As the name implies, the plate and frame filter press is an assembly of hollow frames and solid plates that support filter media. When assembled alternately into a horizontal or a vertical unit, conduits permit flow of the slurry into the frames and through the media. One side of the plate is designed for the flow of the feed. After passing the filter media, the filtrate is accommodated on the other side. The solids collect in the frames, and filtrate is removed through place conduits. In cake filtration, the size of the frame space is critical, and wide. sludge frames are used.

The filter press is the most versatile of filters since the number and type of filter sheets can be varied to suit a particular requirement. It can be used for coarse to fine filtrations, and by special conduit arrangements, for multistage filtration within a single press. The filter press is the most economical filter per unit of filtering surface, and material of construction can be chosen to suit any process conditions. Labor costs in assembly and cleaning are a primary disadvantage, and leakage between plates may occur through faulty assembly. The normal range of flow is three gallons per minute per square foot of filter surface at pressures of up to 25 psi.

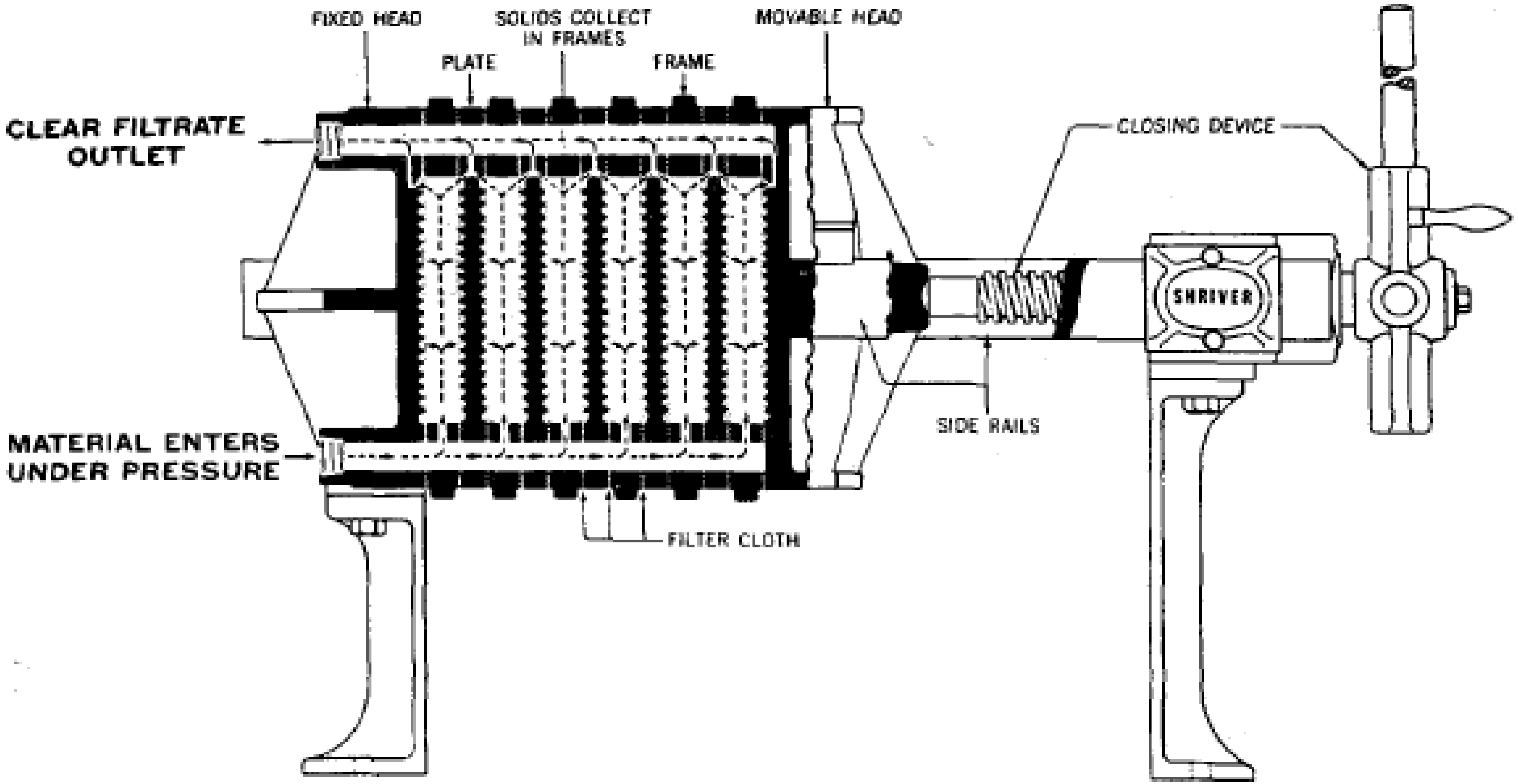


FIG. 7-13. *The plate and frame filter press may have 10 to 100 filtering surfaces and may be filled with pumps, sanitary fittings, sludge frames, or dividing plates for serial filtration. (Courtesy of Ertel Engineering and T. Shriver & Co. Inc.)*

The *disc filter* overcomes some deficiencies of the filter press (Fig. 7-14). Compactness, portability, and cleanliness are obvious advantages for pharmaceutical batch operations. The term disc filter is applied to assemblies of felt or paper discs sealed into a pressure case. The discs maybe preassembled into a self-supporting unit, or each disc may rest on an individual screen or plate. Single plate or multiples of single plates may be applied. The flow may be from the inside out or the outside in Figure 7-15 illustrates the flow schematics through a plate. Fluid flows from the outside along the thin flow channel in the plate.

