3

HANDLING CHEMICALS AND SOLUTIONS

INTRODUCTION

For successful analytical work, the availability of reagents and solutions of established purity is of prime importance. A freshly opened bottle of some reagent-grade chemical can be used with confidence in most applications; whether the same confidence is justified when this bottle is half full depends entirely upon the care with which it was handled after being opened. The rules that are given here will be successful in preventing contamination of reagents only if they are conscientiously followed.

CAUTION *Always read the label twice before using any reagent.*

GENERAL GUIDELINES

1. Select the best available grade of chemical for analytical work. If there is a choice, pick the smallest bottle that will supply the desired quantity of substance.

2. Replace the top of every container immediately after removal of reagent; do not rely on having this done by someone else.

3. Stoppers should be held between the fingers and should never be set on the desk top.

4. Never return any excess reagent or solution to a bottle; the minor savings represented by a return of an excess is indeed a false economy compared with the risk of contaminating the entire bottle.

5. Do not insert pipettes into a bottle containing a reagent chemical. Instead, shake the bottle vigorously with the cap in place to dislodge the contents; then pour out the desired quantity.

6. Keep the reagent shelf and the laboratory balances clean. Immediately clean up any spilled chemicals, even though others may be making the same transfer of reagent in the same area. (Refer to Chap. 2, "Laboratory Safety.")

Personal Safety

Always wear protective safety goggles, aprons, shoes, etc., when handling chemicals, in case of accident.

Always flush the outside of acid bottles with water and dry them well before using. (Wet bottles are slippery.)

REMOVAL OF SOLID MATERIALS FROM GLASS-STOPPERED BOTTLES

Method 1

This method can be used only with those bottles that have a hollow glass stopper capable of containing some of the material.

1. Rotate the bottle in an inclined position so that some of the material will enter the hollow glass stopper (Fig. 3.1). It may be necessary to tap the bottle gently to break up solidified surface material or to actually open the bottle and break up the solid with a clean spatula.

2. Position the bottle so that when the stopper is removed, some of the material will remain in the stopper (Fig. 3.2).

3. Place the bottle on the table. Gently tap the tilted stopper with a finger, pencil or small spatula to dislodge enough of the desired material (Fig. 3.3).

4. Repeat to get the required amount of solid.

5. Return to the bottle *only the excess material that remains in the stopper.* Discard any excess which has come in contact with anything else.

6. Replace the stopper in the bottle.

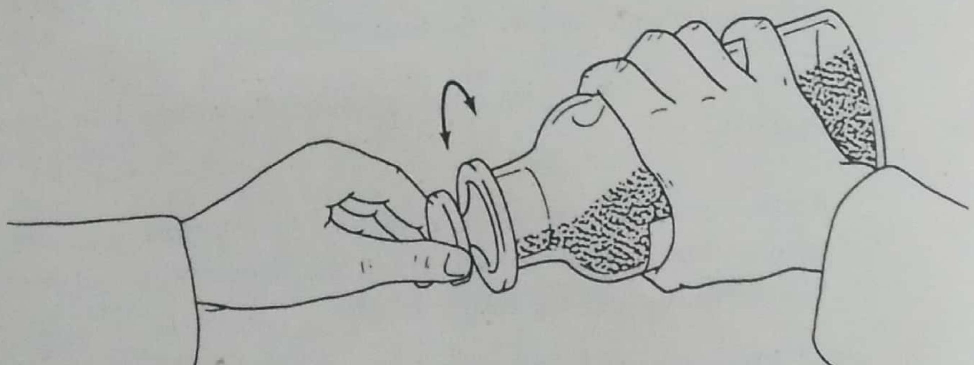


FIGURE 3.1
Rotate the bottle in an inclined position.

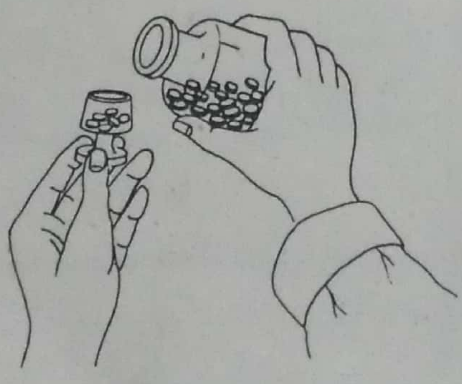
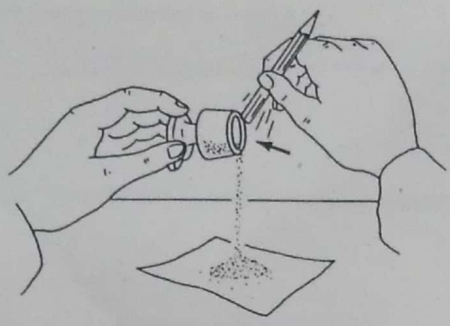


FIGURE 3.2
Remove stopper so that some of the material remains in it.



