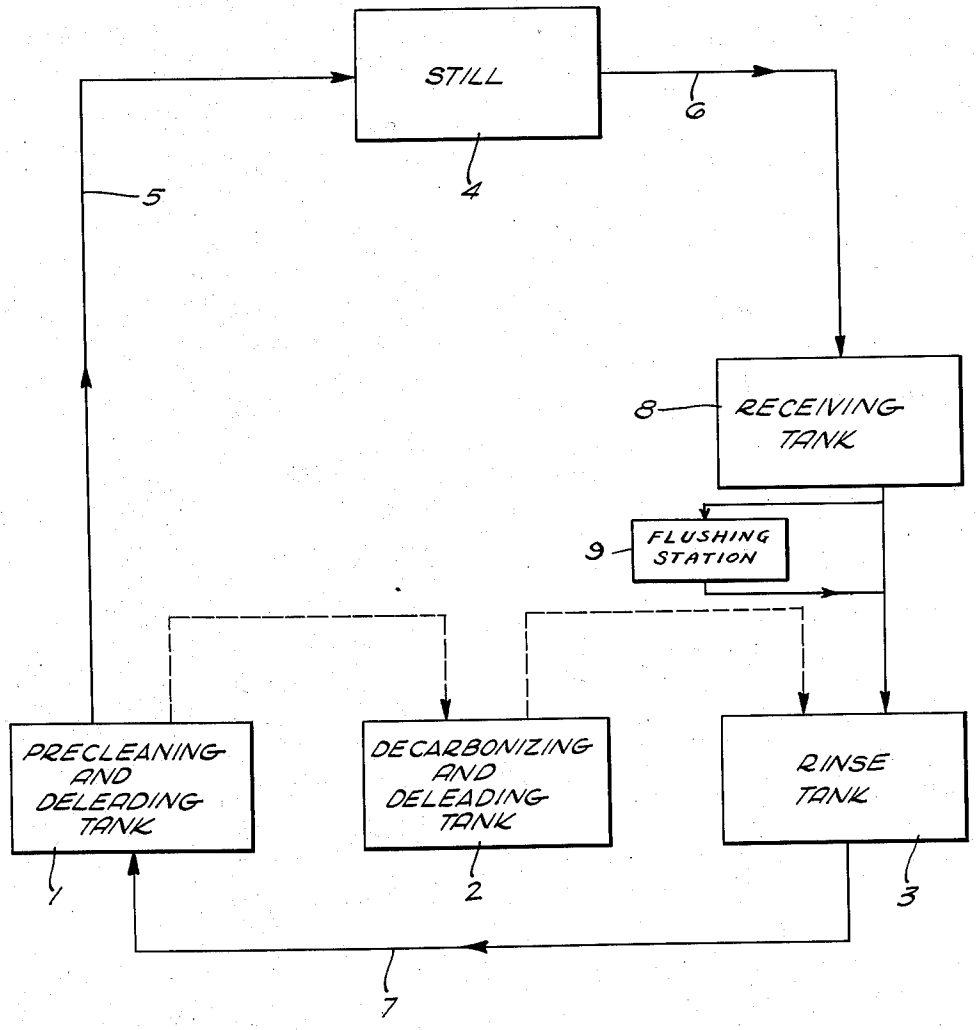
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ENGINE CLEANING PROCEDURE

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ENGINE CLEANING PROCEDURE

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This invention relates to removal of deposits on metallic parts, e.g., the removal of leaded and carbonaceous deposits such as combustion residues, and particularly combustion residues which contain lead or lead compounds. A particularly useful application of my invention is the removal of such leaded and carbonaceous deposits when bound together on the part surfaces. This invention is concerned with novel procedure for the removal of such deposits from metallic surfaces, particularly from internal combustion engines.

In the operation of engines powered by leaded fuels, particularly the piston type of internal combustion engine, deposits are formed on the metallic components of the engine that are in contact with fuel during combustion or in contact with the products of combustion. Such deposits consist of organic material such as gums, resins and other high molecular weight carbonaceous materials and/or carbon which deposits are produced by incomplete combustion of the fuel or partial combustion of the lubricants. The deposits also contain inorganic salts or organic salts of metallic compounds. Of particular interest is the deposit formed by the combustion of fuel containing lead compounds, which lead compounds have been introduced into the fuel for the well known purpose of anti-knock additives. During combustion the leaded additives are completely or partially decomposed and converted into metallic lead or lead compounds, and are deposited on the combustion chamber walls and exhaust systems and are frequently picked up by the lubricant on the side of the cylinder walls and are carried into the lubricating system. The lead compounds in such leaded deposits are composed essentially of the oxides and halides of lead, e.g., PbO, PbO_2, Pb_2O_3, Pb_3O_4, and PbX_2 where X is a halogen such as chlorine or bromine, and in many cases it may also include other salts such as phosphates and carbonates. The composition of the leaded deposit depends in large part on the composition of the fuel and the atmospheric environment in which it is burned, for example, fuels containing tetraethyl lead, organic halides and organic phosphates such as tricresyl phosphates.

These lead deposits are also modified by organic additives which enter the combustion chamber, especially in reciprocating engines, with the lubricant and which combine with the lead to form various components of the deposits. Leaded deposits are thus formed at elevated temperatures because of the presence of lead-containing anti-knock compounds in aviation (or other) fuel.

