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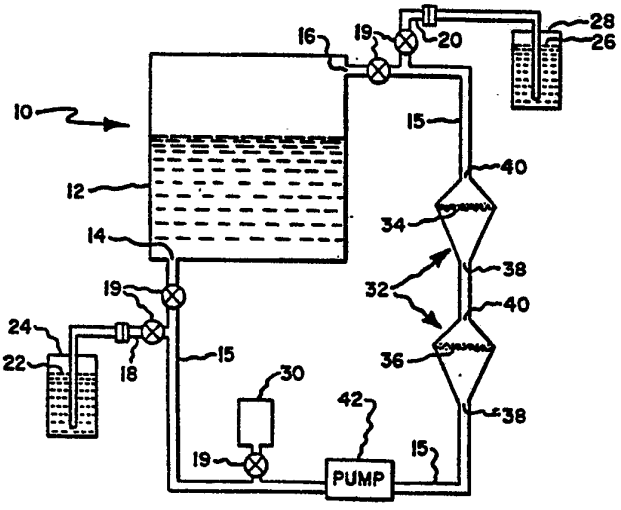
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(54) Title: PROCESS, APPARATUS AND COMPOSITION FOR RECYCLING ENGINE COOLANT



(57) Abstract

A process for physically and chemically treating a used engine coolant from a Domestic, European or Japanese/Asian vehicle containing one or more glycol and/or an alcohol-based antifreeze components. The process includes the steps of oxidation with one or more known oxidizing agents, precipitation with one or more known salt forming agents and filtration through any suitable filtration membrane or other separation means. A chemical additive has been developed for use in carrying out the process of the present invention which initiates and maximizes the amount of oxidation and precipitation occurring within the coolant composition, adds one or more suitable corrosion inhibitors and one or more known buffering agents in a sufficient amount to adjust the pH of the final solution. An apparatus (10) for use in carrying out the process of the present invention is also described herein. This apparatus includes container means (12) to receive used coolant, circulating conduit (15) and filtration means (32) to recycle the coolant.

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Process, Apparatus and Composition for Recycling Engine Coolant

This application is a continuation-in-part of U.S. Serial No. 07/788,863, filed November 7, 1991, and U.S. Serial No. 07/484,114, filed February 23, 1990, now abandoned.

Field of the Invention

This invention relates to internal combustion engine coolants comprising mixtures of glycols and/or alcohols, commonly known as antifreeze, and more particularly, to a process, apparatus and composition for recycling used engine coolant.

Background of the Invention

Antifreeze compositions are additives commonly used to lower the freezing point or increase the boiling point of water. Such additives primarily consist of one or more alcohol and/or glycol-based components. The most commonly used antifreeze component consists of ethylene glycol. When added to an internal combustion engine cooling system at 50% volume concentration, ethylene glycol affords the engine coolant freeze protection down to about -34°F and antiboil protection up to about 235°F, depending on the pressure.

When antifreeze is added to an aqueous-based engine cooling system the glycol and/or alcohol-based components of the antifreeze after time start to break down chemically into various organic acids. The organic acids produced are usually glycolic, formic and to a lesser extent oxalic and glyoxalic

acids. The break down is confirmed by the pH of the engine coolant composition decreasing from a pH of around 10.0 downward toward a pH of about 7.0.

Coolants circulating through an engine cooling system at a pH below about 8.3 show a very corrosive effect on the metals comprising or located within the system. It is believed that at a pH of about 9 the corrosion effect starts and proceeds at a relatively slow rate until a pH of about 8.7 is reached. When the pH of the coolant is below about 8.3 the corrosion proceeds at a very rapid rate. The less noble metals such as steel, iron and cast iron in a coolant system are the first to go into solution as a result of the corrosion process. Furthermore, low pH causes aluminum pitting which readily weakens the wall thickness of its respective components. Also lead from solder goes into solution. Copper likewise corrodes and goes into solution and zinc, which is used to strenghthen various mixed solders in radiators, leaches out and weakens the solder so that leaks develop. The remaining impurities commonly found in coolants are suspended particulate matter, primarly corrosion products (metal oxides), dirt, silt and hard water salt deposits.

Circulating coolant compositions also include several known corrosion inhibitors. The inhibitors are generally formulated in an additive which is added either directly to the coolant or included in the antifreeze solution by the manufactures which is sold as "inhibited antifreeze". Typical corrosion inhibitors include phosphates, silicates, borates, nitrites, nitrates, azoles and molybdates. However, most inhibitors are depleated over a period of time which further contributes to the corrosion and sludge effect on the engine cooling system.

It is generally accepted practice to remove and replace the coolant composition in an engine cooling system after a period of time because the initial coolant accumulates dissolved impurities and suspended particulate matter and looses effective corrosion inhibition and freeze protection capabilities. Although separate cooling system additives may be employed to neutralize degradation products accumulating in the system, these additives are primarily alkaline and include corrosion inhibitors, dispersants, polymers and sequestrants. But, such compounds do not restore the depleted antifreeze components, i.e., glycol and/or alcohol, remove the dissolved impuritie and suspended particulate matter nor increase the freeze protection or raise the boiling point of the used coolant. Additionally, these additives fail to inhibit further degradation of the coolant components.

Also, more states today consider antifreeze a hazardous waste because of lead levels over 5ppm and the glycol content. Consequently, the Federal EPA and various State environmental agencies make discharging of antifreeze illegal and are imposing large fines on any facility that discharges antifreeze into the environment. Therefore, a need exists for a process for restoring or recycling degraded or used engine coolant to a recycled product which may be reintroduced into the engine cooling system, thus eliminating the degredation and disposal problems.

Objects and Summary of the Invention

Accordingly, it is the primary object of the present invention to provide a process for recycling used engine coolant.

Another object of the present invention is to provide an apparatus and additive composition for practicing the process.

Another object of the present invention is to provide an improved recycled coolant which exhibits superior corrosion inhibition and suppressed degradation characteristics of the glycol and/or alcohols.

Another object of the present invention is to provide an improved recycled coolant which exhibits a final pH of from about 8.0 to about 10.5; the pH dependant on what type of vehicle the coolant is to be used within.

The present invention provides a process for physically and chemcially treating a used coolant composition of the type used within an internal combustion engine cooling system to remove unwanted impurities and degradation by-products, the coolant composition containing one or more glycol and/or alcohol-based antifreeze components. The process comprises:

(a) contacting the coolant composition with one or more known agents in an amount sufficient to remove any unwanted dissolved metals and metal based corrosion by-products and nuetralize organic acids present in the composition;

(b) filtering the coolant composition through any suitable filtration membrane or other separation means capable of removing any particulate precipitates formed during step (a) or already present in the coolant;

(c) adding to the coolant composition one or more suitable corrosion inhibitors selected from the group consisting of phosphates, phosphonates, silicates, carboxylates, borates, nitrites, nitrates, azoles, modified acrylates, mayleic polymers and molybdates; and

(d) adjusting the pH of the coolant composition by introducing into the coolant one or more known buffering agents, thereby providing a recycled coolant composition having corrosion capabilities equal or preferably superior to the coolant present in the system when initially added thereto.

The process may further comprise the step of adding an alcohol and/or glycol component, preferably 100% ethylene glycol, in an amount sufficient to restore the freeze protection of the coolant composition down to about -34°F.

The agent used in step (a) of the process of the present inventing may be selected from the group consisting of one or more known oxidizing agents, one or more known salt forming agents, carbamate salts and ion exchange resins or a combination thereof.

A chemical additive has been developed for use in carrying out the process of the present invention. It is understood that the composition of the chemical additive may vary depending on what type of engine the coolant is used within i.e. Domestic, Japanese or European vehicle. Since different vehicle engines are comprised of different metals, it has been determined that the amounts of corrosion by-products, dissolved impurities and suspended particulate matter present in used coolant removed from the different vehicles will vary. Furthermore, the pH of the coolant for the different engines will also vary.

