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selection guide and catalogue

amicon

ultrafiltration

concentration . . . desalting . . . separation
of solutions and suspensions

MEMBRANE FILTRATION

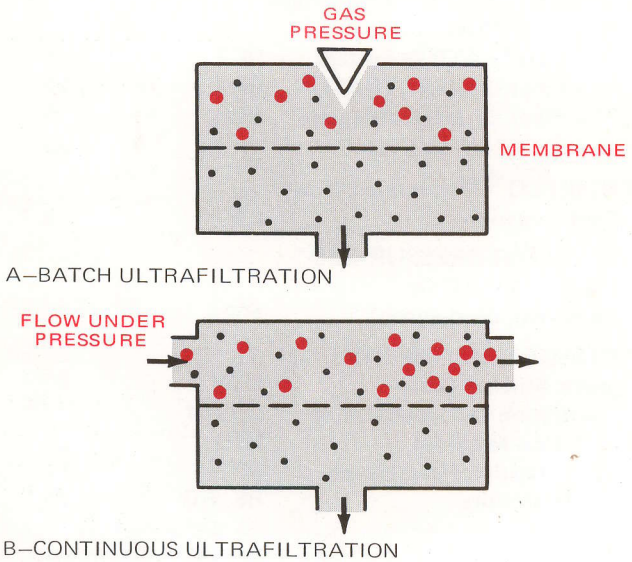
Membrane filtration separates dissolved or particulate material from liquids by means of a semipermeable barrier that retains substances above a predetermined "cut-off" level, allowing solvents as well as micro-constituents to pass.

Ultrafiltration

Ultrafiltration (UF) is a process of selective molecular separation. It employs membranes with pore diameters in the general range of 10 to 500 Å (0.001 to 0.005 μm) which retain solutes and particles of larger molecular dimensions, passing solvent and solutes of smaller size. Driving force is generally provided by hydraulic pressure.

In ultrafiltration equipment, the sample or process liquid is either held "dead-ended" above the membrane (Fig. 1a) or passed across the membrane (Fig. 1b). Pressure – typically 5 to 100 psi (0.4 to 7 atm) is provided by compressed gas (e.g., nitrogen), pumping or centrifugal force. Retained substances are progressively concentrated upstream. Solvent and membrane-permeating species emerge as ultrafiltrate.

Fig. 1–MEMBRANE FILTRATION



A–BATCH ULTRAFILTRATION

B–CONTINUOUS ULTRAFILTRATION

In contrast with UF, reverse osmosis (RO) normally refers to use of membranes capable of retaining solutes within one order of magnitude of the solvent, operating at relatively high pressure, and low flow per unit membrane area. Amicon currently offers no RO membranes; however, the Model 420 cell is designed for RO use.

Particulate filtration employs "microporous" filters with mean porosities upward of 0.1 μm. They retain bacteria, colloidal constituents, or other particulate materials.

An Important Factor

Concentration Polarization

Macrosolute (or colloid) polarization refers to a concentration gradient above the filter – with solute content highest at the membrane surface. Occurring in all filtration systems, the extent of concentration polarization is determined by macrosolute content of the process fluid, temperature (presumably related to viscosity), as well as system geometry. If left undisturbed, concentration polarization restricts solvent and solute transport through the filter. It can also alter filtration selectivity by forming a gel layer on the membrane surface – in effect a secondary membrane. Another consequence is increased rejection of permeating species above approximately 5,000 MW when mixed with a highly retained species; i.e., a species which readily permeates the membrane will no longer pass at the same rate when admixed with a retained substance.

For effective filtration, it is essential to provide operating conditions which minimize concentration polarization, promoting highest transmembrane flow and selectivity. Amicon offers a wide range of systems which make it possible to provide a high degree of polarization control if required.

Those systems include:

Dead-Ended Non-agitated cells – no polarization control.

Stirred Cells – moderate polarization control, and

Thin-Channel (TC) Systems – high polarization control.

NON-AGITATED UNITS (Fig. 2)

No polarization control. Only for low macrosolute content (<1%) and small process volumes (<10 ml).

For partioning or concentrating small amounts of dilute solutions, a small, propellent-pressurized cell finds wide use. Or, with CENTRIFLO membrane cones, small samples may be quickly deproteinized or concentrated almost to dryness in a lab centrifuge.

STIRRED CELLS (Fig. 3)

Moderate polarization control. In batch-type UF cells, magnetic rotary stirring close to the membrane surface, has proven to be highly effective and as efficient as any other agitation method – operating smoothly down to very small volumes. Stirred cells are particularly useful over a broad volume range of dilute solutions (up to 5% macrosolute). Concentration as high as 1000:1 in multiple steps, and solvent recovery up to 99% can be achieved.

