracking phenomenon always occurs and has a general pattern which is common to all types of coffee. According to the present invention, the peculiar pattern of the popping or
25 cracking sound is followed as a variable which is indicative of the state of pyrolysis of the coffee beans being roasted.

The invention will be described by way of exemplary method and apparatus. In the method, the variable of the cracking sound sensed and observed was mainly the volume of the sound. The different qualities of the

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sound (in the embodiment described, the volume) accompanying the roasting of the coffee can be divided into three stages:

- (1) the level of background sound occurring at the outset of the heatup of the batch up to the first crack sound occurring at the beginning of pyrolysis of the beans;
- (2) an interim period of a reduced level of sound following the first crack but preceding the second crack; and
- (3) an increased level of crack sound when the pyrolysis of the beans is at its peak.

It has been established by sound analyses that, in general, the level of the sound developed during the roasting of a batch within the roasting chamber 20 during the first crack is higher than that observed during the interim period. Similarly, the sound level of the second crack is always higher than that of the interim period.

Experiments carried out in the context of the present invention point out to a relationship between the pronouncement of differences in sound levels at the respective stages and to the frequency measured.

Sound level spectra have been analyzed beans utilizing the present invention. The following table contains representative examples of measurements obtained with a particular type of coffee:

Band Crack	Band	1st Crack	Interim	2nd
	Hz	dB	dB	dB
25	971.63	31.5	28.6	30.0
	1539.93	29.2	23.2	28.6
	2053.53	32.2	32.2	29.2
	2585.23	29.0	25.7	30.6
	3447.46	33.5	28.6	34.6
	5158.22	31.6	28.2	35.1

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6493.81	25.2	21.0	29.0
9172.76	23.4	18.2	26.4

5 The duration of the 1st crack may vary from about 30 sec to about 90 sec and that of the Interim and the 2nd crack depends on the desired degree of roast and on the type of coffee being roasted. It is typically from about 3 sec to about 90 sec. The table shows that with the increased band levels the distinction between the Interim period is better pronounced and therefore can be used for the control of the operation of the roasting. Once the second crack occurs, the pyrolysis of the beans has reached the desired
 10 level and the roasting should be stopped. As mentioned above, the sound characteristics vary with different types of coffee beans but once established, they provide a reliable value for controlling the process.

15 The present invention thus provides an improved and simple way of determining the duration of the roasting of a particular type of coffee beans by

- (i) recognizing and differentiating the pattern of first and second cracking;
- (ii) providing the operator with a visual and/or sound signal that the second cracking has started;
- 20 (iii) switching hot air to vent and open the fresh air inlet;
- (iv) starting timer to clock preset time for particular roast (light, medium, dark, very dark) and coffee type.

25 The invention allows the operator to automate the roasting process with a consistent result that cannot be achieved by prior art mentioned at the outset, namely the clocking the time at as of the beginning of the process for reasons explained at the outset of this description. To start clocking at the second crack, i.e. at a point when pyrolysis is at peak,

-12-

provides a united point for any type of coffee beans, assuring consistent repeatability of the degree of roast for the particular type.