The chemical additive for recycling domestic engine coolant comprises a solvent such as zeolite softened or demineralized water; an alkali metal hydroxide for neutralizing or forming salt precipitates with any unwanted organic or inorganic acids; a sodium salt of a carbamate as a precipating

agent for removing dissolved metals from solution; a borate or nitrate for use as a buffer to stabilise the pH of the recycled coolant; and a nitrite, molybdate, and/or azole as corrosion inhibitors to restore the corrosion inhibition capabilities of the coolant composition. Optionally, the additive may comprise a surfactant to prevent cavitation from forming in the engine; a anionic polymeric dispersant for dispersing suspended solids present in the solution, a deposit control agent and a sequestering agent to retard the precipitation of metallic ions out of the recycled coolant.

The present invention further provides an apparatus for practicing the recycling process of the present invention. One embodiment of the apparatus comprises a recycling machine which is used for recycling large quantities of engine coolant, after removal from the engine. Another embodiment of the apparatus comprises a recycling machine which is used for recycling engine coolant directly from the cooling system of a vehicle.

Detailed Description

The term "coolant composition" or "coolant solution" or "coolant", as used herein, refers to a composition which may contain freezing point depressing amounts of at least one alcohol, at least one glycol, or mixtures of one or more alcohol and glycol and water. The alcohol, glycol or alcohol-glycol mixture may comprise about 20% to 90% by volume of the aqueous coolant, preferably about 50% by volume. Any of the water soluble alcohols and glycols known in the antifreeze or coolant art are intended to fall within the scope of the present invention including methanol, ethanol, propanol, ethylene glycol, proplylene glycol, diethylene

glycol, dipropylene glycol, triethylene glycol, glycerol, and glycol ethers of various types. Mixtures of ethylene glycol and diethylene glycol are particularly preferred.

The term "used engine coolant composition" or "used coolant composition" or "used coolant", as used herein, refers to any engine coolant containing an antifreeze solution having undergone partial or complete degradation wherein the coolant exhibits a pH below about 10.0, for Domestic vehicles, and lacks the ability to impart freeze protection to the coolant down to at least about -34°F. A Domestic vehicle is that vehicle which is built in the United States.

The process in accordance with the present invention comprises first contacting the used coolant with one or more agents to remove unwanted dissolved metals and metal based corrosion by-products, and organic acids present in the coolant composition. In one embodiment herein, the agent may comprise one or more known oxidizing agents whereby the dissolved metals are reduced into metallic oxides. The dissolved metals may typically include iron, copper, zinc, aluminum, lead and steel. Preferably, the oxidation is carried out by means of aeration using an aerator. By adding a sufficient amount of gaseous oxygen to the coolant, the oxidation of some of the dissolved metals into solid metal oxide precipitates is accelerated. The precipitates are readily removed from the coolant during the filtration step. Typically, the coolant is agitated by bubbling through the solution ordinary air and/or oxygen gas to expedite oxide formation. It has been found that contacting the coolant solution with air, for at least about 10 minutes, is sufficient to oxidize most of the metals present in the solution. However,

continuous aeration is more preferred to ensure complete oxidation of the metals. It is understood that any suitable chemical oxidizing agent may be substituted for or used in addition to the gaseous oxygen and still be within the scope of the present invention. A preferred chemical agent may include hydrogen peroxide. In another embodiment herein, in addition to the oxidizing agent or in place thereof, the solution may be passed through any known ion exchange resin which will remove low concentrations of hardness and heavy metals from the coolant solution. For example, IONAC SR-5, a chelate forming cation exchange resin manufactured by Sybron Chemicals, Inc., is particularly well suited for removal of divalent metal ions from the coolant composition by forming complexes thereof. Additionally, carboxylic weak acid exchange resins may be used herein.

In addition to the oxidizing agent and/or ion exchange resin, a sodium salt of the class carbamates may be added to the coolant as a precipitating agent to remove dissolved metals from the coolant solution for retention in the filtration means. Preferred sodium carbamates include sodium dimethyl or diethyl dithiocarbamate or sodium trithiocarbamate.

The agent may further comprise one or more known salt forming agents, i.e., bases, added to the used coolant in an amount sufficient to react with any organic or inorganic acid by-products present in the coolant solution thereby forming salt precipitates. Organic acids are formed from the breakdown of the glycol component in the coolant. For example, when ethylene glycol is present in the coolant it typically undergoes degradation forming various organic acids as follows:

$HOCH_2CH_2OH$ ----→ HOOCCOH + $HOCH_2COOH$ + HCOOH

Ethylene Glycol	----→	Oxalic Acid	+	Glycolic Acid	+	Formic Acid

Upon the addition of a salt forming agent i.e., base formation of solid salt precipitates occurs which may be readily removed from the coolant during the filtration step. Examples of salt forming agents may include ammonium hydroxide, alkali metal hydroxides, alkaline earth metal hydroxides and amines. Alkali metal hydroxides such as potassium hydroxide and sodium hydroxide are preferrable. Acids which may be precipitated out of the coolant as alkali metal salts include glycolic acid, formic acid, oxalic acid, glyoxylic acid and acetic acid. The amount and type of the particular salt forming agent added to the solution is dependant on basic stoichiometric considerations which are known in the art.

After the coolant solution is contacted with one or more of the above mentioned agents to form metal oxide precipitates and salt precipitates, the coolant is passed through any suitable filtration membrane or other separation means to remove the precipitates from the solution. Preferably, high flow, chemically inert, reusable filters may be used to remove the precipitated impurities and degradation by-products in the used antifreeze. More preferably, the solution is passed through at least two filters (i.e., 1-5 micron and/or 20-30 micron) arranged in series. Any high flow, chemically inert filtration system may be used, but inert cellulose filters have proven to be particularly effective for the process.

Any other known filtration means may be employed to remove the precipitated impurities and several combinations of filtration means may be used in accord with the process described herein. It has been found that about thirty minutes of filtration per 100 gallons of used coolant is preferred, but this time will vary depending upon the type of filtration system used and the impurities in the coolant composition. The previous steps of adding the agents and filtration may be carried out in any order. That is, the used coolant may be circulated through the filtration means immeadiately upon entry into the apparatus (hereinafter described) and the agents may be added during the filtration step. This will become more apparent when the process is further described elsewhere herein.

The process futher includes the step of adding one or more suitable corrosion inhibitors to the coolant composition. The corrosion inhibitors may be selected from the group consisting of phosphates, phosphonates, silicates, borates, nitrites, nitrates, azoles, modified acrylates, molybdates and any other known corrosion inhibitors in the antifreeze art.

The final step of the process includes adding one or more known buffering agents to the coolant solution to adjust the pH of the final solution. The pH of the solution is measured using standard medium range test paper for alkaline solutions. A recycled coolant will typically have a pH in the range of from about 8.0 to about 10.5, depending on what type of vehicle the coolant is used within. Generally, the recycling process is complete when this pH range is obtained.

After the steps of the recycling process described above have been completed, it is contemplated to determine, the freeze protection of

the recycled coolant composition using a conventional refractometer. For example, a coolant composition having a 50:50 mixture of ethylene glycol and water typically provides freeze protection down to about -34°F. A used coolant composition typically exhibits diminished freeze protection and is usually protected only down to about 0°F. To restore the freeze protection to manufacturer's specification, i.e., between about -10°F and -34°F, a solution of ethylene glycol and/or alcohol is added and mixed with the coolant solution. With reference to Table A, there are shown figures which are intended for use as a starting point in determining how much 100% ethylene glycol to add to each 100 gallons of recycled coolant. The glycol is added slowly allowing mixing with coolant for at least 10-15 minutes prior to taking another refractometer reading to determine the freeze protection. It is understood, depending on whether a glycol and/or alcohol based antifreeze component is used, that the type and amounts to lower freeze protection of the solution may vary.

TABLE A

Actual Freeze Point per 100 Gallons of Coolant	Suggested Starting Point of 100% Ethylene Glycol to add
0°F	6 Gallons
-10°F	5 Gallons
-20°F	3 Gallons
-30°F	2 Gallons
-35°F	0 Gallons

The agent(s) as described above may be added to the coolant solution individually or combined into a single chemical additive composition. To this effect, a chemical additive composition has been developed and contains a combination of ingredients

selected to effectively treat the used coolant such as oxidants to precipitate the dissolved metals, salt precipitates to neutralize or precipitate the organic acids; add corrosion inhibitors to restore the corrosion capabilities and a buffer to adjust the pH of the final solution. Optionally, the chemical additive may also comprise a dispersant, surfactant, wetting agent, sequestrant, common ion of the acid degradation by-products and trace amounts of any other known ingredients in the antifreeze art. The compositional ranges of the individual components of the chemical additive will vary depending on what type of vehicle engine i.e., Domestic, European or Asian, coolant is being recycled from because specifications for the various engine coolants are different.