The primary deposit formed on the surface of the engine parts is carbonaceous or organic material, a portion of which often is in the form of a tough carbon or graphite deposit which tightly adheres to the metal surfaces. These deposits are usually formed in the combustion components of the engine, and are found both bound together with and deposited on the leaded deposits, which are tenaciously held by the carbonaceous material. In many cases massive carbon deposits are formed because of severe conditions of engine operation.

Another portion of the carbonaceous deposit is in the nature of hardened lubricant formed on certain engine parts, e.g., in the propeller hub of aircraft. Here, the lubricant in circulating from the outer cylinder walls through the propeller hub carries with it particles of lead and lead compounds picked up from the vicinity of the cylinder walls, and a portion of the carbonaceous lubricant material carrying such leaded deposit forms a deposit in the propeller hub due to the heat generated, said deposit consisting mostly of carbonaceous material and minor portions of lead sludge distributed more or less loosely throughout the carbonaceous deposit.

Thus, in the above noted primary carbonaceous deposit, there is a substantial portion of lead sludge or leaded deposit which is tightly bound within the carbonaceous material, where as in the case of the other type of carbonaceous deposit made up chiefly of lubricating oil residues, the lead sludge forms only a minor portion of the total deposit and such lead sludge is essentially in loose unbound form within the lubricant deposit. The invention deals with removal of both forms of these deposits.

The term "carbonaceous deposits" as employed herein is intended to include, for example, carbon or graphite, and high molecular weight asphaltine or asphaltic or tarry binders, and the like, which are formed in burning of the fuel, and also lubricating oil residues or deposits, which may be partially or completely burned. The term "leaded deposit" or "lead sludge" is intended to denote lead or any of the compounds of lead formed on engine parts as result of the burning of leaded fuels.

For proper maintenance of the engines, overhaul procedures must be applied during which the engine components are completely and safely cleaned of the above noted carbonaceous and leaded deposits. One of the most important reasons for removing the foreign matter, i.e., carbonaceous and leaded deposits, is to provide clean metal surfaces which are suitable for inspection for flaws by standard techniques.

Conventional procedures for cleaning engine components for removal particularly of carbonaceous and leaded deposits during overhaul are based on a combination of inadequate chemical cleaning methods generally involving a considerable number of steps, rendering such conventional procedures time consuming and expensive. Thus, one method includes the steps of precleaning, rinsing, deleading, rinsing, decarbonizing, rinsing with solvent, and a final rinsing with water. Further, the presence of leaded deposits together with the carbonaceous material complicates the removal of both of these types of deposits.

Also, decarbonizing compositions generally employed usually contain a solvent such as methylene dichloride, phenolic bodies and corrosion inhibitors to prevent corrosion on the metals or alloys being processed. In many instances these corrosion inhibitors are of the chromate type. It is the tendency of the lead or lead components removed from the part in the decarbonizing tank and dissolved in the decarbonizing solution to react with the phenolic bodies and/or chromates to produce a suspension or solution of highly surface active lead compounds that tend to redeposit on the work, usually requiring laborious and expensive hand operations to remove the residue. Further, the solvent employed in the decarbonizing composition, e.g., methylene dichloride, has little tolerance for the lead compounds formed in the decarbonizing solution, resulting in redeposition of the highly surface active lead compounds on the cleaned metal part. Moreover, the prior art solvents employed as a rinse subsequent to the decarbonization treatment, e.g., methylene dichloride or solvents of the petroleum type, have inferior rinsing properties, and appear to "set" any lead and carbonaceous deposits still present on the part, onto the surface thereof, rather than to remove such remaining deposits from the part.

Also, conventional systems for lead deposit and carbonaceous deposit removal employ a number of different solvents which are often incompatible. Hence, considerable care is required in rinsing between stages, which adds further expense to the overall operation as well as requiring the utilization of large quantities of water, making solvent recovery difficult and presenting a sewage disposal problem.

One object of this invention is the provision of a simplified inexpensive procedure for removing leaded and carbonaceous deposits from engine components, particularly aircraft engine parts, resulting primarily from the use of leaded fuels.

Another object of this invention is to provide an efficient decarbonizing and deleading operation for engine parts by the use of solvents which effectively dissolve the organic or carbonaceous binder, and dislodge and remove the commingled leaded deposit.

Still another object of this invention is to provide a deleading and decarbonizing technique for removal of carbonaceous and leaded deposits from engines, e.g., internal combustion engines, wherein intermediate water rinse stages are eliminated and contamination of the decarbonizing and subsequent rinse baths by lead sludge remaining on the part following treatment of the part in the deleading bath, is at the same time materially reduced.

A particular aim of the invention is the provision of a precleaning, deleading and decarbonizing procedure for engine parts, wherein precleaning and some deleading are carried out in a first operation, substantially all of the remaining lead and practically all of the carbonaceous deposit are removed in the decarbonizing step, and in which a final rinsing step substantially removes any remaining minor portions of lead sludge, or carbonaceous material which still may be clinging to the surface of the part.

Yet another object is the provision of a process of the aforementioned nature employing solvents in the deleading, decarbonizing, and final rinsing stages, of a type such that carry-over of solvent from one treatment bath to a subsequent treating bath does not adversely affect said subsequent bath but rather increases the efficiency of subsequent treating stages.