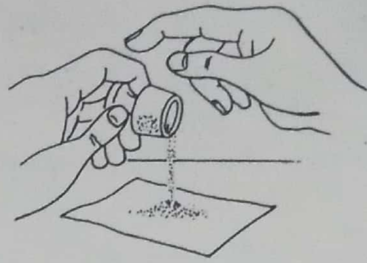


FIGURE 3.3 Gently tap tilted stopper to dislodge desired amount of material (*a*, *b*). (*a*) (*b*)

Method 2

1. Remove the glass stopper by gently twisting, tapping the stopper gently to loosen, if necessary.

2. Use an *absolutely clean spatula* and dig out material, always laying the stopper upside down on the desktop. (See Fig. 3.4.)

3. Tap the spatula gently to cause the desired amount of material to fall off.

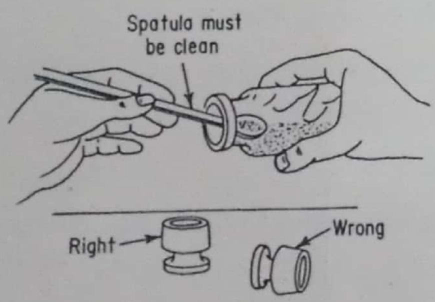


FIGURE 3.4 Proper procedure to dig out material.

Spatulas

Scoop-type spatulas are used to transfer larger quantities of solids, especially from narrow-necked bottles or containers. (See Fig. 3.5*a*.)

Spatulas are available in a variety of shapes, sizes, and designs to be used for special manipulations, from micro size to very large for production jobs. (See Fig. 3.5*b* to *d*.)

Method 3

1. Tap the jar lightly on the tabletop while gently rotating to loosen the material.

2. Remove the stopper and place upside down on a clean surface.

3. Hold the jar over the container and roll and tilt the jar until enough material has fallen out.

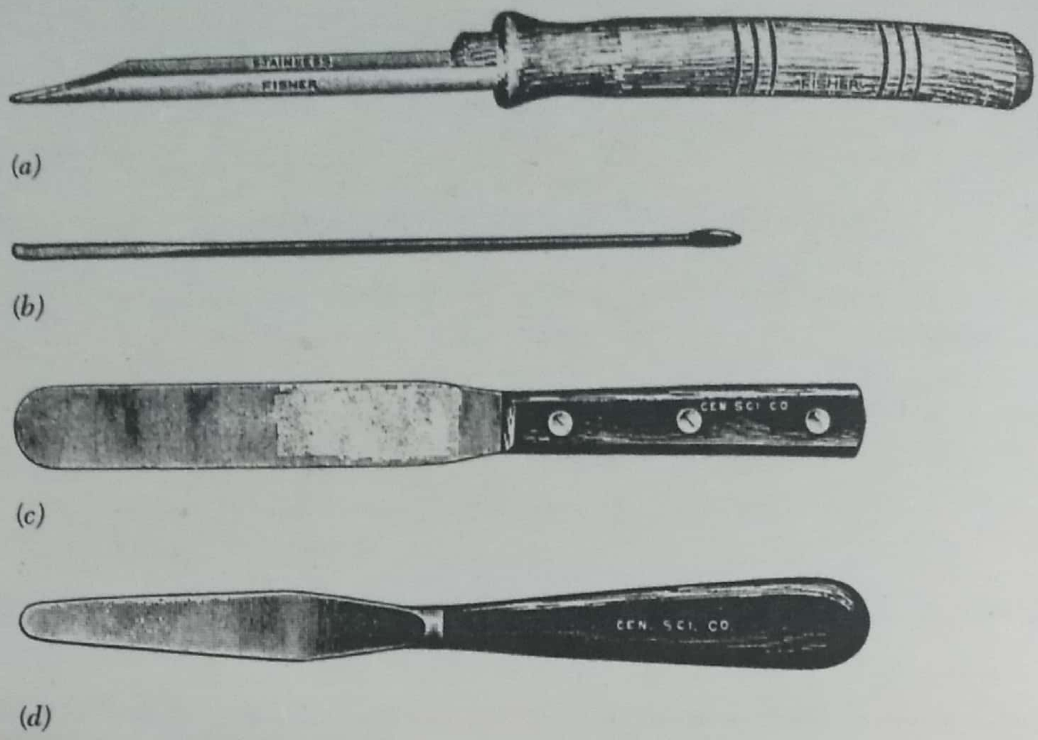


FIGURE 3.5
Various spatulas.

