FILTERS
AND
FILTER PRESSES

F. A. BÜHLER
JOHN JOSEPH EASTICK, F.I.C., A.R.S.M.

From A. M. Duperu. 1874-1944.

FILTERS

AND

FILTER PRESSES

FILTERS

AND

FILTER PRESSES

FOR THE

SEPARATION OF LIQUIDS AND SOLIDS

From the German of

F. A. BÜHLER

With additional matter relating to

THE THEORY OF FILTRATION AND FILTRATION IN SUGAR FACTORIES AND REFINERIES

BY

JOHN JOSEPH EASTICK, F.I.C., A.R.S.M.

WITH 327 ILLUSTRATIONS

LONDON:

NORMAN RODGER

ST. DUNSTAN'S HILL, E.C.

1914

PREFACE TO THE GERMAN EDITION

THE separation of solids from liquids is a frequent and regularly recurring problem in chemical factory practice. To describe and represent pictorially those forms of apparatus that up to the present have proved themselves the most useful is the object of this treatise. The author has avoided handling the subject historically, a method that comes more within the purview of a history of technology.

Looking to the exceedingly great variety of appliances for isolating solid materials from liquids, to the rapidly occurring changes that these undergo to accommodate themselves to the existing conditions in manufacture, and looking as well to the differently constructed apparatus and machinery employed in different countries to serve the same purposes, it is naturally impossible to make an exhaustive survey of this particular field. In general, the standpoint is here taken up that the description and representation of appliances in use to-day in German chemical factories must form the principal contents of this book. As a consequence, besides the private processes in chemical factories, the aids to practice found in the literature, experiments confirmed and refined by experience, are subject matters that must be included, matters that are designed for the technical aid of contractors who supply apparatus of this kind.

In addition, patent literature is drawn upon, for it can afford in some degree an indication of the correct lines upon which the technical development of existing appliances can be further advanced.

So as not to create the wrong impression that the importance of the historical aspect of the progress of chemical technology has been undervalued, its importance from the point of view of the chemical industry is here expressly recognized. A knowledge of the recorded facts in this history gives not only a clear understanding of the present, allows not only an outlook upon the future, but also safeguards the chemist or engineer, under the pressure of the active exercise of his craft, when solving questions arising out of time and money-robbing defects in already old methods of operation and apparatus. Practical men know that such facts are not seldom incorrectly quoted. A detailed historical account would, however, overstep by so much the limits of this treatise that it can best be made the subject of a special volume. An equivalent for it, advantageous also on other grounds, is the description of the inventions found in the patent literature.

As to the arrangement of the matter, the author may be allowed to remark at the very beginning that in the mechanical separation of liquids and solids only a single process, strictly speaking, is in question: namely, filtration.

A division into filters and centrifugals can only be made on exceptional grounds, since a centrifuge is essentially a rotating pressure filter. The forms of this special kind of filter are so manifold, and differ so much from the forms of other kinds of filter, that it appears permissible to leave the centrifuges for separate consideration.

Owing to the exceptionally great variety in characteristics shown by the mixtures to be separated, to the conditions of working to be satisfied, and to the fluctuating capacity for being resolved of a single mixture, any research to lay down at the outset calculations for standard measurements in the construction of filters and centrifuges suitable for each special case, appears hopeless.

We have hitherto been thrown back upon experience or special investigation in deciding upon the applicability of a particular apparatus for a particular purpose. Only those dimensions can be ascertained by calculation that apply to parts of filters or centrifuges, the mechanical demands on which require estimation.

PREFACE TO THE ENGLISH EDITION

In offering to a world-wide circle of English readers a translation of this German work of F. A. Bühler, the compilers have thought it advisable to include a new section so as to enable them to give a full description of the various kinds of filters suitable for and applicable to a given industry, and also incidentally to incorporate some general observations on the Theory and Practice of Filtration. For this purpose the Sugar Industry has been selected because of, first, the magnitude of its operations; second, the large variety of filters employed in its various stages; third, the special precautions needed; and, fourth, the Aids to Filtration found useful.

This addition, it is hoped, will make the volume serviceable to a much larger number of readers than would otherwise have been the case, and will render the work so much the more comprehensive in its character.

It was thought advisable to substitute for the list of German Patents found in the original a list of British Patents covering the same subjects. And in the section covering "Specifications of Sundry Filter Press Patents" the text of the British specification has been followed where available. Otherwise the German version is reproduced in full.

The illustrations in Parts I. and II. being reproductions of those found in the original edition, it has not always been possible to eliminate the German wording and substitute English equivalents. But where this is the case, a glossary has been added below the figure to make the meaning clear.

June, 1914

CONTENTS

PART I.

FILTERS.

FILTERS AND FILTER PRESSES

FOR THE SEPARATION OF LIQUIDS AND SOLIDS

PART I

FILTERS.

INTRODUCTION.

Filters find so many different uses in commerce that the boundaries between the various fields in which they are applied cannot very well be sharply defined. It is, therefore, quite permissible to include in these pages mention of those filters the main function of which lies outside the scope of a chemical industry proper, and serves for purposes of a more general nature. Thus there come into our scope filters for fresh and waste waters, so extensively employed by municipalities. Apart from the desirability of obtaining pure, clear water for domestic purposes, there exists that very important recurring problem of procuring water sufficiently pure for industrial undertakings, and of discharging effluent water in a clear state. Such problems chiefly concern brewing, sugar refining, and those other industries lying within the domain of the food chemist, as well as dye and paper works, which sometimes have installed apparatus on a large scale for the preliminary chemical treatment of their water; in fact, almost all branches of industrial chemistry are interested in the problem of filtration.

The essential element in a filter is the filtering layer which brings about the isolation of the solid constituents from the liquid in a mixture. This layer may consist of loose, detached particles between which are channels so narrow that, while the liquid can readily pass through, the solids are arrested. It may, again, consist of rigid bodies, each composed of a number of particles, themselves permeable, cemented together by a binding material into definite forms; or each composed of impermeable particles that were at the beginning mixed with others and afterwards removed by fire, water, etc., this removal leaving behind channels that render filtration possible. A cloth fabric constitutes another kind of filtering layer.

Other distinctions may be made in filtration apparatus, according to the way in which the process is carried out. When the liquid, acted upon solely by gravity, sinks otherwise unaided through the filtering layer, one speaks of it as an open filter, since the space on both sides of this layer stands or can stand in open communication with the air. But if the speed of filtration be accelerated by some artificial method, such as a lowering of air pressure upon the outflow side of the layer or an increase of pressure upon the inflow side, there is brought into being a closed filter. But any sharp distinction between these two kinds cannot be made.

The subject may be best surveyed by arranging the following descriptions primarily in accordance with the character of the filtering layer.

FILTERS WITH LOOSE FILTERING LAYER.

I. Open Filters.

(1) *Filter-Beds without Regulation of the Flow.*

Here we have to do with the simplest form of filter. The floor of a pit is covered with a filtering medium to which may be added an intermediate layer. If the nature of the subsoil and of the land allow it, the subsoil being sufficiently permeable, the sides and bottom of the pit may themselves act as the filtering layer. Separated from the solid matter, the filtrate diffuses through the enclosing walls and bottom of the pit into the subsoil. In *Figs.* 1 and 2 is shown such a bed. The mixture to be treated, if fluid enough, streams into the pit through the channel *a*—it may be introduced in any other way that is convenient—the solids sink on the walls *b* and spread over the bottom *c*, while the filtrate disappears in the porous subsoil. This simple mode of filtration is sometimes applied to the clarification of effluents and generally requires a large area of ground.

Fig. 1

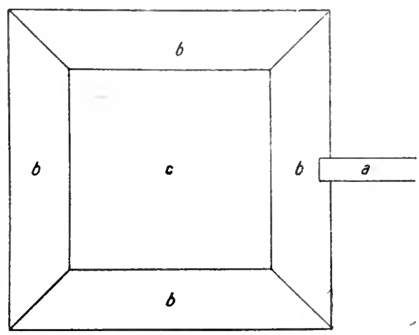


Fig. 2

Owing to the gradual loading of the filter-bed with foreign matter, the action of the filter gradually weakens and finally ceases. To avoid this evil, the co-operation of the sides is mostly dispensed with, and only the bottom utilized (see *Fig.* 1), being covered with a filtering material which can be renewed or purified when the action weakens.

The sides and floor may be made water-tight; in many cases this is a prime necessity. *Fig.* 3 represents such a bed in its least complicated form. The liquid enters the pit *b* at *a*, and penetrates the filtering layer *c*, passes through the opening *d* in the partition wall *e*, ascends the shaft *f*, and then flows off at *g*.

Where the filter-bed is of small size, the need does not often arise for a contrivance capable of distributing the mixture uniformly over the filtering layer. But large installations almost always demand arranging and fashioning in a more or less complicated manner, so that the call upon the layer shall be equal at every part. The fact has to be reckoned with that in most cases the bed serves not merely as a filter but also as a settling-pit, the deposition of the solids varying with the speed and direction of the current. This deposition occurs most freely near to the inlet, where the speed alters most abruptly; and here naturally the filtration most quickly becomes inefficient.

A simple arrangement often chosen for industrial purposes is set forth in *Figs.* 4 and 5. The mixture leaves *a* for the distributing gutter *b*, which communicates with the basin *d* by a number of openings *c* adapted to the re-

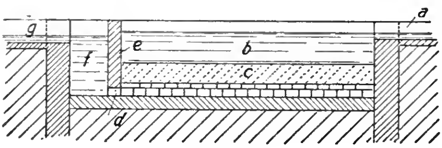


Fig. 3

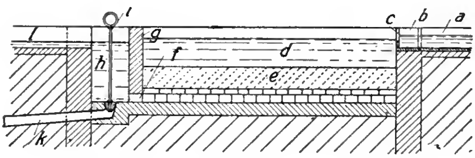


Fig. 4

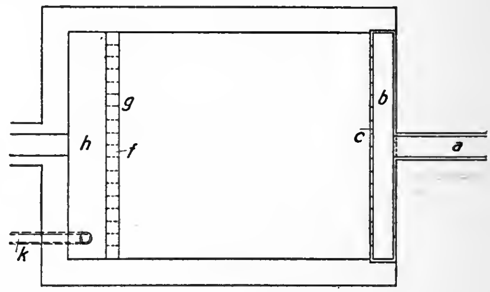


Fig. 5

quired velocity of flow. Passing through the filtering layer, the filtrate gathers at the bottom of the basin and runs through the opening *f* by the foot of the wall *g* into the well *h*, ultimately to discharge by *l*. The drain *k*, fitted with the valve *i*, comes into use during the cleansing of the bed.

In those cases where filtration must be conducted over wide areas, uniformity is attained by sub-division into separate beds. A double filter-bed, as in *Figs.* 6 and 7, consists of two beds *a* and *b* receiving the mixture by the

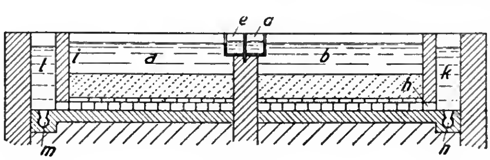


Fig. 6

conduit *c* which is divided into two channels *d* and *e* that may be shut off by the sluice-boards *f* and *g*. Otherwise everything proceeds as in the single beds. Carrying the solid ingredients with it into *a* and *b*, the liquid works through the filtering layer, travels under the walls *h* and *i* into *k* and *l*, and runs off through the orifices *p* and *q* into the outflow gutter *r*. The emptying of the beds takes place through the channels *m* and *n*, which join *o*.

A combination of several filter-beds is illustrated in *Fig.* 8, as regards which, after what has already been detailed, nothing further need be added.

Installations of filter-beds are used on a large scale for the purification of fresh water, as well as for the clarification of municipal and industrial

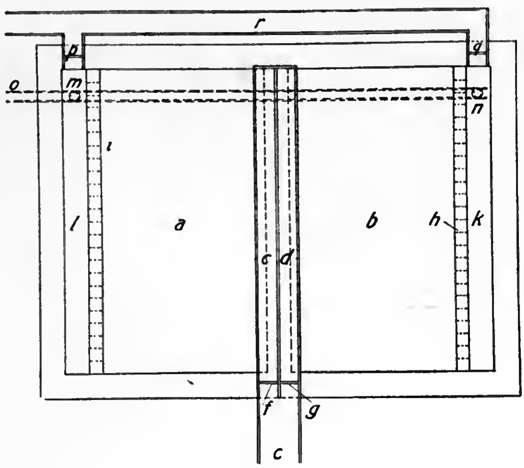


Fig. 7

effluents. The variations in content of solid matter are great among such waters, effluents holding more as a rule than fresh waters.

(2) *Filter-beds with Regulation of the Flow.*

It is in the majority of cases important that the speed of filtration be controlled by regulating the inflow of the liquid. In the ideal case, where

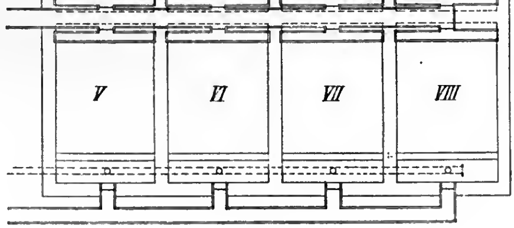


Fig. 8

this is unvaried, an ordinary adjustable sluice-board at the entrance to each filter-bed suffices. A regulating device can also be placed in advance of the outflow channel.

In the system of regulation adopted in *Fig.* 9, the raw-water conduit 1 is provided with a floating-valve 2 to govern the admission of the water according to the water-level in the bed. From the conduit the water enters the shaft 3 and reaches the basin 5 through the pipe 4. The ascending part of this pipe is composed of a telescopic series of rings that determines both the heights of the filtering layer and of the entrance of raw water into the basin. Sinking through the filtering layer 6, which may be of sand, the water advances through the gravel 7 into the interspaces of the stratum of stones 8. Draining the bed is effected by means of the pipe 9.

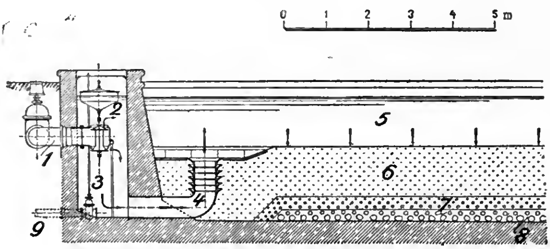


Fig. 9

Regulating the speed of filtration by controlling the rate of outflow is the method explained in *Fig.* 10. Upon the pipe *a*, which discharges the clarified water into the well *c*, sits a valve *b*. Yet neither the filtration pressure *H* in well *c*, nor the speed as evidenced at the exit *d*, can be ascertained.

Represented in *Fig.* 11 is an improvement in one of these directions, for the purified water, after quitting the pipe *a*, mounts into the well *b* before

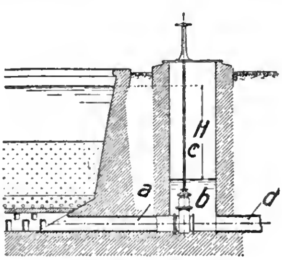
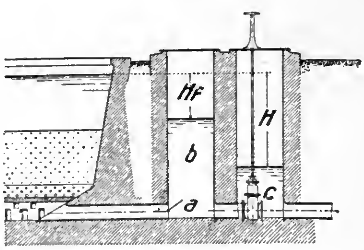


Fig. 10



Fig, 11

passing the regulating valve *c*, so that the pressure may be estimated by comparing the two water-levels. But the speed of filtration remains unknown.

Both factors are determinable with the arrangement given in *Fig.* 12. The water enters the chamber *b* from the pipe *a*, then into the intermediate chamber *d* through the valve *c*, falling eventually over the weir in the wall *e*. Direct observation enables one to estimate the filtration speed.

Regulation of the rate of outflow and control of the filtration speed may be simply achieved by having a weir of adjustable height (*Fig.* 13). The well *b* receives the water from *a* and has fitted to its partition wall *e* an adjustable sluice *d*. The water escapes at *e*.

All the types of regulating mechanism mentioned need to be periodically set by hand. But, for various reasons, it is sometimes desired to have the

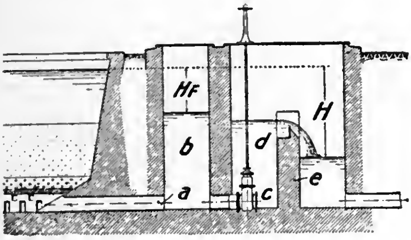


Fig. 12

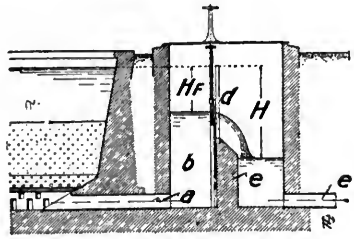


Fig. 13

filtration speed under automatic control. One of the modes of bringing this about is that proposed by Lindley (*Fig.* 14). The filtrate flows out of the basin *a*—after percolating through the layers *b* and *c* and along the double-bottom *d*—by the pipe *e* and pours into the shaft *f*. Within this shaft a tubular

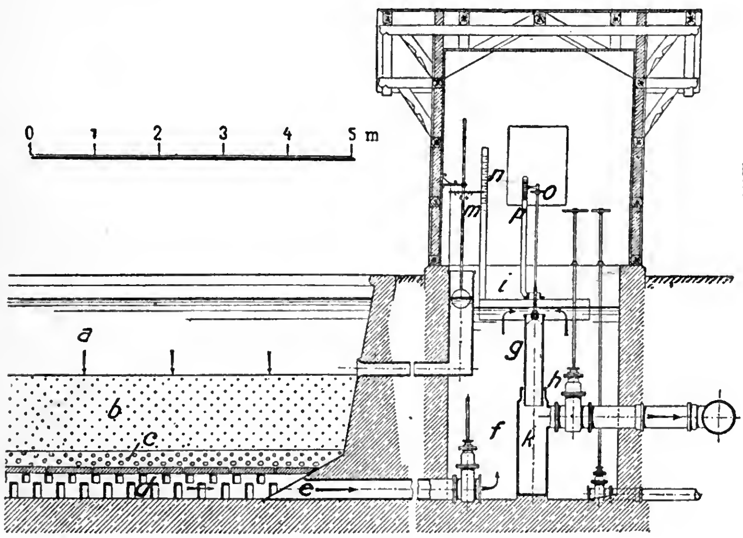


Fig. 14

valve *g* works smoothly in its socket *h* at the entrance to the exit-pipe *k*. For maintaining a high degree of uniformity in speed and pressure, the valve *g* is fastened to the float *i*. To check the pressure there are two pointers. One of these, *m*, fixed to another floating device, indicates the level of the raw water in the basin upon a scale *n* set on the float *i*. The other pointer, *o*, indicates the height of the flow over the top of *g* upon a scale *p*, also set upon *i*.

(3) *Contrivances for Cleansing the Sand.*

Since the efficiency of the filtering layer suffers in course of time through accumulation of the intercepted particles, these must be removed. With small filters, this is done by hand. After lifting all deposit from off the top, the sand is heaped up and worked through with water. With large filters,

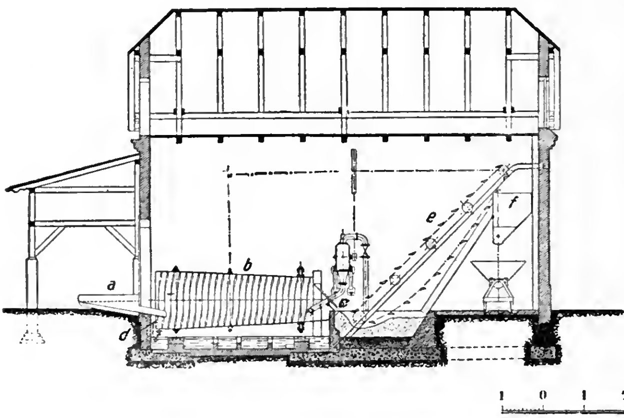


Fig. 15

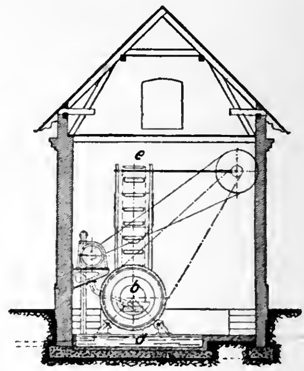


Fig. 16

however, cleansing cannot be done without mechanical contrivances such as that illustrated in *Figs.* 15 and 16. The sand is thrown through an inlet *a*—which may, in case of need, be furnished with a sieve—into a conical cylinder *b*, revolving at a moderate speed, 6 to 8 turns per minute, and is led to the narrow end *c* of the cylinder by a spiral conveyer. The wash water, about 8 parts to

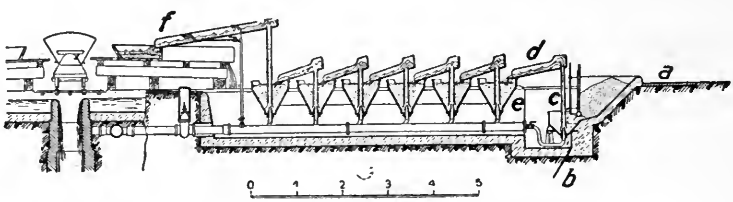


Fig. 17

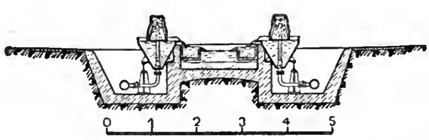


Fig. 18

1 of sand, flows in the opposite direction to the sand and leaves by the broad end *d*. An elevator raises the purified sand and deposits it in the hopper *f*, from which it can be carted away. For driving the cylinder and elevator, any kind of motive power may be used, but where the water for cleansing has a

pressure of 2 to 2.5 atmospheres (30 to 36 lbs.), a hydraulic motor is simplest and cheapest.

Moving parts are avoided by another method of washing with the injector-washer. The dirty sand is put into the funnel *a* (*Figs.* 17 and 18) into which projects a water-ejector *b*. This ejector sucks up the sand and draws it into the tube *c*, the mixture of sand and water coursing along the channel *d* and falling into the second funnel *e*. Part of the silt runs over the edge of the funnel, the rest sinks with the sand to the bottom. Here a second injector transfers the dirty sand to the next funnel, and so on through the other funnels the sand travels until it emerges clean at *f* ready to be taken away. The consumption of water easily doubles that in washing with the cylinder, since 1 part of sand demands 20 parts of water.

(4) *Acid-Resistant Filtering Apparatus.*

An open filter applied to many chemical purposes has the form of a cylinder and contains filtering layers that withstand the action of acids. The arrangement of such an apparatus, as constructed by the Deutschen Ton- und Steinzeugwerke, is sufficiently explained in *Fig.* 19, so that a detailed description is not necessary. In the treatment of small quantities of liquid this, and filters like it, give good results.

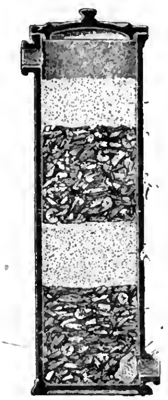


Fig. 19

(5) *Reisert's Cleansable Filter.*

Reisert's filter, made both open and closed, in which the cleansing of the filtering mass follows other lines than those so far noted, may serve as the type for a large number of similar appliances.

In attempting to cleanse a filter merely by causing a backflow of wash-water, the current opens a passage for itself in the filtering layer only so far as that is permeable, and the greater part of the layer sometimes remains choked up with deposit. It appears, therefore, rational to loosen the whole mass so as to be able to wash around every particle.

Using air to do this loosening, the filter, whether open or closed, may be arranged as in *Figs.* 20 and 21. Within the circular or rectangular vessel the filtering material rests upon a sieve-bottom *f*, composed of a perforated plate and wire gauze. The turbid water comes in through the valve *A*, penetrating the filtering medium—generally fine, uniform pearl-sand—and the clarified water issues at *B*. A diminished output indicates the need for washing out. The valve *A* is then shut, and that at the scum outlet *E* opened, as also the valve *C*, and through the valve *D* steam is sent into the injector *L*. Thus air is engulfed and forced into the system of tubes *R*. From these it emerges through numerous minute holes, and, clearing *f*, enters the filtering mass, which it agitates, thereby giving the wash-water admitted at *B* full play in levigating

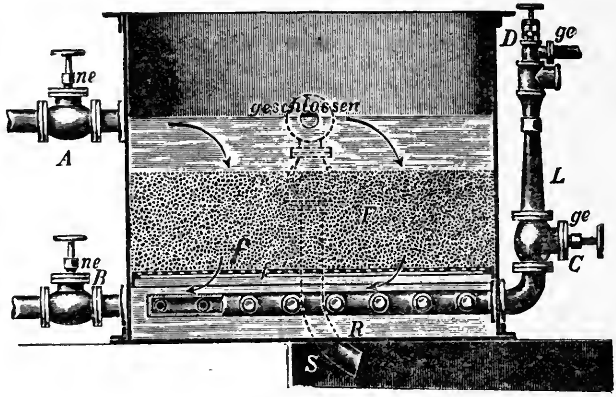


Fig. 20

ne = open ge = shut geschlossen = shut

it. The separated scum flows off at *E*, the air escaping above. After some minutes the steam valve *D* is closed, but the wash-water is allowed to run through *B* for two or three minutes longer to remove all air from the filtering material and to leave it perfectly clean. The mean outturn of such a filter

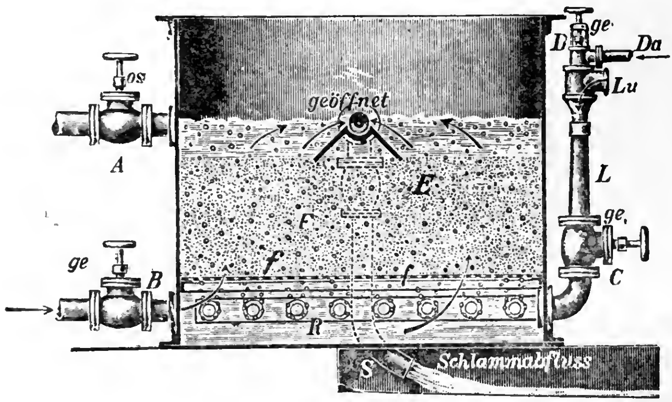


Fig. 21

os = shut ge = open geöffnet = open Da = steam
Lu = air Schlammfluss = slime outflow

amounts to 1,486 gallons per hour per square yard of filtering surface, and therefore the speed of filtration averages nearly 9 cubic yards of filtrate per square yard of filtering surface per hour.

An advance upon the open filter just detailed has been made by Reisert (*Figs.* 22 and 23). The raw water runs out of the channels *A* into the filter-basins and diffuses through the filtering layer *F*; clarified, it collects in the space between the sieve-bottom and the solid partitions *E* of the clear water basins *R*, into which it then descends by the tubes *O*. From these it ascends the regulating shafts *P*, fitted with the controlling devices *N*, *M*, *E*, and makes for the channel *B* and the outside. In beginning cleansing operations, *N* is closed and air is forced out of *L* under the roof *E*. The clear water thus driven

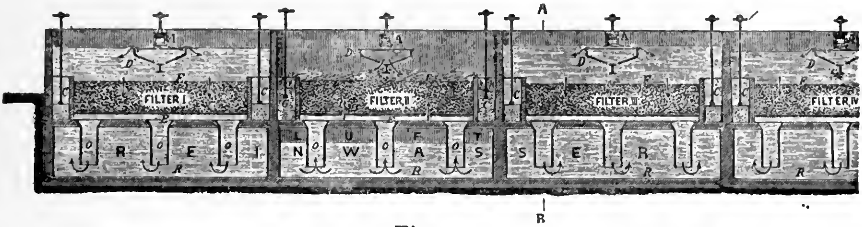


Fig. 22

through the tubes *O* stirs up the filtering layer and, laden with the silt, pours into the channels *C*.

(6) *Open Filters with Stirring Devices.*

Mechanical stirring devices are often added both to open and closed filters for energetically churning up the sand to help in freeing it from sludge. Beyond the stirring apparatus, the filters seldom present any noteworthy

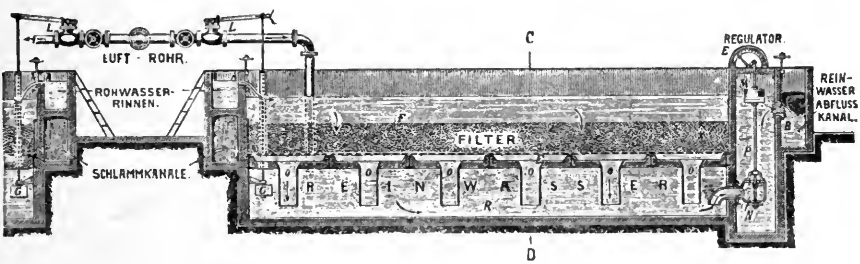


Fig. 23

Luft Rohr = air pipe
Schlammkanale = slime channel
Rohwassen Rinnen = raw water channel
Reinwasser Abfluss-Kanal = clean water outlet

features. A simple open filter has been chosen for illustration (*Fig.* 24). Within the cylindrical casing *a*, which may be replaced by brickwork or concrete, lies a sieve-plate *b* supporting the filtering material *c*. A vertical shaft *d*, working in two bearings, carries a bevelled gear-wheel *e* and a horizontal arm *f*, which in turn carries the stirring prongs *g*. This shaft is rotated by the bevelled gear-wheel *m* on the horizontal shaft *l*, at the other end of which are the belt pulleys *n* and *o*. When the filter becomes choked, the inlet *h* is shut off, the outlet *i* opened, and water from the cleansing pipe *k* runs under the sieve, and gushing upwards, it seizes upon the particles of sludge loosened by the stirrer and expels them at the outlet *i*. The filter can be emptied through the pipe *p*.

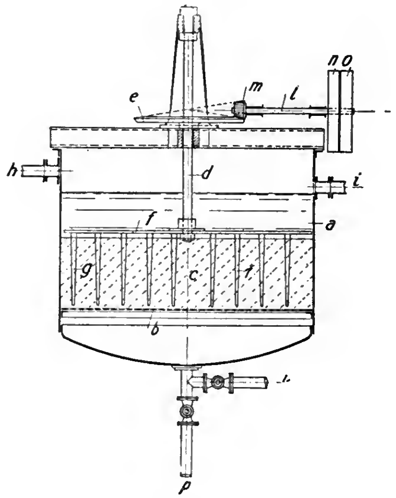


Fig. 24

Should want of room prevent the adoption of filter-basins, there are methods by which the filtration outturn may be increased, and thus ground space be saved. This can be attained by making the cleansing action last for the shortest time possible, the particles of the filtering mass being kept in motion by mechanical means while at the same time a stream of wash-water is directed through it. Such filters may be open or closed, with circular or rectangular basins, and with stirring or other devices for agitating the sand.

II. CLOSED FILTERS.

(1) *Gutmann's Drum Filter.*

An appliance with enclosed filter-chamber and a distinctive means of conveniently cleansing the filtering material is built by Gutmann. This rotary filter is turned out in sizes that give yields of 220 to 11,000 gallons per hour, the filtration velocity being over 14 ft. per hour. A smaller or larger velocity means a smaller or larger output.

Sections of a filter having an output of 220 gallons per hour are presented in *Figs*. 25 and 26. The water is introduced through the axle at *a*, spreads into four radial channels, and thereby reaches the circular channel *c*. Into this open the brass tubes *d*, and the water makes its way through slots in their walls into the filter-chamber, where it leaves the silt behind in the filtering material (sand). Near to and around the axis of the drum are disposed slotted, brass collecting-tubes *e*, which take up the filtered water, emptying it into the space *f*, to issue from the apparatus through the bore *g* in the second shaft. Access to the tubes *d* and *e* is easy by removing the covers *h* and *i* of the spaces *c* and *f*. The filter can be cleared through the cock *m*.

After some time, so much silt has accumulated as to induce a distinct falling off in output, and the water current is then reversed for cleansing. Admitted at *g*, the wash-water flows in succession through the space *f*, the tubes *e*, the sand, the tubes *d*, the circular channel *c*, the radial channels *b*, and emerges through the bore *a* in the first axle.

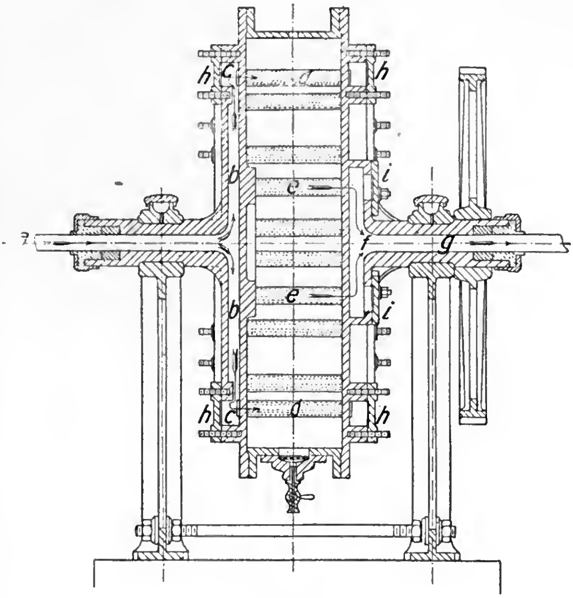


Fig. 25

Because the action of this reversed current is not always adequate to ensure perfect purification, provision has been made for revolving the filters with gear-wheels turned by cranks. The rotation disturbs the loose filtering material, and its particles slide and rub against one another, the silt being in this way freed so as to be readily withdrawn in the wash-water. Additional displacement of the sand due to its being tossed against the outer series of slotted tubes assists this freeing action. The washing out of the filter can be further aided, when any particular filtration process necessitates it, by blowing in air or steam. At the top is fixed a cock *k* through which escapes any air led into the filter along with the water; and any partly atomized water is conducted downwards by the tube *l* to avoid squirting. The filter can be emptied through the cock *m*.

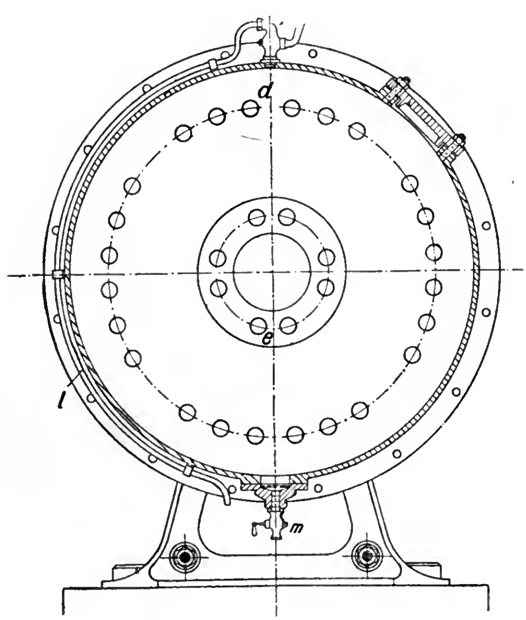


Fig. 26

The smaller sizes have cast-iron casings; in the larger the drum is composed of plating with screwed-on, cast-iron channels. These large ones are set on rollers for facility in rotating; the smaller, like that described, revolve in axle bearings. In *Fig.* 27 is shown photographed a small filter with a capacity of 220 gallons per hour; that reproduced in *Fig.* 28 can turn out 11,000 gallons.

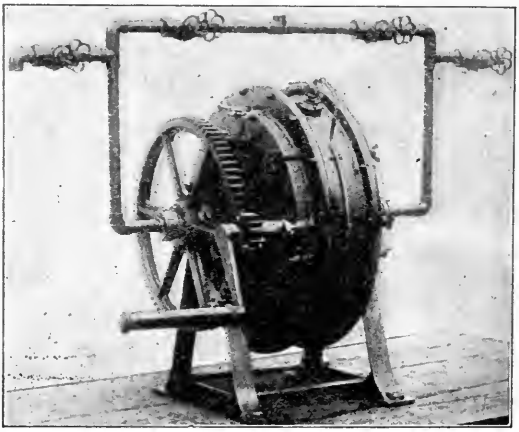


Fig. 27

(2) *Filtration combined with Chemical Purification.*

With easily filtrable liquids only raw and clear water basins are needed; but in many cases sand filtration alone is inadequate. The mixture must be acted upon in some additional way to remove the soluble impurities. Usually this action is a chemical one, and to the process the terms "chemical purification" and "softening" are generally applied. The effect is sometimes to cause the formation of a flocculent precipitate, thereby enhancing the effectiveness of the filtering layer; or in other cases substances dissolved in the water, or other liquid to be filtered, are transformed into an insoluble form.

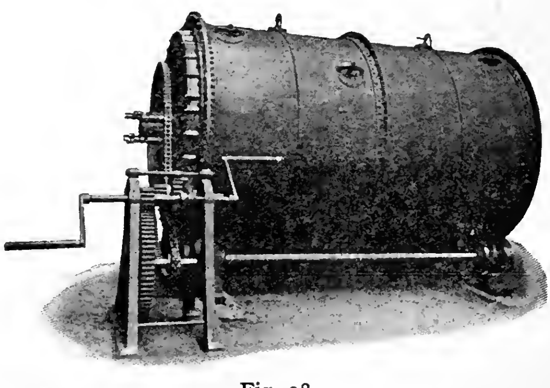


Fig. 28

To a great extent this process finds its object in the treatment of boiler feed-water; also for many other industrial and public purposes is it used.

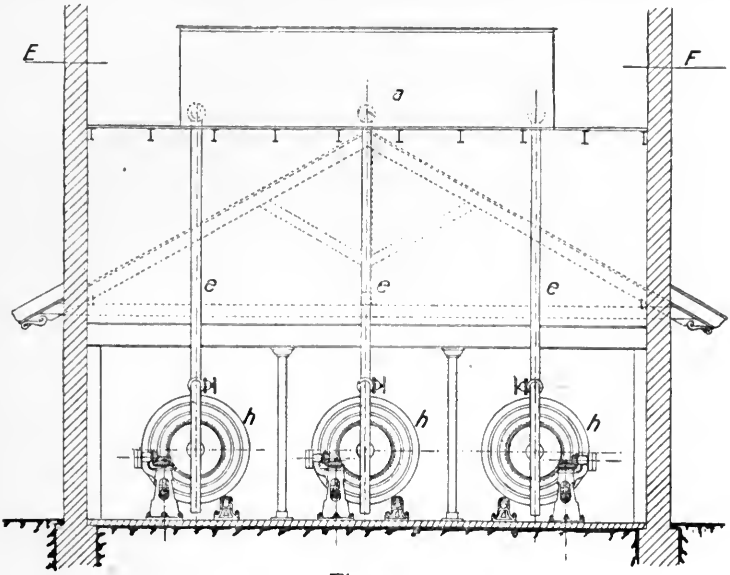


Fig. 29

It interests us here in so far as the arrangement and construction of filters are affected.

A simple contrivance for carrying out the process, conjoined with one of Gutmann's filters, is indicated in *Figs.* 29–32. The pumps *b* draw the raw water from the pipes *c* and propel it through the pipes *d* into the cistern *a*, where the coarser impurities are deposited. The water next descends through the pipes *e*, passes the valves *f*, and along the inflow branch-pipes *g* to the filters *h*, whence it emerges, having been clarified, to travel through the outflow branch pipes *i*, the valves *k* and the outlet pipes *l*. While this is going on, the valves *m*, *n* and *o* remain shut.

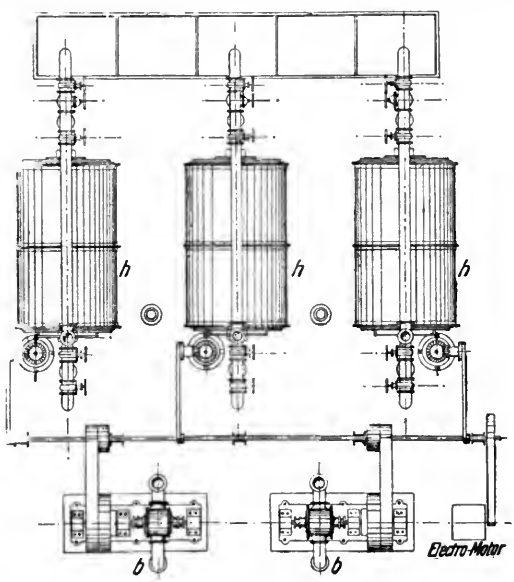


Fig. 30

In cleansing the filters, the raw water proceeds to them by the circuit *e, p, n* and *i,* and the dirty water runs off by *g, o* and *q.* When putting the cleansed filter again into action, the raw water left behind in it

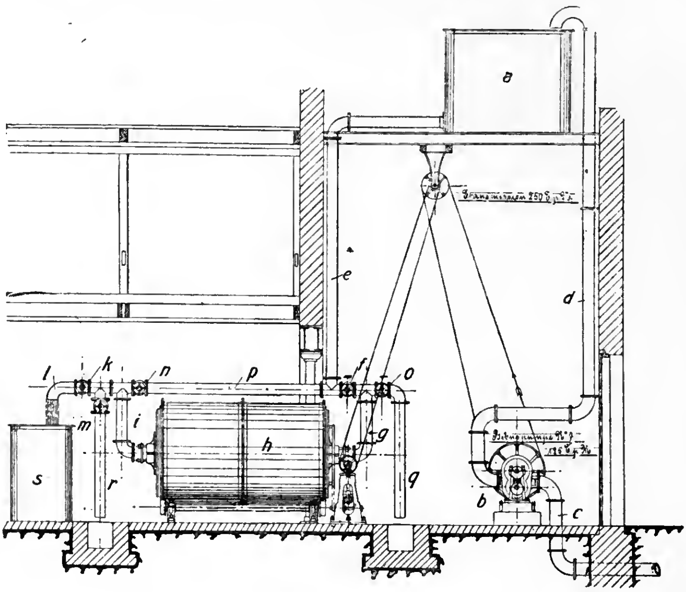


Fig. 31

must not be allowed to enter the clear water receptacle *s* ; instead, it is sent through *i* the valve *m,* and the pipe *r,* until the effluent looks clear.

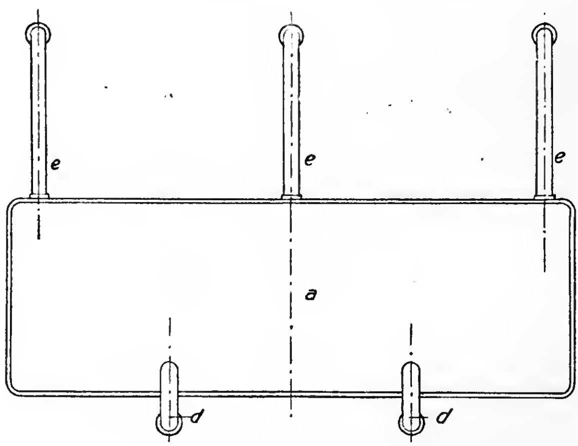
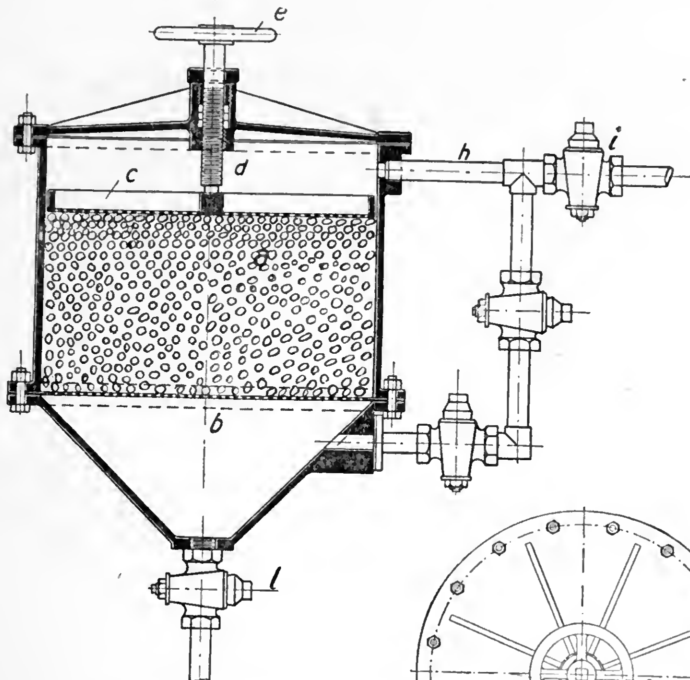


Fig. 32

(3) *Gutmann's Pressure-Filter.*

In closed filters the yield can be raised by accelerating the speed of filtration, and with smaller apparatus this end is arrived at by building the filter as in *Figs.* 33–35. The filtering mass is packed between two sieve-plates, the upper of which can be raised and lowered by means of a perforated pressure-plate *c* under the control of a screw *d* with hand-wheel *e*. From the lower



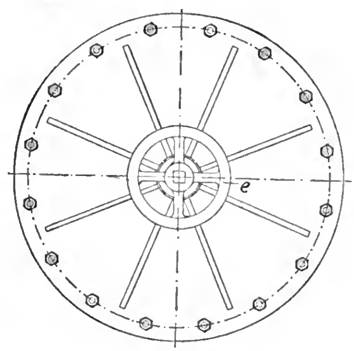
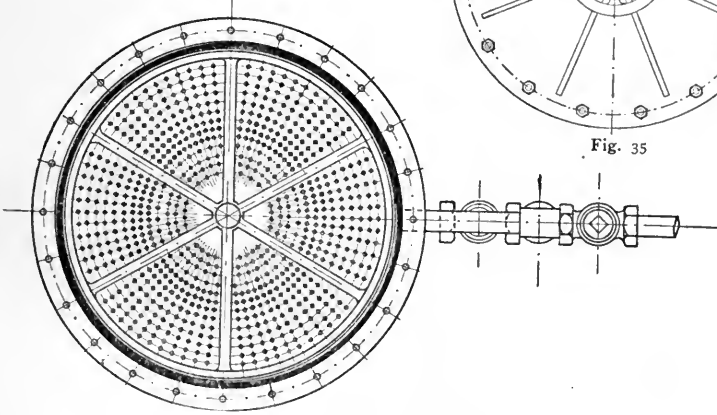


Fig. 35



Figs. 33 and 34

part of the filter the liquid rises through the sieve *b*, traverses the filtering layer and departs by *h* and *i*, the cock *k* being kept closed. For washing out, the direction of the current is reversed. The cock *l* is for emptying the filter.

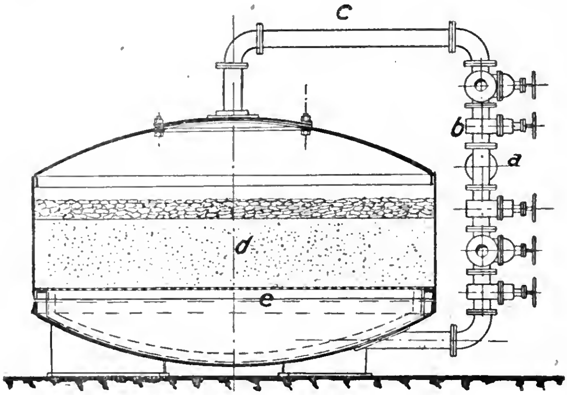


Fig. 36

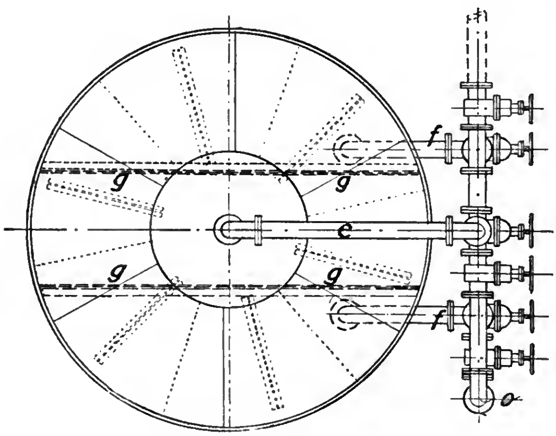


Fig. 37

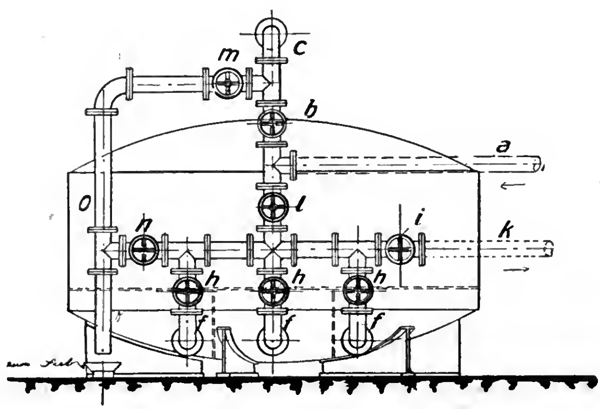


Fig. 38

A pressure-filter for larger outputs by Gutmann is designed as in *Figs.* 36–38. Arriving by way of the pipe *a*, and clearing the valve *b* and the pipe *c*, the raw water diffuses through the filtering material *d*, which, according to requirements, may be arranged in one or more layers above the sieve-plate *e*, and issues from the filter by three pipes *f*, each draining one of three divisions separated by partitions *g*. Leaving behind the valves *h* and *i*, the clarified water departs by *k*. In the meantime, the valves *l*, *m* and *n* continue closed. Cleansing is conducted in the manner repeatedly detailed, the outflow pipe *o* coming into function. There are also provided two cocks (not shown in the figures), one above for the escape of air, and an emptying cock below for water.

(4) *Reisert's Pressure-Filter.*

An improved pressure-filter by Reisert is exhibited in section in *Fig.* 39; *Fig.* 40 represents an installation of several filters. In *Fig.* 39 the procedure in clearing away the sediment is demonstrated. The usual sieve-plate *f* sustains the layer of filtering substance *F* and situated beneath it is an unperforated

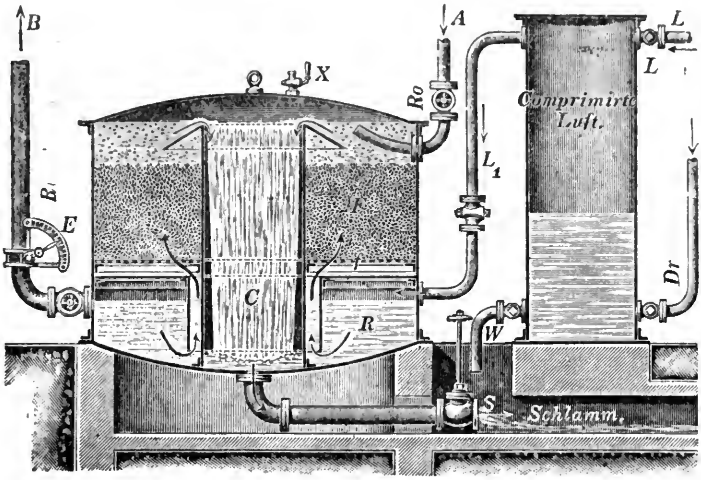


Fig. 39

Re = clean water Ro = raw water L = air Dr = hydraulic pressure
Comprimirte Luft = compressed air Schlamm = slime

plate from the centre of which descends a wide tube. A second, narrower tube *C* firmly bolted to the bottom of the chamber, ascends within the first

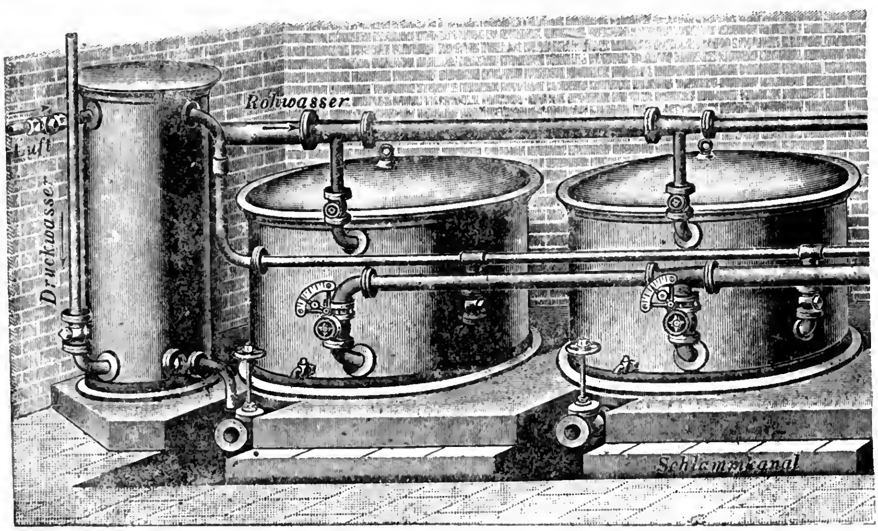


Fig. 40

Rohwasser = raw water Druckwasser = hydraulic pressure Luft = air
Schlammkanal = slime channel

tube and through the sieve-plate and filtering layer to end at such a distance from the roof of the chamber that the cross-section of the inflow surfaces equals the cross-section of the tube, the same relation holding between the first tube and its distance from the bottom.

