

**The Basics of Alkaline In-Process Cleaning  
for Metal Substrates**

**by**

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This paper pertains mainly to alkaline cleaners, but includes solvents and acids. Iron phosphate products, which make up the bulk of the acid cleaners, will not be covered. The objective is to acquaint you with metal cleaners, the differences between them, what to look for, and how to choose a cleaner.

Regardless of the type or category, all cleaners remove soils by one or more of the following principles:

1. Solvent Action - This property enables the cleaner to dissolve the oils present on the metal surface.
2. Saponification - In this highly alkaline process, drawing compounds (lard oils, fatty acids) are chemically converted into a soap and rendered water-soluble.
3. Detergency - Surface active wetting agents reduce the interfacial tension of surface oils, enabling cleaning solutions to better penetrate and displace soils from the metal surface being cleaned.
4. Emulsification - The suspension of oil particles in an aqueous phase permits them to be rinsed away easily. This is normally accomplished in the presence of surfactants.
5. Deflocculation - In this process, the soil is converted into very fine particles and is suspended in the cleaning.

Throughout this paper, we will refer to two general types of materials which must be removed prior to processing. One is oily and the other is particulate. Oil, by definition, is a petroleum based product. However, for our purposes, simple waxes, vegetable oils or animal fats may be part of the oily soil: This oil may have been applied to assist the working of the metal, or for rust proofing.

Particulates could be any finely divided solids which appear on the surface of the substrate to be cleaned, This can be smut, pigmented drawing materials, shop dirt, and so on.

At this point, a brief discussion of the metal cleaning methods used in industry would seem to be in order.

## CLEANING METHODS

1. **Solvent Wiping** - The material used is usually a petroleum or chlorinated solvent applied by some absorbent material, usually a rag. Oil is removed by the action of the solvent while the soils are removed, or at least reduced by the rubbing action. The rags and solvent quickly become dirty and must be replaced frequently. This makes a solvent wiping expensive. Another drawback to solvent wiping is that it does not lend itself to automation. Many solvents used are flammable, hence a fire hazard; whereas nonflammable solvents are generally a health and environmental hazard.
2. **Vapor Degreasing** - The material used is a chlorinated solvent or freon which removes oil only. The part to be cleaned is placed in a chamber containing the vaporized solvent. To remove soils, accessory equipment is sometimes used, such as a pressure spray or an ultrasonic device. A chief advantage is that an oil-free, dry part is achieved in one step (i.e. no rinsing or drying is required). Although this method can be automated, it is expensive due to the cost of the solvent, the cost of disposal of the spent solvent and, more recently, a hefty use tax. The escaping solvent is also a serious health hazard.
3. **Emulsion Cleaning** - Emulsion cleaning employs an organic solvent suspended in water. The solvent-water combination is applied on the ware to be cleaned. Cleaning of oils is very effective with the solvency and with the action of the surfactants, other soils are also removed. Since the major constituent is water, this is an economical way to clean. Emulsion cleaning can be automated and by the addition of alkali, soil removal can be improved. Many times, a thin oily film remains for rust protection. Since this method involves a solvent, it can present a fire hazard. Disposal can also be a problem.

4. Alkaline cleaning - Alkaline salts, usually caustic, silicates and phosphates, together with a balanced amount of surface active agents, constitute a very effective blend for metal cleaning. For dissolving in hot water and spraying on the dirty ware, this kind of cleaner generally removes most soils. This is the cheapest and best method of automated cleaning.
5. Acid Cleaning - Materials used here are usually mineral acids, although organic acids can be used. By the addition of wetting agents to the acid-water solution, cleaning as well as metal, rust and scale removal can be accomplished. A detergent containing acid pickle is an example of this type of cleaning. Since soils and oils are best removed on the alkaline side, the use of acid materials is somewhat limited for our purposes.
6. Mechanical Cleaning - The materials used here include some type of an abrasive-steel brush, sandpaper, or nylon rolls impregnated with abrasive. The cleaning is accomplished by metal removal from the surface. This method is widely used on strip lines.