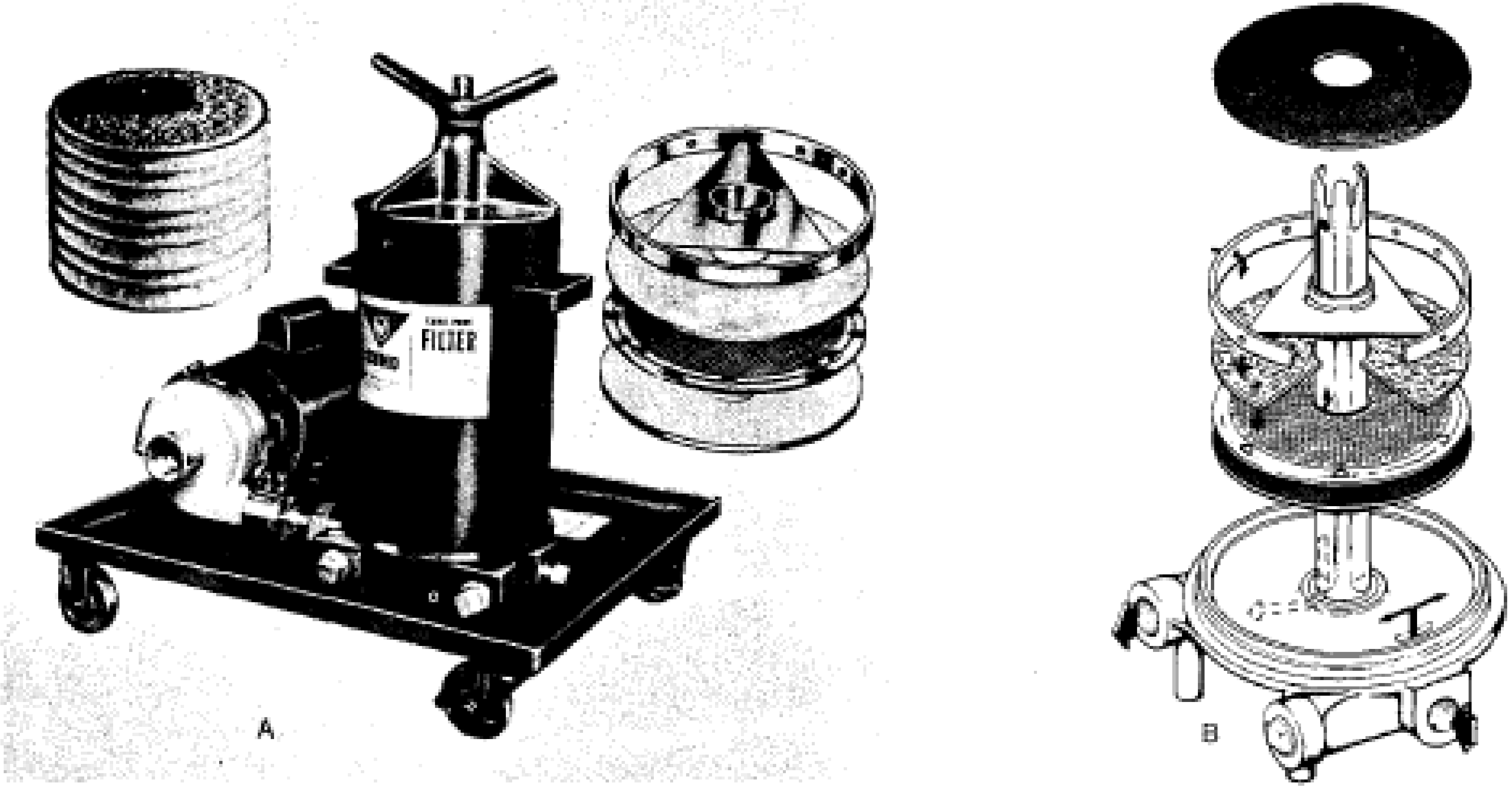