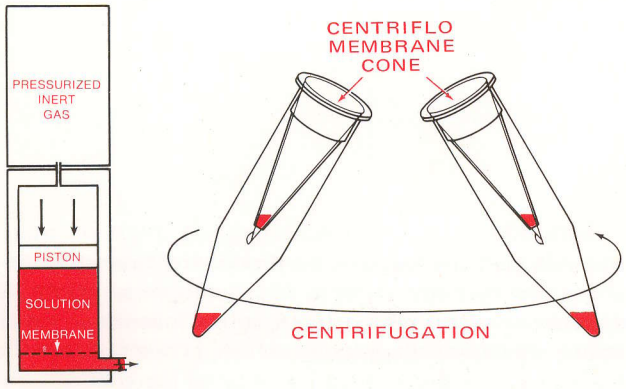


Fig. 2—NON-AGITATED UF DEVICES for relatively dilute solutions: (left) Model 10PA propellent-pressurized UF Cell; (right) CENTRIFLO

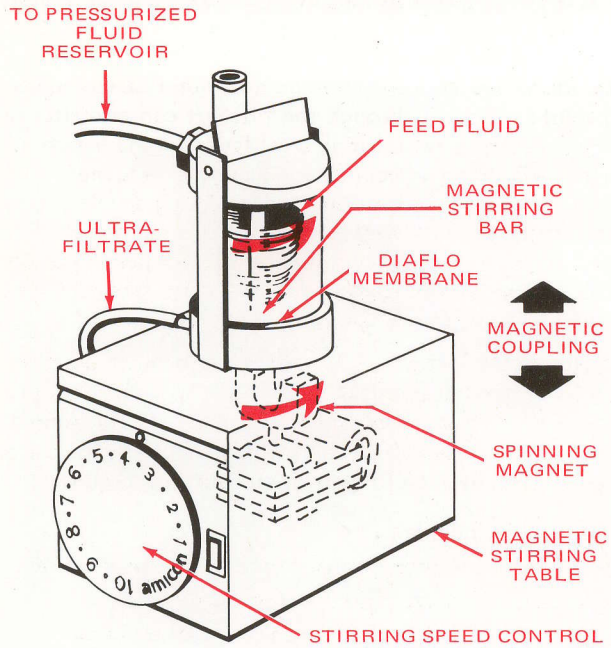
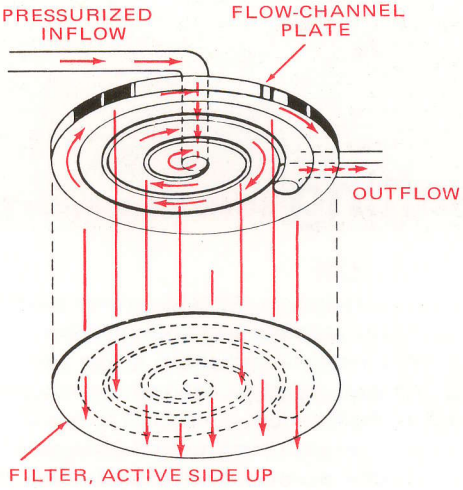


Fig. 3—STIRRED CELL for moderate polarization control, widest general usefulness



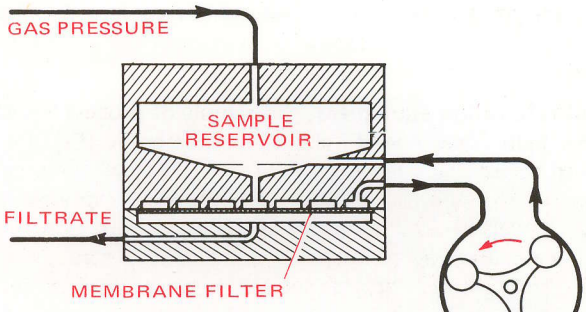


Fig. 4—THIN-CHANNEL SYSTEM. Recirculation of process stream through shallow channel minimizes concentration polarization, sustains high-rate filtration

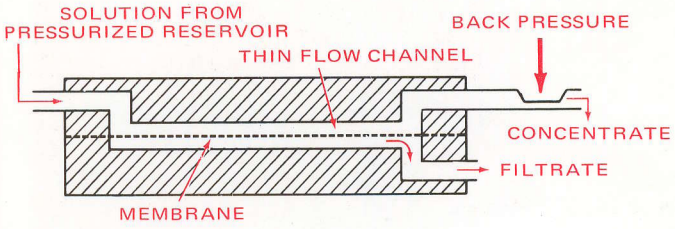


Fig. 5—SINGLE-PASS FLOW through thin channel, for easily denatured solutes

THIN-CHANNEL (TC) SYSTEMS (Fig. 4)

High polarization control. The fluid sweeps across the membrane through shallow channels, with accompanying shear at the membrane surface. This results in increased transmembrane flow — several times higher than in agitated "dead-ended" systems.