#### SELECTING A CLEANER

A most important phase of metal working, fabricating, and finishing is cleaning. The cleaning method can be varied, depending on the work at hand, the amount of material involved, the possible need for quick automated cleaning and the over all effect on subsequent operations. Cleaners are many in number and vary in type and formulation. Since the highest percentage of cleaning operations require alkaline cleaners, we will concentrate on this group.

Alkaline cleaners are specifically formulated (proprietary) chemical blends which consist of alkaline salts, wetting agents, and sequestering (chelating) agents.

Wetting Agents - soap and synthetic detergents -- allow oil to be removed by displacing the oil from the surface and creating an emulsion in which the oil droplets are dispersed in water. One end of the wetting agent molecule is soluble

in oil (organophilic); the other is soluble in water (hydrophilic), and holds the oil in solution. The resulting oil in water emulsion is then easily rinsed away. Heat can greatly accelerate this emulsification process by reducing the oil viscosity and increasing the activity of the wetter.

The term "**Alkaline Builders**" covers a broad group of chemicals: caustic soda (NaOH), caustic potash (KOH), phosphates, silicates, and carbonates. This group supplies the alkalinity for the cleaner. High alkaline products saponify fats, lard, and vegetable oils into soluble soap. The alkaline salts also neutralize acid soils and aid in dispersing oils.

- I. Caustics (KOH, NaOH)
  - A. Highly alkaline, pH 12-14
  - B. Saponify fats and vegetables oils
  - C. Work with surface active agents to disperse and deflocculate soils
  - D. Neutralize any acid soils
  - E. Not safe on soft metals (aluminum, zinc case, galvanize)
- II. Silicates
  - A. Medium alkalinity, pH 11-12.5
  - B. Exhibit good detergency
  - C. Neutralize acid soils
  - D. Inhibit alkaline attack on soft metal
  - E. Tend to become insoluble at pH values less than 10
  - F. Tend to form scale at higher temperatures
- III. Phosphates
  - A. Medium alkalinity, pH 9.5-11.5
  - B. Exhibit detergency
  - C. Neutralize acidic soils
  - D. Generally safe on soft metals
  - E. Condition hard water.
- IV. Carbonates
  - A. Mildly Alkaline, pH 9.0-9.5
  - B. Neutralize acidic soils
  - C. Generally safe on soft metals
  - D. Provide reserve alkalinity to the other alkaline builders in the product.

Sequestering or Chelating materials have two (2) functions:

1. To condition water, which permits better rinsing and cleaning
2. To hold iron or other metals in solution to prevent this keeps them from redeposition on the part. Some Chelates such as EDTA hold heavy metals very tightly, hence could be a problem in waste treatment. Gluconates are more desirable in these cases.

Alkaline cleaners owe their detergency (cleaning ability) to the displacement of soil by surface active materials and alkaline builders to create emulsions that are easily rinsed away. The correct blend of builders, surfactants and conditioners will provide the aqueous cleaner you need.

Finally, to select a cleaner you must:

- **Determine the types of metal(s) processed to assure the alkaline cleaner will not attack the metal (important with aluminum, zinc, and some exotic metals)**
- **Be sure the cleaner is formulated to effectively remove the soils you encounter.**
  - Drawing/Stamping compounds require heat and many cases higher alkalinity to saponify animal fats if present.
  - Simple light rust protective oils, water soluble coolants are easily removed with mildly alkaline cleaners at moderate temperatures.
  - Waxes, heavy oil rust prevents and other durable corrosion prevention compounds require high heat and more aggressive alkalinity. incorporation of water soluble solvents help remove these soils.
- Choose a cleaner suitable for the mechanics of your system. Immersion cleaners normally require different surfactant systems than spray cleaners.
- Remember conditioners in the cleaning product are critical to counteract the undesirable effects of hard water salts on cleaning solutions.
- Consider whether a liquid or powdered product would favor your operation.
  - Liquid are easily automated and
  - Available in bulk or bins hence eliminating drums.
  - Powders are normally manually added but more economical in smaller operations