In washing out the filter, the valve *S* and the air-cock *X* are opened and the valves on the raw and clear water pipes *A* and *B* closed. Soon the water ceases to come out of *S*, when the cock on the pipe L_1 is opened. Compressed air from the air-compressor, forced into the latter by a water-jet blower,

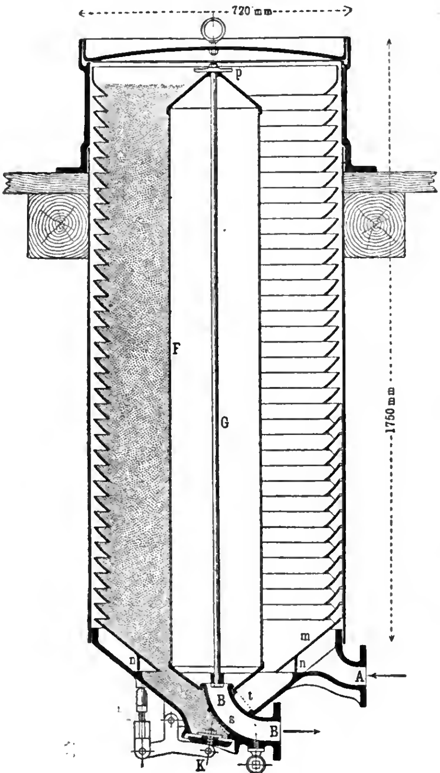


Fig. 41

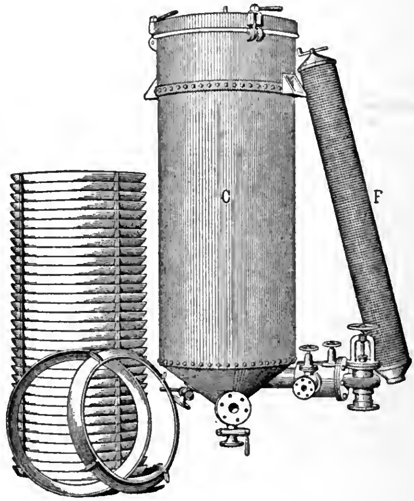


Fig. 42

a compressor, or the like, then rushes into the space *R* below the unperforated plate and expels the water. This water, moving in the direction indicated by the arrows, courses with such a speed through the filtering mass that the latter is at first uplifted, to fall back against the current, which, however, sweeps the sediment into the tube *C* and out at *S*. By re-opening the valves on *A* and *B* and closing *S* and *X*, the filter is prepared for another operation. Any air contained in *R* can be recovered, passing back into the air-compressor through *L*.. Dissipated compressed air may be replaced by allowing some of the water to flow out of the compressor through W, after L_1 and the valve on its water-supply pipe have been closed and that on L opened.

Where a number of filters are worked together (*Fig.* 40), a single air-compressor suffices.

(5) *A Special Filter for Sugar Juice.*

In *Figs.* 41 and 42 is made clear the arrangement of a sand filter that finds a place in sugar manufacture. To clean the sand properly before its insertion

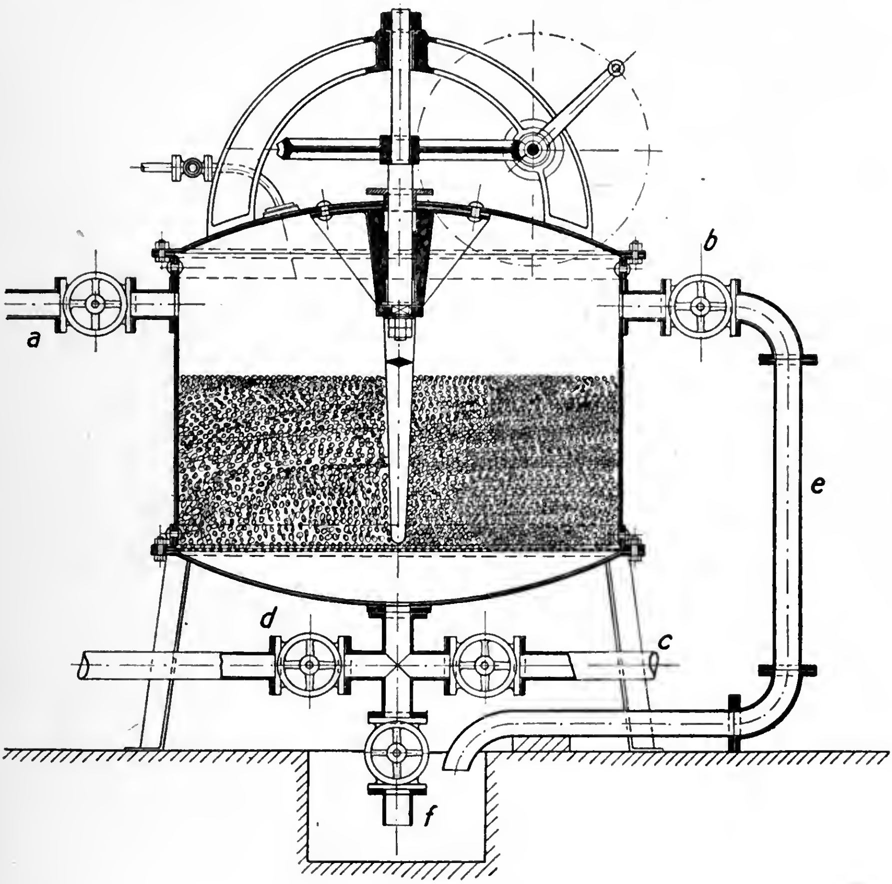


Fig. 43

in the filter, it is washed with hydrochloric acid, next with water and is finally treated with steam. Owing to the value of the liquid being clarified, the cleansing of the sand after use cannot be performed by the usual methods, and calls for a special machine.

The filter itself comprises an iron casing *C* with conical base, within which are piled up a vertical series of conical rings borne one upon another by feet vertically aligned, so as to give strength in supporting the load. A deeper cone than the remainder, the lowermost ring *m* rests upon the rim of the circular neck *n*. Between the outer casing and the edges of the rings is left a narrow space. In the centre of the filter stands a tubular sieve *F*, the conical ends of which are kept in position by a tie-rod *G*, with hand-wheel *p*. The outflow pipe *B* is connected with the tubular sieve. Introduced from above, the clean sand completely fills the spaces between the rings and around the sieve, yet without running over the edges of the rings. Having entered the filter by the orifice *A*, the juice rises throughout the whole interior, diffusing through the sand and the wall of the sieve, to quit the apparatus at *B*.

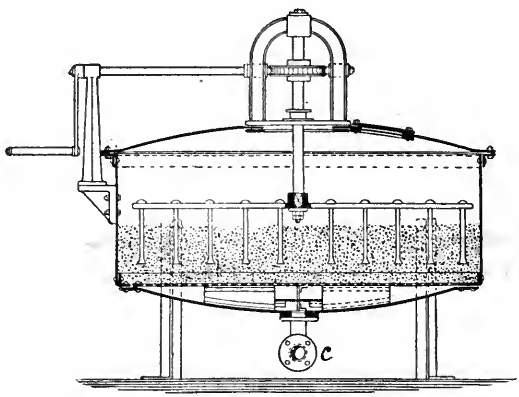


Fig. 44

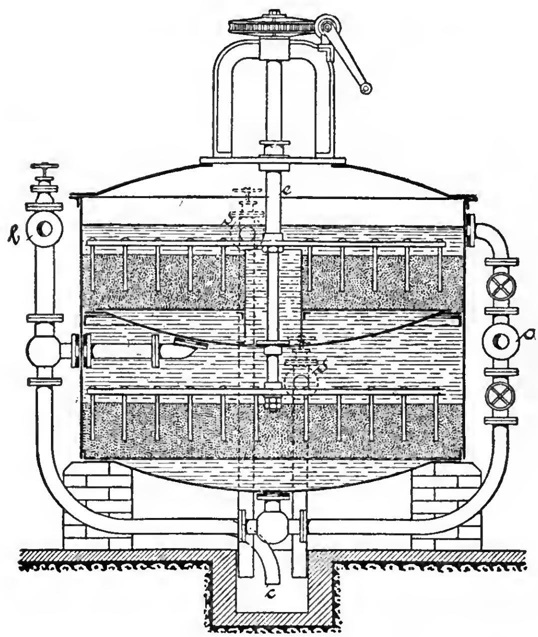


Fig. 45

When the filter has become fouled, the juice present in the sand is washed out with clean water, and the sand then withdrawn through the trap-door *K* in the base for further treatment in the proper washing machine.

(6) *Pressure-Filters with Stirring Devices.*

Mechanical stirrers may be employed with advantage, as already stated, in closed as well as in open filters. *Figs.* 43 and 44 are sections of two similar forms of apparatus, arranged in essentially the same way as that previously described (*Fig.* 24). The water pours in through *a* (*Fig.* 43), penetrates the filtering layer and passes out by *c*. When starting to wash away the sludge, the valve *a* is closed and that at *b* opened; then the cleansing current is made to enter at *d*, presses from below through the sand, and retires through *b* and the pipe *e*. After completion of the washing out and resumption of the filtration, the turbid liquid emerging at first is sent through *f* into the waste water channel. The stirring device can be driven by hand or mechanically, through a worm and wheel attachment.

Economy in space may be arrived at by setting two or more filtering layers one above another (*Fig.* 45.)

A view of a large filtering plant with a capacity of 88,000 gallons per hour is given in *Fig.* 46. Yet it does not enable one to recognize sufficiently its compactness and the relatively small area occupied. Here the stirrers are propelled mechanically, so that active agitation of the sand during washing is possible.

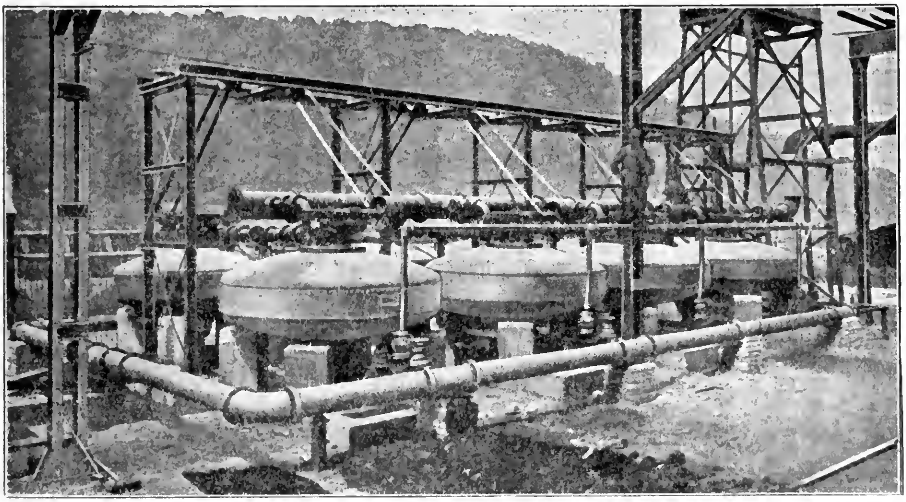


Fig. 46

Closed filters permit the handling of mixtures that may be filtered only under increased pressure; and they can be constructed to withstand any pressure.

III. IRON REDUCTION APPARATUS.

Along with the filter must be considered all apparatus in which solids are precipitated by additive (chemical) processes, to be afterwards filtered off.

One of the simplest ways of effecting the clearing of water is that of treatment with air. The iron in water separates in flocculent form upon mixing air with the water, soluble ferric oxide changing into the insoluble hydroxide. Iron elimination proceeds spontaneously in standing water exposed to the air, but this takes as a rule too long a time to be available industrially. To hasten the process the water is finely divided, so as to expose a large surface.

(1) *Gutmann's Smaller Iron Reduction Apparatus.*

In this arrangement, for dealing with small quantities of liquid (*Figs.* 47 and 48) a rose *b* sprinkles the raw water supplied by the pipe *a* upon a sieve-plate *c*, where the air comes into intimate contact with it. It dribbles downwards in fine streams and drops through the cake *d* contained in the cylinder *e*, and is brought again into close touch with the air when it reaches the grating *g*. The reaction continues below in the second layer of cake d_1, and, if necessary, in

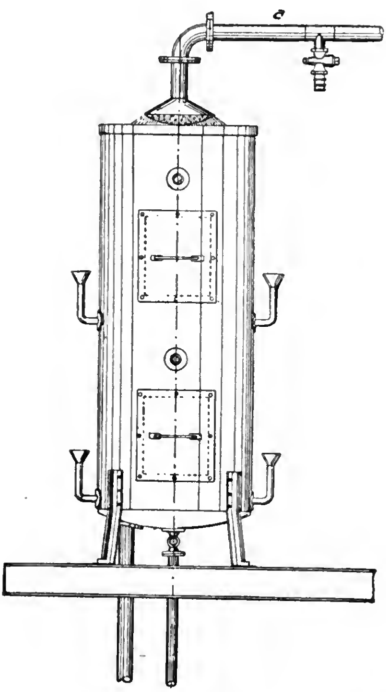


Fig. 47

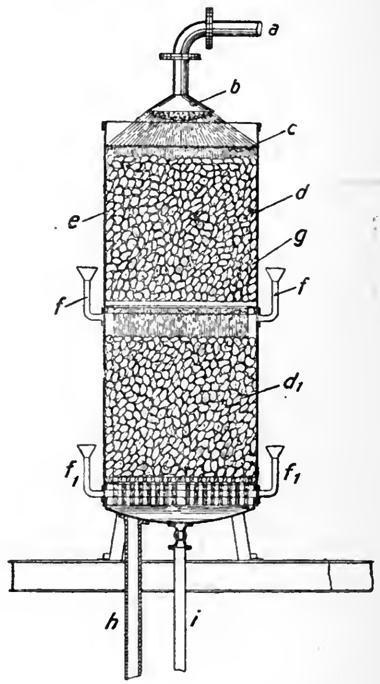


Fig. 48

a third and fourth layer. For leading in air serve the tubes *f* and f_1. Along with the insoluble iron hydroxide, the water makes its way out by the pipe *i* and goes on to the filter for separation of the precipitate. In case the air absorbed through the tubes *f* and f_1 is inadequate, more can be forced in through the pipe *h*.

(2) *Gutmann's Iron Reduction Apparatus yielding 220 gallons per hour, combined with Drum-filter.*

Such an apparatus, with hand-driven filter, is reproduced in *Fig.* 49. The pump *a* propels the raw water through the pipe *b* into the iron reducer, where it trickles over the two layers of cake e, e_1. The air-pump d alongside the water-pump pushes air through the pipe f—U-shaped to prevent water entering the air-pump—and onwards through the grating g_1 near the bottom of the cylinder,

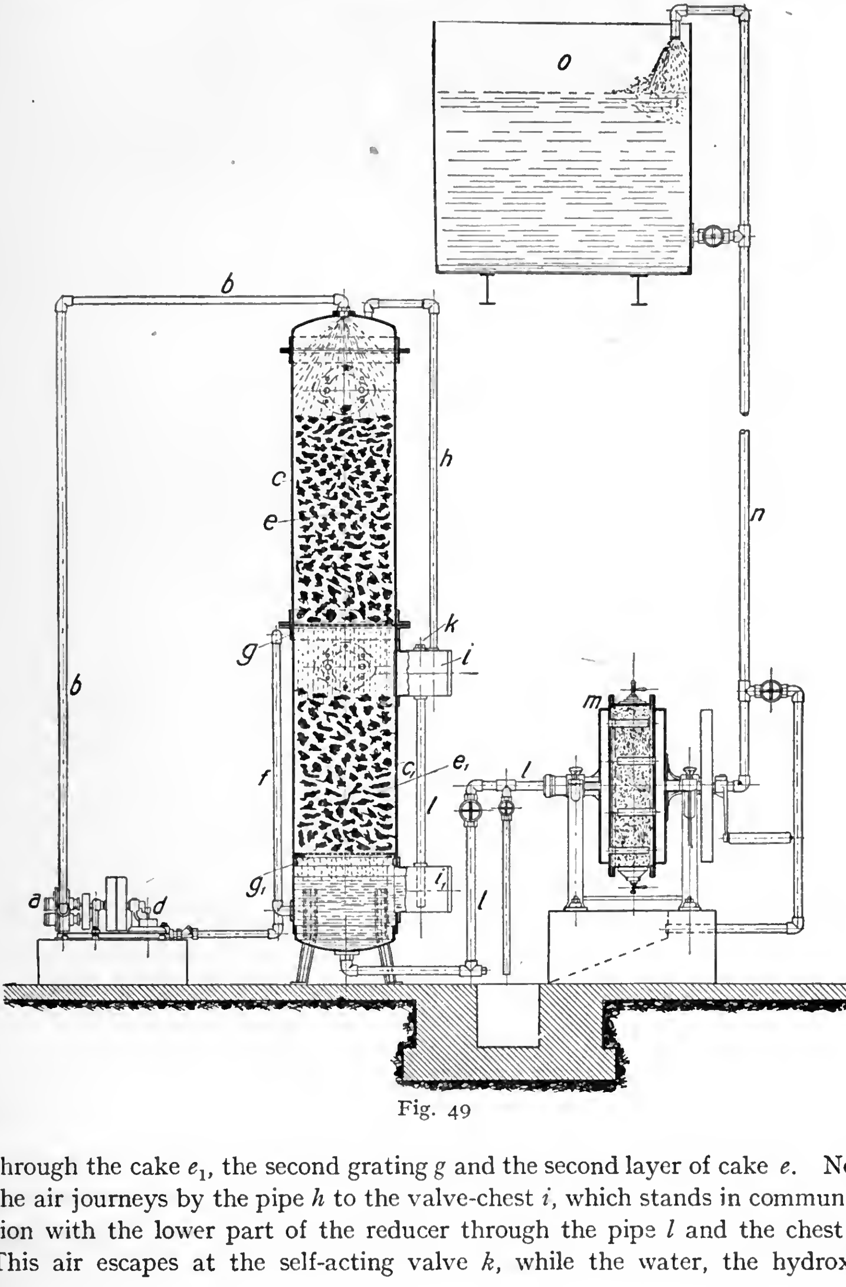


Fig. 49

through the cake e_1, the second grating g and the second layer of cake e. Next, the air journeys by the pipe h to the valve-chest i, which stands in communication with the lower part of the reducer through the pipe l and the chest i_1. This air escapes at the self-acting valve k, while the water, the hydroxide

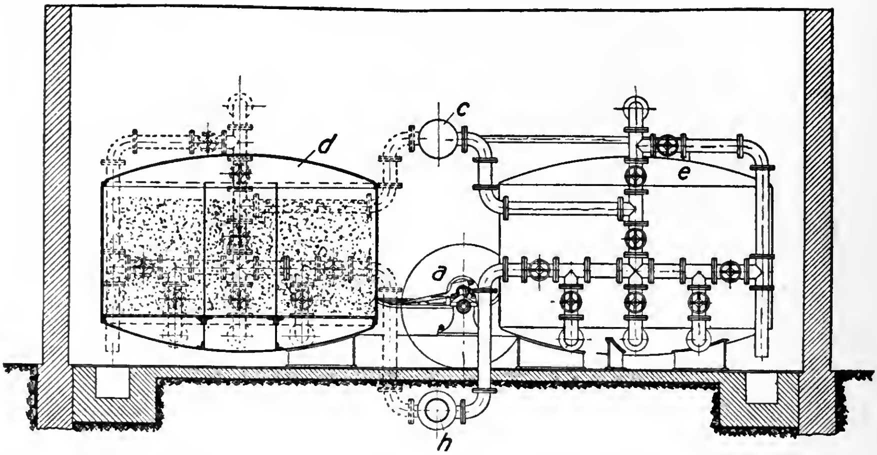


Fig. 50

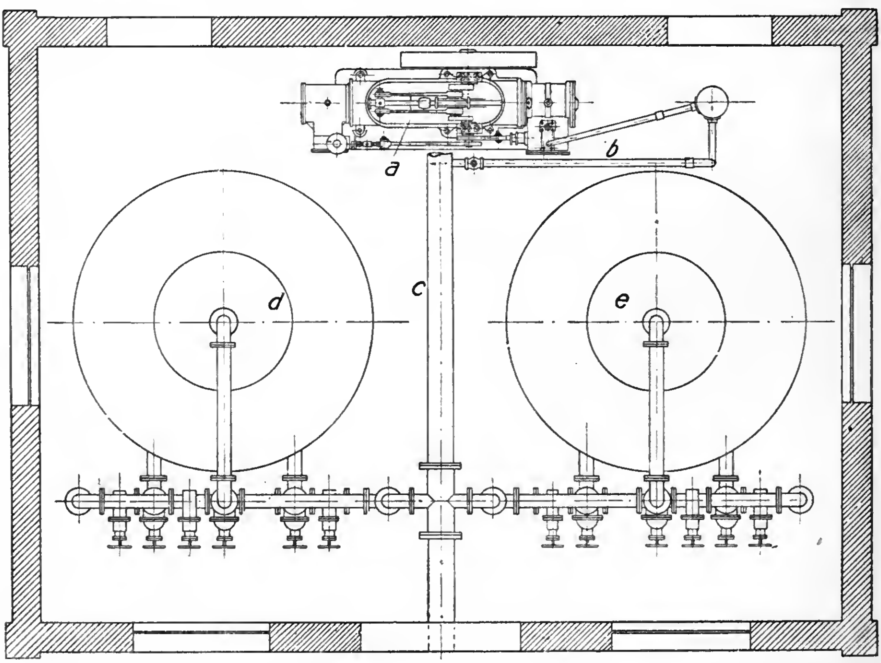


Fig. 51

mingled with it, gains the drum-filter *m* through the pipe *l*, eventually reaching the cistern *o* by the pipe *n*. The internal pressure of the air is regulated so that water cannot find an outlet at the valve *k*. Cleansing of the filter *m* is carried out as before.

(3) *Apparatus yielding* 4,400 *gallons per hour.*

The reaction chambers take the form of two shallow pressure-filters

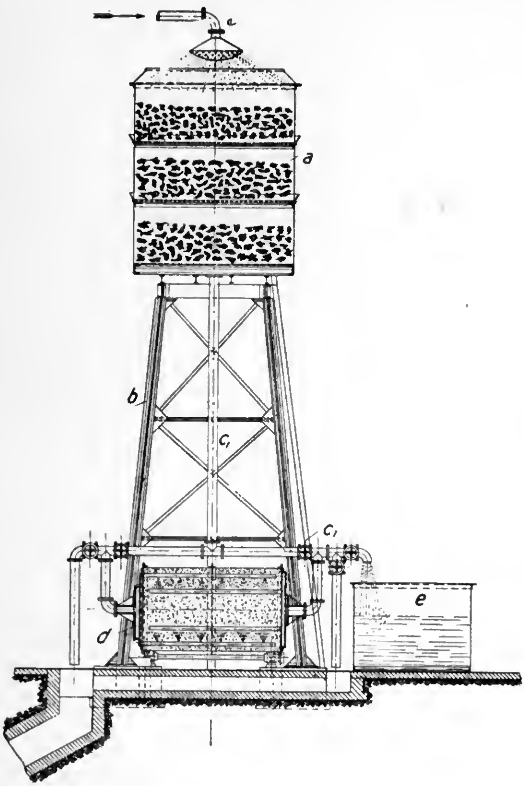


Fig. 52

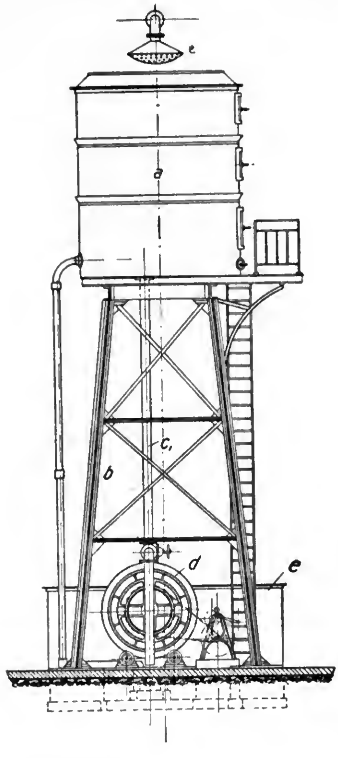


Fig. 53

(*Figs.* 50 and 51). Filters of this type, constructed by the above firm, can be used for iron reduction without the intervention of a cake tower. The air is driven by the pump *a* into a receiver and then into a pipe *b*, in which is inserted a back-pressure valve. After passing through this valve, it enters the water main *c* which leads to the filters *d* and *e* (*Fig.* 51). Iron reduction is accomplished in the upper layer of the filters and filtration in the lower fine-grained layer. Through *h* the purified water flows to the spot where it is required.

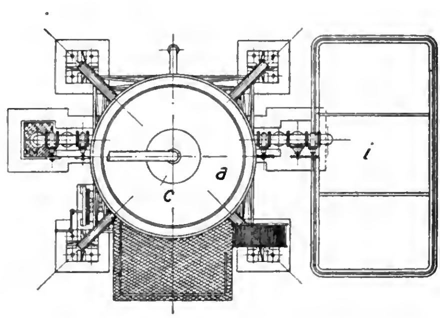


Fig. 54

Removal of the precipitate from the filtering layer is done with compressed air from the pump, and with back-flow of the water in the manner already explained. Vigorous action is possible, the wash-water being introduced separately into the three divisions in the lower part of the filter.

(4) *Apparatus yielding 13,200 gallons per hour.*

A cake holder *a* set upon an iron tower *b* (*Figs.* 52, 53 and 54) receives the raw water through a large rose *c*. The mixture of water and iron hydroxide gravitates through c_1 to the drum-filter *d*, and the purified water collects in the cistern *e*.

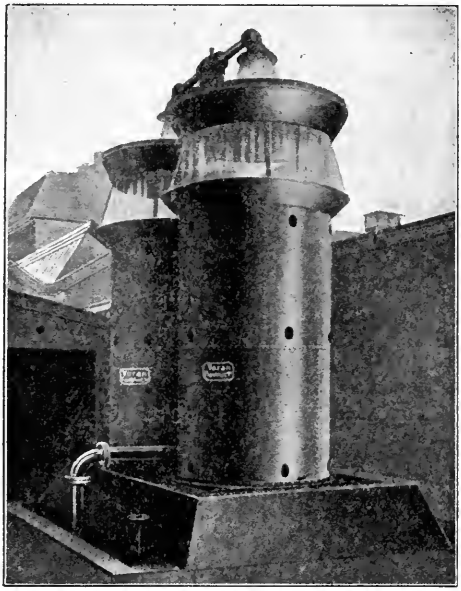


Fig. 55

(5) *Open Iron Reduction Apparatus.*

A noteworthy make of iron reducer is that illustrated in *Fig.* 55.* After the above accounts, nothing need be added except that, besides obtaining perfect results by simple means, the apparatus has the recommendation that the admission of water can be controlled from outside.

IV. THE WATER SOFTENER.

The expulsion of substances from water other than that effected by air is demanded for many purposes. For this chemicals are added. According to the character of the water and its objective, the chemicals and the method of separation are varied. The chemical treatment and subsequent clarification of water is named in brief "water softening," while the term "waste-water purification" refers to the removal of harmful ingredients from water already used.

A wide and important field for water softening is the withdrawal of encrusting salts from the feed-water of steam boilers. In addition to free carbonic acid gas, often feed-water contains the bicarbonates and sulphates of calcium and magnesium carbonate and sulphate, usually together with small amounts of calcium and magnesium chlorides, and nitrates, silicic acid, etc. Among the softening salts employed, the most general are quicklime and caustic soda. The quicklime decomposes the calcium and magnesium salts, withdrawing a molecule of carbonic acid, so producing simple carbonates, which are insoluble and settle down. The soda reacts with the calcium sul-

* Made by the Voran Apparatebau Gesellschaft

phate, the formation of calcium carbonate and sodium sulphate resulting, of which the first precipitates, and the latter remains in solution.

The quantities of these alkalis which have to be put in are sometimes determined from analysis of the water, and it is the task of the water softening apparatus to mix the requisite quantities with the water at a uniform rate and to suitably separate the precipitated salts from the treated water.

In response to the great need for such apparatus, a large number of different designs exist. To describe them all would not answer any useful purpose, particularly as most of them display some common features.

(1) *Gutmann's Water Softener.*

A typical appliance is manufactured by Gutmann (*Figs.* 56 and 57). The raw water reaches it from a tank, or is transmitted by a pump, through the pipe *a*, and enters the cistern *b*, a small stream flowing down the pipe *c* through the lime-saturator *d*. In this it comes into contact with the milk-of-lime previously introduced through the aperture closed by the lid *e*, dissolving the lime as it ascends towards the top of the saturator. Particles of the lime are agitated by the water-current until they are dissolved, their escape being hindered by the sieves *f* and *g*. The lime-water proceeds by the pipe *h* — furnished with an automatic float-valve to govern the outflow—to the cistern *k*.

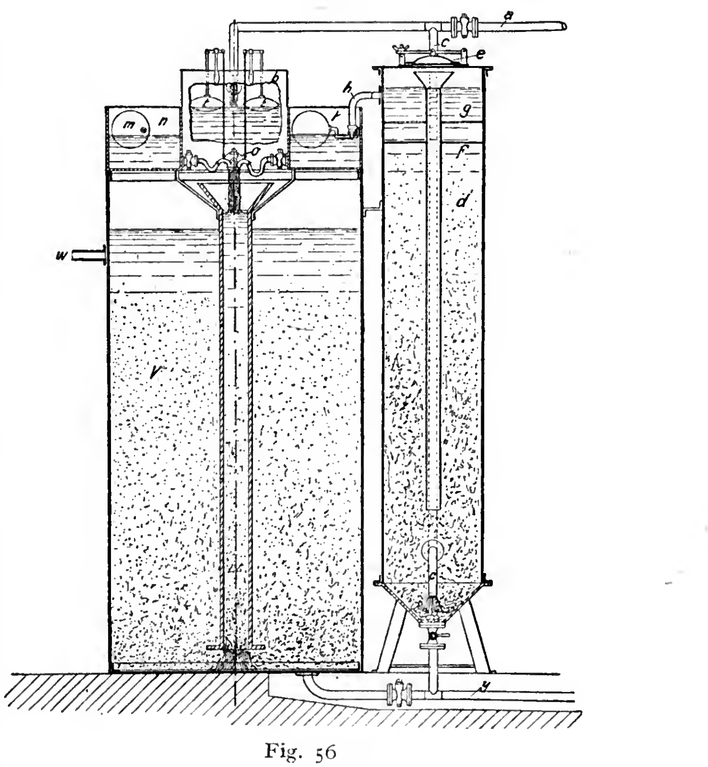


Fig. 56

Before commencing the work, the caustic soda solution is prepared in the cistern *l*, from which it reaches the cistern *n* by the pipe *m*, also fitted with automatic valve.

The cock *o* on the cistern *b* is set so that the water-level in the latter maintains a certain height under normal quantities. A proper relation between this height and the water-levels in *k* and *n* is kept by means of the levers *p* and q, attached at one end to the floats t in the cistern b. From the other end are suspended tubes which lead the solutions from k and n. The cocks r and s emit the correct amount of lime-water and soda solution to act upon the water coming from b. Should the bulk of raw water entering b alter, the rise or the fall of the water-level in it affects the floats t, and as a consequence changes the level of the outflow ends of the suspended tubes. Thus is preserved the relationship between H, the height of pressure in b, and h, that in k and n. Since the quantities issuing are in the proportions of $\sqrt{2gH}$ and $\sqrt{2gh}$, the chemicals added always remain in the same ratio to the raw water.

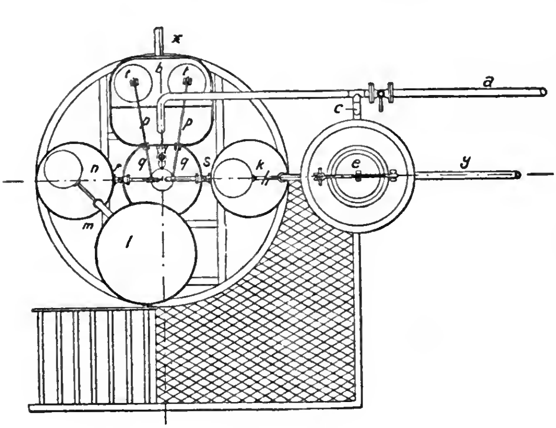


Fig. 57

The water and the added chemicals after being thoroughly mixed in the central funnel, emerge from the tube u into the settling tank v. Here the chemical reaction is finished, and the softened water mounts to the exit, leaving the precipitate to sink slowly to the bottom. This solid matter can be discharged from d and e through the pipe y. Only the finest particles continue in suspension and require filtering off.

(2) *Halvor Breda's Water Softener.*

With the last apparatus the softening is carried out in the cold, while one made in different sizes by Halvor Breda provides for the treatment at higher temperature. In the smaller sizes, without special filter, the cistern a (*Fig.* 58) receives the water first, and for keeping this water always at one level, a floating valve comes into activity on reduction of the height, while an overfall limits its increase. Below the cistern lies a second vessel, divided by a partition into two portions, of which one, d, functions as pre-heater, and the other, e, as holder of the caustic soda solution. The water, after leaving the cistern, and separating, as before, into two currents, clears the cocks b and c, each supplied with pointer and scale, and runs into the pre-heater d and the lime-water saturator f respectively. These cocks are so arranged that f takes in and gives out as required the requisite quantity of water, and the pre-heater is then under control.

The raw water may be warmed with live or with waste steam. So efficacious is pre-heating that the hardness of water treated in the cold amounts to 6—7 degrees in the German scale of hardness, while, when treated at 60°C., the hardness equals only 1—2 degrees.

The lime-water saturator, a cylindrical vessel with a conical base, admits the water through the funnel fixed at the top of a central tube which ends near the base. Air is thus entangled and the bubbles rise from the end of the tube towards the upper part of the saturator, agitating, as they do so, the particles of lime. But they are soon entrapped by the funnel-like base of a second and wider tube, which conducts them out of the saturator and leaves undisturbed the slowly ascending current of lime-water, that is gradually becoming saturated

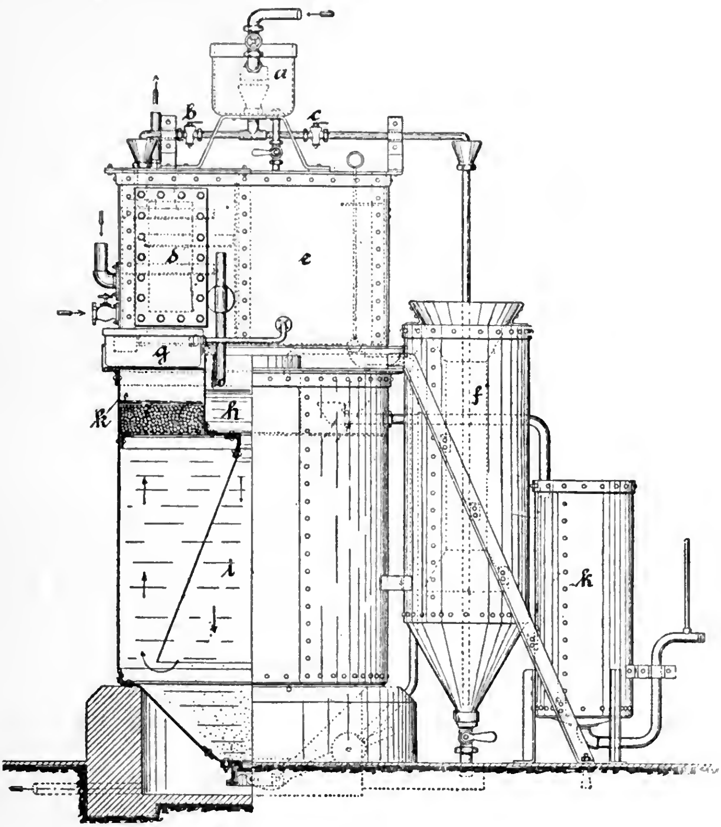


Fig. 58

The necessary amount of caustic soda solution is daily put into the receptacle *e*, and from this it proceeds to the regulating cistern *g*, where a floating-valve maintains the water-level. Next, it passes an adjustable cock to the mixing chamber *h*, which receives also the lime-water from *f*, and the water from *d*. The reactions between the solids in the water and the softening materials take place within the mixing chamber, and the whole gravitates sluggishly down the inverted funnel *i*, the solids which have been produced in a flocculent form falling into the bottom to be removed periodically through a run-off valve. Other finer particles of these precipitates are conveyed upwards with the current towards the filter *k*, which is an ordinary open filter, and has wood-wool as the filtering medium, piled upon a false bottom, and pressed down by one or more removable perforated plates. Exhausted filtering material is replaced by new.

Apparatus of this type has a capacity per hour of 75 to 340 gallons.

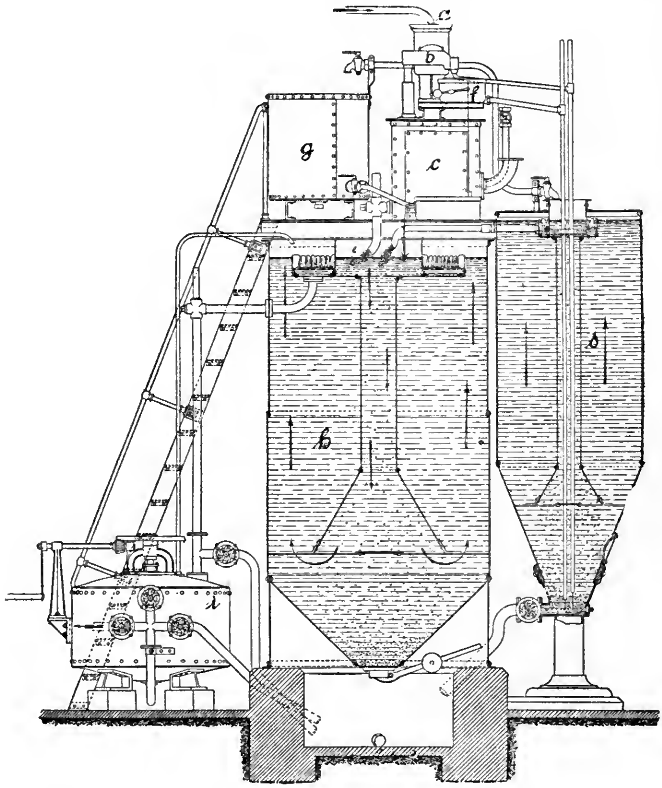


Fig. 59

The larger sizes—with a capacity of 440 to 22,000, and even more, gallons, per hour—are built on somewhat different lines. While in the smaller sizes the exact proportions of the chemicals are inserted by hand, in the larger ones this is done automatically. To this end has been devised the following system (*Fig.* 59) :—

After entering and leaving the circular vessel *a*, the raw water reaches a by-wash *b*, where it forks into two streams on meeting a current divider. As before, one stream goes to a pre-heater *e*, the other towards a lime saturator *d*.

The latter becomes itself divided, one branch flowing directly into the lime saturator, the other into a tilting-box *f*, which fills and empties about five times a minute. This box has the duty on the one hand of carrying air into the lime-water receptacle at its periodical emptyings, on the other of taking in at every heave a scoopful of soda solution from the regulating box connected with the soda cistern and of discharging it into the mixing chamber *e*. A floating valve keeps the liquid in the soda cistern at a constant height. In the mixing chamber the essential reactions take place, and the mixture then gravitates into the settling-tank *h* and ultimately undergoes clarification in a filter like that pictured in *Fig.* 43.

An external view of a large water softener capable of dealing with 6,234 gallons per hour is reproduced in *Fig.* 60. Other still larger apparatus give yields up to 44,000 gallons.

(3) *Gutmann's Water Softening Plant.*

A plant for turning out the last quoted quantity has two vessels *a* and *b* (*Figs.* 61–63) out of which pour the solutions into a common channel *c*, then down a pipe *d* into the settling-tank *e*. The mixture rises to the top of the latter and through the pipe *f* reaches the sand-filters *g*, built on principles already described, and from these the softened water passes by the pipe *i* towards the tank *k*. Here the mixing is not under automatic control, but demands constant supervision.

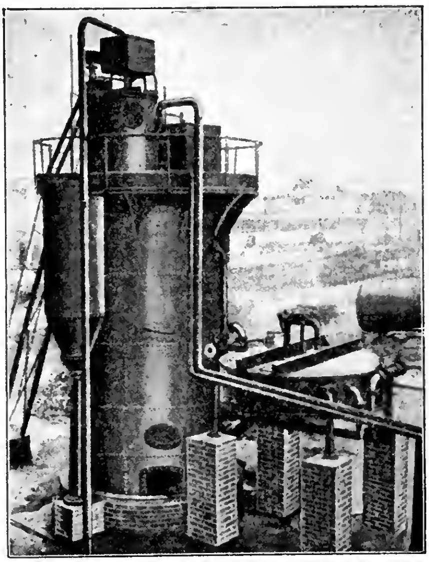
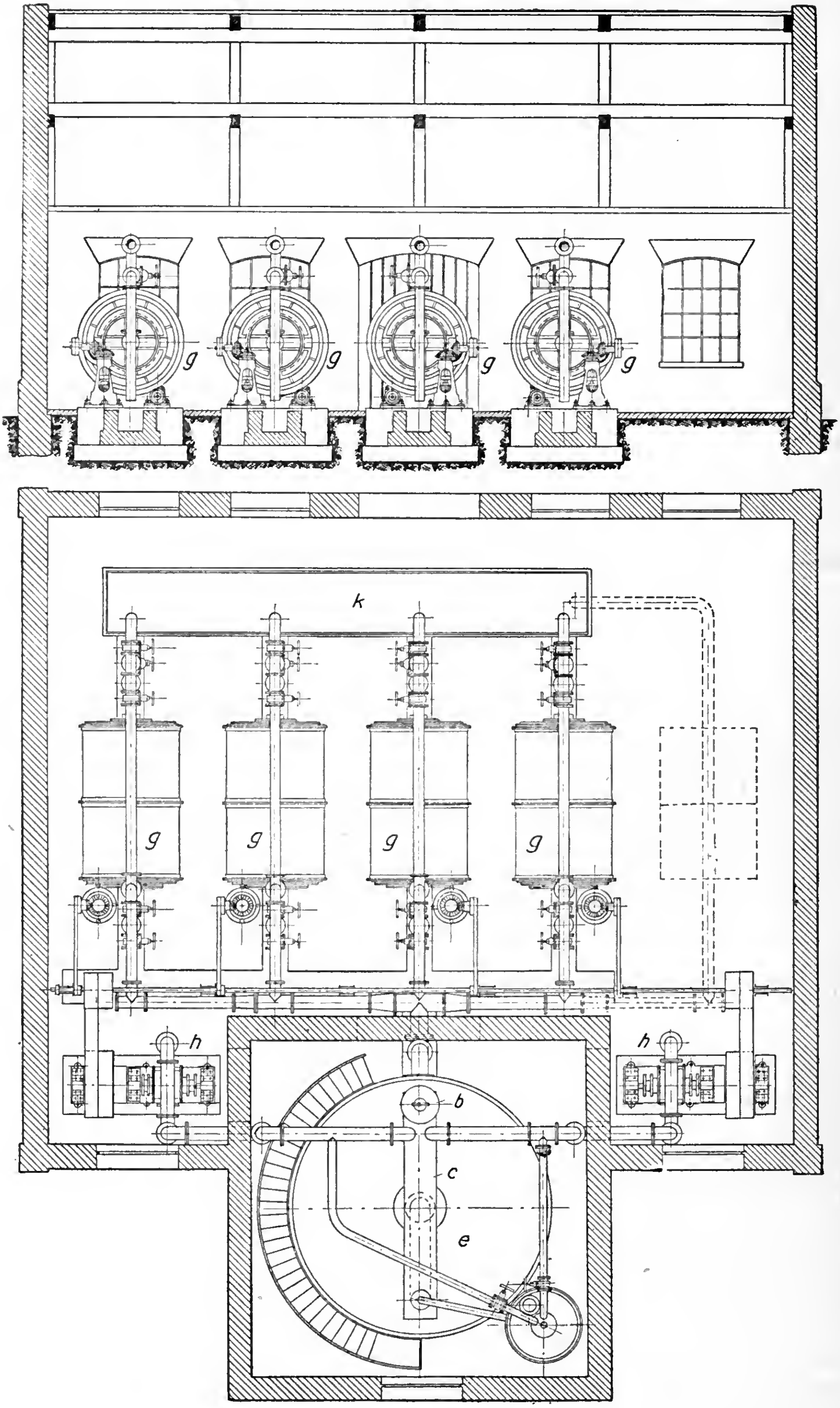


Fig. 60

V. SPIRIT FILTER.

In conclusion, mention may be made of a filtering apparatus which is not strictly speaking used for separating solid particles from liquid, but owing to the nature of working comes under this heading. The filter in question is the wood-charcoal filter used by distillers for extracting fusel oil from spirit before the latter is rectified (*Figs.* 64 and 65). The wood-charcoal fills the interior, supported upon a sieve-plate; the spirit enters from above, and by gentle heating, with a steam coil situated on the false bottom, the process is encouraged.



Figs. 61 and 62

The charcoal is introduced through the upper manhole, at the base of which is a sieve; and, when exhausted, is removed by means of the lower manhole.

A number of such filters are generally combined in batteries.

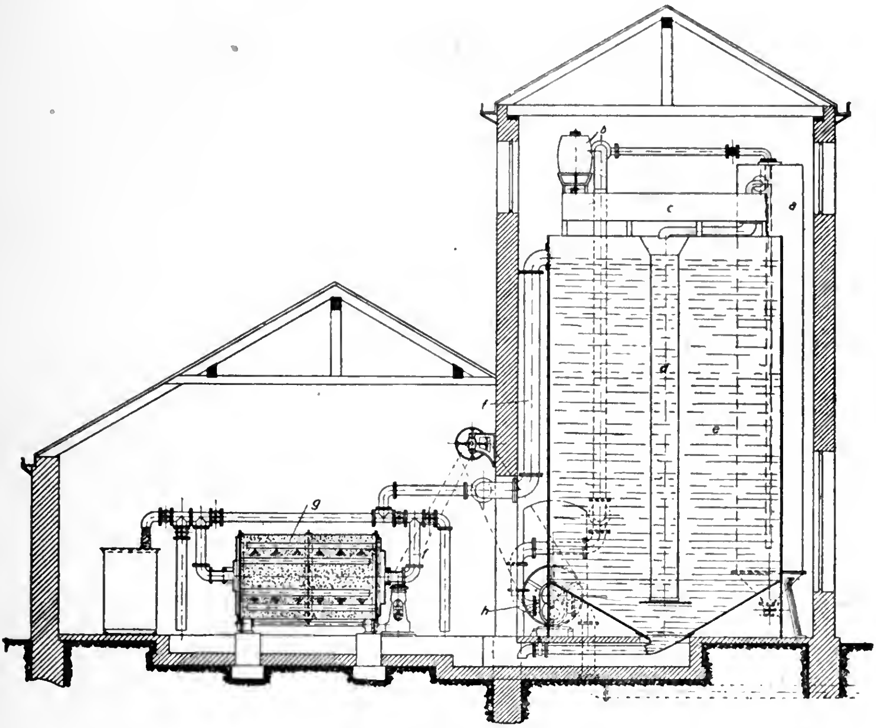


Fig. 63

FILTERS WITH WOVEN OR FELTED FILTERING MEDIUM.

I. Open Filters.

As distinguished from the foregoing types with loose filtering mediums, these are designed chiefly for smaller amounts of liquid and are applied almost exclusively to industrial objects. The filtering material may be variously composed: of vegetable fibres, worked up into paper, pasteboard or woven fabric; of animal fibres, as hair and wool; of mineral fibres, as asbestos; or of woven wire in the form of gauze and cloth. According to the nature of the mixture to be treated, its content of acid or alkali, and its temperature, the character of the material and the shape of the filter differ. But so numerous are the purposes of these filters that it appears impossible to classify them from this standpoint.

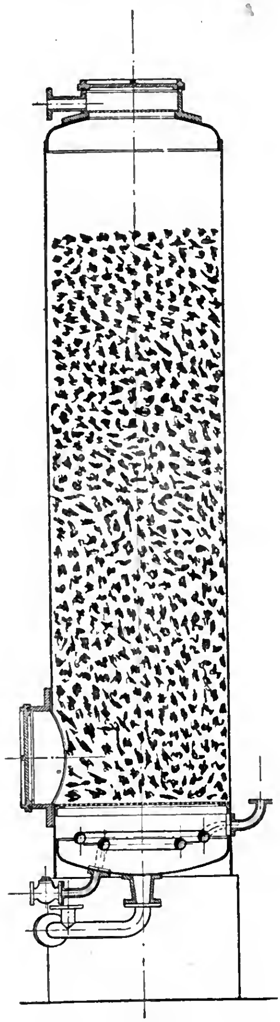


Fig. 64

(1) *Funnel or Bag Filters.*

The paper filter of the laboratory familiar to all chemists, and having the recommendation that it can be incinerated without leaving much ash, is also sometimes used industrially, especially where small bulks of valuable liquid are concerned. Incineration being sometimes so desirable, the paper is composed of cellulose as free as possible from mineral substances, occasionally treated with acid to remove the salts, and is prepared from the best raw materials. Since this paper does not possess any tensile strength when wet, provision has to be made for maintaining its shape.

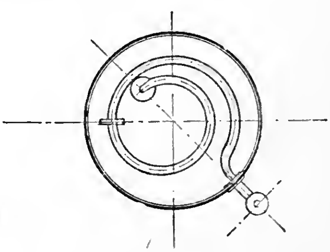


Fig. 65

Generally it is folded into a cone and put into a glass, wooden or metal funnel, deeply fluted to help the draining of the filtrate.

The simple conical shape is that usually taken by the fibrous filter bag, the fibres being either animal, or vegetable. Penetrating the wall of the bag, the liquid leaves the solid matter behind in the apex. Another simple form is the flat filter, involving the use of straining cloth, above which the liquid must be collected in sufficient amount by some special appliance. The most convenient and least complicated is the drainer.

(2) *Open Drainer.*

Drainers are circular or rectangular receptacles, having false bottoms covered with filter-cloth. The liquid may pass through under the influence of gravity alone, or by the creation of a partial vacuum, or by the application of increased pressure.

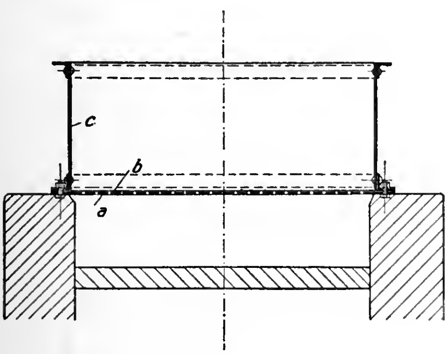


Fig. 66

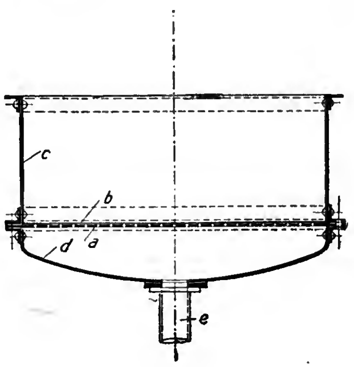


Fig. 67

In *Fig.* 66 is delineated a very simple arrangement. Closely covering the perforated bottom *a* of resistant material is the filter-cloth *b*; and as a circular or rectangular frame *c* is firmly bolted to the false bottom of the filter, the cloth makes a tight joint.

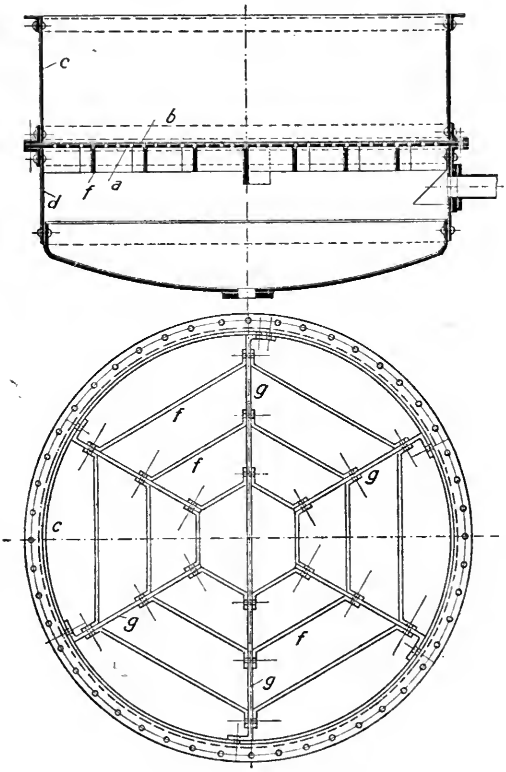
(3) *Simple Drainers enclosed below.*

Usually drainers find their application where, in comparison with that of the liquid, the proportion of residue—its recovery being sometimes the chief aim of the filtration—is relatively great. Liquid dropping from a drainer of the type just shown in *Fig.* 66 disappears in a pit, escape-pipe, or the like; but if it has to be retained, beneath the sieve-plate *a* (*Fig.* 67) is fastened a bottom *d* with an outlet pipe *e*.

