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(54) Process and apparatus for cleaning used containers using vacuum evaporation.

(57) Process for cleaning dirty metal containers wherein the containers are subjected to a vacuum while they are rotated and heated throughout by eddy currents.
The containers are first deaerated and rotated in rest position with about 20 to 60 revolutions per minute,while being connected to a vacuum line and a condensor. Material damaging for the environment can be removed.
An apparatus with vacuum connection, heating means and condensor for condensing withdrawn gases is described in Figure 3.

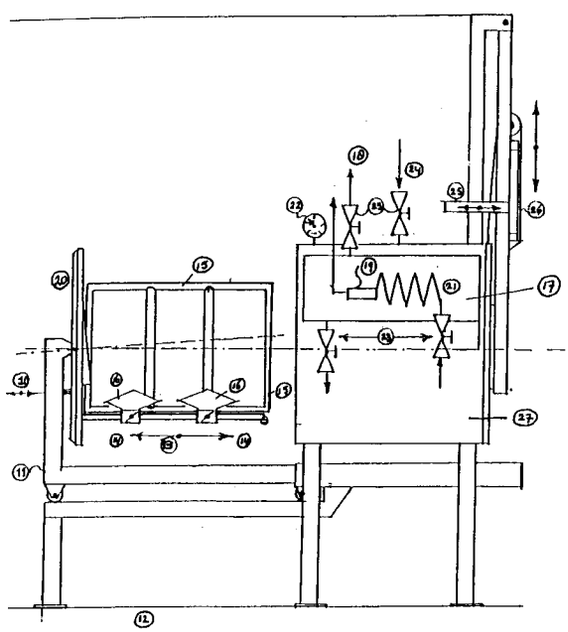

FIG. 3

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The invention relates to a process for cleaning used containers by vacuum evaporation as well as apparatus designed therefor. The invention especially relates to the cleaning of used containers to make them suitable for reuse without burdening the environment.

Containers or drums are used on a large scale as packaging material for various purposes, e.g. for solvents, raw materials for polymers and various chemicals etc. After use these containers may be prepared by the user or reconditioner for reuse, because this is attractable for protecting the environment by reducing the quantity of material to be destroyed. A method for cleaning used containers is based on using vacuum, recovery of the container possibly by applying an interior coating, whereafter by sealing, a leakage test and painting the container again can be used.

The rinse liquids used for this cleaning are during cleaning decontaminated with chemical compounds. Thus, processing of these liquids compatible with environmental requirements is necessary before they are disposed, which, however, is difficult and costly.

There is a problem that there are various types of containers of many materials, and also depending on the contaminated materials rinsing is not always possible and the container must be cleaned in another way.

To remove the last traces of contaminants the contents of the containers are often burned. In this way, however, the occurrence of poisonous compounds like dioxins cannot be avoided. Especially a difficult problem is avoid to that dioxins and other poisonous compounds, like PCB's contaminate the environment.

It is an object of the invention to provide a process for cleaning used containers enabling them to be used again and to avoid environment contamination.

It is another object of the invention to provide a process for cleaning used containers wherein especially containers are used for chemical use and other materials damaging for the environment can be cleaned in an environmental acceptable manner and be prepared for reuse.

It is another object of the invention to give used containers contaminated with polymer and other solid contaminants such an after treatment that pyrolysis of the solid materials occurs and the containers can be disposed without damage to the environment.

It is a further object of the invention to treat used containers which are contaminated with very poisonous compounds, like PCB's according to the process of the invention selecting particular temperature areas and times such that chlorine cleavage occurs and "cracked" products arise which are less poisonous and can be recovered and reused or disposed more easily.

Thus, the invention relates to the cleaning in an environmental acceptable manner of used contaminated drums or containers, or drums or containers which contain remainders of compounds damaging for the environment, especially of metal, by a vacuum treatment, which is characterized in that the drums or containers etc. are subjected to a vacuum treatment while they are kept in a rotating movement and are entirely heated.