For purposes of illustration, a chemical additive for recycling coolant from a Domestic vehicle is described below in detail. Corrosion inhibitors which may be incorporated into the chemical additive composition comprise nitrites, nitrates, azoles, molybdates and/or silicates. The corrosion inhibitors incorporated into the additive should be water soluble and, therefore, alkali metals thereof are preferred, such as sodium salts thereof. The corrosion inhibtors may comprise at least .25% to about 15% by weight of the composition. The prefered nitrite component is sodium nitrite present in the additive in an amount of about .75% by weight of the composition. The preferred nitrate component is sodium nitrate present in the additive in an amount of about 2.0% by weight of the total composition. The nitrite and nitrate component are effective corrosion inhibitors against cast iron, steel and aluminum surfaces as well as act as a pH buffer.

The azole component generally includes thiazoles, triazaoles, salts thereof, such as the alkali metal salts, and any mixture of two or more thereof. Typical azoles include 1-mercaptobenzothiazole, 1,2,3-benzotriazole, tolytriazole, and the sodium salts thereof. Preferably, sodium tolytriazole (50% solution) will comprise at least 0.1% to about 5.0% by weight, and most preferably about 2.0% by weight of the total composition. The azole is an effective corrosion inhibitor against copper and its alloys.

The preferred molybdate component comprises alkali metal salts of molybdates such as sodium molybdate, the dihydrate being particularly preferred. Sodium molybdate decahydrate will preferrably comprise about 1.5% by weight of the total composition. The molybdate component is an inhibitor for steel, cast iron and aluminum surfaces.

The silicate component also is water soluble and, therefore alkali metal salts of silicate such as sodium silicate are preferred. The more preferred silicate comprises a sodium silicate solution such as Philadelphia Quartz N solution (8.9% Na_2O, 28.7% SiO_2) comprising about 1.0% by weight of the total composition. To prevent the silicate form combining with metals in the solution such as magnesium or calcium, a silicate stabilizer is added to the additive. The preferred stabilizer is Dow Cornings Q1-6083 (sodium methyl methyl phosphonate and sodium 3-(trihydrosilyl) propylmethyl phsophonate, balance methyl alcohol (4%) and water), although any known stabilizer may be employed herein. Preferrably, the stabilizer is present in the additive in an amount of about 0.5%.

The chemical additive composition also includes suitable basic and/or acidic compounds such as borates, hydroxides and silicates to adjust and maintain the pH of the final coolant solution in the range of about 8.0 to 10.5, depending on the type of vehicle the coolant is removed. For example, for Domestic vehicle engine coolant, the pH of the final recycled coolant is preferably between about 9.5 to about 10.5, and most preferably about 10.0. For a European vehicle engine coolant, the pH of the final recycled coolant is preferably between about 8.0 to about 9.5, and most preferably about 9.0. For a Japanese/Asian vehicle engine coolant, the pH of the final recycled coolant is preferably between from about 8.0 to about 9.0, and most preferably about 8.5. Preferred buffering agents such as sodium tetraborate and sodium nitrate are effective to increase the pH of the final coolant solution. The buffering agent(s) comprises at least 0.5% to about 5.0% by weight of the total composition.

The chemical additive composition further includes suitable salt forming agents in an amount sufficient to react with any organic or inorganic acid by-products present in the coolant solution to form salt precipitates thereof. Alkali metal hydroxides, preferably flakes or beads, or any other known bases which neutralize and/or precipitate as a salt thereof the acid by-products is within the scope of the present invention. The preferred alkali metal hydroxides are sodium hydroxide and/or potassium hydroxide and will comprise at least 0.5% to about 15% by weight of the total composition. About 4.0% by weight of sodium hydroxide is preferred. It is understood that the additive composition may comprise the salt forming agent in addition to, the ion exchange column.

An additional precipitating agent which may be added to the additive comprises a sodium salt of the class carbamates to remove dissolved metals from the coolant solution for retention in the filtration means. Preferred sodium carbamates include sodium dimethyl or diethyl dithiocarbamate or sodium trithiocarbamate present in the additive in an amount of about 0.5%.

Optionally, an anionic polymeric dispersant, a surfactant, a deposit control agent and sequestering agent may be included in the additive composition. The anionic dispersant may be included in the chemical additive for dispersing solids which may be present or generated in the cooling system and for preventing the metals from dropping out of solution. Typical polymeric dispersants include water soluble carboxylic acid polymers such as styrene maleic anhydride copolymer or an amide/imide. Preferably, the dispersant comprises a modified acrylate copolymer having a molecular weight of about 4500 comprisins at least 0.1% to about 12% by weight, and more preferably the copolymer ACCUMER 3000 (WTP-1), manufactured by Rohm and Haas, comprising about 1.5% by weight of the total composition, although other polymers exhibiting similar characteristics may be substituted herein. Additionally, the polymer Belclene 201, manufactured by Ciba-Geigy, may be included in the additive to prevent and/or remove metal deposits.

The surfactant may be included in the chemical additive to prevent cavitation corrosion due to foam formation and mineral scale build-up. Typical surfactants i.e., anti-foaming agents, include silicone emulsions and/or polyglycols. Preferred surfactants comprise polyalkylene glycol

(50-HB-5100) (also called UCON 5100) and dimethyl silicone and comprise at least 0.1% to about 3.0% by weight. It is understood that any surfactant exhibiting similar characteristics to that of polyalkaline glycol (50-HB-5100) and/or dimethyl silicone may be substituted herein.

In Clifton, et al, "DEGRADED AQUEOUS GLYCOL SOLUTIONS: pH VALUES AND THE EFFECTS OF COMMON IONS ON SUPPRESSING pH DECREASES", *Solar Energy Materials*, 12 pgs. 77-86 (1985), which is hereby incorporated by reference, it was shown that common ions (anions of the acid degradation products) are effective in suppressing the degradation of ethylene glycol and proplylene glycol used in flat-plate solar collector systems into organic acid by-products and consequently, effective in suppressing the decrease in pH of the solution. Therefore, the chemical additive of the present invention may also comprise salts of the organic acid by-products. Specifically, the additive composition may include in amounts sufficient to have a suppressing effect on the degradation of the ethylene glycol, the alkali metal and/or alkaline earth metal salts of the acids glycolic, formic, oxalic and glyoxylic. More preferably, the additive composition comprises sodium glycolate, sodium formate, sodium oxalate and sodium glyoxylate.

A dye capable of imparting a color to the final reconditioned solution may also be incorporated within the chemical additive or it may be added to the coolant solution directly. Preferred dyes are selected from the family of Alizarine Cyanine Green G Extra 100%, Uranine and/or anthene or acid family permanent dyes. The dye is added to the coolant solution to give an aesthetically pleasing appearance to the final product and to distinguish it from clear

water. The dye is added in a concentration of about 2 ounces per 1500 gallons. For the domestic engine coolant additive, the dye may comprise OEM GREEN, Designation 17331, Chem. Central, Detroit, Michigan. For the European engine coolant additive, the dye may comprise BOND BLUE A, Designation 17042, Chem. Central, Detroit, Michigan, and for the Japanese/Asian engine coolant additive the dye may comprise ACID RED #14, designation 15425, Chem. Central, Detroit, Michigan.

The remainder of the chemical additive comprises a known aqueous solvent such as water. The preferred solvent being Zeolote softened or de-mineralized water.

The following table sets forth a formulation for the chemical additive utilized in recycling engine coolant from a Domestic vehicle in accordance with the process of the present invention. The compositional ranges of the various components are by weight percent of the total composition.

TABLE B

(a) From about 0.5 to about 15 percent of one or more known salt forming agents;

(b) From about 0.1 to about 15 percent of one or more known corrosion inhibiting agents;

(c) A buffer compound in an amount sufficient to maintain the pH of the additive in the range of about 8.0 to about 10.5;

(d) From about 0.1 to about 3.0 percent surfactant;

(e) From about 0.1 to about 12 percent polymeric dispersant; and

(f) Balance aqueous solvent.

