The complete function performed by a continuous vacuum filter from start to completion of separation is called the "filter cycle".

There are four basic forms of vacuum filters: (1) The rotary drum exterior type, (2) the rotary drum interior type, (3) the rotary disc type, and (4) the rotary horizontal type.

ROTARY DRUM EXTERIOR FILTER

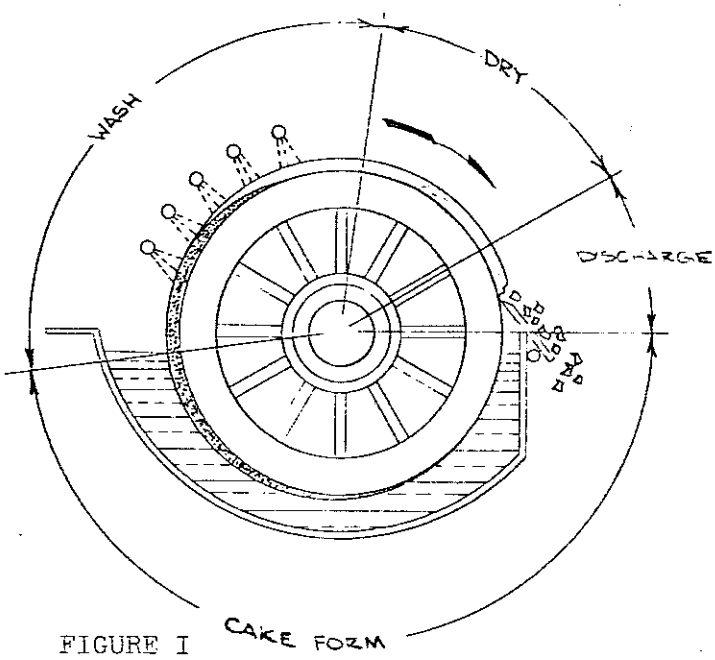


FIGURE I

TYPES OF FILTERS

Nearly all vacuum filters use the same general principles and component parts in their function, namely:

1. A container to hold the filter feed. ---This is called the filter tank.
2. A material which allows passage of the liquid or filtrate but stops the passage of the solids or cake.--- This is called the filter medium.
3. A means of support for the filter medium which is usually called the cover support or decking to denote the complete structure, its component parts being subdivided when named specifically.
4. A passage for the filtrate to pass out of the filter which is usually called piping.
5. A means of generating sub-atmospheric pressure differentials to cause the filtrate to pass through the filter and be separated from the cake.---This is usually called the vacuum system.

The drum filter is perhaps the best known filtration unit and has served as the basis for the many variations in use today. Its basic design incorporates a compartmented drum or cylinder which revolves in a shallow tank containing slurry to be filtered. At the start of the cycle, the drum is submerged in the filter tank. Vacuum draws the slurry against the medium, allowing the filtrate to pass through, while cake is deposited on the filter medium. After passing through the medium or cover, filtrate is collected in the compartments and fed through pipes to a filter valve.

During the initial pickup very few solid particles are deposited on the filter medium, allowing some of the finer particles to get through. The filtrate at this point is usually cloudy and not as

clear as might be desired. But, as the cake builds up, it itself becomes a filter medium. It compacts tighter and tighter, and the filtrate begins to clear up. Just before the section leaves the slurry in the tank, the cake reaches its maximum thickness. All of the above takes place with the section submerged.

As soon as the section has emerged from the slurry it is in the open and further work can be done on the cake from the outside of the drum. The use of a solvent wash helps to further dissolve any particles which may still be included in the cake, and which must be removed from the cake. The vacuum draws the solvent wash liquid through until it has transversed the entire thickness of the cake.

The section then moves on to a position where clear water may be used to further wash the cake.

After the washing cycle, there is usually a certain part of the cycle allowed for merely pulling air through the case in order to dry it out as much as possible. This portion of the cycle is sometimes equipped with a hot air hood over the filter drum which allows hot air to be drawn through the cake, and which accelerates the drying. Following the drying part of the cycle, the section is now ready for the final stage which is discharging the cake.

CROSS SECTION ROTARY DRUM FILTER

The scraper blade removes the solids (cake) from the medium during each revolution. This presents a clean cloth for each pass through the slurry.