POURING LIQUIDS FROM BOTTLES

Method 1

1. Loosen the stopper by gently twisting it.
2. Grasp the stopper either between the second and third fingers as in Fig. 3.6 or between the palm and fingers as in Fig. 3.7.
3. Pour the liquid as needed.
4. Replace the stopper immediately in the bottle. Never lay it on the desk.

FIGURE 3.6
Handling a glass stopper.

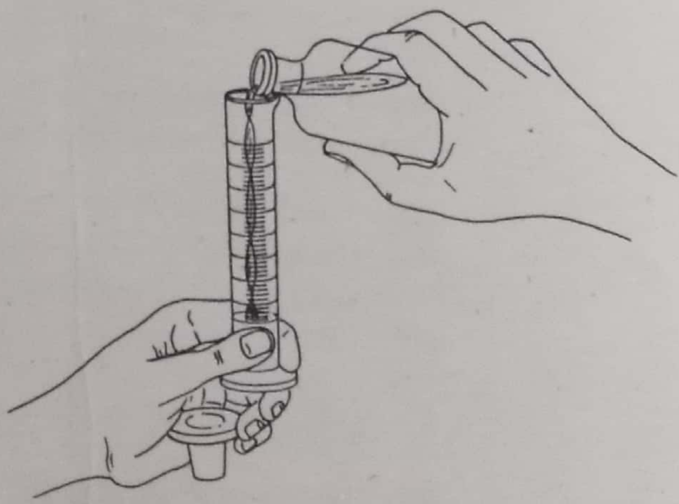


FIGURE 3.7
Alternative method of handling a glass stopper.

Method 2

An alternative procedure for pouring from a bottle:

1. Tilt the bottle so that the contents wet the stopper. Rotate the stopper completely.

2. Withdraw the stopper, then moisten the inside of the neck of the bottle with the wetted stopper.

3. Reinsert the stopper and again rotate completely so that all contact surfaces are wetted. Remove the stopper using standard procedure, with the back of the hand.

4. Pour the liquid. The wetted inner surface of the neck and lip of the bottle enables the liquid to flow smoothly out of the bottle without gushing.

POURING LIQUIDS FROM BEAKERS OR OTHER CONTAINERS

1. Hold a glass stirring rod against the pouring lip of the beaker.

2. Tilt the container, allowing liquid to flow around the stirring rod, which guides the liquid to the receiver. (See Fig. 3.8.)

3. When the desired amount of liquid has been poured, position the pouring beaker vertically, allowing the last liquid to drain off the lip and down the rod.

FIGURE 3.8
Use of stirring rod to guide liquid.

TRANSFERRING SOLUTIONS INTO CONTAINERS FROM PIPETTES OR MEDICINE DROPPERS

1. Fill the pipette or medicine dropper. (Review the section on pipettes in Chap. 25, "Volumetric Analysis.")

2. Hold it above the solution to which it is to be added. *Do not* immerse it in the solution because it will then become contaminated by the solution. (See Fig. 3.9.)