The following table sets forth a preferred formulation for the Domestic chemical additive utilized in the recycling process of the present invention. The compositional ranges of the various components are by weight percent of the total composition.

TABLE C

(a) From about 0.1 to about 5.0 percent sodium tolytriazole;

(b) From about 0.1 to about 12.0 percent acrylate copolymer;

(c) From about 0.1 to about 3.0 percent polyalkylane glycol;

(d) From about 0.25 to about 15.0 percent sodium molybdate;

(e) From about 0.25 to about 15.0 sodium nitrite;

(f) From about 0.5 to about 5.0 sodium tetraborate;

(g) From about 0.5 to about 15.0 percent potassium hydroxide;

(h) From about 0.5 to about 15 percent sodium hydroxide; and

(i) Balance solvent.

The following table sets forth a still another preferred formulation for the Domestic chemical additive composition utilized in the recycling process of the invention. The compositional ranges of the various components are by weight percent of the total composition.

TABLE D

(a) About 1.0 percent sodium tolytriazole;

(b) About 2.0 percent acrylate copolymer;

(c) About 0.5 percent polyalkylene glycol;

(d) About 1.0 percent sodium molybdate;

(e) About 0.75 sodium nitrite;

(f) About 1.0 percent sodium tetraborate;

(g) About 0.25 percent potassium hydroxide;

(h) About 1.0 percent sodium hydroxide;

(i) From 0.1 to about 10 percent glycolate, oxylate or formate salts; and

(j) Balance solvent; preferably zeolite softened or demineralized water.

The following table sets forth a more preferred formulation for the Domestic chemical additive composition utilized in the recycling process of the invention. The formula by weight comprises 8.70 lbs./gal. The compositional ranges of the various components are by weight percent of the total composition.

TABLE E

(a) About 1.5 percent COBRATEC T-50-S;

(b) About 2.0 percent ACCUMER 3000;

(c) About 1.5 percent BELCLENE 201 or 200;

(d) About 2.0 percent sodium molybdate;

(e) About 0.75 percent sodium nitrite;

(f) About 1.0 percent Borax 5 mol;

(g) About 1.5 percent potassium hydroxide;

(h) About 2.58 percent sodium hydroxide;

(i) About 0.5 percent polyalkylene glycol; and

(j) About 87.25 percent soft water.

The following table sets forth the most preferred formulation for the Domestic chemical additive composition utilized in the recycling process of the invention.

The compositional ranges of the various components are by weight percent of the total composition.

TABLE F

(a) About 2.0 percent sodium nitrate;

(b) About 1.5 percent ACCUMER 3000;

(c) About 1.5 percent BELCLENE 201;

(d) About 1.5 percent sodium molybdate decahydrate;

(e) About 0.75 percent sodium nitrite;

(f) About 2.0 percent sodium tolytriazole 50% solution;

(g) About 0.5 percent dimethyl or diethyl dithiocarbamate;

(h) About 1.5 percent sodium hydroxide;

(i) About 0.1 percent dimethyl silicone;

(j) About 0.5 percent polyalkylene glycol;

(k) About 1.0 percent Philadelphia Quartz N solution;

(l) About 0.5 percent Dow Corning Q1-6083; and

(m) About 85.15 percent softened water.

As previously mentioned, the additive composition will vary depending on what type of vehicle engine the coolant is used within. In this regard, with reference to Table G, there is shown the preferred additive composition for recycling engine coolant from a Japanese/Asian vehicle, in accordance with the process described herein. The additive formula by weight comprises 8.45 lbs/gal. The compositional ranges of the various components are by weight percent of the total composition.

TABLE G

(a) About 87.0 percent zeolite softened water;

(b) About 1.0 percent sodium hydroxide;

(c) About 1.5 percent sodium tetraborate;

(d) About 2.5 percent sodium nitrite;

(e) About 3.0 percent sodium molybdate;

(f) About 1.5 percent BELCLENE 201 or 200;

(g) About 2.0 percent Rohm & Haas WTP-1; and

(h) About 0.5 percent polyalkylene glycol;

(i) About 1.5 percent COBRATEC TT-50-S.

The pH of the additive composition should be adjusted to between about 13.6 to about 14.0 with sodium hydroxide. The additive is colored with a water based red dye to a very light pink. The dye is Acid Red #14, designation No. 15425, Chem. Central, Detroit, Michigan.

With reference to Table H, there is shown the preferred additive composition for recycling engine coolant used within a European vehicle in accordance with the process described herein. The additive formula by weight comprises 8.40 lbs./gal. The compositional ranges of the various components are of the total composition.

TABLE H

(a) About 88.0 percent zeolite softened water;

(b) About 1.5 percent sodium hydroxide;

(c) About 1.5 percent sodium tetraborate;

(d) About 2.5 percent sodium nitrite;

(e) About 2.0 percent sodium molybdate;

(f) About 1.0 percent BELCLENE 201;

(g) About 2.0 percent Rohm & Haas WTP-1; and

(h) About 0.5 percent polyalkylene glycol;

(i) About 1.5 percent COBRATEC TT-50-S.

The pH of the additive composition should be adjusted to between about 11.7 to about 12.3 with sodium hydroxide. The additive is colored with OEM fluorescent blue dye to a very pale blue. The dye is Bond Blue A, designated No. 17042, Chem Central, Michigan.

The chemical additive is preferably added to the used coolant composition after filtration has begun as will become more apparent hereinafter. The amount of the chemical additive added to the solution will depend upon the starting pH of the used coolant. Used Domestic coolant typically has a pH in the range of 8.0-10.5, and sometimes below 8.0. The objective is to yield a recycled coolant solution for Domestic vehicles having a pH of about 10.0, about 9.0 for coolant for a European vehicle engine and about 8.5 for Japanese/Asian vehicle engine coolant. An initial pH reading is obtained prior to adding the additive composition. With reference to Table I, the amounts shown are intended for use as a starting point in determining how much chemical additive will be required to recycle or recondition each 100 gallons of used coolant solution.

TABLE I

Actual pH reading	Starting Quantity of Chemical Additive
7.0 - 7.5	3 Gallons
7.5 - 8.0	2.5 Gallons
8.0 - 8.5	2 Gallons 1 Quart
8.5 - 9.0	2 Gallons
9.0 - 9.5	1 Gallon

The process of the present invention may be more fully understood when considered in connection with the apparatus of the present invention which is used to carry out the process.

With reference to Fig. 1, there is illustrated a schematic of one embodiment of the recycling apparatus of the present invention, generally indicated 10. Apparatus 10 includes a container means 12 adapted to receive used coolant therein. Container 12 has an inlet portion 14 and an outlet portion 16. Any suitable container capable of retaining a liquid solution is within the scope of the present invention. Connected to inlet 14 and outlet 16 is any suitable circulating conduit means 15, such as PVC piping, for circulating the coolant which is being recycled. An injector means 30 is connected to circulating means 15 for introducing the chemical additive of the present invention into the used coolant. Any conventional container of sufficient type and size that permits the dispersement of fluid can be employed. Injector means 30 is connected to conduit 15 via a directional valve 19. Alternatively, the injector may be connected directly to container means 12.

Apparatus 10 further comprises a filtration means, generally indicated 32, for removing the impurities and dissolved particulate matter from the used coolant as it is circulated therethrough via conduit 15. Filtration means 32 is comprised of a pair of filters 34, 36, each having an inlet 38 and outlet 40. Filters 34, 36, employed in the present invention are 1-5 and 20-30 micron filters, respectively. It is understood that any separation means may be employed in accordance with the present apparatus and still be within the scope of the present invention. Attached to conduit means 15 is a conventional pump for conveying the used coolant from container 12, through filtration means 32 via inlet 38 and outlet 40 therein, to cause removal of the

impurities in the used coolant, and for returning the coolant through conduit 15 to container means 12 through via outlet 16. When the chemical additive is added through means 30, conduit means 15 further facilitates the mixing of the additive with the used coolant. Pump 42 also introduces air into contact with the used coolant via conduit 15 by an aspirator located in the container thereby oxidizing the dissolved metals present in the used coolant into metallic oxides.