## RINSING

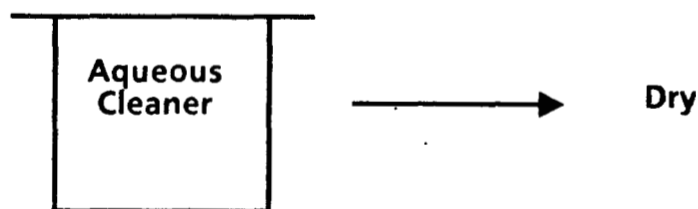
An important part of the cleaning process is the water rinse. As the substrate leaves the cleaner stage, it carries spent cleaner, emulsified soils and other contaminants. The rinse must remove these unwanted materials and not interfere with the subsequent operations. Therefore, the choice of cleaner is also governed by its rinsability.

Caustic and silicate, two major ingredients of cleaners, are poor rinsers. Phosphate, on the other hand, is relatively easy to rinse. Hot water can assist in rinsing. Care must be exercised so that drying does not occur just before the rinse tank. Also, blends of caustic, silicate and phosphates rinse more freely.

Double rinsing is utilized quite often. With the final rinse being deionized water for spot free parts or with a corrosion inhibitor if rusting is a problem.

## NORMAL SEQUENCES IN AQUEOUS CLEANING

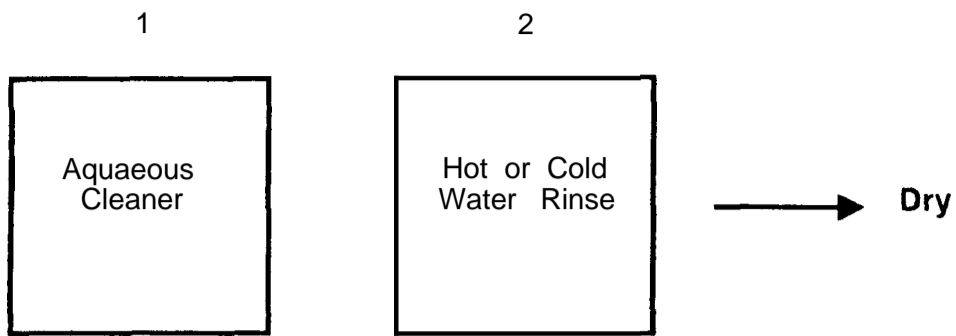
1. Single stage, clean only, no rinse



- Should contain rust inhibition if parts are ferrous steel.
- Should be skimmed frequently to remove floating oils which extends cleaner life and prevents redeposition.
- Equipment
  - Immersion Tank - low volume or batch work.
  - Automated cabinet spray washer - more efficient for low volume batch work.
  - Conveyerized Spray - high volume, continuous production work.
  - Ultrasonic

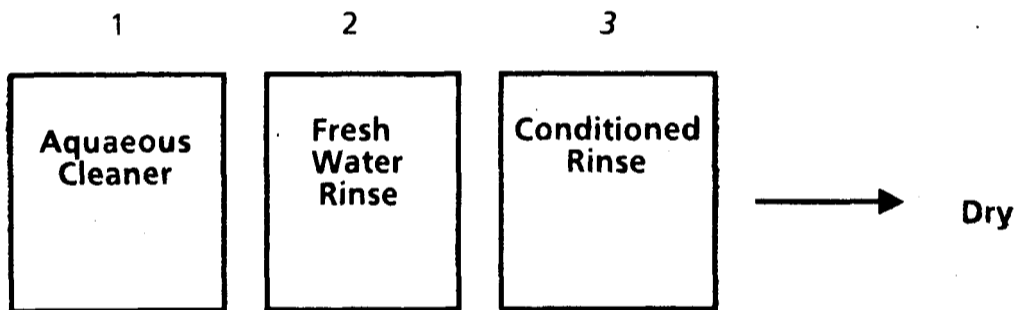


2. Two stage, Clean/Rinse



- Stage one should be skimmed frequently to remove oils which extends cleaner life and prevents redeposition.
- Rinse should be skimmed and changed frequently. A rust inhibitor may be used here.
- Equipment
  - immersion Tank
  - Automated cabinet spray equipment with rinse cycle.
  - ConveyORIZED spray
  - Auger washer
  - Ultrasonic

3. Three Stage, Clean Rinse, Rise



- This system can produce the cleanest part.
- First Stage should be skimmed.
- Second Stage rinse should be kept clean by overflowing.