A further object is the provision of a novel combination of deleading and rinsing operations, or a novel combination of deleading, decarbonizing and rinsing operations for the aforementioned purpose.

A still further object is to provide an efficient technique for purification and recovery of the solvent utilized in the deleading and rinsing stages.

These and other objects of the invention are accomplished in the manner described below.

I have found preferably through use of certain solvents, that leaded deposits, particularly of the type formed on various components of internal combustion engines, such as engine parts and associated parts, and especially when contaminated with carbonaceous deposits, can be loosened and removed in substantial measure from the surface of the part in a first stage precleaning operation, and that any residual lead sludge still adhering to the surface of the part can be removed in a subsequent rinsing stage. I have also found that the use of such solvents in an initial precleaning operation prior to decarbonizing, and in a final rinse operation, subsequent to a decarbonizing treatment which may preferably, although not necessarily, also involve use of such solvents, results in improved efficient removal of both carbonaceous and leaded deposits from engine components, by a minimum number of operations.

In the case where the engine components contain leaded deposits contaminated by combustion products deposited at high temperature such as in the cylinders, the precleaning operation of the invention removes loosely held deposits of carbonaceous material and lead sludge. In those engine parts on which the leaded deposit is found together with carbonaceous material formed from the engine lubricant and not exposed to high combustion temperatures, the precleaning operation removes substantially larger portions of leaded deposit than in the aforementioned case, said leaded deposit in the latter instance generally being located close to the outer surface of the carbonaceous deposit.

The solvents employed in the precleaning and final rinsing operations, according to the invention, are preferably the same as, but in any event are at least compatible with, the solvents employed in the decarbonizing treatment. In the decarbonizing step wherein both carbonaceous material and leaded deposit are removed from the parts, surface active lead compounds are suspended in the solution and tend to be adsorbed back onto the part and to be tightly held onto the surface. By treating the parts in a rinsing solution composed of a solvent compatible with the decarbonizing solution, and which has the property of removing or dissolving leaded and carbonaceous deposits from the part surface, I can remove such deposits from the initially contaminated parts in a minimum of operations. Thus, the solvents of the invention should have the power to remove remaining surface active lead sludge and carbonaceous deposit from the part after decarbonizing, and should be soluble in or miscible with the decarbonizing solution so as to carry away the decarbonizing solution from the surface of the part.

I have found that certain chlorinated organic solvents have properties which adapt themselves particularly to the above procedures. These solvents are polychlorinated hydrocarbons each containing from 2 to 6 carbon atoms and from 2 to 4 chlorine atoms, there being at least two chlorinated carbon atoms and when the hydrocarbon is a saturated aliphatic compound containing only two carbon atoms there are at least 3 chlorine atoms linked to such carbon atoms, these compounds being free of groups comprising 3 adjacent chlorinated carbon atoms. Such compounds include cyclic and acyclic polychlorinated hydrocarbons, for example, polychlorinated aromatic, alkyl and alkylene (or unsaturated alkyl) hydrocarbons. A particularly useful class of solvents suitable in my process are polychlorinated hydrocarbons as defined above and having at least one unsaturated carbon to carbon linkage with at least one chlorine atom connected to each of the two adjacent carbon atoms of such linkage.

Specific illustrative examples of polychlorinated hydrocarbon solvents which may be used in the invention are 1,1,2-trichloroethylene, tetrachloroethylene, 1,2-dichloropropane, dichloropentanes such as 2,3- and 2,4-dichloropentane, orthodichlorobenzene, paradichlorobenzene, 1,2,4-trichlorobenzene, and the like. The preferred solvent is orthodichlorobenzene.

It is particularly significant that other chlorinated hydrocarbons having a structure generally related to the above noted chlorinated solvents, but not within the structural definition set forth above, have been tried but found unsuitable for the purposes of the invention. Such unsuitable compounds include, for example, methylene dichloride, ethylene dichloride, 1,2,3-trichloropropane, hexachloroethane and hexachlorobenzene.

The chlorinated hydrocarbon solvents employed in the invention may be liquid or solid at ordinary temperature. Where such solvents are solids at ordinary temperature or at the temperature of treatment according to the invention, the solid chlorinated material may be dissolved in a solvent therefor, and the resulting mixture of solvents is employed rather than the chlorinated hydrocarbon itself. Thus, for example, paradichlorobenzene, a solid at ordinary temperature, can be dissolved in kerosene or other solvent, and the resulting solution employed. It will be understood, of course, that mixtures of one or more of my above defined chlorinated solvents can

also be employed. Further, my chlorinated hydrocarbon solvents can be employed in conjunction with other solvents, or as commercial materials which may contain minor amounts of impurities, even including minor amounts of the above noted unsuitable solvents, provided that my chlorinated hydrocarbon solvent is present in major proportions. Thus, for example, I may employ a mixture consisting of a major proportion of 1,2-dichloropropane and a minor amount of 1,2,3-trichloropropane.

It is believed that the chlorinated hydrocarbon solvents of the invention function to loosen or remove lead and lead compounds from the contaminated parts by forming some sort of complex. The complex so formed is either suspended or dissolved in the solution. While the above is given as a theory as to how the invention solvents function in my process, it is to be understood that the invention is not to be limited by any particular theory as to how the above defined operative chlorinated solvents function to produce the results of this invention.