Each of the drum filters can be varied in a number of different ways. For instance, filter tanks can be equipped with agitators of various types to prevent segregation of feed solids, submergence of the drum can be varied in an effort to affect cake moisture, and types and methods of filter medium support can be altered. Vapor tight or vapor retaining hoods can be provided on vacuum filters for noxious gases and sterile conditions. Another wide variation in drum filters is the method of cake discharge, whether it be scraper, wire, roll, or string. Perhaps the widest possible variations exist in materials of construction which have run the gamut from wood to plastic, mild steel to various alloy steels, as well as rubber covered metal.

ROTARY DRUM INTERIOR FILTER

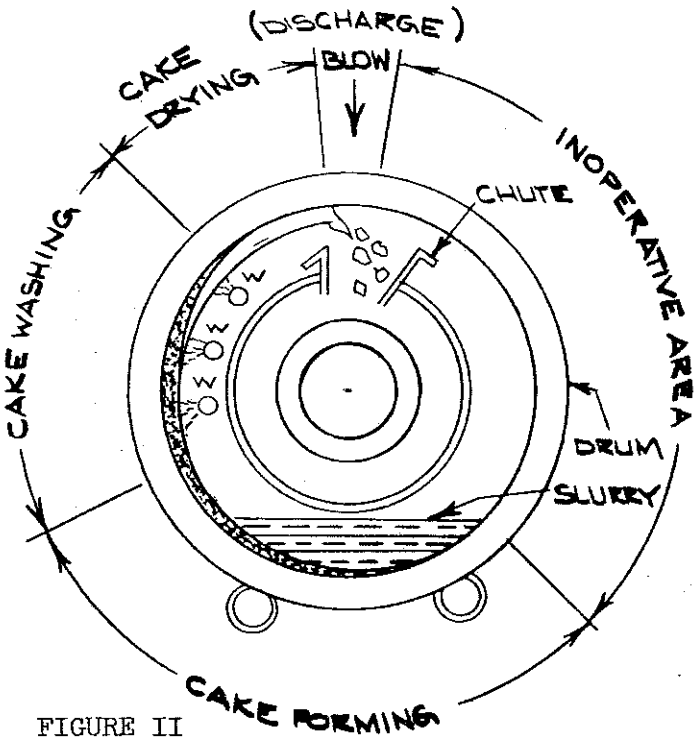
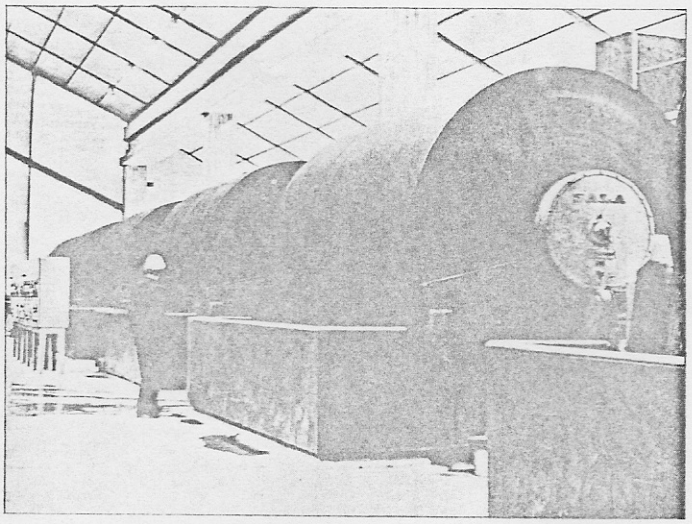


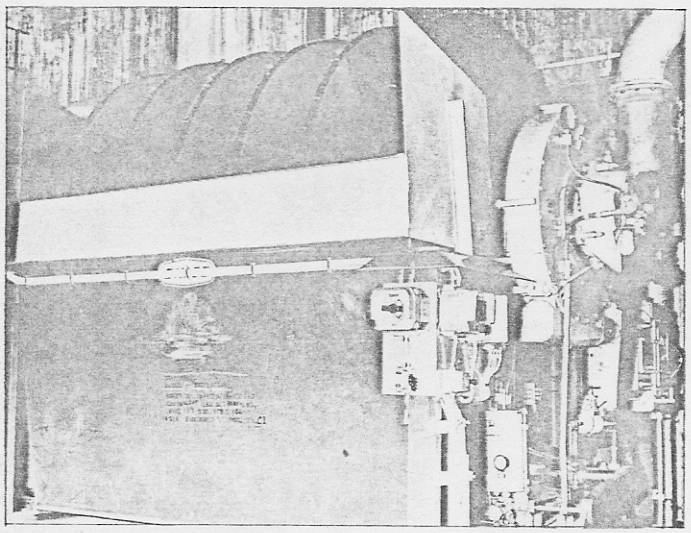
FIGURE II

The internal type of rotary drum filter shown in Figure II is also known as the Dorrco filter. This filter was brought out originally by the Dorr Company. Each section goes through a cycle similar to the exterior drum type which we just discussed. The filter, of course, as the name implies has the cake formed on the inside of the drum shell. The cake formation is more by gravity than it is by vacuum, although the vacuum does help to form the cake. The slurry is poured in the bottom of the drum. The drum rotates and the cake which is formed then leaves the level of the slurry and approaches the wash section. Here, the same thing happens as in the case of the external type drum. At the top of the center position, the cake is discharged