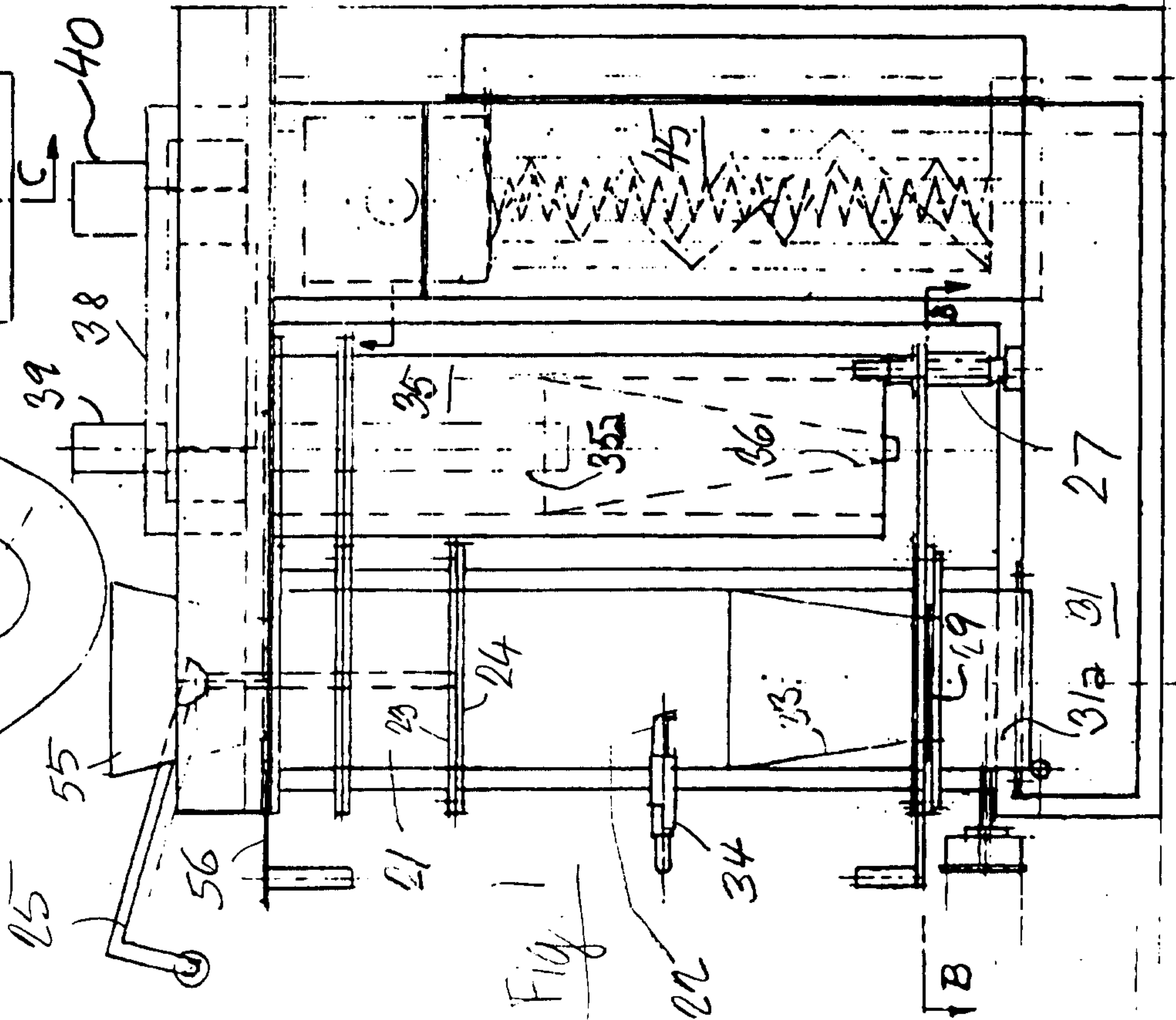
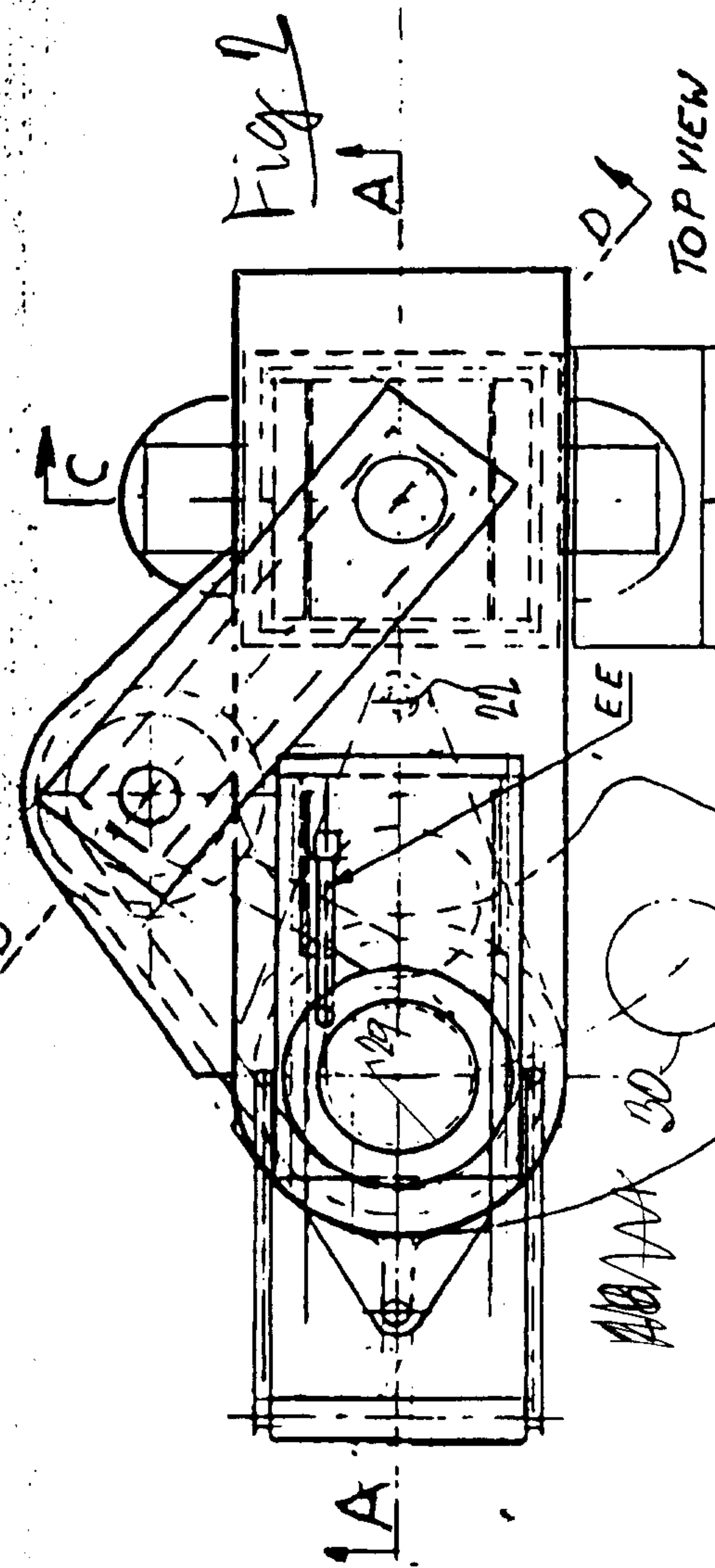
-13-