Thin-channel UF offers significant advantages:

- High ultrafiltration rates despite macrosolute content up to 40% or higher.
- Improved fractionation (partition) of macromolecular mixtures. Minimizing the accumulation of larger species on the membrane gives smaller species better access to and improves their passage through the membrane.

Recognizing that solutes differ in susceptibility to shear during recirculation through a pumped system, Amicon also offers thin-channel equipment designed for single-pass flow (Fig. 5). This has proven extremely effective for the rapid concentration of delicate biologicals — without cell lysis or solute denaturation. Single-pass flow offers the additional advantage of immediate output at **full** concentration.

With microporous DIAPOR filters, thin-channel equipment is often remarkably effective for separating colloidal and particulate systems with high solids content which tend to plug the membrane in conventional, dead-ended filtration equipment.

Amicon's DIAFIBER Hollow Fiber Cartridges have the geometry of thin-channel systems. They provide, therefore, a high degree of polarization control.

For details of the above equipment, see Equipment Selection and Catalog Sections.

Desalting Solute Extraction or Exchange

DIAFILTRATION

In simple ultrafiltration, as the total volume is reduced, the concentration of membrane-permeating species (microsolutes or salts) remains unchanged in the retained fluid. As shown in Fig. 6, effective removal of microsolute may be achieved by diafiltration – repeated or continuous dilution of the solution with fresh solvent (dialysate). This, in effect, washes the permeating species through the membrane. This technique takes 1/10 to 1/100 the time of conventional dialysis. Diafiltration may also be used for salt exchange: dialysate, with the desired microsolute, "washes" the undesired species from the process solution while introducing the new environment. With appropriate membranes, diafiltration effectively partitions mixed macrosolutes, facilitating removal of those species which, as mentioned earlier, are impeded by the polarization of larger material.

Continuous diafiltration (with automatic solvent replacement matching the ultrafiltration rate), requiring less dialysate and consequently less time, is far more efficient than the discontinuous method. The typical set-up shown in Fig. 6 employs a special valve (CDS10) which keeps sample

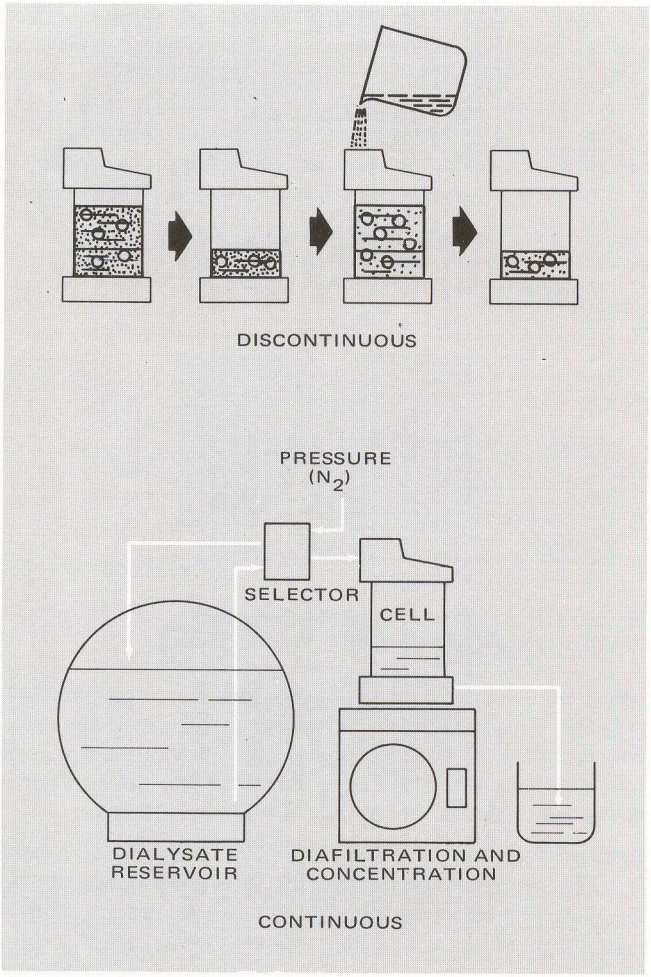


Fig. 6 - DIAFILTRATION BIJ ALTERNATE METHODS. Continuous diafiltration is far faster, uses less dialysate. For example, 99% salt removal from 5 ml by repeated dilution requires 99 ml of dialysate. Only 23 ml needed for continuous diafiltration - a 4 : 1 saving.