Attached to conduit 15 is an inlet conduit 18 for introducing the used coolant 22 from a storage barrel 24 into conduit 15 and therethrough to container 12 via inlet 14. This is accomplished by adjusting standard directional valve 19 in the appropriate direction to facilitate the flow of the used coolant into container 12. Likewise, attached to conduit 15 at the upper end of the apparatus near the outlet portion 16 is a means 20 for removing the recycled coolant from container 12 via outlet 16 and conduit 15 after the process has been completed for storage of the recycled coolant 26 in a clean storage barrel 28.

With reference to Figures 2 and 3 there is shown one embodiment of the recycling apparatus of the present invention for recycling used coolant in accordance with the process described herein, wherein the recycling machine is used in the bulk recycling of large quantities of engine coolant, after removal from the engine. The apparatus generally indicated 44, includes a container or tank 46 constructed of a polyethylene material having a side 48, a conical shaped bottom 50 and an open top 52 bordered by lip 54. The container or tank is mounted on a rectangular platform 56 which in turn is mounted with the rest of apparatus 44 onto pallet 58.

Pallet 58 may be mounted on a conventional truck for easy transportation. A conduit pipe 60 is attached at the base of conical bottom 50 of container 46 for the flow of coolant from the container. The conduit 60 comprises an opening 62 which opens into the inner portion of container 46 for receiving the used coolant therethrough. The conduit of the present apparatus is PVC piping having reinforced joints. The PCV piping is connected to the container in such a manner such that the used coolant is circulated therethrough from and back to the container. Connected to the conduit piping 60 is a Nordel self-priming pump 62 for circulating the coolant through the system. The pump 62 is constructed of a plastic material and has a strainer basket 64 for filtration purposes. The motor is drip proof 1½ horsepower at 3450 rpm, 110/208 volts. It is understood that any conventional motor pump can be utilized in the apparatus of the present invention. The pump also functions to introduce a sufficient amount of aeration into the system thereby causing the oxidation of the dissolved metals in the coolant to form metallic oxides. Alternatively, an aspirator (not shown) may be mounted in container or tank 46 to introduce oxygen into the engine coolant. Attached to conduit piping 60 is a shot feeder 66 for introducing the chemical additive of the present invention into the used coolant. For purposes of illustration only and not limitation, the shot feeder 66 shown herein is 3½ gallon container, is made of polyethylene and connected by pipe 60 to the suction side of the pump. Further attached to conduit 60 is in inlet member 68 adapted to introduce the used coolant into container 46 via conduit 60 by adjusting the specific directional valves 70 in the appropriate position to allow the flow of the fluid inward toward

container 46. The apparatus also has a similar outlet means 72 for removing the recycled coolant from container 46 by turning the appropriate valves 70. The filtration system of the present invention comprises two high-flow chemically inert reusable cartridge filters constructed of any cellulose type media generally indicated 74.

As best viewed in Fig. 3, the filters are constructed in series with one another. The first filter 76, is a 25 or 50 micron filter designed to remove larger by-products and particlate precipitate matter from the used coolant. The second filter 78 is a 5 or 1 micron filter designed to removed the smaller dissolved particles in the used coolant. A pressure gauge 80 indicates to the user when the filters need to be cleaned due to pressure buildup from the used coolant not flowing properly through the filters because of clogging. A by-pass conduit pipe 80 is included in the apparatus for allowing the circulation of the coolant without passing through filters 76 and 80. This is desired when the user is either filling the apparatus with used coolant or removing the recycled coolant therefrom. A tube 82, is adapted to be connected to the top of container 46 for removing the upper layer of coolant which may also contain the various types of other contaminants such as oils.

An optional embodiment (not shown) would include the placement of a cylinder or other suitable housing containing from about 1-4 pints of a suitable ion exchange resin of the type Ionac SR-5 base metal selective chelating resin manufactured by Sybron Chemicals Inc. For ease of construction, the ion exchange resin should be attached to apparatus 10 in a manner permitting the used coolant to circulate therethrough.

For example, the ion exchange resin container may be attached immediately adjacent outlet portion 16 (Fig. 1). The embodiment of the recycling apparatus previously described may be used in the bulk recycling of engine coolant. That is, large quantities of engine coolant are recycled at any given time i.e., 50-500 gallons. The apparatus is typically mounted on any conventional flatbed truck for ease of portability between job locations, although it may be supported on a pallet in a stationary position for use on site. Basically, the bulk recycling process is a 4-step process. First, the system is filled and the pump turned on after opening the appropriate valves (priming the pump when necessary). During the next step, the coolant is circulated through the filtration means by again opening and closing the appropriate valves and is continuously aerated. The third step comprises adding the chemical additive to the system to complete the recycling process. Lastly, the coolant is removed from the system during what is referred to as the fill off mode.

An alternative embodiment of the recycling apparatus of the present invention includes a portable apparatus (not shown) for recycling engine coolant directly from any vehicle, about 5-18 gallons at a time. The portable apparatus may comprise a scaled down version of the bulk recycling machine described above. Additionally, the portable apparatus is adapted to connect directly to the cooling system of the automobile. For example, the portable apparatus also includes inlet and outlet means (hoses) which may be connected to the vehicle cooling system by, for example, a conventional Tee in the heater hose and in the radiator cap or inlet fitting. This is advantageous because the engine

coolant may be recycled by backflushing through the system without first removing the coolant from the engine. The portable apparatus may comprise additional features such as a compressed air pump and pressure gauge for testing the pressure of the cooling system and the radiator cap operation. In using the portable apparatus of the present invention to recycle a vehicle coolant, annual antifreeze purchases may be reduced as well as coolant disposal concerns eliminated. Additionally, the coolant system may be pressure tested for leaks, the radiator cap operation checked and the cooling system reverse flushed to remove unwanted silt and metal build-up during the recycling process. The process carried out by the portable apparatus basically is a 3-step process after initial hook-up of the apparatus. After the vehicle engine is shut off, the apparatus is hooked up to the vehicle by clamping the heater outlet hose with a pair of clamps or pliers to crimp the hose. Then the hose is cut between the clamps and a Tee fastened into place. The first step of the process, pressure testing the system and radiator cap, is accomplished by attaching the inlet means (hose) of the apparatus to the T-clamp and then turning on the compressed air pump to a pressure of about 15-20 psi, which is the pressure of the cooling system during normal operation. If the pressure gauge decreases, then a leak is apparant. Subsequent to this test, the pressure is increased to about 30 psi, and if the radiator cap doesn't release the pressure then it is faulty and should be replaced. After pressure testing, the outlet means which may comprise a hose with an attached radiator cap or cross flow adapter is fastened to the radiator in place of the normal radiator cap or to the inlet piping to a cross flow radiator, the appropriate

valves opened and the pump turned on. The pump circulates the coolant through the engine via the apparatus and filtration means. Then flow is opposite that of normal flow of coolant through the engine, thus backflushing the system which functions to loosen unwanted metals and other build-up. Lastly, chemical additive of the present invention is added which completes the recycling process.

Example 1

A hundred gallons of used coolant was introduced into the apparatus container shown in Fig. 2 through the heavy duty suction hose via a 55 gallon storage drum. The pump was engaged allowing the used coolant to circulate through the 25 or 30 micron and 5 or 1 micron filters for approximately 5 minutes. Thereafter a sample of the used coolant was withdrawn from the container and the pH of the sample was measured using standard medium range test paper or glass electrode pH pen, to determine pH. The pH was found to be 8.8. Thereafter the chemical additive comprising 1% sodium tolytriazole, 2% acrylate copolymer, .5% polyalkaline glycol, 1% sodium molybdate, .75% sodium nitrite, 1% sodium hydroxide and about 92.5% solvent was added through the shot feeder in accordance with the specific amount indicated in Table, based on the pH of the sample i.e., 2 Gallons. The used coolant and additive was allowed to mix while circulating through the filtration apparatus for about 10 to 15 minutes. A new sample was taken and the pH was found to be about 9.9. A refractometer reading was then taken by deposing a two or three drop sample of antifreeze removed from the container under the hinged plastic cover on the plastic plate of the refractometer. The reading indicated freeze protection to -10°F.