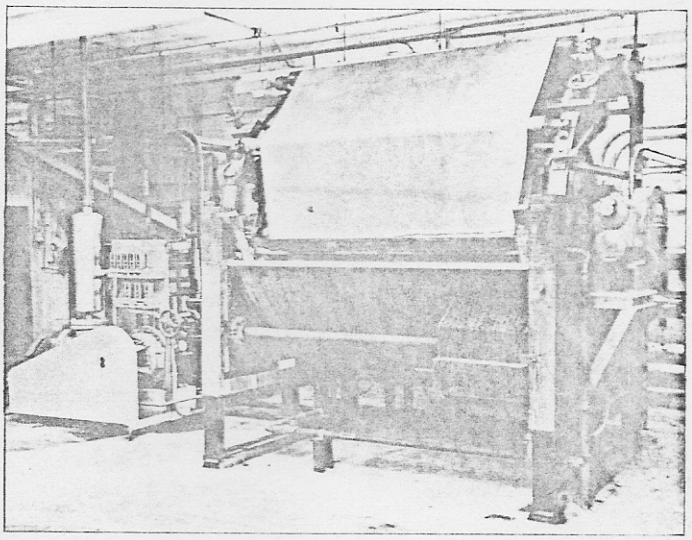
by means of a blow. This filter is primarily used for slurries which will not form a good filtrable cake on the exterior type drum filter. It is used quite successfully on slurries of magnatite or iron ore, and other granular heavier types of cake which are quite porous and would be difficult to hold on an exterior type drum filter.



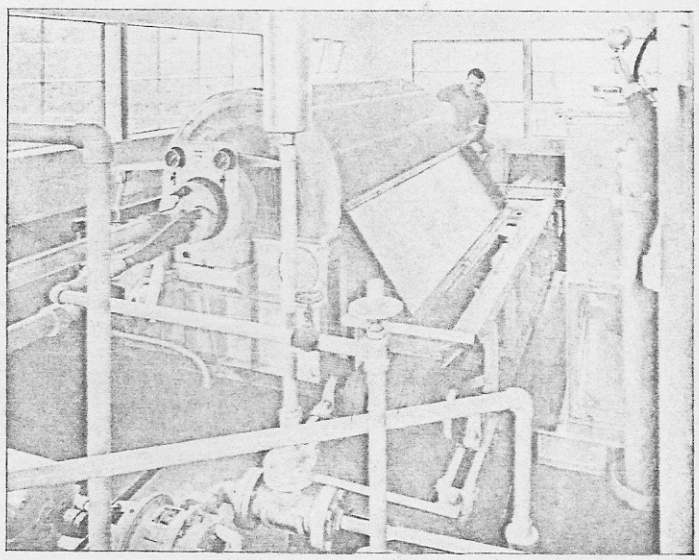
Sala drum filters in a Swedish ore processing plant use Nash vacuum pumps.



Eimco disc filters in a Swedish Taconite plant.



Ametek filters using Nash vacuum pumps in a metal works.



A Dorr-Oliver filter in a sewage treatment plant using a Nash pump for its vacuum source.

ROTARY DISC FILTER

The disc or American type filter is shown on Figure III. Here again, operation is very similar to the drum filter as far as the cycle is concerned, although the construction is considerably different, Figure IV.