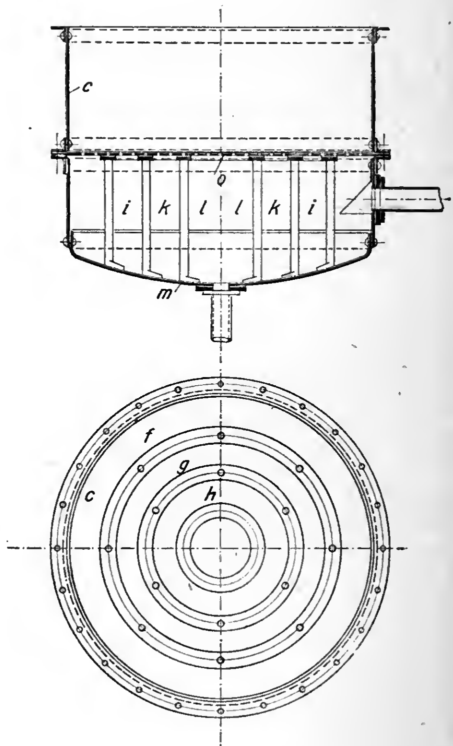
(4) *Drainers with Strengthened False Bottoms.*

If the drainer is of considerable diameter, the sieve-plate must be fortified below, otherwise it will, owing to its weight, fall through. In simpler cases, flat (*Figs*. 68 and 69) or section iron is sufficient. Flat-iron bars *f* and *g* are screwed or rivetted to one another and to the wall *d*, giving ample support to the sieve-plate *a*. Strengthening can also be achieved by placing iron stools below the sieve-plates, these stools being strong iron rings with feet resting on the solid bottom. *Figs*. 70 and 71, *f*, *g*, and *h*, show these stools, with their feet *i*, *k* and *l*, bearing up the sieve-plate *m*.

Excepting the first of these drainers (*Fig*. 66), all the above are adapted for accelerating the filtration bv generation of a partial vacuum, no more being



Figs. 68 and 69



Figs. 70 and 71

necessary than to put the space below the sieve-plate into communication with an air exhauster. The filter-cloth forming an airtight joint between sieve-plate and frame, atmospheric pressure forces the liquid through the cloth.

(5) *Drainers with Mechanical Appliances.*

In ordinary drainers the difficulty arises that when the cake of residue is nearing dryness, cracks develop (*Figs*. 72 and 73) due to shrinkage, leaving large gaps through which the air passes without exercising its proper function of expelling the liquid lying in the capillary interspaces of the cake. The development of cracks is thus an evil that must be obviated, say, by stirring the surface. As a rule this is done by hand, but the labour costs for operations on a large scale have led to the devising of mechanical apparatus (*Figs.* 74–76.) Upon the walls of the drainer *a* travels a carriage *b* holding a stirring appliance *c*, the height of which can be adjusted. Two endless chains *d* draw the carriage to-and-fro, the reversal of the motion resulting through pins on the carriage and by a connecting rod *e*, which alternates the open and crossed belts upon *f*, the driving pulleys.

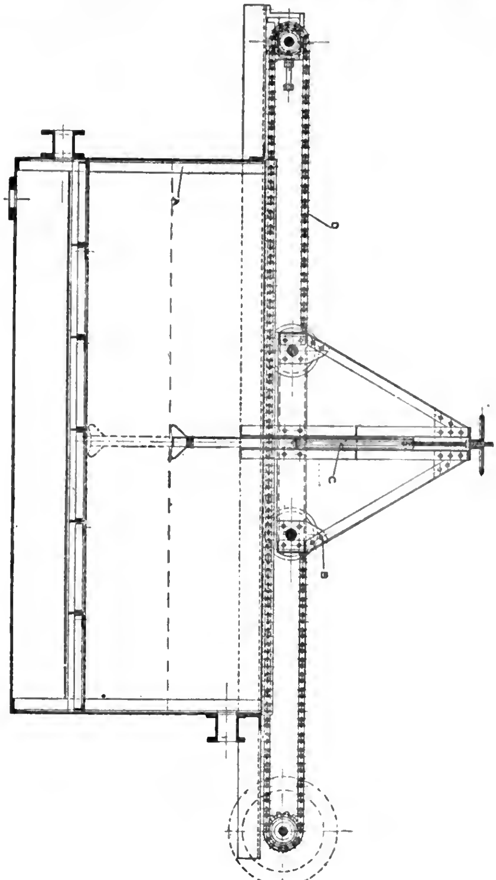


Fig. 74

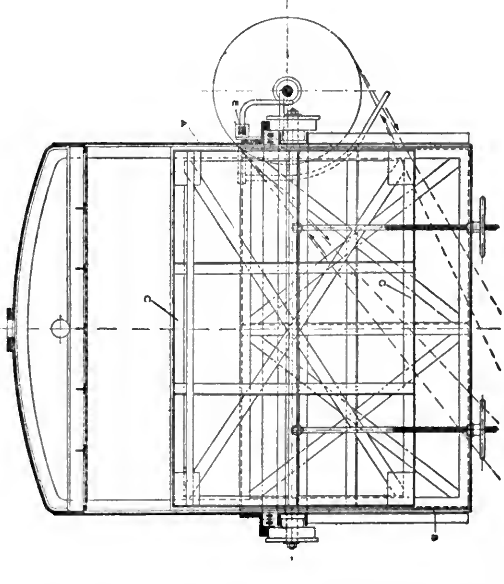
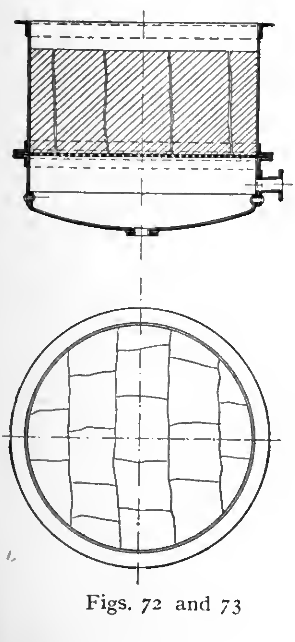


Fig. 75



Figs. 72 and 73

The continuous stirring has an excellent effect upon the surface, and masses such as precipitated gypsum of lime, that otherwise drain with difficulty or insufficiently, can by this method be handled with success.

(6) *Air-Pumps for working with Drainers.*

The partial vacuum is generated by air-pumps belonging to two different systems. By means of wet air-pumps both liquid and air are sucked out and removed together.

They are seldom used along with drainers, since in many cases the liquid must not come into contact with the inside of the pump. With dry air-pumps a vessel is inserted between the drainer and pump to separate the air from the

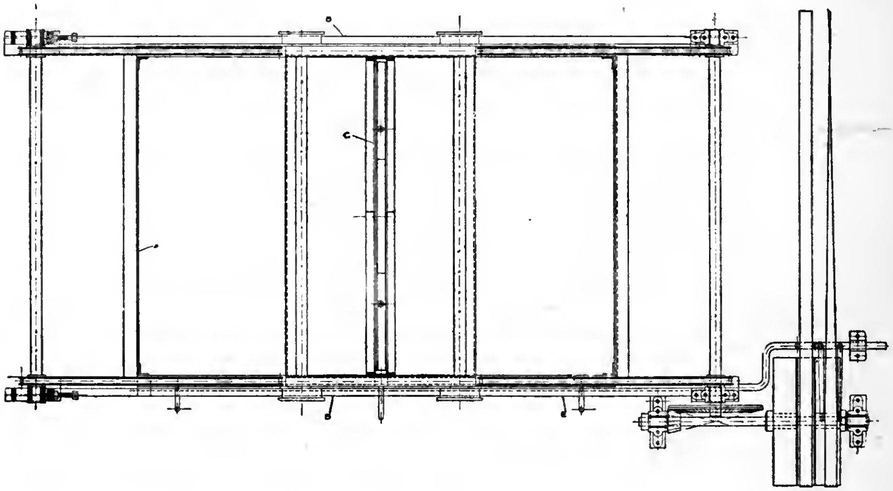


Fig. 76

liquid. Most dry pumps nowadays are piston-pumps. Rotating pumps, either with rotary pistons or blades (centrifugal) are in the minority, a high degree of exhaustion not being realizable with the latter.

Simple Air-Pumps (American) with Clack Valves.—The principle of these pumps is indicated in *Fig.* 77. Through the openings *A* and *B* air is drawn into the suction chamber, which has two flap-valves *C* and *D* that open on reduction of the pressure inside of the cylinder and shut on its increase. The air escapes under the flap-valves *E* and *F* to the exhaust pipe. For limiting the backward swing of the valves, stops are placed at *G*, *H*, *I* and *K*.

Heckmann's Plate-Valve Pumps.—Besides these simple American models, a noteworthy one is that made by Heckmann (*Figs.* 78 and 79). Plate-valves replace the flap-valves, and negative pressures arising at changes in direction of the piston are compensated for. To this end serve two injector valves A, in front of the openings B and C, which absorb water or glycerine from the trough G to fill the harmful vacua. This liquid runs back to the trough by the aperture D in the bottom of the chamber F. The air finds an outlet at E.

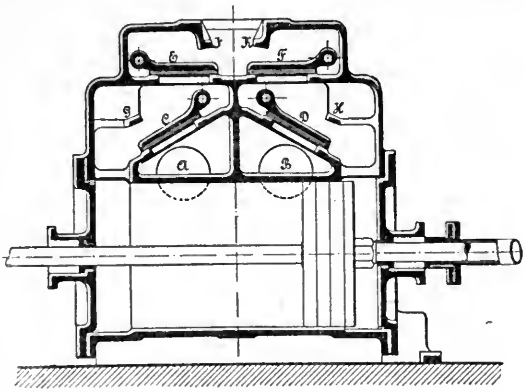


Fig. 77

Pokorny and Wittekind's Slide-Valve Pump.—This firm manufacture, on the Koster pattern, an air-pump in which the movement of the air is governed by a slide-valve. The essential feature of the pump consists in that, the air being sucked in and forced out through the passages M_1, M_2 and P in the

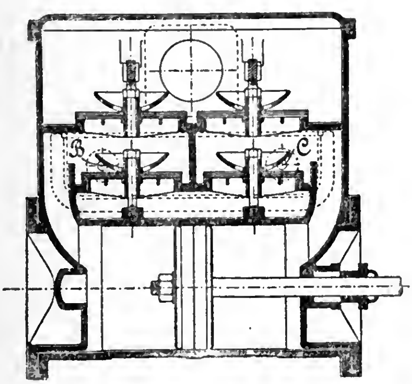


Fig. 78

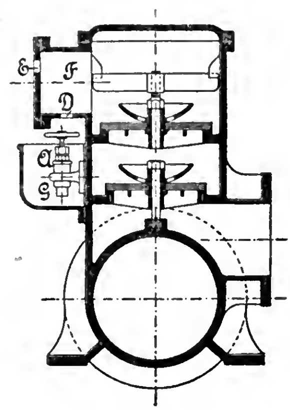


Fig. 79

valve (*Figs.* 80 and 81), this can open up the channels to the interior without exposing them. From the point of view of accessibility and safety in working, these are advantages that must not be undervalued.

In the position indicated, the air is being drawn out of the suction-pipe through S_2, and the passage M_2 of the valve, and on through K_2 into the space C behind the piston. At the same time, the air upon the other side of the piston escapes through K_1, P and the exit D. The pressure adjustment, that is, the transfer of air interfering with the vacuum, from one side of the

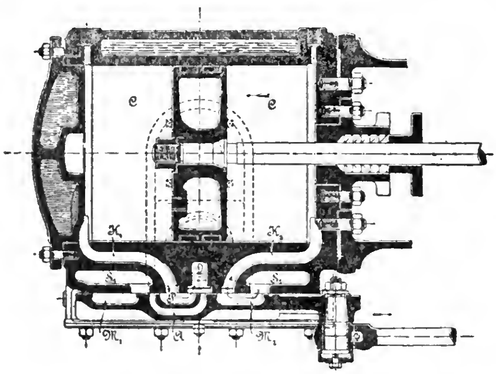


Fig. 80

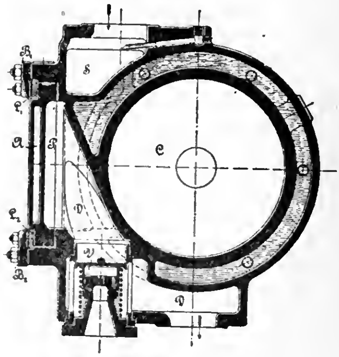


Fig. 81

piston to the other, where it is removed, occurs at about the dead centre position of the piston. For the purpose of this transfer a passage A exists in the slide-valve.

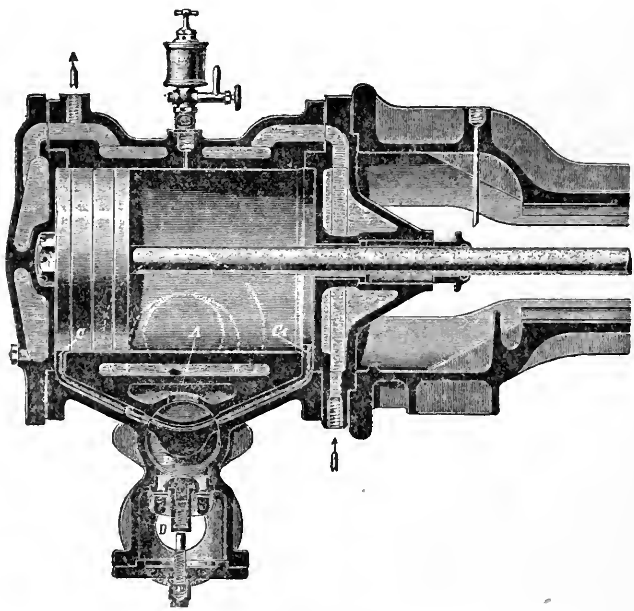


Fig. 82

C. A. Schutz's Rotary Valve Air-Pump.—The rotary valve B in this air-pump (*Fig.* 82) leads the air taken in at A through the passages C and C_1 alternately to one side or other of the piston. To compensate, the refractory air quits one side for the other in the position shown in the figure by way of the slit *E* in the valve. The exhausted air emerges at the connecting branch *D*.

A view of the whole pump, which may be driven by belting from an electric motor or steam engine, is given in *Fig.* 83.

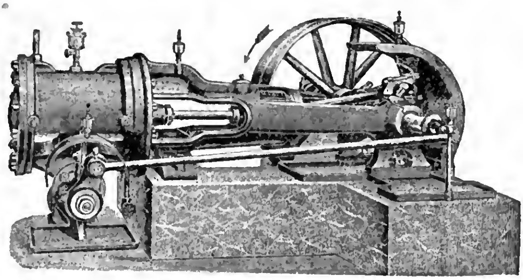


Fig. 83

Wet Air-Pumps.—Such pumps, either vertical or horizontal, are characterized by a plunger or valve piston. In *Figs.* 84 and 85 are represented two single-acting pumps in which the suction and pressure sides are cut off from one another by ordinary plate-valves.

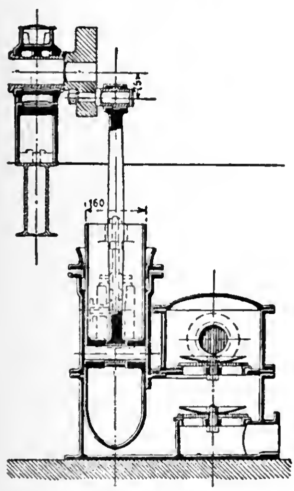


Fig. 84

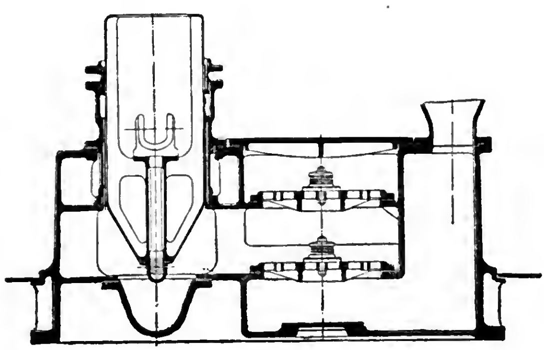


Fig. 85

An improved apparatus is set forth in *Fig.* 86, the mixture of air and water flowing automatically to the pump. Pouring through *A* into the double-walled cylinder *C*, where works the piston *B*, the mixture commences to penetrate the ring-shaped slit *D* once the upper edge of the piston has cleared it, and fills the hollow of the latter, being forced through *D* by the piston's downward movement. At the return movement of the piston, of course, part of the mixture gets back into C through the slit D; however the aggregate yield is good enough, and the omission of the suction valve is a gain not to be lost sight of.

Since they are only single-acting, the outputs of the air-pumps described in *Figs.* 83–86 equal only half those of the double-acting pumps now to be examined.

In the pump with differential pistons outlined in *Fig.* 87, a certain amount of mixed air and water is absorbed through the lowermost valves at the up-stroke of the pistons. At the down-stroke these valves close and the mixture is propelled above the piston through the valves in it. As the space above is less than that below, a portion of the mixture must escape through the delivery valves, while at the upstroke the remainder is thrown out. If it be wished to make the amounts lifted at the up and downstrokes equal, the plunger must have seven-tenths the diameter of the piston.

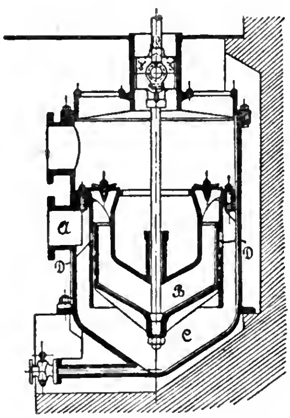


Fig. 86

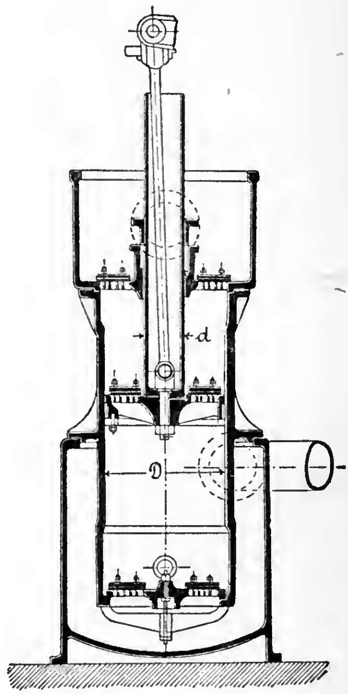


Fig. 87

Air-Pumps with Separate Air and Water Feeds.—A horizontal air-pump with separate feeds is exhibited in *Figs.* 88–91. At each end of the cylinder are situated two suction valves F, two delivery valves G, and two small air valves H. The space on the right side of the piston in this particular position is filled with water. When the piston moves towards the left, the water-level lowers, while the delivery valves G keep closed under pressure by the atmosphere, and thus arises a vacuum under these valves. The water being no longer in contact with the air valves *H*, air passes through them from the

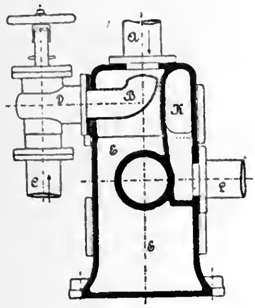


Fig. 88

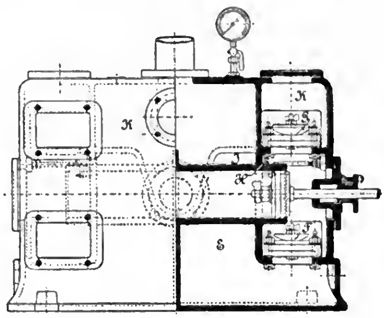


Fig. 89

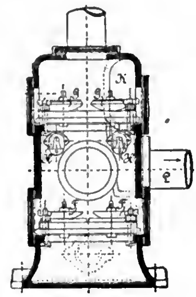


Fig. 90

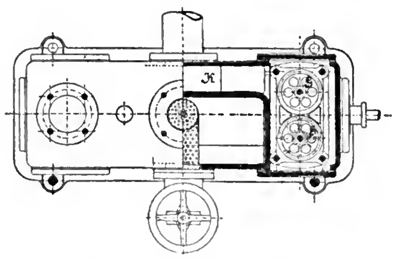


Fig. 91

suction to the piston chamber; and since the same pressure rules in both, water also pours in through *F*. Air and water together reach the exterior through *K* and *L*.

Figs. 92 and 93 show Riedler's double-action air-pump. The distinctive point about this pump is the leading of the exhausted air to the highest point of the condenser by a tube with a suction valve at its lower end. Other suction valves at the base of the cylinder admit the water.

A double-acting piston air-pump, shown in *Fig*. 94, is turned out by the Orlikon factory; and L. A.

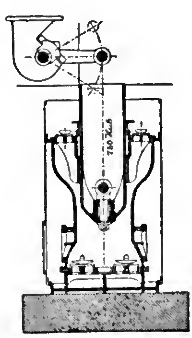


Fig. 92

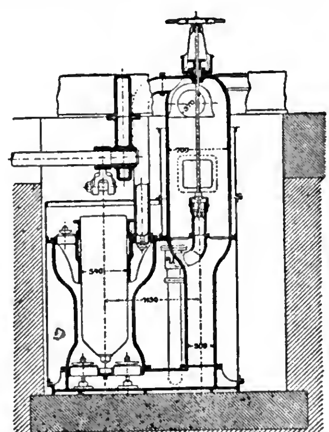


Fig. 93

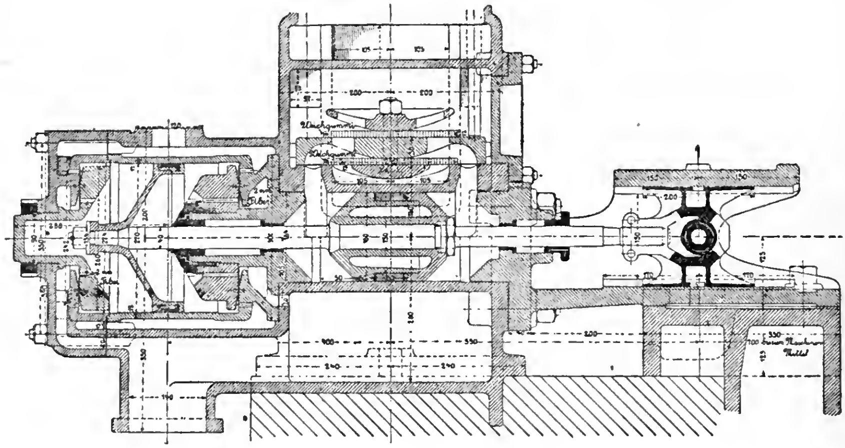


Fig. 94

Riedinger makes a horizontal double-acting air-pump with rubber clack-valves, as in *Fig.* 95. Both are much employed in condensation installations.

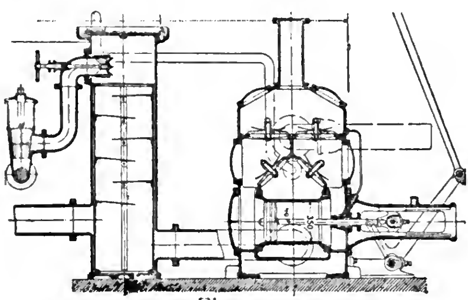


Fig. 95

(7) *Batteries of Drainers.*

Usually a number of drainers are linked together in a battery and are worked by a common air-pump, which, since a dry air-pump may officiate also as an air-compressor for low pressures, can be utilized also in driving away the filtrate.

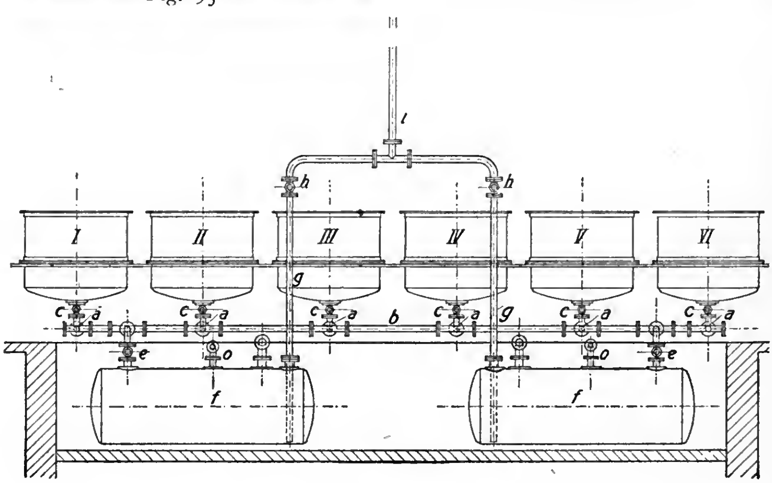


Fig 96

The arrangement of a battery is outlined in *Figs.* 96–98. Terminating in a common pipe *b*, and leading from the drainers I–VI, the outflow pipes *a* may be cut off independently by the cocks *c*. From *b* proceed two connecting-pipes *d*, with cocks or valves *e*, to the two tanks *f*, where accumulates the

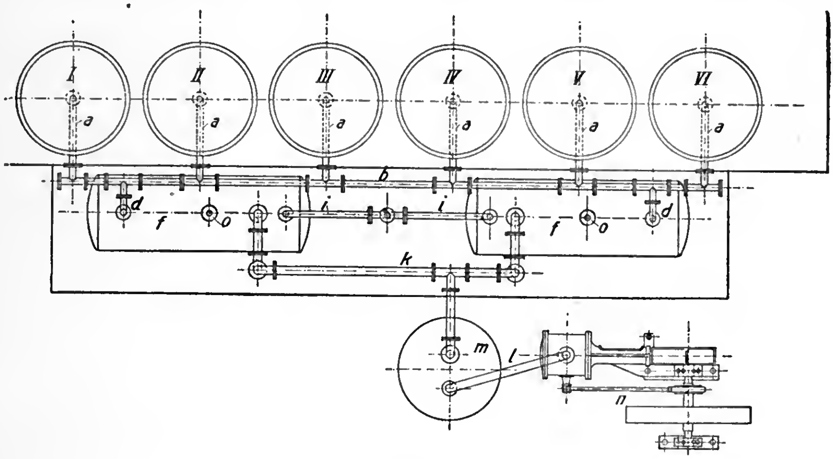


Fig. 97

liquid that is drawn into them by exhaustion from the air-pump *n*. Between these tanks and the pump is inserted, for neutralizing acid liquids, an intermediate vessel, charged with a suitable reagent and connected with the tanks by *k* and its branches. The pump acts, therefore, directly upon *m*, and through it, and the pipe *k*, upon the tanks. When emptying these, *m* and the drainers are shut off, and compressed air is driven through *o* to propel the liquid in *f* through the pipes *g* and cocks *h*, and away through *i*. So long as there is a vacuum in the tanks, the cocks *h* remain automatically closed.

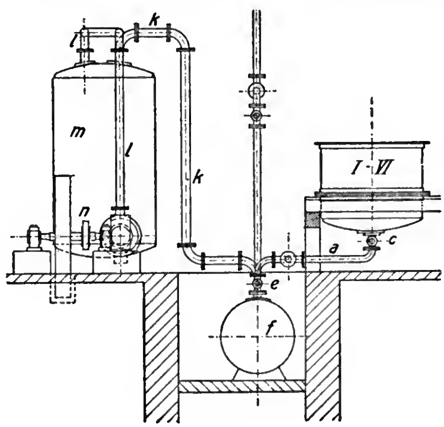


Fig. 98

Another draining battery is explained in *Figs.* 99 and 100. Upon the strong collecting-tubes *b* are fixed the drainers *a* in tens or twenties, the collecting vessels *c* receiving the liquid from them. A powerful vacuum-pump induces the necessary suction, the air-cocks *e* being then closed. When draining has been completed, the valves *f* are closed, and these cocks opened. Evacuation of the vessel *c* is through the valves *g*.

(8) *Mechanically-emptied Drainers.*

The emptying by hand of drainers means loss of time and increase in working costs. Often the process of draining itself occupies so long a period, frequently many days, that the time spent in emptying is relatively short. But the case is quite different where the draining lasts only for a brief period, as with the covered vessels resorted to in the potash industry, and clearing these more capacious drainers involves much waste in time and labour.

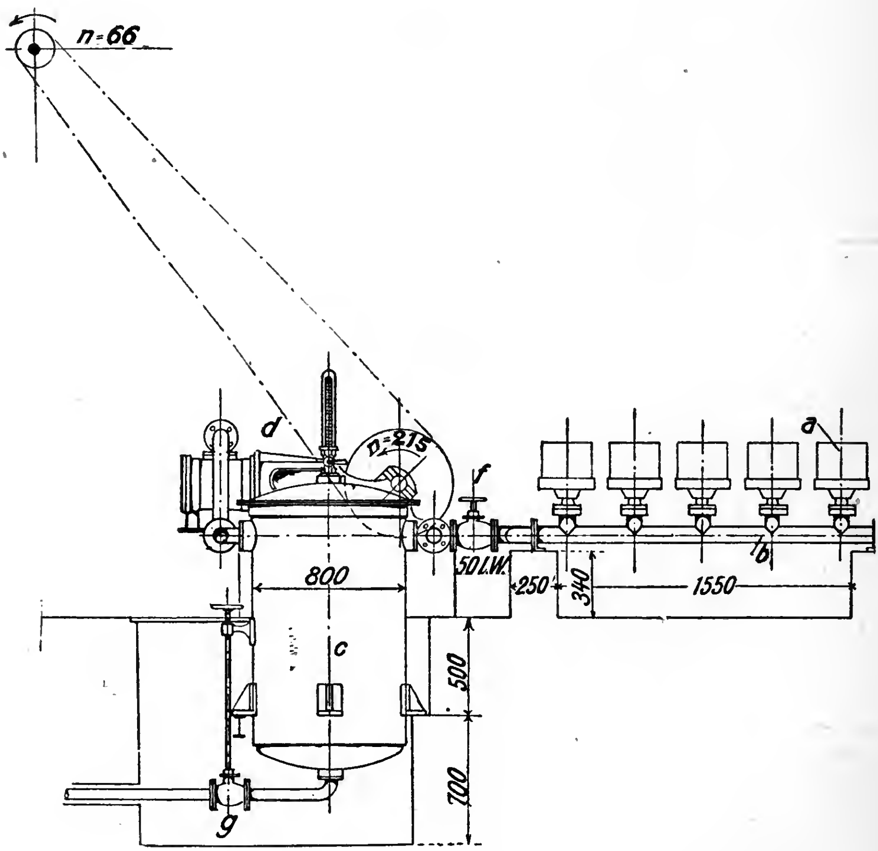


Fig. 99

Economy is achieved by having the drainers to turn around an axis set below or at their centres of gravity, a revolution through 180° causing the contents to fall out. So suspended, they are to a great extent made use of in the potash industry, and are also found in saltworks, their introduction being warranted wherever large quantities of non-adhesive residues are concerned.

The drainer includes a casing *a*, a false bottom, and a solid bottom *c* (*Figs.* 101 and 102). Two gudgeons in ordinary bearings *g* are bolted to the casing, one of them *d* being hollow and connected through a bent pipe with the space below the false bottom, while it is coupled by means of a stuffing-box with the exhaust pipe *i*. A worm-wheel on the gudgeon d_1, is actuated

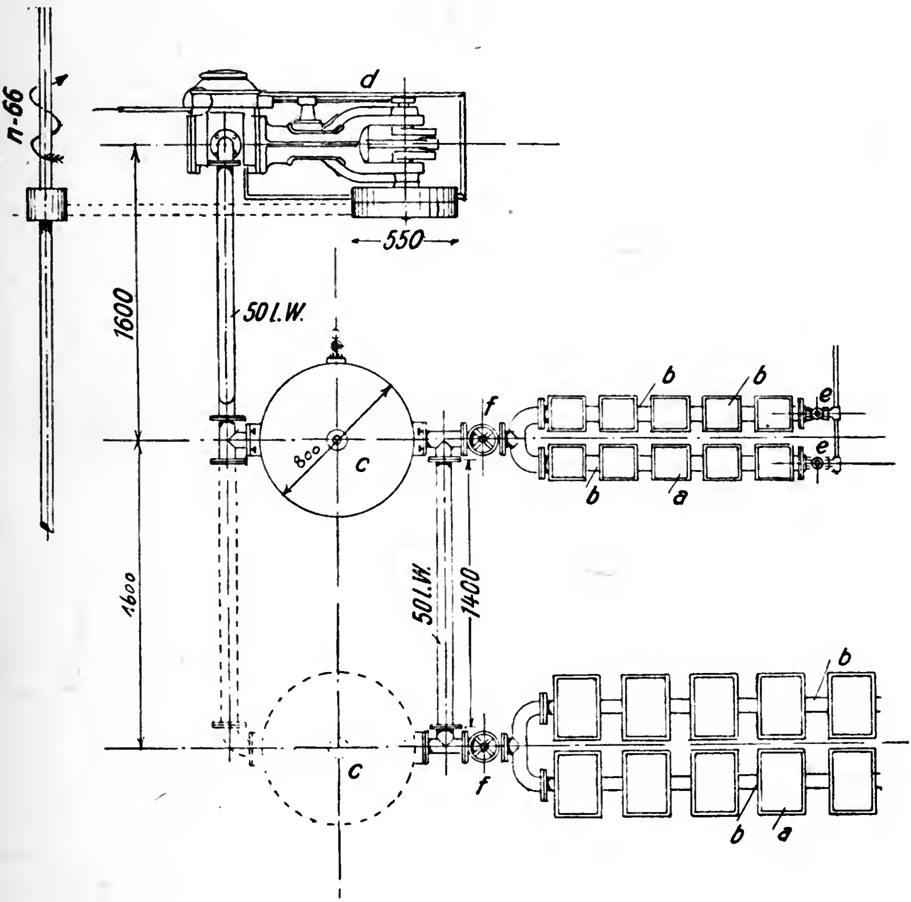


Fig. 100

by a worm *l*. Most of the liquid separates by its own pressure, and then the cock *n* is shut and the extraction of the rest assisted by the exhaustion of the air. After collecting in the bottom the liquid is run off through *m* and the cock *n*. Before the drainer is inverted this cock must be opened.

In *Figs.* 103–105 are shown the plans of a tilting drainer with a high capacity. The essential features are as before and enumeration of the details may be omitted.

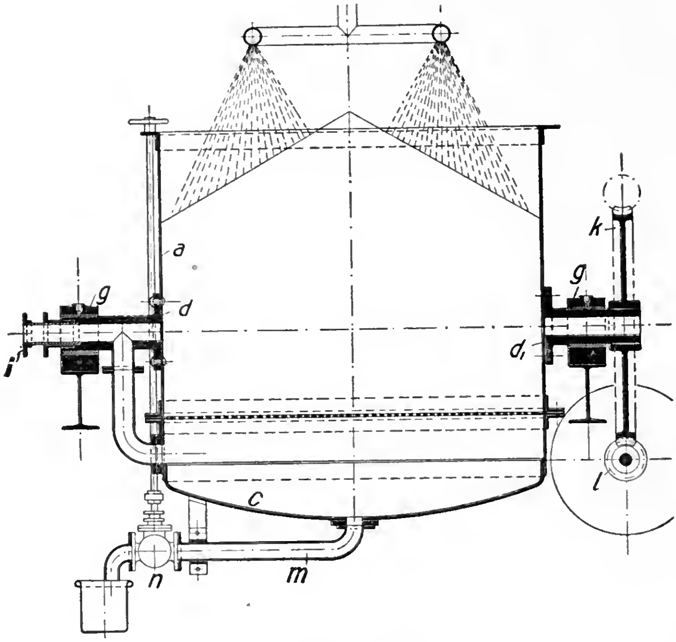


Fig. 101

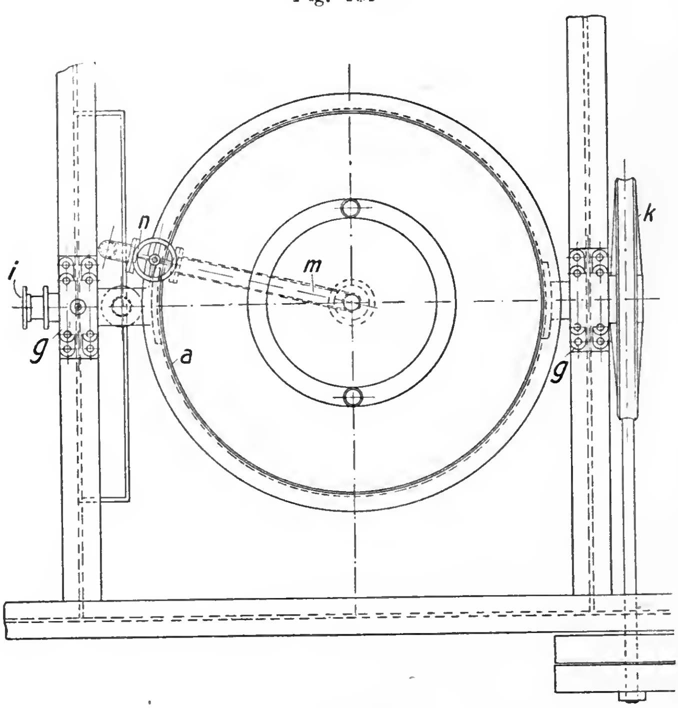


Fig. 102

(9) *Fesca's Storied Drainer.*

This apparatus, manufactured by Albert Fesca & Co., renders possible a saving in floor space, and when compared with hand-emptied drainers, reduces labour charges. As may be observed in *Figs.* 106–109, four drainers occupy the room of two, including the space required for charging and discharging, while eight take up the room of four. The drainers A_1, A_2, A_3 and A_4 wheel around the pillar B, which also serves as exhausting pipe, and from their bases D tubes E pass to the pillar for the air exhaustion. Upon C is coupled the pipe leading to the air pump or intermediate exhaust vessel. Drained liquid collecting in the lower parts of

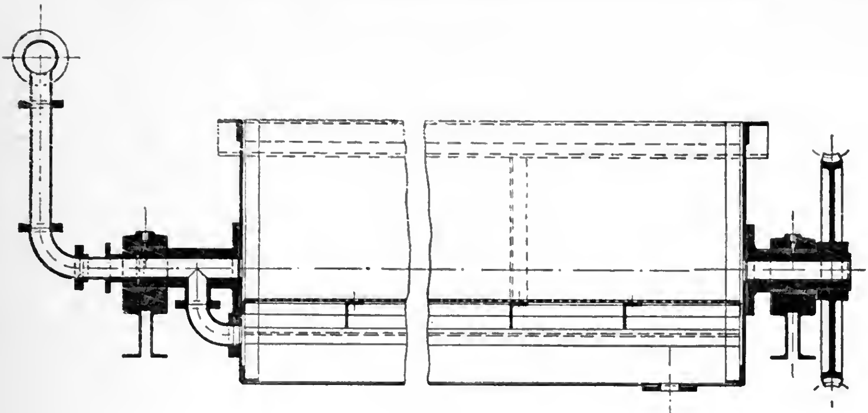


Fig. 103

the drainers is let off through the cocks *G*. When a drainer is to be emptied, it is wheeled into the position shown by the dotted lines, and is tilted around the gudgeons *H*, to be charged again when convenient. Where eight drainers are set on a single pillar, they are made for wheeling in pairs.

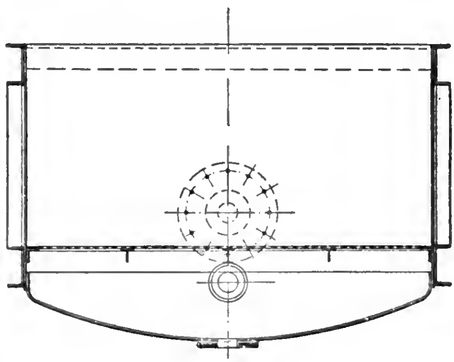


Fig. 104

With drainers of large size, mounting upon one pillar is not practicable, and they are supported upon two, there being only two tiers (*Figs*. 110–113). The tilting of the two drainers a, a_1 around their bearings upon the two pillars b, b_1 is effected by the toothed gearing c, d, d_1, and the handle e. The bottoms of the drainers and two connecting branches g, g_1 on the pillar b are connected by two flexible tubes f, f_1, and both connecting branches open into the pipe h that conducts to the storing tank.

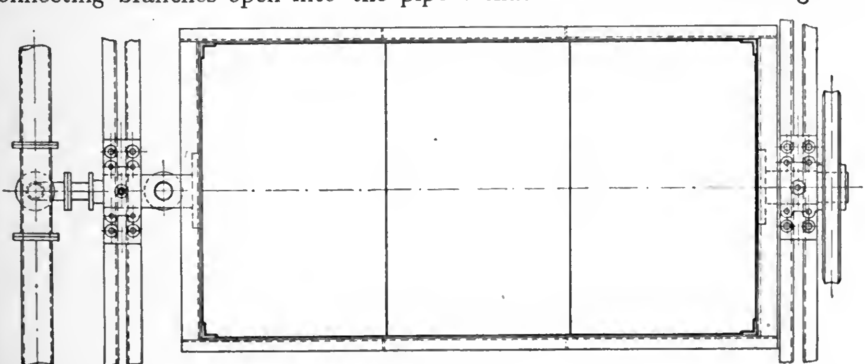
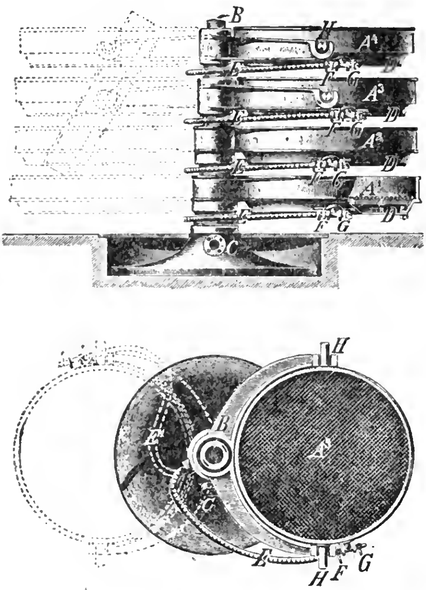


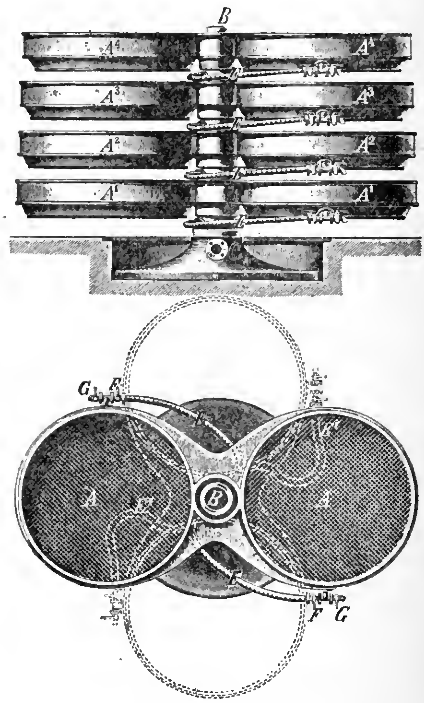
Fig. 105

II. CONTINUOUS-ACTION DRAINER-FILTER.

Where the bulk of solids is small compared with that of the liquid, an apparatus with endless filter-cloth may be profitably used. Such filters have a considerable vogue in the paper and cellulose industries and in wood grinding. In the former, though also in the cellulose industry, they are installed for intercepting valuable fibre remaining in the wash and waste waters. In wood grinding works the particles of ground wood are screened from the water, and, where millboard is manufactured, the wood led to the rolling machine. For the recovery of paper-making material from effluents, the filter of H.



Figs. 106 and 108



Figs. 107 and 109

Füllner, of Warmbrunn, among others, is widely distributed among paper factories. It comprises, as appears from *Fig.* 114, an angular filter-drum *d*, with open ends, and a system of guiding and compressing rollers *b*, around which, drum and rollers, moves an endless cloth *a*. The drum revolves in a trough with cast-iron ends, through perforations in which the water escapes, and with sides of wood, concrete or brickwork. For caulking the interval between the ends of the drum and ends of the trough, broad endless bands of rubber, leather, or felted cotton are inserted (*Fig.* 115). One edge of each of these

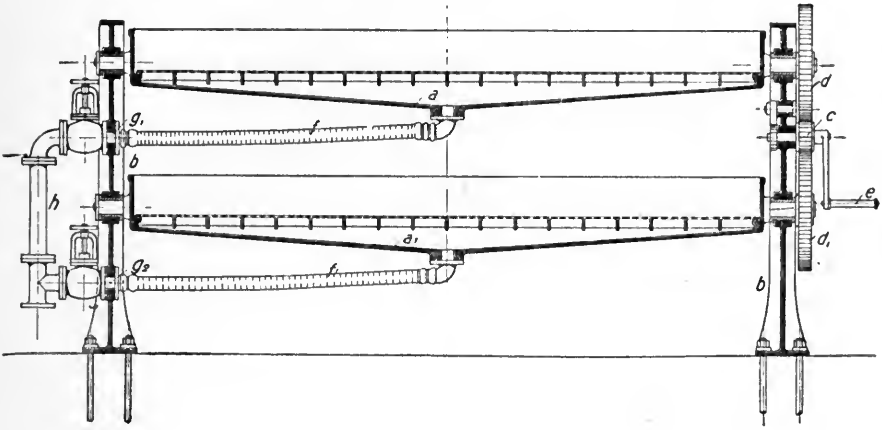


Fig. 110

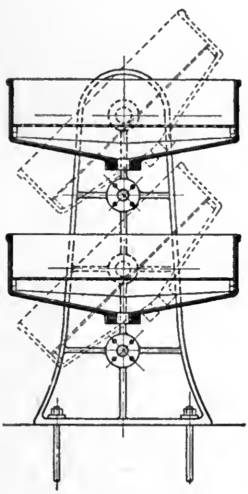


Fig. 111

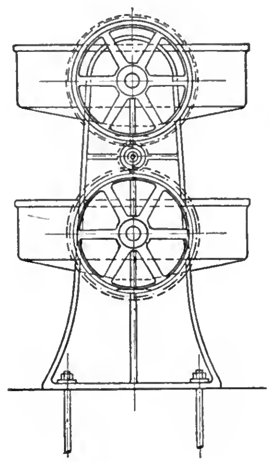


Fig. 112

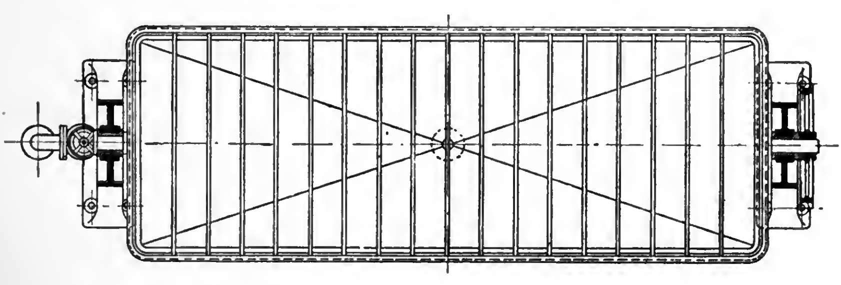


Fig. 113

bands is drawn tight upon flanges projecting from the ends of the drum by means of a steel band with turn-buckle (*Fig.* 116). The other edge glides easily upon a flange projecting from each end of the trough, and is tightened by a steel band only so far as not to prevent this slipping. In order to prevent the caulking-band from sinking into the interval between the flanges, it is fitted on its two sides with wooden blocks (*Fig.* 116).

So as to prevent the cloth shrinking transversely, the drum is wrapped with wire, winding from the middle line spirally outwards, on both sides, as in *Fig.* 117; this precaution ensures a uniform support.

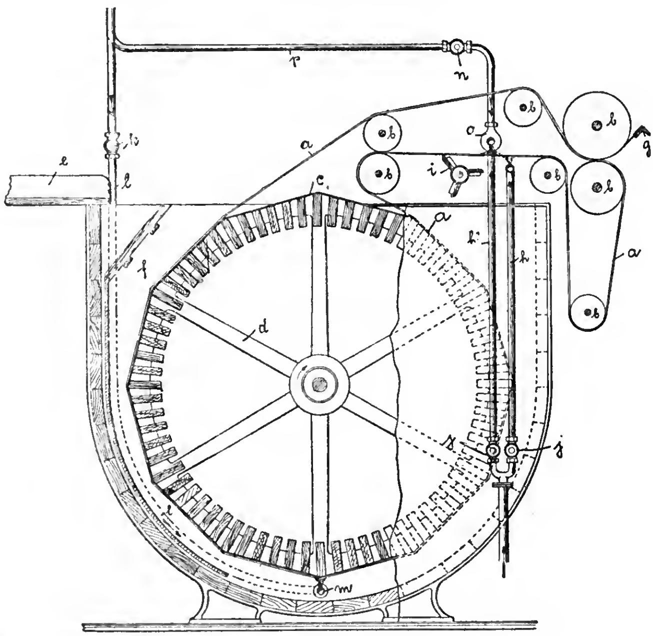


Fig. 114

Any solid particles floating on to the cloth are transported by it over the first two of the rollers *b* (*Fig.* 114), and adhering to the upper of the two compressing rollers, they are taken off it by the scraper *g*. The filter cloth is then cleaned by two sprinkling pipes h, h_1, and a rotary beating-axle *i*.

For aiding in the cleaning, a steam-pipe *l*, furnished with valve *k*, passes below the drum, having at its end a tube transverse to the drum for spurting steam. A second steam-pipe *p* branches off from the main pipe before *l* and ends beyond the valve *n* in the upper spurting tube, to which h_1 is joined by the mixing valve *o*.

When the cloth becomes impermeable, the flow of raw water is stopped, and the water in *f* drawn off. The drum being still in motion, the three valves *j*. *j*, and *n* are opened, the wash-water dammed in the trough by setting up a

12-inch board, and warmed by opening the steam-valve *k*. The clearing away of the material choking the felt is aided by forcing hot water under strong pressure out of the mixing valve *o* upon its inner surface.

The yield of this drainer depends upon its size and upon the nature of the water coming to it, attaining in the largest size over 660 gallons per minute, a good output considering the limited area of the filtering surface. Shown in *Fig.* 118 are the results of its action upon various waste waters, and it may

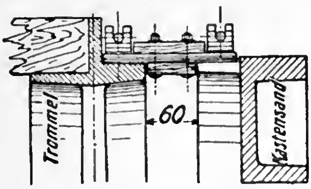


Fig. 115

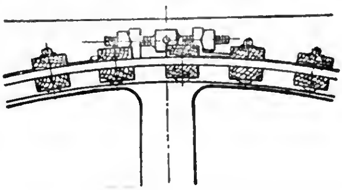


Fig. 116

there be seen that this is not absolutely complete. Nevertheless, considerable sums are saved the national industries by such filters.

Drawings of a continuous drainer with a drum of 80-inch diameter are given in *Figs.* 119–121, and others of one with a 120-inch drum in *Figs.* 122–124. The diameter of the drum in a bigger type of rotary filter (*Fig.* 125) ranges from $5\frac{1}{4}$ to $8\frac{1}{2}$ feet in the smaller machines, and from $6\frac{1}{2}$ to 10 feet in the larger.