Since it is desirable to provide the coolant with freeze protection down to -34°F, sufficient 100% ethylene glycol was added to the 100 gallons of recycled filtered coolant in accord with the amount indicated in Table A. The 100% ethylene glycol was allowed to mix for about 10-15 minutes with the coolant prior to taking another refractometer reading which indicated freeze protection down to about -34°F. The recycled and reconditioned coolant was thereafter removed from the apparatus via the discharge hose into a clean storage drum.

The process described above was repeated over a period of two years on used coolant solutions removed from the engine cooling systems of 2200 domestic vehicles. The recycled coolant obtained in accordance with the process of the present invention was reintroduced into the vehicles after treatment and tested after an extended period of use of about 6 years. A corrosion test was employed on the recycled coolant pursuant to standard test ASTM D-1384 under conditions of 190°F for two weeks and 260°F for two weeks utilizing 50% glycol and 50% de-ionized water, with air bubbling. The corrosion rate in MPY (mils per year) of 0.001 inch metal loss per year is indicated in Table using comparisons for tap water, for coolant solution containing commercially available uninhibited and commercially available inhibited ethylene glycol antifreeze compositions and the recycled engine coolant in accordance with the present invention.

Table

Metal	Tap Water	Un-inhibited Ethylene Glycol	Inhibited Ethylene Glycol	Recycled Engine Coolant
Copper	0.09 mpy	0.22	0.13	0.08
Solder	3.25 mpy	46.3	0.12	0.06
Brass	0.36 mpy	0.44	0.09	0.09
Steel	10.01 mpy	48.3	0.03	0.03
Cast	29.3 mpy	58.3	0.12	0.08
Aluminum	16.3 mpy	21.0	0.52	0.14

The recycled coolant in accordance with the process of the present invention showed a significant decrease in corrosion rate when compared to tap water and the coolants containing the inhibited and uninhibited ethylene glycol. Based on the above data, the recycled coolant obtained as a result of the inventive process described herein, exhibits superior corrosion inhibition capabilities to that of coolant compositions containing standard antifreeze compositions currently on the market.

It will be understood that the foregoing description and illustration is by way of example only and that such modifications and changes as may suggest themselves to those skilled in the art are intended to fall within the scope of the present invention as defined by the appended claims.

What is claimed is:

1. A process for recycling a used engine coolant directly from a Domestic, European or Japanese/Asian vehicle engine cooling system, said process being carried out by an apparatus comprising a container for holding a quantity of said used coolant which is being recycled, said container having an inlet and outlet, means for introducing said coolant from the vehicle into said container, filtering means for removing unwanted impurities and degradation by-products in said coolant, said filtering means having an inlet and outlet, means for introducing a chemical additive for chemically treating said coolant, said treatment including neutralizing or forming salt precipitates with any unwanted organic acids present in said coolant, increasing the pH of said coolant and restoring the corrosion inhibition capabilities of said coolant, means for removing dissolved metals present in said coolant, means for circulating said coolant from the outlet of said container through the filtering means, past the additive introducing means, and back to said container inlet, and means for returning the recycled coolant solution from said container back into the vehicle, said process comprising:

connecting said apparatus directly to the vehicle engine cooling system;

continually circulating said coolant from the engine cooling system into said apparatus, through said filtering means and back into the engine, thereby flushing the engine cooling system; and

introducing a chemical additive into said coolant for chemically treating said coolant, said treatment including neutralizing or forming salt precipitates with any unwanted organic acids present in said coolant, increasing the pH of said coolant, restoring the corrosion inhibition capabilities of said coolant and removing dissolved metals present in said coolant, thereby providing a recycled engine coolant composition having corrosion capabilities equal or superior to that of the original coolant composition.

2. A process for recycling a used engine coolant from a Domestic, European or Japanese/Asian vehicle engine cooling system, after removal from said system, said process being carried out by an apparatus comprising a container for holding a quantity of said used coolant which is being recycled, said container having an inlet and outlet, means for introducing said coolant into said container, filtering means for removing unwanted impurities and degradation by-products in said coolant, said filtering means having an inlet and outlet, means for introducing a chemical additive for chemically treating said coolant, said treatment including neutralizing or forming salt precipitates with any unwanted organic acids present in said coolant, increasing the pH of said coolant and restoring the corrosion inhibition capabilities of said coolant, means for removing dissolved metals present in said coolant, means for circulating said coolant from the outlet of said container through the filtering means, past the additive introducing means, and back to said container inlet, and means for removing the recycled coolant solution from said container, said process comprising:

filling said container with said used coolant;

continually circulating said coolant from the outlet of said container through the filtering means, past the additive introducing means, and back to said container inlet;

introducing a chemical additive into said coolant for chemically treating said coolant, said tr atment including neutralizing or forming salt precipitates with any unwanted organic acids present in said coolant, increasing the pH of said coolant, restoring the corrosion inhibition capabilities of said coolant and removing dissolved metals present in said coolant, thereby providing a recycled engine coolant composition having corrosion capabilities equal or superior to that of the original coolant composition; and

removing the recycled coolant from said container.

3. A process for treating a used coolant composition of the type used within an internal combustion engine cooling system to remove unwanted impurities and degradation by-products, said coolant composition containing one or more glycol and/or alcohol-based antifreeze components, said process comprising:

filtering said coolant composition through any suitable filtration membrane or other separation means capable of removing any particular precipitates;

adding to said coolant composition the chemical additive according to claims 21, 23, 24, 25, 26 or 27;

thereby providing a recycled engine coolant composition having corrosion capabilities equal or superior to that of the original coolant composition.

4. The process of claim 3, wherein said process further comprises the step of:

mixing one or more additional antifreeze components selected from the group consisting of glycols and alcohols with said coolant in an amount sufficient to provide freeze protection for said recycled engine coolant composition down to the range of about -10°F to about -34°F.

5. The process of claim 4, wherein said glycol is ethylene glycol.

6. The process of claim 3, wherein said separation means includes at least two chemical inert filters.

7. The process of claim 6, wherein said filters are arranged in series.

8. The process of claim 7, wherein said filters are capable of removing particulate matter of a size greater than one micron.

9. Apparatus for recycling used coolant solution by physically and chemically treating the used coolant solution to remove unwanted impurities and degradation by-products contained therein, said apparatus comprising:

main container for holding a quantity of used coolant solution which is being recycled, said main container having an inlet and outlet;

filtering means for removing the unwanted impurities and degradation by-products in said used coolant solution, said filtering means having an inlet and outlet;

injector means for introducing agents for chemically treating said used coolant solution, said agents being capable of neutralizing or forming salt precipitates with any unwanted organic acids present in the coolant solution, increasing the pH of the coolant solution and restoring the corrosion inhibition capabilities of the coolant solution;

aerating means for aerating said coolant solution, said aeration being capable of oxidizing the dissolved metals present in said coolant solution to form metal oxides thereform;

circulating means for circulating the coolant solution from the outlet of the main container through the filtering and aerating means, past the injector means, and back to the main container inlet, the circulating means including a pump and conduit means, said conduit means facilitating the mixing of said coolant solution and said chemical additive, said filtering means being capable of filtering out the unwanted impurities and degradation by-products; and

means for removing the recycled coolant solution from said main container means.

10. The apparatus of claim 9, wherein said injector means is a shot feeder container.

11. The apparatus of claim 9, wherein said aerating means is a pump driven aspirator.

12. The apparatus of claim 9, wherein said circulating means is a self priming pump.

13. The apparatus of claim 9, wherein said conduit means is a hollow tubing hose or pipe.

14. The apparatus of claim 9, wherein said means for removing the recycled coolant is a suction hose.

15. Apparatus for recycling used coolant solution by physically and chemically treating the used coolant solution to remove unwanted impurities and degradation by-products contained therein, said apparatus comprising:

a container for holding a quantity of used coolant solution which is being recycled, said container having an inlet and outlet;

means for introducing the recycled coolant solution into said container;

filtering means for removing unwanted impurities and degradation by-products in said used coolant solution, said filtering means having an inlet and outlet;

means for introducing a chemical additive for chemically treating the used coolant solution, said treatment including neutralizing or forming salt precipitates with any unwanted organic acids present in the coolant solution, increasing the pH of the coolant solution and restoring the corrosion inhibition capabilities of the coolant solution;

means for removing dissolved metals present in said coolant solution;

means for circulating the coolant solution from the outlet of said container through the filtering means, past the additive introducing means, and back to said container inlet; and

means for removing the recycled coolant solution from said main container means.