The highly simplified technique for deleading and decarbonizing internal combustion engine parts, according to the invention, basically consists of but three steps, namely (1) precleaning and deleading, (2) decarbonizing and deleading, (3) rinsing. One or more of the above noted solvents of the invention, preferably orthodichlorobenzene, is employed as the chief ingredient of the initial precleaning solution, which briefly precleans or degreases the part and also loosens and removes a portion of the leaded deposit in a single operation. The decarbonizing solution removes organic or carbonaceous material acting as binder for the leaded deposit, especially when such carbonaceous deposit is formed in the combustion portions of the engine, and simultaneously removes most of the leaded deposit so bound. The above noted solvents and preferably orthodichlorobenzene, are also employed in the solution used in the final rinsing of the part, for removal of any lead sludge or carbonaceous material still adhering to the part following the deleading and decarbonizing treatments.

Preferred use of the above noted chlorinated solvents also in the decarbonizing step has the advantage of decreasing the amount of lead sludge or smut remaining on the part after it is treated in the decarbonizing solution, and hence decreases the amount of lead contamination of the final rinsing solution. However, as previously noted, I need not employ a chlorinated hydrocarbon solvent of the type used in my precleaning and final rinse operations, in the decarbonizing bath, but I may employ conventional decarbonizing solutions as the latter bath.

It will be seen that according to the invention process, I have eliminated the intermediate rinsing and washing steps heretofore required in conventional processes, between the first step of precleaning and deleading, and the second decarbonizing step. Further, particularly since I may also employ a chlorinated solvent of the type described above, e.g., orthodichlorobenzene, as a component of the decarbonizing solution, carry-over of solvent by the part from the initial precleaning solution to the decarbonizing solution, and from the decarbonizing solution to the final rinsing solution, does not adversely affect the decarbonizing and rinsing solutions, but rather increases the efficiency thereof.

As another feature of the invention I have rendered my process still more efficient by continuously removing a portion of the spent solution from the precleaning tank and continuously distilling the spent solution to remove the lead, oil, carbon and other contaminants thereof. The rejuventated purified distillate, e.g., orthodichlorobenzene, is circulated to the final rinse tank so that the latter tank always contains clean solvent for the final rinse. A portion of the solvent in the final rinse tank is preferably continuously bled back into the first tank containing the precleaning solution. This feature of my process thus reduces solvent costs by the utilization of a highly effective precleaning and rinsing solvent that can be inexpensively reclaimed by distillation.

My system as above described cleans internal combustion engine parts, particularly aircraft engine parts, and jet engines, diesel equipment and the like, more efficiently in a three-step operation than is accomplished in conventional five or seven-step installation. This simplicity is especially attained by improving the initial precleaning and final rinse operations, eliminating the water rinses between operations, and by minimizing contamination of the various solutions by dragover of lead sludge, carbon deposit and solvent from one bath to a subsequent treating bath.

Since my process eliminates the charging and disposal of water solutions used for rinsing between the various operations, maintenance and waste disposal problems are materially reduced. My system also reduces costs for precleaning solutions by utilizing precleaning solutions which also function as deleading solutions, such solutions having the additional advantage of being inexpensively reclaimed by distillation. Further, labor costs are minimized because of my improved precleaning and deleading, decarbonizing and rinsing techniques.

In practice of my invention, referring also to the drawing showing schematically a system embodying a preferred mode of procedure, the precleaning solution is charged into tank **1**, the decarbonizing solution into tank **2** and the rinsing solution into tank **3**. All three of the tanks **1**, **2** and **3** preferably contain agitators for maintaining the various solutions therein uniform, and to provide efficient contact of the parts being treated with the solutions. The tanks also are preferably provided with baffles to prevent loss of solvent, means such as coils for steam heating of the solutions, and grids at the bottom of the tanks to entrap lead sludge and other solid foreign matter. Means, such as an automatic overhead conveyor system, can be employed for transferring engine parts to be treated from one tank to another, the parts generally being placed in baskets which are dipped or immersed in, and withdrawn, as desired, from the treating solutions in the respective tanks. If desired, an automatic conveyor system may be employed in which the parts are continuously moved at a predetermined rate through these solutions and in which the operations are timed by a cycle timer. A continuously operated still **4** is connected by suitable piping indicated at **5**, with tank **1**, for continuously distilling spent solvent from tank **1**, the distillate being conveyed into a receiving tank **8** and into tank **3** by means of piping indicated at **6**. A pipe **7** connects the final rinse tank **3** with the precleaning and deleading tank **1**. The dotted lines indicate carry-over of a small amount of solvent from tank **1** to tank **2**, and from tank **2** to tank **3**. It is understood that the system above described is merely illustrative and is not intended to limit the invention.