Continuously-acting drainers of this kind are the only filters with automatic removal of the residue and automatic cleansing of the filtering layer

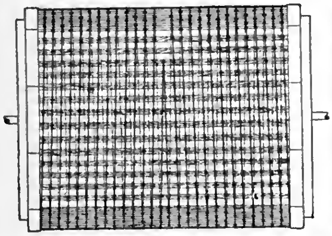
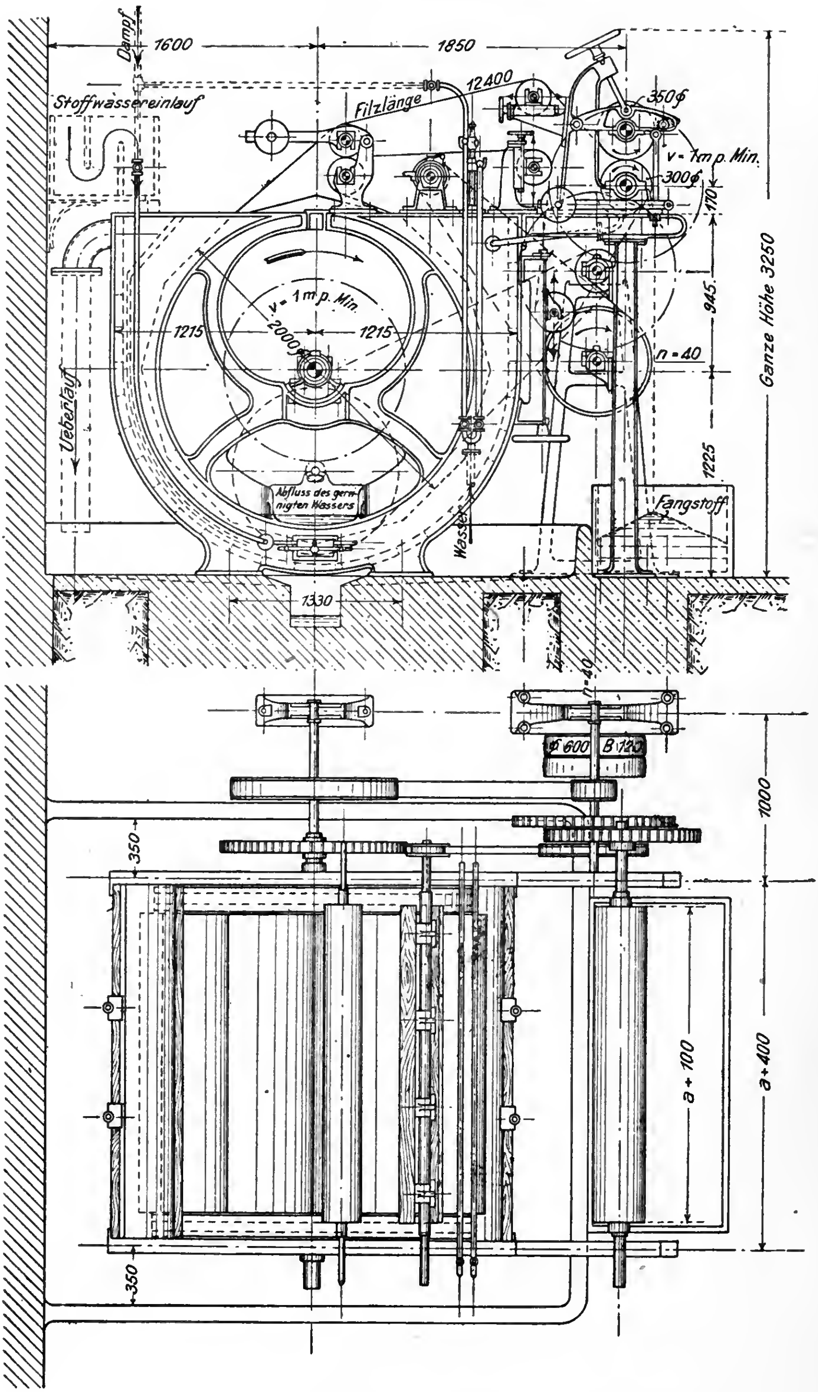


Fig. 117

Fig. 118

that are generally adopted. As already mentioned, this principle is chosen in the manufacture of pasteboard and paper. Thick pasteboard is still as a rule made with the assistance of endless bolting-cloth that renders up its layer of wood-pulp to a roller on which the board is gradually built. This pasteboard and paper are formed in machines with endless metal bolting-fabric as the essential feature, serving both as drainer and transport band. While upon this endless sieve, the pulp loses most of its water through a shaking



Figs. 119 and 120

Abfluss des gereinigte Wassers = Outlet for purified Water
Stoffwassereinlauf = Mixture Inlet Filz = Filter-cloth Ueberlauf = Overflow
Fangstoff = Sediment

movement, which also felts the fibres. The exceedingly great extension of the paper industry induces one to assume that this apparatus is the most widely spread of all. A detailed account of it may be spared, since it belongs rather to the special subject of paper manufacture.

III. BAG OR FRAME FILTERS.

The bag-filter holds an intermediate position between the filters with endless cloth and the filter presses. Over an iron frame, spirally wrapped

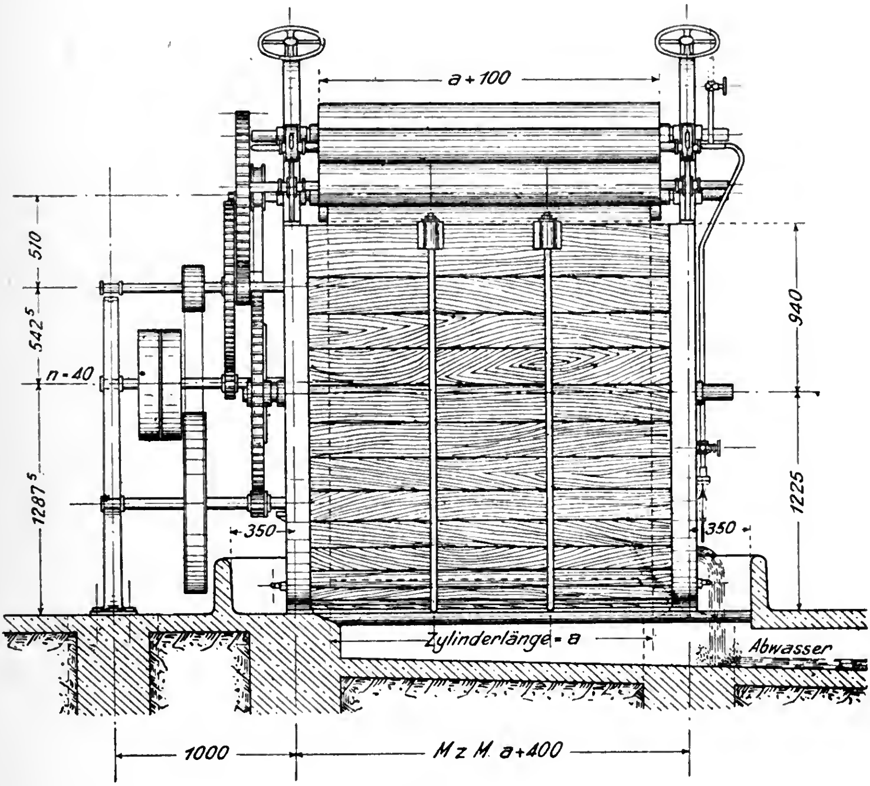
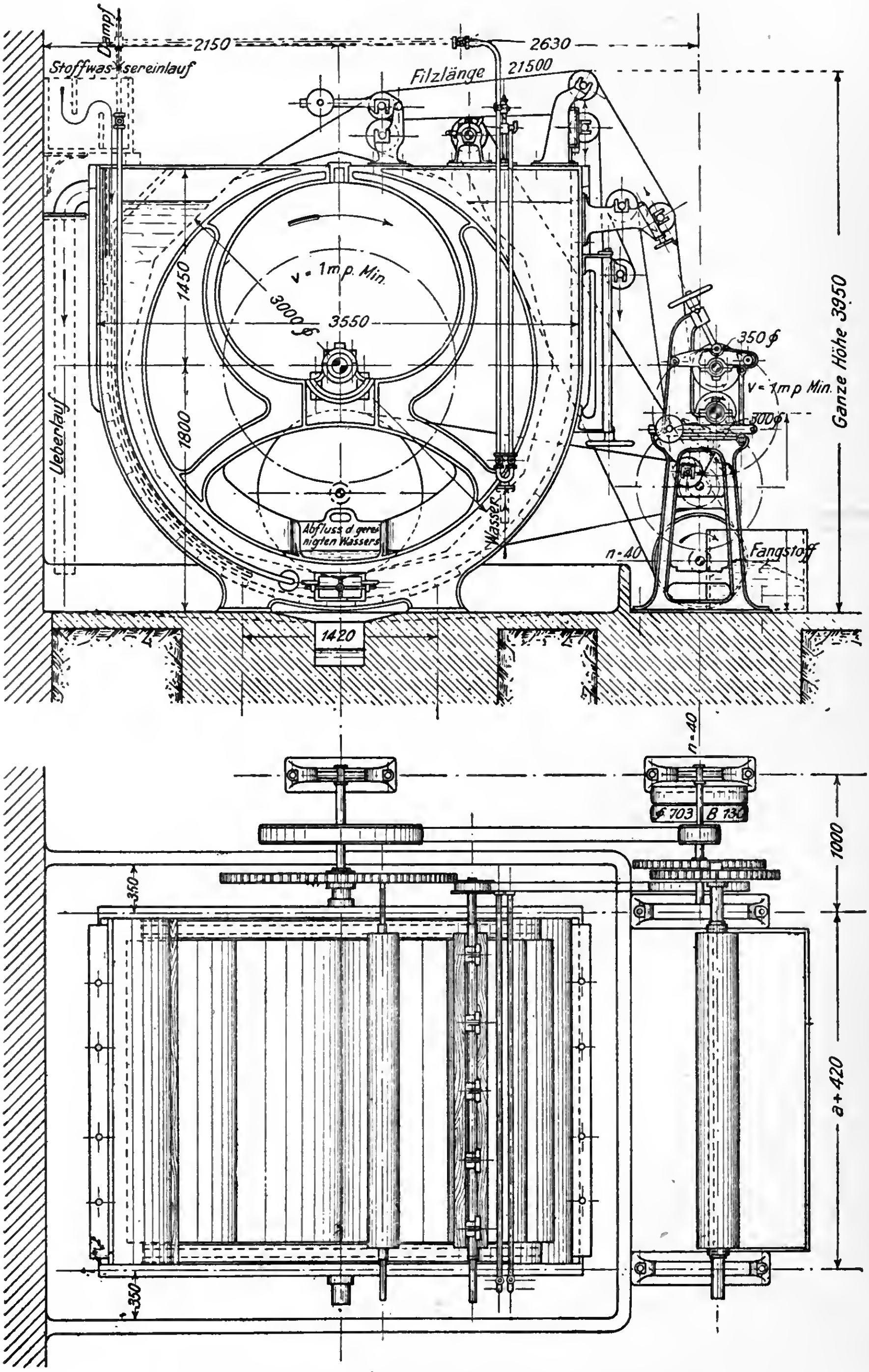


Fig. 121

with wire, is drawn a bag of filter-cloth corresponding to it in shape and fitting closely to the upper rim of the frame. The frames are suspended in a chest by these rims as shown in *Fig.* 126. A longitudinal section of such filters, known under the names of Kasalowski's, Danek's, Rasmus's, etc., appears in *Fig.* 127.*

* For a full description of this type as applied to *Sugar* see Part III,, p. 123.



Figs. 122 and 123

Abfluss des gereinigte Wassers = Outlet for purified Water
Stoffwassereinlauf = Mixture Inlet   Filz = Filter-cloth   Ueberlauf = Overflow
Fangstoff = Sediment

IV. EHRENSTEIN'S PRESSURE CHAMBER-FILTER.

The Ehrenstein filter (*Figs.* 128 and 129) foreshadows the filter press. Within the cylindrical, cast-iron casing *A*, with its airtight lid *B*, stands the indispensable filtering device. The horizontal, perforated chambers *e*, covered with cotton cloth, communicate with the bore of a vertical slotted pipe *d* that is screwed to the exit pipe *b* by a flange *c*. A screwed-on lid *g* closes the

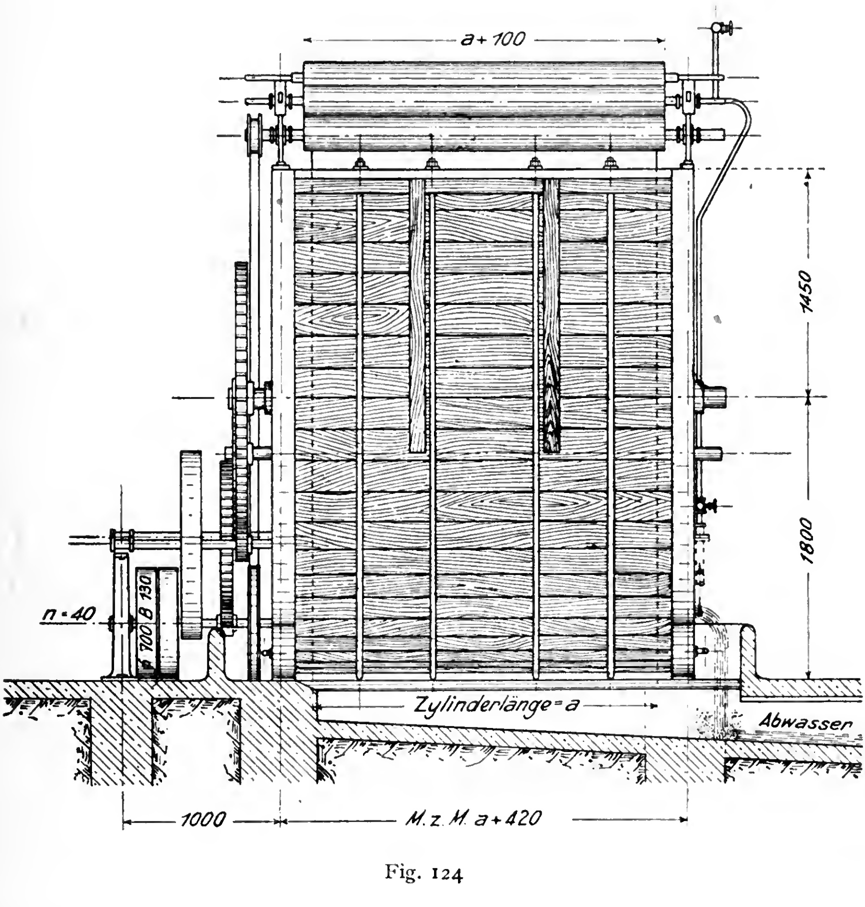


Fig. 124

end of *d*. To secure the proper intervals between the chambers, iron distance rings are inserted between them. All joints between the rings and chambers and between these and the vertical standard pipe *d* are packed tight. The liquid enters the filter at *a*.

Here the evil is that a leakage, and especially the point of the leakage, cannot be at once discovered. And the exchanging of the bags involves

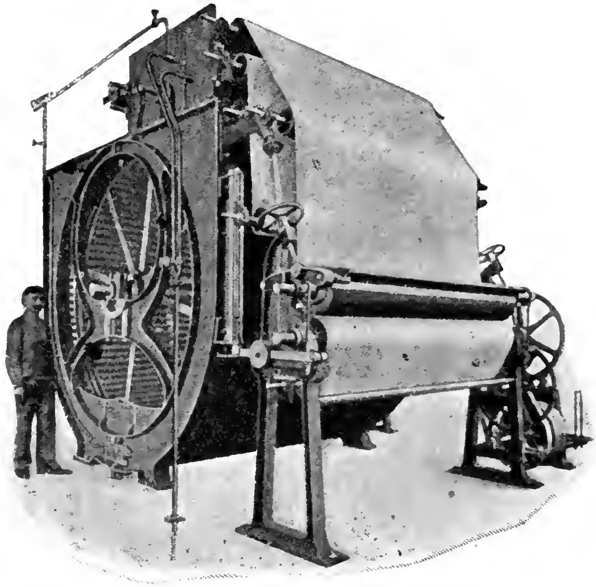


Fig. 125

taking to pieces the whole of the internal part, while its putting together again is by no means an inexpensive undertaking.

Such disadvantages are avoided in the class of apparatus next described.

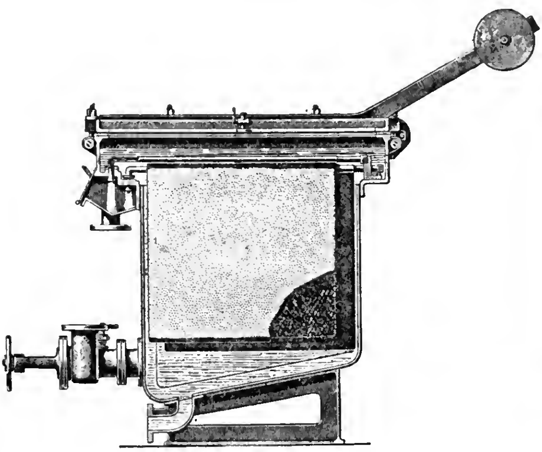


Fig. 126

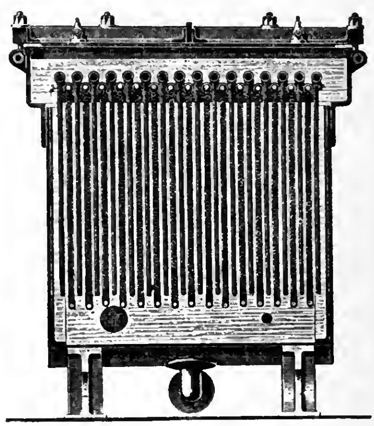


Fig. 127

V. THE FILTER PRESS.

(1) *Introduction.*

Included under this designation are arrangements of a number of separate flattened filters, in shape rectangular or circular, set in horizontal series, the joints between them being made water-tight by the filter-cloth squeezed by pressure-plates. The filter press used so much in the chemical industry, and also in other directions, possesses such unique advantages that to-day it is never displaced by any other kind of filter. These advantages may be recapitulated: The apparatus offers a very large filtering surface within a small space; all joints are under direct observation and control; the working of every chamber can at all times be regulated separately, and the chamber can, when it is necessary, be taken out; replacing of the filter-cloths is easy; and access to the internal parts offers no difficulty, nor does the cleaning. The construction of the press is simple and therefore not costly; it contains no displaceable parts; wear and tear is low; and its fashioning is such as to allow its application to various purposes. Finally, the filtration may proceed under any pressure desired.

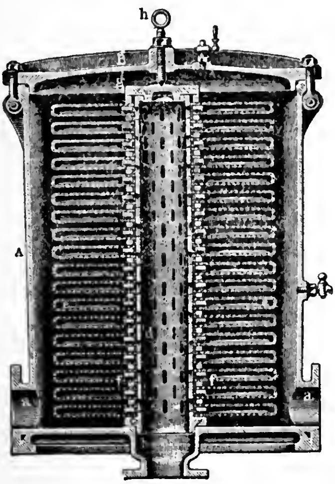


Fig. 128

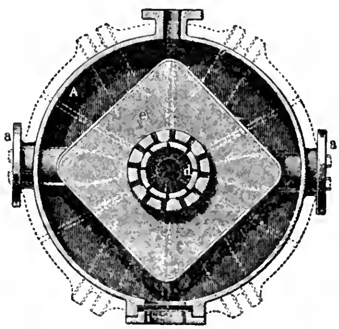


Fig. 129

These advantages, which explain the unassailed position of the filter press, are opposed by one disadvantage, only appreciated when mixtures are dealt with that leave behind relatively large amounts of solid matter. The expense of frequent emptyings then arouses the desire that the costly labour should be replaced mechanically. But attempts to discover a satisfactory mechanical method have been unsuccessful so far.

There are chamber presses and frame presses. In the chamber press the components are plates with raised edges, so that when they are aligned in a horizontal series, each pair encloses a chamber. Across the middle of the chambers stretches the filter-cloth, which is gripped between the raised edges of the plates. In the frame press are plates without raised edges, for which latter are substituted hollow frames that separate the plates and enclose the chambers. Between the frames and the plates lie the filter-cloths, the plates being grooved to allow the escape of the filtrate behind the cloths.

Simple in itself, the arrangement of the components is altered to accord with the function of the press. But before embarking upon a discussion of these modifications, the complete disposition of a press in all its features should be made clear (*Figs.* 130–134); in this case a *frame press* is implied.

(2) *Description of a complete Filter Press.*

A strong top-plate *a* firmly supported upon the ground, is joined by the two truss-rods *c* to a cross-head *b* as solidly supported. In the top-plate are

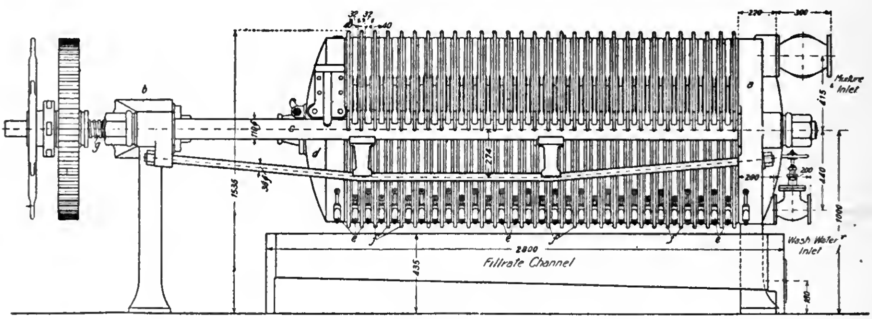


Fig. 130

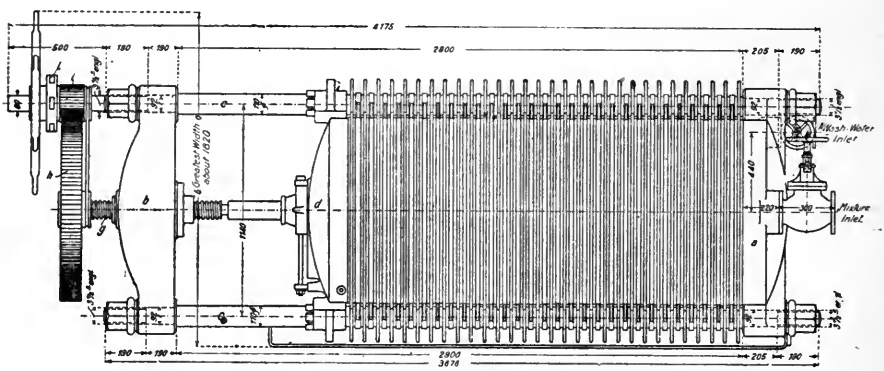
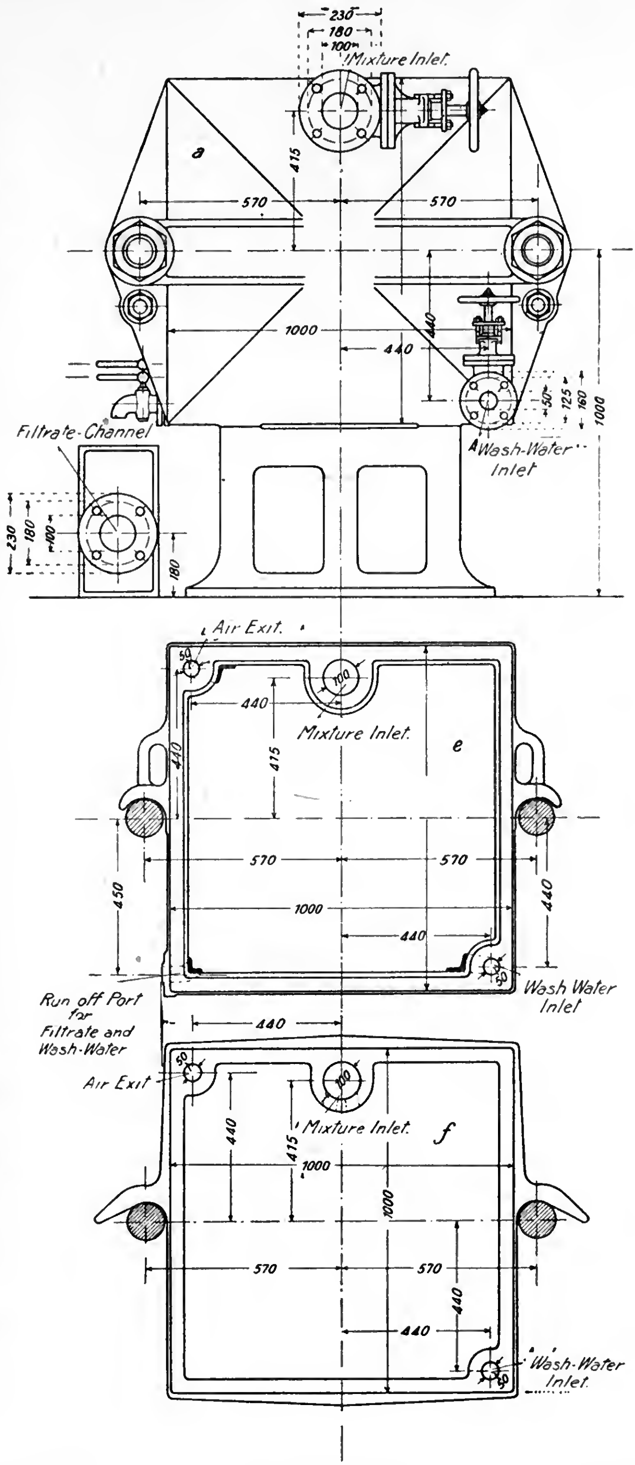


Fig. 131

the apertures for the entry of the mixture and of the liquid for washing the residual cake, and for the passage of the cooling or heating media sometimes called for. Between the top-plate *a* and the foot-plate *b* extend the filter-plates *e* and frames *f*, resting upon the truss-rods by lateral projections. The cross-head carries a contrivance for moving the adjustable foot-plate *d* and for exercising pressure upon it. This contrivance comprises a powerful screw, worked either directly by a hand-wheel, or, in large presses, as here, by cogged wheels *h* and *k* under the propulsion of a hand-wheel *i*. The screw turns in a female screw set in the cross-head, or threads are cut in the cross-head itself. When the power directed through the hand-wheel is insufficient, a lever can be inserted in the slots of the sleeve *l* to develop increased force.

The filter-plate (*Fig.* 133) has three openings passing through it, two of which, the channels for the escape of air and for the admission of the wash-water, communicate with the chambers through transverse parts in the rims of the plates. In one corner is a transverse part leading straight to the outside, the filtrate and wash-water exit. Three openings appear also in the frame, the largest of them for the admission of the mixture, communicating with the enclosed chamber by suitable passages. Before laying the filter-cloths between plates and frames, they are cut where the openings come.

In the press chosen for explanation, the mixture is introduced



Figs. 132—134

by way of an inlet valve and the channel represented by the largest of the three openings, and reaching the chambers, these are gradually filled. The run-off taps are meantime closed, and the air is accordingly expelled through the filter-cloth, and through the proper channel for its extrusion. Once the chambers are filled with the mixture, the run-off taps are opened, being set so that the filtrate, having oozed through the filter-cloth and cleared the transverse part in the corner of each plate, issues from all at an equal rate.

When the chambers become occluded owing to the accumulation of solid matter, filtration must be interrupted. Should the filtrate be of the nature that the part of it retained in the residual cake has some value, then filter presses are adopted that are provided with arrangements for simple washing or thorough extraction. This particular press possesses the former characteristic. To wash the cake, the run-off taps are closed and the cock controlling the air-channel, with the valve admitting the wash-water, is opened. Any air lying behind the filter-cloth becomes forced out through the air-cock, but once water emerges, it is closed, whereupon the water penetrates the filter-cloth and the cake, driving out the remanent filtrate. The cocks on the plates, by which the water enters, are closed, and the liquid accordingly flows off by every second outlet cock.

(3) *Arrangement for Thorough Extraction.*

The procedure in the complete extraction of the filtrate from the cake can be followed in *Figs.* 135–137, it being noted that a chamber press is here under consideration. At the beginning of the washing all the taps i are closed

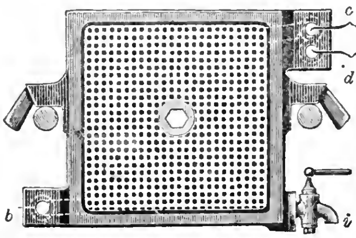


Fig. 135

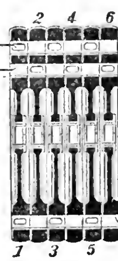


Fig. 136

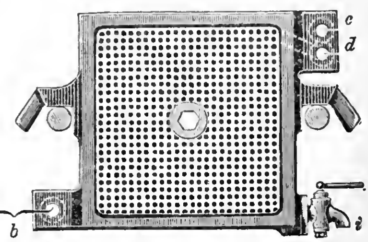


Fig. 137

and both taps c (*cf.* also *Figs.* 138 and 139) at the ends of the air-channel opened, as well as the valve leading to b—here situated in a channel-flap—which permits the inflow of the wash-water or other liquid. From b the water flows through small ports in the plates 1, 3, 5, etc., and ascends behind the protective sheets covering the grooves in the plates and presses out the air, which leaks out through c. When the air has gone, the taps c are closed and valve d opened. The water then forces itself horizontally throughout the whole area of the cake, collects on the other side of it, and makes its exit into the collecting channel d, through small lateral ports in the plates 2, 4, 6, etc.

Sometimes it is desirable to determine easily and quickly when the washing-out has been pursued as far as it is practicable and expedient. To do this, a hydrometer measures the concentration of the issuing liquid received in the spacious collecting gutter, so that the operation can be stopped when a definite degree of dilution is indicated. After a number of determinations of the point where a continuously uniform density is reached, this point is afterwards a sufficient guide to the completion of the process.

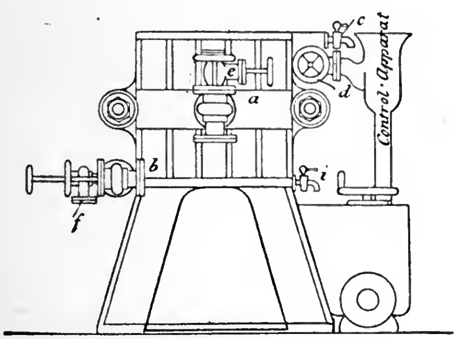


Fig. 138

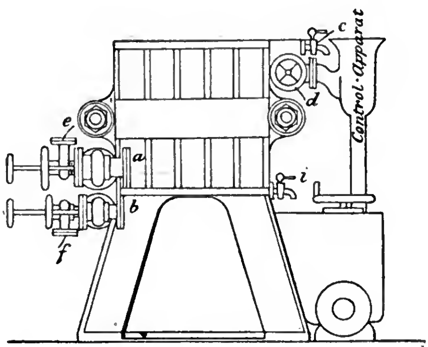


Fig. 139

(4) *Exposition of the Details.*

From a study of *Figs.* 138 and 139 it may be perceived that the arrangement of the inlet and outlet channels alters with different makes. In the *Figs.* we have:—

a The inlet channel for the mixture;
b That for the wash-water;
c The air cock;
d The outlet valve for the wash-water;
e A valve for the introduction of air or steam; and
f One for running off the clean water before opening up the press to empty it.

Several variously designed iron filter-plates are illustrated in *Figs.* 140 and 141, while *Fig.* 142 shows some modifications in wooden ones.

It will be seen from these drawings, and from a previous remark, that there is a gain in placing a perforated sheet between the plate and filter-cloth, otherwise the cloth tends to become forced into the grooves of the plate and so obstructs the passage outwards of the filtrate.

Fitting the cloths is easily accomplished. If there are x chambers, then x—1 double cloths and 2 single cloths must be prepared. Cuffs are required for channel flaps. The double cloths and the cuffs are for the filter-plates, the single cloths for the ends. When putting in the cloths, the filter-plates and movable foot-plate are pushed back as far as can be. A single cloth is then laid over the stationary top-plate and fastened to the knob on it. In presses with central inlet the cloths are gripped there, at the feed-hole, by

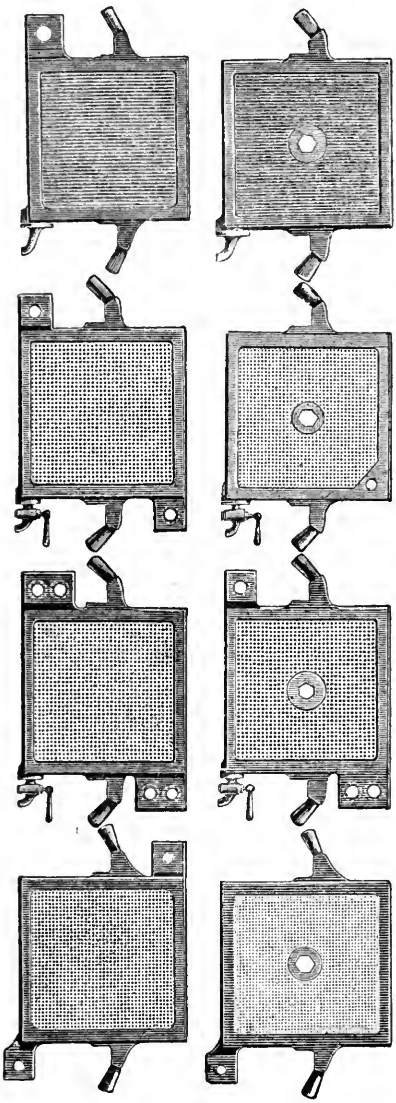


Fig. 140

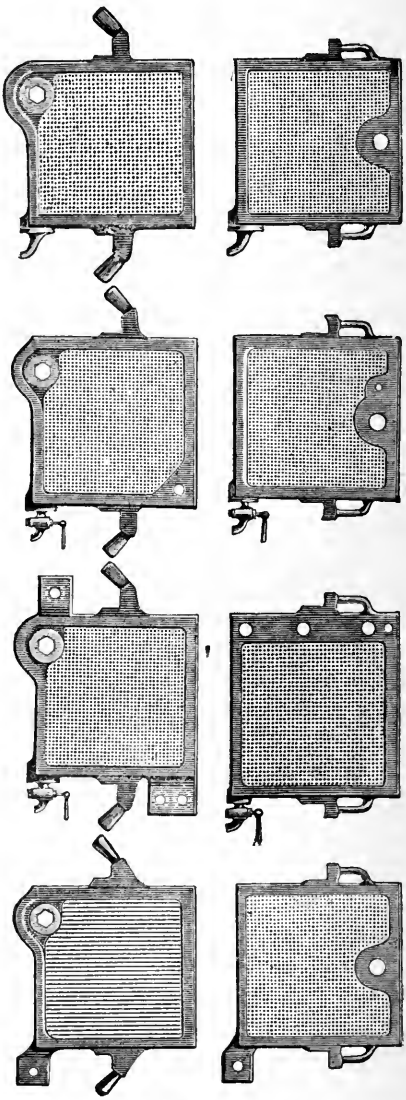


Fig. 141

union-screws, care being taken to ensure an even spreading of the cloth. Double cloths are simply hung over the filter-plates if a frame press is being fitted out (*Fig.* 144); but if it is a chamber press they are screwed down on both sides (*Fig.* 143). The screwing down at the centre is sometimes avoided by joining the centres of two cloths with a short cloth tube, twisting one of the cloths to pass it through the feed-hole and opening it out again (*Fig.* 145); but this mode of fixing, owing to its troublesomeness, is seldom chosen. *Figs.*

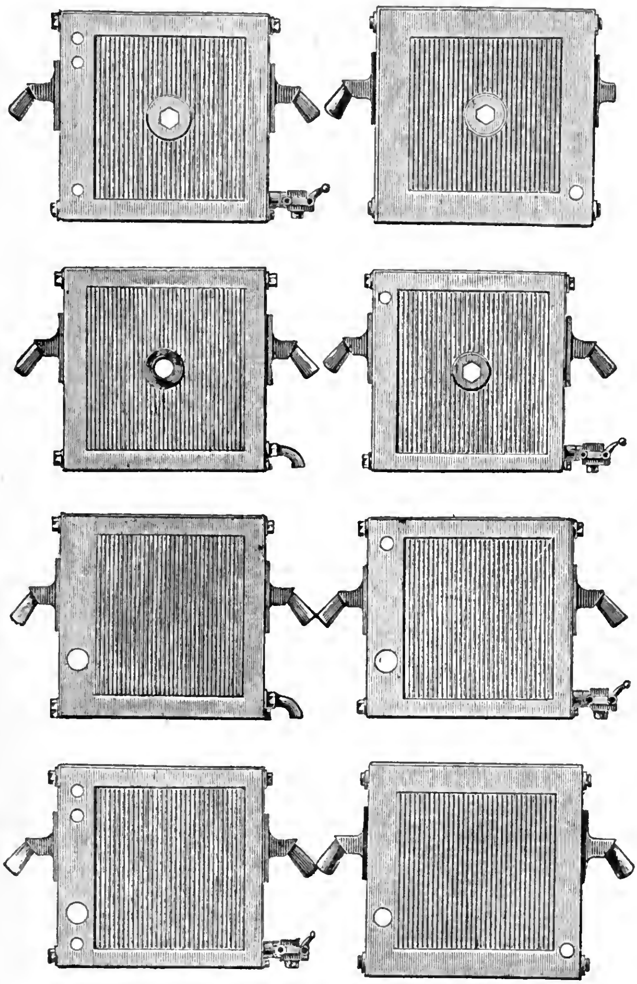


Fig. 142

146 and 147 demonstrate the method of fixing the cuffs on channel flaps. A convenient and reliable fitting for the flaps is by means of rubber rings (*Fig.* 148) fastened in a countersinking.

Bending over corners often causes a heavy strain from which the cloths suffer. To obviate this danger, another material—pasteboard, rubber, etc.—

is fastened around the outside of the cloth, while its borders dip into grooves in the plate and are held tight there by an inserted cotton cord, an efficient method of tightening (*Figs.* 149 and 150). The cloths lie evenly upon the perforated sheets; they do not undergo any strain; and in liquids that weaken

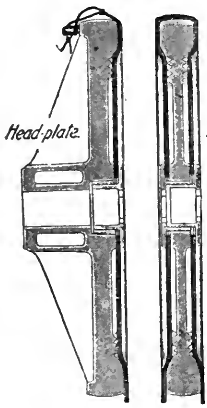


Fig. 143

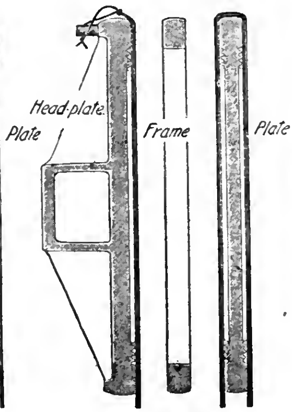


Fig. 144

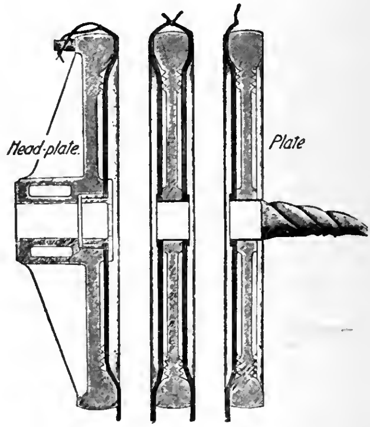


Fig. 145

them, perhaps even when rotten, they remain firm for a long time. Another economical way of securing the cloths is evident from *Fig.* 151. The cloths lie between two perforated sheets, the outer of which is screwed down to the filter-plate. Between the sheets and cloth may be interposed wire-gauze.

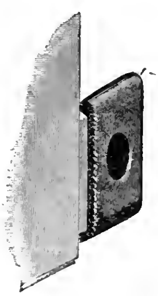


Fig. 146

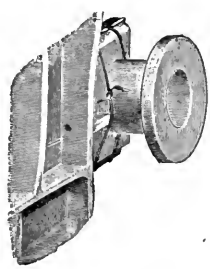


Fig. 147

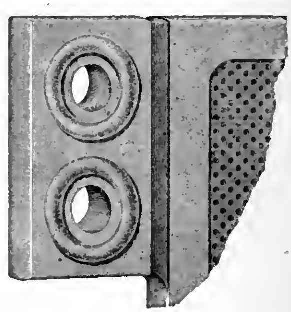


Fig. 148

Now and then cooling or heating of the filter-plates is demanded. For this channels, everywhere well insulated from the interior of chambers, are left in the cross-head and plates (*Fig.* 152).

Often contact between the liquid and iron must be prevented owing to attack by the former and its resulting contamination. Since in most cases plates and frames of other metals than iron would be too expensive, the plan followed is to deposit on the iron a protective layer of tin, lead or vulcanite (*Figs.* 153 and 154), all resistant to acid or alkali.

Beeg's filter press plates—one kind with internal, the other with external wash-water channels (channel-flaps)—are much used in sugar manufacture.

Fig. 149

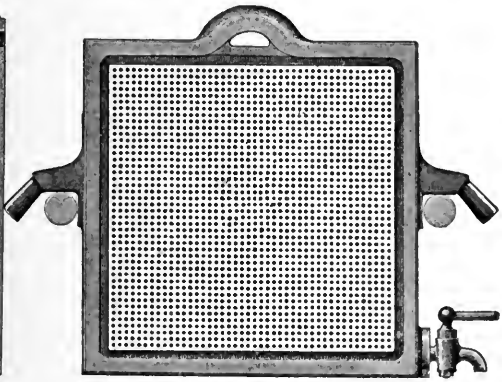


Fig. 150

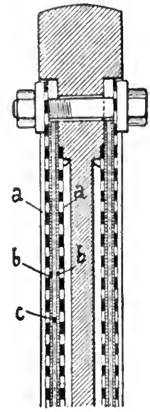


Fig. 151

The juice comes in through the channel *a*, while *d* is the water-channel, *b* that for the wash-liquid, and *c* the passage for the escape of air. (*Figs.* 155 and 156).

Devices for making tight the filter-cloth at the entrance channel are illustrated in *Fig.* 157. The border *a* of the filter-plate must be cut away at

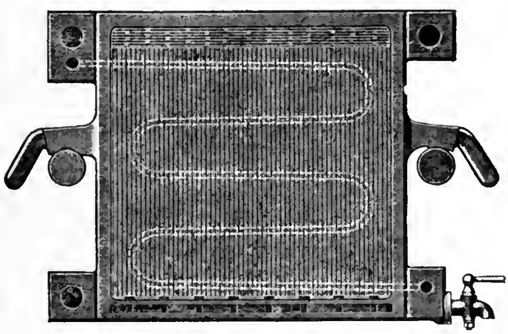
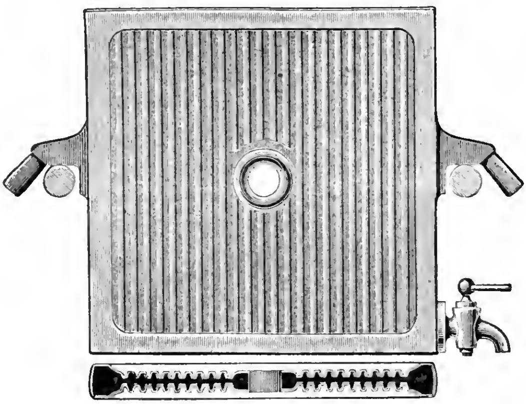


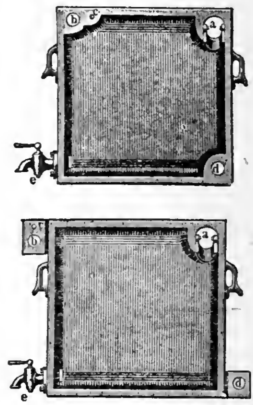
Fig. 152

the lower part of the entrance channel to form the aperture by which the juice gets into the chamber, and to prevent this from wandering behind the cloth there are introduced bronze fittings *c*, which set closely to the curve of the channel and are hinged at *e*. Their apposing surfaces *d* lie in the same plane as the apposing borders *a* of the plates. When the press is screwed up, these bronze clips nip the cloths firmly and effect a perfect closing.

The residual cake in the chamber usually contains an appreciable amount of filtrate or wash-liquid, and very often the reduction of the moisture content is desired. In many instances, after the filtration is finished, air, sometimes



Figs. 153 and 154



Figs. 155 and 156

warmed, is blown through the cake. This process is not always practicable and generally necessitates a great expenditure of compressed air. To limit this, strong elastic membranes, which can be subjected to pressure by air or water conducted through a special channel, are laid over the filter-plates

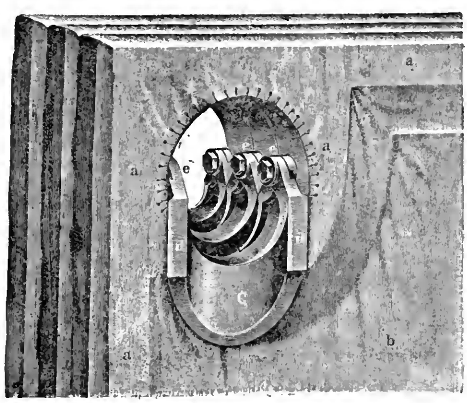


Fig. 157

(*Fig.* 158). Compressed laterally, the cakes yield up the water, which runs off through special openings. This, and the following innovation, have been patented by the firm of A. L. G. Dehne.

For preventing the filtrate becoming turbid from a leak in any of the chambers—and this, through lack of attention, may injuriously affect the whole filtrate—there is an appliance for shutting off automatically the leaking chamber

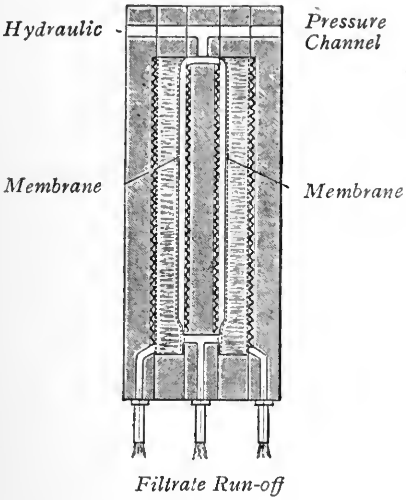


Fig. 158

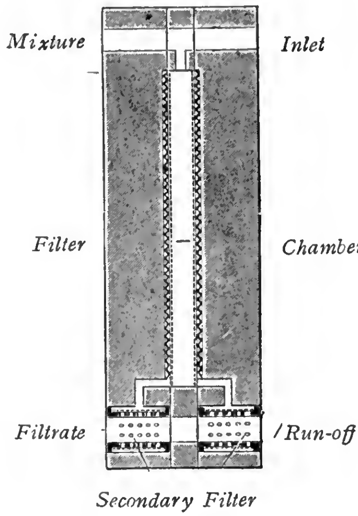
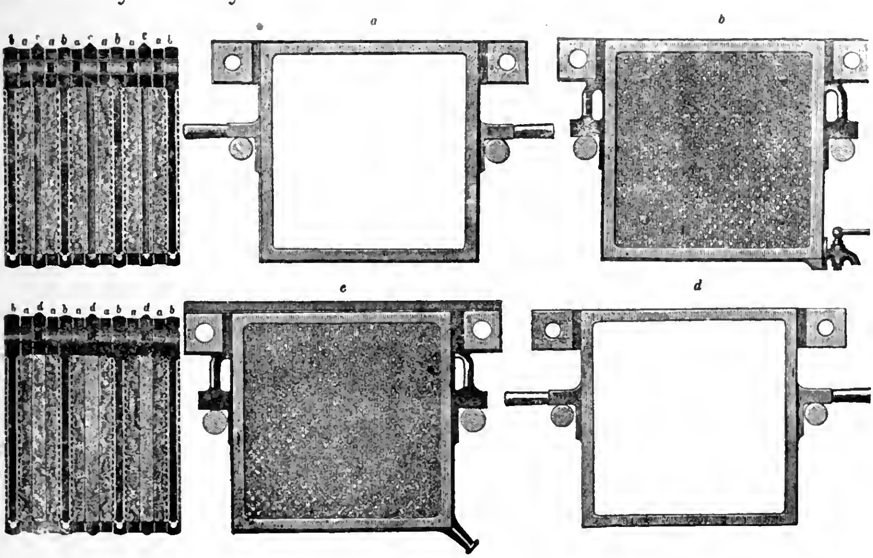


Fig. 159

(*Fig.* 159). Between the outflow channel of each plate and the channel collecting the filtrate is interposed a small secondary filter, which chokes up with the onset of any turbidity.



Figs. 160—165

Frequently the use of filter-cloth does not guarantee complete clarification; and it is replaced by layers of a material suited to the mixture to be treated and made up in special frames in or outside of the press. *Figs.* 160–165 illustrate the first alternative; the second is made clear later in the description of a filter press for brewers. The frames *a* and plates *b* have the usual form, and for moulding the filtering layer the perforated plates *c* are inserted. After closing up the press, the loose filtering material is floated in through the frames *a* and compressed into a solid mass, when the perforated plates *c* are taken out and their places occupied by the frames *d*. The mixture enters first these latter frames, the filtrate filters through the moulded layer into the frames *a*, and passes off through the plates *b*.

Diverse types of compressing contrivances are adopted for the filter press. For small presses an ordinary screw with hand-wheel or spoked wheel is selected. In large presses a cog-wheel gearing moves the screw, or a worm and wheel.

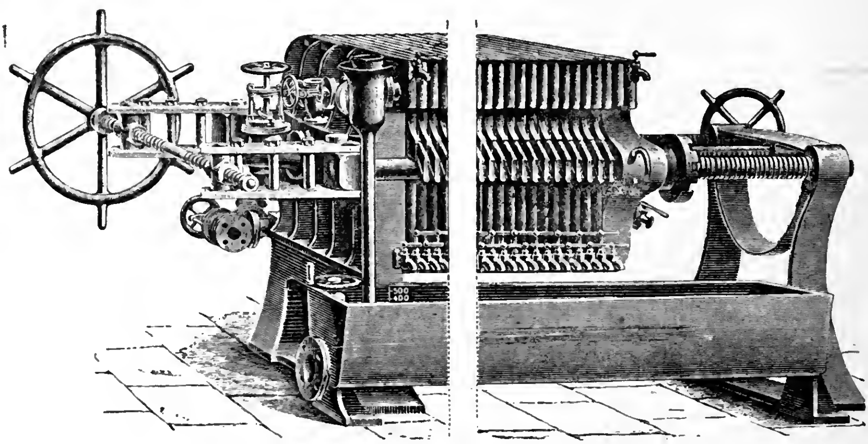


Fig. 166

So that there may be enough play when exchanging a faulty plate, a swing-out spacing-block (see *Figs.* 130 and 131) is occasionally fixed on the movable foot-plate, a replaceable die set in the latter receiving the pressure of the screw. This device gives abundance of room for thrusting back the foot-plate without shifting the screw.

Time may be saved by the introduction of swing-out bearings for the cross-head. Revolving on a foundation block, with only a slight preliminary movement of the screw, it carries the screw with it, and the foot-plate and filter-plates are released.

One way of closing large presses is with the bent-lever system of Messrs. A. L. G. Dehne (*Fig.* 166). Upon each of the truss-rods, threaded along part of their length, is a nut that can be tightened up by a special key to compress the plates together. When this keying-up cannot be pushed any further, the bent levers come into operation. Their longer arms are drawn towards one another by the turning of a spindle with right and left-handed threads, and their shorter arms being coupled with the ends of the truss-rods, a second and much greater pressure is brought to bear upon the plates.

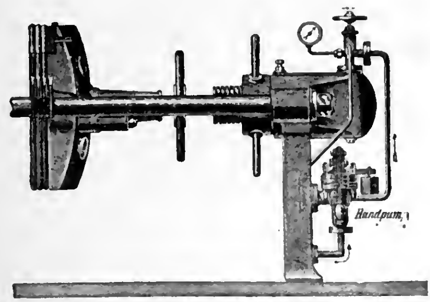


Fig. 167

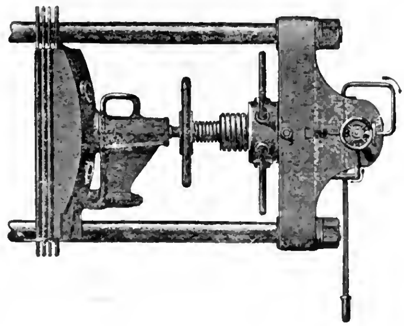


Fig. 168

But in quite large apparatus, even this falls short of requirements, and recourse has to be made to hydraulic closing. A male screw (*Figs.* 167–169) turns within a hollow spindle another male screw which itself works within the ram of a hydraulic press. This expedient permits the greatest possible play between the foot-plate and the end-traverse (cross-head). The male screws having been drawn out to their uttermost, the ram comes into action and the compression is finished. The hydraulic press may be worked by hand or mechanically.

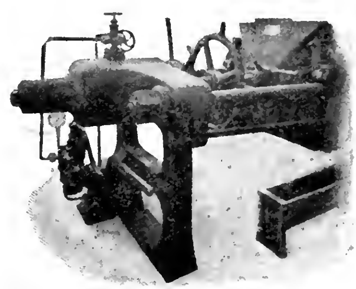


Fig. 169

Where many filter presses need attending to, this latter device will be chosen, combined with an accumulator, to save time and labour. Such an installation is seen in *Figs.* 170 and 171.