16. The apparatus of claim 15, wherein said means for introducing said additive is a second container connected to said apparatus.

17. The apparatus of claim 15, wherein said means for removing dissolved metals is a pump driven aspirator.

18. The apparatus of claim 15, wherein said circulating means includes a self priming pump and conduit means, said conduit means facilitating the mixing of said coolant solution and said chemical additive.

19. The apparatus of claim 18, wherein said conduit means is tubing hose or pipe.

20. The apparatus of claim 15, wherein said means for introducing and removing the recycled coolant is a hose.

21. A chemical additive composition for use in a process for recycling a used coolant solution of the type used within a Domestic vehicle internal combustion engine cooling system, said additive comprising by weight:

(a) from about 0.1 to about 5.0 percent sodium tolytriazole;

(b) from about 0.1 to about 12.0 percent acrylate copolymer;

(c) from about 0.1 to about 3.0 percent polyalkylene glycol;

(d) from about 0.25 to about 15 percent sodium molybdate;

(e) from about 0.25 to about 15 percent sodium nitrite;

(f) from about 0.5 to about 5.0 percent sodium tetraborate;

(g) from about 0.5 to about 15 percent potassium hydroxide;

(h) from about 0.1 percent sodium diethyldithio-carbamate;

(i) from about 0.5 to about 15 percent sodium hydroxide; and

(j) balance aqueous solvent.

22. The chemical additive of claim 21, wherein said additive further includes common ions of acid degradation by-products of said coolant in an amount sufficient to suppress the degradation thereof.

23. A chemical additive composition for use in a process for recycling a used coolant solution of the type used within an Asian vehicle internal combustion engine cooling system, said additive comprising by weight:

(a) about 1.0 percent sodium tolytriazole;

(b) about 2.0 percent acrylate copolymer;

(c) about 0.5 percent polyalklyene glycol;

(d) about 1.0 percent sodium molybdate;

(e) about 0.75 percent sodium nitrite;

(f) about 1.0 percent sodium nitrate;

(g) about 0.5 percent sodium diethyldithio-carbamate;

(h) about 1.0 percent sodium hydroxide;

(i) from about 0.1 to about 10 percent anions selected from the group consisting of glycolate, oxylate and formate salts; and

(j) balance solvent; preferably zeolite softened on demineralized water.

24. A chemical additive composition for use in a process for recycling a used coolant solution of the type used within a Domestic vehicle combustion engine cooling system, said additive comprising by weight:

(a) about 2.5 percent sodium hydroxide;

(b) about 1.0 percent sodium nitrate;

(c) about 5.0 percent sodium diethyldithio-carbamate;

(d) about 0.75 percent sodium nitrite;

(e) about 2.0 percent sodium molybdate;

(f) about 1.5 percent BELCLENE 201;

(g) about 0.5 percent polyalklyene glycol;

(h) about 1.5 percent cobratec TT-50-S; and

(i) about 89.75 percent soft water.

25. A chemical additive composition for use in a process for recycling a used coolant solution of the type used within a European vehicle engine cooling system, said additive comprising by weight:

(a) about 1.5 percent sodium hydroxide;

(b) about 1.5 percent sodium tetraborate;

(c) about 5.0 percent sodium diethyldithio-carbamate;

(d) about 2.0 percent sodium molybdate;

(e) about 1.0 percent BELCLENE 201;

(f) about 2.0 percent acrylate copolymer;

(g) about 1.5 percent CORBATEC TT-50-S;

(h) about 88.0 percent zeolite softened water.

(i) about 0.5 percent sodium nitrate

(j) about 1.0 percent sodium salt of tricarboxylic acid; and

(k) about 0.5 percent polyalkylene glycol.

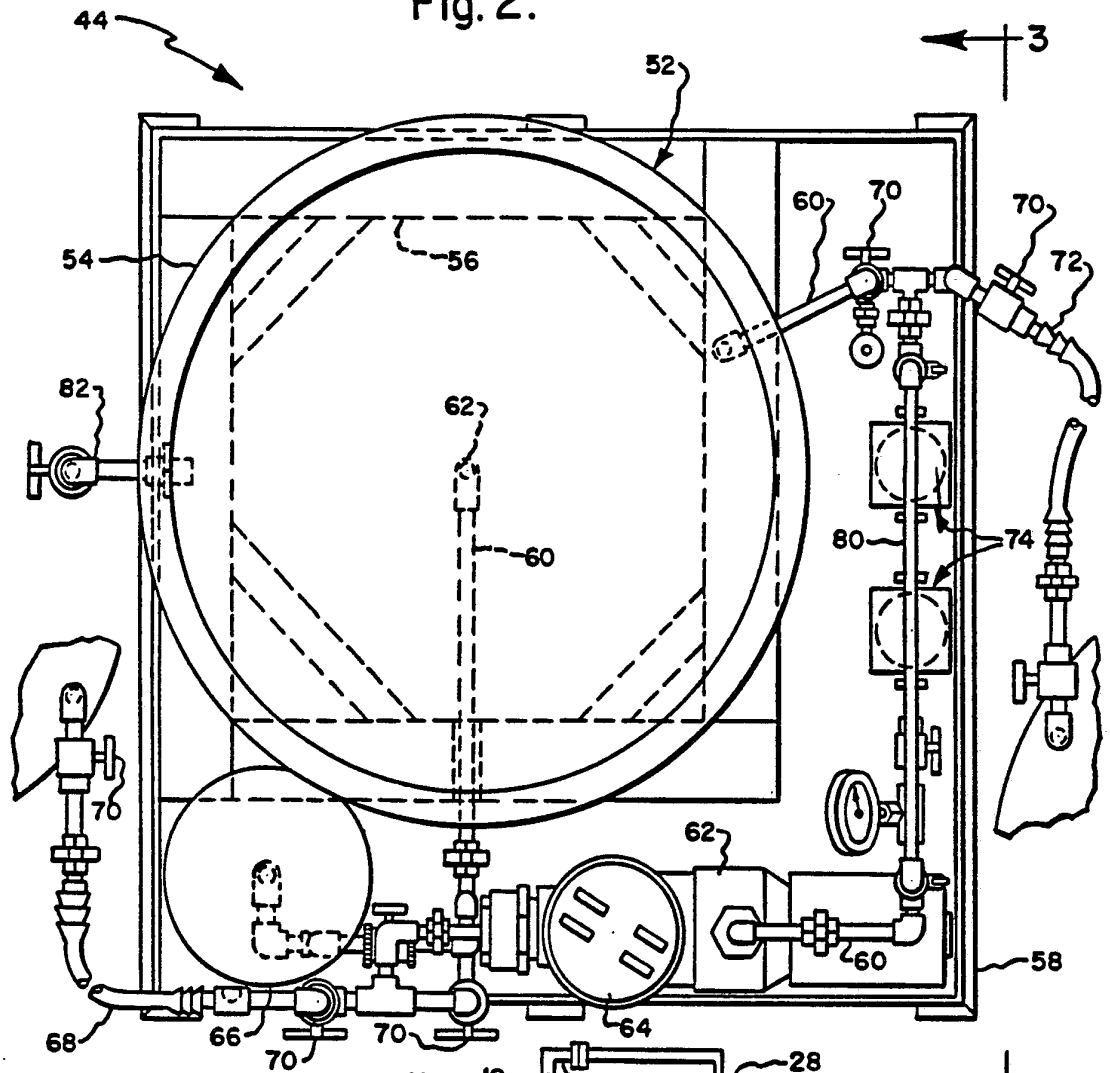
26. A chemical additive composition for use in a process for recycling a used coolant solution of the type used within a Japanese and/or Asian vehicle engine cooling system, said additive comprising by weight:

(a) about 1.0 percent sodium hydroxide;
(b) about 1.5 percent sodium tetraborate;
(c) about 2.5 percent sodium nitrite;
(d) about 3.0 percent sodium molybdate;
(e) about 1.5 percent BELCLENE 201;
(f) about 2.0 percent acrylate copolymer;
(g) about 1.5 percent CORBATEC TT-50-S; and
(h) about 88.0 percent zeolite softened water.

