The method of decontaminating electro-mechanical apparatus from polychlorobiphenyl comprises the steps of:
- maintaining the apparatus to be decontaminated submerged in a sealed chamber in vapours of a suitable solvent; and
- constantly changing the pressure and temperature of this solvent so as to permit at any time a condensation of the solvent vapours on the surfaces under treatment.

The solvent vapours can be produced inside the sealed chamber and, by providing a top condenser, a reflux washing can be obtained, or the vapours can be produced outside the sealed chamber and then injected therein at the required pressure and temperature.
The present invention generally relates to a method of decontaminating from polychlorobiphenyl electro-mechanic apparatus.

As known, for antifire purposes, fluids on the basis of polychlorobiphenyl (PCB) as insulating fluids in electrical apparatus or as hydraulic liquids in mechanical apparatus have been often used in the past. These fluids, generally a mixture of 40% of hexachlorobenzene and 60% of polychlorobiphenyl, exhibit antifire properties which assure a reliable operation of electrical or mechanical apparatus even in environments in which the fire conditions could be promoted.

For example, there are in Italy only tens of thousands of transformers, circuit breakers and other electric apparatus still filled with this fluid and an undefined number of hydraulic apparatus almost certainly still contaminated by PCB.

The suspected cancerous action or at any rate the harmfulness of PCB has caused the use of these fluids in the above mentioned apparatus to be suspended, which fluids are gradually substituted by other less dangerous fluids.
The aggressiveness of fluids on the basis of PCB towards the components of these apparatus is so great that their decontamination becomes an extremely difficult operation and the great harmfulness thereby exhibited causes it to be more convenient to bury all the apparatus into suitably prepared pits than to try a decontamination thereof.

Of course, for economical reasons, this has given rise to the problem of the recovery of these apparatus by trying to decontaminate them as much as possible by reducing the PCB contents at least within limits which are permissible and tolerable from the ecological standpoint.

Recently, attempts have been made to wash the contaminated apparatus with suitable solvents in a liquid phase, however this method has proved to be difficult, time consuming, expensive and it has not successfully.

In fact, the PCB absorbed by materials such as paper and wood which are normally present in most apparatus and the PCB adsorbed by the inner portion of the magnetic lamination pack or the electric windings cannot be totally removed, at least in a short time, because of its aggressiveness and therefore a portion thereof remains attached to these apparatus so that, with the passing of time, it can be dissolved in the new liquid used in substitution thereof, thereby forming a contaminating element for the latter.

It is therefore the main object of the present invention to obviate the above mentioned disadvantages of the known method by providing a new method permitting the above mentioned apparatus to be decontaminated as much as possible, however within ecological acceptable limits so that the appa-
ratus can be reused.

It is another object of the present invention to provide a method of decontaminating from PCB electrical and mechanical apparatus, which can be carried out without the intervention of operators in contact with the PCB.

It is still another object of the present invention to provide a method of the above mentioned kind, which assures in the most absolute way any possibility of environment contaminations.

It is a further object of the present invention to provide a method of the above mentioned kind, which provides a quick decontaminating action so as to be inexpensive, and which can be carried out as simply as possible without requiring sophisticated and expensive equipment.

These and other objects of the present invention, which will be more apparent from the following description, are attained by a method of decontaminating electro-mechanical apparatus from polychlorobypheynyl, which, according to the invention, is characterized in that it comprises the steps of:

- maintaining the apparatus to be decontaminated submerged in a sealed chamber in vapours of a suitable solvent; and
- constantly changing the pressure and temperature of this solvent so as to permit at any time a condensation of the solvent vapours on the surfaces under treatment.

According to a feature of the present invention, the solvent vapours are generated in the sealed chamber by associated heating means.

According to another feature of the present invention
the solvent vapours are generated in the sealed chamber by heating means and condensed at the top of the sealed chamber so as to perform a reflux washing of the apparatus.

According to a further feature of the invention, the solvent vapours are generated outside the sealed chamber and then injected therein to wash the apparatus.

The solvent is suitably chosen so as to have, in addition to a dissolving power with respect to the polychlorobiphenyl, also a chemical inertia thereto so as not to give rise to compounds or combinations therewith.

The solvent has preferably an inherent non toxicity to the contact and the inhalation of its vapours and is also compatible with the apparatus materials.