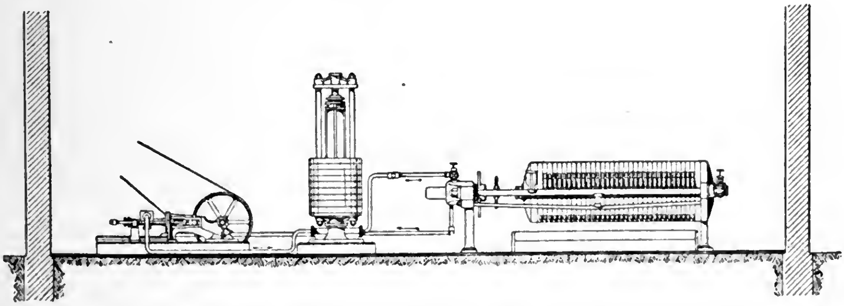


Fig. 170

(5) *Filter Press Pumps.*

If the mixture does not contain much in the way of solids, the filter press can be charged either by an ordinary piston or plunger pump or from a tank under air pressure. But if there be much residue to little liquid a pump with

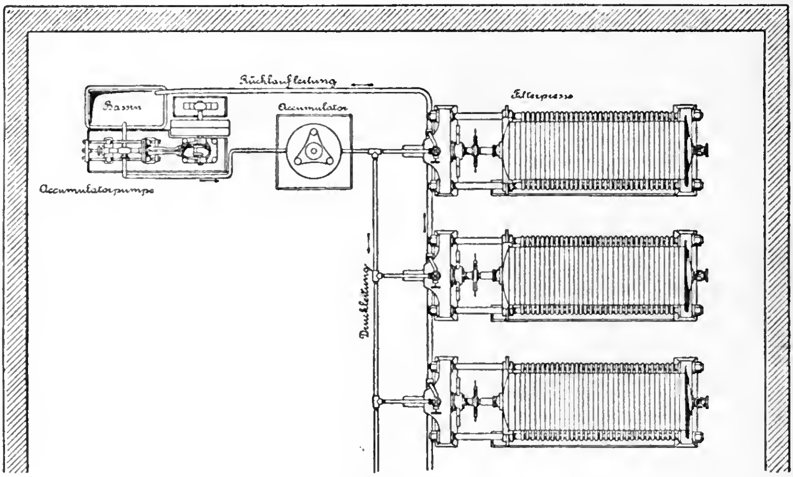


Fig. 171

ball valves serves better (*Fig.* 172). In plunger pumps the liquid comes into contact with the plunger, and where this is objectionable a membrane must be put in (*Fig.* 173.)

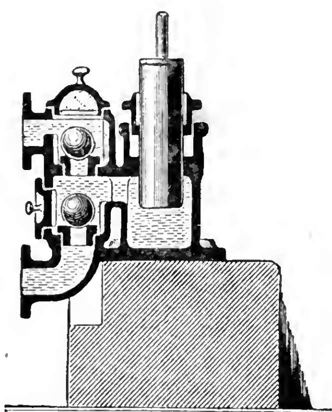


Fig. 172

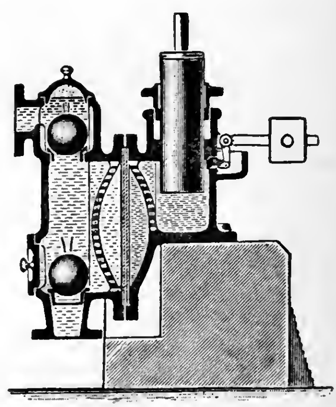


Fig. 173

Vertical filter press pumps with steam drive are suited for large outturns and high pressures, and they may be placed in any convenient space, the site where the power is transmitted being a matter of little importance.

Such a pump is pictured in *Fig.* 174. The larger pumps are constructed with two or more horizontal or vertical cylinders.

For feeding the more extensive filter press plants, the Dehne firm turns out a practical and convenient pump. This, the so-called automatic pump, supplies the filters with the mixture at a uniform pressure, and is provided with a regulating device controlled both by a governor and by the pressure in the air-vessel. When the filtrate ceases to emerge, these pumps come to a standstill.

The degree of pressure exercised by the pumps in filling the filters is determined by the physical characters of the mixture and the desired dryness of the residual cake. Pumps with belt-drive are as a rule used only for generating low pressures. The pressures called for by viscous mixtures may be quite considerable. While in most cases pressures of 30–60 lbs. are successful, these sometimes rise to 142 lbs. per square inch and even higher ; indeed, filter presses are built to withstand over 700 lbs. to the square inch.

For large outputs pumps are used that differ from ordinary water pumps only in the structure of the valves. They are driven by special steam cylinders, piston rods at one end acting directly upon the plunger, and at the other end, for the maintenance of a regular speed, turning a fly-wheel by means of connecting-rod and crank.

Fig. 174

(6) *The Types of Filter Press in Use.*

The exceptionally wide distribution of filter presses and their importance in chemical manufacture—there are scarcely any chemical works without one —prompts a review of the principal types.

A large frame press with modern features is that designed by Messrs. Klein, Schanzlin and Becker (*Fig.* 175). The powerful cog-wheel gearing for turning the screw through which the whole of the pressure is applied, will at once be noticed. These parts cannot be too strong, for no slight call is made upon them by the spoked wheel. The foot-plate has rollers for running upon the truss-rods, and in large presses rollers also appear upon the frames and plates.

If the truss-rods be very long, they must be prevented from sagging: by tie-rods, as in *Fig.* 175, or by pillars, as in *Figs.* 176–178. In the latter case the collecting channel must be narrowed to make room for the pillars, or the pillars be so shaped as to allow for the channel.

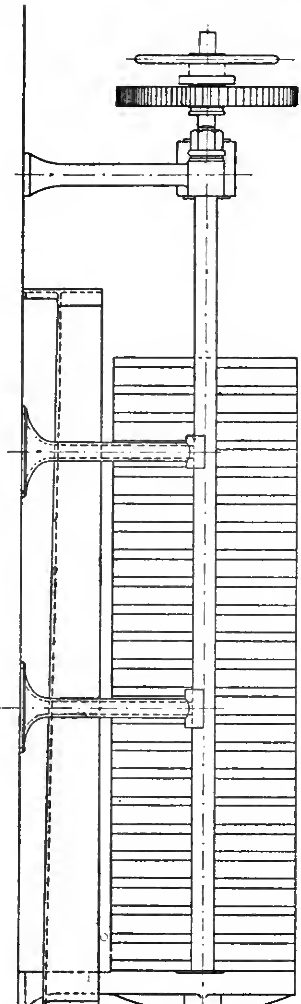


Fig. 176

Fig. 179 is from a photograph of a heavily-built chamber press for working under high pressures. In opening it, heavy weights, with draw-ropes and pulleys, pull back the foot-plate against the cross-head. Compression is effected by means of a hydraulic ram.

Another frame press of heavy build is shown in *Fig.* 180, and it may be seen that, even with a relatively small number of plates and frames—in this case 14—resort has been made to stiffening the truss-rods with tie-rods, as plates and frames are rather heavy and in large presses their weight is a serious factor. Understandable from

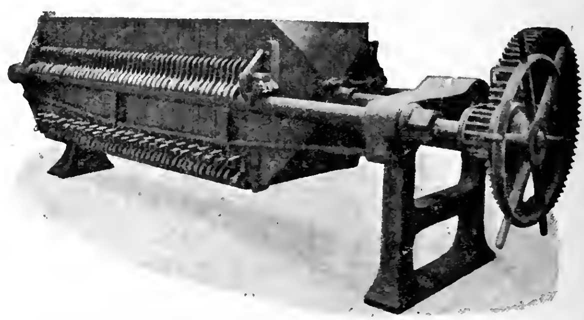


Fig. 175

the figure is the operation of the spindle with worm-wheel drive, that comes into function when the power of the primary pressure-screw, worked by the large hand-wheel visible behind, is exhausted.

The Figure *No.* 181 reproduces a frame press with bordered cloths. The entrance channel for the mixture, as also the channels for the exit of air and water are placed on top.

Filter presses with wooden plates and frames form a special class. Those metals that are of industrial utility are sensitive to very many chemical products, and a

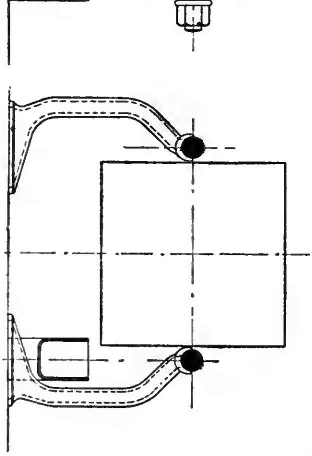


Fig. 177

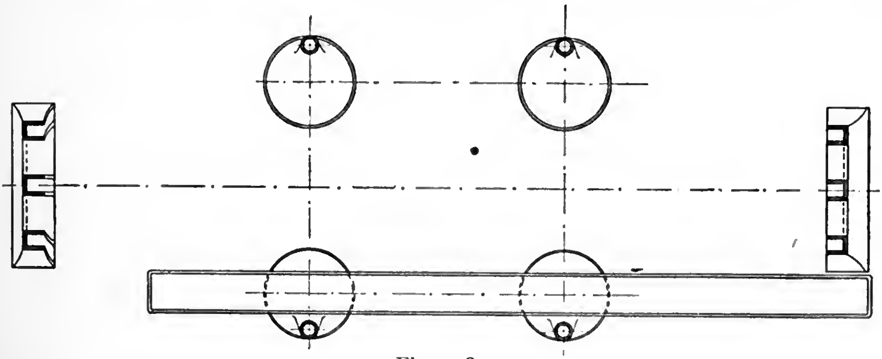


Fig. 178

clear filtrate can only be obtained when certain parts are constructed of wood. While the general character and mode of action resemble those of iron presses, the structure of the plates and frames must evidently conform to

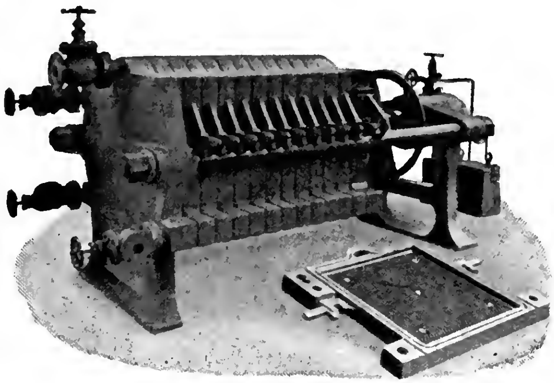


Fig. 179

the innate qualities of the material. The plates are composed of numerous grooved rods fastened together by bolts running through the whole plate.

In the filtration of hot mixtures, the wearing out of wooden plates and frames is sometimes a very grievous matter. And, further, the consumption of filter-cloth is in the case of all presses considerable; it has always been so, and is seemingly unavoidable.

With heavy precipitates, uniform filling of the press by the ordinary method is sometimes impossible, and difficulties are precluded by regulated feeding

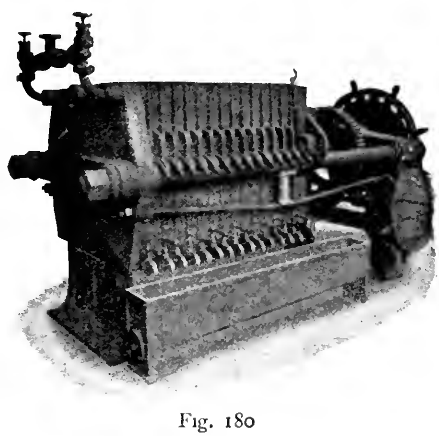


Fig. 180

from above. In the filter press exhibited in *Fig.* 183, rubber tubes join the chambers to the filling pipe, and by means of cocks on them each chamber can be shut off independently. Before emptying the press, the tubes are taken off, one by one, after which the press is opened as other presses, and the cakes removed.

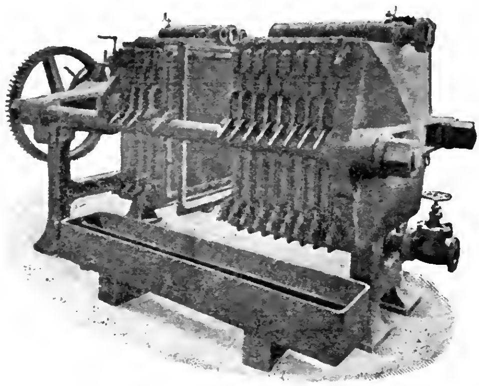


Fig. 181

For laboratories, small filter presses of simple design are available, generally upon one stand with the pertaining pumps, a photograph of such an apparatus being reproduced in *Fig.* 184. Having been poured into the funnel of one of the pumps, the mixture is drawn in by working the handle *A*. The pump *B* delivers the washing liquid to the press. To filter larger amounts, a small chamber, or frame press of the usual form is combined with two pumps in the same way.

When an air-compressor replaces the liquid pump, an air-pump alongside it generates the pressure for forcing the mixture into the press (*Fig.* 185). Mobile mixtures, in which the percentage of solid to liquid is small, especially lend themselves to treatment by an air-compressor installation, which allows large quantities to be handled at a time.

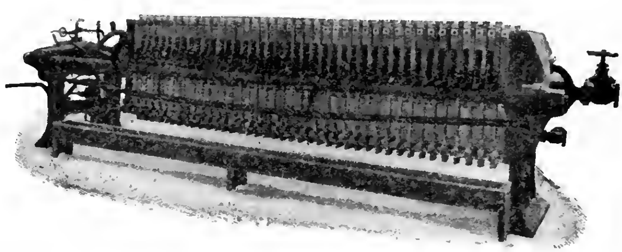


Fig. 182

The disposition of a filtering plant, including a filter press, for a large factory is shown in *Fig.* 186. Often the mixture must be warmed, filtering in the cold not being feasible, and this warming is performed while the mixture is in the forcing vessel, specially introduced into the circuit, which contains a steam coil for the purpose. With the air-regulating tank *C* as intermediary, the air-pump *B* develops the pressure in the forcing vessel to drive the mixture into the filter press *D*. The cistern *E* holds the mixture.

Another plant with forcing vessel is delineated in *Figs.* 187–189. The air-compressor impels the air through the air-regulating tank into the forcing

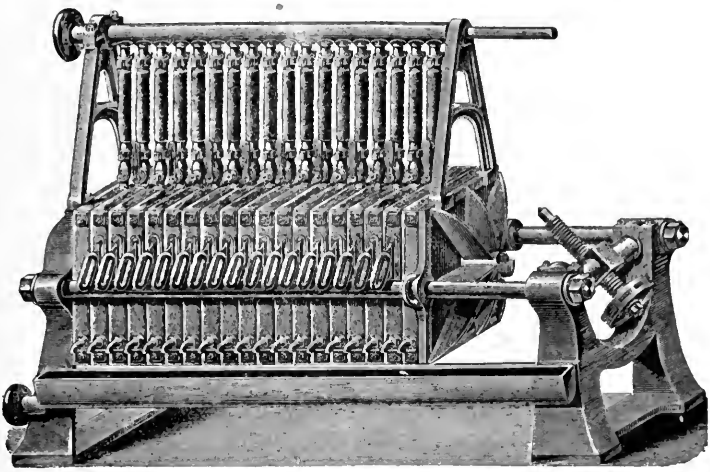


Fig. 183

vessel (*montejus*), which feeds the filter presses in turn. Power for closing and pressing is got from a hand-driven hydraulic pressure pump.

No general statements can be made about the outputs of filter presses.

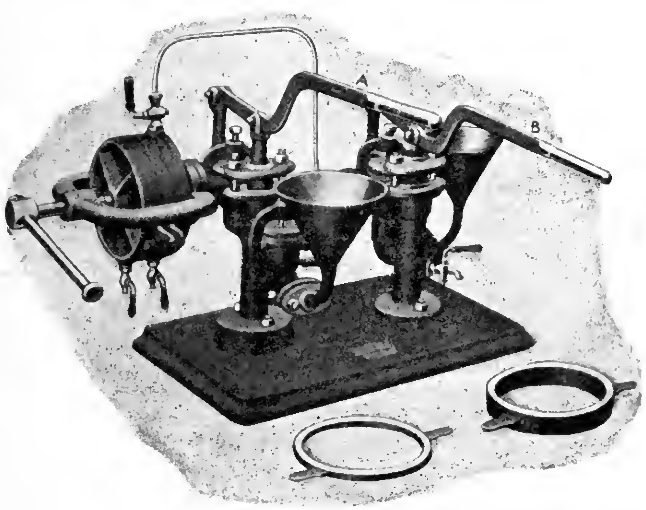


Fig. 184

The build and yield of the press varies in accordance with the nature of the mixture, its viscosity, its content of solid matter, the working pressure, and the temperature.

For large undertakings presses are made with plates measuring 18½ to 60 inches, and the chambers number 4 to 60. The weights of the presses range from 4 cwts. to about 60 tons and the prices from £10 to £1,000.

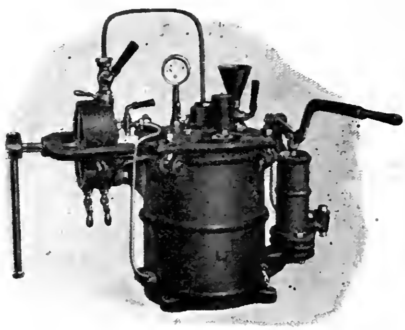


Fig. 185

In presses with wooden components the press-cake may attain a thickness of 6 inches.

The choice of a filter press is in all cases a matter of practical experience or personal investigation.

(7) *Filter Presses for the Fermentation Industries.*

A special make of press has recently been adopted in these industries. Often the filtrate must not only be clear, but also be uncontaminated with iron. Such provisions as tinning, galvanizing, or enamelling the plates and frames are useless, so also is covering with rubber. A simple plan is to make them of an inert material as vulcanite, or of secret mixtures the composition of which is a trade secret. The firm of Enzinger turns out such a press. In

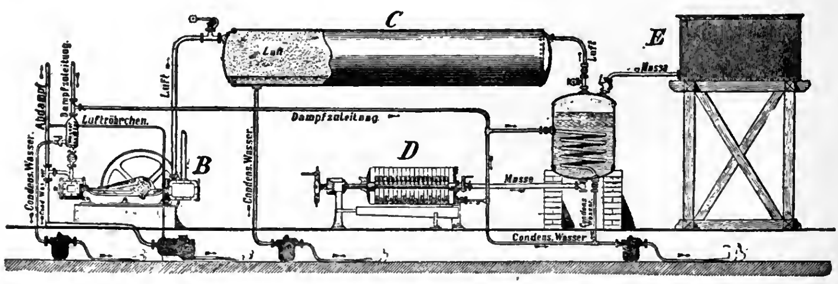
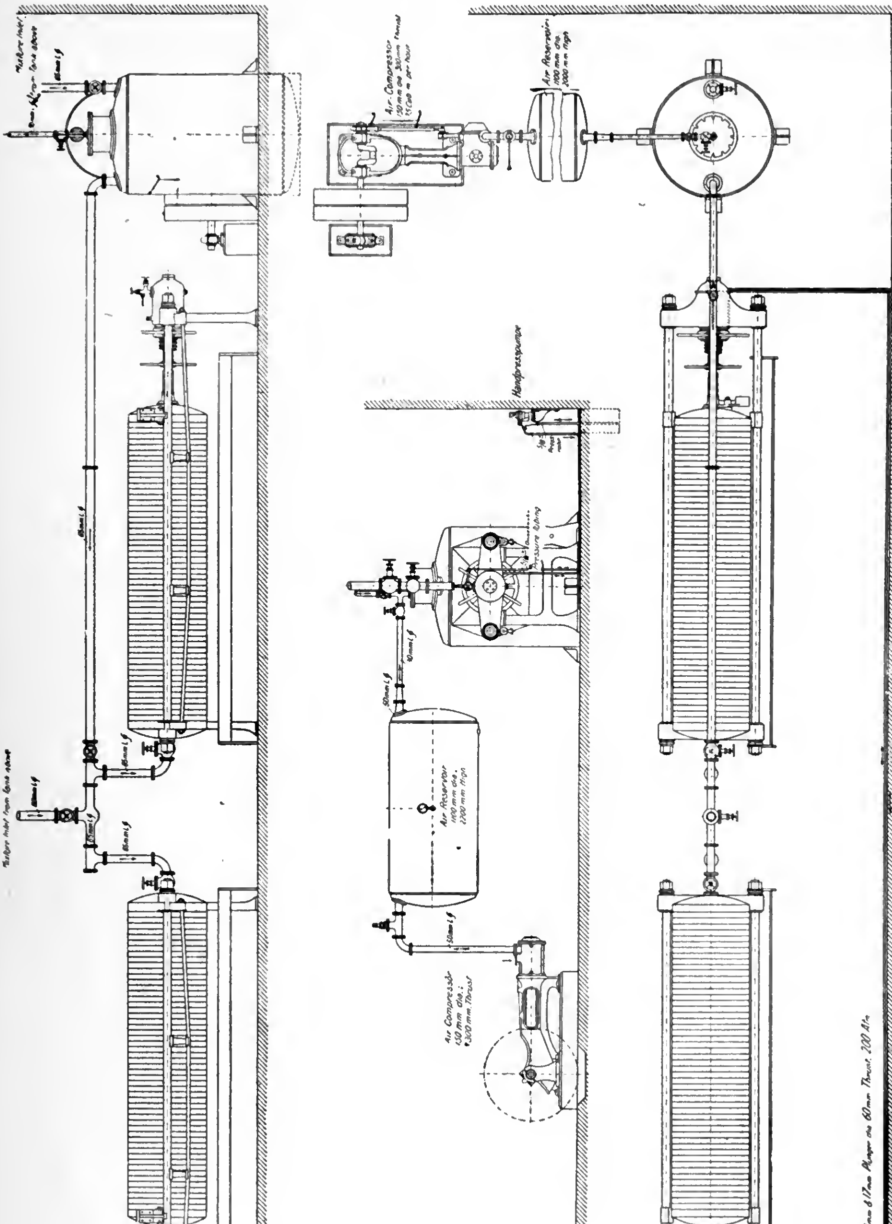


Fig. 186

Dampfzuleitung = Steam inlet. Condens. wasser = condensed water
Luft = air Masse = mixture Luftrohrchen = Air pipe.
Abdampf = Exhaust steam.

place of the filter-cloths, a special fibrous material is fabricated in the frames into sheets, in a press made for the purpose, so that the frames and their packing can be easily transported and handled. These filter presses work without washing of the residue, and are simple in construction. *Fig.* 190 shows a section of the apparatus, and *Fig.* 191 the plan of a chamber.

A complete idea of such a filter press may be gained by examining *Figs.* 192–194. It comprises the following essentials: two cast-iron horses linked by two truss-rods, and between the head and foot-plates the frames and par-


Air Reservoir
1100 mm dia.
2200 mm High
Air Compressor
130 mm dia.
300 mm Thrust

Figs. 187—189

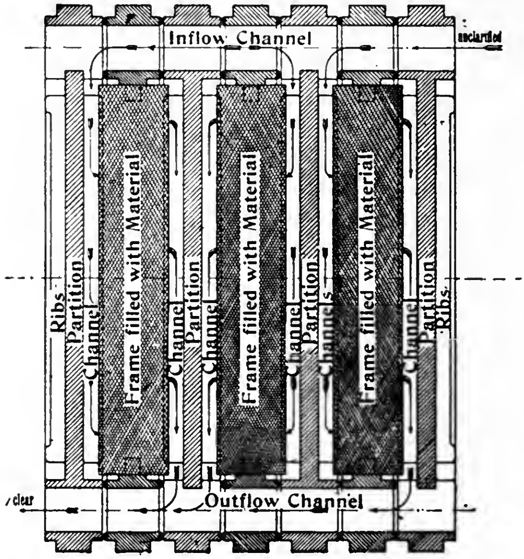


Fig. 190

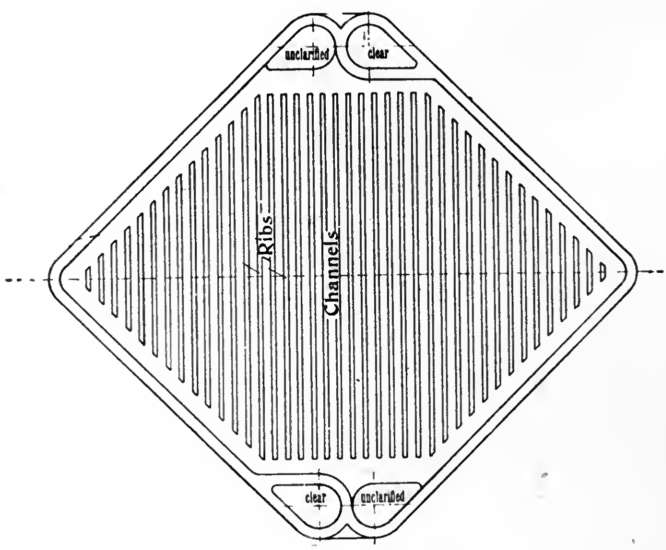


Fig. 191

titions of the special material, the chief constituent of which is rubber, which is inert to most liquids. The elasticity of the rubber, aided by a particular sort of packing, ensures perfect tightening at all joints, thus preventing all

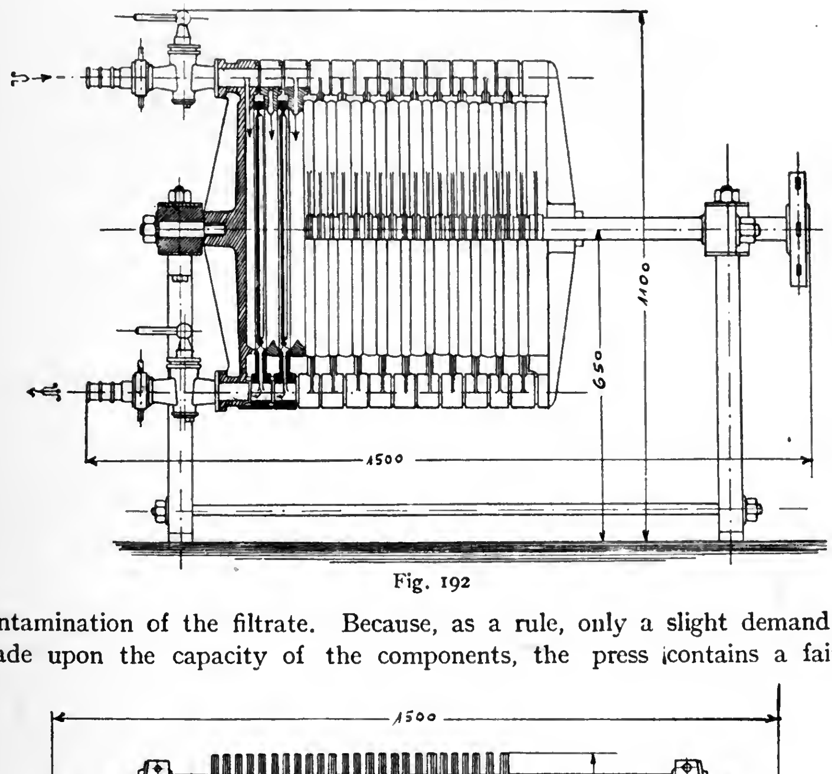


Fig. 192

contamination of the filtrate. Because, as a rule, only a slight demand is made upon the capacity of the components, the press contains a fairly

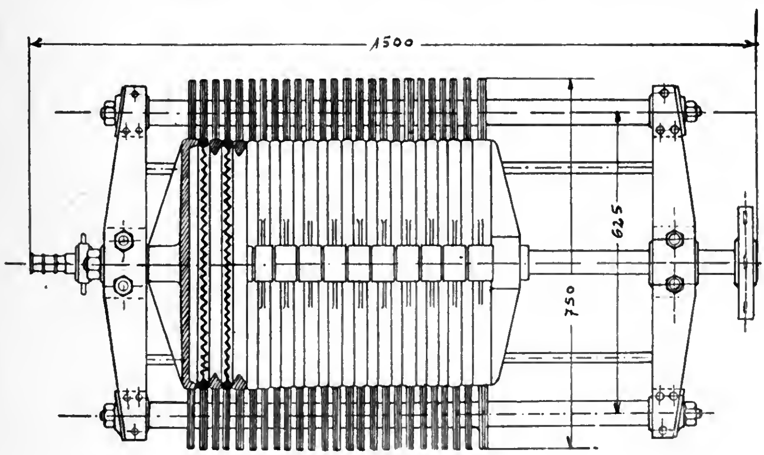


Fig. 193

large number of them. For watching the colour of the filtrate, observation glasses are fixed upon the outflow and air-cocks. The press may easily be moved about by mounting it upon wheels (*Fig.* 195).

Another special filter press is the beer filter on the Sellenscheid system. Perforated plates hold the filtering substance together in the frames, and this admits the use of thinner filtering layers for the same kind of liquid than those in the press just described. There is a saving in material and in pressure. As appears from *Fig.* 196, a lid *D* closes the casing *G* which surrounds the frames. Muslin and perforated plates, fitting perfectly everywhere, enclose on both sides the material of the filtering bodies *F*, which are arranged in pairs. These are free on all sides except on top and where they join the channel *S* below. The liquid enters at *E*, diffuses through the filtering bodies into the space between the pairs, and leaves through the channel *S*.

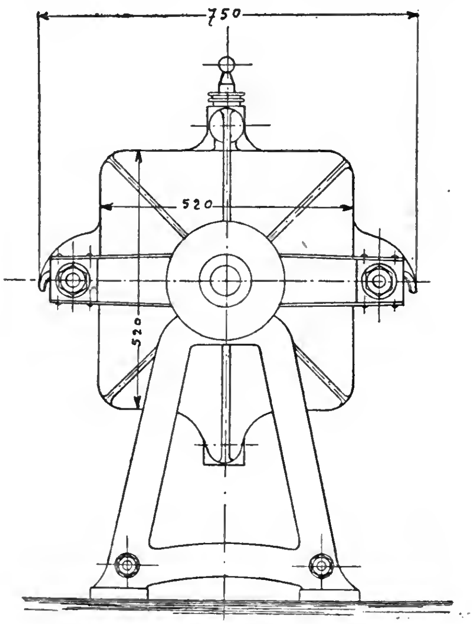


Fig. 194

(8) *Washing Machines for Filter-Cloths.*

Filter-cloths from the press must be washed when dirty, if they

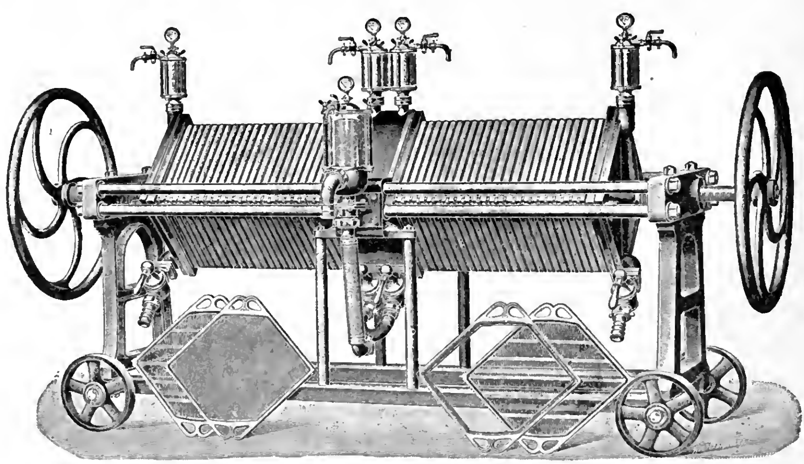


Fig. 195

are to be used again. For large establishments a mechanical appliance for cleaning them suggests itself, in fact, a kind of washing machine. Such a machine, of a simple pattern, has been put on the market by the firm of Enzinger (*Fig.* 197). In a hemispherical trough, furnished with a close-fitting lid, a perforated drum can be revolved by mechanical or hand-power. The dirty

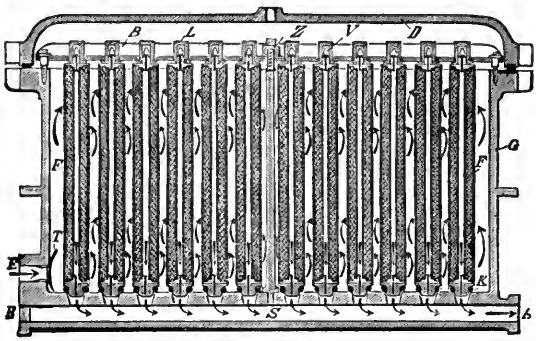


Fig. 196

cloths are put into the drum, the trough charged with water, and some detergent added. The contents having been warmed with steam, the drum is set in motion, and the cloths thereby being rubbed against one another, the particles of dirt are loosened. Then clean water is allowed to stream in, the

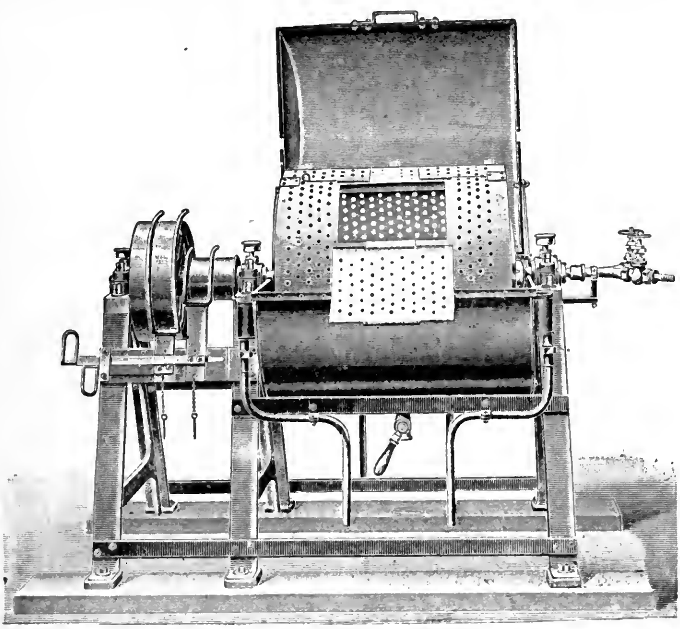
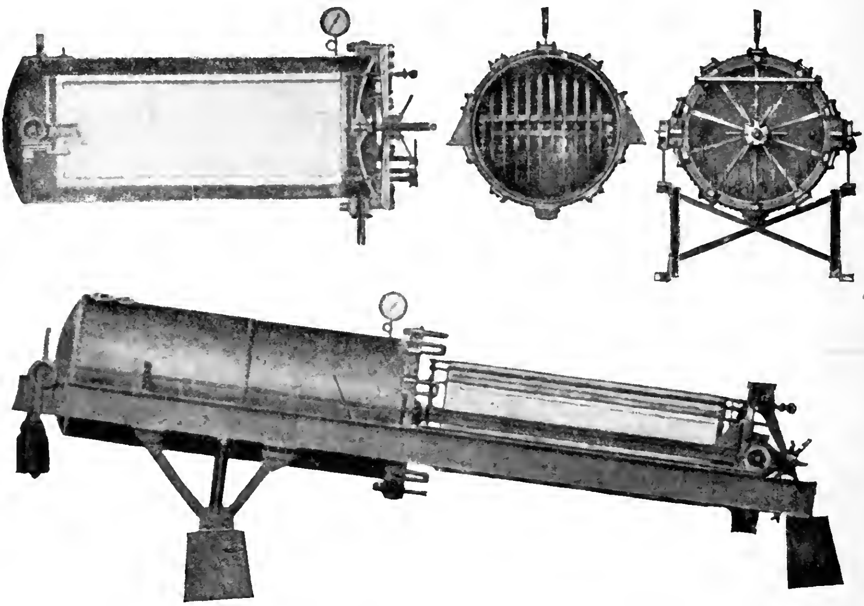


Fig. 197

outflow cock being opened, until what issues forth is clear. These operations may be repeated or be reversed in order, according to the nature of the cloths and of the dirt.

(9) *Filter-Cloths.*

These may be woven with cotton, wool, asbestos, or whatever fibre is suitable for the filtrate. For acid liquids, nitrated cloths have been selected, nitrated cellulose being unattacked by certain acids. But caution in the handling of the latter is advisable, for they are very inflammable when dry, and under some conditions may give rise to explosions. They should therefore be used only when wet, and always be stored in that state.



Figs. 198—201

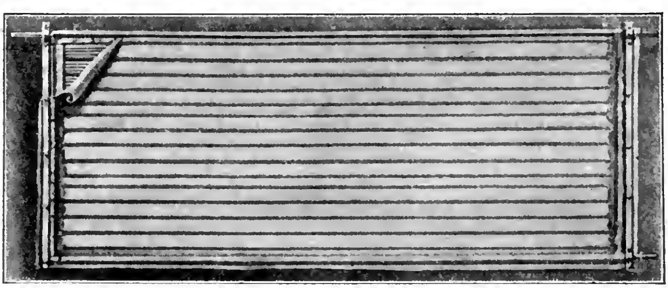


Fig. 202

(10) *Automatic Filter Presses.*

A filter which has almost all the advantages that could be possessed by an automatic filter is that manufactured by the Kelly Filter Press Company. This filter is being used with success for treating gold slimes, alumina precipitates, and in alkali and acid works; but its most important use is in the sugar industry. *Figs.* 198–204 are illustrations of this filter, which is fully described in Part III. in the section devoted to "The Filtration of Sugar Solutions."

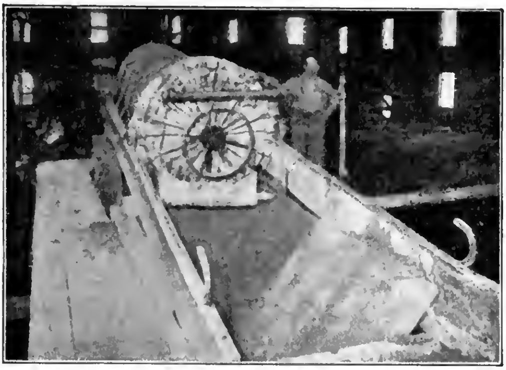


Fig. 203

An automatic apparatus with endless filter-cloth, represented in *Figs.* 205–207, serves mainly for isolating precipitates difficult to filter. The filter-cloth shifts with periodical movements across the porous platten *g* of a hydraulic ram *h* which forms the lower part of the filter-chamber *k*. The upper part occupies the place of the stationary head in a hydraulic press,

Fig. 204

but is hollow. Upon the upward motion of the platen on the top of the ram, the cloth packs the joint between the two sections of the filter-chamber and makes it watertight. Through the connecting branches *o* and *p* is admitted the mixture, and, as required, the compressed air or washing-liquid. When the filtration of one instalment of the mixture is ended, the ram *h* drops and the cloth, freed from between *k* and *g*, moves around the rollers *f*, *e*, *d*, *c* and *b*, and another instalment is treated. A scraper *u* fetches off the deposit, which falls into the trough *v*, to be taken away by the spiral conveyer *w*. By the combined action of the washing trough *t*, the roller brush *r*, the sprinkling tube *g*, and the scraper *s*, the cloth is cleansed. Changes in its length are

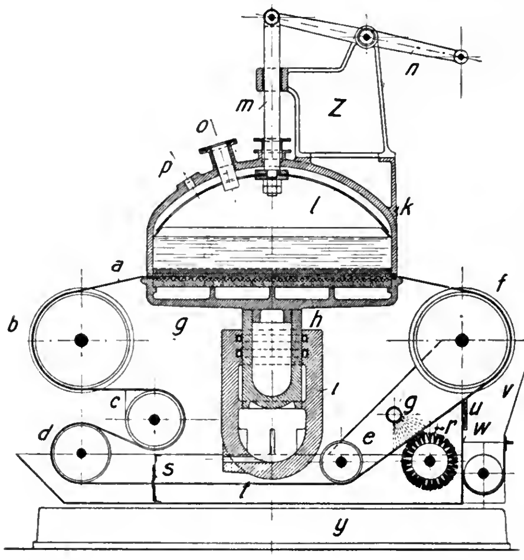


Fig. 205

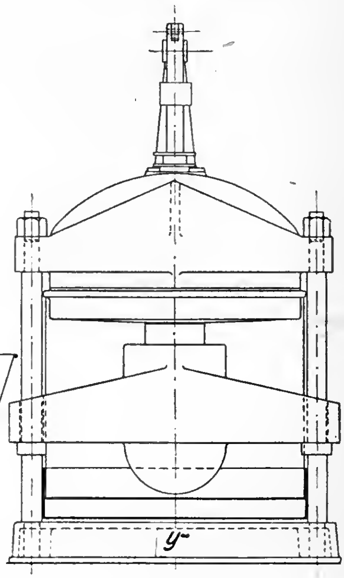


Fig. 206

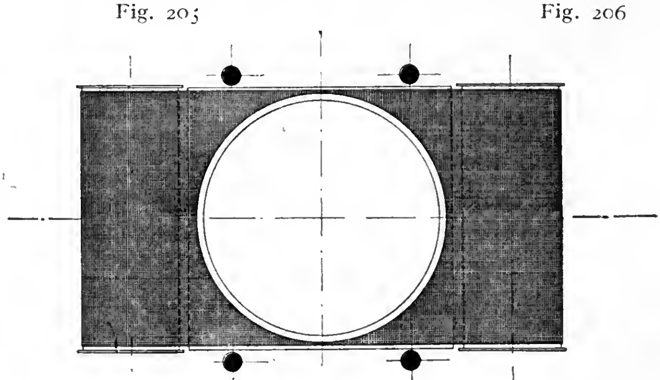


Fig. 207

compensated by the tension roller *c*. The whole arrangement rests on the solid base *y*. For removing solid matter adhering to the walls of *k*, a lever *n*, pivoted on the trestle *z*, works up and down the rod *m* with the scraper *l* at its end.

None of the types of automatic filter so far brought to our notice have proved more valuable than this last.

FILTERS WITH RIGID FILTERING LAYER

The last group of filters to be considered are those in which the active layer consists of particles linked together by a binding medium in a definite way so that between them exist channels which condition the filtering power. At the beginning of the book were mentioned alternative ways of forming these channels. Often the particles are mineral in nature. A pit inlaid with permeable filtering bricks constitutes the fundamental type of open filter of this kind. So narrow are the channels in the bricks that they readily give passage to the liquid but not to the solid matter intermixed with it.

There is some choice as to the shape of the filtering elements. Very often these are tiles, blocks, or cylinders. The side which faces towards the mixture, the inside, is smooth and fine-pored; the other side, outer or lower, is usually grooved and coarse-pored. The filter may be open or closed.

Open Filters.

Schuler's tiles and blocks. applied as the linings of pits and rectangular and circular vessels of all sorts, have been widely adopted. Their power of filtration is excellent and their durability almost unlimited. Paper manufacturers line with these stones their bleaching-pits, in which the paper stuff is subjected to the action of bleach liquor, or chlorine gas in solution, the liquor, after doing its work, passing away through the stones.

Cylindrical filter ware, the liquid percolating from the inside to the outside, or vice versa, are also found as open filters, but their proper mission is in closed types.

Closed Filters.

Owing to the fine filtration possible with filter bricks, so fine that even bacteria can be held back, increased or reduced pressure is necessary, either to make the filtration at all possible, or to raise the yield to the pitch desired.

(1) *Closed Filters with Tiles.*

Within the pressure-resistant casing A shown in *Fig.* 208 rests an inner vessel B composed of acid or alkali-resistant material or with its walls defended by a protective layer against attack. Filter-blocks cover the bottom, where is the outlet for the filtrate. Enough space remains between A and B to ensure that any pressure bears equally on both sides of B, which may therefore be manufactured of a substance without any great strength.

For large outputs an arrangement is provided such as that illustrated in *Figs.* 209 and 210. In the chamber B are a number of trays A, their bottoms inlaid with filter-bricks, the space beneath which communicates with the outside by the exit pipes *C*. The trays are withdrawable and are made to tip in special frames for easy emptying.

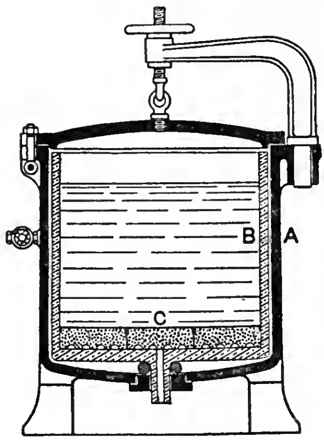


Fig. 208

(2) *Candle Filters.*

One of the principal shapes taken by the filter with rigid layer is that of the candle filter, the candle being a cylinder with one end closed, the open end leading to the outflow, so that the liquid must penetrate the wall of the candle before it can be cleared. So narrow can the pores be made by the selection of a suitable material that bacteria of even the smallest size cannot get through, so that the filter may be devoted to the separation of the finest of particles. They may be set in open filters, or in filters worked under a vacuum or increased pressure, usually the latter. The working pressure may be increased at pleasure without concern as to the strength of the candle, only the outer casing being made resistant, which is a simple matter. For treating acid liquids, the candle is enamelled.

A well-known candle filter is the Berkefeld filter, largely employed for obtaining water free from germs.

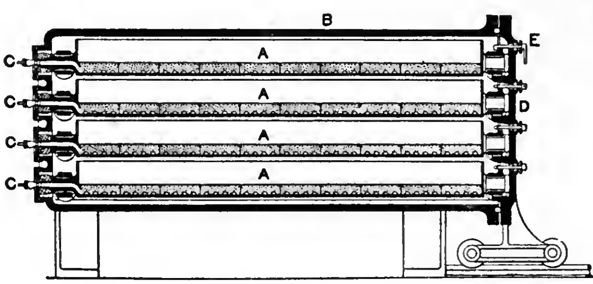


Fig. 209

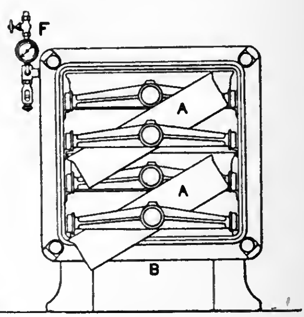


Fig. 210

A simple filter for working under pressure is that represented in *Fig.* 211. The water from the main reaches the outside of the candle through the cock *a*, diffuses through the filtering layer, is filtered, and leaves the apparatus by the tube *e*. For the bacteriological testing of filtering masses the cocks *b* and *d*, with vessel *e*, are provided, but these are usually lacking unless the filter is required for such tests.

A candle filter for larger yields is shown in *Fig.* 212. There is a device for cleansing the surfaces of the candles *A*. These are enclosed in a mantle *B* and are firmly screwed into the bottom of the chamber. Surrounding the lower parts of the candles, between them and the mantles, is some granular material *D*, the cleansing agent. The liquid to be filtered streams under pressure through the cock *H* into the interior *J* of the filter and on through holes in the mantles *B* to the candles, to penetrate over their whole area, as the cleansing material is easily passed through. Eventually it attains the outlet cock *N* by way of the tubes *L*, and the collecting space *M*. In the bases of the mantles are openings *E* which communicate with the air-chamber *G* by means of slits *F* opposite to them.

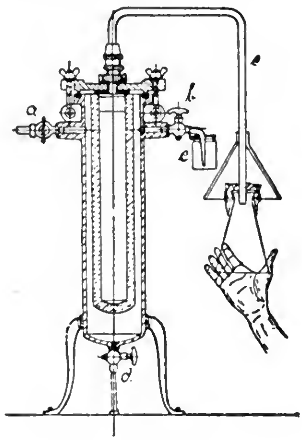


Fig. 211

As the impurities settle down upon the candles, their power of filtering gradually weakens and cleansing becomes necessary. Then the cocks *N* and *H* are closed, and compressed air enters at *O* and the water for washing at *P*. The force of the air sets the granular masses *D* in motion, so that the particles scour the outsides of the candles, bringing away the deposit of dirt and opening up the pores. The dirty water escapes through *R*. By adopting this system of cleansing for a great number of sets of candles like this, large outputs can be obtained.

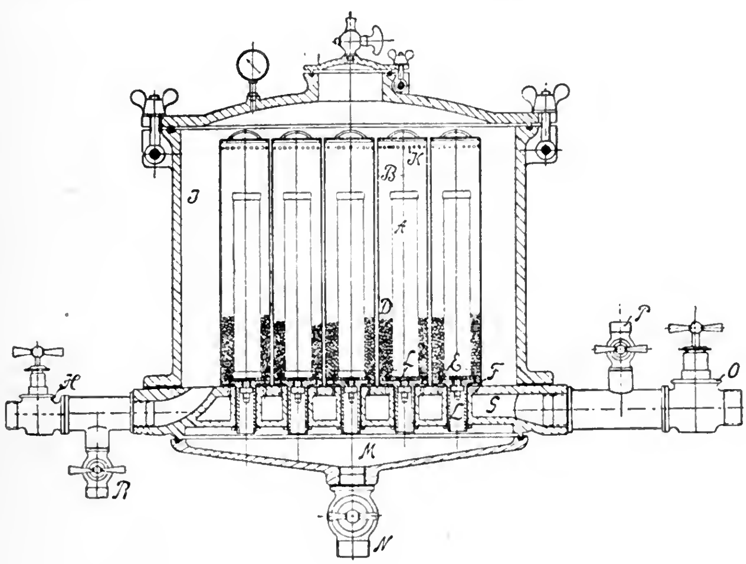


Fig. 212

SEPARATING APPARATUS WITHOUT FILTERING LAYER.

I. Decanting Vessels.

Often in isolating solid particles from liquids, advantage is taken of the spontaneous deposition of solids under the influence of gravity, the clear liquid being run off, or, as it is called, decanted. Relatively simple appliances suffice for this.

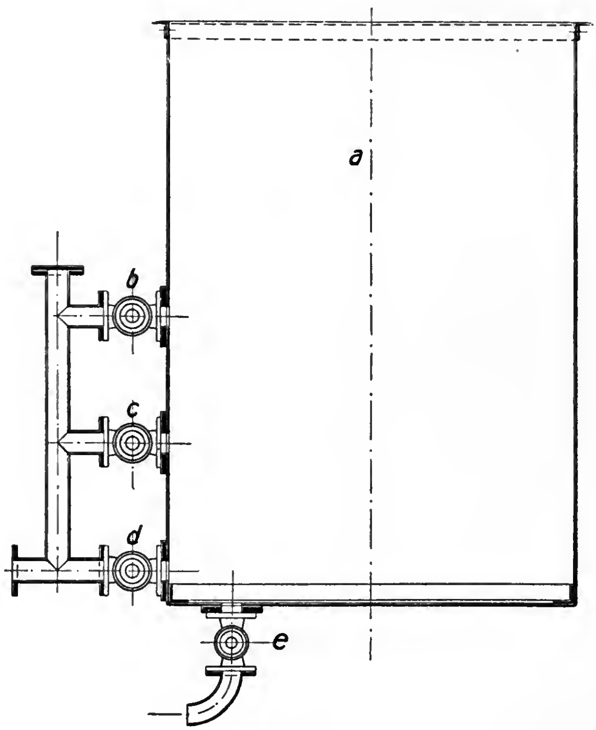


Fig. 213

A series of run-off cocks may be fitted down the sides of a tank holding the mixture for drawing away the liquid at different levels. In the apparatus exhibited in *Fig.* 213, the cocks *b*, *c* and *d* decant off the liquid at such levels as it is clear. Cock *e* is for emptying the vessel.

Instead of a series of cocks, one is sufficient if that be joined inside by a revolvable bent tube, as in *Fig.* 214. The horizontal limb of the tube passes through the wall of the tank *a* and with a cock *c* is made to turn. The position of the other limb determines the height from the bottom at which the liquid is removed.

In many industries the principle is utilized that the retardation of the eddying movements in a liquid causes any solid matters in it to fall to the bottom,

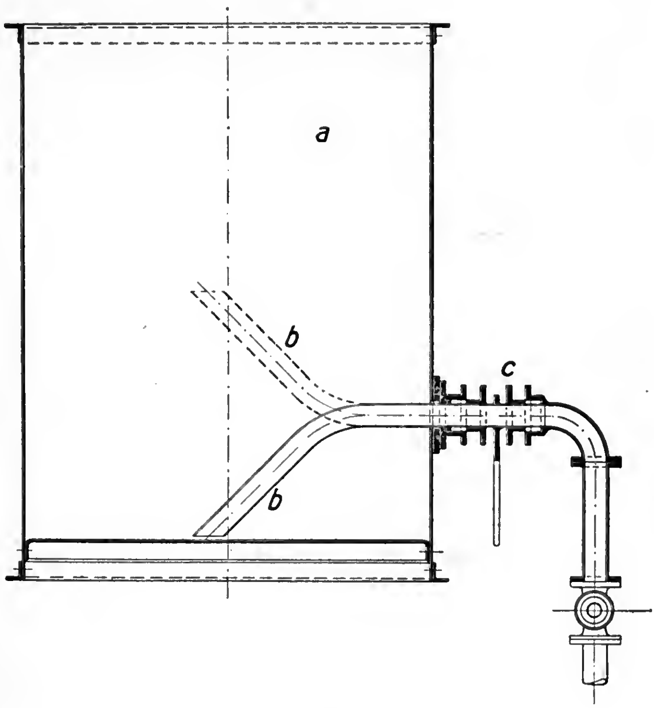


Fig. 214

to become heaped up continuously by means of a suitable contrivance. This principle is adopted on a large scale for the treatment of ores, but the forms of apparatus devised for handling ore washings are so manifold, and the subject so remote, that this brief reference will be enough.