- Third Stage can utilize deionized water for spot free parts and/or incorporate a water soluble rust inhibition if needed.
- Equipment
  - Immersion Tanks
  - Automated cabinet spray equipment with three indexed cycles-wash, rinse, conditioned rinse.
  - Conveyerized spray
  - Auger washer
  - Ultrasonic

#### WHAT LIES AHEAD IN METAL CLEANING?

Vapor degreasing, we believe, will disappear from the cleaner scene. At the present time, alkaline cleaners in conjunction with equipment changes are successfully replacing many vapor degreasing operations. These aqueous systems are undoubtedly the wave of the future.

Biodegradable surfactants are being manufactured at an increasing rate. Most all cleaners now contain them. The cleaner life is being extended so that less frequent dumping is required. This is brought about by a combination of mechanical equipment improvement in conjunction with improved chemical technology.

We see much more emphasis on "compatible systems" whereby the steel mills endeavor to apply more easily cleaned mill oil. By the same token, manufacturers of metal working fluids and compounds are also producing products which are more readily removed in subsequent aqueous cleaning operations.

As a final note -- for a cleaner tomorrow work must continue to replace products harmful to the environment -- whether these products be solvents, rust proofers, metal working compounds, or cleaners.

## GLOSSARY OF TERMS AND DEFINITIONS USED IN THIS SEMINAR

ACID:	A substance whose molecules yield hydrogen ions (H +) in water or under other suitable conditions. For practical purposes, you may consider any chemical with a pH of less than 7 an acid. Example: Hydrochloric Acid.
ACID CLEANER:	An aqueous blend of surfactants and acid
ACID PICKLE:	The removal of rust and scale from metal, using acid.
ALKALINE:	The definition of any material which has a pH between 7 and 14. Also called base.
ALKALINE BUILDERS:	Alkaline salts used with wetting agents (surfactants) to build a cleaner.
ALKALINITY:	A property of water soluble substances (or mixtures) causing the concentration of hydroxylions (OH) in water solutions to be higher than the concentration of hydrogen ions (H +). The result is a pH greater than 7.
AQUEOUS CLEANERS:	Water base cleaners or cleaner intended to be used in water.
BASE:	Opposite of acid; same as alkaline
CAUSTICS:	A strong alkaline; the term, when used alone, usually refers to caustic soda (sodium hydroxide). Caustic soda is the alkali used in the manufacture of many cleaning products. It is also used as a neutralizing agent for acids.
CHELATED:	The mechanism by which chemicals used for softening water in cleaning compounds "blind" calcium and magnesium ions to prevent them from causing precipitation reactions which result in hard water scale.
CHROMATE CONVERSION:	The result of the action of a chromic acid solution, generally used on aluminum to form a corrosion resistant coating.
DETERGENCY:	Materials which have cleaning ability, i.e. remove soils, suspend soil, and prevent redeposition of soils.
DIPHASE SOLVENTS:	Generally, solvent cleaners with a water seal. The water is the top layer, the solvent is then on the bottom. Very common with solvent paint strippers.
DISPERSANT:	A material that increases the stability of particles suspended in a liquid.
DRAWING COMPOUNDS:	Metal working compounds (liquids or paste) which protect the metal, forming dies, and simultaneously preventing the metal being formed from tearing or galling.