The invention especially relates to the cleaning of used metal drums which may contain contaminants of various types, which, however, are all damaging for the environment when they are disposed therein. The invention also comprises the treatment of drums and containers etc. containing PCB-containing materials, which also comprises addition to such drums of materials of which it is known that they contain PCB's in damaging quantities, to convert the PCB's in materials which are not dangerous for the environment or materials which are ready for reuse.

The invention is based on the fact that by subjecting the drums or containers etc. to a rotation movement and to heat them totally it is possible to reach a fast and thorough removal of contaminants which are present on and in the walls of the drums or containers etc.. By the rotating movement new surface film layers are continually exposed which evaporate relatively quickly by the heating applied. Thus, the treatment can take place quickly so that a large production, number of drums per hour, is possible. The drums treated, possibly after they have been repaired, can be again commercialized as such.

The combined vacuum, rotation and heating treatment preferably is carried out only after the air and gas present in the drum or container etc. are removed by drawing off. Thus, the risk of fire explosion etc. by contact with oxygen with the evaporated chemicals is prevented.

The drums are in total heated in such a way that the walls (including the bottom and top) of the drum or container are thoroughly heated. This can be carried out in any suitable way, e.g. by infrared radiation or open steam. For drums of conductive material, such as is the case for the majority of drums, the heating preferably is carried out by generating eddy currents in the walls of the drum or container. Around the drum or container an induction coil is arranged wherein a HF-current is caused to flow. Then there are created eddy currents in the conducting material by which the total drum is heated. Suitable frequencies are 10-40 KHz. The temperature and duration of the treatment are chosen dependent on the used and contaminated drums to be treated and they may vary

from short treatments at low temperatures, of several seconds and tens of degrees to minutes and hundreds of degrees and still higher. For benzene contamination a temperature of about 10 °C at a several minutes treatment time is sufficient, while for naphtalene the temperature should be at least 100 °C. For the treatment of PCB's-containing contaminants the temperatures may rise to 300-600 °C. The time and temperature are mutually dependent; at higher temperatures shorter times are possible. The upper limit of the temperature in fact is determined by the melting point of the drums etc.; the lower limit by the boiling point of the component which during the vacuum treatment is the most difficult to remove.

The rotation velocity should be sufficient to rebuild in combination with the evaporation velocity continually new films which evaporate quickly. For this purpose velocities of 20-60 revolutions per minute are sufficient for most drums and containers. Here again the type of contamination is of influence and for high viscous contaminants higher rotations are desirable.

It is to be understood that the treatment as described is mostly carried out at a pressure which is as low as possible to further the withdrawal of the contaminants from the walls of the drums and containers. The choice of the underpressure thereby depends on the contaminants to be removed from the drums, as well as the temperature and the duration, but, generally, the vacuum treatment takes place at a lower pressure starting from 900-700 to 100-200 mbar and even lower. The vacuum treatment often can be distinguished in a pretreatment and a main treatment. In the pretreatment the drums or containers etc., after they have been introduced in the vacuum chamber are opened, evacuated without heating and without rotation, to remove the air and other gases from the drum. The pressure thereby is reduced to a value which is meant for the main treatment, whereafter one switches to the main treatment by starting rotation and heating.

The removed gases are carried through a condensor in the vacuum line wherein first cleaning takes place. Thereafter the vapour is carried through a second condensor at atmosferic pressure for a second removal, whereafter finally the residual gases, after passing through coal filters or other filters, are disposed, without burdening the environment in any way. One preferably uses two or more filters, especially coal filters, such that one or more filters are used and the other filter(s) then is (are) regenerated in a manner known per say.

The invention is especially advantageous for the treatment of drums and containers with contaminants containing PCB's, of which it is known that they are difficult to dispose and may give rise to the formation of dioxins. It has been found that at temperatures in the area of 300 to 400 °C and higher the chlorine groups of the PCB's are cleaved and in the "cracked" products HCl, Cl_2, bifenyl and other compounds have been demonstrated. HCl and Cl_2 can separately be caught or separated. The remaining materials can be used as such as fuel materials or for other purposes without this having a disadvantageous effect on the environment. In a variation of this embodiment one may use this cleavage effect by filling the drum to be treated partly with materials of which it is known that they are contaminated with PCB's, such as cooling oils and isolation oils of used transformers and capacitors. The duration of the treatment will then be longer and may amount to several hours. It is possible to add other materials furthering this "codestillation", especially when there are consistently mixed contaminants in the drums.