II. SETTLING APPARATUS.

The settling apparatus employed by the paper manufacturers to recover fragments of paper stuff that have evaded the sieves of the paper or pasteboard machine also deserves a brief mention. This comprises generally a cylindrical tank of wide diameter and with conical base. By conducting the water into it in a certain manner, eddying is prevented, with the result that the fibres floating in the water settle down. An apparatus of this kind may function as preliminary to the continuous-action drainer-filter (*Figs.* 114–125).

The details of these apparatus vary very much. In the one illustrated in *Figs.* 215 and 216, the raw water comes through *a* into the circular

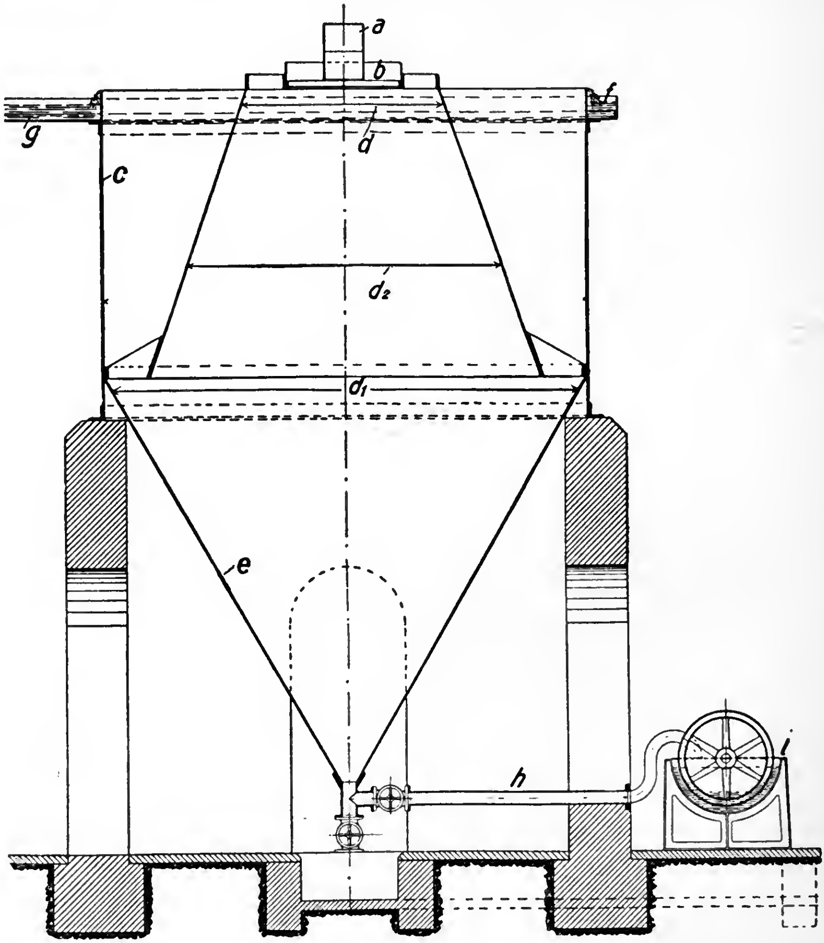


Fig. 215

distributing vessel *b* and passes down into the upper cone suspended within the casing *c*. The solids sink into the lower cone *e* and the water flows upwards outside the upper cone towards the gutter *f* and the upper discharge pipe *g*. The measurements at *d*, d_1 and d_2 are so related that eddying is discouraged. Through the lower discharge pipe *h*, the regained fibres, mixed with a little water, are led to a filter *i* for complete separation from the liquid.

In *Fig.* 217 a somewhat different arrangement is set forth. The raw water is received through the central inlet *a*, across which are two sieves for detaining the coarser ingredients that would otherwise block the outlet at the bottom. As the mixture descends in the cone *b*, the heavier particles fall into the conical base *c*, and can be extracted at the connecting branch *d*. Thus

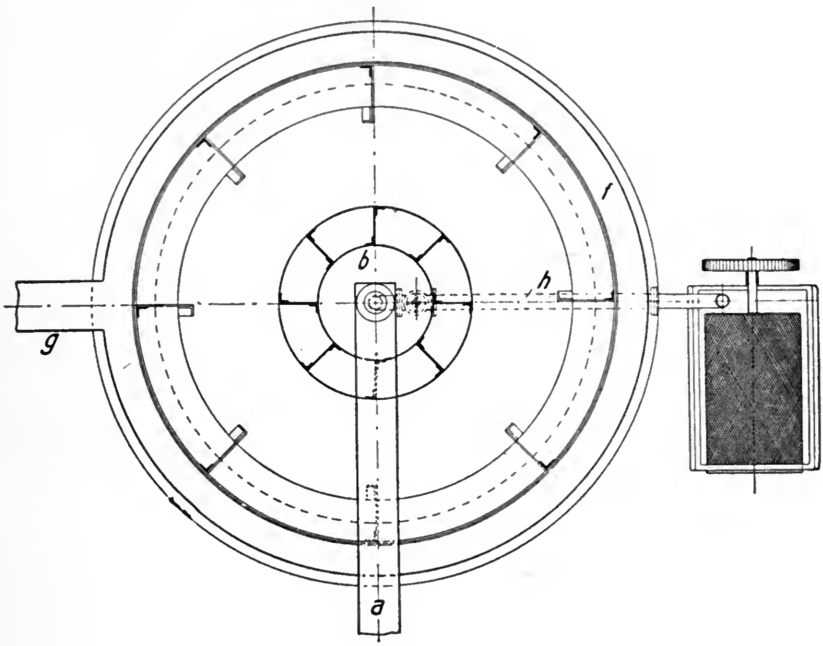


Fig. 216

partly cleared, the water travels upwards outside of *b* and under the cones *e*, *f*, *g*, *h* and *i*, where the lighter particles drop out. At the top the cleared water is absorbed by pipes *k*, *l*, *m*, *n*, *o* and *p*, which join the vertical pipes *q*, and enters the circular pipe *r*. The number of collecting pipes is fixed to correspond with the desired yield. The latter, in an apparatus with outside diameter of 160 inches, amounts to 220–264 gallons per minute, and in one of 240 inches to 440–550 gallons.

PART II.

PRESSES FOR THE SEPARATION OF LIQUIDS AND SOLIDS.

All the appliances so far described have this in common, that they deal with mixtures whose content of liquid is high compared with that of the solids. There are cases where the pressure available in ordinary filter presses and

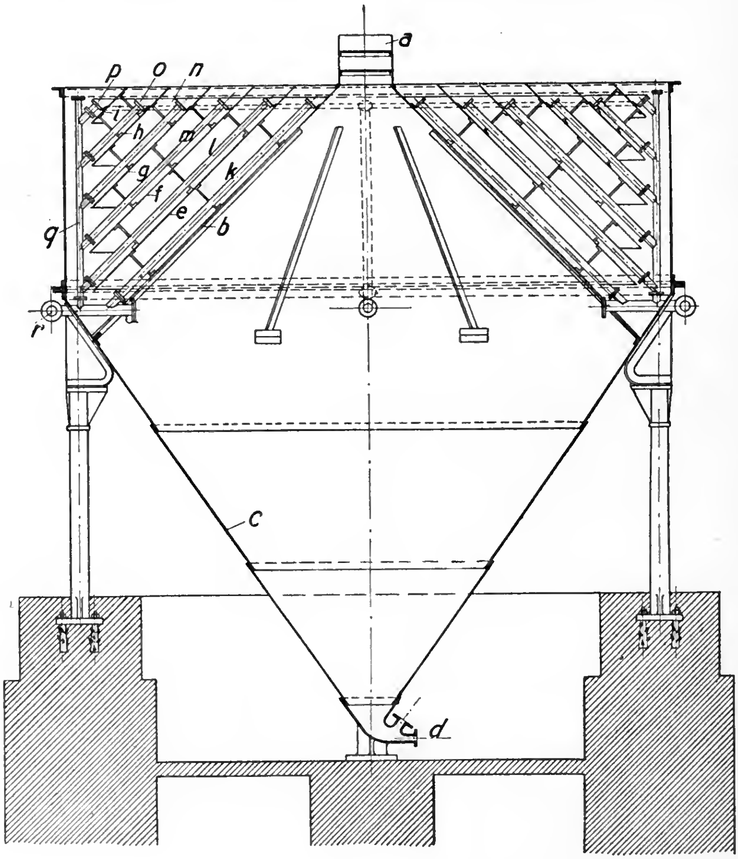


Fig. 217

pressure filters falls short of that requisite for denser mixtures or masses and recourse has to be made to special presses. These are typically hydraulic presses, between the platen and head of which the mass, enclosed in properly devised receptacles, undergoes the necessary squeezing.

I. PRESSES WITH PRESS-CLOTHS.

If the substances to be handled can be wrapped up in cloth, the simplest of presses is available. The press cakes, so enfolded, and if need be divided

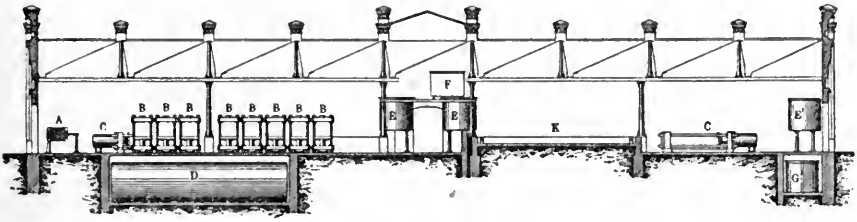


Fig. 218

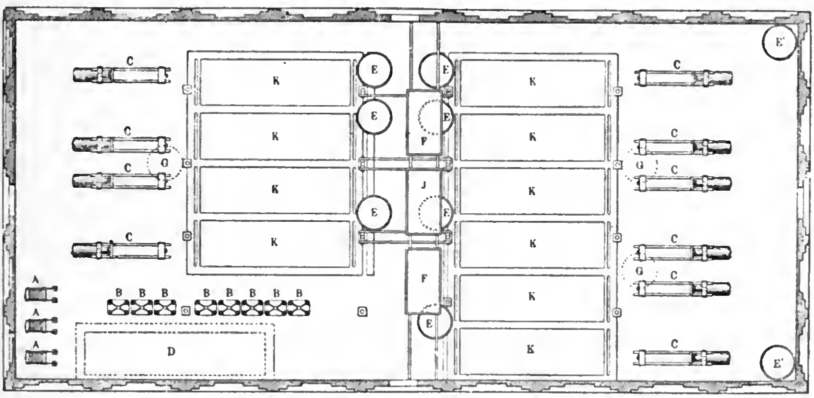


Fig. 219

from one another by sheets of a strong material, are laid between the platen and head of the press. Any liquid expressed discharges at the edges of the cakes.

Horizontal presses are selected for the treatment of oil-fruits, stearine, margarine, paraffin-wax, anthracene, and the like. In brown coal-tar works,

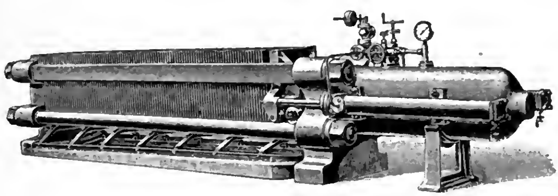


Fig. 220

however, vertical presses accompany the horizontals. The press-room of a paraffin-wax factory is shown in *Figs.* 218 and 219. For the preliminary stage the vertical presses *B* serve while the cakes of wax are submitted to the final pressing in the horizontal presses *C*.

Fig. 220 is a picture of a horizontal press for a stearine or paraffin-wax factory. In response to the high pressures demanded, up to some hundreds of atmospheres, the diameter of the hydraulic ram and the length of its stroke are very considerable.

On account of the excessive wear and tear of the cloths, the inconvenience and the time wasted in handling the cakes, this method is costly, and the cloths have been replaced by strong press-baskets.

II. PRESSES WITH PRESS-BASKETS.

A small press, used mainly in laboratories, is shown in *Fig.* 221. The basket *a* rests in the cup-like end (platen) *b* of a hydraulic ram seated in the lower part *C* of the press. Turning in the head *e* of the press is a threaded spindle *d* with a hand-wheel at one end and at the other a suitable fitting for introducing into the basket. When the maximum pressure with the hand-wheel is attained, the double handle *h* sends the screw *g* into the liquid behind the ram, which rises and finishes the extraction.

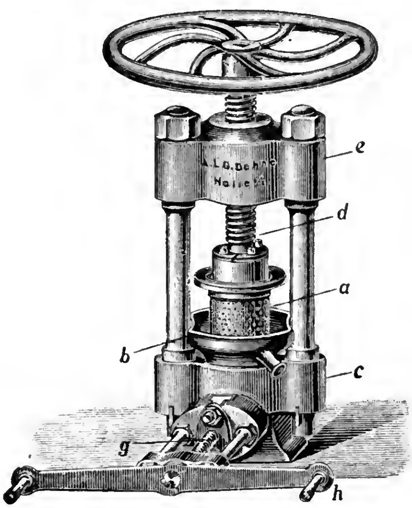


Fig. 221

From olden times down to the present day presses with baskets have been employed in the making of wine for separating from the skins the liquor so valuable to mankind. In the vine-growing districts even now may sometimes be seen ancient presses with their giant levers; but better results are got from the modern screw press.

In *Fig.* 222 is reproduced a screw-press with hand-drive. A strong, threaded spindle, firmly fixed to the basal pan, carries a female screw that is turned with a latchet device. The pressure of this female screw upon the contents of the basket is sustained by cross-heads and split springs with suitable underlays. Held together by powerful hoops, the basket consists of strong staves with slits between. The squeezed recrements on the surface of the mass form a filtering layer and prevent the extrusion of the remainder.

Presses with hydraulic power, as in *Fig.* 223, are capable of high yields.

A requirement of to-day is the saving in the cost of labour. And in order to get the best possible out of the press, by saving in time, the baskets are made to swing out (*Fig.* 224). The necessary pressure, generally about 128–142 pounds per square inch, is generated by a ram below the basket.

But for very high pressures, such appliances are unsuitable. Oil bearing fruits, paraffin-wax and naphthaline, which call for more concentrated pressure,

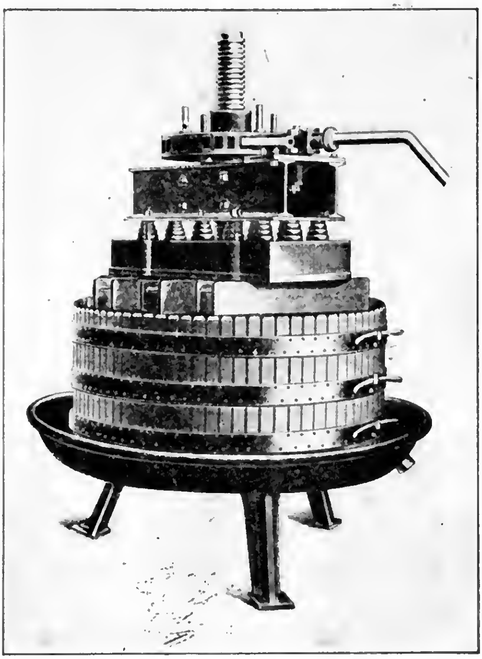


Fig. 222

undergo it in baskets of some very strong material, as iron or steel. These take the shape of staves or of perforated cylinders from which oozes readily

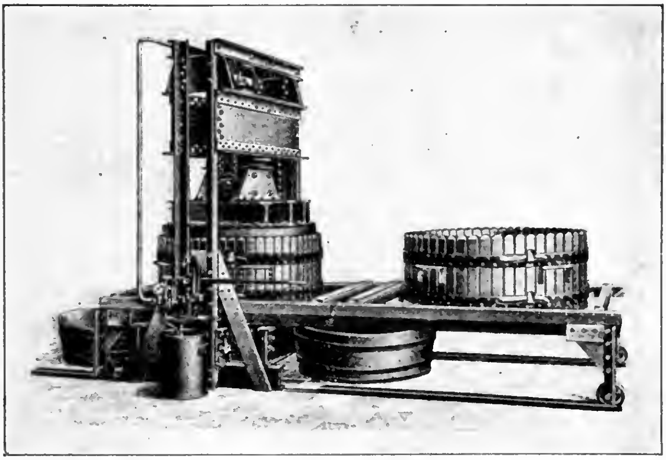


Fig. 223

the expressed liquid. The sizes and outputs of these presses vary within wide limits.

When the material does not lend itself to treatment in the thick layers usual in basket-presses, pot-presses are substituted, the pots being perforated cylindrical vessels, closed below, which, for facility in emptying, revolve around one of the pillars on supporting rods that keep them at definite distances apart.

III. PRESSES WITH HEATING OR COOLING.

The character of the material often requires that the process be carried out at raised temperatures to encourage the withdrawal of the liquid; or at lower temperatures. In presses where cloth holds the press-cakes, the plates

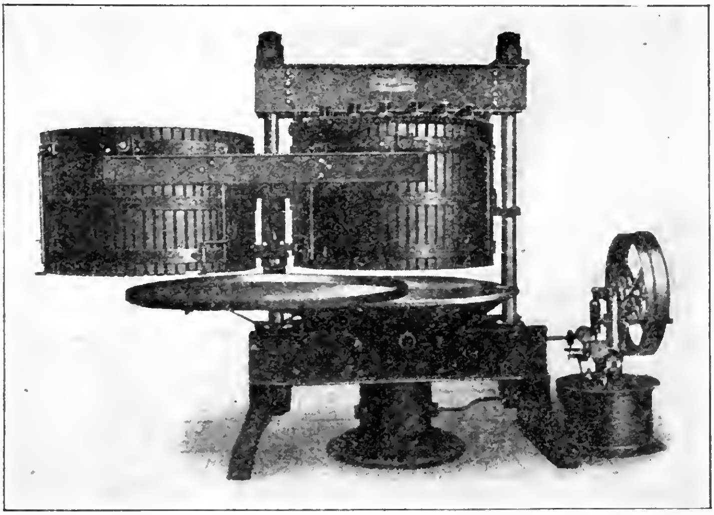
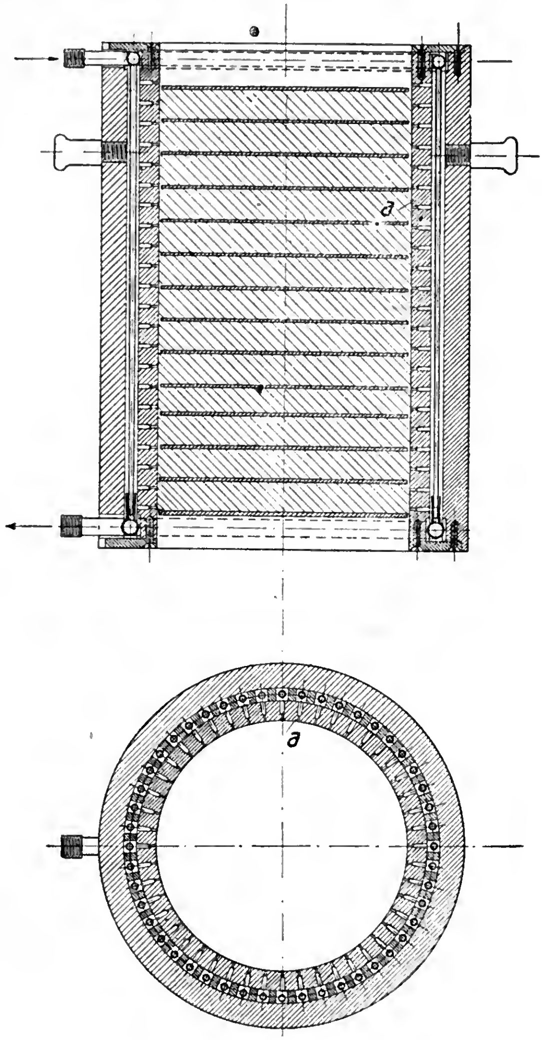


Fig. 224

between are warmed by steam or water. Press-baskets also accommodate themselves to heating and cooling, and in naphthaline works heated as well as unheated baskets are found.

The naphthaline is filled into the basket *a* (*Figs.* 225 and 226), a steel cylinder of 16–20 inches internal measurement, with walls about 1·6 inches thick and bored by thousands of minute holes 0·04—0·08 inches in diameter. Surrounding the basket is a second cylinder *b*, the space between them being 0·8—1·2 inches. Within this intermediate space alternate solid rods, which transfer the pressure to the outer cylinder, and tubes belonging to the heating arrangement.

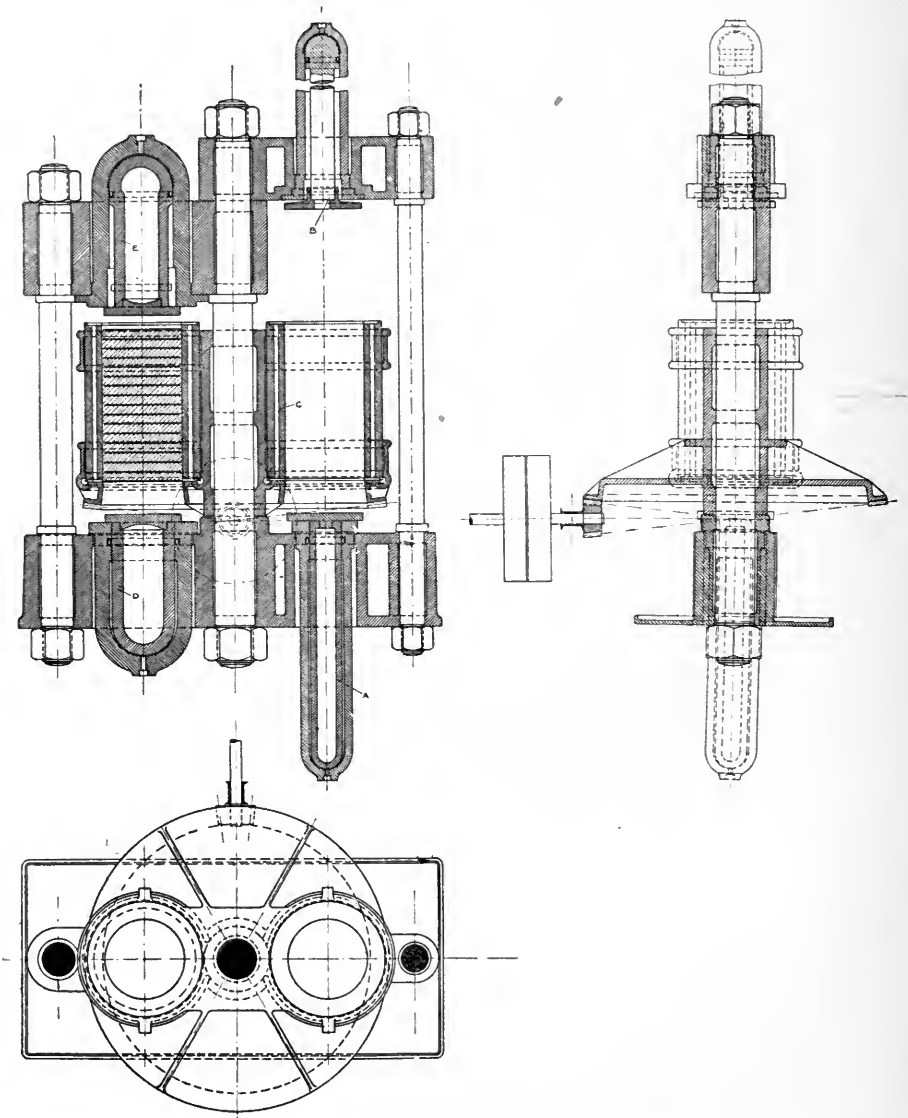
The press itself is illustrated in *Figs.* 227–229. As is evident, it has swing-out baskets and alternate pressing devices, the rams *a* and *b* for filling and emptying the baskets *c*, the rams *d* and *e* for compressing. In filling a basket, the ram *a* is elevated to its highest, leaving enough room at the top of the basket for a naphthaline cake 2–4 inches thick. Upon this layer is put an iron plate and the ram is lowered to make room for a second cake; and so the packing is continued until the basket is full. From time to time pressure



Figs. 225 and 226

may be exercised by the ram *b* to provide more space for further loading. By means of the swinging mechanism the basket is then brought between the rams *d* and *e*, which approach one another to carry out the pressing. Meanwhile the heating medium has been turned on. When the extraction is ended, the basket is swung back again, another taking its place, and it arrives over the ram *a* to have its charge thrust out and another put in.

For such substances as cannot be efficiently dealt with in thick layers,



Figs. 227—229

and require exceedingly high pressures, special apparatus may be procured. That shown in *Fig.* 230, an oil-seed press, possesses five tiers and as many holders for the material. There are contrivances for easy emptying of the holders, which remain at their proper distances on the withdrawal downwards of the ram and may be swung out.

Fig. 230

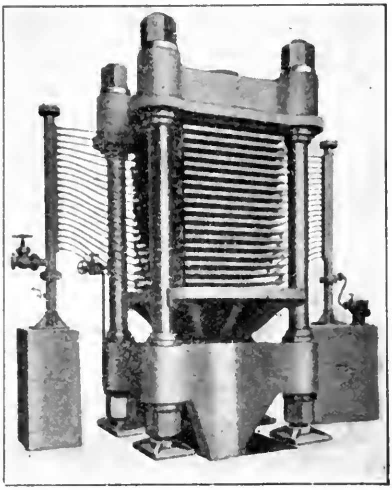


Fig. 231

A vertical press with heated plates appears in *Fig.* 231. The heating medium—water, steam, oil, etc.—is led to and from the plates by flexible tubing, or tubing of metal.

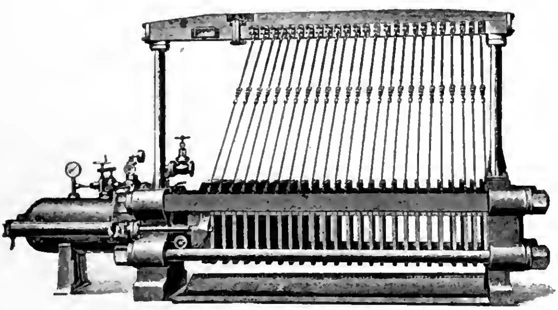


Fig. 232

In the horizontal apparatus reproduced in *Fig.* 232 the heating medium comes from a cross-head situated above the press, and goes off by a collecting-pipe below or alongside.

PART III.

FILTRATION AND AIDS TO FILTRATION AS APPLIED TO THE SUGAR INDUSTRY.

By J. J. Eastick.

THE THEORY OF FILTRATION.

In the previous chapters the various types of filters have been described, and also suitable methods of arranging them to minimize labour and space. We will now consider the theory of filtration and describe the preparation of the solutions for filtration, the substances used as aids to filtration, and the precautions to be taken. To discuss fully these questions for all industrial purposes would take up too much space; we therefore have selected the sugar industry, in which more difficulties than usual are met with, where greater precautions are necessary and where the operations are carried out on large quantities; and only incidental reference will be made to special operations in other industries.

Filtration is the act or process of mechanically separating and removing undissolved particles; these may be described as precipitate, sediment, cake, sludge, residue, deposit, etc. The clear liquid is termed the filtrate, clear liquid, fluid, outflow, clean water, etc.

The separation is effected by the passage through a porous partition or layer having spaces either smaller than the particles but sufficiently large to allow the liquid to pass freely, or spaces larger than the particles but partially throttled by particles accumulating therein. In this last case the first portion of the filtrate will not be bright.

If in a mixture of solids and liquids all the solid particles to be filtered off were of uniform size and shape, the construction of the filtering medium would be such that the pores or meshes would be slightly smaller than the particles; unfortunately in practically every case met with in the arts and industries the particles are practically never uniform in size, shape or structure.

Consequently the filtering medium must be such that either the smallest particles are retained or the meshes must be partially throttled by the particles of the deposit. When the former is attempted with sugar syrups or juices, it is found that the cloth very soon becomes covered with a slimy impenetrable layer which retards further filtration. In other words, this means that the meshes are throttled. To overcome this difficulty it is advisable to use a coarser cloth and to add to the liquid an *aid* to filtration, whose function it is to prevent this throttling and thereby allow a very much larger quantity to be filtered through the cloth without the excessive pressure necessary to overcome the friction of the filtrate through very fine pores. This result is obtained by depositing a substance of a granular or crystalline nature on the surface of the cloth, which forms a network and thus prevents the meshes being closed up. Each succeeding layer of the deposit will also be an open network, so that the whole thickness of the layer will be permeable. To assist this, it is advisable to work with a reduced pressure at the beginning and gradually to increase it as the thickness of the deposit increases, and make the final pressure the highest. By this means the first layers of the deposit are of a spongy, porous nature, which allow the liquids to pass through with ease; the final high pressure tends to dry the deposit. It is a mistake, however, to think that a great pressure at any time makes very much difference in the drying of the cake, as most of the particles being rigid they are not acted upon, and the non-rigid may be forced through the cake.

All filtering mediums and cakes must be porous bodies. Crystalline or granular substances occupy definite spaces which do not completely cover the surface of the filter but pack adjacent to each other's edges and surfaces and leave small or large channels, according to their shape and size, which are not affected by pressure and which offer free passage to the filtrate; when the filtering medium is of this nature the filtration will be rapid.

If the grains used are irregular, the small ones will pack in the interspaces left by the larger grains and reduce the size of the free passages, thus causing the filtration to be retarded.

Gelatinous substances will spread over the whole surface and will block the pores of the filter; with these precipitates filtration will soon be stopped.

In the two last instances, if the pressure is increased cloudy liquor will come through the filter.

With gelatinous precipitates, even when using aids to filtration such as needle-shaped kieselguhr or long crystals of sulphate of lime, it is important that the speed at first should be slow, for if this is overlooked some cloudy liquor will come through at the beginning. On the other hand, the speed should be sufficient to keep the filtering chambers filled to the top, so that the whole surface of the filtering medium is uniformly covered.

When forming crystals it is generally important to obtain them as large as possible, so that only a low pressure is necessary. Assuming that the same form of crystal, or other aid to filtration is used, but in one case the particles are three or four times as large as in the other, then the successive layers of precipitate will pack very differently; in the large crystals the openings or spaces will be few but large, in the smaller crystals the interstices will be smaller but more numerous, and as the friction through small openings is greater than that through large openings the pressure must be greater, and all the extra pressure required costs money in fuel, also in wear and tear of cloth due to strain. It is found that needle-shaped aids to filtration are the most suitable, as they build up a felt-like layer, which ensures perfect filtration, at the same time leaving numerous small passages for the liquid to pass through without much friction.

Sulphate of lime if formed under the proper conditions is a very good aid to filtration, but if formed under adverse conditions is a great hindrance. If the microscope reveals a precipitate of well shaped needles the filtration will be aided.

A good press cake of sulphate of lime will become wet when handled; this is because in filtering, the particles do not arrange themselves in the manner they would do when shaken, but contain more free passages, therefore the cake will contain more water. For this reason washing should follow immediately, otherwise the cake may sag and an empty space of several inches may be left at the top, through which washing water will pass without doing effective work, also it is the reason why, if pressure is not uniform, the particles are shaken so as to reduce the free filtering passages and thus retard filtration in the later stages.

In the separation of solids from liquids by means of filter presses the rate of flow of the filtrate per unit area of filtering surface will depend upon several factors, such as pressure, viscosity, temperature, character of precipitate and filtering medium; assuming that all the other factors are negligible, then the rate of flow will be directly proportional to the square of the pressure, and on the same assumption inversely proportional to the thickness of cake.

The other factors vary with different solutions, and the constants for each solution will require special tests, as every factor has a determining influence on the rate of filtration.

According to Messrs. C. Almy, Jr., and W. K. Lewis (*Journal of Industrial and Engineering Chemistry*, 1908, page 528), the law governing the rate of flow may be solved by the following equation:—

$$\text{Rate of Flow} = K \frac{Pm}{Vn}$$

where K is a constant varying with the nature of the liquid and its viscosity, P equals the pressure and V the volume of flow of filtrate, while m and n are constants which vary with the nature of the precipitate, etc. As the flow of the filtrate is analogous to the flow through a capillary tube, the rate of flow will be influenced by the areas of the openings between the particles of the filtering medium and the cake, and, consequently, a crystalline precipitate will have many more larger passages for the liquor to pass through than a less rigid precipitate, as the particles of the latter are pressed together to form a slime. Therefore, as non-crystalline particles are so easily compressed, any increased pressure will only tend to increase the impermeability of the cake and to force the particles through the filtering medium (crystalline precipitates act in the same way but to a far less degree).

The rate of filtration is also influenced by the viscosity, and this latter depends upon the various factors, such as the degree of dilution of the liquid, temperature, etc.

With sugar solutions an increase in the dilution, in the pressure or in the temperature increases the rate of filtration, but these factors are controlled either by the cost of fuel or the question of colour.

The mechanism of filtration by means of a filter press and the factors connected therewith have not received the attention which they deserve; this is probably due to the fact that the variations of each successive charge of a filter press, the filter, the filtering medium, temperature, pressure, the viscosity of the liquor, etc., are so great that the possibility of obtaining accurate results, which would have a general application, does not at present appear feasible.

In choosing a filtering medium the nature and condition of the solution to be filtered must be taken into account. A solution of sulphuric acid may be filtered through a silicious material such as sand or kieselguhr, but if an alkaline solution is filtered through this medium the probabilities are that some of the filtering medium would be dissolved and the purity of the solution greatly impaired.

Consequently, insoluble media must be used, and in the case of caustic soda a medium of crushed limestone is utilized.

To enumerate all the filtering mediums used in practice would take up too much space ; they usually consist of one of the following classes of materials —bibulous paper, gravel or sand, vegetable fibre, precipitates, fabrics of cotton, wool, hemp, hair, metal, asbestos, etc., porous bricks or stone, charcoal (animal or vegetable), bagasse, sawdust, vegetable horse hair, kieselguhr, cork, wood and shavings.

Bibulous paper is sometimes used as a filtering medium in filter presses for solutions that contain very fine suspended precipitates such as in the brewing industries. The paper is made into a pulp with water and put into a "form" press and there moulded into a cake having the shape of the filter press frame.

These cakes are dried and placed in the filter press frames and serve to retain the very finely divided precipitate. When the paper pulp has become clogged with dirt, it is taken out of the press, pulped, washed, and used again. The liquor is filtered through about two inches of closely packed filtering medium which requires less to drive the filtrate through than that required when using a sufficiently fine woven filter-cloth ; further, the precipitates are usually of a gelatinous nature and, as in sugar juices, will soon clog a medium such as filter-cloth.

Fabrics for filtering purposes are made of many different materials. and these are supplied of various thicknesses, textures and tensile strengths, to suit the various demands for industrial purposes. Fabrics have the advantage that they are easy of manipulation, washing and renewing, and can be used in any position. They are now chiefly used to suspend or retain the sediment, for which purpose they have an open texture, the slime being collected on and in the "aids to filtration."

Vegetable matters as lignite and sawdust are frequently used as aids to filtration.

When lignite was first used in sugar solutions, it was considered not only a good aid but also a good decolourizer; prolonged tests, however, indicated that the colour removed was only that particular part of the colour more easily removable by animal char.

In 1883 and again in 1888 Paul Casamajor took out patents for the use of sawdust as an aid to filtration. This sawdust first of all had to be treated with caustic soda and washed so as to remove all compounds that would give a taste to the sugar. Two to 5 per cent. of this prepared sawdust was added to the sugar solutions and kept thoroughly agitated and passed through filters in the usual way. The action of the sawdust was similar to that as described under kieselguhr.

On account of the cost of the preparation of the sawdust, an apparatus was designed to treat the spent sawdust by agitating it with water and allowing the slime to pass through very fine wire mesh sieves revolving partly in water. By this means the sawdust was freed from its impurities and was then suitable for using over again.

Porous bricks are largely used for separating precipitated sulphide of arsenic from sulphuric acid. The bricks are usually made about 9 × 6 × 24 inches, and are built up on draining tiles at the bottom of a tank. A square yard of these bricks will filter about 2½ cwts. of sulphuric acid at a specific gravity of 1.550. These bricks are commonly used for gravitation filters, but may be used for pressure filters.

Lately, similar porous slabs have been patented for use in the sugar industry, but they provide only a limited filtering area, chiefly to remove colour, taste, odour and only incidentally to remove suspended particles.

There is a great variety of methods for filtration according to the object sought; sometimes it is the soluble portion or liquid that is required, at other times it is the precipitate that is valuable and occasionally both are required. Where the bulk of material to be operated on is small and cold, it is very convenient to use vacuum filters, but it is not convenient to work with a vacuum higher than 25 inches of mercury in pressure; but if the precipitate is crystalline and granular it is easy to filter and obtain a material containing only about half its weight of water. Where larger quantities have to be operated upon, it is far better to use one of the well known filter presses, especially as very much higher pressures can be utilized.

The separation of crystalline substances can be readily done in hydro-extractors or centrifugal machines, as in the ammonia soda industry, where the bicarbonate of soda is separated from the mother liquor, also in the preparation of extracts from dye woods, etc. Where very high pressures are required, and where the filtration is a slow one, hydraulic presses are more suitable, i.e., in the separation of oils from fats.

In filtering gelatinous or albuminous substances, as we have in sugar juices and syrups, which would slime up the filtering cloth before much of the filtrate had passed through, it is necessary to have an "aid to filtration."

Sometimes these aids are made to serve a double purpose, as in the neutralization of acids by lime with the formation of insoluble compounds with some of the impurities, also of chalk when excess of lime is used with carbonic acid gas, also when sulphurous acid is added to bleach the colouring matter and when sulphuric acid is added to invert the sugar, and the acid neutralized with lime with the precipitation of crystalline calcium sulphate.

All these form crystalline substances, on which the slimy matters are entangled and collected in filter presses. In all cases, where possible, care should be taken to make these crystals grow as large as is necessary in order to ensure quick filtration.

It is important to note that the shape of crystals varies under different conditions of formation, especially temperature.

SUGAR FILTRATION

When filtering sugar solutions we have several conditions to deal with.

The filtering of carbonatated beet sugar juices is the easiest and most satisfactory as the temperature can be high. The filtering of cane sugar carbonatated juices presents more difficulty owing to the presence of glucose. Here the temperature of the alkaline solution should be kept between 55° and 60° C.

In carrying out these operations, the chemist and engineer must co-operate, as the problem is both a physical and chemical one. The engineer knows that by increasing the temperature the filtration is much quicker, but the chemist must watch to see that the albumen is thoroughly coagulated, also that glucose is not converted into dark-coloured products by excessive heat.*

Owing to want of co-operation the filtration of cane sugar liquors has not hitherto received the attention it deserves. It is not enough for the chemist to test when the right amount of alkalinity or acidity has been reached, the character of the precipitated matter must also be examined under the microscope to see if it is amorphous or crystalline, or if the crystals are small or large, and their shape should also be noted, as all these have a very important bearing on the rapidity of filtration, and the brightness of the filtrate also in increasing or decreasing the loss of weight of the sugar, and the quantity of washing water required.

Space will not permit of a detailed examination of all the various operations, but the following general observations will assist in elucidating the best conditions.

Filtration is retarded by decreasing the temperature, increasing the density, and by very minute particles. The particles of matter can often be increased in size or altered by coagulation in the albumen naturally present or by adding albumen when the solution is below the coagulating point. The latter is far more effective when the solution is not alkaline.

Clay, when present from the soil, flocculates best when the solution is not acid.

Silicates in a soluble form are frequently present ; these give gelatinous silica in an acid solution, and thus retard filtration. The pores of the filter-cloths soon become closed on account of the accumulation of the silica. Washing with hydrochloric acid will not remove it ; the most convenient method of cleaning the cloths is to wash them in a dilute solution of washing soda.

Magnesia, from bad limestone, when present, is converted into a gelatinous precipitate by gassing, forming a combination of the hydrate and carbonate of magnesia, and is very difficult to filter.

* See page 5 "Plantation White Sugar Manufacture," Harloff & Schmidt. (Norman Rodger, London.)

Carbonate of lime formed in the carbonatation process should be so produced that the precipitate is of a granular crystalline form.

The form in which a precipitate occurs depends upon the condition prevalent at its birth and growth. When formed rapidly, it is generally amorphous, and too fine for good filtration. To increase the size, the following points should be noted. The slower the growth the larger the crystal. The addition of powdered crystals of the material required to be formed acts as seed, and these grow larger and larger as in seeding the vacuum pan. High temperature at the birth of a precipitate induces a good crystalline structure.

Usually in carbonatation the quantity of lime added is found by trial, on each quality of juice. The rapid settling of the suspended matter leaving a clear supernatant liquor is a good indication that the filtration of the muddy liquor will yield a bright liquid. The writer has invariably found that he could get good filtration from the use of less lime than usually prescribed by paying strict attention to the method of carbonatating. It is not advisable to gas too rapidly, neither is it advisable to add all the lime at one time ; intermittent application of both lime and gas result in a great saving of lime with the corresponding benefits in other directions, but care must be taken to prevent over-gassing at any stage of the process.

In the ordinary clarification of cane sugar juices, the juice after defecation is either allowed to subside and the moderately clear juice decanted, or the juice is filtered. In both cases the settlings, scum or mud, are filtered through presses, but when aids to filtration are used the whole is filtered in one operation.

The liming, carbonatating and filtering of cane sugar juices is very similar to that of beet sugar juices, but in the former greater precautions are necessary owing to the presence of glucose, which is destroyed in alkaline solutions if the temperature is raised much above 50° C.

In the carbonatation of sugar for the manufacture of cubes and loaf sugar, the object is to destroy the glucose, but in ordinary carbonatation in the cane sugar factory this destruction is avoided by keeping the temperature as low as possible and reducing as much as possible the time of contact of the juice with the lime or lime salts.

Beet and cane juices vary considerably in purity and facility of filtering ; lime should be added so that in all cases a good firm cake can be obtained, any excess of lime over this being waste of time and material.

Over-carbonatating will result in the precipitated chalk being re-dissolved and again precipitated after filtering.

Under-carbonatation will result in a gelatinous precipitate, hydrosucro-carbonate of lime, and probably trouble in washing out sugar from the cake, owing to the presence of tribasic sucrate of lime, will be encountered.

The lime used should contain as little magnesia as possible, because in single carbonatation the magnesia remains in solution and produces difficulties in colour and viscid syrups, and incrustation in the evaporators. In double carbonatation the quantity of magnesia remaining in solution is very much reduced; the bulk of it is filtered off in the first stage, but as in this stage the magnesia had been precipitated as a gelatinous hydrate, it gives great trouble in filtering, and higher temperatures and pressure must be used. The cloths will frequently require washing with hydrochloric acid.

The value of filtering by mechanical means has long been appreciated in beet sugar factories and sugar refineries, but it has not been so adequately appreciated in cane factories, this being probably due to the difficulty of proper supervision in tropical countries.

The results have been that sugar refiners are continually complaining that cane sugars do not filter well, and thus check their refining output; they therefore buy beet sugars whenever convenient. Also, such users of cane sugar as brewers, jam manufacturers, confectioners, etc., complain that these cane sugars contain dirt, which forms a scum in their operations, and they are compelled, very often against their wishes, to purchase "First Marks Granulated" beet, because it is much cleaner.

The cane sugar factories naturally feel this competition keenly, and complain that sugar refiners seem to prefer to purchase beet, but no manufacturer of raw cane sugar seems to realize the reason why beet is preferred. It is largely due to the difficulty of filtering cane sugar solutions unless unduly diluted.

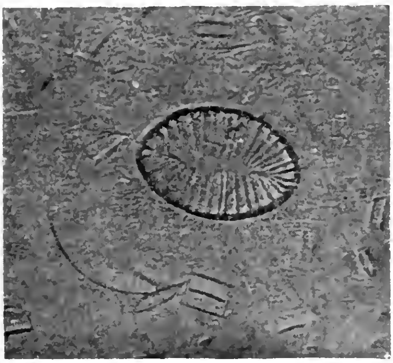
This difficulty in filtering applies, more or less, to all raw cane sugars, and is one of the reasons why refiners prefer to work beet sugars, and it behoves the cane industry to put its house in order instead of complaining that the beet has the preference; they must realize that raw beet has been thoroughly filtered, during the course of its manufacture, and therefore concentrated solutions of it give little trouble in this respect during refining operations.

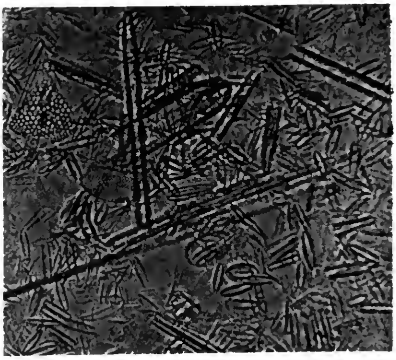
It is common knowledge that the first test of genuine Demerara yellow crystals (by public analysts) is to see if it gives a cloudy solution as compared with its substitutes, which do not.; yet these genuine Demerara crystals are made from supposed specially cleared juices.

Cane factories can do the filtering at a small part of what it will cost the refiner, because all solutions filter better when in the diluted form, therefore cane sugar manufacturers should make sure that the cane juice is perfectly bright before concentrating. They should keep in mind that a refiner cannot afford to dilute the sugar down to the juice stage for filtering, as this would require a greater amount of fuel to re-concentrate. Beet sugar can be filtered at the higher densities, because practically all the slime has been removed before the juice was concentrated. At present in raw cane sugar factories the juice is separated into two portions, after defecation and clarification, one of which will consist of 90 per cent. of a moderately clarified juice, and the other portion will be the scum and residue mixed with the other 10 per cent. of juice. These scums are further limed and allowed to settle, and the clear liquor run off, and the scum is pressed or the whole is passed on to the filters.

Generally no perfect filtration is attempted, but the use of kieselguhr as an aid to filtration is now spreading to the cane factories (it is not required where the lime carbonatation process is used), and probably we shall soon have cane sugars filtered as clean as beet.

KIESELGUHR. Kieselguhr is known under several other names : Bergmehl ; Infusorial Earth ; Fossil Meal ; Diatomite, etc. ; and it is found in most





(a) Algerian Fig. 233 (b) Australian

Natural state, × 390

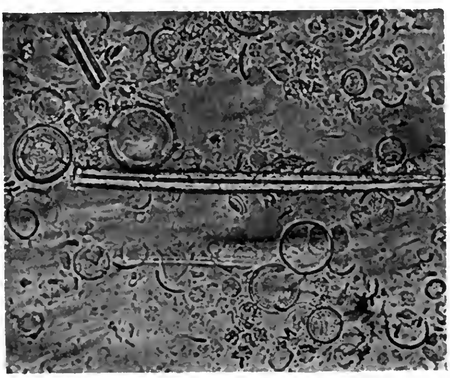


Fig. 234
Spanish, treated with HCl, × 390

parts of the world, the chief sources of supply for Europe being Germany, Ireland, Norway and Sweden, Algeria and Spain, while Northern Australia, Chile and other parts of America have large deposits from which supplies are drawn.

Fig. 233 indicates Algerian and Australian kieselguhr in the natural state ; while *Fig.* 234 indicates Spanish kieselguhr after washing with hydrochloric acid. The minute particles, chiefly chalk, in the Algerian variety prevent it being a good aid to filtration ; the preponderance of needles in the Australian type makes it a very good aid ; while the Spanish variety when its impurities have been washed out forms a medium aid to filtration.

Kieselguhr consists of the skeletons of minute water plants called Diatomaceae ; these plants are of various shapes and sizes, according to the species to which they belong, and samples of kieselguhr from different parts of the world exhibit characteristic differences when seen under the microscope.

These small organisms are to be found in any pond ; and where the conditions are favourable to their growth, they multiply rapidly, and on decaying fall to the bottom, forming layers of varying thickness. These deposits are then, through some geological disturbance, drained, and in the course of time the organic matter decomposes, and only the pure silicious skeletons are left.

More recent deposits of kieselguhr are usually covered with peat or sphagnum moss, and vary in depth to as much as 35 feet. These deposits consist of practically pure silica, with a few pieces of decaying trees, roots, etc., and varying quantities of moisture and impurities such as chalk, clay, iron oxide, etc.

The following are analyses of samples of kieselguhr from different parts of the world .

	SPANISH.	IRISH.	GERMAN.
Silica	82.46	82.96	80.90
Calcium carbonate ...	2.53	0.30	0.60
Alumina and iron oxide ...	1.10	6.15	4.50
Alkalis	3.10	1.10	0.40
Water	7.81	5.10	8.30
Organic matter	3.00	4.39	5.30

These deposits of kieselguhr are, as a rule, easily worked, being usually soft, and as they are found near the surface may, consequently, be easily quarried.

The chief property of kieselguhr is its porosity, consisting, as it does, of millions of minute skeletons of silica, the interspaces of which are full of air, and it is to this condition that kieselguhr owes its great lightness, a cubic foot of kieselguhr weighing in some cases as low as 12lbs. (sand=100lbs.). The silicious nature of kieselguhr renders it absolutely inert to chemicals, with the exception of strong alkalis and hydrofluoric acid, and it may be used with the utmost safety in the filtration and purification of foods. This pure silicious material contains no food for ferments or putrefactive germs.

It is impossible to obtain a good hard cake from the scum presses unless a quantity of kieselguhr or of some other aid has been added to the scum which comes from the clarifiers. When a good hard cake is obtained, the washing is more complete, and the saving in sugar pays for the use of kieselguhr. There is also a great saving in labour and time, and the triple effect pipes are kept cleaner.

The above remarks also apply if Taylor or other filters are used, but the use of filter presses is recommended. The quantity of kieselguhr to use depends upon the quantity of gums or pectinous bodies present in the juice, but should be sufficient to give a hard cake, which readily falls away from the cloth.

At first refiners used kieselguhr to break up the slime in the old Taylor filters by adding 1 cwt. of kieselguhr per 10 tons of sugar; now, however, refiners are discarding the Taylor filters in favour of filter presses, and it is in this connection that the use of kieselguhr is more advantageous.

To properly work filter presses it is essential that a full cake should be obtained, otherwise the bulk of the washing water will pass through where there is least resistance and excessive loss of sugar will occur. If the cake is sloppy, it is an indication that sufficient kieselguhr has not been used.

In filtering sugar solutions which are of a gummy or slimy nature without kieselguhr, it will be found that the meshes of the filter-cloth quickly become clogged up, and even under pressure filtration is slow, and if the pressure is increased the sludge often comes through with the solution. In the beet sugar industry, and in some cane factories, this difficulty is overcome by using the carbonatation process, and the majority of the substances present in the solution are entangled in the precipitated chalk, and thus the precipitate aids the filtration, as the slime is spread over the large surfaces of the small particles instead of being forced in a layer on the cloth, and a dry solid cake results.

Where kieselguhr or the carbonatation process is not used, it will be found almost impossible to use filter presses on account of the rapid sliming up of the cloth, and at the best only cakes of about ¼-inch thickness are obtained, and the resultant sloppy mass is difficult to wash and handle, and the cloth requires a great deal of labour to clean.

The use of kieselguhr overcomes all these difficulties to a very large extent, and when it is used in filter presses as an aid to the filtration, the deposit which collects on the cloth is a mixture of slime and kieselguhr, through which the sugar solution can easily pass, and with the deposition of more slime and kieselguhr a solid but porous cake 1½ inches or more is formed in the press instead of the slimy impermeable cake of ¼-inch thickness. The slime is deposited all through the cake, which can easily be removed from the cloth, leaving the latter almost clean.

The very best filter-cloth is not required, as it is a mistake to regard the cloth as the filtering medium; it is really the supporting fabric for the kieselguhr which should filter off the slime before it reaches the cloth. To save expense in washing cloths it will be found convenient to supplement them with common calico sheets; these are light and easily handled, and when a press is opened the slightest shake should remove the cake, and the calico sheets can be replaced in a very short time and the presses re-started. The calico is easily washed for the next press, and the true filter-cloths need not be washed until after several operations.