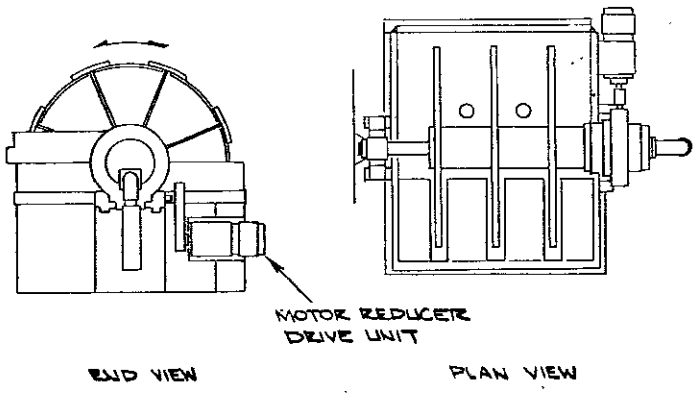


FIGURE III

In place of the cylindrical drum, the disc filter utilizes a number of circular discs mounted vertically on a horizontal, rotating shaft. The discs are composed of a number of removable sectors, each of which has a suitable medium support and drainage. To replace the medium, the complete sector is removed and a replacement inserted while the unit is in operation, if desired. Disc units - primarily of the vacuum type - are commonly applicable to dewatering the cement, flue dust, and metallurgical slurries. Washing is generally not practical due to the limited cake drying time and vertical position of the cake. Mechanical agitation may be employed to maintain a uniform suspension of solids in the slurry tank. It is also possible to split this tank so that two products can be handled simultaneously.

HORIZONTAL ROTARY FILTER

The last of the vacuum type filters is the horizontal rotary filter illustrated in figure IV. This type of filter is basically a revolving horizontal table. The filter table is divided into a number of pie shaped sections. Feed and wash are supplied from overhead piping. A formed cake is removed by a scroll discharge which leaves approximately 1/4" heel on the medium. A takeoff on this type of filter is the "tilting pan" or prayon design which is manufactured in this country by Bird Machine. This was brought about primarily by accelerating development of the fertilizer industry. As indicated by its name, with this filter each pie shaped pan or section we talked about in the past overturns. Discharge with a cake blow permits full cake discharge and immediate cleaning. Although its high initial cost and space requirements limit its general application, it is widely in use in the production of phosphoric acid. It can be advantageously applied with high solid slurries producing a thick cake.

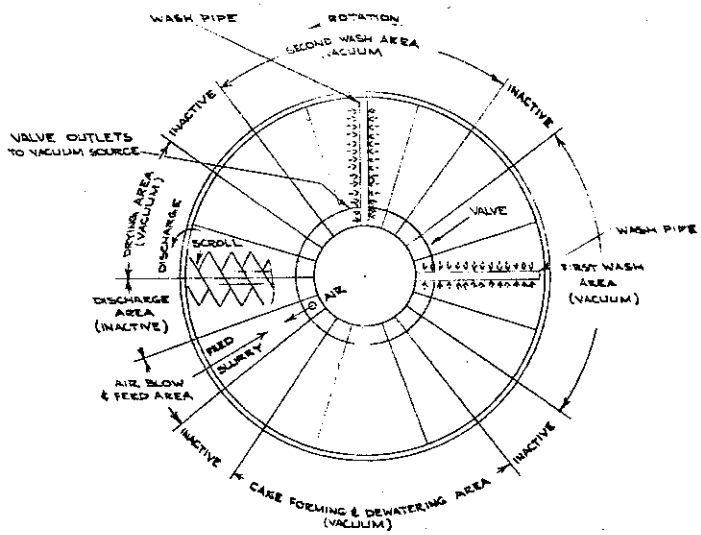


FIGURE IV

The horizontal type filter is one of the newest in the filtration field and its application is not as fully developed as the other types. Primarily, it has been used for dewatering and washing operations. As a rule the horizontal filter is applicable where cake forming is rapid

and feed solids are high. The horizontal is more expensive than a drum unit, but capacity is higher on a square foot basis because it handles thicker cakes at higher speeds.

TYPICAL APPLICATIONS OF CONTINUOUS FILTERS

Following is a partial list of materials filtered on each of the filter types discussed: Drum - external - internal, Disc, and Horizontal.

DRUM	DISC	HORIZONTAL
Potash	Alumina	Gypsum
Nickel Sulfate	Cement	Monosodium Glutamate
Calcium Carbide	Pickle Liquor	Polyvinyl Chloride
Magnesium Chloride	Waste Waters	Potash
Vinyl Acetate	Coal	Sodium Ferrocyanide
Gluconic Acid	Metallurgical	Potassium Nitrate
Ethylene Glycol		Caustic Salt
Acetic Acid		Silica Gel
Titanium Sulfate		Alumina Trihydrate
Sodium Hypochlorite		Sodium Sulfate
Oil		Silica Sand
Pigments		

VACUUM PUMP REQUIREMENTS

It is not only beyond the scope of this article, but also beyond the capabilities of Nash sales engineers to attempt to size pumps for filter service. Air requirements for filters are based on innumerable variables. As a result, each manufacturer conducts exhaustive tests and retains empirical data for various applications. You, then, are called upon to select and price Nash equipment based on capacity requirements furnished by the filter manufacturers. However, for general information only, we have attached a list of typical capacity requirements listed in terms of cfm per square foot of total filter area at the required vacuum.