The process according to the invention generally has the advantage that it can be carried out at location. Thus, there is no necessity of transport of contaminated drums to a central plant. The contaminated drums are stored and locally treated after a certain time periode or when there is a certain amount gathered. It is an advantage of the apparatus that it can be made transportable.

The invention also comprises an apparatus to be used for carrying out the above described process which generally comprises a vacuum stove with vacuum connections and a vacuum pump, means for putting the drums in the stove, means for rotating the drums placed, means for the complete heating of the drums, measuring means for measuring the process parameters, as well as condensors in the line for condensating the gases withdrawn. In a preferable embodiment the means for placing a drum in the vacuum stove is a cylinder wherein the drum can be arranged appropriately and placed in the stove; which cylinder is provided with a heating means, such as a magnetic coil which is arranged around the circumference of the drum and may be connected to a HF-voltage to generate a HF-current causing eddy currents to flow in the drum. Preferably, the means for causing to rotate the drum are rolls arranged in the stove.

It is to be understood that the drums and containers may be rotated lengthwise in horizontal position.

The invention will be further illustrated by the drawing wherein

figure 1 is a flow sheet of the vacuum cleaning installation,

figure 2 is a general flow sheet, and

figure 3 is a particular embodiment of the apparatus according to the invention.

In figure 1 the vacuum stove is indicated by 1. After the drum 8 is put in the stove, it is closed and

evacuated by means of the vacuum pump 3. After the air is removed from the drum, the contaminants, which exit in vapour form, are guided to a condensor 2 wherein they will condense. This condensate is caught in a reservoir 4. The gases, which are now free from contaminants, are possibly carried through a second condensor at atmosferic pressure where the residual non-condensed compounds are precipitating. Thereafter the gas is carried through regenerable active coal filters 6 to be sure that the emitted gases no longer contain contaminants or only very little. The arrows indicate the course of the process. The thick arrow shows the path of the drum to be cleaned. The lesser thick arrow the path of the gases and the thin lower arrows the path of the condensate.

In the flow sheet of figure 2 V.D. indicate the evaporator, V.C. the vacuum condensor, V.P. the vacuum pump, A.C. the atmosferic condensor, Afsch. the liquid separator and A.K.F. the regenerable coal filters. The thick arrow relates to the air-with-gas flow, the double arrow to the liquid flow and the open arrow to the filtered air flow. On the right hand side A (the drawing off part) the pretreatment takes place. Drum 8 is drawn empty. The gases are carried away through the active coal filter and the liquid Is caught in the reservoir E. The left hand side exists of an evaporation part B, a condensation part C and an air cleaning part D. The cleaned air exits at F. The coal filters are mutually in connection with the vacuum pump for regeneration (arrow 6).

In figure 3 an embodiment of the apparatus of the invention is indicated. This comprises a lifting cylinder 10 by which the drum to be cleaned can be lifted to the exact height. The lifting cylinder 10 is part of the load- and unload system 11 which is arranged on a frame 12 and is transportable thereon. The drum 8 is taken up in the transport cylinder 13 which may move in the direction of the arrows 14. This cylinder is provided with a high frequency coil 15 which is arranged around the circumference. The drum rests on carriers 16 in the cylinder 13. By fork 20 the drum 8 is lifted in the vacuum stove by advancing the cylinder. The vacuum stove 17 is provided with a vacuum pump connection 10. In the stove 17 there are further a thermostat 19, which is connected to a condensor. Hereby cooling water is circulated, line 21. The stove further contains a vacuum control timer 22, while 23 show magnetic stop corks, which are able to close the lines when that is desirable. Further, an aeration connection 24 is present. At the upper side of the vacuum stove there are still a positioning cylinder 25 and a lifting cylinder 26. In use the drum 8 is put on the load- and unload device 11 by the lifting cylinder 10 and placed in the transport cylinder 13. Cylinder 13 is moved in the vacuum stove 17 and put in the exact place. Thereafter vacuum is applied and the air is drawn out of the drum 8, whereafter further vacuum is made and the HF-heating 15 is activated. Further the vessel is then rotated by rolls (which are present in part 27 (not indicated)).