As a further feature, the solvent has a distillation temperature well lower than that of PCB in order that the PCB can be readily recovered for its reuse and possible PCB entrainments during the washing can be avoided.

Advantageously, the distillation temperature of the solvent is lower than the maximum temperature tolerable by the apparatus to be decontaminated.

The distillation temperature of the solvent is suitably higher than the room temperature for handling and conservation facility thereof and in order to have the possibility of simply using water at room temperature for the solvent condensation and moreover the solvent can be distilled without rests.

Preferably, dearomatized heptane or trichloroethane is employed as solvent.

According to still another feature of the invention the condensing temperature of the solvent vapours is set
stepwise as a function of the average temperature of the apparatus to be decontaminated.

The invention will be now described in more details in connection with a preferred embodiment thereof, given by way of example only and therefore not intended in a limiting sense, which is shown in the accompanying drawing, wherein:

Fig. 1 is a diagrammatic sectioned view of a box containing the electric apparatus to be decontaminated, for example a transformer, and provided with the necessary means for carrying out the method of the invention;

Fig. 2 diagrammatically shows the solvent action during the washing step in a liquid phase;

Fig. 3 diagrammatically shows the solvent action during the washing step in a vapour phase;

Fig. 4 is a plot of the diagram of the solvent condensation temperature vs. time, during the washing process;

Figs. 5 and 6 show a diagram of the PCB contents in the apparatus under treatment vs. the removal time thereof for the liquid phase washing and the vapour phase washing respectively, showing the more than good results obtained by means of the method of the invention.

As can be seen from Fig. 1, the apparatus under treatment is put in a box B which is heated on the bottom and on the four lateral walls by means of jackets E through which a suitable heating fluid passes, which is fed through an inlet G, through a valve I and is discharged through an outlet H. On the top of the box B a condenser L is arranged through which water flows, the temperature of which is
controlled by a thermostat M controlling a water discharge valve N.

Inside the box B the temperature is controlled by a thermostat F controlling the valve I and the pressure is controlled by a vacuostat O controlling a solvent discharge valve P, everything so as to keep constantly the apparatus A submerged in the solvent vapours under vacuum and to cause the solvent vapours to be always condensed on the walls thereof and to flow downwardly thereon thereby developing their flooding action according to the plot of Fig. 4, where T1 designates the vapour condensation temperature and T2 designates the average temperature of the apparatus A under treatment. Preferably the solvent used in this case is deaerated eptane which exhibits all of the above mentioned features for performing the washing operation.

As can be seen from Fig. 4, the temperature T1 is stepwise controlled as a function of the temperature T2 taken over by the apparatus A, i.e. as the temperature T2 of the apparatus A approaches to vapour condensation temperature T1, the latter is increased of a step $\Delta T$, and this operation is repeated until the washing is ended. The box B is further provided with a solvent inlet S, a thermometer V for measuring the solvent vapour temperature and an inert gas source R connected to the box through a valve Z, a non-return safety valve Q calibrated so as to assure that the pressure inside the box B does not exceed the safety values and a drainage tube O for the gravity discharge of the polychlorobiphenyl.
Once the washing operation is ended it is sufficient to evacuate the box B through the valve P and to condensate the solvent vapours, by recovering all the solvent through the outlet C while the removed PCB is readily discharged through the drainage tube D.

The inert gas source R during the solvent discharge operation is connected to the box B in order to avoid the air to enter therein, which could give rise to possible combustion of the hot solvent.

Although the described embodiment shows a washing method with solvent reflux, the same method could be carried out without the top condenser, or it could be otherwise carried out by providing outside the box B a solvent vapour source and then injecting the solvent vapours into the box B following the requirements for performing the washing operation.

Figs. 2 and 3 diagrammatically show the action of the solvent on the PCB during a liquid phase washing operation and during a vapour phase washing operation, respectively. As can be seen from Fig. 2, the area A is static and therefore there is a poor solvent substitution which, when it is saturated, stops its penetration, whereas in Fig. 3 there is a continuous solvent substitution with resulting higher penetrability into the components of the apparatus to be decontaminated.

By means of the method according to the invention an automatic washing without the intervention of operators in contact with the PCB occurs. During the full washing cycle all the necessary equipment does not come into contact with PCB and, once the washing operation is ended, it is
fully cleaned and decontaminated, with the exception of the lower PCB collecting zone. Furthermore, any possibility of environmental contamination is avoided since the system does not provide circuits for the PCB containing solvent (pumps, pipes, connectors etc.), which could give rise to contamination problems. The washing efficiency is very good since the solvent retains always its dissolving capacity without ever reaching the saturation and moreover the solvent can completely penetrate within interstices also of capillary nature.