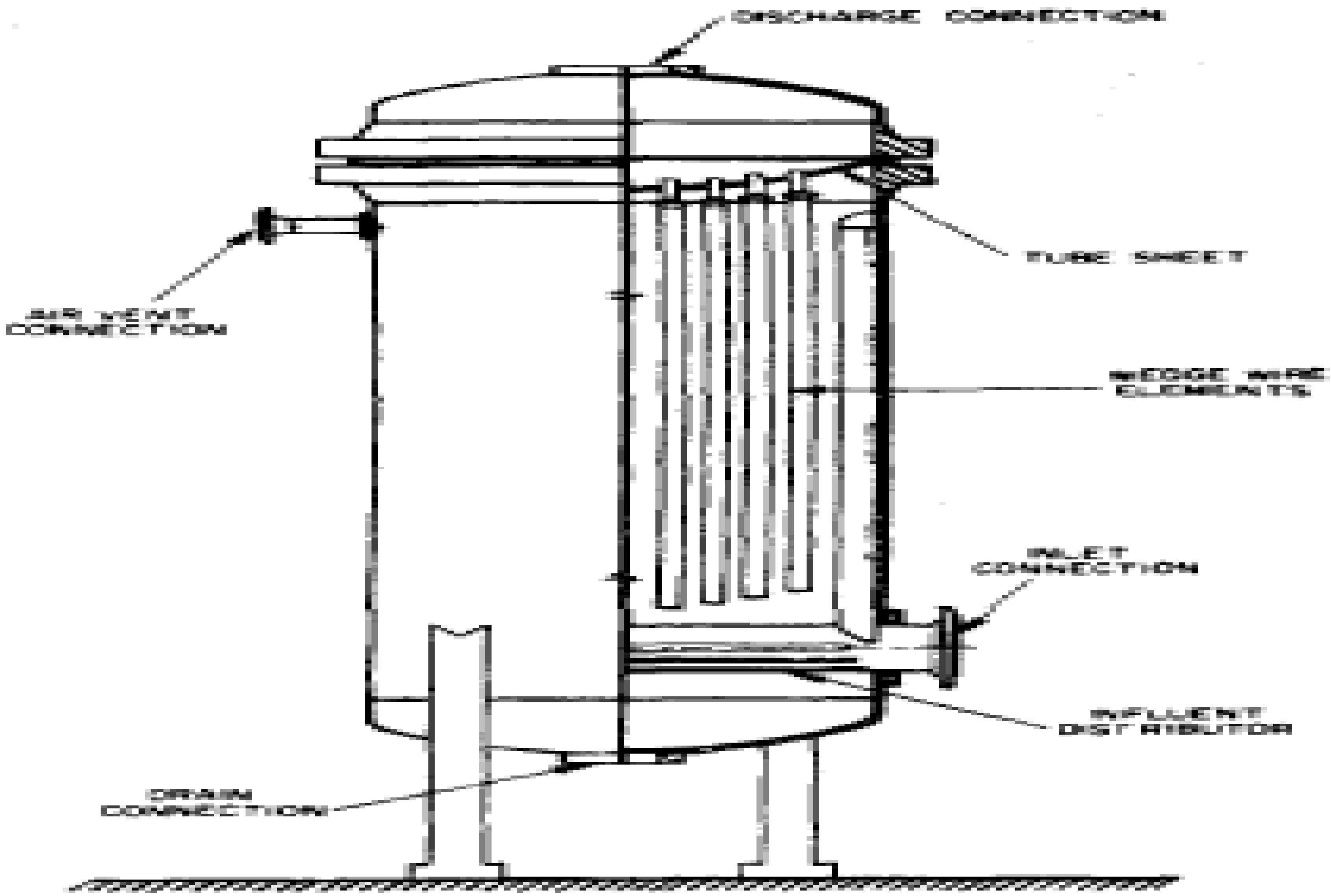