CLAIMS

- 1 1. Method of controlling the roasting of a batch of a type of coffee in a
2 roasting chamber of a roasting device, comprising the steps of:
 - 3 (a) charging a batch of nonroasted coffee beans to the roasting chamber;
 - 4 (b) subjecting the batch to the flow of air having the temperature
5 required for bringing the beans of the batch to the pyrolysis;
 - 6 (c) sensing at least one of variables of the pattern of the cracking sound
7 generated by the beans of the batch as the batch is heated to the
8 point of pyrolysis, said variables including (i) the rapidity of popping
9 sound; (ii) the frequency of the popping sound; (iii) the volume of the
10 popping sound;
 - 11 (d) using said sensing to determine three stages of said pattern: (1) a
12 first crack sound at which the respective variable/variables is/are
13 measurably above zero; (2) an interim period following the period of
14 said first crack sound, at which interim period the respective
15 variable/variables is/are virtually zero; and (3) a second crack sound,
16 following said interim period at which the respective variable/variables
17 is/are measurably above zero;
 - 18 (e) when the pattern reaches said second crack sound, initiating the
19 operation of clocking means preset to a predetermined time length;
 - 20 (f) upon expiry of said predetermined time length generating an output
21 signal for stopping the roasting operation and discharging roasted
22 coffee from said roasting chamber.
- 1 2. Apparatus for roasting a batch of a type of coffee comprising:
 - 2 (a) a roasting chamber having a bottom portion and a top portion and
3 operatively associated with heated air supply flowing in a direction
4 from said bottom portion to said top portion;
 - 5 (b) a sound probe mounted in said chamber for sensing characteristics of
6 noise generated by the batch in said chamber as it is being roasted;
 - 7 (c) said sound probe being operatively connected to an activating device
8 adapted to become actuated at the end of the roasting process.

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- 1 3. Apparatus for roasting coffee comprising a roasting chamber
2 disposed within a hot air circulation system which includes an air circulation
3 control device, said air circulation control device comprising:
- 4 (a) circulation conduit section having an upstream portion and a
5 downstream portion, said upstream and downstream portions
6 connecting the conduit section to a hot air circulation system of said
7 apparatus;
- 8 (b) fresh air inlet port disposed at said downstream portion;
- 9 (c) spent gases vent port disposed at said upstream portion;
- 10 (d) valve means operatively associated with said ports and having valve
11 members adapted to simultaneously selectively close both ports and
12 open the passage through said conduit, or to simultaneously close
13 said passage and open said ports, or to simultaneously assume a
14 state where the passage and the ports are all partly open.