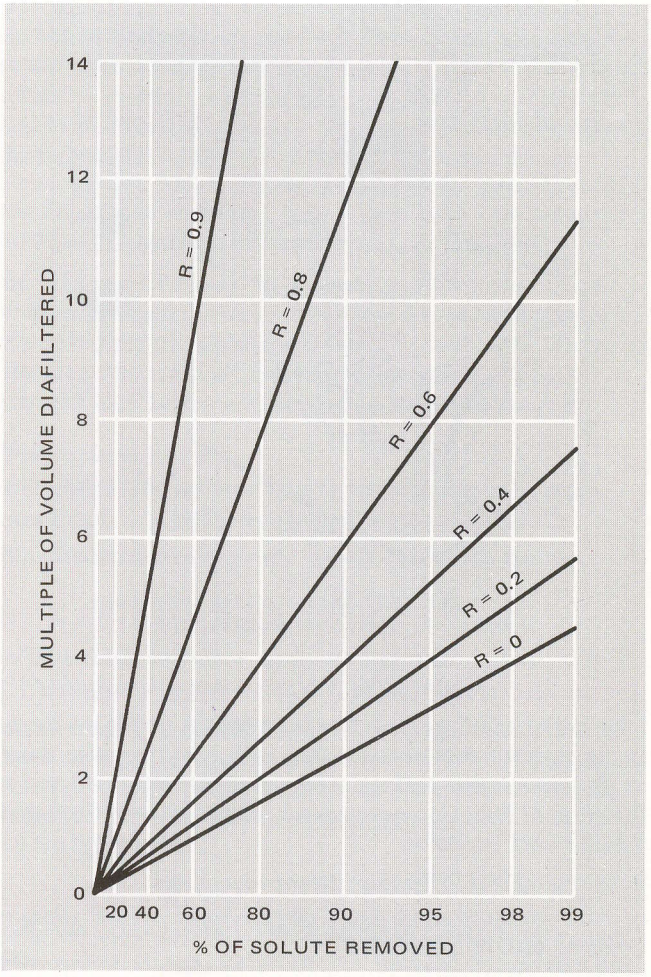


Fig. 7 - SOLUTE SEPARATION by continuous diafiltration. Clearance of solutes with different degrees of retentivity shown in terms of dialysate volume (multiples of the sample volume). R = rejection coefficient. (R = 1.0 for total retention by membrane; R = 0 for free passage; For calculation; see Applications Manual, Pub. 427.)

volume constant. Salt and other microsolutes (Rejection = 0) may be rapidly removed or exchanged by this technique, 99% effective wash-out (or wash-in) occurring with a 5-volume turnover. Fig. 7 shows the solvent volumes required for various degrees of solute removal, as a function of rejection.

Most Amicon equipment — stirred cells, thin-channel systems, and hollow fiber systems — can be used in the diafiltration mode. For detailed descriptions, please refer to the Catalog Section, the APPLICATIONS MANUAL, or individual equipment data sheets referenced in this publication.

DIALYSIS

Some of Amicon's hollow fiber equipment provides for the use of DIAFIBER Membrane Cartridges in the conventional dialytic mode. As illustrated by Fig. 8, the process stream flows through the fiber interiors while the dialysate stream moves around the fiber bundle. Microsolutes (salts) exchange through the fiber walls. In Model DC2 (Fig. 9), salts and other membrane-permeating species also pass through the fiber convectively, i.e., by UF. This combination of diffusive and convective transport results in extremely high desalting rates with DIAFIBER Membrane Cartridges.