27. A chemical additive composition for use in a process for recycling a used coolant solution of the type used within a Domestic vehicle combustion engine cooling system, said additive comprising by weight:

(a) About 2.0 percent sodium nitrate;
(b) About 1.5 percent ACCUMER 3000;
(c) About 1.5 percent BELCLENE 201;
(d) About 1.5 percent sodium molybdate decahydrate;
(e) About 0.75 percent sodium nitrite;
(f) About 2.0 percent sodium tolytriazole 50% solution;
(g) About 0.5 percent dimethyl or diethyl dithiocarbamate;
(h) About 1.5 percent sodium hydroxide;
(i) About 0.1 percent dimethyl silicone;
(j) About 0.5 percent polyalkylene glycol;
(k) About 1.0 percent Philadelphia Quartz N solution;
(l) About 0.5 percent Dow Corning Q1-6083; and
(m) About 85.15 percent softened water.

Fig. 2.


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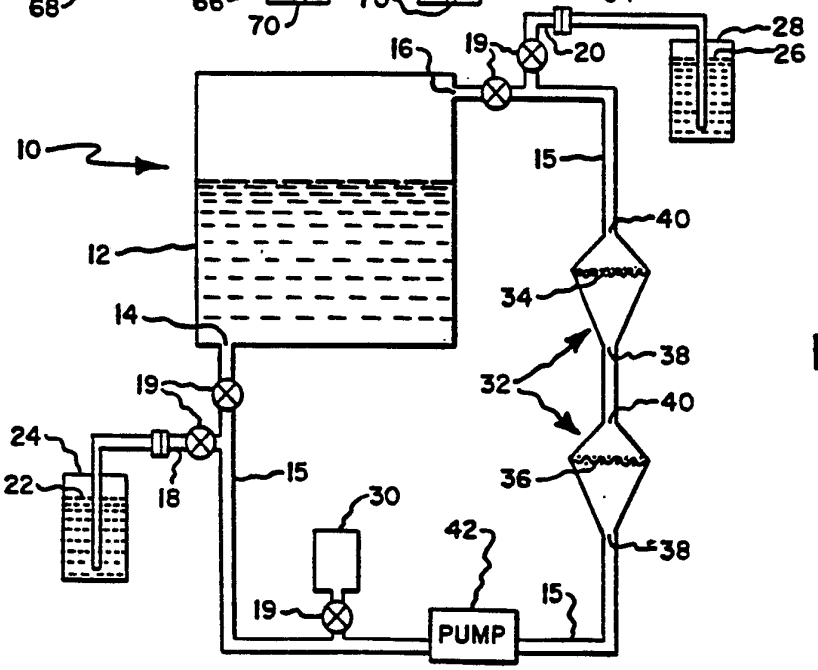
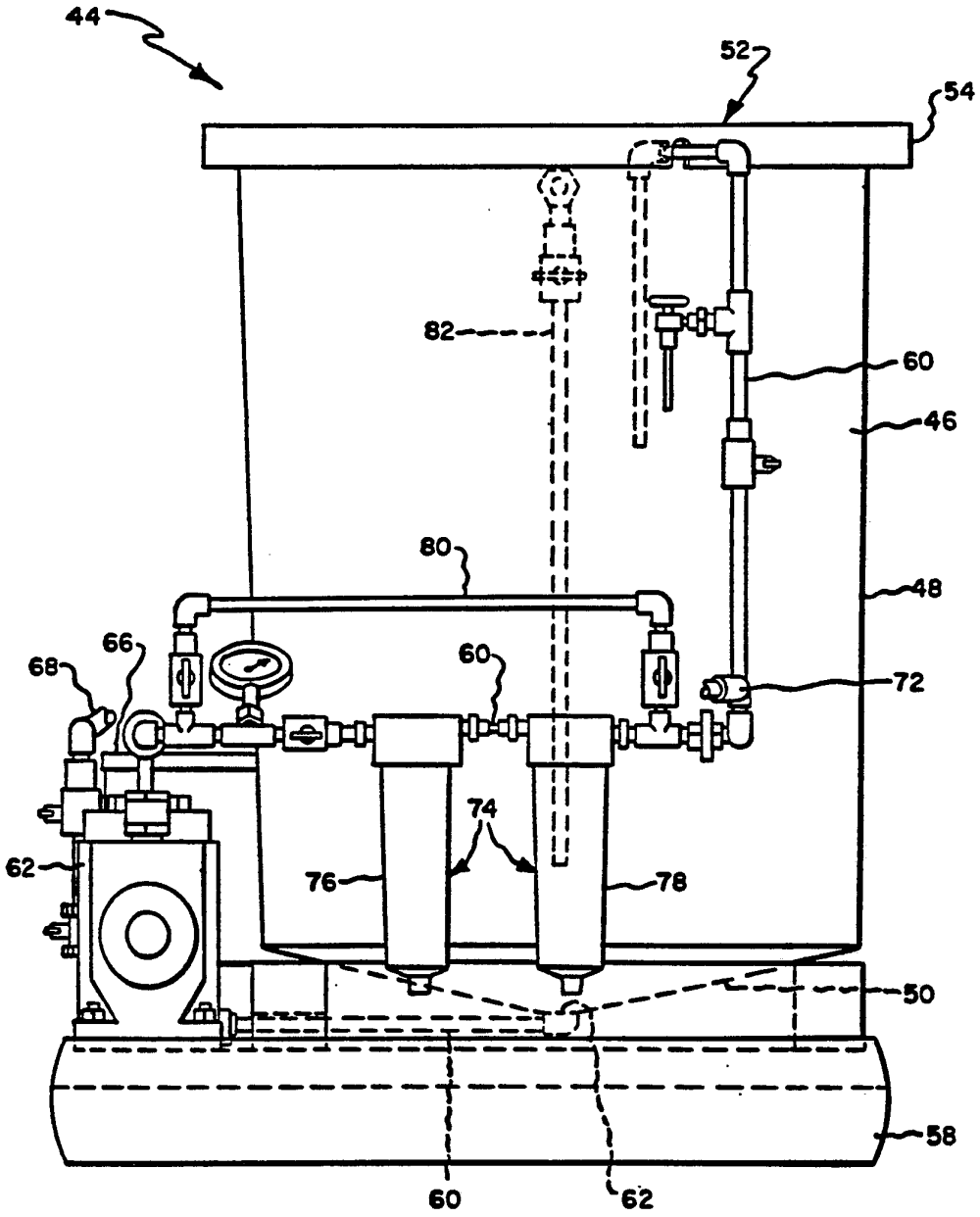

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Fig. 1.

Fig. 3.



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/00555

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) :B01D 17/12
US CL :210/805
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 210/639,771,195.1,295,167; 252/74,77,389A

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS SEARCH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,946,595 (MILLER, JR.) 07 August 1990, see entire disclosure.	1-20
Y, E	US, A, 5,091,081 (HILGREN) 25 February 1992, See entire disclosure.	1-20
Y	US, A, 4,692,251 (HILGREN) 08 September 1987, See entire disclosure.	1-20
Y	US, A, 4,793,403 (VATARU) 27 December 1988, See entire disclosure.	1-20
Y	US, A, 4,901,786 (VATARU) 20 February 1990, See entire disclosure.	1-20
Y	US, A, 5,078,866 (FILOWITZ) 07 January 1992, See Abstract.	1-20
Y	US, A, 4,728,452 (HANSEN) 01 March 1988, See entire disclosure.	21-27
Y	US, A, 3,932,303 (HOLLINGSHAD) 13 January 1976, See entire disclosure.	21-27
Y	US, A, 4,455,248 (WOOD) 19 June 1984, See entire disclosure.	21-27

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 MAY 1992	13 AUG 1992
Name and mailing address of the ISA/ Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer ANA M. FORTUNA NGUYEN NGOC-HO INTERNATIONAL DIVISION Telephone No. (703) 308-1340

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/00555

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,382,870 (ABEL) 10 May 1983, See Abstract.	21-27
A	US, A, 4,717,495 (HERCAMP) 05 January 1988, See Abstract.	21-27
A	US, A, 5,021,152 (FILOWITZ) 04 June 1991, See Abstract and Fig. 1.	9-20