SECTION AA

FRONT VIEW

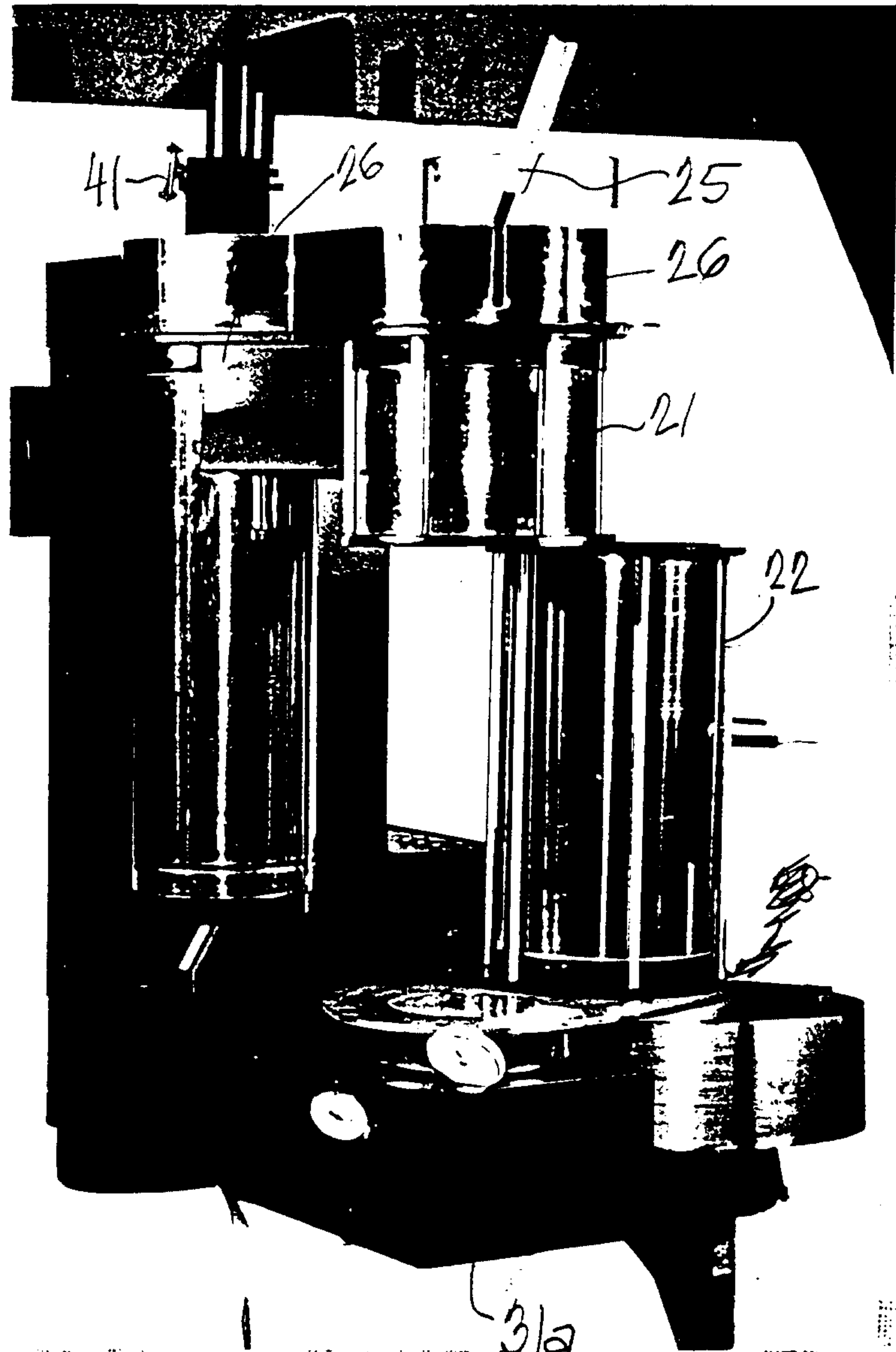