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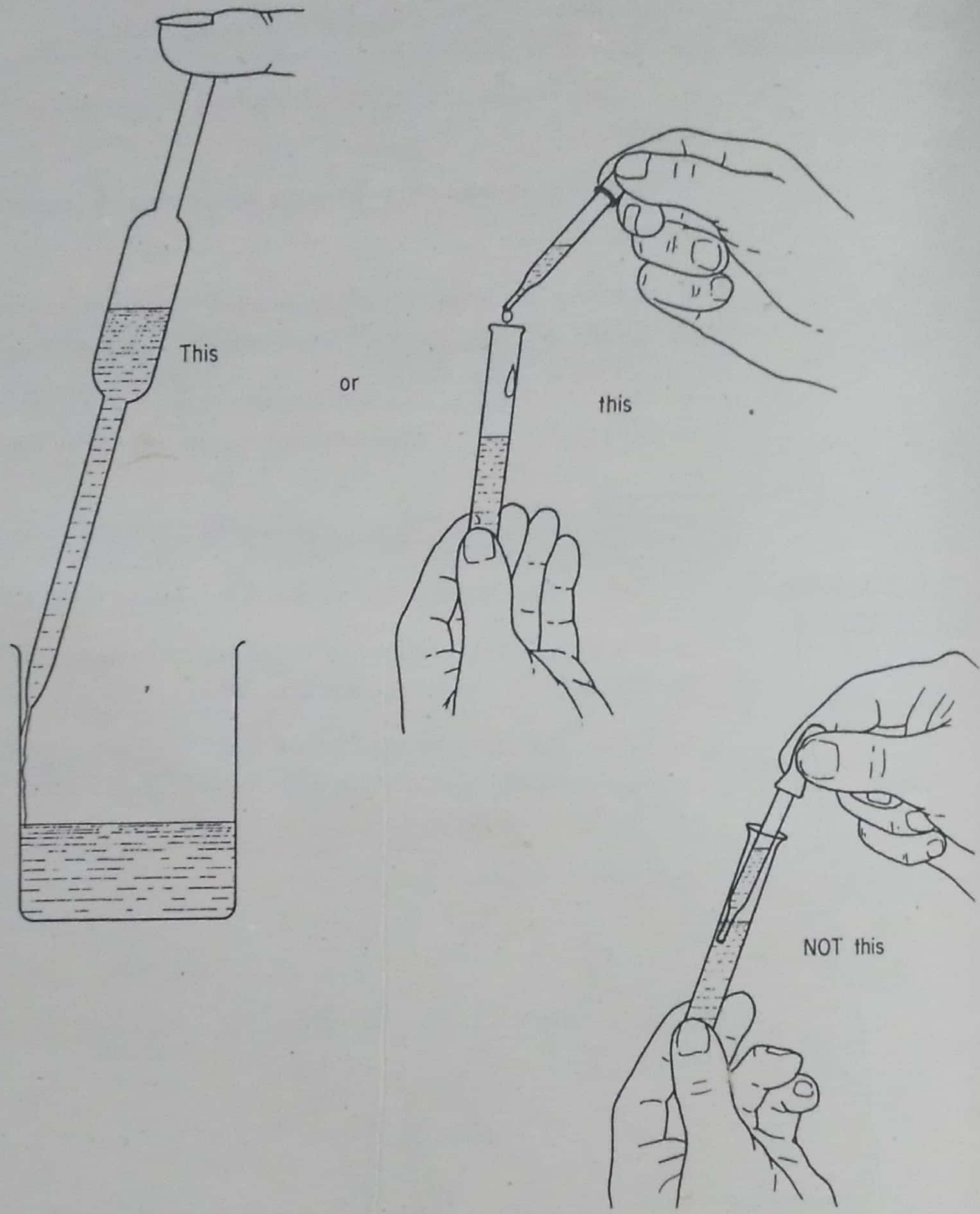


FIGURE 3.9
Proper use of a medicine dropper or pipette.

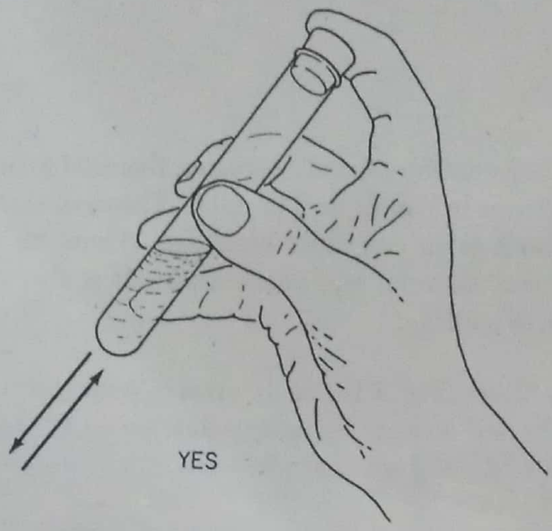
SHAKING A TEST TUBE

To mix substances in a test tube, always use a suitable, clean, cork or rubber stopper; never use your bare finger. The liquids may be corrosive and damage your skin, or your finger may be dirty and contaminate the solution. Shake with an up-and-down motion. (See Fig. 3.10.)

CAUTION Use care when the stopper is removed. Pressure may have built up, and the liquid may foam out or spew from the test tube.

MIXING SOLUTIONS IN A TEST TUBE

1. Use a glass rod (Fig. 3.11), preferably with a small rubber policeman.
2. Agitate sideways, so that liquid is not spilled (Fig. 3.12).



(a)

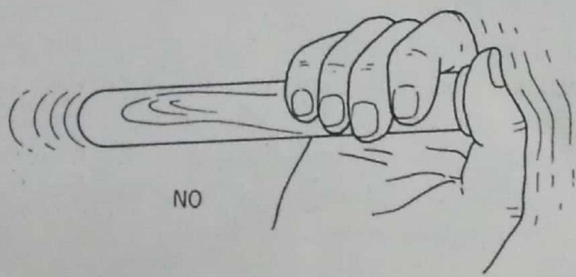


FIGURE 3.10
Proper way (*a*) and improper way (*b*) to shake a test tube. (*b*)