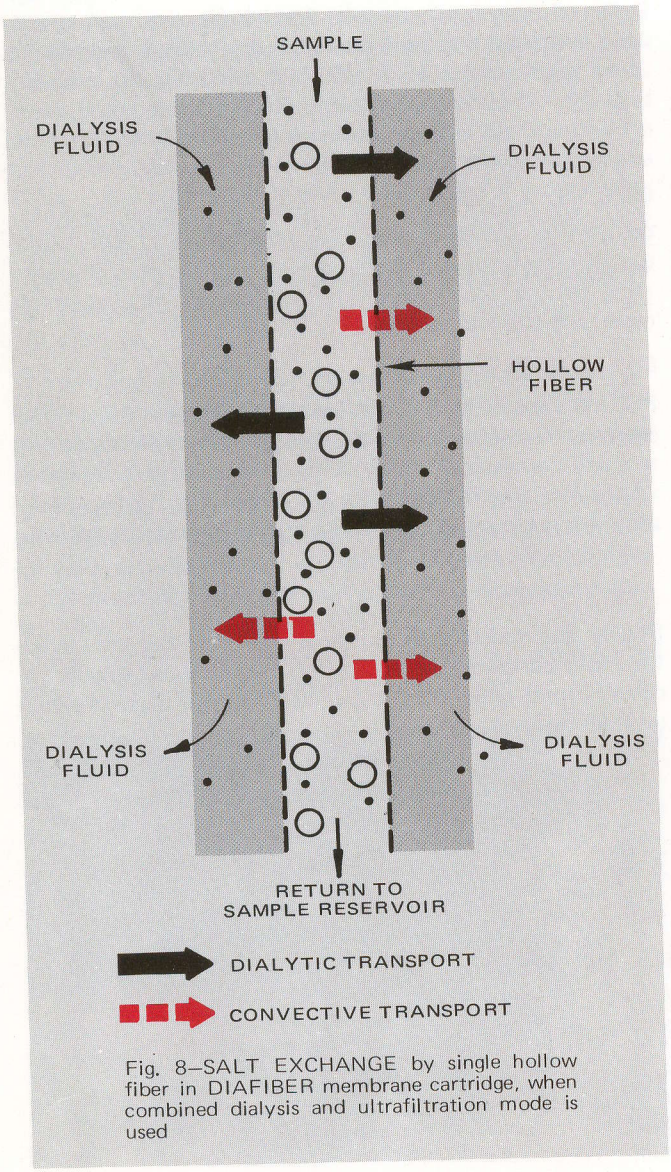


Fig. 8—SALT EXCHANGE by single hollow fiber in DIAFIBER membrane cartridge, when combined dialysis and ultrafiltration mode is used

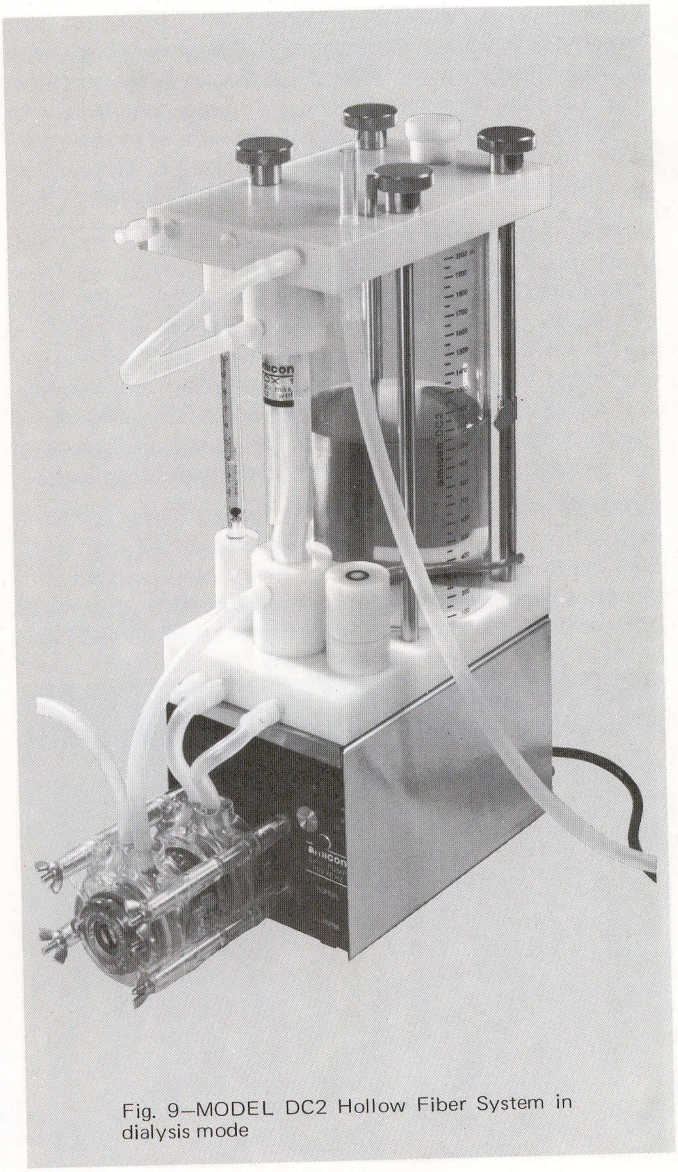


Fig. 9—MODEL DC2 Hollow Fiber System in dialysis mode

EQUIPMENT CATALOG

This section presents equipment designed to take maximum advantage of the unique properties of Amicon's membrane filters. With accessories, these units can be combined into systems to perform a variety of functions or to operate unattended. For selection guidance, see pages 10-13.

For detailed descriptions of applications, please refer to the APPLICATIONS MANUAL, Publication 427, or to individual Technical Data Brochures. In addition, each unit is shipped with detailed Operating Instructions.

Stirred Cells

STANDARD CELLS

Models 12 through 402

Designed for quick opening and reassembly of all parts without tools. One-step clamp opens and closes cell. Magnetic stirring minimizes concentration build-up near membrane surface, avoids foaming when volume is low. Stirring bar easily removed for cleaning or replacement. Membrane, held on disposable porous disk in bottom, is installed or removed in seconds. Transparent sleeve calibrated in ml. Fittings assure leak-free seal by finger-tightening. Magnetic stirring table required (see page 27).