Fig. 4

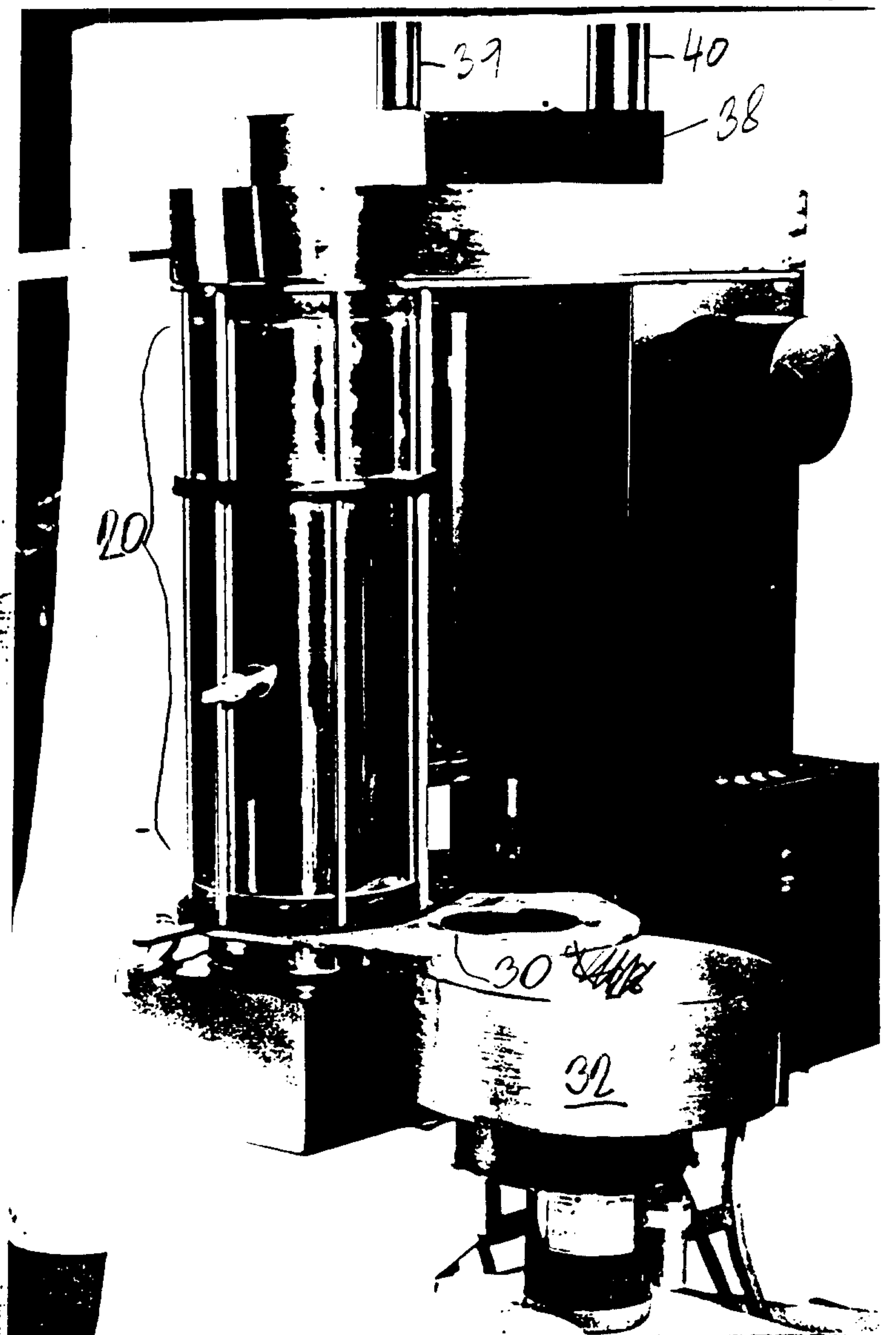
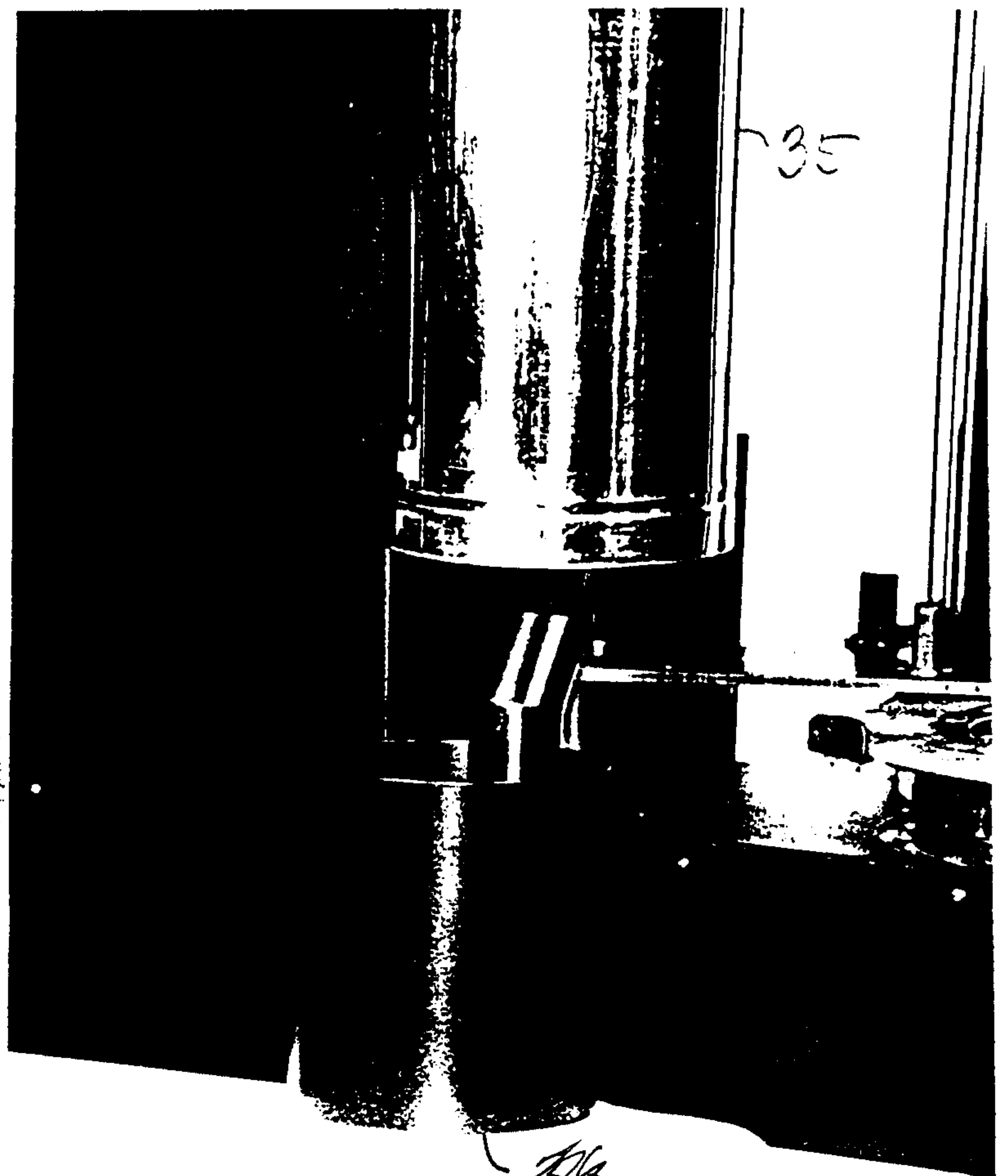