ELECTRO-CLEANER:	Generally, aqueous cleaners which utilize electrical currents to aid in cleaning.
EMULSIFY:	The dispersion or suspension of fine particles or globules of one or more liquids in another liquid.
HYDROPHILIC:	Philic is from the Greek meaning "loving". Water loving; defined by the American Society for Testing and Materials as "a descriptive term applied to the group or radical of a surfactant molecule that makes or tends to make it soluble in water." Molecule which has an affinity for water.
METAL FORMING LUBRICANTS:	Same as drawing compounds
METAL REMOVING OILS:	Water soluble oils, straight oils, and soaps which are used in the grinding or machining of metals.
NEUTRALIZE:	Neutral refers to the point at which a solution or product is neither acidic or basic. Neutral corresponds to a pH of 7. Neutralization is the act of adding an acid to a base, or vice-versa, in order to obtain a neutral solution.
ORGANOPHILIC:	Philic is from the Greek meaning "loving", hence organic (oil) loving. An organophilic molecule has an affinity for organic materials (fats, oils). Soluble or tends to be soluble in organic solvents (oils, kerosene, diesel fuel, chlorinated solvents, etc.)
PH:	A means of expressing the relative degree of acidity or basicity of a solution. The pH scale ranges from 0 to 14 with 7 being neutral. Descending numbers from 7 indicate an increase in acidity. Increasing numbers from 7 indicate an increase of alkalinity.
PHOSPHATES:	The "work horse" of built detergents. Phosphates are alkalis which sequester hard water, provide alkalinity, peptize, suspend soils, and add bulk to cleaning compounds. Can also refer to the coating formed on certain metals by the reaction of acid phosphate with the metal; i.e. iron phosphate, zinc phosphate.
PHENOLIC:	A highly active organic molecule. Greatly increases effectiveness of paint strippers, carbon removers. It is now considered hazardous.
PEPTIZE:	The process of breaking up large oily droplets into smaller ones
PLATING:	Usually this means using the flow of electricity through a solution to deposit a coating of metal generally decorative, on an object of some other (cheaper or stronger) metal.
PRECLEANING:	Cleaning which precedes another process. Generally, precleaning metal before phosphatizing and painting.

**SCALE:** A layer of insoluble salts of calcium or magnesium carbonate, or phosphate, which have been precipitated from water by heat or chemical reaction, or have been left behind when water evaporates. Heat scale is carbonaceous material which remains on metal after heat treating.

**SAPONIFY:** The making of soap by the action of a base on a fat or oil. This term is often erroneously used in place of neutralization when fatty acids are the soil being removed by an alkali. However, the end product is a soluble soap in either case.

**SEQUESTERANT:** This refers to the use of polyphosphates to "sequester" or chemically lock-up the lime and magnesium in hard water, thus preventing the formation of film on parts or scale in machines.

**SILICATES:** These are water soluble white solids used in powder or granular form as ingredients of metal cleaning compounds. They contribute emulsifying power, alkaline reserve, and protection of metals against corrosion.

**SOIL:** This is "dirt" - any substance where you don't want it to be.

**SOLUBLE:** The amount of solute that can be dissolved in a given amount of solvent.

**SOLVENT:** Dissolves grease, hoping that the soil will then drop away. Often solvents are combined with true washing agents for better over all work.

**SPRAY WASHER** A mechanical washing device used in industry generally to clean metal and plastic prior to another process. It consists of a large metal cabinet or tunnel, spray nozzles in the interior reservoir tanks and pumps.

**SURFACTANT:** A chemical agent which reduces the surface tension of water. You might say it makes water "wetter", allowing it to penetrate faster. Synonymous with wetter.

**SYNTHETIC COOLANTS:** Metal working fluids which are not straight mineral oils. They are generally derived from other organic materials. They lubricate and cool simultaneously.