Pressure relief valve set for 90 psi (6.3 atm), with built-in, easy-bleed feature. Combined with fill port plug.

All materials in contact with liquid are biologically compatible nylon, Teflon* or other inert plastics. Sleeves are polycarbonate plastic, membrane support disks of porous polypropylene. For use with solvent or solvent/water systems, Model 401S is recommended. These cells withstand repeated autoclaving or water boiling, exposure to ethylene oxide, 70% alcohol, 5% formalin.

Furnished with 1/4-inch O.D. polyethylene tubing, extra O-rings, and membrane support disks.

Table 8 — STIRRED CELL CHARACTERISTICS

		Standard Cells				High Flow	Special Cells		Micro-Systems	
MODEL:		12	52	202	402	2000(1)	401S	420	8MC	MMC
Max. Internal Volume	(ml)	10	65	200	400	2000	400	350	8	10 (x8)
Stirred Min. Volume	(ml)	1	2.5	5	10	60	15	15	0.3	0.3 (x8)
Membrane Diameter	(mm)	25	43	62	76	150	76	76	25	25 (x8)
	(in)	1	1.75	2.5	3	6	3	3	1	1 (x8)
Effective Membrane Area	(cm^2)	3.6	12.5	27.5	39.2	162	39.2	39.2	2.8	2.8 (x8)
	(in^2)	0.56	1.94	4.27	6.08	25	6.08	6.08	0.4	0.4 (x8)
Max. Operating Pressure	(psi)	75	75	75	75	100	250	1500	75	75
	(atm)	5	5	5	5	7	17.5	105	5	5
Dimensions (approx.)	(in)	4x2	5x2	6x3	8x4	17x8	8x4.5	8x4.5	5x6x2	7x5x2.5(2)
(HxDia or HxLxW)	(cm)	11x5	13x5	15x7	21x9	45x19	20x11	20x11	13x15x5	18x13x6(2)
Weight (approx.)	(lbs)	0.5	0.5	1	2	22.5	7	13	2.5	7.6(3)
	(kg)	0.25	0.3	0.45	0.85	10	3	6	1.1	2.6(3)
See page		14	14	14	14	16	16	16	17	17

Notes: 1 — For unit with Teflon-coated stainless steel sleeve, Order No. 2000C.
2 — Dimension of Cell only. Reservoir (HxDia.) 7x4½ in (18x11.5 cm).
3 — System weight includes reservoir.

*T.M. DuPont Co.

COMPLETE SYSTEM for CONCENTRATION and DIAFILTRATION

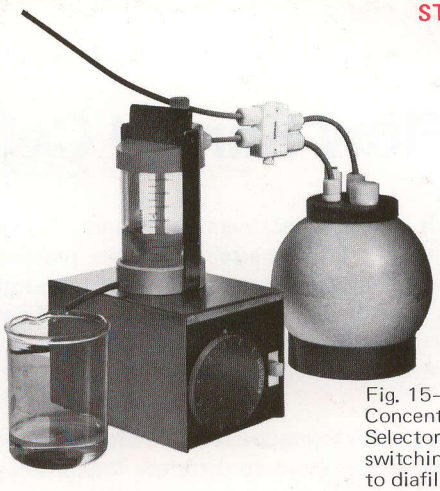


Fig. 15–
Concentration/Dialysis (C/D) Selector permits instant switching from concentration to diafiltration

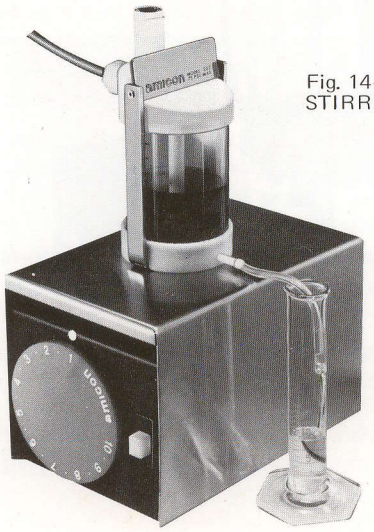


Fig. 14–MAGNETICALLY STIRRED UF CELL

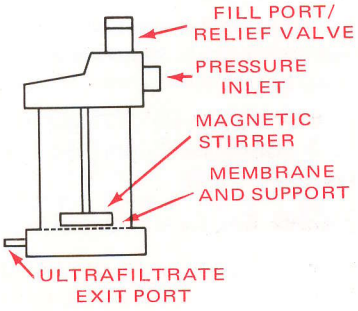


Fig. 16–STIRRED CELL SCHEMATIC

Fig. 17–STANDARD STIRRED CELLS

High-Flow Stirred Cell

Model 2000

High-output unit, with large membrane area. Integral, motor-driven, magnetic stirring assembly, easily removable for cell sterilization. Solid-state power supply smoothly controls stirring from 0 to 800 rpm. Stainless steel parts, incl. knurled fittings. Fill port removable without tools. Pressure relief valve set for 125 psi (9 atm), with knob for manual bleed.