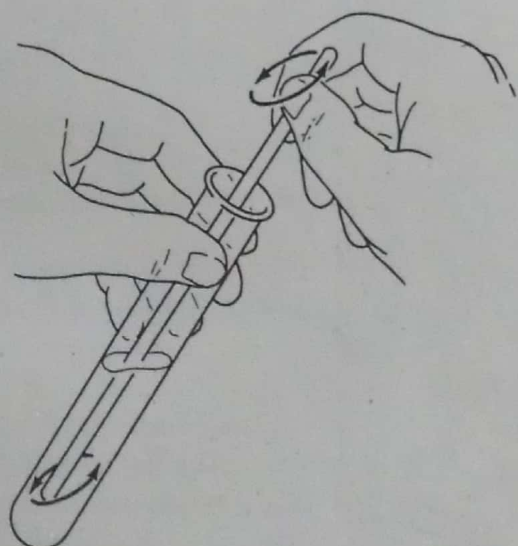


FIGURE 3.11
Stirring a solution in a test tube. Don't poke out the bottom.

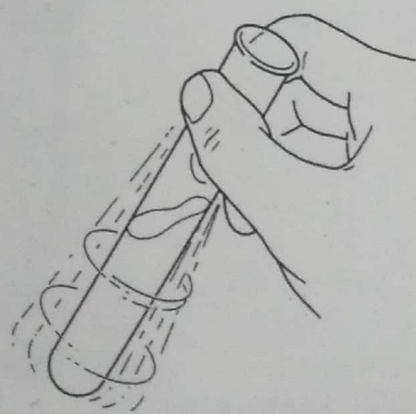


FIGURE 3.12
Agitate a solution sideways in a test tube.

SAFE HANDLING OF LIQUIDS

Carboys and Large Bottles

Handling

Carboys and large bottles of acids, caustics, flammable liquids, and corrosive materials are dangerous to handle and to move. They are extremely fragile, and a slight mechanical shock or jar can cause breakage. When this happens, the broken glass and the corrosive material may cause injury. It is also very difficult to pour from them because of spillage.

Safety carboy tilters (Fig. 3.13) enable you to pour faster, safer, and easier. You also minimize spills and leakage by using a safe pouring spout (Fig. 3.14), which permits the entry of air and prevents spurts and splashes.

Safety hand pumps (Figs. 3.15 and 3.16) enable you to pump liquids out of carboys and large bottles safely and easily. Furthermore, you can pump out exactly the volume you wish.

Transporting

Moving large bottles and carboys is a dangerous operation because of the danger of bottle breakage and liquid spillage. Accidents can and do happen; therefore always use safety carts and safety bottle carriers (Fig. 3.17). The safety bottle carriers securely hold the bottle in place and cushion the bottle from shocks to prevent breakage. They should always be used when more than one large bottle is being moved on the same cart.

FIGURE 3.13
Carboy tilter.

FIGURE 3.17
Safe transportation for carboys and large bottles: (*a*) plastic protective shield for carboy; (*b*) carboy transporter; (*c*) movable table.

Drum cradles (Fig. 3.19) enable you to position the drums horizontally at a convenient height for safe liquid withdrawal.

Volatile flammable-solvent vapors escaping from openings in drums can be accidentally ignited, causing fire. This hazard can be eliminated by the use of flame arrestors installed in the drum openings (Fig. 3.19).

Leakage through faulty drum spigots or by careless and sloppy work can cause hazards. Always place a safety drip can beneath the spigot (Fig. 3.19).

Transporting

To transport large drums and barrels you should use the proper handling truck (Fig. 3.20). You can safely handle the drum, because the locking device is designed to prevent accidents, and the load rests on the wheels, not on you.

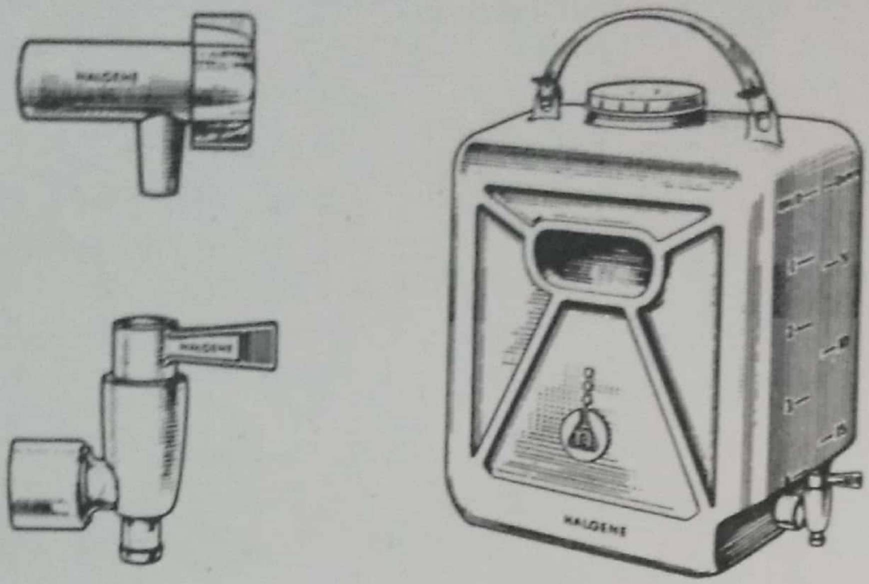


FIGURE 3.14
(*a*) Carboy spout. (*b*) Plastic safety container with spout.