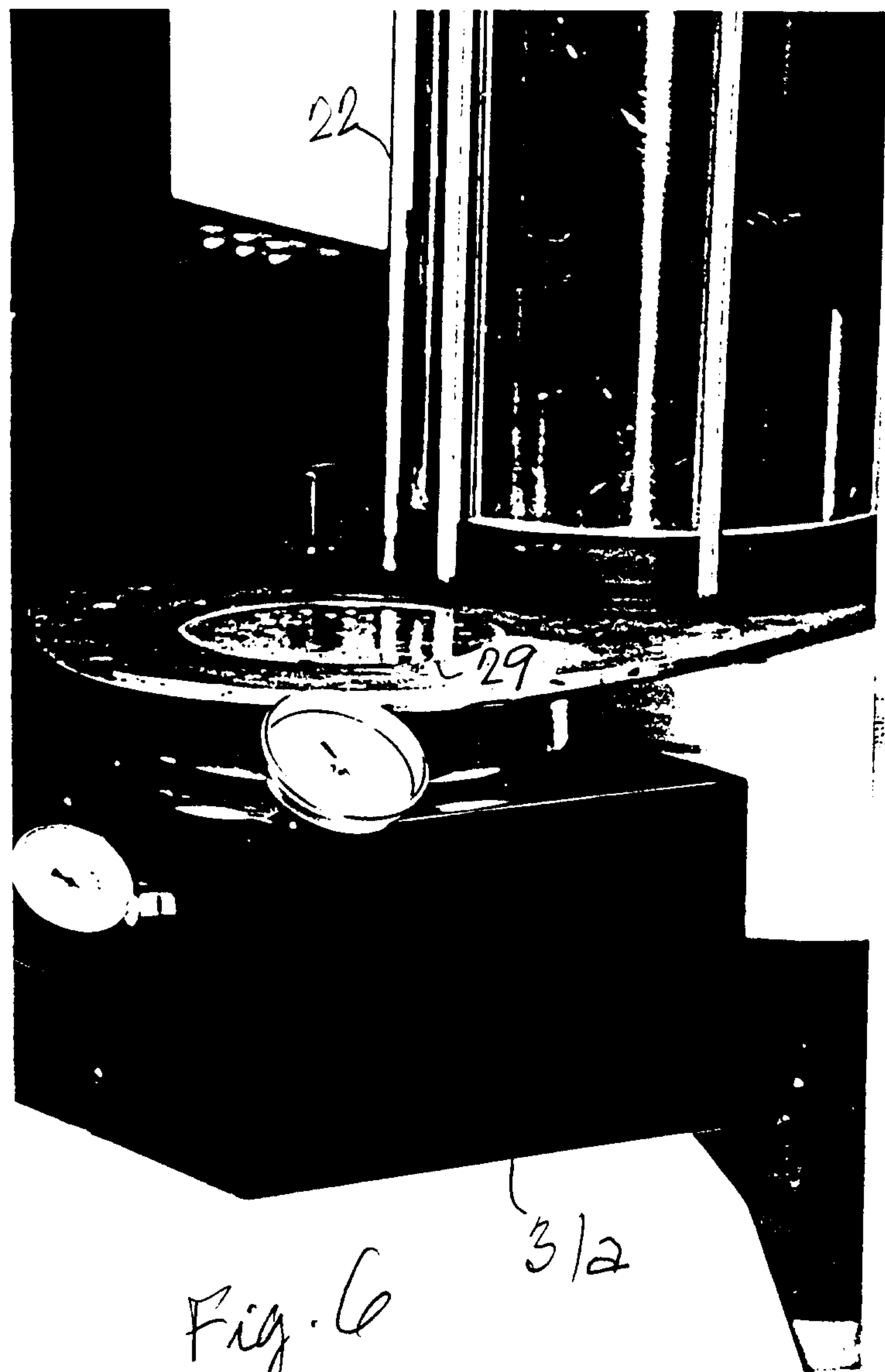