All parts in contact with liquid are inert. Transparent sleeve of acrylic plastic; other internal parts are Teflon-coated stainless steel, Delrin* or acrylic. Delrin stirring assembly rotates in nylon bearings. The acrylic cylinder may be sterilized with ethylene oxide or 5% formalin. All other parts in contact with solution may be autoclaved or chemically sterilized. To obtain unit with Teflon-coated stainless steel sleeve, Order No. 2000C.

Furnished with 1/4-inch (6 mm) O. D. polyethylene tubing, extra O-rings, and membrane support disks. Polypropylene tubing furnished upon request.

SPECIFICATIONS See Table 8, page 14.

Fig. 18B –MODEL 2000

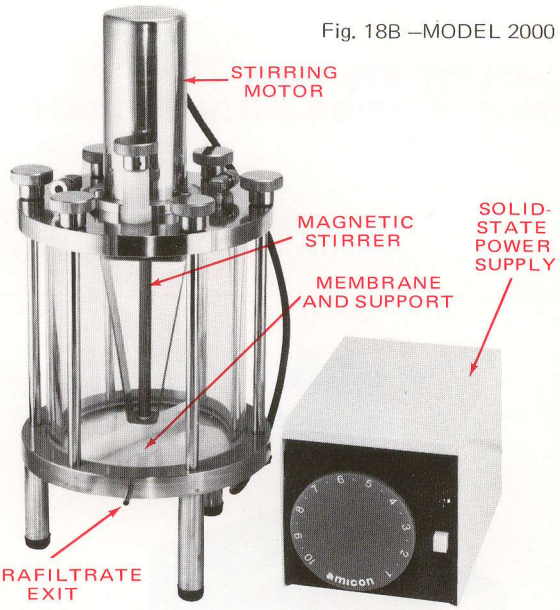
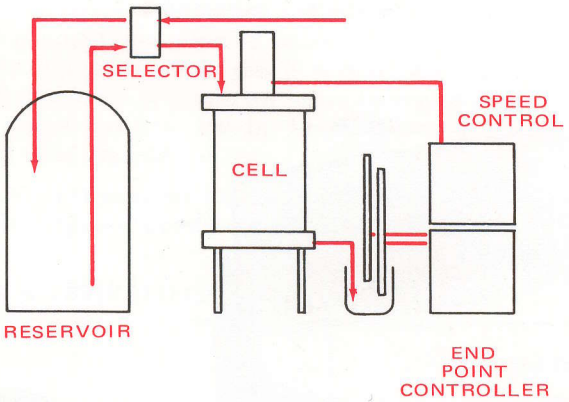


Fig. 18A–DIAFILTRATION SYSTEM



Special Cells

HEAVY-DUTY CELL
Model 401S

For elevated pressures and for use with corrosive liquids or organic solvents. Type 304 stainless steel, inside entirely Teflon-coated. Inert magnetic stirring assembly (magnetic stirring table required). Pressure relief valve set for 250 to 300 psi (17.5 to 21 atm), with toggle lever for manual bleed.

May be sterilized chemically or by autoclaving. Furnished with extra membrane, support disks, O-rings, polypropylene tubing.

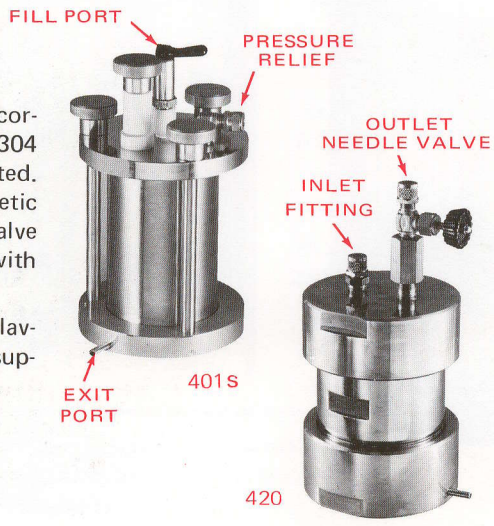


Fig. 19–SPECIAL CELLS

HIGH PRESSURE CELL
Model 420

Exceptionally sturdy, for use at pressures up to 1500 psi (105 atm). Built-in magnetic stirring assembly. Due to heavy steel construction, use of Amicon's high-performance magnetic stirring table MT2 is recommended (see page 27). Typical applications include desalination or other reverse osmosis operations on a laboratory scale.