The kieselguhr should be first mixed into a cream in a pail with some of the solution or water, all the lumps being broken up by hand, and the resultant mixture passed through a 30-mesh sieve, and then added to the solution in the blow-ups, etc., as required, or a Lilleshall Mixer may be used (*Fig.* 235). The required quantity of kieselguhr will be found by experiment, and is that which will just form a dry solid cake.

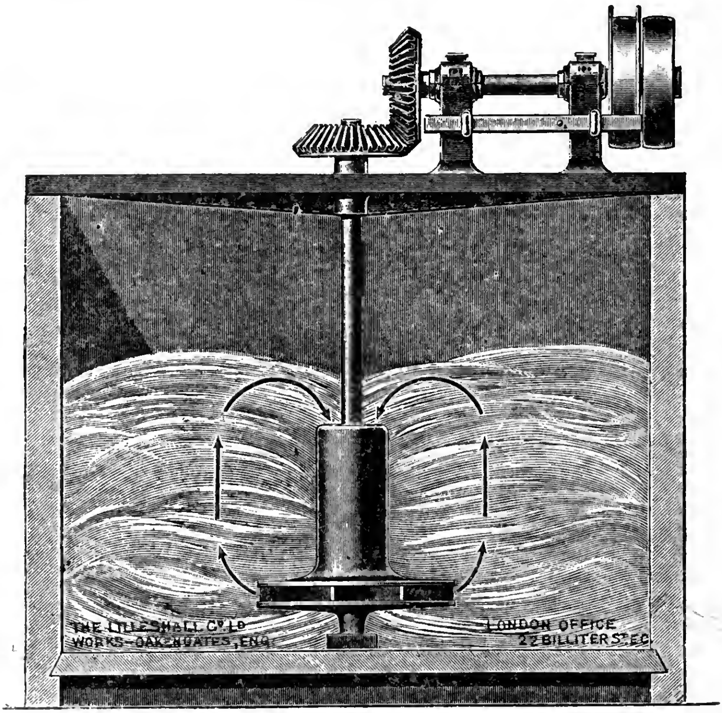


Fig. 235

LILLESHALL MIXER

In filtering solutions by which the small holes of the supporting fabric or cloth are quickly throttled by the deposition of the precipitate, so that the free passage of the liquid is retarded, this throttling occurs on the face of a fine cloth more rapidly than the throttling of the successive layers of the precipitate; it is therefore advisable to pump a small quantity of kieselguhr and water through first, without the solution containing the smaller particles or slime, which are the chief cause of the difficulty, and then proceed as usual. Some sugar experts of high standing have stated that cane juices, even after the addition of infusorial earth, have filtered well for a few minutes and then the cloth has been soon covered with a slimy layer. The author's experience is that this result is due either first, to an insufficiency of kieselguhr; second, to not having proper or efficient mixing or agitating apparatus; or third, to clay being present in an acid solution.

When processes for the recovery of the spent kieselguhr are adopted, there will be no excuse for the first. The mixer of Lilleshall and others should remove all excuse for the second, and care will eliminate the third.

The quantities of kieselguhr to be used vary with the grade of sugar to be filtered, and from refinery experience the following are recommended :—

Washed Java sugar ...	12 cwt.	kieselguhr per	100 tons.
Ordinary Java, 14 D.S. ...	24 cwt.	,,	,,
Low cane sugars	30 cwt.	,,	,,

The kieselguhr should not be added to the sugar solution all at once, and it is important that it should be added so that the slime is not forced into the cloth, but is as evenly distributed throughout the cake as possible.

The best method to follow is to add a larger amount of kieselguhr to the first blow-up than to the following ones ; for instance, if a filter press will cope with 5 blow-ups of 10 tons of sugar each (washed Java) it will require about 12 cwt., and the kieselguhr should be added as follows :—

To the first blow-up add 4½ cwt., to the second blow-up add 3 cwt., and to the third, fourth and fifth add 1½ cwt. each ; frequently the last will not require any at all.

If this method is used, the first layers of the cake consist of a large quantity of kieselguhr, through which the solution can easily pass, and as the cakes increase the ratio of kieselguhr to slime becomes smaller. At the surface of the cloth, where usually the sliming takes place, there is now a fairly clean medium through which the solution can easily pass, and towards the end of the filtration, when the pressure is increased, the slime will have to pass through a thick layer of semi-porous material before it can be forced on to or through the cloth.

The pressure at first should not exceed 25 lbs. per square inch, and 50 lbs. at the last two blow-ups.

The cost of using kieselguhr should work out at about 1s. 6d. per ton of sugar for very low sugars, and sixpence per ton for good washed cane sugar.

When required for filtering purposes, a good kieselguhr should contain a large number of the long ladder or needle-shaped diatoms, as these, when used, interlace over each other and form a " felt-like " filtering surface, while on the other hand a sample of kieselguhr containing many broken pieces and small round diatoms will not offer such a good filtering surface, as the small pieces tend to block up the interspaces between the large diatoms.

A good kieselguhr for filtering purposes should not contain clay, and this is of special importance when using kieselguhr for filtering cane sugar solutions, which are of an acid nature, as this clay will clog the filter; with alkaline solutions, as in the beet sugar industry, it is not of so much importance, as the clay coagulates and does not slime.

By the above processes, clear, bright and sparkling liquors are obtained all through the various departments of the factory and refinery, the boilings of sugar are free from greyness due to improper filtration, and a superior and bright syrup, especially suitable for the manufacture of table syrup, is obtained.

The washings from the Taylor filters, filter presses, and from the charcoal filters remain clear and bright to the end; less washing waters are required, and less impurities are re-introduced into the syrups, the sulphate of lime trouble is to a large extent eliminated, and the slight dimness or fluorescence due to iron and albumen is much decreased.

When table syrup is made direct from frosted canes or diseased canes (which yield juices of a very gummy and slimy nature) by partly inverting with sulphuric acid, the sulphate of lime precipitate is frequently not sufficient to prevent the sliming up of the cloth in the filter, and in these cases the use of kieselguhr is exceedingly advantageous.

When the syrup from the last sugar boiling is used for making table syrup, and a portion of the syrup is fully inverted, the sulphate of lime formed is, as a rule, sufficient to form a hard cake, without the addition of kieselguhr, unless the sulphate of lime has not been crystallized into good needle-shaped crystals.

If the whole of the syrup is used and only partially inverted, then the smaller amount of sulphate of lime precipitated is not sufficient to form a cake without the addition of a small quantity of kieselguhr.

Where tannic acid or tannin materials, or sulphide of soda is used to remove iron, 1 per cent. of kieselguhr is an advantage in assisting the filtration.

Raw sugar made at a factory at which extra care is taken in clarification and defecation, and where the solutions are filtered perfectly bright, will require far less kieselguhr at the refinery than an ordinary raw cane sugar.

At first sight a refiner will hardly realize the benefits of kieselguhr, and is apt to consider the cost of its use greater than the advantages, but in a few weeks he will begin to realize that the sugars are improving in appearance, the filters are sweetening off more rapidly, the loss of sugar due to inversion is much smaller, and less sugar is being thrown away in the refuse. The iron is reduced and the animal charcoal gives better results, lasting much longer, as the finely suspended organic matter is no longer present to block up the pores of the charcoal.

The importance of perfect filtration is now receiving greater attention by refiners than formerly. Previously depth of colour rather than brightness was mostly considered; but now it is being generally recognized that dimness means minute particles in suspension and that in the centrifugals many of these particles are filtered off by the sugar and held there, being washed off with difficulty. On the other hand a perfectly clear but darker syrup is easily removed from the sugar.

When dim, cloudy water is obtained from washing char, it is found profitable to dump unwashed kieselguhr cakes from the presses into an agitating tank with the cloudy char water, and after well agitating the mixture to re-press it, washing the sugar out, thus obtaining clear, bright washings.

A machine that is well suited for grading and washing kieselguhr, in the raw state, or for recovering kieselguhr from the refuse press cake, is Gee's Centrifugal Separating, Grading and Filtering Machine. This apparatus is distinguished from the usual perforated hydro-extractor, in that the walls of the rotating drum are impervious. The centrifugal force is utilized to effect the sedimentation of the suspended solids on the inner surface of the drum, and, by reason of the flow of the liquid through the drum, a grading or sorting of the solids takes place, so that the apparatus not only recovers the suspended solids, but also grades or classifies them in the one operation.

The apparatus is seen in sectional elevation in *Fig.* 236, and in cross-section in *Fig.* 237. The drum *A*, fitted with a base *B*, is mounted on a shaft or spindle *C*, the whole being

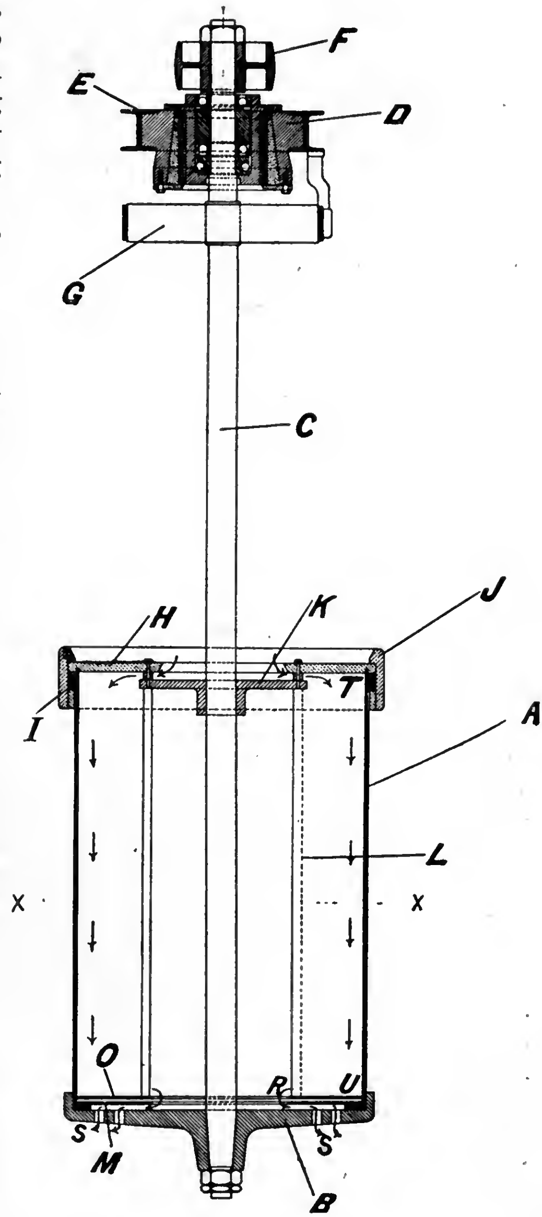


Fig. 236

suspended from a ball-bearing of special design at *D*, supported between girders at *E*, rotation is imparted by the pulley *F*, to which a hand brake is fitted at *G*.

The upper end of the drum is closed by a cap *H*, which makes a watertight joint with the drum at *I*, when clamped by the locking ring *J*. This forms a species of bayonet joint.

The cap *H* has a hole in the middle, and is held central on the spindle by means of the casting *K*, which is a sliding fit on the spindle, and is connected with the cap by the upper ends of the six rods *L*. At the bottom of the drum at *M* is fitted a weir-plate or diaphragm.

Depending from the cap into the drum is a kind of cage, seen best in the section, consisting of six vertical square rods *LL*, to which are attached radial vanes or blades *NN*. These blades extend the whole length of the drum,

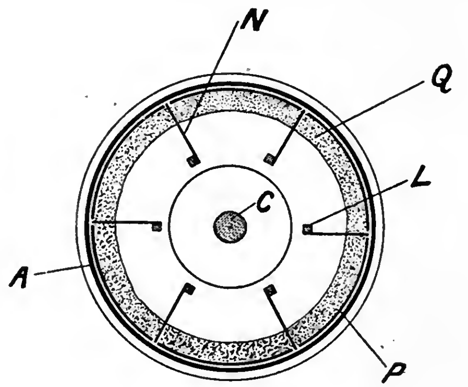


Fig. 237

being connected to the cap at the top end, and to a circular plate *O* at their lower end. The "container," as it is called, slides easily in the drum, which it divides into six longitudinal compartments. Each compartment is provided with a curved plate *P*. It will be understood that the container is, in effect, a removable lining to the drum, on which the recovered solids are received, as shown in the horizontal section at *Q*. The operation of the machine is as follows :—

The requisite speed (usually between 100 and 200 ft. peripheral velocity per second) being attained, the water containing in suspension the solid matter to be separated and graded is fed in a steady stream, through the hole in the middle of the cap on to the casting *K*, which also serves the purpose of a distributing plate. The centrifugal force generated by the rapid rotation causes the water to fly to the wall of the drum and distribute itself thereon, so that an inner wall of water is soon formed, which, when a given thickness is attained, overflows as indicated by the arrow at *R*, and passes out of the drum through the holes in the bottom, under the weir-plate *M* and *S*.

It will be understood that a slow, steady current of water is thus set up in the drum, in the direction of the arrows, and in passing down the drum the solids in suspension are gradually deposited on the plates which line the drum. The coarse or heavy particles are very quickly separated, and these are found near the inlet at *T*. The finer particles are carried further along before they become separated, until the finest are deposited at *U*, near the outlet.

Consequently, the material is recovered in the form of a graded slab, about 18 inches wide by about 54 inches long, ranging from the coarsest at one end to the finest at the other, with every possible degree of quality in between. These slabs are cut into lengths, each length or division representing a given quality. The effluent water is quite clear.

When a sufficient charge of material has been recovered, the machine is stopped, the cap is unlocked, and the container drawn up by lifting gear (not shown) until the bottom plate *O* is within a few inches of the top end of the drum. The curved plates can be readily removed, with the slabs of recovered material adhering to them; and after fresh plates are inserted, the container is lowered into the drum and locked, and the operation repeated.

Four to five "journeys" per hour are made, and each operation in the usual-sized drum (3ft. diameter by 4ft. 6in. long) recovers about a quarter of a ton of graded material. Naturally, so long as the machine is always run at the same speed, and fed at the same rate, and the slabs are cut in the same way, an exact standardization of quality may be maintained. The clay, plus any fine sand or ferric oxide, will be found in the upper portion, the remainder being kieselguhr, eminently suitable as an aid to filtration.

When it is desired to recover spent kieselguhr after use in sugar works, or when preparing kieselguhr containing an extra amount of broken or very minute skeletons which are not suitable for filtering, the operation as described above is slightly modified by increasing the rate of feed so that the slimes and very minute particles have not time to be separated on the curved plates, but are carried away in the effluent water.

FEED PUMPS AND MONTJUS.

Mechanical filters are apparatus by which solids are rapidly separated from the liquids in which they are mixed.

Force is required to assist the process of filtration, and the following are the commonest kinds used: gravity, usually applied in the form of a column of liquid; pressure produced by means of force pump or screw press; steam, air or gas pressure exerted usually by the medium of a montjus (as steam caramelizes the sugar it should not be used in sugar works); centrifugal force as in the Gee and Kopke machines.

Vacuum filters utilizing atmospheric pressure are not often used in sugar-house work because to filter rapidly the liquors must be hot, and when a high vacuum is applied the hot liquids begin to boil and thus destroy the vacuum.

Where floor space is limited, *Fig.* 238 is a very useful pump for filter presses; it will be noticed that there are two air chambers larger than usual; this is a decided advantage, as it tends to give a more uniform pressure in the presses, which is essential to good work.

No filter press gives the best result if there are great pulsations in the feed; for this reason air compressors where available should be used.

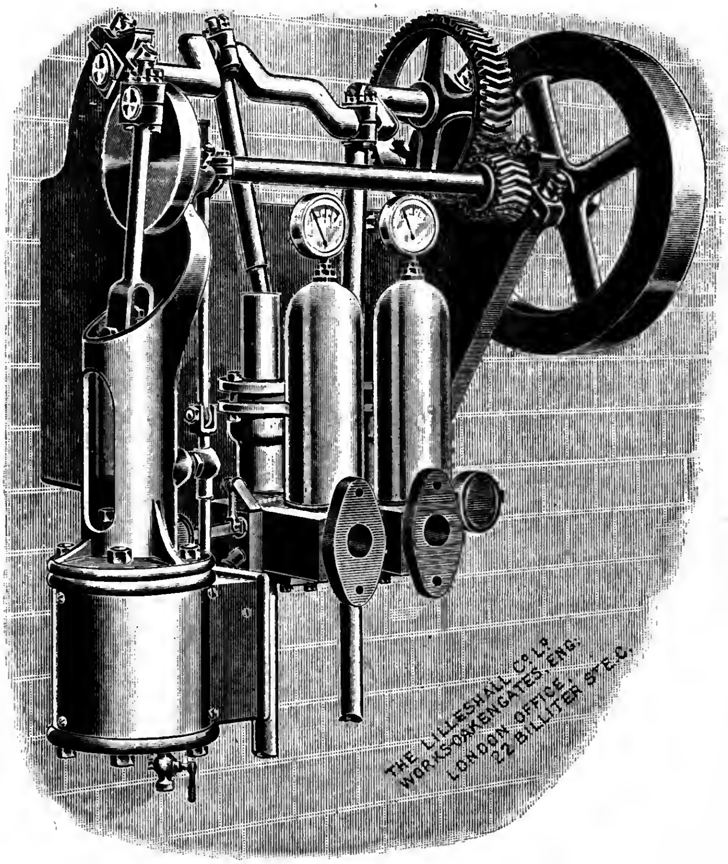


Fig. 238

LILLESHALL PUMP

The use of montjus actuated by steam is not recommended for sugar-house work, firstly, because the sugar juices are discoloured by the excessive heat, the upper portion being caramelized; secondly, there is dilution by the steam condensing; and, thirdly, the sediment collects at the bottom and is difficult to remove.

SUGAR FILTERS.

The usual filters in use in sugar works are Taylor's bag filters, the various forms of filter presses, frame filters, sand filters and centrifugal filters.

The use of filter bags was introduced into the sugar industry in the year 1824, by Cleveland, and the method of arrangement was greatly improved in 1830, by Taylor.

The Taylor filter (*Fig.* 239) consists of a chamber of cast iron open at the top and having a horizontal plate about one foot from the top, the receptacle

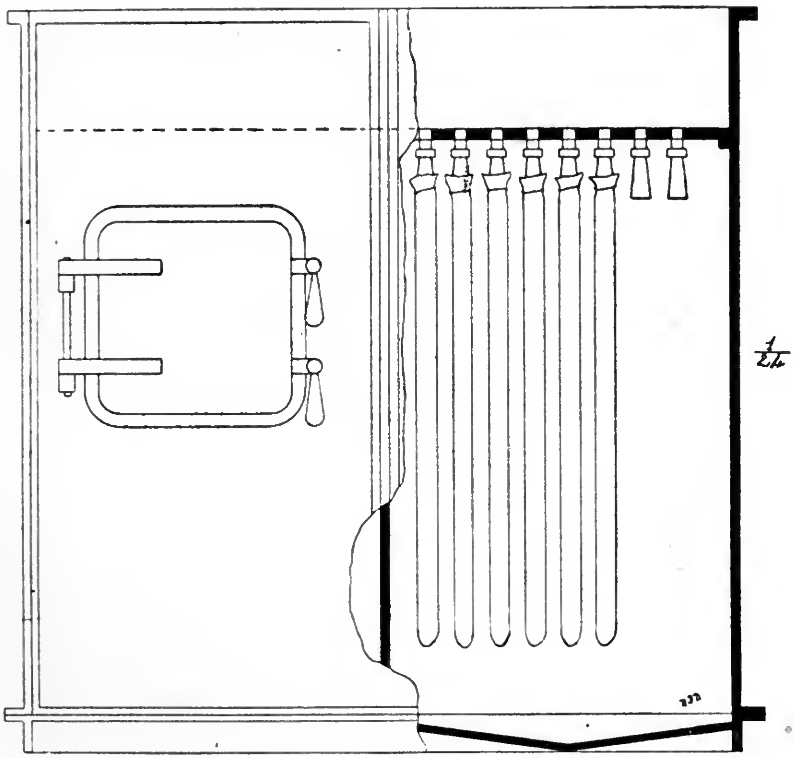


Fig. 239
TAYLOR BAG FILTER

formed by this plate serves as storage and the inlet for the muddy liquor. Rows of holes fitted with sockets are made into this plate at regular intervals, and into these are screwed gunmetal "bottles," or "bells," and it is to these bottles that the filter bags are attached.

The bags are firmly tied to the bottles, and over them are placed coarsely-woven hemp sheaths, about 6 inches longer than the bag and 14 inches in circumference. The bags are usually made of twilled cotton, and are about

6 feet long by 3 feet in circumference. The sheaths prevent the expansion of the bags and thus a relatively large filtering surface is obtained in a small space.

The chamber is provided with suitable doors, so that the bags may easily be fixed in place. There is also a steam cock for heating, and an outlet cock for draining off the filtered liquor. The bottom of the filter chamber is usually inclined to facilitate the draining of the liquid. The number of bags in one chamber may be as many as 500.

After the bags and sheaths have been securely fixed to the bottles, they are then screwed into place. If not properly tied cloudy liquor may result.

The doors are now screwed up and the steam turned on for a few minutes to warm the filter, and water that has condensed is run away. The liquor is then run into the receptacle at the top of the filter chamber, and thence into the bags. A careful watch is kept on the filtered liquor running away, and if it should be cloudy the top of the filter is examined, and any bag that may have broken can usually be detected by the unusually rapid rate of the liquor flowing into it, or air and steam coming out. The hole to which this bag is attached is at once plugged up. When the bags become dirty and slimed up the liquor supply is turned off and the bags allowed to drain. They are then filled with hot water and thoroughly warmed up by steam. After draining for some time they are again washed, and these washings are repeated until most of the sugar has been washed out. The washings from the bags are kept separate from the filtered liquor. The bags are then removed from the bottles and sheaths and bags turned inside out and washed.

In the United States of America the refiners have a special method for washing Taylor filter bags. They use an appliance consisting of an ironpipe $\frac{3}{4}$-in. diameter, and of a sufficient length to nearly reach the bottom of the bags. The lower part of the pipe is perforated for about 6 inches and the bottom end closed. A short cross-bar of iron is fitted to the top to prevent the pipe from going too far into the bag, and it is connected by a tap and rubber hose to a hot water tank at the top of the building.

First Method of Washing.—After the liquor has drained from the bags the pipe is inserted into them one after another, and hot water run in until the bag is full, and begins to run over the nozzle. The effect is to churn up the mud, and by washing twice in this way practically all the sugar is removed.

This method has the advantage of removing the whole of the sweet from the mud, and the washing is systematic, so that every bag gets a proper amount of water.

Second Method of Washing.—When the bags are clogged up and full of liquor and mud, the liquor is removed by a similar pipe, the bottom end of which is open, and without perforation. It is attached to a receiver and vacuum, or to a pump. The liquor is sucked out in this way, and run back to the blow-up, after which the mud is washed as described in Method *No.* 1.

Third Method of Washing.—In one refinery the mud, after being washed in this way, is turned out of the bags and has a small quantity of lime added to it. It is then filter-pressed, the filtrate containing 2 per cent. of sugar. The adoption of either of these methods of working greatly reduces the time necessary for washing the filters, and consequently increases the amount of work that can be done, and reduces the loss by fermentation. In hot climates it is advisable to have the top with the bags *in situ* removable, so that the cleaning can be done outside the casing.

The chief advantage of the Taylor filters is that they provide a large filtering area in a small space. They are, however, very expensive as regards labour, and also make an excessive quantity of sweet-water; and unless great care is taken fermentation takes place.

High class raw sugars are usually filtered at 30 Bé and 180° F., medium sugars at 28 Bé and 180° F., and very low sugars, such as jaggery, at 27 Bé and 190° F.

To filter jaggery in Taylor filters having 150 bags, 2ft. wide and 6ft. long:

= 25 bags per ton or 6 tons per filter.
= 4 hours' filtering.
= 10 to 12 hours' steaming.
= 4 hours' washing, stripping and putting in.

Six men will be required to wash and put in a new set of bags, and this will take them about 3 hours.

Java sugar will need about 12 bags per ton, and beet about 7 bags per ton, the time for filtering and steaming being less in a similar proportion.

When the double carbonatation process is used the liquor after the second carbonatation is usually filtered through filter presses, but sometimes the liquor is filtered through a modification of a bag filter. The chief filter of this latter type is that of the *Société Philippe* (*Fig.* 240). The filter is made in the form of a tank containing a number of frames, over which cotton sheaths are drawn, the juice filtering from the outside to the narrow space within the frames, which keep the cloths apart. These filters are formed of a rectangular wrought iron tank with a sloping bottom. At the upper part is a cast iron rim forming a seat for the counterpoised cover, which makes a tight joint on the tank, with an india-rubber ring and bolts. The filtering frames are suspended in the tank, each being formed of a web or spiral of galvanized steel wire, supported on a pipe perforated on the lower side. The filtering cloths are of thick cotton sewn in the form of a bag, with flaps left at the tops to wrap round the pipe after the frame is inserted into the bag. The whole is made tight by a zinc clip. The use of a metallic web of spiral thread has the advantage of leaving the whole of the filtering surface of the cloth free, since it only bears on the exterior axis of the spirals. The pressure necessary for filtration is regulated by means of the supply cock, which is opened more fully as the impurities accumulate on the cloth. The advantage of these filters is the ease and readiness by which they can be cleaned and set up, the plates being merely suspended in the tank and the pipes forming a tight joint by their own weight.

As a rule each bag has a filtering surface of about 10½ square feet, and each bag can filter about 2,200 gallons of the juice after the second carbonatation in 24 hours; if used for filtering syrup of a density of about 25° Bé, each bag will cope with about 770 gallons per 24 hours. A filter usually contains from 20 to 30 elements.

A simple form of the bag filter is that of *Purvez*, which consists of a tank about 6 feet long and 16 inches deep, divided into narrow horizontal compartments, in each of which is fixed horizontally a stocking or bag, the mouth

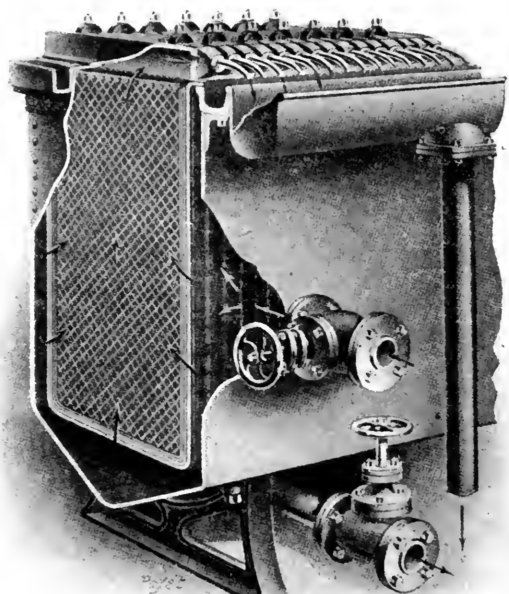


Fig. 240

being tied round the inlet and the other end tied to a wooden plug. The boiling hot juice enters the bag under a pressure of 3 feet of liquor. The filters run for 3 or 4 hours, after which fresh filters previously soaked in warm water are started.

Where the direction of flow is the reverse of that of the Purvez and Taylor filters, as in the *Kasalowsky* and *Société Philippe* filters, the separated matters, instead of adhering to the cloth, are deposited as sediment in the filter chamber, from whence they may be drawn off from time to time.

A near approach to a continuous and automatic filter which will do its work efficiently is in the form of the *Kelly* filter press, which has only been on the market for a few years, and judging from the reports from firms who are using it the claims made by the manufacturers appear to be perfectly justified.

This filter is essentially a leaf filter, to be worked under pressure, and has been constructed so as greatly to facilitate the washing of the cake, removal of the cake, etc.

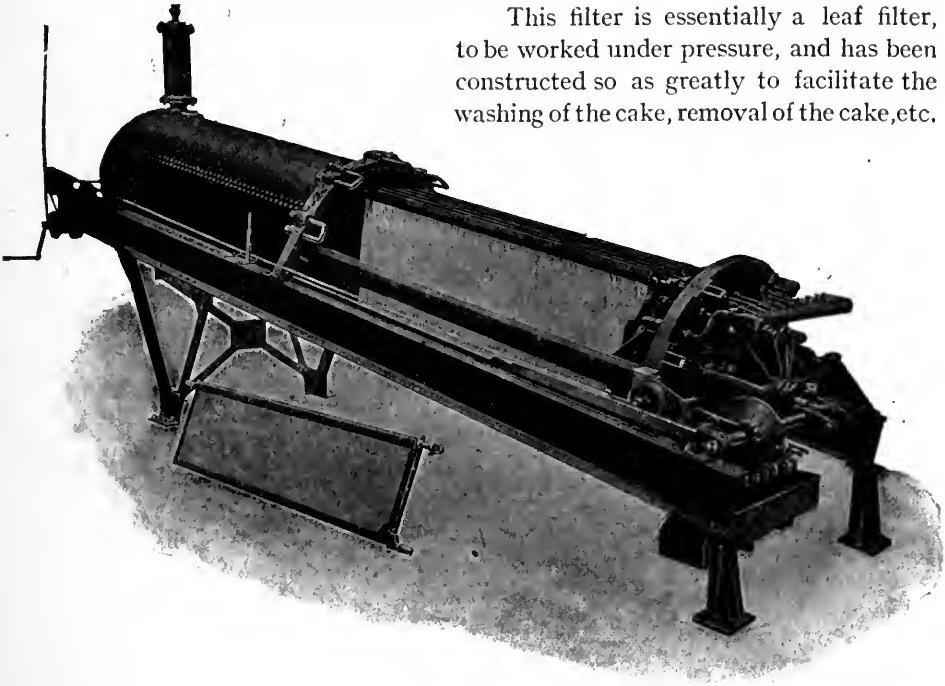


Fig. 241
KELLY FILTER PRESS

This filter is well illustrated in *Figs.* 241 and 242 and consists of :—

A—A cylinder, which serves as a receptacle for the muddy liquid under pressure.

B—A travelling carriage mounted on wheels, which carries

C—The filter frames, which are covered with suitable filter-cloth.

D—A locking device, situated on the head of the filter, by means of which the press is securely fastened.

E—A trussed iron frame, which carries the whole filter press.

And a combination of valves, which insures automatic air regulation.

The cylinder *A* is made of sheet metal, and is permanently closed at one end. The other end is open, so as to allow the telescopic movement of the carriage; when the filter frames are in the press, the filter is entirely closed by the filter head.

The filter carriage itself is mounted on wheels (1) and carries the filter head and the frames; this self-contained moveable carriage can easily be telescoped in or out of the pressure chamber *A*. The frames *C* are so arranged in the cylinder that they give a maximum filter area for ordinary work. They are rectangular in shape, all being of the same length, but differing in width to conform with the circular section of the pressure chamber. They are placed about 4in. apart, but this depends upon the required thickness of cake. Each frame forms a rigid element, being made of wire or other corrugated material, over which the cloth is drawn, and then firmly clamped against one end of the

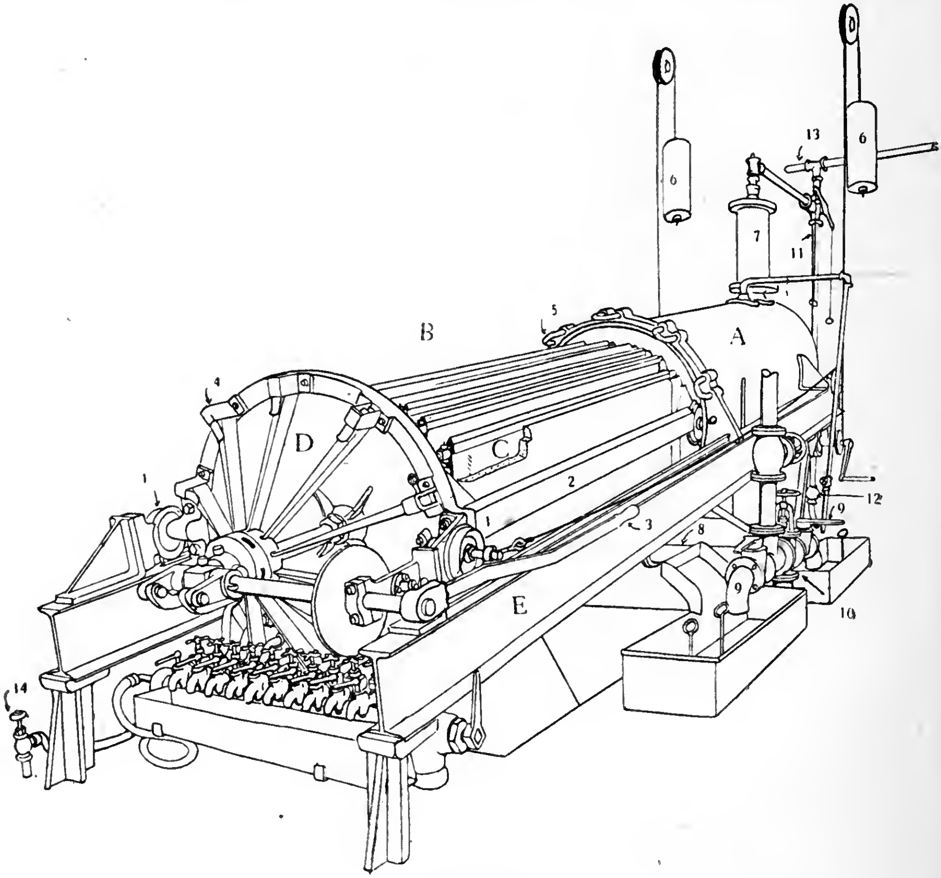


Fig. 242

KELLY FILTER PRESS

frame. The corrugations are sufficient to carry off the filtrate from the under sides of each bag to a channel running along the bottom of the frame, and fastened to both ends of the carriage.

Each channel has its outlet through the head of the filter head, and these cocks are fixed. A gutter is placed to collect the filtrate from these cocks, and to carry the filtrate away.

The whole apparatus slopes from back to front, in order that when the filter press is opened the weight of the cake will cause the carriage to run out of the pressure chamber. After the cakes have been removed the counterpois weights (6) are sufficiently heavy to draw the carriage up the incline into the pressure chamber.

The working of the filter is very simple; the carriage is allowed to run into the pressure chamber and the filter is securely closed by means of the locking device. The inlet valve (10) is opened, and the muddy liquor is allowed to flow into the chamber. As the juice enters and submerges the filter elements, filtration begins, by means of the regulator (7) and the blow-off valve (12), the otherwise imprisoned air escapes, and as soon as the filter is full the blow-off valve is automatically closed; this valve opens and closes with the variation of the level of the liquor in the presses. Faulty filtration is detected by close observation of the outlet cocks, and any faulty frame is thrown out of action by this means.

During filtration a small portion of the muddy liquor may be permitted to flow through the circulating pipe back to the source of supply. This tends to prevent the heavier particles settling out in the lowest portion of the press.

As soon as cakes of sufficient thickness have been formed, the excess liquor in the press is drained out by means of the valve (9). This operation is helped by low pressure air, which is introduced through the blow-off valve (12). As soon as the liquor has been fully drained, wash-water is run into the cylinder and the imprisoned air is forced through the blow-off valve (12) as before.

When the cakes have been washed sufficiently, the excess water is drained off, and the lock on the filter head released. The carriage runs down the incline, a supply (14) of compressed air or steam is attached to the filter elements, and the cakes blown off by this means; as soon as the cakes are removed the counterpoise weights (6) draw the carriage back into the pressure chamber (*A*).

As to the advantages claimed for this filter, one need only refer to the ease by which the cake is removed and the fact that there is only one joint to be made water-tight.

These presses are very efficient where the solution to be filtered contains large quantities of suspended matter, e.g., carbonatated sugar solution.

One of the latest forms of leaf filters is that manufactured by The Sweetland Filter Co. *Fig.* 243 is an illustration of the filter partly open. The filter body consists of two semi-cylindrical steel castings, the upper part being held rigid upon a suitable support, and the lower hinged in such a manner as to permit it to swing open. The filter leaves are constructed to meet various requirements, and usually consist of corrugated wooden slats, or of a wire screen.

These leaves are each provided with a drainage nipple, which serves as an exit for the filtered liquid, and as a means of attaching the leaves to the filter

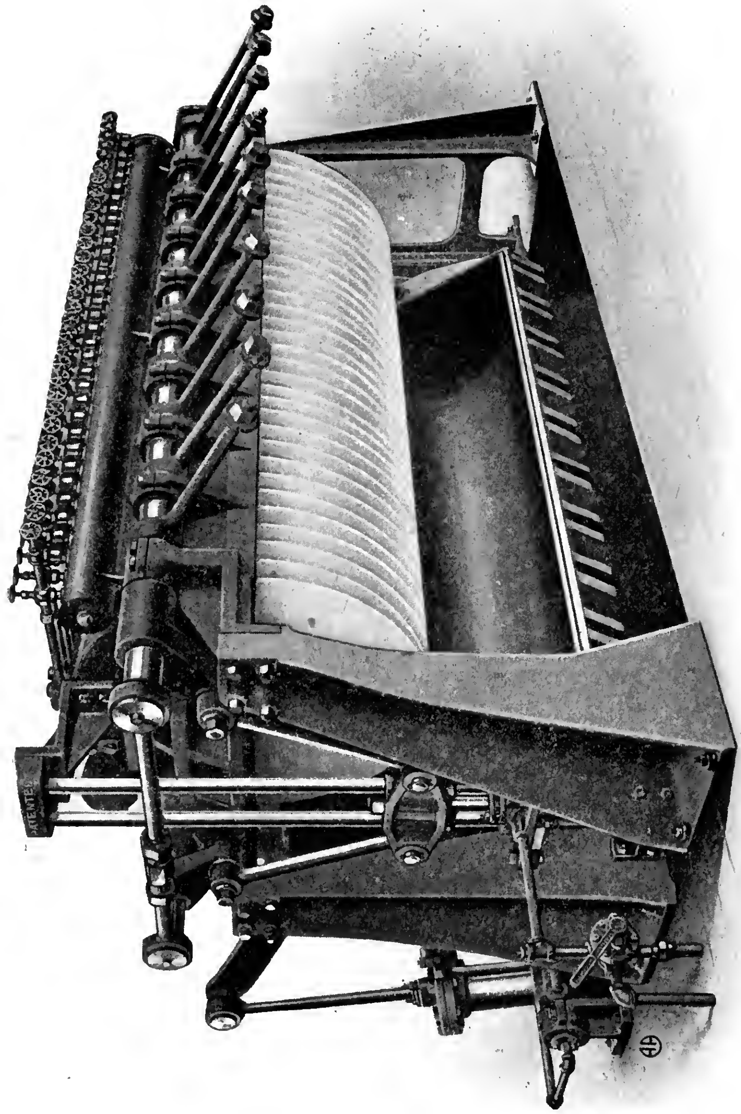


Fig. 243
SWEETLAND LEAF FILTER

body. The leaves are completely enveloped by the filter-cloths, so that both sides of them are available for filtration.

The muddy liquor may enter at the top of the filter by means of a pipe provided with outlets situated centrally between the leaves or by means of a feed pipe situated at the end of the filter. The liquor flows into the filter, passes through the cloth, leaving the mud, and finds its way into the filtrate conduit situated at the top of the filter. When cakes of the required thickness have been obtained the muddy liquor supply is shut off, and water is introduced through the same inlets. The pressure in the filter is not allowed to drop, and the water is passed through until the cakes are washed free from sugar. The filter lends itself to other methods of washing, but the above is the simplest. To discharge the cakes the lower part of the filter is swung open, and the cakes blown off by the introduction of a supply of compressed air into the interior of the leaves. The cloths may then be washed by means of steam or water passed from the interior to the exterior of the leaves. The filter is supplied with suitable and efficient means by which the bottom part is swung open, and the various joints rendered water-tight. The leaves may be spaced according to the required thickness of the cakes, and they may be interchanged in the smallest amount of time. Steam jackets are also provided for the filters if necessary.

Filter presses were probably used in the sugar industry by Howard, in 1834, to replace Taylor's filter bags; Jacquin, at Seelowitz in 1864, conceived the idea of filtering the saturated juice through such presses as were used for filtering pottery clay and beer yeast. Danêk, in Prague, was the first to make these filtering apparatus for the sugar industry. In these early appliances the difficulty was to wash the sugar from the cake until the use of separate channels for the muddy liquor and the water for washing was adopted.

To fully describe all the various modifications of filter presses as used in the sugar industry would require a volume in itself; but a few typical machines may be conveniently referred to here.

Fig. 244 is a representation of a serviceable filter press, as made by the Lilleshall Company at their works at Oakengates, Shropshire.

The plates are made of cast-iron, bronze, lead, wood, etc., to suit special requirements. They are supplied in many forms, such as:—

The recessed type, with filter-plates, having a shallow depression on each side, thus forming a closed chamber in which the sludge collects. Where difficult slimes are to be treated, which will only give thin cakes, this type is suitable, but for the general run of sugar-house works the plate and frame type of press is most suitable, as much thicker cakes can be produced, thus saving labour and time. Owing to the filter-plates being flush, the cloth is not strained, as in the recess type, and there is therefore far less wear and tear.

The distance frames can be made narrow or wide so as to produce any thickness of cake. In this type of press the labour of putting on and taking off the cloth is reduced to a minimum, as they simply hang over the plates, no screw unions or other connections being required.

Both the above types of filter presses are provided with washing arrangements, and thus reduce the loss of sugar to a minimum, but in practice it has been found that less sweet water is produced in the plate and frame type than in the press with only plates.

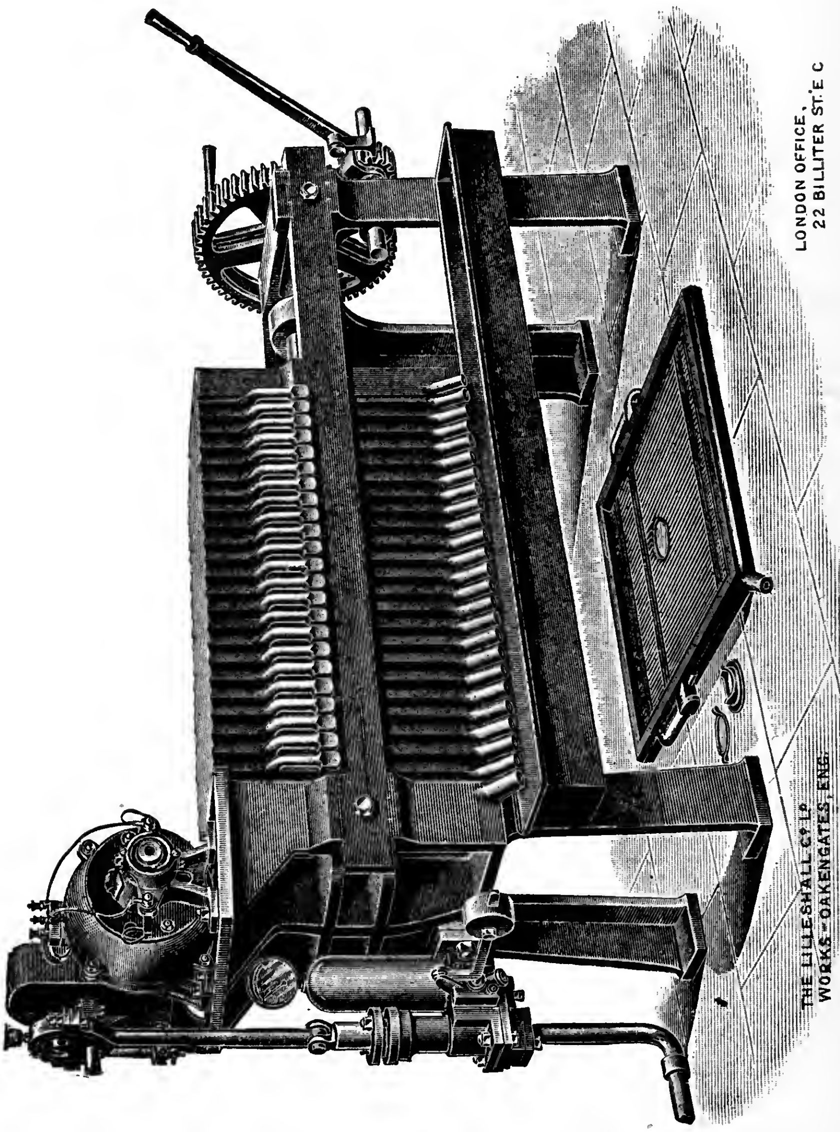


Fig. 244
LILLESHALL FILTER PRESS

The filtering surfaces are either grooved or pyramid plates; with the latter there is less wear of the cloth.

Arrangements are made for the filtered liquor either to leave each plate by an opening with or without a separate cock into an open trough, or the discharge can be by one enclosed efflux channel collecting the filtrate from all the plates. For sugar work this is to be preferred, as there is less cooling, and it is cleaner, and air is not churned into the liquor. The disadvantages are that if one cloth is defective it cannot be shut off, but in practice there is now little trouble of this kind, as all parts of the press-plate on which the cloth is pressed are well rounded off so as to prevent cutting or straining the cloth.

In the sugar industry filter presses are probably the most extensively employed of all the forms of filters. The following are some of the advantages.

The plates relieve the cloths of all strain, and consequently there is less danger of bursting than in bag filters.

The cloths are removed, washed and replaced without much trouble.

The quantity of filter-cloth used is less than in the majority of other forms of filters.

As each pair of filter-cloths has a separate cock, any faulty ones can at once be detected, and shut off without stopping the other filtering elements.

The residue is more easily removed than in the majority of other filters.

The cake can be thoroughly washed, and consequently there is very little sugar lost.

Owing to the facility with which the pressure can be altered, filter presses are more adaptable to varying conditions of liquors, and a much drier cake can be obtained than in other filters except, perhaps, in the case of the scum press.

The floor space required by filter presses is very small; in comparison with other filters it is probable that no other form occupies such a small space for the quantity of liquor that it filters.

Loss of sugar and the formation of coloured products are reduced to a minimum by the rapid filtration obtained when using filter presses.

The plates may be provided with steam channels so that the liquor may be kept at any desired temperature.

Filter presses can be adjusted to treat difficult or easily filterable liquors as, by varying the thickness of frames, cakes of various thicknesses may be obtained.

Any lactic or other ferments may be killed, and the plates, cloths and channels rendered absolutely sterile before use by passing steam through the press.

Contrary to the usual practice the writer found it advantageous, instead of washing the filter cake from the first carbonatated juice in the press, to drop them into a U-shaped receptacle situated beneath the press, and by means of a mechanical scraper to convey the cake to a pug mill fixed inside a tank. All washings and thin liquors from the factory, and generally a little extra hot water, are run into the U-shaped vessel, which has a slight fall towards the pug mill tank. A small jet of carbonic acid gas is passed through the mass to decompose any sucrate of lime, and the mixture re-pressed.

A revolving drum to mix the cakes and water, known as *Ledocte Malaxeur*, may also be used for the washing of cakes, the re-pressing taking place as usual.

Gravel has been used as a substitute for animal char with some success in Hanover, this process being introduced by F. O. Licht & Co., of Magdeburg.

Mayer, in 1878, patented the use of sand as a filtering medium, and he claimed that as regards carbonatated beet juices it was as efficient as animal charcoal, and, of course, far cheaper. The sand was really gravel, being about the size of peas. As the sugar solution takes up various impurities from the sand, the latter required washing with hydrochloric acid before using.

The following is a description from the *International Sugar Journal*, (1913, pp. 524–5), of an up-to-date sand filter :—

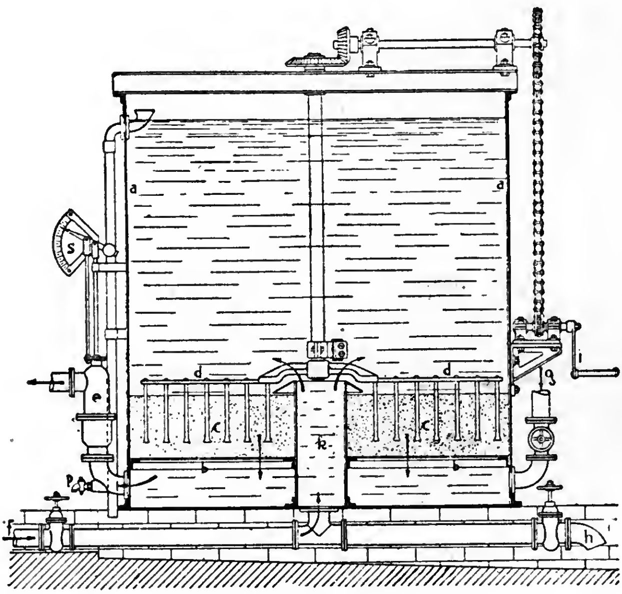


Fig. 245

OPEN GRAVEL FILTER

"Gravel filters are coming more and more into use for removing mechanical impurities from different liquids, and as they are well adapted for use in the sugar factory and refinery, a description of this type of installation may not be unwelcome.

"Gravel filters are made open or closed, and the latter type is often erected in double storey. The material used is quartz gravel, carefully washed and sieved, of different sizes and with sharp edges. This medium is not subject to detrition, and is free from any hygienic objections. Usually the mantles are of iron, though masonry or concrete may be used to reduce the cost of the installation.

"After use the gravel is readily cleaned, and this is done in different ways, namely by steam, compressed air, scouring blast pipes, or agitating rakes. According to the experience of the writer, agitating rakes effect the most efficient purification of the filtering medium, and the power required for the movement of the rake, which only lasts three to seven minutes, is very small, owing to the up-lifting effect of the wash-waters present. If the filter is only a small one, this agitation may easily be effected by hand.

"In *Fig.* 245 is shown a filter of the open type. In the bottom of the cylindrically formed tank *a*, which is open above, is fixed the sieve *b*, covered with bronze wire gauze, and on this is placed the gravel filtering material *c*. The unfiltered liquid enters through the valve *f* and the pipe *k* into the upper

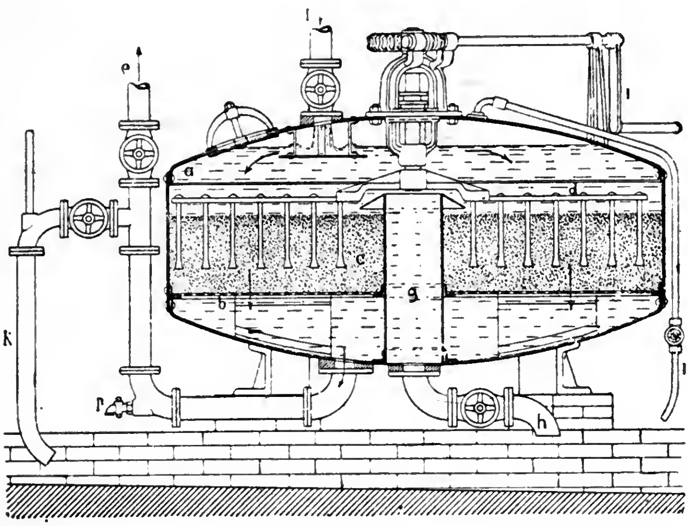


Fig. 246

CLOSED GRAVEL FILTER

part of the filter, spreads over the layer of gravel, flows through it, and finally leaves through the exit *e*, provided with a regulating appliance. This regulator is a very useful accessory ; it makes the passage of the water very even, and renders the water independent of the cleanliness or otherwise of the gravel layer.

"The water for washing is contained in a tank placed on a high level, and when this is not installed, a pump must be employed to secure the necessary pressure. This wash-water enters the filter by the pipe *g*, penetrating the layer of gravel from below, cleaning it, and then flowing off charged with mud through the pipe *k* and the valve *h*. At the same time the rake or stirrer *d* is set in motion by the handle *i*, the arms of the stirrer being placed against one another, so that no single part of the layer is left unwashed, as very often happens with filters which are cleaned by means of compressed air or steam. The washing process lasts only a few minutes, and the quantity of wash-water is very small.

"In *Fig.* 246 is shown the closed type of filter.* Amongst other advantages, closed filters need only one pump for introducing the water into the apparatus, and forcing it through to the clean-water tank placed at a high level. Naturally, this means that the filter must be built very strong.

"In the vessel *a*, which is formed by two arched pieces and a cylindrical mantle, the gravel layer *c* and the stirrer *d* are installed. The muddy water enters at *f*, penetrates the medium *c* and the sieve bottom *b* to rise to the high level tank by a suitable connecting pipe and its extension *e*.