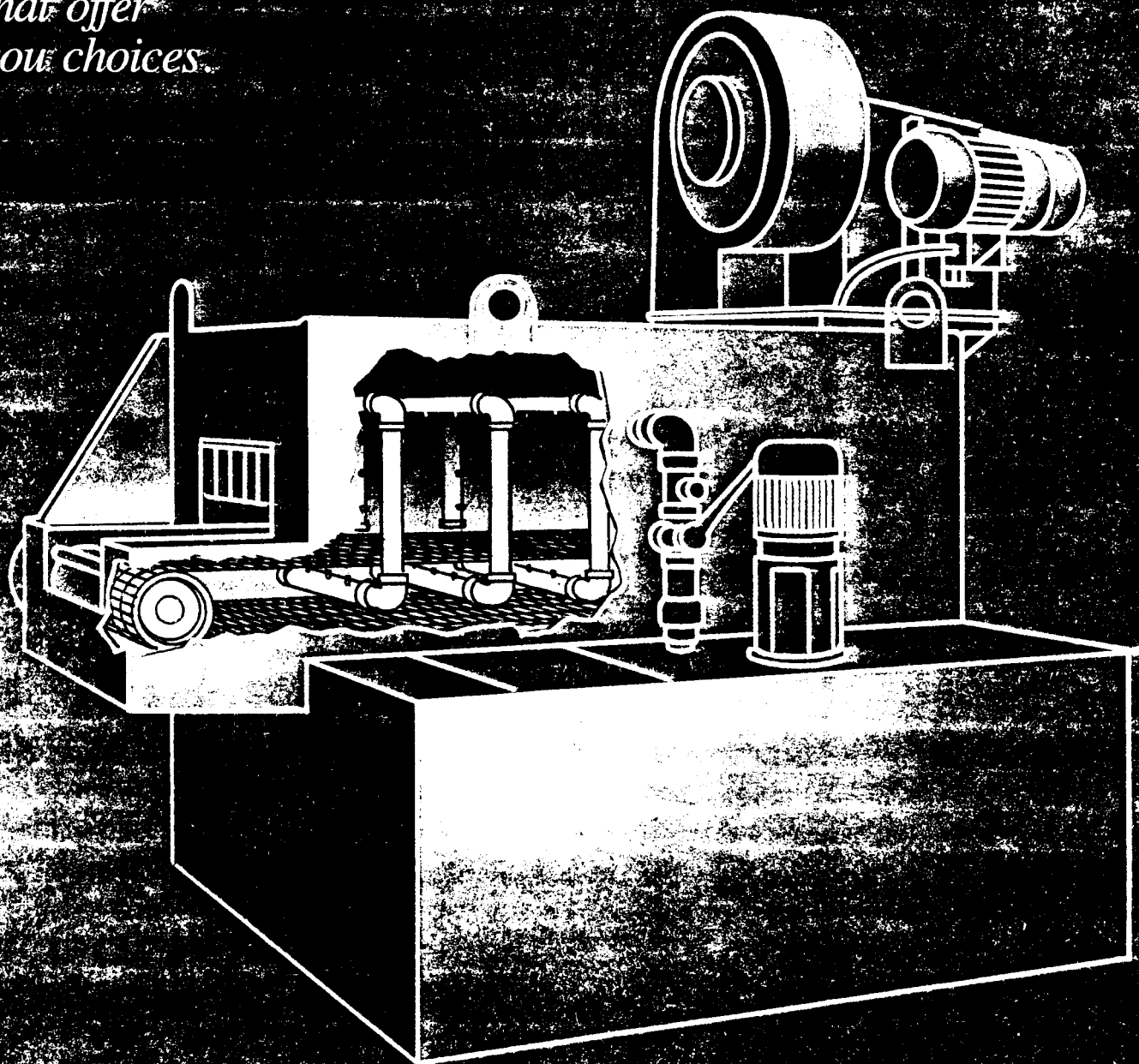
**WATER CONDITIONER:** A material that improves the quality of water for a given application or use. Generally a chelate or Sequestrant.

**WETTER:** A chemical which reduces the surface tension of water, thus making it penetrate soils or surfaces better. It makes water "wetter". Synonymous with surfactant.