(*a*) (*b*)

Drums

Handling

Many chemicals, such as solvents, plasticizers, raw materials, etc., are shipped in 55-gal drums, which weigh around 800 lb when full. You can easily be injured and cause a serious accident when you try to withdraw the material from the drum without the proper equipment (Fig. 3.18).

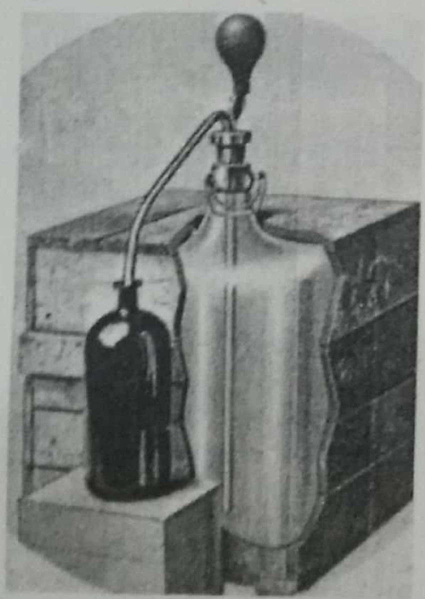


FIGURE 3.15
A positive-pressure acid pump. Squeezing the rubber bulb forces acid through the exit tube. The instantaneous relief valve stops the flow; this aids one to make precise measurements and is a good safety device. Be sure the stopper is secure.

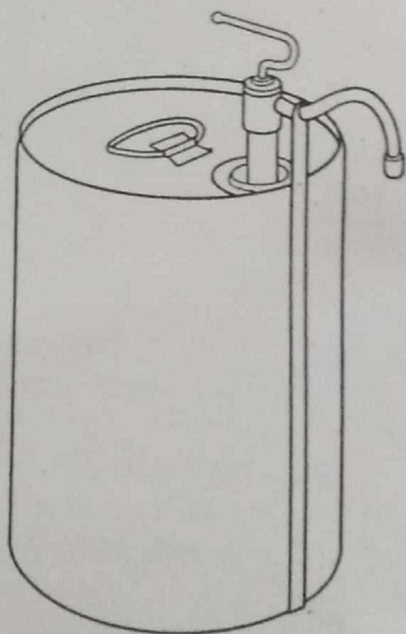


FIGURE 3.16
A positive-acting pump that delivers solvents quickly and safely from cans or larger containers. A vertical movement of the handle causes the pumping action.

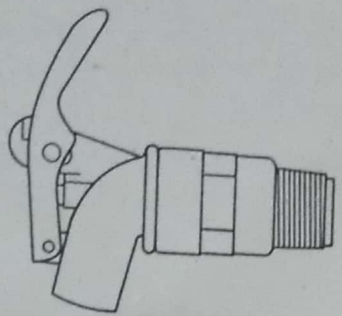


FIGURE 3.18
Safety spout for drums.

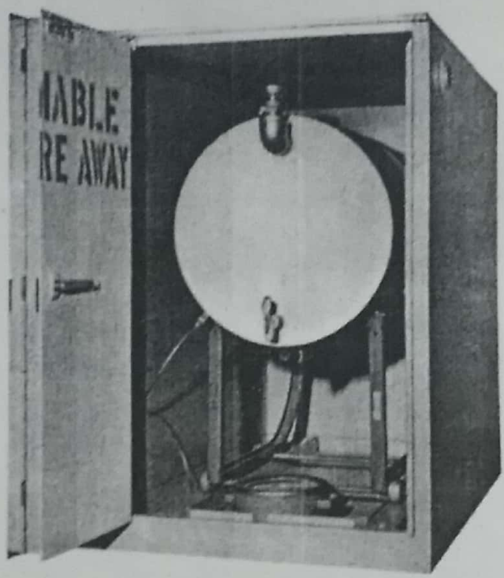


FIGURE 3.19
Safety cradle for drum, which is fitted with flame arrestor and safety drip can.

Safety Cans

Safety cans (Fig. 3.21) prevent leakage or evaporation of solvents and automatically permit escape of excessive gas pressure. Use of these cans for storage and transportation of flammables reduces the hazards to a minimum.