The precleaning solvent described above and charged to tank **1**, is preferably orthodichlorobenzene, although any of the suitable chlorinated hydrocarbon solvents described above or mixtures thereof can be used. In preferred operation, a minor proportion of water is added to the solvent, such water floating on the surface of the solvent in the preclean tank **1** to function as a seal to reduce evaporation of solvent and release of solvent odors, and as a stripping agent to remove solvent from the engine part, e.g., during withdrawal of the part from the solution. One reason for preferring the use of orthodichlorobenzene is that orthiodichlorobenzene for all practical purposes does not hydrolyze in water, whereas, some of my other chlorinated solvents, for example, trichloroethylene and tetrachloroethylene, do to a limited extent. However, it will be understood that the above noted water seal need not necessarily be employed, in which case there is no problem of hydrolysis with

respect to use of any of my suitable chlorinated solvents.

The preferred orthodichlorobenzene for precleaning may also be employed together with aromatic or aliphatic petroleum solvents such as kerosene or other solvents such as other chlorinated hydrocarbons, aromatic or aliphatic alcohols, and the like. Azeotropic mixtures of orthodichlorobenzene and/or other solvents may be employed if desired to facilitate distillation of the spent solvent, and recovery of substantially the same solvent composition as distillate but this is not necessary. For precleaning and the deleading which takes place in the initial step, in preferred operation, the solution should contain at least about 50% of my chlorinated solvent, e.g., orthodichlorobenzene, by weight. However, the use of smaller amounts of these solvents in the precleaning and deleading solution also materially aids the action thereof according to the invention.

The precleaning and deleading treatment is generally carried out at about ambient or room temperature, although lower or higher temperatures can be employed. Time of treatment of the engine parts immersed in tank **1** will vary with the type and amount of carbonaceous material deposited on the part surface, the nature and amount of leaded deposit also present with the carbonaceous material, and the particular chlorinated solvent of the invention employed. The duration of treatment of the engine parts in tank **1** for precleaning and a certain amount of deleading may vary say from 15 minutes to 2 hours.

The chlorinated solvent, e.g., orthodichlorobenzene, employed in tank **1** first acts to remove dirt and grease from the surface of the engine part. Simultaneously, such solvent removes any loose or unbonded leaded deposit, which may include inorganic and organic lead compounds and also free lead, the amount of said removal depending on the composition of the leaded deposit formed on the part, the nature of the carbonaceous deposit, the temperature of the treating solution and the duration of treatment. Where the carbonaceous deposit is made up essentially of lubricating oil residues, with a minor portion of leaded deposit which is mostly in loose form, practically all of the leaded deposit is removed in the precleaning bath. But where the carbonaceous material is a hard, tenacious, refractory type of material formed in the combustion parts of the engine at high temperature, and a substantial portion of leaded deposit is bound tightly therewith, only a minor portion of such leaded deposit is removed in the precleaning bath. Thus, while I term the initial step of my process a "precleaning" operation, it is understood that in addition to removal of dirt and grease from the part, a substantial amount of leaded deposit may also be removed in this operation, depending upon the type of carbonaceous and leaded deposits initially formed on the part.

Tests have shown that orthodichlorobenzene, for example, in the precleaning bath will remove most or a portion of the leaded deposits 5 to 10 times faster than the same amount of leaded deposit can be removed in conventional aliphatic petroleum type solvents heretofore employed. Moreover, the lead sludge formed by conventional solvents tends to redeposit on the surface of the part, and must be removed in subsequent steps, whereas the loose sludge carried into the precleaning solution when employing therein my solvents, e.g., orthodichlorobenzene, do not redeposit on the part and require removal in subsequent steps, e.g., the decarbonizing solution, resulting in further contamination thereof.

Following the precleaning and deleading operation, the engine parts are transferred to tank **2** containing a decarbonizing solution for removal of carbonaceous deposit and any remaining lead deposit from the metal part. Any suitable decarbonizing solution can be employed. Such solutions may include conventional decarbonizing compositions, but I preferably employ a composition including my chlorinated solvents such as ortho dichlorobenzene, usually together with other components. The decarbonizing solution is generally a compounded mixture of a number of ingredients including, for example, soaps, wetting agents and corrosion inhibitors such as alkali metal chromates. The following are illustrative of suitable decarbonizing compositions:

Composition A:	Percentage
Orthodichlorobenzene	43
Cresylic acid	22
Potassium oleate soap (anhydrous)	12
Water	20
Sodium alkyl aryl sulfonate wetting agent	3
	100

Composition B:	
Trichloroethylene	52
Cresylic acid	20
Oleic acid	7.2
Potassium hydroxide	1.4
Water	14.1
Sodium alkyl aryl sulfonate wetting agent	5
Sodium chromate (anhydrous)	0.3
	100.0

Composition C:	
Cresylic acid	23
Potassium oleate soap (anhydrous)	7
Water	70
	100

Composition D:	
Cresylic acid	20
Soap	10
Sodium chromate (anhydrous)	0.3
Methylene dichloride	54
Water	15.7
	100.0