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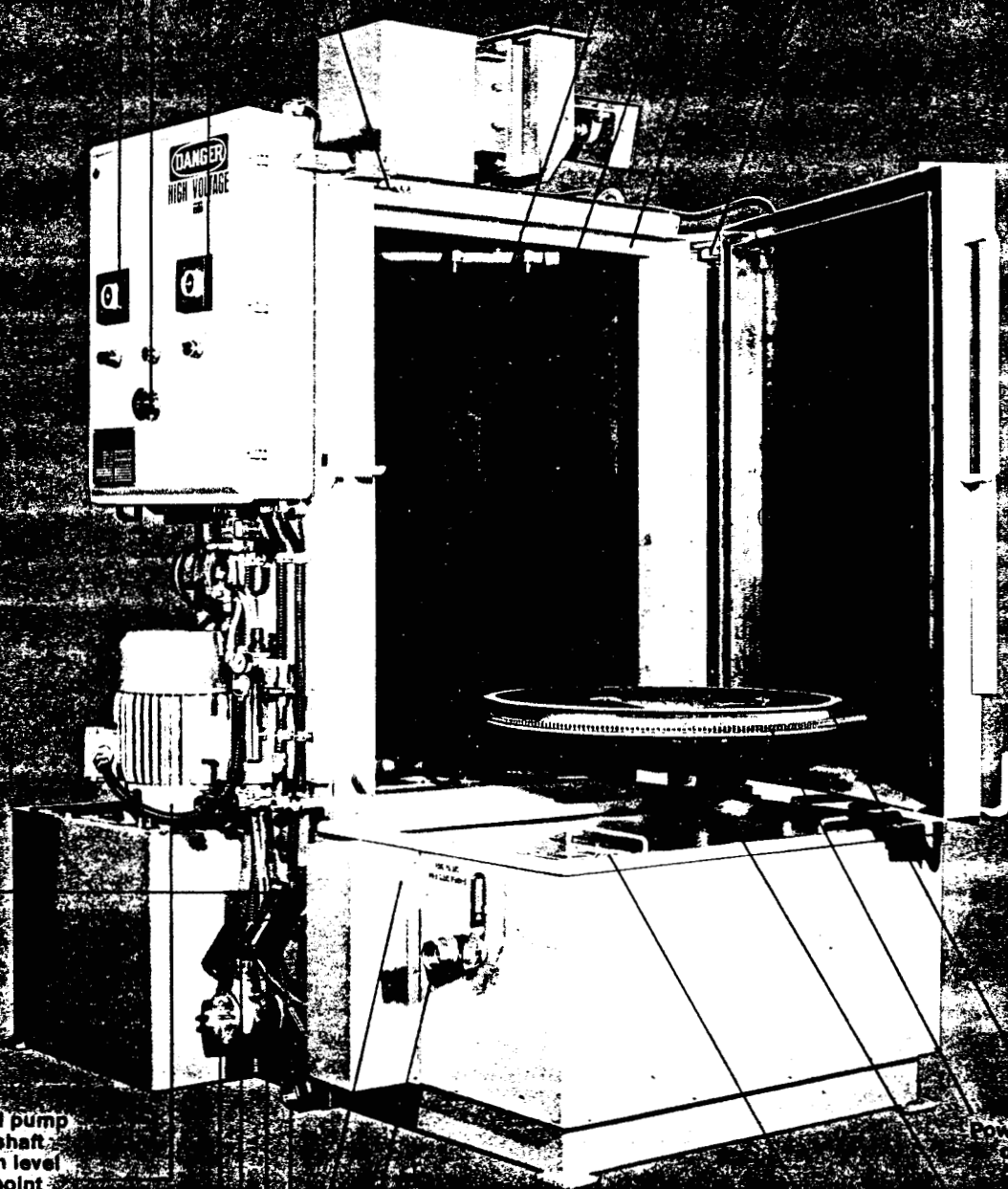
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OPTIONAL  
 Rinse timer  
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Steel labyrinth floor  
 Door is mounted on turntable  
 support column which  
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Submerged wet end pump  
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 seals below solution level  
 and no lubrication point

Electric heater  
 Temperature indicator  
 Thermostat  
 Drain valve

OPTIONAL  
 Automatic diverter  
 baffle returns wash  
 solution to tank and  
 rinse water to drain  
 Oil skimmer, dam and valve

Part basket  
 optional  
 Power turntable  
 drive by gear  
 motor

Door with pull  
 out cover with locking  
 handles.  
 Stainless steel  
 screen tray  
 just below