Safety Pails

Always transport acids and caustics in safety pails made of plastic or molded rubber. Never use glass because of the dangers involved in the event of accidental breakage.

USE OF PUMPS FOR TRANSFERRING LIQUIDS

In the laboratory two kinds of pumps are used: the centrifugal pump and the volume-displacement pump. Centrifugal and gear pumps must be fabricated out of materials that will not corrode and will not contaminate any solutions being transferred. Usually, stainless steel or plastic component pumps are used.

FIGURE 3.20
Truck for moving drums and barrels.

FIGURE 3.21
Lightweight safety storage cans for storing flammable liquids. The positive spring-lid closure prevents both loss due to spillage and hazard from fire.

Centrifugal Pumps

In general, the centrifugal pump finds the widest use for recirculating liquids and general transfer work (Fig. 3.22). When pumps are used to transfer reaction solutions, it is important to avoid contamination, to clean the pump after use, and to get the centrifugal pump primed. Before centrifugal pumps will work, they must be primed and the inlet pipe and impeller must be completely filled with liquid. This can present a problem when working with corrosive solutions.

Volume-Displacement Pumps

There are several types of volume-displacement pumps: gear or modified-gear types, flexible-contact impeller type, housing type, or flexible-tubing squeeze type.

The gear-type volume-displacement pump does not have to be primed (Fig. 3.23). When started, the pump will prime itself, provided that it is in reasonably good condition and that the gear drive is not too far above the surface of the solution. The problem of using a clean pump, free of contaminants, always faces the technician.

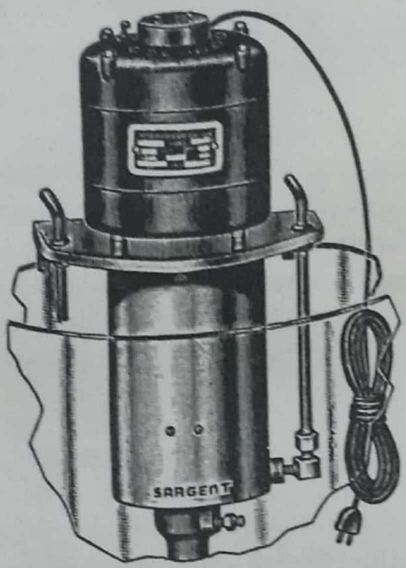


FIGURE 3.22
A centrifugal pump used to constantly circulate water in constant-temperature baths. It cannot be used for corrosives.

The volume-displacement pump offers the technician the best means of transferring corrosive solutions, because the mechanical components of the pump never come in contact with the solution. The squeezing action of these pumps moves the liquid to the desired container, the liquid coming in contact only with the tubing (Fig. 3.24). Various kinds of flexible plastic tubing are available to meet the need. (Refer to Chap. 17, "Plastic Labware.")

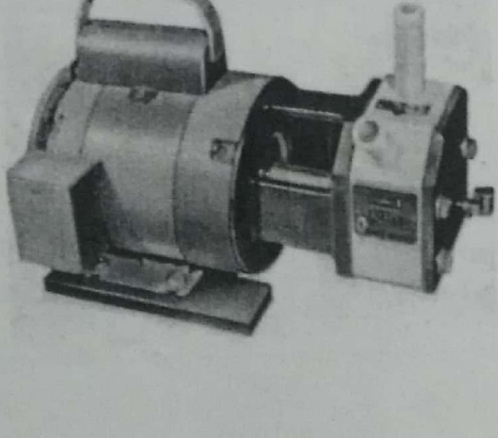


FIGURE 3.23
All-purpose transfer pump for corrosive liquids. It is self-priming and has a flexible, replaceable line. It pumps a fixed volume per minute unless a variable-speed motor is used.

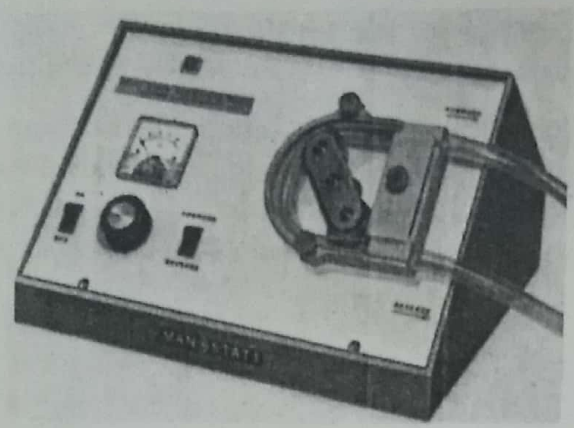


FIGURE 3.24
Transfer pump for positive transfer of corrosive, sterile, or acid fluids. The fluids have no contact of any kind with the pump. The pump acts to squeeze the tubing, causing the transfer of the liquid. The speed and direction of pumping can be varied.