Temperature of treatment of the parts in the decarbonizing solution can range from ambient room temperature say to about 160° F. or higher, a temperature of about 140° F. being preferred to accelerate time of treatment. Composition A above is a preferred solution, and can be operated efficiently at say 140° F., although Compositions B, C and D are also suitable. Time of treatment of the parts in this solution can vary, for example, from 15 minutes to 2 hours or more depending on the thickness of the carbonaceous deposit, its hardness and its degree of tenacity to the part surface. Practically tall of the organic or carbonaceous deposit including most of the hard tenacious deposits of carbon, can be removed from the part in the decarbonizing solution, little, if any, carbonaceous deposit other than grease and very loose organic material being removed in the precleaning stage. Along with the carbonaceous deposit, there is removed substantially all of the remaining leaded deposit which is bound up with said carbonaceous deposit. Where the initial deposit is formed in the combustion region of the engine and is composed of hard tenacious combustion residues with a substantial portion of leaded deposite bound therewith, the leaded deposit removed in the decarbonizing step constitutes practically all of the initial leaded deposit, since only a minor portion of such leaded deposit is removed in the initial precleaning step under these conditions. It will thus be noted that the precleaning step removes loose lead deposits while the decarbonizing step removes the more obdurate leaded deposits usually bound up with the carbonaceous deposit. Thus, while I term the second step of my process a "decarbonizing" operation, it is understood that in addition to removal of most of the carbonaceous deposit, a substantial portion of the leaded deposit may also be removed in this operation depending on the nature of the initial carbonaceous and leaded deposits formed on the parts.

If desired, more than one decarbonizing bath may be employed, for example, two or more decarbonizing tanks in succession may be utilized where, for example, the organic carbonaceous deposit is in a recessed or difficultly accessible crevice of the part, or where the carbonaceous material is particularly thick or obdurate, and thus difficult to remove.

Carry-over of chlorinated solvent, e.g., orthodichlorobenzene, from the initial precleaning and deleading solution in tank **1** to the decarbonizing solution in tank **2** does not adversely affect the latter solution, particularly where one of the components of the decarbonizing so'ution is one of my chlorinated solvents, e.g., orthodichlorobenzene, as in Composition A above.

Following treatment in the decarbonizing solution, the engine parts are immersed in tank **3** containing one of my chlorinated solvents, preferably orthodichlorobenzene, as the chief active ingredient. In this connection, the same solvents noted above for use in the precleaning operation are employed in tank **3** for rinsing. However, I may employ as little as 10% of my chlorinated solvent, e.g., orthodichlorobenzene, in the rinse solution. Preferably, I employ orthodichlorobenzene alone or with a 10% water seal, as described above, in both the precleaning tank **1**, and in the rinse tank **3**. If desired, I can utilize orthodichlorobenzene as chief ingredient of the solutions in all three tanks **1**, **2** and **3**, e.g., when using Composition A for decarbonizing, in which case carry-over of orthodichlorobenzene from one tank to the next by the parts increases rather than decreases the efficiency of the process. The rinse operation can be carried out at solution temperatures preferably about room temperature, although such temperature may be made to vary as desired.

The rinse solution functions to remove any leaded deposit and also any residual carbonaceous material still adhering to the engine part. Since my chlorinated solvents can loosen or aid in dissolving higher concentrations of lead deposit than conventional solvents or water solutions, before the lead deposit removal and rinsing efficiences of my solvents are impaired, these solvents are superior to conventional rinse solutions in their ability to rinse off lead containing precipitates, including highly surface active lead compounds that have deposited on the metal surfaces from lead contaminants in the decarbonizing bath, such as lead soaps and lead pheolates or cresylates, and particularly lead precipitates formed by the addition of corrosion inhibitors such as chromates to the decarbonizing solution, as in Compositions B and D above, and which form insoluble lead chromates. Conventional type rinse solvents have a tendency to "set" precipitated lead onto the parts if used as final rinse, which is not the case when employing my above chlorinated solvents, e.g., orthodichlorobenzene. Also, the rinse solvent functions to dislodge and remove any mechanically bonded carbonaceous or other deposits that have been loosened but not removed in the decarbonizing bath.

After the parts have been rinsed in tank **3**, the basket containing such parts can be suspended over said tank and given a quick flush with the purified solvent, and if desired, a subsequent tap water rinse can be applied to the parts. These latter flush and rinse operations are understood to be optional and not necessary.

To purify the above chlorinated solvents, e.g., the orthodichlorobenzene, employed in the process, the solvent in tank **1** containing lead sludge and other contaminants can be withdrawn from said tank **1** via line **5** and conducted to the still **4**, wherein the spent solvent is continuously or intermittently distilled. The distillate is condensed in conventional manner, the condensate or distillate passing via line **6** to a receiving tank **8** closely adjacent rinse tank **3**, preferably directly over tank **3**. After the engine parts have been rinsed by immersion in tank **3**, the parts can be suspended above

the rinse tank at a flushing station indicated at **9** in the drawing, and hosed off with the fresh solvent from the receiving tank **8**, as described above, the solvent then draining into the rinse tank **3**. The slightly contaminated rinse solvent from tank **3** is permitted to recirculate back to the preclean and delading tank **1**, via pipe **7** in the amount required to balance the spent solvent removed from tank **1** to the still.

Particularly where the solution in the decarbonizing tank contains one of my chlorinated solvents, e.g., Composition A or B above, after a period of use the spent solution in tank **1** can be processed batchwise to recover the chlorinated solvent for re-use in the process.

The following are examples of practice of my invention:

Example 1

A basket of piston-type aircraft engine parts having leaded and carbonaceous deposits, and other foreign particles on the surface thereof, the carbonaceous deposit being of the tenacious type formed by combustion within the engine and the leaded deposit being principally bound with the carbonaceous deposit, are first dipped in an agitated tank of a mixture of orthodichlorobenzene and about 10% water based on the weight of orthodichlorobenzene. The solution is maintained at about room temperature and the parts are treated for about 30 minutes therein. After this period the parts are withdrawn from the solution, and are observed to be free of grease, with a portion of the leaded deposit removed from the surface of the parts.