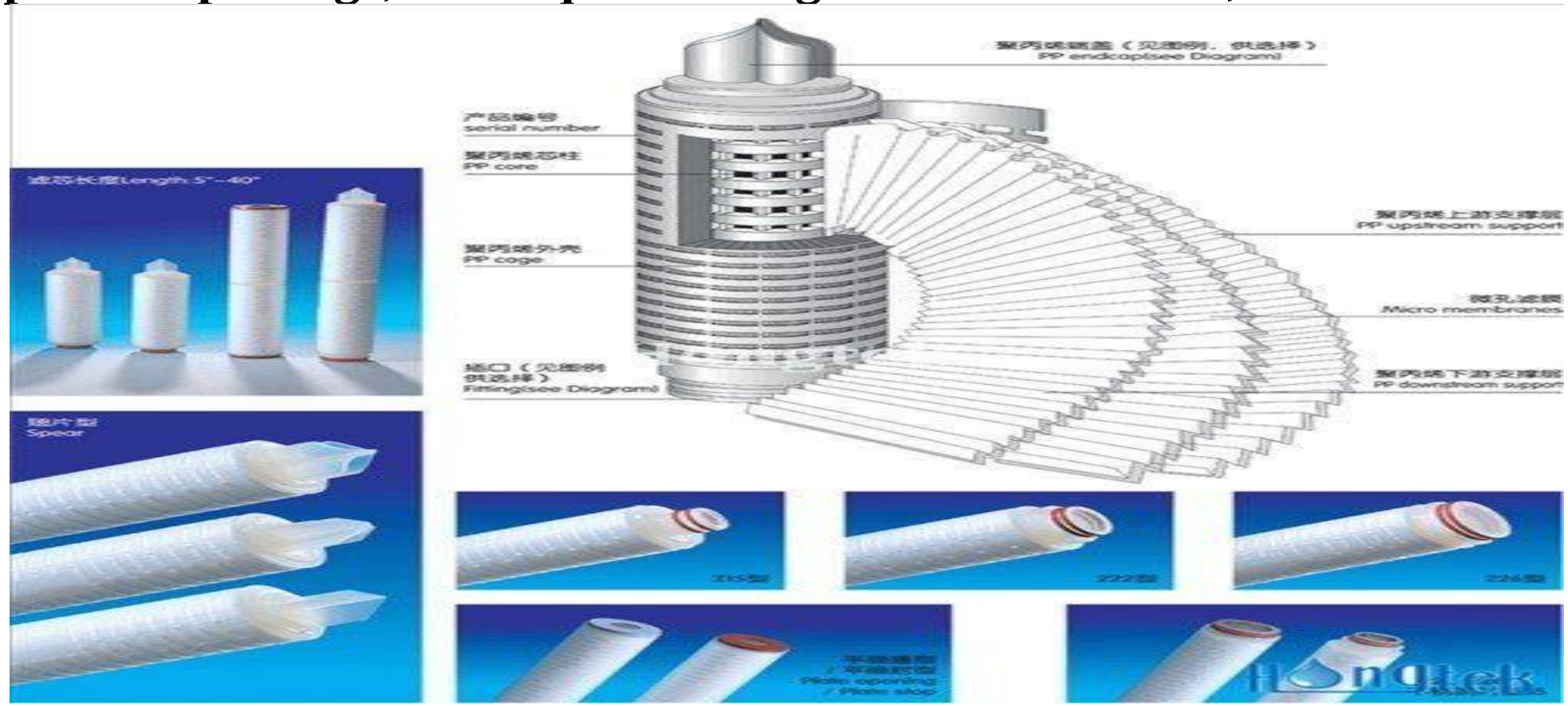
FIG. 7-14. *Disc filter casing* (A) *accommodates precompressed cartridges or disc media. Exploded view* (B) *shows liquid flow through assembled disc. (Courtesy of the Cuno Engineering Corporation.)*