C.F.M. PER SQ. FT. TOTAL FILTER AREA REQUIRED FOR VACUUM FILTRATION *

1. CEMENT SLURRIES

Cake non cracking, lime stone + clay, or chalk + clay	0.5
Cake cracking slightly, LS + shale	0.6-0.8
Cake cracking steadily, LS + slag	1.2
Cake cracking freely, slurry + kiln dust	1.5

2. CHEMISTRY

$AL_2(HO)_6$ in NaOH Soln. 1%	2.0	Calcium Tungstate ppd	2.5
" " " in Na_2SO_4 Soln., Dilute	1.5	Dyes, Slimy 0.5 Granular	1.0
$AL_2(HO)_6$ From Bauxite (Bayer*Process)		Dyes, Indigo	2.3
Nash Pumps for Dorrco	5.0	Lead Arsenate Cold 0.5 Hot	1.0
Benzoic Acid	1.5	Lime and Sulphur Mix	1.6
Boric Acid Crystals	1.4	Lithopone Crude, 140°F.	2.0-3.5
Bordeaux Mixture	3.0	" Finished, Cold 1.0 Hot	2.0
$BaSO_4$ ppd	1.0	$MgCO_3$ ppd., also basic carb.	4.0
Ca_3 (AsO)	2.0	Mg Bicarb, with flapper	2.6
$CaCO_3$ ppd, Whiting, with flapper	0.8	Napthalene from creosote	1.5
$CaCO_3$ ppd, Whiting, no flapper	6.3	$2NaSbO_3 \cdot 7H_2O$ crystals	2.0
$CaCO_3$ Finely Ground	1.0	$NaHCO_3$, with press rolls	20.0
Lime Mud (Causticizing) (2000 to 3000 lbs./sq.ft./day)	6.0	Sodium Nitrate Crude Mud	2.5
Lime Mud (Kraft) (up to 4000 lbs./ sq.ft./day)	10.0	Sulphur Black, with flapper	3.0
		Sulphur Blue	1.0
Calcium Citrate	2.5	Sulphur From Scrubbing Towers (City Gase) (20-22" Hg. Vac)	4.5
$CaSO_4$ From H_3PO_4, 6° BE. 100°F.	3.0	Titanium Oxide Pigments	2.0
" " " 30° BE. 165°F.	8.0	White Lead	1.0
$CaSO_4$ ppd from various solutions	2.0	ZnO Zinc Oxide	1.0
		$Zn(OH)_2$ - Zinc Hydroxide	2.0
		*Barnium Sulphate Ammonia Disc Filter	2.00

$CaSO_4$ From Phosphoric Acid - Nash Pumps 20" Hg. 5.0-5.5
(Depends on size and type CF crystal - OK for 30°BE on horizontals)

Crystal Products 15" Hg. or less vacuum

Woven wire cover is used (except for $NaHCO_3$). Nash Pump recommended.

$Na_2B_4O_7 \cdot 10H_2O$, Borax	13-20	$Na_2CO_3 \cdot H_2O$ (Monohydrate)	50
$MgSO_4$ Epsom Salts	40	" " $10H_2O$ (Sal Soda)	60
NaCl from glycerine	50	$NaNO_3$. Nitrate Crystals	50
NaCl from NaOH		$Na_3PO_4 \cdot 12H_2O$	90
(Caustic salt on tank type)	50-60	Na_2SO_4. (Anhydrous).	50
(Caustic salt on horizontals)	30	Ditto (From 40°BE Chromate	
$NaHCO_3$, with hot air hood)	30	Liquors--10" Hg. on horizontals)	20

* Capacities listed are approximate and should not be used for vacuum pump sizing without confirmation from filter manufacturer or The Nash Engineering Company.

Crystal Products, 7" Hg. or less vacuum

Woven wire cover is used and Connersville or Elliott Exhauster.

Ammonium Sulphate - (Large Crystals)		$FeSO_4$ (Copperas)	90
(on top feed- (1 1-1/2% moist.)	40	Na_2SO_4 10 H_2O (Glaubers Salt)	64
(on horizontal)	7	Grainer Salt, hot air hood	100
		Vacuum Pan Salt, hot air hood	90

Top Feed Materials, 1" - 3" Hg. Vacuum

Up to 150 cfm for Top Feed Olivers, see OSF #342-F.
Up to 200 cfm for Top Feed Dryers for bone dry salt.