The parts are then dipped or immersed in a second agitated tank of a solution of Composition A described above, said solution being maintained at about 140° F. After about 30 minutes' treatment, the parts are withdrawn from the bath. Practically all of the carbonaceous material and the remaining substantial portion of leaded deposit are removed from the surface of the parts.

The parts are then dipped in an agitated third tank containing a mixture of orthodichlorobenzene and a 10% water seal, the same composition as in the first tank. With the solution in the third tank maintained at about room temperature, the parts are treated therein for a period of about 20 minutes. Following this the parts are lifted out of the third tank and rinsed with fresh orthodichlorobenzene, which is permitted to drain into said third tank. The parts are then rinsed with water and are now clean, being practically entirely stripped of all leaded deposits and carbonaceous material.

Spent orthodichlorobenzene containing dissolved grease and leaded and carbonaceous material is continuously withdrawn from the first tank below the surface of the water layer therein and passed to a still operating continuously. The orthodichlorobenzene distills over at about 173° C. and is condensed and passed to a receiving tank. The purified orthodichlorobenzene from the receiving tank is employed to rinse the parts suspended over the third tank, as aforementioned. A portion of the orthodichlorobenzene in said third tank is passed continuously to the first tank to balance the portion of orthodichlorobenzene removed therefrom and passed to the still for purification.

Tests of the rinse solution in the third tank show this solution to remain uncontaminated by large amounts of carbonaceous material and/or lead sludge over extended periods of use.

Example 2

The procedure of Example 1 is repeated employing only 1,1,2-trichloroethylene as solvent in the first and third tanks, without the use of a water seal, and distilling the spent trichloroethylene from the first tank and passing the distillate to said third tank. Excellent results similar to those of Example 1 are obtained.

Example 3

The procedure of Example 1 is carried out employing Composition B as the decarbonizing solution in the second tank. Substantially the same results are realized as in Example 1. It will be noted that the presence of sodium chromate in Composition B, which forms lead chromate in the decarbonizing solution, as noted above, does not affect the ability of the solvent solution in the third tank to rinse the parts clean of remaining leaded deposit, some of which may be in the form of tenacious lead chromate.

Example 4

The same procedure as in Example 1 is followed, except that the solvent used in the first and third tanks is methylene dichloride or ethylene dichloride.

It is found that the engine parts so treated have remaining portions of carbon and leaded deposit "set" into the surface thereof which deposit is not removed by the rinse solution. Also the relatively expensive decarbonizing solution in the second tank becomes rapidly contaminated with carbonaceous and lead precipitate.

Example 5

The same procedure as Example 1 is followed, except that Composition D is employed as the decarbonizing solution in the second tank, the temperature of Composition D being maintained below 100° F. Results similar to those of Example 1 are obtained, except that there is less contamination of the decarbonizing solution employed in Example 1.

Examples 4 and 5 show that while methylene dichloride is unsuitable for use in the precleaning and rinsing stages of my process, it is effective when employed as a component of the decarbonizing solution.

Example 6

Engine parts having carbonaceous deposits thereon formed chiefly from lubricating oil residues with leaded deposit loosely distributed in the carbonaceous material near the surface thereof, are treated according to substantially the same procedure as in Example 1.

It is noted here that practically all of the loosely held leaded deposit is removed in the precleaning tank with very little lead sludge being removed from the part in the decarbonizing tank. Due to almost complete removal of leaded deposit from the part in the precleaning solution, the decarbonizing solution as well as the rinse solvent are only contaminated to a minor degree with lead sludge.

Example 7

The procedure of Example 3 is repeated using tetrachloroethylene as solvent in the first and third tanks instead of 1,1,2-trichloroethylene, with very good results being obtained.

Example 8

The procedure of Example 1 is repeated using 1,2,4-trichlorobenzene in place of orthodichlorobenzene. Excellent results similar to those of Example 1 are obtained.

Example 9

The procedure of Example 3 is repeated employing a commercial grade of dichloropentane, believed to be essentially a mixture of 2,3- and 2,4-dichloropentanes, instead of 1,1,2-trichloroethylene, with excellent results being obtained.

From the foregoing, it is seen that I have developed a novel, simplified process for precleaning, deleading and decarbonizing internal combustion engine parts, particularly aircraft engine parts, to produce clean metal surfaces, which procedure represents a substantial improvement over conventional processes. Among the advantages of my invention are (1) the use of certain types of chlorinated hydrocarbons solvents as removers of leaded deposits, which solvents are markedly superior to conventional solvents, e.g., other chlorinated solvents, petroleum type solvents or water solutions, in their ability to remove lead-containing engine sludge, especially from recessed and remote areas of engine parts, my solvents being further superior to conventional solvents in their ability to cleanly rinse off lead precipitates, especially those formed by the addition of corrosion inhibitors such as chromates and phenolic and cresylic compounds to the decarbonizing solution; (2) intermediate water rinses are eliminated and an essentially three-stage simple precleaning, decarbonizing and rinsing procedure is provided; (3) use of make-up solvent for initial precleaning and final rinsing is greatly reduced by provision of a distillation technique for purifying and recirculating purified solvent to these operations; (4) contamination of solvents in the successive operations by carry-over of solvent from a preceding operation is reduced; (5) the distillation technique for purifying solvent minimizes sewage disposal problems with respect to spent solvent; (6) the system reduces maintenance costs; (7) the process is flexible, being readily adaptable to continuous, automatic or batch operation, and to the incorporation of any desired additional equipment, essentially all of the equipment used being of standard design; (8) the solvent used for final rinsing in my process reduces the chances of post rusting and corrosion of the engine parts treated in my process.