Metering Pumps

Metering pumps are available in a wide range of designs and capacities, providing adjustable flow ranges from fractions of a milliliter per minute to fractions of liters per minute. They are self-priming, capable of lifting a solution to heights equivalent to about 20 ft of water. Their output stroke is adjustable, and they are made in a variety of materials (plastics, stainless steel, Monel, etc.). The selection is determined by the procedure.

Finger Pumps

When solutions and slurries must be pumped or transferred and must be protected from any possible contamination, the answer may be the flexible-tubing finger pump. Solutions never come in contact with any portion of the pump; therefore no contamination of the solution results, and the pump does not have to be cleaned. A series of metal fingers actuated by an electric motor gently forces the solution through the tubing. (See Fig. 3.25.) These pumps can be used to move corrosive liquids, to pump several solutions at the same time, and to feed and mix solutions. They also find use in metering operations for column chromatography.

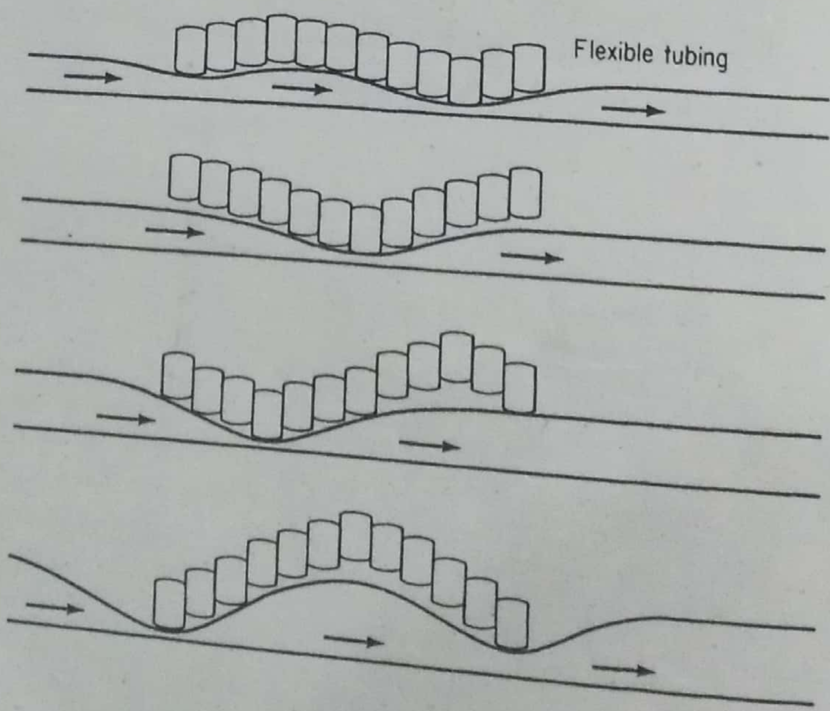


FIGURE 3.25
Sequence of squeezing action in finger pumps.

Computer-Controlled Pumps

There are several types of microprocessor-controlled pumps, ranging from models that are only slightly "smarter" than manual pumps, to fully computer-compatible models. At the low end of the scale, the pumps can be calibrated to compensate for variations in tubing or fluid and have remote control connections similar to those of the manual drives. The ability to calibrate these drives makes them far more accurate than the manual drives, although other features remain similar to those of the manual models. Most microprocessor-controlled pumps have brownout protection to allow them to retain memory of settings in the event of a loss of electricity. Figure 3.26 is a typical microprocessor-controlled chemical pump.

Other microprocessor pumps have one or two built-in programs to allow for ease of use in a production environment. These pumps usually have a "dispense" or "copy" mode, which allows you to program a specific volume to be dispensed or copy a volume that you have already dispensed. These pumps are not usually computer-compatible, although they often have remote control connections that allow the use of all functions when preprogrammed.

FIGURE 3.26 Microprocessor-controlled chemical pump. *(Courtesy Cole Palmer Instruments.)*

The most elaborate computerized drives are also the most expensive. These are the fully computer-compatible drives that can be run remotely through software on your PC. These drives can also be controlled through the keypad on the unit, although the program will contain more functions than the keypad allows. The best pumps of this class have bidirectional connections with the computer, allowing you to "daisy chain" pumps together so that each pump may be programmed individually. This provides a user-friendly interface for a broad range of programming options. Many programs will allow the operator to control a balance or mixer as well as pumps. The pump should have a safety override switch for use in emergencies. These features provide you with an almost completely automated system. However, the usually lengthy setup time can cause problems when diverse flow rates are constantly required. In these instances, a manual pump might offer the better solution.