Example

A drum of 200 liter (steel drums) possibly with a plastic inner lining is placed on the transport cylinder 13 and placed in the vacuum stove 17 with open screwing caps in the vacuum stove 17, and after closing of the stove vacuum was made (20 sec.) to a pressure of about 100 mm bar absolute. In this way air was drawn off the drum to prevent possible explosion or fire dangers. It appears that still about 50-100 cc toluene as liquid was present in the weld lines of the vessel. The vacuum treatment was followed by a pressure meter. Next the HF-coil present in cylinder 13 and placed around the drum was activated to heat the drum by means of eddy currents. Simultaneously the drum was rotated with 60 r.p.m. by means of driven rolls in the stove. The heating took about $1\frac{1}{2}$ minute, the power input amounting to 20 KW (with the aid of a 100% transformer). The temperature of the wall of the drum then was 30 to 40 °C. The frequency used for the heating was 10 KHz. The greater part of the toluene removed was trapped in the vacuum condensor (10 seconds still drawing). The drum was ready for reduce after possible recovery treatments (removal of rust, removal of dents, putting on weld line) and an aftertreatment (internal coating, putting in sealing, leakage test, painting) (final value several dpm toluene).

It is to be understood that for other materials, like benzene, naphtalene, xylene, acetone, polycyclic compounds the same treatment can take place, wherein, however, dependent on the volatility of the compounds in question at subatmosferic pressure the temperature and treatment time must be adjusted. The present process is also of use for the removal of adsorbed water from drums. In this way also adsorbed mercury can be removed from drums.

For drums which are provided with a coating or other adhesive layer originating from a used product like polyurethane, which cannot be evaporated, the process of the invention after the air removal step is carried out at increased temperatures to about 500-700 °C to carbonize the solid materials. After this pyrolysis treatment, wherein the damaging materials are removed and only a coal layer remains, the drums can be processed without problems, for instance by melting in a blast-furnace.

Claims

1. Process for cleaning metal containers or drums containing used contaminated compounds or residues of compounds which are damaging for the environment, in a for the environment acceptable manner, wherein the metal containers or drums etc. in a vacuum stove are subjected to a vacuum treatment while they are kept in a rotating movement and completely heated.

2. Process according to claim 1, wherein the drums, containers, etc. are heated by eddy currents.

3. Process according to claims 1-2, wherein the drums, containers, etc., before they are heated and rotated, are subjected to a vacuum treatment to remove enclosed air and gas.

4. Process according to claims 1-3, wherein the drums in thq horizontal position are rotated with a velocity of 20-60 r.p.m.

5. Process according to claims 1-4, wherein the residual gases are carried through a condensor in the vacuum line and next to an atmospheric condensor.

6. Process according to claim 5, wherein the residual gases are first carried through a coal filter before the cleaned air is vented in the atmosfere.

7. Process according to claims 1-6, wherein the temperature and treatment time are adjusted dependent on the contaminant which is most difficult to remove.

8. Process according to claims 1-7, wherein a drum or container contaminated with PCB's is heated to a temperature of 300-400 °C at a treatment duration of a half to forty-eight hours.

9. Process according to claim 8, wherein materials contaminated with PCB's are added to the drum or container.

10. Process according to claims 1-7, wherein codestillation-promoting-materials are added.

11. Process according to claims 1-7, wherein drums and containers with fixed adsorbed contaminants are heated to higher temperatures of about 600-700 °C to coke the solid materials.