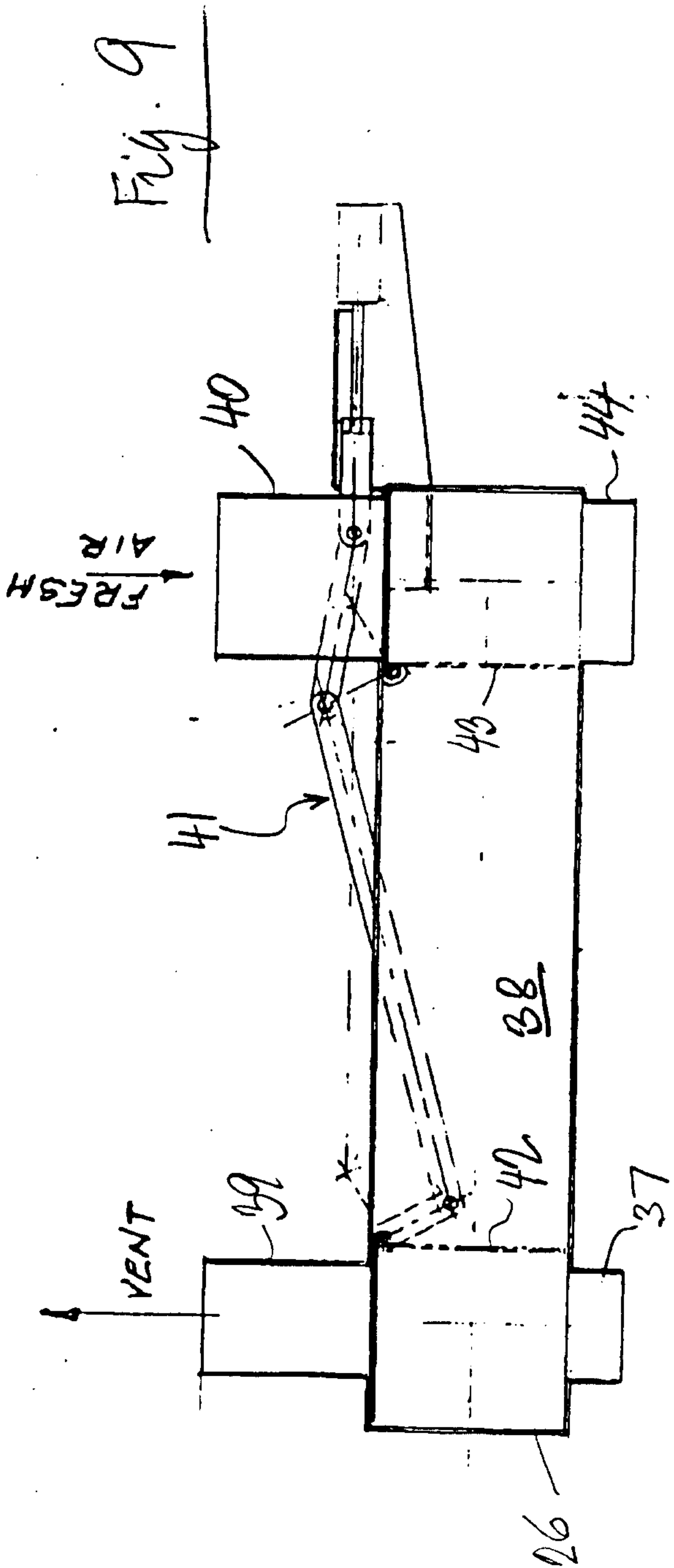
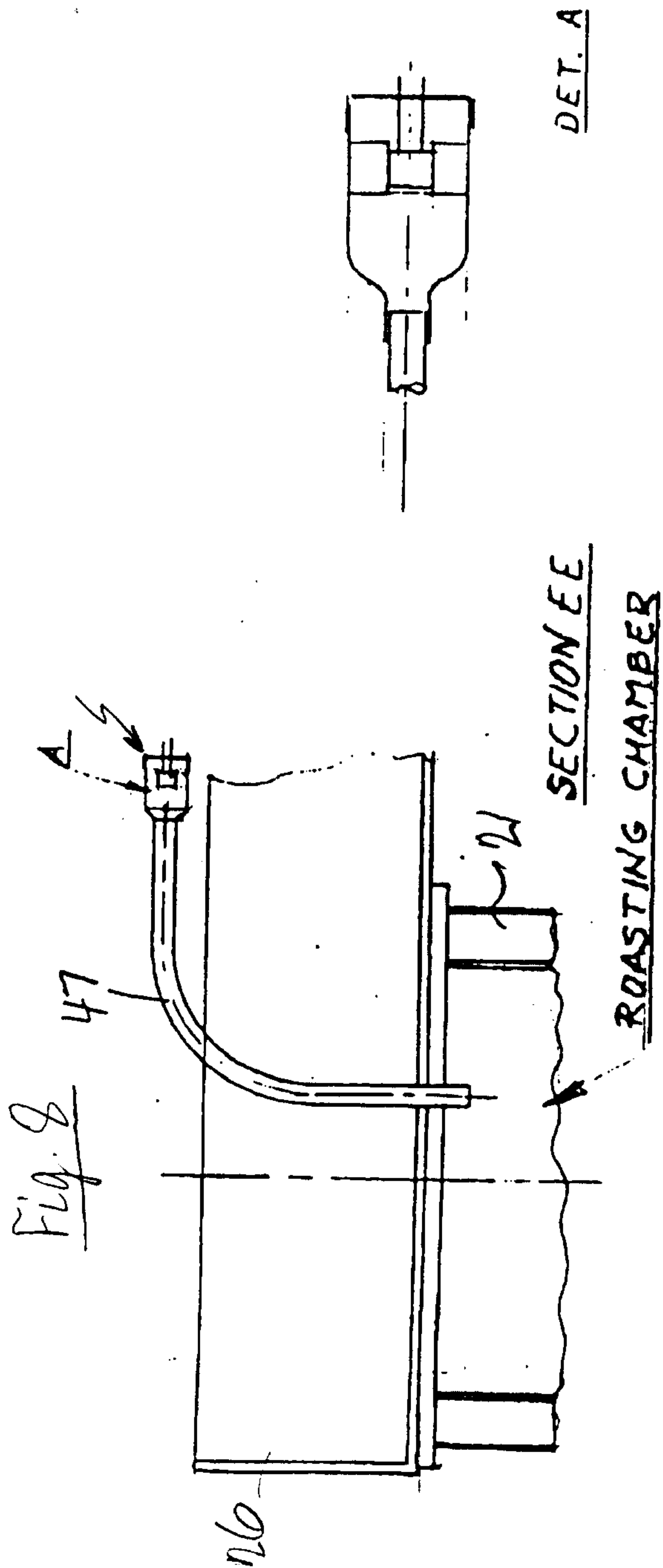