DISCHARGE CONNECTION
AIR VENT CONNECTION
TUBE SHEET
WEDGE WIRE ELEMENTS
INLET CONNECTION
INFLUENT DISTRIBUTOR
DRAIN CONNECTION

A

Cartridge Filters and Systems

Cartridge filters have an integral cylindric configuration made with disposable or cleanable filter media and utilize either plastic or metal structural hardware. With the discovery of strong pleatable membranes such as cellulose nitrate, polyamide, polyvinylidene chloride, PTFE, and nylon, cartridge filters have revolutionized the filtration industry. Cartridge filters provide maximum filtration area in the smallest possible package, allow quick change out of the media, and save time and money.



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Cartridge filters of different shapes, structures, forms, and sizes for different applications in the pharmaceutical industry are now available in disposable and non disposable forms. The housings for cartridge filters come in a wide variety of configurations for both micron and submicron filtration. The major differences in various housings are in the design, materials of construction, seals that are used to install the cartridge in the housing, and the application for which they are used in the pharmaceutical industry. The housing for cartridge filters are described in terms of the height of the cartridge and in the number of cartridge receptacles in the base end of the housing. When a user purchases a housing from one manufacturer, he is usually not "locked in“ to that manufacturer's cartridges.

Adaptors are available that allow the cartridge filter of one manufacturer to fit into virtually any other manufacturer's housing.

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Filter media can be formed into cartridge form by either tubular-wound, string-wound, or pleated formation. Alternate layers of filter media and separator material are rolled into a spiral configuration, and by potting the ends of the cartridge, form the "dead-ended" or "crossflow“ type of flow channels. String-wound cartridges are the most commonly used and inexpensive filters available. Pleated cartridges are modified tubular configurations with a large filtration area.

Disposable or permanent *cartridge filters* are used for fluid clarification or sterilization. Standard elements for nonsterile filtration may be interchanged between cartridge holders offered by several companies (Fig. 7-16). Increases in capacity result from multi-element holders, and 12 element units are usually adequate for batches of 500 to 1000 gallons. The cost of disposable elements is offset by labor savings inherent in the simplicity of assembly and cleaning of cartridge clarifiers.

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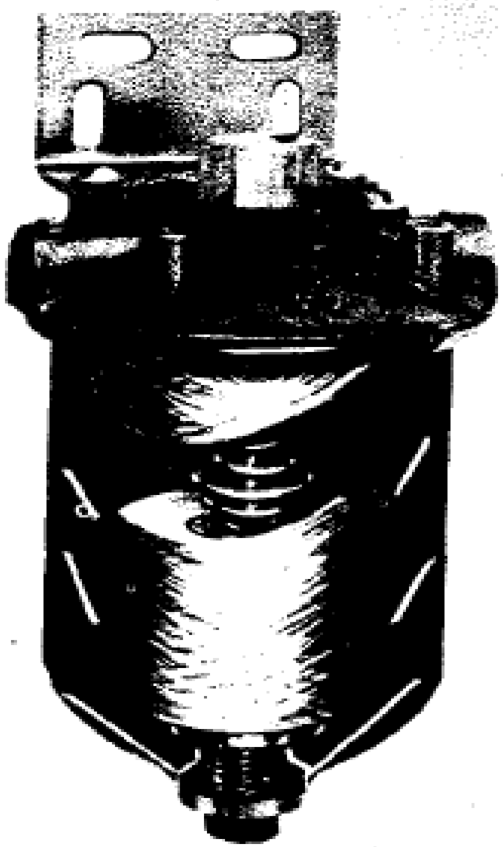

FIG. 7-16. *A disposable wound cartridge is installed in holder. Liquid flows through the element and is discharged through the core. (Courtesy of the Filterite Corporation.)*

The metallic *edge filters,* particularly those with self-cleaning devices (Fig. 7-17), are excellent security filters for suspensions that may plug or blind conventional Wire mesh. A cleaning blade combs away accumulated solids, which fall into a sump in the filter casing.