The decontamination operation is extremely quick. It has been experimentally proved on a typical series of electric transformers that the PCB embedded in the paper or wood or enclosed in too near walls forming the magnetic core or the windings thereof, is very difficult to remove (see plot of Fig. 5, wherein the curve shows the PCB decontamination efficiency with liquid phase solvent, where after about three hours of treatment the decontamination rate is about 40% of PCB) whereas, according to this method, the PCB is almost fully removed in the same time (see Fig. 6 wherein the curve shows that in the same time as in Fig. 5 the PCB has been removed in a very high percentage).

From tests effectively carried out it has been proved that the amount of PCB remained on a transformer containing 200 Kg of insulating liquid is less than 100 gr.

Another advantage of this invention is the very low amount of solvent required for the decontamination and easy recovery thereof since it is sufficient an amount
less than 1% of the amount required for carrying out
the liquid phase washing, which results in a lower cost
of solvent recovery, as this can be recovered by taking
advantage of the heat supplied by the heaters by simply
evacuating the box once the washing is ended and the PCB
has been separated therefrom.

The so decontaminated apparatus can then be recov-
ered and reused by substituting for the PCB an usual oil
or a silicone oil or a liquid usually employed to this end.

From the foregoing it will be readily apparent that
the method according to this invention permits a deconta-
mination from PCB with very high yields to be obtained,
what could not be obtained till now. Although the present
invention has been illustrated and described in connection
with a preferred embodiment only, it should be understood
that various changes and modifications can be made thereto
by those skilled in the art, without departing from the
scope of the invention.
CLA I N S

1. Method of decontaminating from polychlorobiphenyl electrical or mechanical apparatus, characterized in that it comprises the steps of:
   - maintaining the apparatus to be decontaminated submerged in a sealed chamber in vapours of a suitable solvent; and
   - constantly changing the pressure and temperature of this solvent so as to permit at any time a condensation of the solvent vapours on the surfaces under treatment.

2. Method as claimed in claim 1, characterized in that the solvent vapours are generated in the sealed chamber by associated heating means.

3. Method as claimed in claim 1, characterized in that the solvent vapours are generated in the sealed chamber by heating means and condensed at the top of the sealed chamber so as to perform a reflux washing of the apparatus.

4. Method as claimed in claim 1, characterized in that the solvent vapours are generated outside the sealed chamber and then injected therein to wash the apparatus.

5. Method as claimed in anyone of claims 1-4, characterized in that the solvent is suitably chosen so as to have, in addition to a dissolving power with respect to the polychlorobiphenyl, also a chemical inertia thereto so as not to give rise to compounds or combination therewith.
6. Method as claimed in anyone of claims 1-4, characterized in that the solvent has preferably an inherent non-toxicity to the contact and the inhalation of its vapours, is also compatible with the apparatus materials and has a distillation temperature well lower than that of PCB in order that the PCB can be readily recovered for its reuse and possible PCB entrainments during the washing can be avoided.

7. Method as claimed in anyone of claims 1-4, characterized in that the distillation temperature of the solvent is lower than the maximum temperature tolerable by the apparatus to be decontaminated and suitably higher than the room temperature for handling and conservation facility thereof and in order to have the possibility of simply using water at room temperature for the solvent condensation and moreover the solvent can be distilled without rests.

8. Method as claimed in anyone of the preceding claims, characterized in that dearomated heptane or trichloroethane is employed as solvent.

9. Method as claimed in anyone of the preceding claims, characterized in that the condensing temperature of the solvent vapours is set stepwise as a function of the average temperature of the apparatus to be decontaminated.
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document with indication, where appropriate, of relevant passages</th>
<th>Relevant to claim</th>
<th>CLASSIFICATION OF THE APPLICATION (Int. Cl.)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>B 08 B 3/08</td>
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</tbody>
</table>

The present search report has been drawn up for all claims.

**TECHNICAL FIELDS SEARCHED (Int. Cl.)**

A 62 D  
B 08 B

**CATEGORY OF CITED DOCUMENTS**

- **T**: theory or principle underlying the invention  
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