Fig 5





SECTION EE



DET. A

48

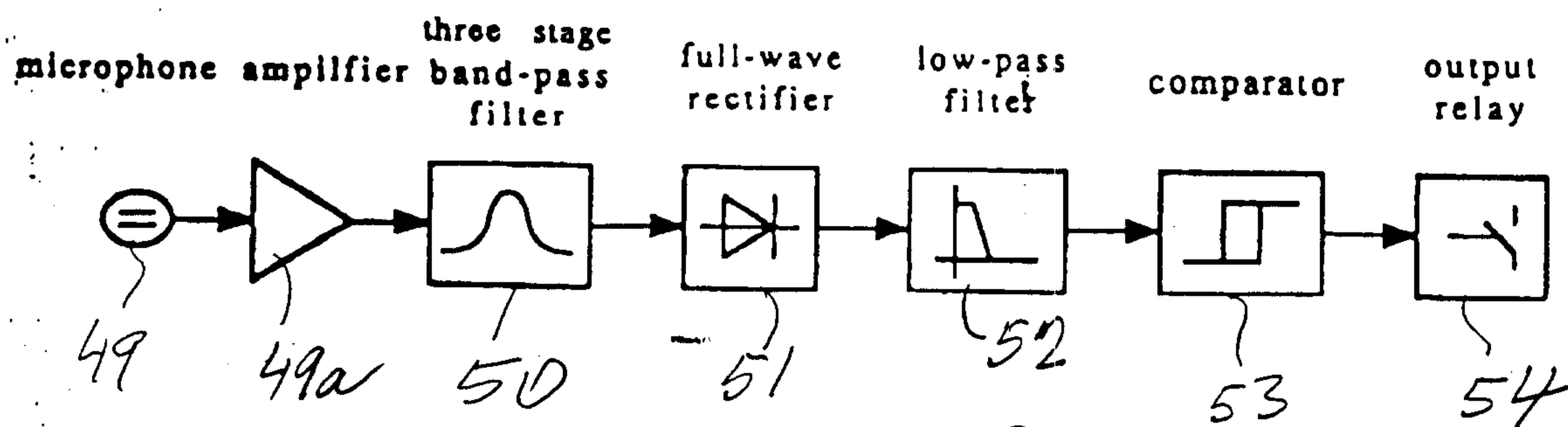
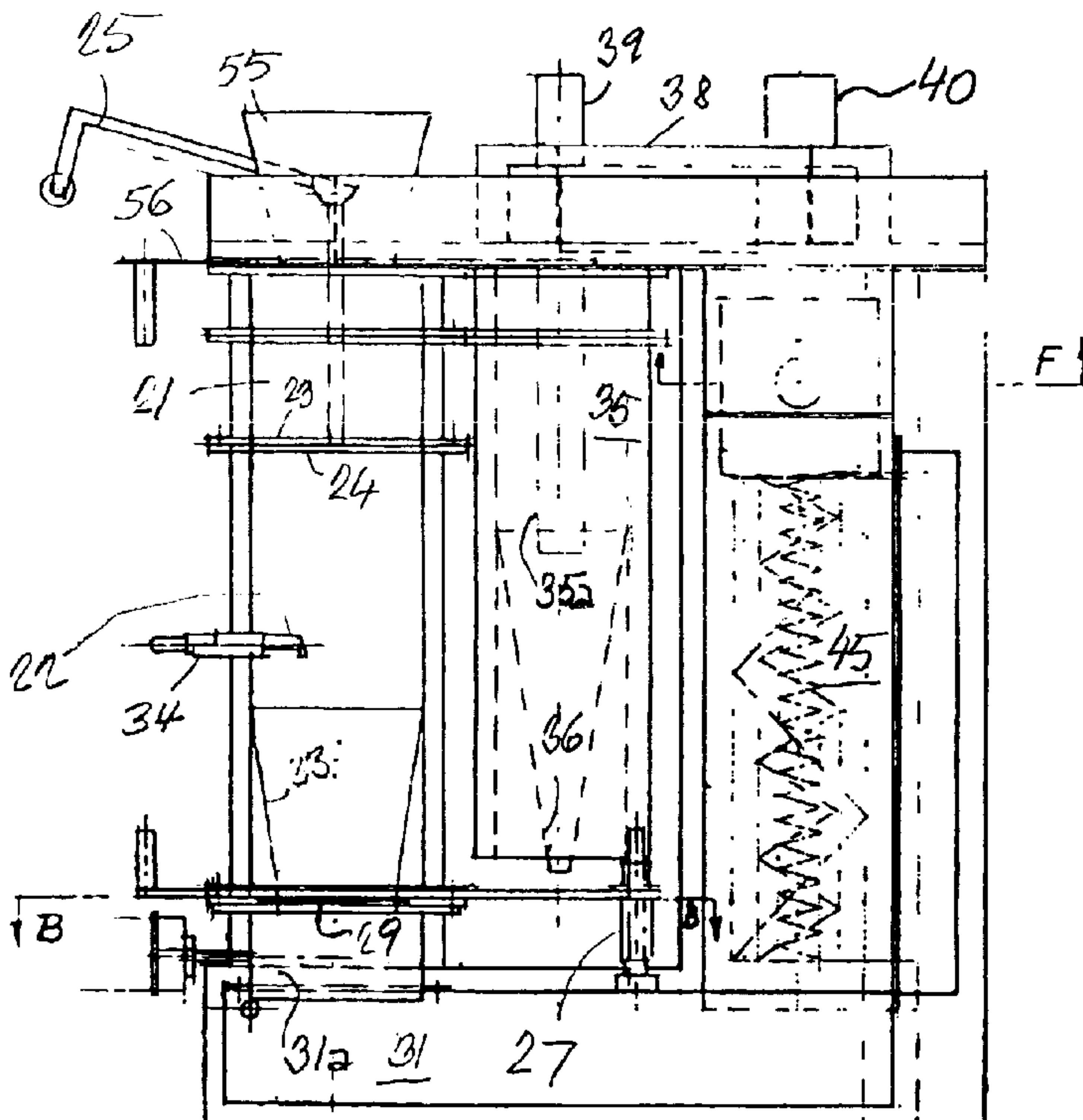


Fig. 10

~~block diagram.~~



SECTION AA