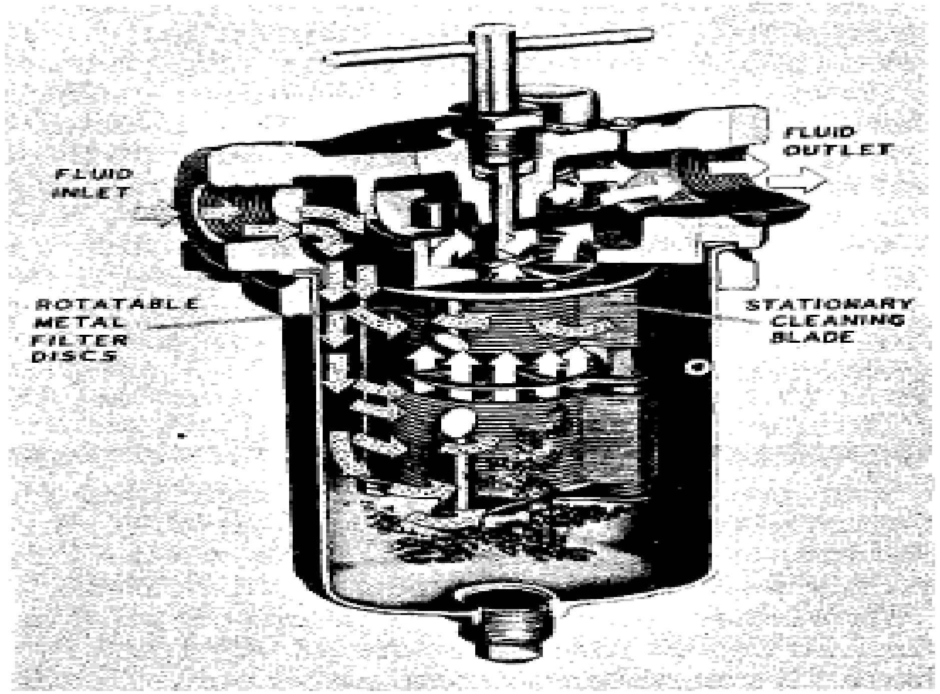

FIG. 7-17. An edge filter with automatic cleaning device may be automated by replacing handle with motor. (Courtesy of the Cuno Engineering Corporation.)

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Laboratory Filtration Equipment

Laboratory equipment catalogs offer a wide choice of funnels and flasks adaptable to pharmaceutical filtration studies. Although a Buchner funnel test permits analysis of the major difficulties in a filtration problem, development laboratories should have additional procedures and apparatus that produce the qualitative conditions expected in large-scale production.

For gravity filtration, conventional glass percolators are applicable, in which case the bottom tube is covered with fibrous material. The filtering funnel is the most common of all laboratory filter devices. Filter paper is used with funnels.

Sometimes, a plug of fibrous material may be used instead. Filter bags for laboratory use are made of fabric and are mounted for gravity filtration.

The uncertainty of adequate clarification with *glass beads* or *sand* has restricted their use as gravity filters for certain operations in the laboratory.

Suction filters are greatly utilized in the laboratory.

Usually, a conical funnel and the Buchner funnel are used for suction filtration, as are immersion and suction-leaf filters. Immersion filter tubes, also known as filter sticks, are generally used for small-scale laboratory operations.

Small-laboratory pressure filters have been used substantially in recent years for both sterile and nonsterile filtration operations.

Gravity and suction filters are used mostly for nonsterile filtration.

Filter paper in circular form is the most common medium for laboratory filtrations. Filter papers are available in a wide variety of textures, purities, and sizes and are available for different uses. They may be circular (1 to 50 cm in diameter), folded, or arranged in sheets or rolls.
Among the special types of laboratory filter paper for pharmaceutical industry are:
1. Filter papers impregnated with activated carbon for adsorption of colors and odors in pharmaceutical liquids.

2. Filter paper impregnated with diatomaceous earth for removal of colloidal haze from liquids with low turbidity.
Minimum laboratory equipment includes a plate and frame press, a membrane filter holder, and a single-element housing for disposable cartridges.
A 6- or 8-inch, stainless steel filter press with four to eight filter surfaces and sludge frames is adequate.