While I have described particular embodiments of my invention for the purpose of illustration, it should be understood that various modifications and adaptations thereof may be made within the spirit of the invention as set forth in the appended claims.

I claim:

1. A process for removing leaded and carbonaceous deposits on an engine part, which comprises treating said part in a first bath of chlorinated hydrocarbon solvent, said solvent being a polychlorinated hydrocarbon containing from 2 to 6 carbon atoms and from 2 to 4 chlorine atoms, there being at least two chlorinated carbon atoms and when said hydrocarbon is a saturated aliphatic compound containing only two carbon atoms there are at least 3 chlorine atoms linked to said 2 carbon atoms, said polychlorinated hydrocarbon being free of groups comprising 3 adjacent chlorinated carbon atoms, treating said part with a second bath containing orthodichlorobenzene and an alkali metal chromate, and rinsing said part in a third bath containing as chief active ingredient a chlorinated hydrocarbon solvent as defined above to remove any remaining leaded and carbonaceous deposits still adhering to said part.

2. A process for removing leaded and carbonaceous deposits on an engine part, which comprises treating said part in a first bath consisting essentially of a chlorinated hydrocarbon solvent, said solvent being a polychlorinated hydrocarbon containing from 2 to 6 carbon atoms and from 2 to 4 chlorine atoms, there being at least two chlorinated carbon atoms and when said hydrocarbon is a saturated aliphatic compound containing only two carbon atoms there are at least 3 chlorine atoms linked to said 2 carbon atoms, said polychlorinated hydrocarbon being free of groups comprising 3 adjacent chlorinated carbon atoms, and removing at least a portion of said leaded deposits, treating said part with a second bath having a composition different from said first bath and containing a solvent for said carbonaceous deposit and cresylic acid, and removing most of said carbonaceous deposit, and rinsing said part in a third bath which is less contaminated than said first and second baths, and containing a chlorinated hydrocarbon solvent as defined above to remove any remaining leaded and carbonaceous deposits still adhering to said part.

3. A process for removing leaded and carbonaceous deposits on an engine part, which comprises treating said part in a first bath consisting essentially of a chlorinated

hydrocarbon solvent selected from the group consisting of orthodichlorobenzene, 1,1,2-trichloroethylene, tetrachloroethylene, 1,2-dichloropropane, dichloropentane, paradichlorobenzene and 1,2,4-trichlorobenzene, treating said part with a second bath having a composition different from said first bath and containing an organic solvent for said carbonaceous deposit and cresylic acid, said first and second baths loosening and removing the major portion of said leaded and carbonaceous deposits, and rinsing said part in a third bath which is less contaminated than said first and second baths, and containing a chlorinated hydrocarbon solvent as defined above to remove any remaining leaded and carbonaceous deposits still adhering to said part.

4. A process for removing leaded and carbonaceous deposits on an engine part, which comprises treating said part in a first bath consisting essentially of orthodichlorobenzene, treating said part with a second bath having a composition different from said first bath and containing an organic solvent for said carbonaceous deposit and cresylic acid, said first and second baths removing the major portion of said leaded and carbonaceous deposits, and rinsing said part in a third bath which is less contaminated than said first and second baths, and containing orthodichlorobenzene, and removing any remaining leaded and carbonaceous deposits.

5. A process for removing leaded and carbonaceous deposits on an engine part, which comprises treating said part in a first bath consisting essentially of a chlorinated hydrocarbon solvent, said solvent being a polychlorinated hydrocarbon containing from 2 to 6 carbon atoms and from 2 to 4 chlorine atoms, there being at least two chlorinated carbon atoms and when said hydrocarbon is a saturated aliphatic compound containing only two carbon atoms there are at least 3 chlorine atoms linked to said 2 carbon atoms, said polychlorinated hydrocarbon being free of groups comprising 3 adjacent chlorinated carbon atoms, and removing at least a portion of said leaded deposits, treating said part with a second bath having a composition different from said first bath and containing said polychlorinated hydrocarbon as solvent for said carbonaceous deposit and cresylic acid, and removing most of said carbonaceous deposit, and rinsing said part in a third bath which is less contaminated than said first and second baths, and containing a chlorinated hydrocarbon solvent as defined above to remove any remaining leaded and carbonaceous deposits still adhering to said part.

6. A process for removing leaded and carbonaceous deposits on an engine part, which comprises treating said part in a first bath consisting essentially of orthodichlorobenzene, treating said part with a second bath having a composition different from said first bath and containing orthodichlorobenzene and an alkali metal chromate, and rinsing said part in a third bath containing orthodichlorobenzene to remove any remaining leaded and carbonaceous deposits still adhering to said part.

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