12. Apparatus for carrying out the process according to claims 1-11, which comprises a vacuum stove with a vacuum connection and a vacuum pump, means for placing the drums in the stove, means for causing to rotate the placed drums, means to heat the drums through and through, measuring means for measuring the process parameters, as well as condensors in the vacuum line for condensing the gases withdrawn.

13. Apparatus according to claim 12, wherein the heating means for conducting drums consist of an HF-coil arranged at the circumference of the drum or container with electric termination to generate eddy currents in the drums or containers.

14. Apparatus according to claims 11-13, wherein the means for placing the drum or container in the stove comprises a transporting cylinder provided with heating means at the circumference.

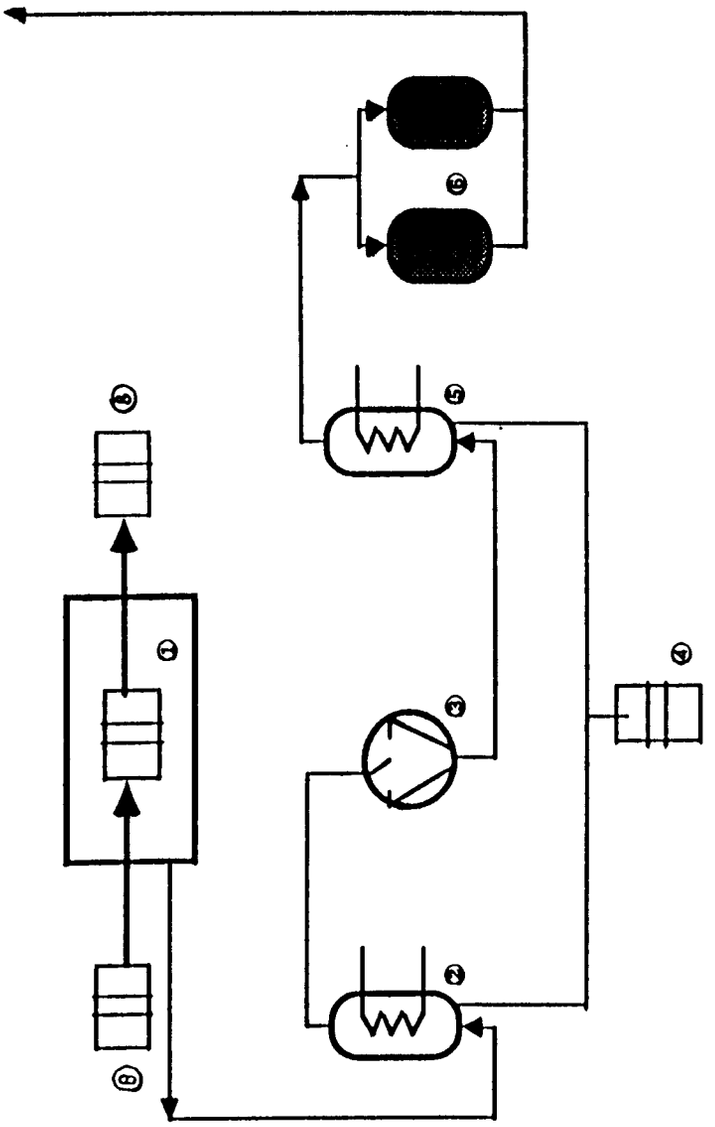

FIG. 1

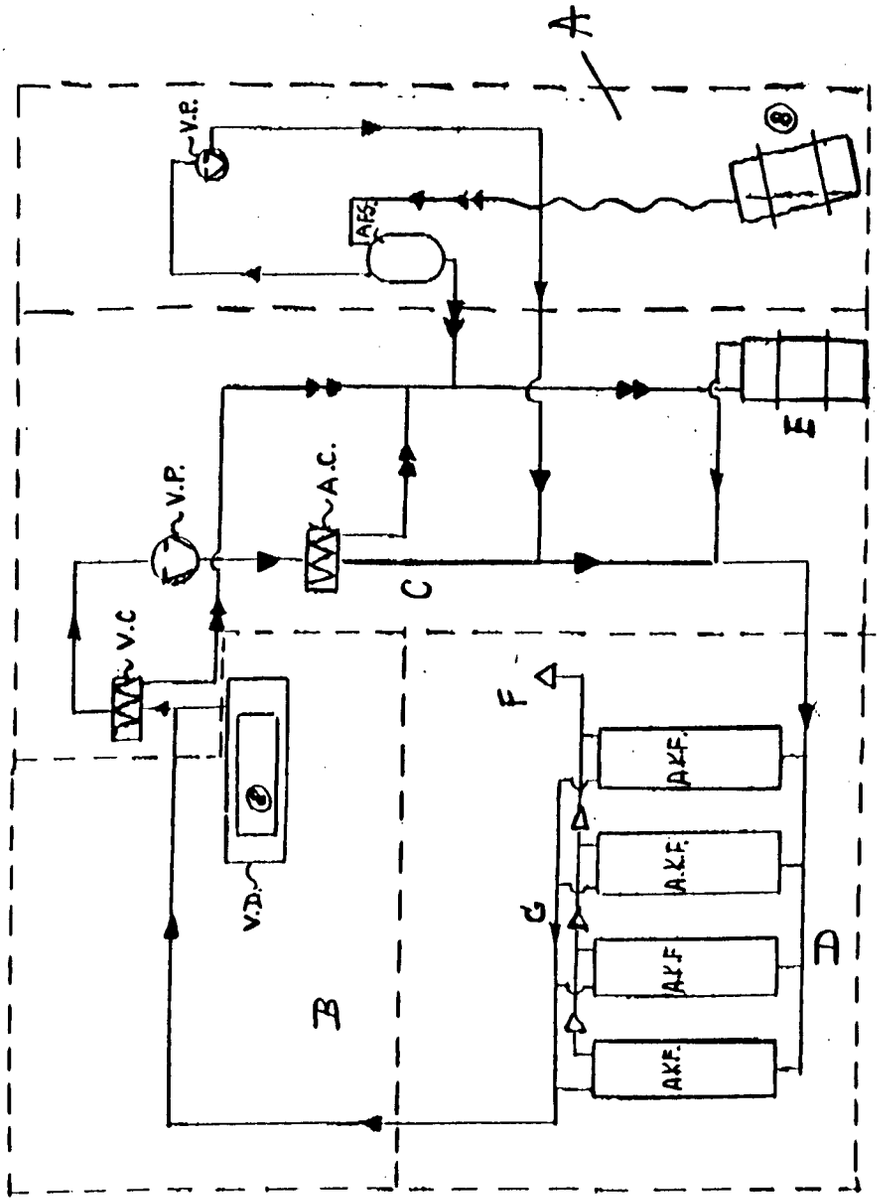

FIG. 2

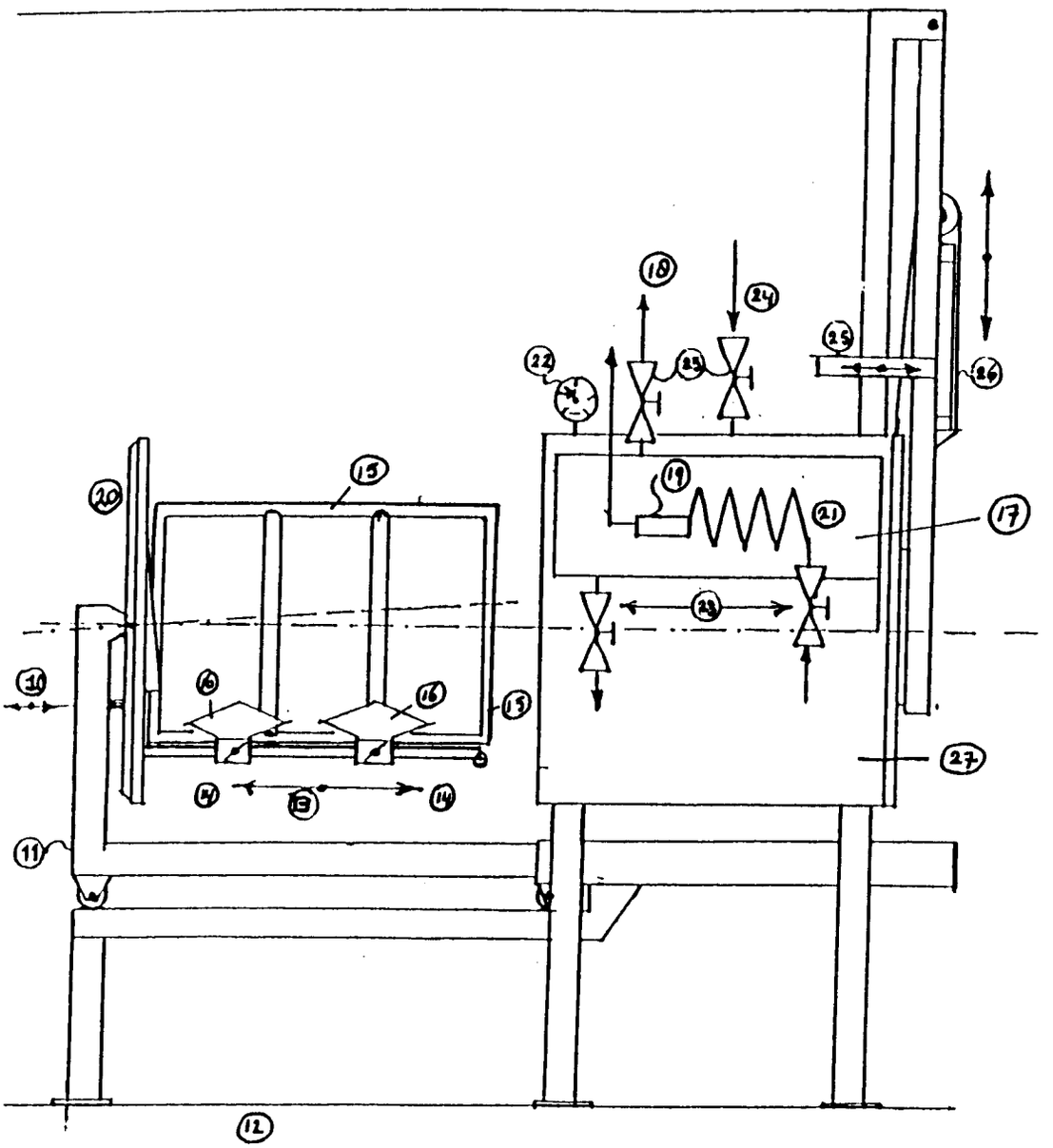

FIG. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 20 2182

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
E	NL-A-9 000 314 (BLONK) 2 September 1991 the whole document	1-14	B08B9/40 B08B7/00 C23G5/00
A	DE-A-3 311 749 (M.A.N.MASCHINENFABRIK AUGSBURG-NÜRNBERG AG) 11 October 1984 * page 5; figures 1-2 *	1,12	
A	DE-U-1 916 786 (SCHERING AG) 2 August 1085 * page 5 - page 7; figures 1-3 *	1,12	
A	DE-A-3 923 685 (AEG KABEL AG) 24 January 1991 * column 1; figure 1 *	1,2,12, 13	
A	US-A-4 141 373 (KARTANSON ET AL) 27 February 1979 * column 7, line 3 - line 38; figures 1,2 *	5	
A	DE-A-3 725 330 (SIEMENS AG) 9 February 1989 * column 1 - column 2 *	3,5	
A	US-A-4 057 438 (MAINORD) 8 November 1977 * column 1, line 50 - column 2, line 11 * * column 2, line 51 - line 56; figure 1 *	5,11	TECHNICAL FIELDS SEARCHED (Int. Cl.5) B08B C23G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	08 MAY 1992	VOLLERING J.P.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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