Cake Filtration

Cake filtration in which solids recovery is the goal is an important- pharmaceutical process.

Personnel involved in synthesis or fermentation to produce bulk active ingredients consider cake filtration to be the primary aim of the unit operation.

The plate and frame press and precoat pressure filters used for clarification also are applied to solids recovery. The basic design is often modified to reduce the high labor factor. In general, these pressure filters are restricted to batch operation and recovery of moderate weights of expensive materials.

For large-scale operations, continuous vacuum filters are most widely used. The *rotary drum vacuum filter* is divided into sections, each connected to a discharge head. The slurry is fed to a tank in which solids are held in suspension
by an agitator. As the drum rotates, each section passes through the slurry, and vacuum draws filtrate through a filter medium at the drum surface.
The suspended solids deposit on the filter drum as a cake, and as rotation continues, vacuum holds the cake at the drum surface. The cake is washed and dried as it moves toward the discharge point. It may be scraped from the drum or it may be supported by strings until it breaks free under gravitational forces. Many variants of the basic design are needed to accommodate differences in cake formation, drying rates, and discharge properties.

Rotary Drum Vacuum Filter

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https://www.911metallurgist.com/equipment/rotary-drum-filters/

***Filtering centrifuges* are another general class of solids recovery devices. In this method of filtration, centrifugal force is used to affect the passage of the liquid through the filter medium.**

This type of filtration is particularly advantageous when very fine particles are involved.

This device is fitted with a perforated basket, which supports the filter media. The basket revolves inside the casing. Slurry is sprayed into the basket, in which centrifugal action forces the filtrate through the media on which the cake deposits. Continuous discharge of solids is possible, but batch units that require shutdown for removal of solids are also common.

Whenever solids recovery is the primary goal, centrifuges must be considered as an alternative to filtration.

Membrane Ultrafiltration

Membrane ultrafiltration has become a commercially feasible unit operation in the past decade. Unlike conventional filtration, ultrafiltration is a process of <u>selective molecular separation.</u>

It is defined as a process of removing dissolved molecules on the basis of membrane size and configuration by passing a solution under pressure through a very fine filter.

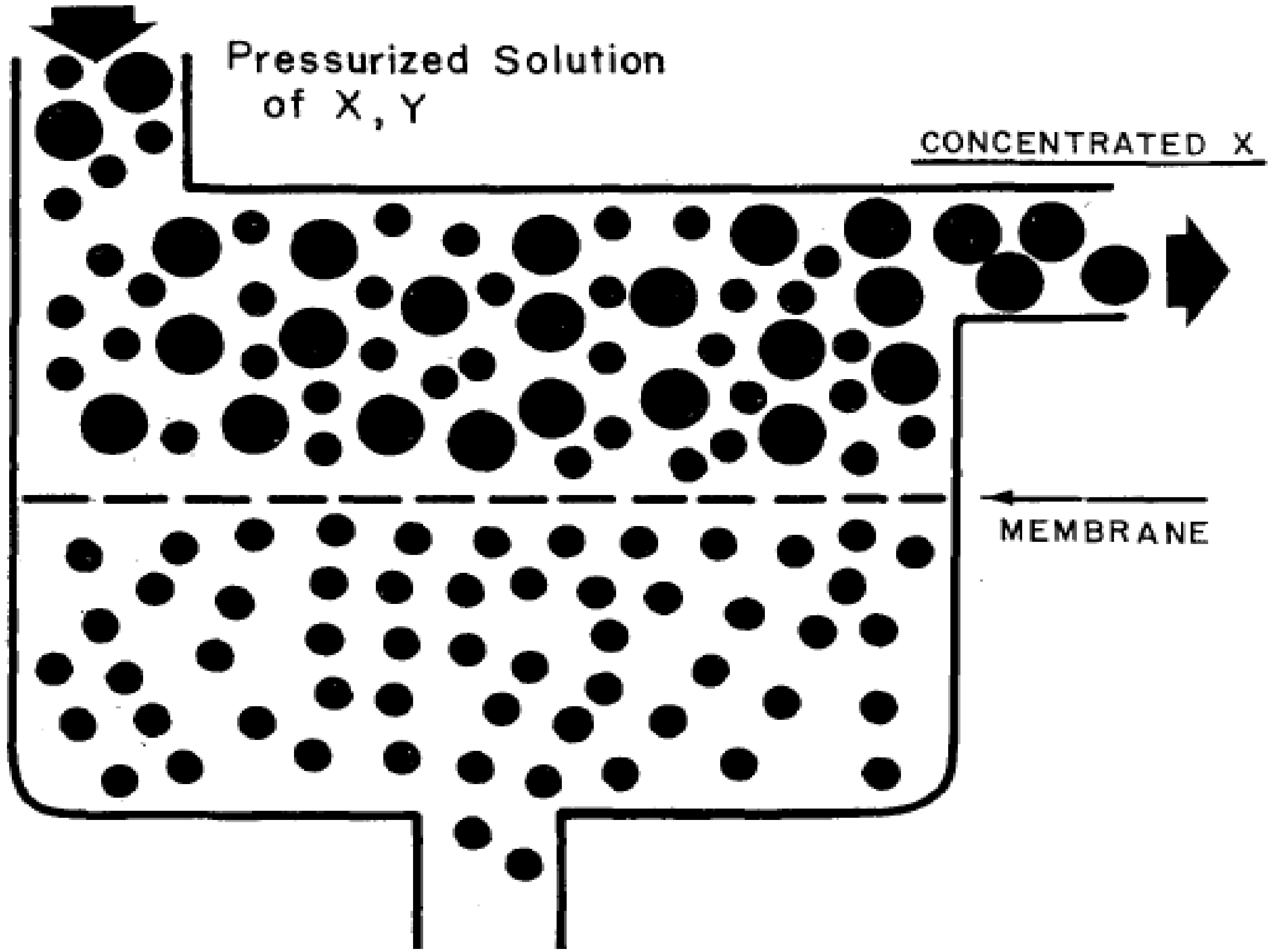
Ultrafiltration membrane retains most macromolecules while allowing smaller molecules and the solvent to pass through the membrane, even though the membrane is not rated as absolute.