Peep hole for  
 inspection of  
 solution level

**A TYPICAL CABINET WASHER**

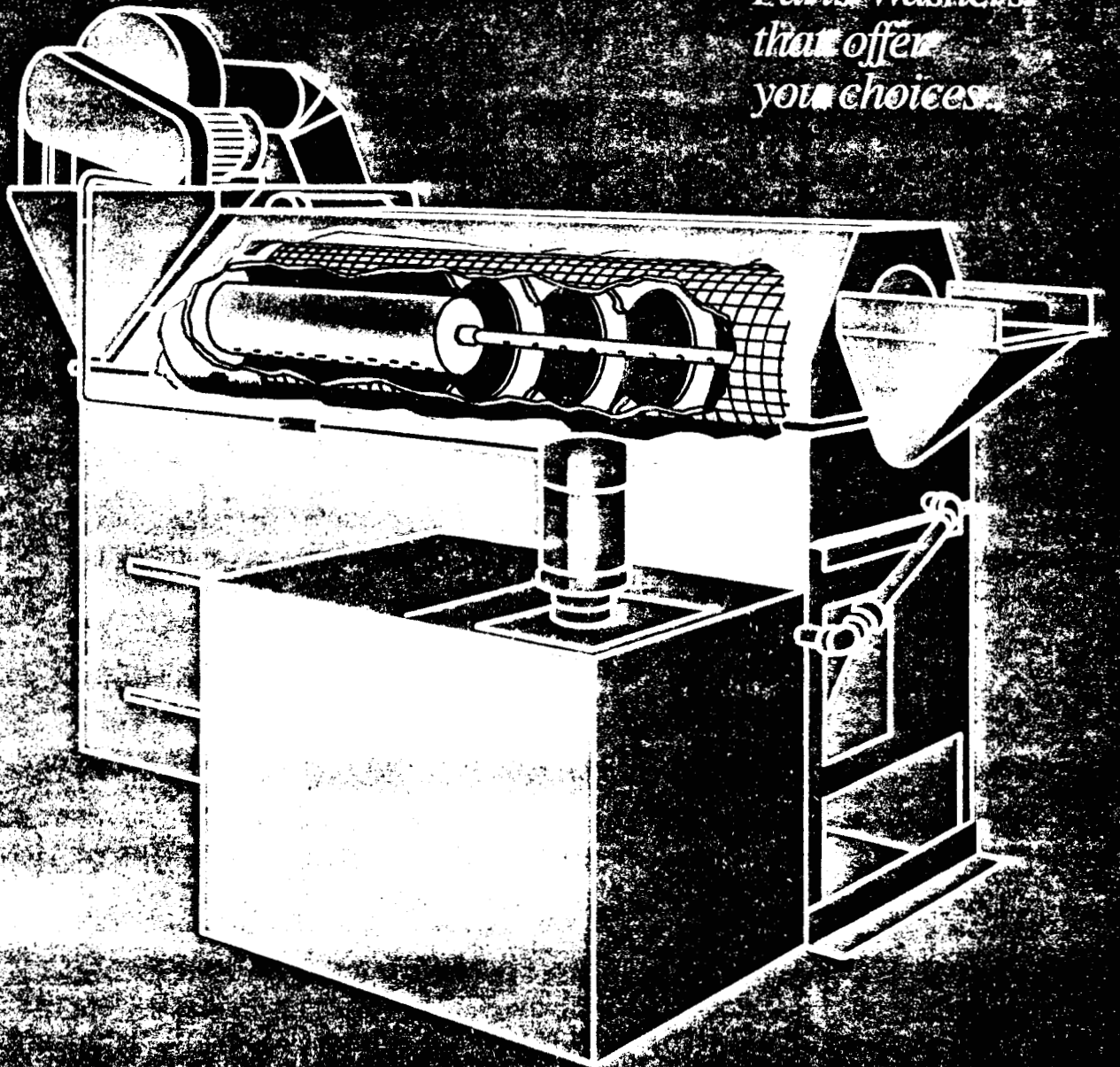
Cleaning solution  
 is strained and  
 recirculated to  
 minimize pollution

For energy conservation, machine is insulated  
 with 1" polyurethane, covered with 16 gauge  
 steel sheet and finished with two component  
 epoxy coating.

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**Drum Series**

*Parts Washers  
that offer  
you choices...*



A TYPICAL AUGER WASHER