3. FOOD PRODUCTS

Corn starch, wet for glucose	2.0	Maize from maltose	2.0
Dry process for pear starch	4.0		

4. INDUSTRIAL

Blanc Fixe, $BaSO_4$ ppd	1.0	Clay, activated	3.0
Carbide Residue	2.0	Coal + 28 mesh 5.0	-28 mesh 4.0
Carbon, Gas Wash Box	2.5	Coal flot, concts.	2.2-4.5
Carbon, Press Belt Used	10.0	Lampblack	2.5
Carbon, Oliver-Borden Thickener	0.5	Rubber reclaiming, press belt	2.5-8.0
Carbrox	1.9	Whiting (ppd $Ca\ CO_3$)	0.8
Kaolin	0.5	Yellow Ochre	3.5

5. METALLURGY

Cement Copper, Metallic ppd	3.0	Gravity Concts. -100 mesh	1.0
Cyanide Tailing 100 mesh	1.25	" " coarser	2.5-6.0
Cyanide Tailing 70% - 200 mesh	0.75	Sand products	5.0
Cyanide Tailing Finer - clay	0.5	Slime, electrolytic residues	5.0
Flot. Concts. not fine	1.5	Slate, finely ground	1.0
" " 90% - 100 mesh	1.0	Slimy and close grained ppts	0.5
" " 75% - 200 mesh	0.75	Colloidal Slimes	0.3
" " special dry cake	2.0	Roasted zinc concts., leached	1.5
Flue Dust, iron blast furnace	4.0	For Deslimed ore and coarse	
" " with flapper	3.0	Products use Dorr Co. Filter	5.0
" " cement kiln	1.5		

6. OILS, FATS AND WAXES

Dewaxing lube oil with filter aid	3.0	Lead sulphide from gasoline	2.0
Filter aid recovery from wax	3.0	Dewaxing sardine oil (no.F aid)	4.0

7. PAPER AND PULP

Board Machines	4.5	Primary Br. Stock Washers (Nash)	5.0
For coarse board pulps (not refined or reground)			6.0

8. SEWAGE

Raw or Digested, Plus $FeCl_3$	1.50	Activated, Plus $FeCl_3$	1.33
" " " " " "		Chemically ppd.	1.75
and Lime	1.75		

Sewage Aeration - Gentle agitation is 0.3 cfm per 1/8" hole in aeration piping.

9. SUGAR BEET

Continuous Carb. 1.0 Batch	0.7	Cold Saccharate	1.2
O.B. Thickeners	0.02-0.08	Hot "	4.0

10. SUGAR CANE - RAW

O.C. Cachaza Mud	0.75	Kieselbuhr Recovery	
Can Carbonation	1.0	(wet cake discharge)	1.0
O.B. Thickeners	0.1	(dry cake, press rolls and belt)	4.0

11. SYNTHETIC RUBBER

(called "Sinrub Filter")
Butol 19 to 20

12. PRECOAT FILTERS

For precoating (Nash Pumps preferred) -2 -2-1/2 (Western sales division prefers 4 cfm, but have not tried use of grooved bridges from point of discharge to resubmergence to reduce amount of air)
For operation while filtering 1

DEFINITIONS

Feed slurry:	Material which will undergo the filtration process.
Filter Medium:	Material through which or onto which feed slurry is passed.
Filtrate Receiver:	Final receiver of liquid portion of feed slurry.
Filter Tank:	Container for feed slurry.
Decking:	Framework which supports filter medium : filter deck.
Drum:	Rotating member into which decking is built as a component.
Scraper blade:	Blade which removes cake from the drum.
Cake:	Material left on the filter medium after feed slurry has been passed through solid portion of the feed slurry.
Filtrate:	The liquid portion of the feed slurry, that which passed through the filter medium.
Agitator:	Apparatus to keep the solids suspended in the feed slurry.
Solvent Wash:	A liquid spray to further dissolve any particles which are left in the case after deposit on the filter medium - spray nozzles.
Drum Piping:	Piping through which filtrate is transported from filter to outside.
Blow Bridge:	Section of filter where pressure is reversed, and cake is loosened from filter medium prior to discharge by scraper blade.

TYPICAL VACUUM PUMP HOOKUP, ROTARY DRUM FILTER