The difference between microfiltration and ultrafiltration is significant. The former removes particulates and bacteria; the latter separates molecules. Application of hydraulic pressure reverses the normal process of osmosis, so that the membrane acts as a molecular screen through which only those molecules below a certain size are allowed to pass.

Separation of a solvent and a solute of different molecular size may be achieved by selecting a membrane that allows the solvent, but not the solute, to pass through. Alternatively, two solutes of different molecular size may be separated by choosing a membrane that passes the smaller molecule, but holds back the larger one (Fig. 7 -20). Ultrafiltration is similar in process to reverse osmosis; both filter on the basis of molecular size. Ultrafiltration is different from reverse osmosis in the sense that it does not separate on the basis of ionic rejection. Dialysis and ultrafiltration are similar in the sense that both processes separate molecules, but ultrafiltration is different in that it does involve the application of pressure. The selectivity and retentivity of a membrane are characterized by its molecular weight cutoff. It is difficult to characterize the porosity of an ultrafiltration membrane by means of precise molecular weight cutoff. The configuration of the molecule and its electrical charge may also affect the separation properties of the membrane. Ultrafiltration membranes are available as flat sheets, pleated cartridges, or hollow fibers.

These membranes are fragile structures, however, and usually require a backing plate of porous material to withstand operational pressure. During the processing of a solution, a region of high solute concentration also develops at the surface of the membrane, resisting further passage of solvent. Providing essential support for the membrane and overcoming concentration polarization through shear effects have resulted in a wide variety of commercial apparatus, including tangential-flow cassette systems, process ultrafiltration cartridges, hollow fiber beakers, and collodion bags. Since the technology continues to change rapidly, reliance on technical expertise of the manufacturer is advisable.

Applications in the pharmaceutical industry are predominantly in the concentration of heat labile products, such as vaccines, virus preparations, and immunoglobulins. Ultrafiltration also has been used to recover antibiotics, hormones, or vitamins from fermentation broths, to separate cells from fermentation broth, to clarify solutions, and to remove low-molecular-weight contaminants prior to using conventional recovery techniques. The most important application of ultrafiltration is the removal of pyrogens.



Pressurized Solution of X, Y
CONCENTRATED X
MEMBRANE