Stainless steel, with all internal surfaces heavily Teflon-coated. O-rings of Buna-N. Membrane support of porous stainless steel. High-pressure valve is provided at the gas inlet. Sterilizable chemically or by autoclaving. Special wrenches included.

SPECIFICATIONS See Table 8, page 14.

*T.M. DuPont Co.

Accessory Equipment

MAGNETIC STIRRING TABLE
Model MT2

A reliable accessory for stirred ultrafiltration cells as well as for general laboratory duty.

Gives off virtually no heat. Solid-state controller assures smooth stirring speed control to very low rpm. Heavy-duty, ball-bearing motor drives oversize magnet, assures proper coupling with stirring bars at all speeds – from 50 to 1500 rpm. Illuminated power switch. Stainless steel top plate easy to clean, unaffected by spilled reagents or solvents. Indentations in top plate provide accurate location of Models 12, 52, 202, 402,and 401S.

SPECIFICATIONS

Power	230V, 50 Hz.
Dimensions (WxLxH)	5x8x5 in (12 x 20 x 12 cm)
Weight	7 lbs (3 kg)

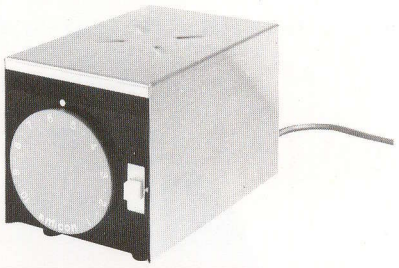


Fig. 38–MODEL MT2
Magnetic Stirring Table

CONCENTRATION/DIALYSIS SELECTOR
Model CDS10

A valve block with sliding control for instant manual switching of a system from concentration to diafiltration. By switching gas and liquid lines simultaneously, this unit greatly simplifies operation and avoids the need for multiple T-fittings and valves.

Rugged construction, with components of Delrin and polypropylene plastic. It can be sterilized by autoclaving or chemically.

Furnished with fittings and tubing. Fig. 39 illustrates the functions of the two positions.

SPECIFICATIONS

Max. Operating Pressure	250 psi (17 atm)
Dimensions	3x3.5x0.75 in (7.5 x 8 x 2 cm)
Weight	8 oz (226 g)

Fig. 39–MODEL CDS10
Concentration/Dialysis Selector

PUSH-BUTTON MANIFOLD
Model MF2

A valuable tool for the laboratory equipped with multiple ultrafiltration cells and reservoirs. Provides instant direction of gas pressure or liquid flow in multi-cell or multi-reservoir systems.

Possible arrangements:

- Pressurize several cells or reservoirs from one gas source. Push buttons to turn individual units on and off.
- Feed several cells from one reservoir. Diafilter (dialyze) several samples simultaneously with a common solvent or buffer source.

Made of inert plastics. May be autoclaved or chemically sterilized.

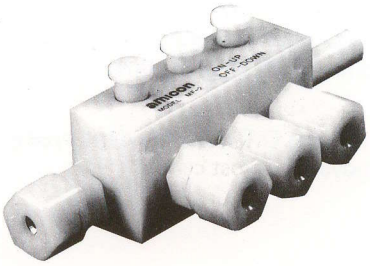


Fig. 40—MODEL MF2
Push-Button Manifold

SPECIFICATIONS

Pressure Rating:	250 psi (17 atm)
Dimensions (WxLxH)	4 x 4 x 1.75 in (10 x 5 x 4.5 cm)
Weight	8 oz (226 g)

PRESSURE REGULATOR and GAUGE
Model PR1

Double-stage regulator for use with nitrogen or argon. Uniform and constant pressure regulation assured. Safety check valve interrupts flow of high-pressure gas. Stainless steel diaphragms in high- and low-pressure stages will not "set" under pressure.

Equipped with special quick-connect/disconnect outlet fitting for attachment of UF systems without tools.

SPECIFICATIONS

Max. Output Pressure	120 psi (8 atm)
Weight	5 lbs (2.2 kg)

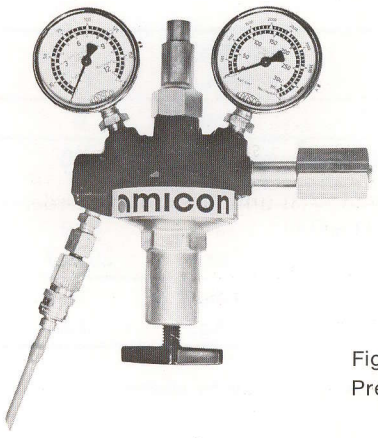


Fig. 41—MODEL PR1
Pressure Regulator and Gauge