"After closing the valve *f*, and opening the pipe *h*, the washing of this filter is effected by water from the high level tank, which passes through the gravel in the opposite direction, the agitating rake *d* being meanwhile set in motion by the handle *i*. After having reversed the valves, the first lot of water coming off, which is somewhat muddy, is allowed to flow away by the pipe *k* before opening the valve leading to the high level tank. The valve *p* is for emptying the filter, and the small valve *l* serves for occasionally blowing off any air or other gas which may be liberated from the liquid being treated."

Sand filters are useful in cane sugar works. The sand can conveniently be replaced by crushed limestone or coral, but in all cases the grain should be uniform in size; the smaller the grain the slower the filtration, but with large grains the filtration is quicker but less perfect. These filters can be easily washed and cleaned.

The success of the centrifugal cream separator has led engineers to utilize centrifugal force to assist filtration. In 1883 the writer used ordinary centrifugals with the perforated gauze replaced by an impervious sheet to remove sulphate of lime, etc., from full-weight sugar syrups.

Several forms of centrifugal filters have been specially made—Hignett's and others, for example—but as they are still in the experimental stage it is not advisable to devote much space to them. In so far as they relate to juice filtration, the difficulty presented is that in cane juice the insoluble impurities consist of three parts, one that floats, another that remains suspended, and a third, the heavier portion, that easily separates.

As centrifugal action is similar in its action to gravity, it will be realized that in any centrifugal for filtering cane juices, provision must be made for the same, the nearest practical approach, so far, to the desideratum being the *Kopke* Centrifugal for sugar juices and *Gee's* Centrifugal for preparing aids to filtration.

The Kopke centrifugal separator or filter consists essentially of an ordinary centrifugal machine, with the perforated basket replaced by a solid one; when a mixture of bodies of different densities is subject to the action

* These illustrations are supplied by Messrs. The Halvor Breda A. G. Charlottenburg, Berlin, the makers of the apparatus.

of centrifugal force in such an appliance, those of the higher densities will tend to move towards the outer part of the system, and since the matter precipitated from cane juice in the process of clarification is in general of higher

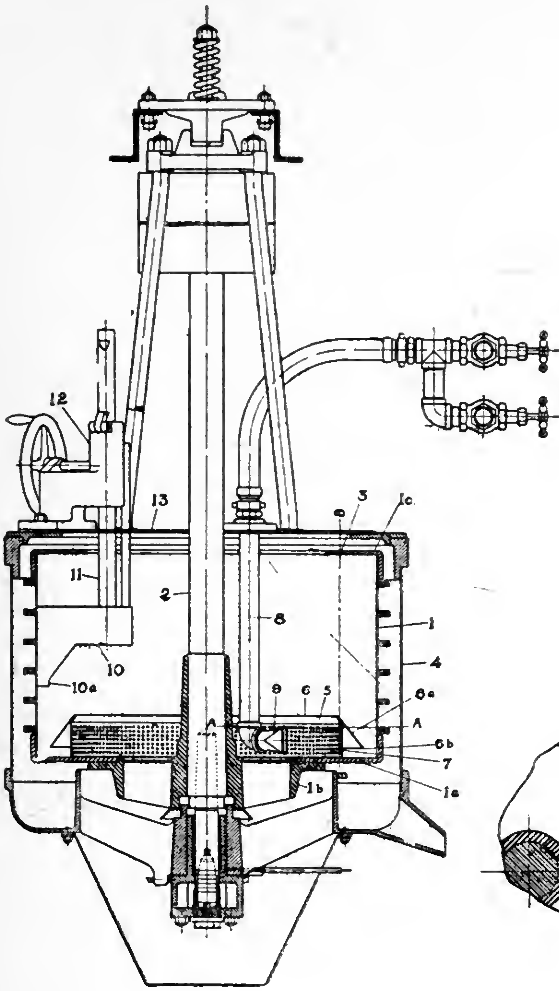


Fig. 247

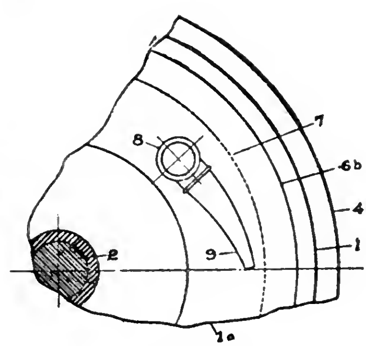


Fig. 248

KOPKE CENTRIFUGAL FILTER

density than the juice itself, the dirt and scum will arrange themselves next to the wall of the revolving drum, inside of which will be a layer of clear juice.

In the accompanying drawings, *Fig.* 247 represents in sectional elevation a portion of a centrifugal clarifier or separator embodying this invention.

Fig. 248 is a sectional plan view of a portion of the bowl of the machine on the line *A*—*A* of *Fig.* 247, showing the inlet nozzle.

Referring to the drawings, the revolvable bowl 1 may be mounted in any suitable manner; for example, with its spindle 2 suspended from the top, as in the Weston type of centrifugal machines. The revolvable bowl 1, which has imperforate sides, is provided with a lower head 1*a* secured to the hub 1*b* attached to spindle 2, and with a flat ring-shaped upper head 1*c*. This upper head 1*c* is provided with slots, or holes 3, through which the clarified liquor is discharged from the bowl into the tub or curb 4.

An introduction chamber 5 is formed concentrically within the bowl 1 by means of a plate ring 6, supported by a vertical cylindrical perforated plate 7. The upper portion of the plate-ring 6 is flat, and approximately horizontal, and its lower or outer portion 6*a* is conical and declines from the upper portion downward and outward, as shown. The lower edge 6*b* of the conical portion 6*a* is made true and concentric with the bowl 1, and is near the imperforate walls of the bowl and adjacent to the lower head 1*a*. The lower edge of the cylindrical perforated supporting plate 7 is secured to the lower head 1*a*. This plate 7 is vertical and concentric with the bowl 1, and is located slightly outside the vertical lines passing through the discharge outlet holes 3, as represented by the line *B*—*B* in *Fig.* 247.

The liquor to be treated is introduced through the pipe 8, provided with the nozzle 9, through which the liquor enters the introduction chamber 5 in a ribbon-like stream, and in a direction as nearly tangential as possible to the liquor inside of the perforated supporting plate 7. The position of this ribbon-like discharge from the nozzle 9, within the introduction chamber 5, toward or away from the perforated supporting plate 7, may be altered by turning the pipe 8. The nozzle 9, however, must always clear the inner surface of the liquor of maximum horizontal depth within the introduction chamber 5.

The mud discharge blade 10 is secured to the lower end of the rod or bar 11, adapted to be moved vertically in the bracket casting 12, supported by the plate-cover 13 of the tub or curb 4. The bar 11 may be raised or lowered by turning the hand-wheel 14, by means of the well-known rack and pinion movement. This blade 10 is shaped such that it clears the plate-ring 6 when it is lowered, and its lower end 10*a* is in contact with the lower head 1*a* of the bowl I. The rod or bar 11 clears the inner edge of the upper head 1*c* of the bowl I.

Dr. H. C. Prinsen Geerligs in his work, "Cane Sugar and its Manufacture,"* describes the use in raw sugar mills of vegetable horse-hair in Bouvier's Decanting Filter as follows:—

"This filter consists of a rectangular iron tank, 3 feet high, 3 feet broad, and 5 feet long, which is divided into 8 or 10 compartments by iron baffle plates, which extend to within a couple of inches from the top and bottom alternately, causing the juice to take a zig-zag course before it reaches the

* Published by Norman Rodger, London. 12*s.* net.

outlet. Those compartments wherein the juice flows upwards contain baskets filled with the vegetable horse-hair filtering material, while the other compartments are empty and have discharge cocks at the lower part of the inclined bottom. The juice enters an empty compartment of the filter, and during its downward course deposits heavy impurities at the bottom. It then enters the second compartment containing the filtering medium, which holds back the finer impurities. This goes on four or five times, until it leaves the tank completely filtered. The subsided dirt is removed from time to time by opening the cocks at the bottom, the filtering medium when saturated with dirt being removed and replaced by fresh material. It is said that four such filters are sufficient for the filtration of the juice from 600 tons of cane per twenty-four hours."

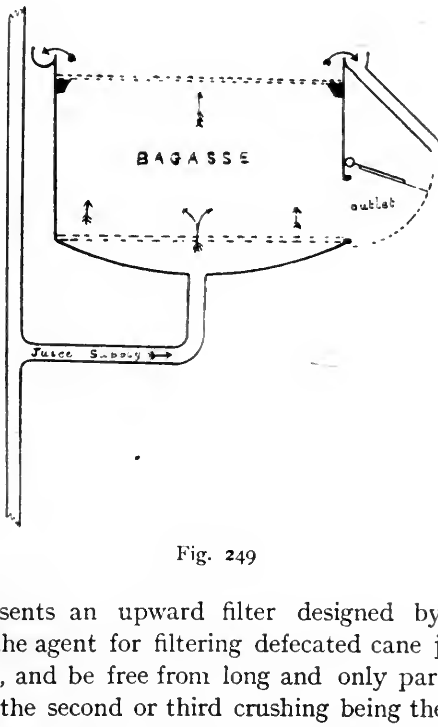


Fig. 249

Fig. 249 represents an upward filter designed by J. J. Eastick for utilizing bagasse as the agent for filtering defecated cane juices. The bagasse should be fairly fine, and be free from long and only partially crushed cane, generally that from the second or third crushing being the most suitable.

The bagasse, when charged with mud, is returned to the second set of rollers, and its sugar contents pressed out, thus avoiding the necessity of any washing in the filter. The maceration and milling is performed in the usual manner.

The filtering material may be exchanged for fresh as often as required. No washings or dilute sugar solutions are produced,

The filters are constructed and worked in the following manner :—

They consist of rectangular or cylindrical vessels, having a false perforated bottom placed a short distance above the actual bottom. The perforated bottom is so arranged as to prevent the bagasse from dropping to the actual bottom of the vessel, but, nevertheless, so as to permit the free passage of the liquor being filtered evenly through all parts of the filter. The space above this false bottom is filled to a depth found suitable by experience, say some three or four feet with bagasse, as it issues from the mills, but slightly pressed together; care is however taken only to put pieces of bagasse of small size into the filters. This bagasse forms a filtering medium. On the top of this bagasse a cover is placed, composed of perforated metal or other suitable material, the perforations being of such a size as to prevent bagasse passing through same, but not small enough to prevent the flow of the cane juice over the whole surface of the filter. This perforated top-cover is prevented from rising, when the bagasse swells, by stops, which can easily be so placed as to hold down the cover or be removed or altered in position so as to permit the cover to be taken out of the filter. This cover is so arranged as to exert a slight pressure downward on the bagasse filtering medium. It is removed when it is desired to charge the filter with bagasse, which is usually done from a shoot situated over the filtering vessels. There is a large manhole placed in the side of the vessel, giving access to the space which is filled with bagasse. This opening is provided with a sliding door or other arrangement of door capable of being quickly opened and closed and made tight. The object of the opening is to permit the bagasse, when it has served its purpose as a filtering medium, to be quickly emptied out of the filter. An opening with a door is also provided to the space between the perforated false bottom and the actual bottom of the vessel to enable this space to be cleaned out.

The two openings, one above and one below the false bottom, may be combined so that only one movement is necessary to close them both.

In operation the cane juice to be filtered enters each vessel at the bottom, in the space between the actual bottom and the false bottom, rises up through the bagasse filtering medium and through the perforated metal cover placed over the bagasse, and flows out at the top of the vessel over an overflow lip or weir.

When, from observation, it is ascertained that the filtering medium in any one of the filtering vessels has become clogged, juice is turned off from this particular vessel.

When it is desired to renew the filtering medium, the upper perforated cover is removed, the door at the side of the filter is opened, and the sweet bagasse is emptied out. The door on the side of the vessel is then shut and fastened. A fresh charge of bagasse is put into the vessel, the upper cover is replaced and retained in position by the stops or catches arranged for the purpose. The filter is then ready for the cane juice being again turned into it. The soaked bagasse removed in cleaning out the filter is placed on one of the carriers, usually that between the first and second mill, thence it passes through the crushing rolls, and the liquid contained in it is pressed out and passes away from the mill with the cane juice. In this way all loss of sugar from the process of filtering is avoided. The bagasse from the filters then becomes mixed with the ordinary cane bagasse, and having been freed by passing through the crushing rolls from the greater portion of the moisture and sugar it contains, it goes forward with the rest of the bagasse for use as fuel, etc.

It is usual to instal several of these filters, so that whilst one or more of the filters is in use and is dealing with the output of the cane juice, another one can be undergoing the cleaning out and recharging process, so as to be ready for the admission of cane juice for filtering purposes as soon as any of the others get into such a state as to require the removal and renewal of their filtering medium.

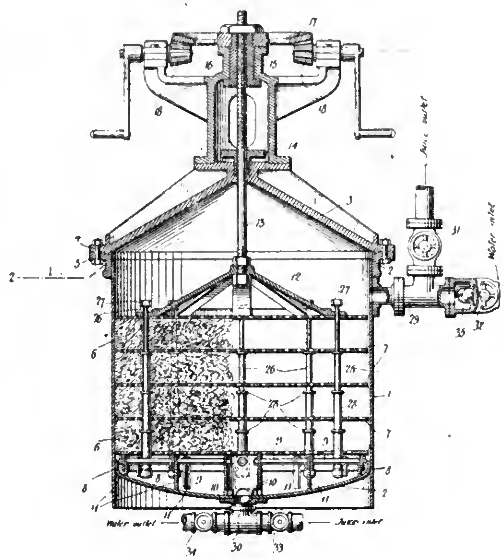


Fig. 250

HALL'S FILTER

Provision is made to discharge the liquid then contained in the filter into some receptacle, so that it is not wasted. It is usually convenient to return it into the raw juice tank.

W. G. Hall has recently patented a filter, (*Fig.* 250), suitable for the filtration of clarified cane juices, in which bagasse or other material may be used as the filtering medium.

The filter provides mechanical means for compressing the filtering material so as to make the filtration more perfect, and when the filter has become throttled by impurities the pressure is relieved and a return current of water is forced through so as to wash out the impurities from the filtering medium.

By the aid of several perforated plates, the filtering material is arranged and retained in several superimposed layers.

Sugar juices to be filtered frequently contain large pieces of impurities. In the best lime there is always danger of lumps of unburnt limestone, and odd pieces of trash, metal, etc., frequently fall into the tanks; therefore, it is always advisable to have a strainer and to prevent any interruption in the work; a twin strainer such as Royle's (see *Fig.* 251) is preferable, as one department can be cleaned while the other is in full operation, since they can be

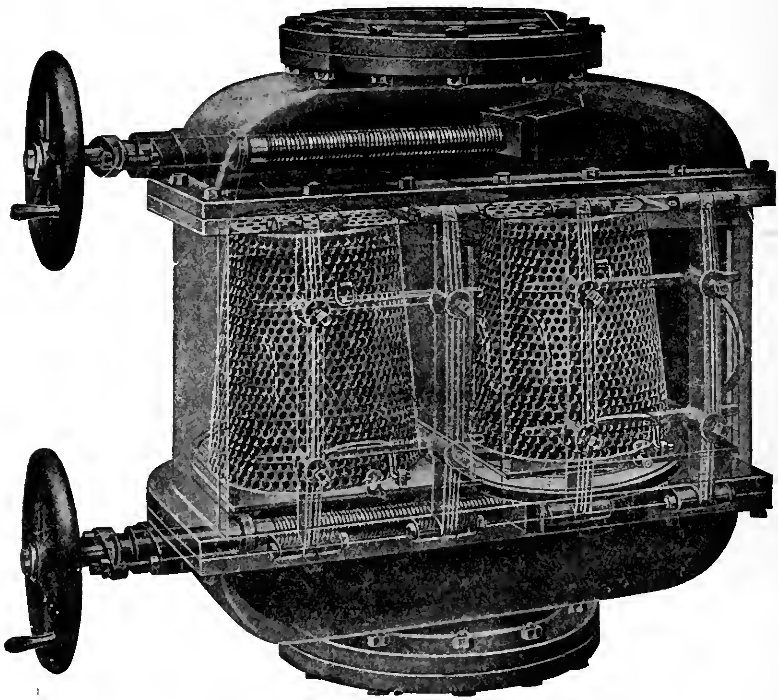


Fig. 251
ROYLE'S TWIN STRAINER

alternately thrown in and out of operation by simply opening one valve and closing the other. The dirty basket can be removed, cleaned and replaced in a few minutes.

In making and refining sugars, the various operations have for their object the separation of impurities from the sugar, therefore the water used should be free from objectionable impurities, or the latter should be removed.

In addition to the numerous methods previously mentioned, we give an illustration (*Fig.* 252) of a separator which explains itself; the block has been supplied by the Patterson Engineering Company. The choice of apparatus depends largely on the composition of the impurities.

Suspended matter in water may consist of that which is naturally present, and that which is produced chemically during a softening process. The particles of this natural or artificial matter vary a great deal in size. When using high-speed mechanical filters in which sand or gravel is the filtering medium for such water, it will be necessary to use a filter-bed of very fine sand, so as to ensure perfect filtration, but the surface will soon become slimed up and the filter throttled, and frequent washing of the sand will be necessary.

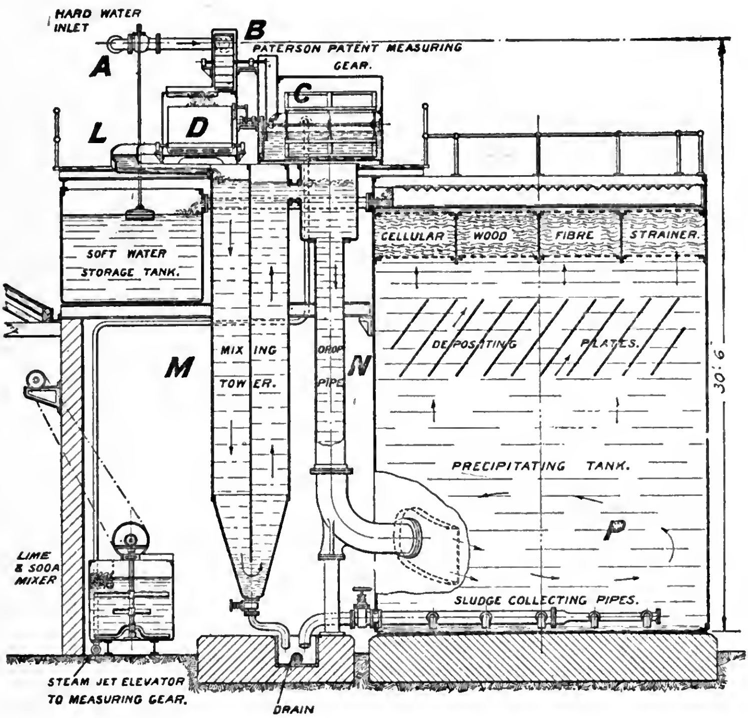


Fig. 252

PATTERSON SEPARATOR

If all the particles are large, or if they can be coagulated in such a manner that relatively large aggregates of the suspended matter are formed, then the filter bed may consist of very coarse sand or even gravel, and the filter will not be so readily throttled.

In some mechanical filters the device of building up the filter bed of different grades of sand has been employed. The layer through which the water passes first being the coarsest and that from which it issues being the finest. The disadvantage of this method is realized when the filter bed requires washing, as the different layers of sand become mixed together.

A mechanical filter which overcomes these difficulties is manufactured by the Candy Filter Co. The filter medium of the Candy compound filter consists of two layers of sand or other material. The upper bed, termed the "Pre-filter," is of a comparatively coarse grade of material resting on a false bottom, through which the water, freed from coarse suspended matter, flows on to the surface of the fine filter, from which the brilliantly clear water issues.

Both beds are washed at the same time by a method which is exceedingly simple and effective. The fine bed is washed by means of a reversed flow of

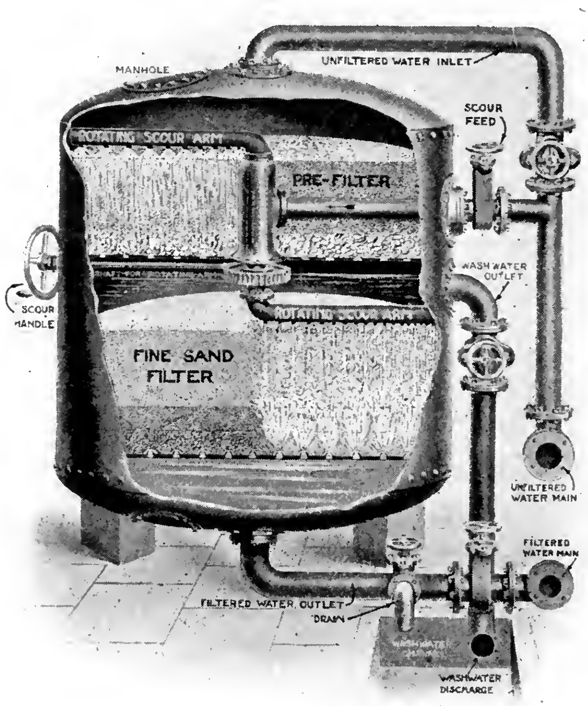


Fig. 253
CANDY FILTER

filtered water, and at the same time streams of water under high pressure are played upon the surface of the filter bed by means of a slowly rotating arm. These streams of water penetrate to the bottom of the bed, and the suspended matter is washed upwards by means of the reversed flow of water.

A great advantage of this method of cleaning is that the top surface of the sand, which contains most of the dirt, is at once churned into a muddy suspension, which is carried away from the cleansed sand. The rotating arm ensures a thorough washing throughout the whole of the filter, and the formation of channels in the sand being thus prevented. The pre-filter bed is washed by means of another rotating arm, which discharges water under high pressure on to the surface of the filtering medium, washing the dirt through the false bottom ; this dirty water meets the washings of the fine filter and then flows out of the filter through the wash-water outlet situated between the false bottom supporting the "pre-filter" and the surface of the fine filter. The washing operation occupies only about 10 to 15 minutes. The filter is illustrated in *Fig.* 253, and its working is fully explained by the wording.

The rotating scour arms are placed above the level of the filter beds, and consequently there is no danger of damage to the driving cogs, as in filters the arms of which are placed in the filtering medium ; for these filters special spring valves are necessary for the discharge of the water from the scouring arms, but in the Candy compound filter the position of the arms obviates the necessity of these special valves.

The power required for turning the arms is so small that they are usually turned by hand, although other power may be utilized if available.

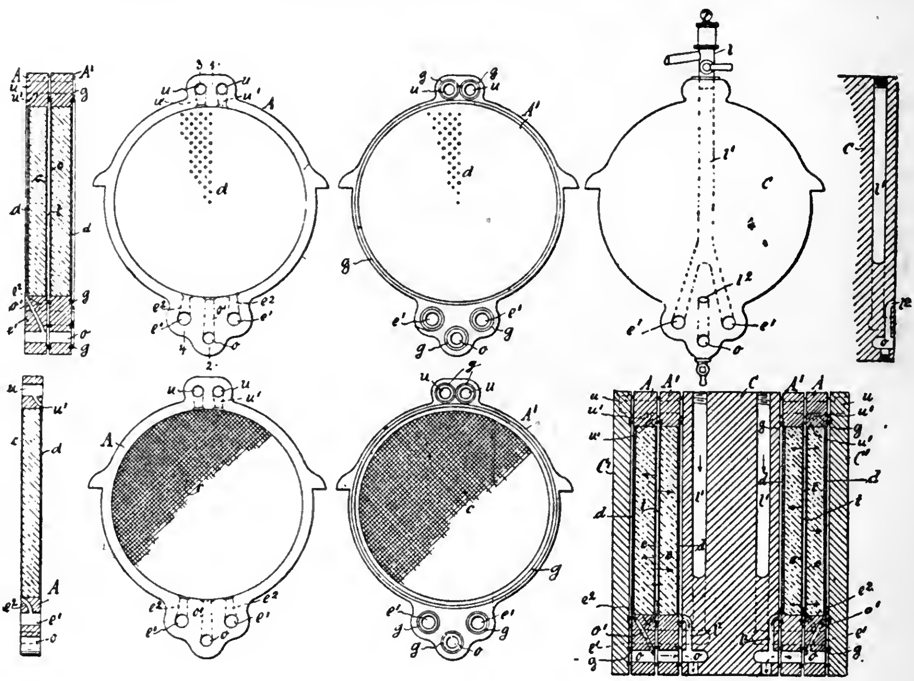
The water-pressure required for the hydraulic scours is from 20 to 35 feet, and for the reversed upward flow from 6 to 10 feet. The unfiltered water is used for the hydraulic scours. The filter is fitted with gauges, which indicate the pressures during filtering and washing, so that the attendant can see when the filter requires washing, and also regulate the pressures during washing.

As in all sugar manufacturing operations, hot water is required, and as all filtrations are facilitated by heating, it is advisable, when convenient, to heat the water before filtering, especially when magnesia salts are present. There are many sources of hot water in sugar works (free from the oil used in the steam cylinders), such as the condensed water from vacuum pan coils, the juice heaters ; in addition these sources can be supplemented by using J. J. Eastick's double condensers.

SPECIFICATIONS OF SUNDRY FILTER PRESS PATENTS

No. 112775. **Filter Press.** 19-1-98. Georg Nicol, Berlin.

This press contains very small chambers and is therefore only suitable for filtering liquids which contain but little solid matter. In *Figs.* 254-262 the essential parts of the press are shown. Each filter chamber is formed between two plates, a tight joint being obtained by means of a circular ring between. The filter plates A, A_1 have small channels u, e and o passing through them. The unfiltered fluid enters the chamber t by means of e^1 the channel u serving for the removal of the air in the chamber. The filtered fluid runs out of the channel o. The channels u_1 e_1 and o_1 in plate A are in communication



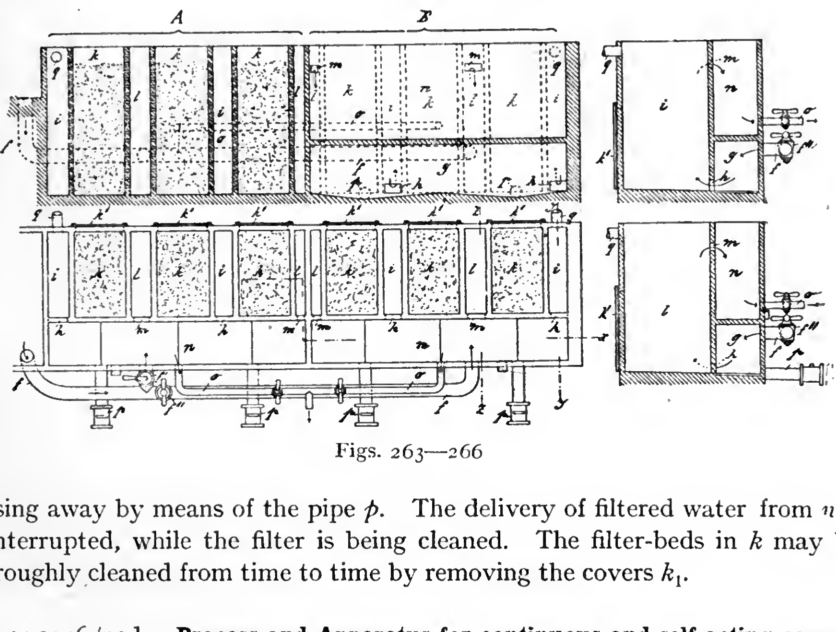
Figs. 254—262

with the filter chamber by means of small openings. The plates have perforated linings c, d, the filter-bed being between. The filtering process is carried out as follows:—The liquid to be filtered enters by means of l and channel l^1 through e^1 e^2 into the chamber t, the air escapes through u^1, and the filtered liquid passes from o^1 in A. It then runs away from here through o and l_2.

The perforated linings d and frame of A are in one piece, while the plates c are loose. The press is capable of standing 12 atmospheres' pressure (175 lbs. to sq. in.)

No. 113783/12d. **Water Filter with cleaning contrivance.** 23-1-97. C. Sellenscheidt, Berlin.

By means of this open water-filter (see *Figs.* 263-266), it is possible to clean the filter-bed without interrupting the supply of filtered water. The filter may be divided into two or more parts *A B*, the water to be filtered passing by means of pipe *f* into the chamber *g* of either *A* or *B* as required. This water then passes through the opening *h* into the small chambers *i*, thence through the perforated walls into the filter chambers *k*. The filtered liquid flows then by means of *l* and *m* into the storage chamber *n*. When the filter-beds in *k* are dirty, then the supply of unfiltered water must be shut off. The water remaining in *k* runs off through the perforated walls of the gravel chamber, afterwards



Figs. 263—266

passing away by means of the pipe *p*. The delivery of filtered water from *n* is uninterrupted, while the filter is being cleaned. The filter-beds in *k* may be thoroughly cleaned from time to time by removing the covers k_1.

No. 113946/12d. **Process and Apparatus for continuous and self-acting separation of suspended matters in fluids.** 26-7-98. P. Pfleiderer, London.

This patent relates to apparatus more suitable for the separation of two fluids, but it may also be used for the separation of finely divided matter in a fluid.

The operation consists in bringing the liquid to be purified in contact with another liquid which will take up the suspended matter easily, and then be conveniently separated from it. The cylindrical vessel *A* (see *Fig.* 267) contains a stirring arrangement *F* rotated by *f*. The specifically lighter fluid enters by tube *B* with cock *b* and finely perforated worm *B* into *A* and floats upwards, the other fluid containing the finely suspended matter enters through *C* with cock *c* and the worm *C* into *A*. The two fluids mix in the vessel, the lighter fluid now containing the suspended matter flows out through *E*, whilst the purified fluid passes out through *D*. The fine sieves *g* and *h*, besides effecting a proportionate movement of the two fluids, cause a more perfect separation. The lighter fluid containing the suspended matter may be conveniently separated from it by evaporation or filtration.

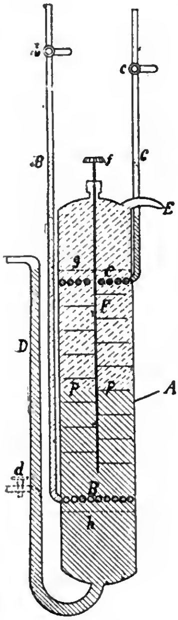
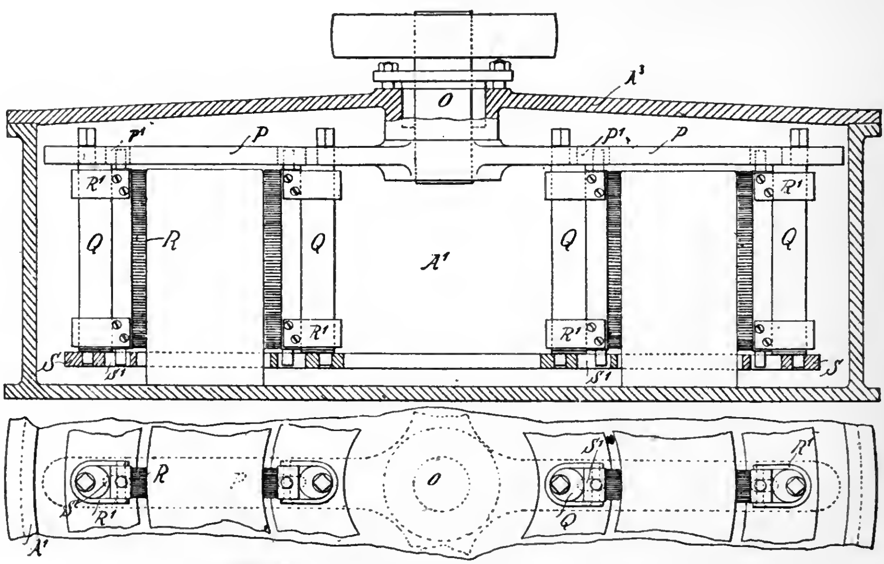


Fig. 267

No. 115443. **Filter Apparatus with rotating brushes.** 20-10-99. David Black and James McLuckie Wright, Glasgow.

Suitable filtering apparatus may be cleaned by means of rotating brushes, but the great fault is that new brushes press too hard on the filter-cloth or plate, thus wearing both filter-cloth and brushes out, rapidly causing the latter to become ineffectual. In order to avoid this the brushes in this apparatus are made moveable (see *Figs.* 268, 269). Through the upper part of the apparatus A^1 passes a shaft *O* which carries a number of radial arms P. To these are attached the arms *Q*. These revolve between the filter cylinders and are provided with brushes or scrapers. The arms *Q* are fastened underneath by *S*, S^1. The brushes *R* are fixed by bushes R_1 and the brush-holders fit in the slides P^1, S^1. The pivots of *Q* are eccentric to the middle line. By turning *Q* on these pivots the brushes are brought nearer or farther to the cloths.

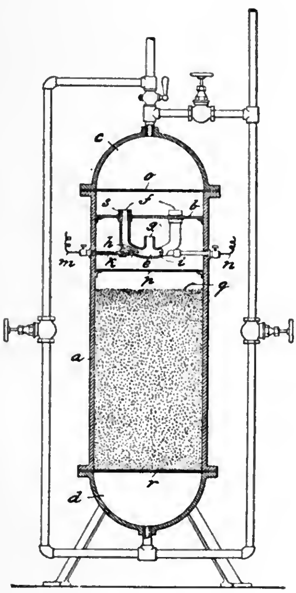


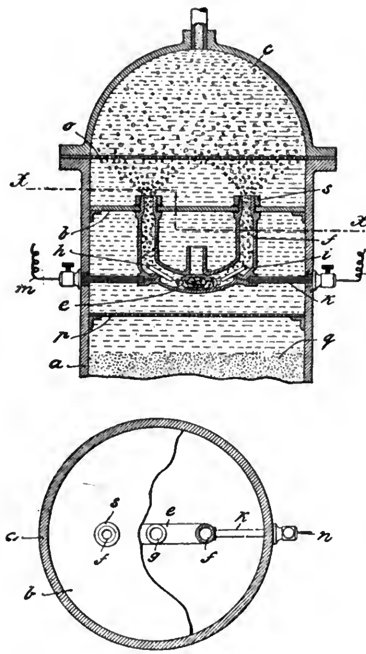
Figs. 268, 269

No. 122018. **Electrical Water Filter.** 3-1-00. William Luther Teter and John Allen Heany, Philadelphia.

The electric current may be used in the separation of organic substances from water, as by its means bacteria and other organisms are destroyed.

As *Figs.* 270-272 show, a U-shaped tube is inserted in the cover *b*, a third leg of the U-tube *g* discharges itself under the cover. The current passes through wires *m*, *n*, which pass through the insulating tubes *k* and end in electrodes *h*, *i*.





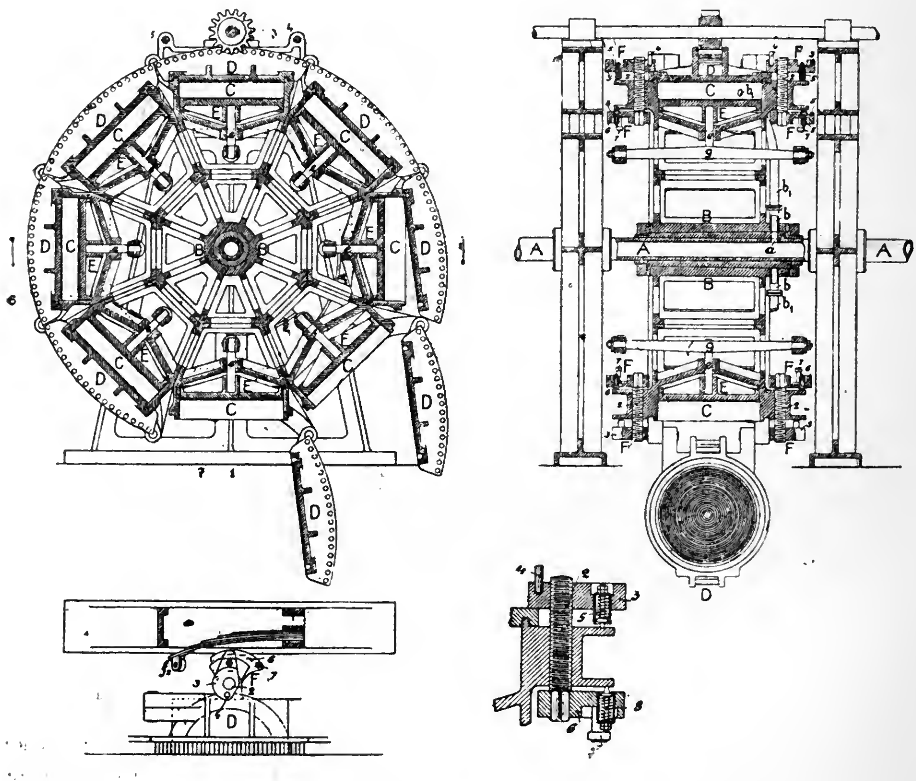
Figs. 270—272

The current thus passing between *h* and *i* destroys the bacteria and other organisms. The water and any inflammable gas then passes out of *g* and runs through the perforated plate *p* into the filter. The filter is provided with a contrivance for washing the filter-bed as required.

No. 131464/12d. **Rotating Filter Press with chamber covers which open and shut automatically.** 26-2-01. Eugen Wernecke, Gerstewitz b. Weissenfels, Germany.

This automatically working filter press is shewn in *Figs.* 273-276. The need of such a press is increasing to compensate employers for dearer manual labour. The press is very useful where large quantities of residue have to be dealt with.

Round the hollow cylinder *A* which contains small channels *a* rotates the part *B* carrying with it the filter-chambers *C*. *B* has a number of channels passing through it, corresponding in number with the number of filter-chambers *C*. By means of the small pipes *b b* communication is made between *A* and C. The chambers *C* are closed by covers *D* and contain a thick movable press-plate *E*. The mixture to be filtered passes from *A* into chamber *C* when the



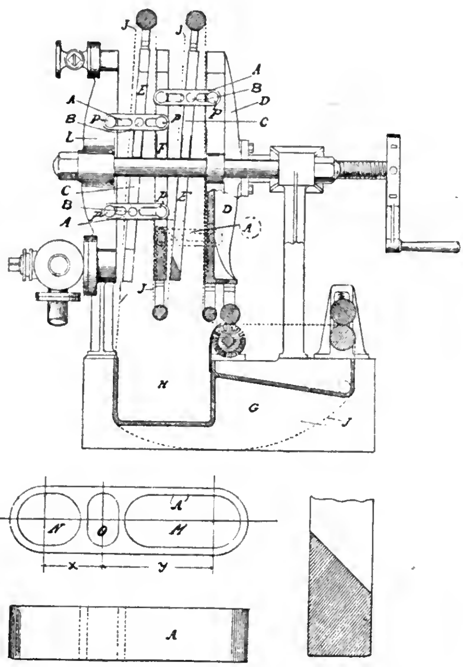
Figs. 273—276

small channels and pipes mentioned above are all in one line. The filtrate passes through the filter-bed on *E* and runs away by means of suitable pipes which are not shown in the illustrations.

The residue is removed from each chamber *C* by opening cover *D* when the lowest position is reached by each chamber, and if it does not fall out of its own accord is made to do so by the movable press-plate *E*. By rotating the press the cover *D* again fits on its chamber and by special mechanism automatically closes.

No. 131933/12d. **Frame Presses in which the residue may be easily removed from the frames.** 5-11-01. John Wilson and The Wilson Filter Syndicate, Ltd., Glasgow.

This press is shown in *Figs.* 277-280. The plates in ordinary filter presses usually stand in a vertical position, and thus the residue does not completely fall off, but has to be removed partly by hand. The plates in this press can be slightly tilted by means of an arrangement, thus facilitating the removal of the residue. The frames *E* are provided with horizontal pivots *B* which pass through slides *A*. The slits *M*, *N*, in *A* to the right and left of *B* are of different lengths *x* and *y*. The ends of *A* reach to headpieces *L* and *D* and also to plate



Figs. 277—280

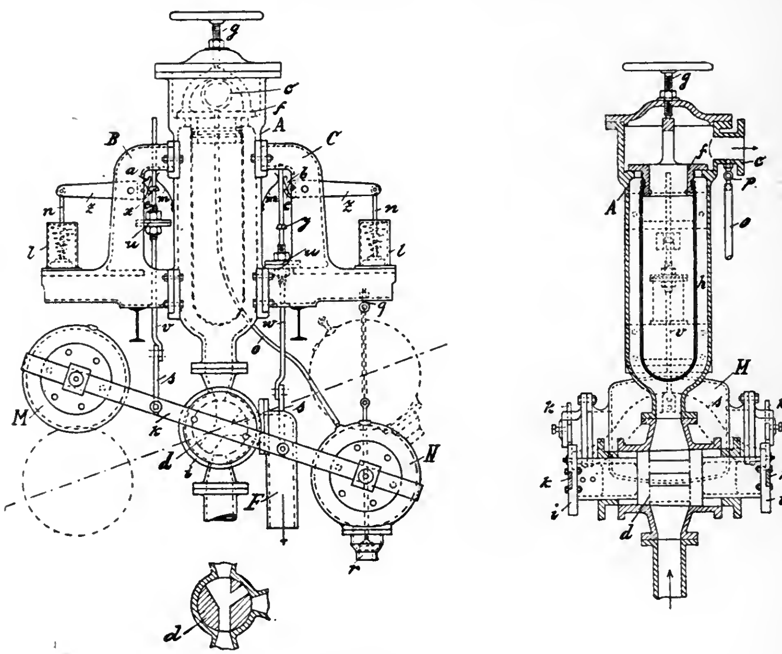
F. These possess pegs and the arrangement is that when the upper peg of a plate catches in the long slit of *A* then the lower peg catches in the short slit.

The press can be closed immediately. On opening, the frames take up the slightly tilted position. By this tilting the residue falls out easily. The filter-cloth *J* is endless and fixed between frame and plate, and can be mechanically cleaned from residue.

No. 134554/12d. **Filtering Apparatus with automatically changing periods of filtering and cleansing.** 22-2-02. Max Richter, in Hirschberg, Silesia.

In ordinary pressure-filters, the cleansing from time to time of the filtering medium has to take place by a return of current of the filtered water. This is brought about in most cases by manual operation of the parts involved, but in this filter the return current effects the cleansing automatically. The untreated water enters through the three-way cock *d* into the filter casing *A*, (see *Figs.* 281-283) which is fixed between the brackets *B* and *C*. Filtration goes on by *c*. The filtering body *h* is arranged in the casing *A*. The three-way cock is connected on the one hand with the casing *A* and on the other with the inlet piping of the untreated water and the discharge piping of the cleansing water.

Both ends of the plug of the cock bear on discs *i*, to which a double-armed lever *k* is attached. At the two ends of *k* are two hollow bodies *M* and *N*, of



Figs. 281—283

unequal weight. In the normal process of filtering *M* is in the lower position, so that the untreated water passes on towards *A*. *N* is connected by means of flexible piping with the clean water piping *c*.

During the filtering an amount (which can be regulated) of water passes constantly through cock *p* to *N*, which it gradually fills. Thereby the weight of *N* becomes greater than that of *M*. *N* sinks and so acts on the three-way cock that the inlet of untreated water is cut off. The clean water under pressure presses back, cleanses out the filter, and escapes through *F*. When *N* reaches its lowest position, an outlet-valve *r* opens. The water escapes, the weight of *N* diminishes, and *M* thereupon again sinks. In order that the weights may not balance and place the lever in a neutral position as regards the three-way cock, catches are attached to the arms of the lever which they only release when the difference of weights on the respective arms has attained a certain fixed amount.

No. 136476/12d. **Centrifugal Filter.** 20-3-01. J. H. Pullon, Leeds.

The object of this filter is a complete cleaning of the filter surface during working. Two cylinders *a* and *k l, j,* (see *Fig.* 284) rotate in equal sense round an equal axis. The cylinder *a* carries a screw-shaped scraper *i* which brushes against the inner surface *k*. The rotatory power of both cylinders varies very

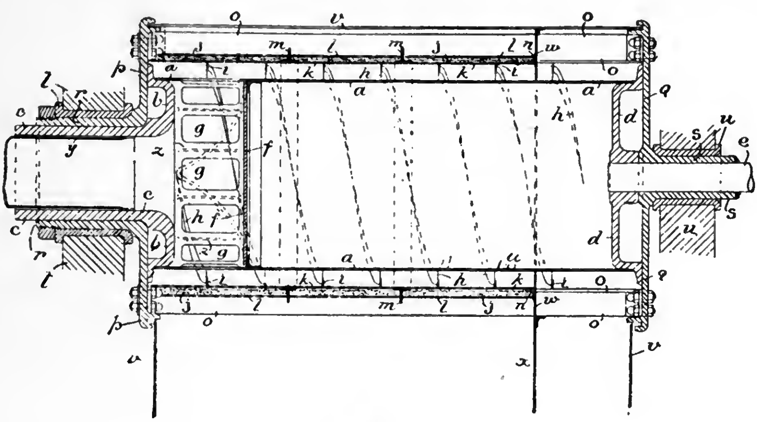


Fig. 284

slightly so that the scraper *i* has a transporting effect on the solid residue on the surface of *k*. The water to be filtered, entering by means of *y*, passes through the openings *g* into the perforated cylinder. The filtered water flows off by *v x*. The solid residue is carried forward by the scraper *i* and passes out by *x v*. The walls *v, x, v* are fastened to the cylinder walls *p, w, q*.

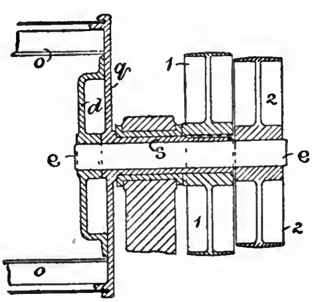


Fig. 285

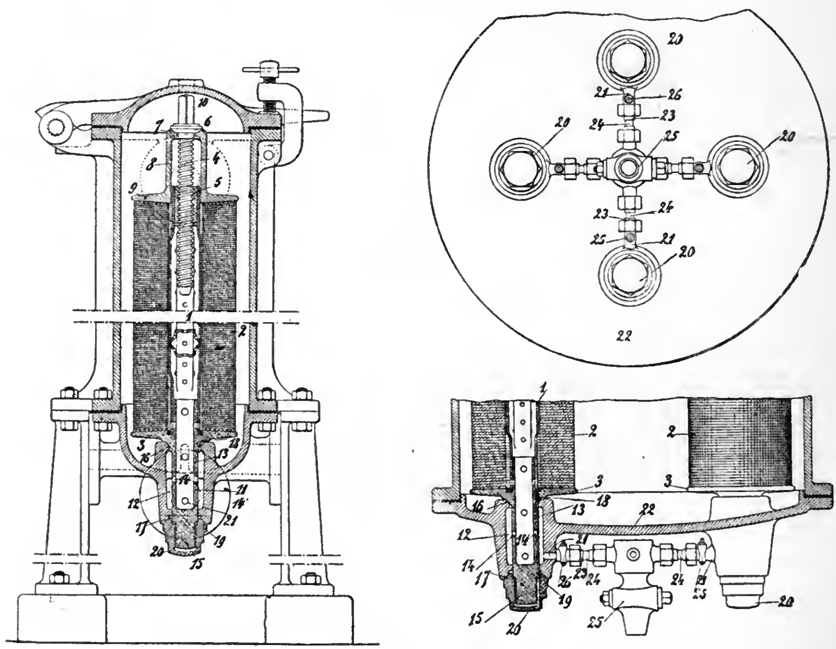
In *Fig.* 285 is shown the motive power arrangement of the cylinders. On the shaft are two pulleys 1 and 2 very slightly different in size. This difference is just sufficient to cause the transporting effect on *i*.

No. 145055/12d. **Filter with columnar filter cells consisting of suitably apposed filter blocks.** 3-6-02. Emanuel Simoneton, Paris.

In column filters consisting of suitably apposed filter cells, the fact that the occasionally requisite cleaning necessitated a taking apart of the filter columns was a serious disadvantage. Bad fastening rendered the combination of several columns in a common casing impracticable.

The column filter shown in *Figs.* 286-288 avoids this disadvantage in simple fashion.

The filter consists of the central collecting tube 1, to which is apposed filter block layer 2, and two press-plates 3 and 9, which can be made to approach each other by a screw, 4. On the upper part of the collector 1 an internal



Figs. 286—288

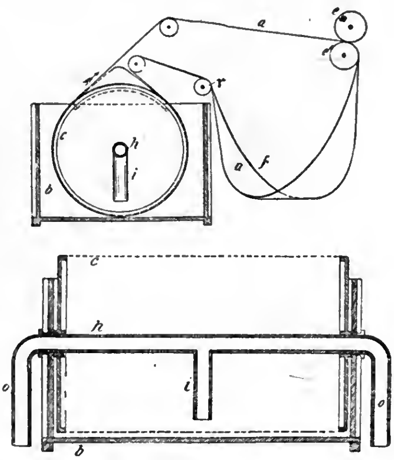
screw enters firmly, whilst the lower part is firmly held by a cylindrical continuation of 9. Screw 4 is operated by a square head turned by a key, hand-wheel, or the like, and tightens on support 8 by bringing down the collar 6 on head 7.

The filter body is fastened to the bottom of the filter casing by means of the lower continuation 13 of plate 3. The internal screw 20 corresponds to end 15 and tightens by means of coned surface 19 on the corresponding surface 17, in the same manner as surfaces 16 and 18. The filtered water runs out of the collecting tube into the lower hollow supports and through opening 14 into the casing, so as to reach the discharge pipe through 21. *Figs.* 287 and 288 show the combination of several filters in a common filter casing.

No. 146547/12d. **Apparatus for filtering fluids by means of endless filter-cloths.** 8-1-03. Johs Groendahl, Baegna, Prov. Hoenefos, Norway.

Filtering with endless filter-cloth has the disadvantage that the pores of the cloth soon become clogged, so that from time to time it must be taken out and thoroughly washed.

By the arrangement shewn in *Figs.* 289 and 290 this is unnecessary. The endless filter-cloth carried by rollers surrounds the perforated drum *c* which rotates round a hollow axis *h* and is contained in a vessel *b*. The filter-cloth hangs beneath the rollers *r* and e_1, which cause the cloth to slowly revolve. The water is drawn in the cylinder through *i* and hollow axis *h* by means of special suction apparatus fixed to *o*. The solid residue is removed from the filter-cloth by the roller *e*.



Figs. 289 and 290

No. 160468/12d. **Drum filter with bar frame embedded in the filtering material,** Carl Membach, Berlin.

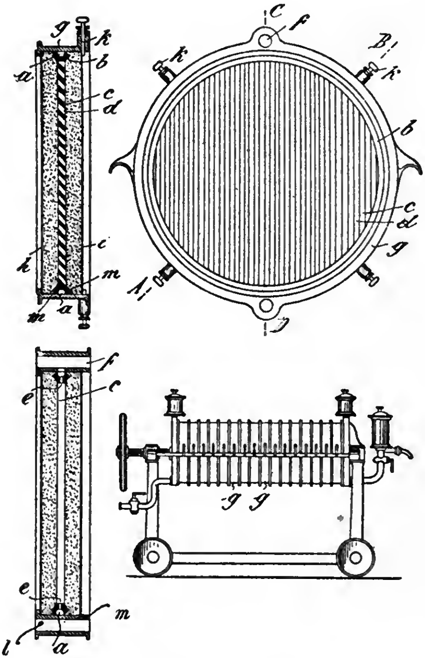
In order to dispense with the insertion of a sieve in drum filters with filtering material, a grating is set in the filtering material (see *Figs.* 291-294); the grating consists in a frame *b* which exteriorly shows a collecting tube *a* and inward oblique bars *c*. From each collecting tube *d* between two such ribs there branch off outlet tubes *e* to *a*, which are connected with the tube *f* of the drum filter *g*. The filtering material, composed of fibrous matter, is confined in the drum on the outer surfaces by means of sieve-plates *h* and *i*, *i* being held in the proper position by means of pins *k*.

The frame *a* is cone-shaped externally, so that these surfaces press the filtering material outwardly and have a caulking effect. *Fig.* 294 shows the arrangement of several such frames. The fluid to be filtered then passes through a lower inlet tube *l* and small bore-holes *m*, and takes the above-described course. The obliquity of the frame bars *c* stops the filtering material from penetrating into the intervals *d*.

No. 161170/12d. **Contrivance for separation of solid matter from a fluid by means of sloping walls and filters.** 6-5-03. Carl Bachler, Zurich.

The arrangement for effecting separation of solid matter from a fluid is shown in *Fig.* 295, and is a combination of settling and filtration methods.

The mixture enters by means of the opening *a* into the side of apparatus b b_1, and passes through the opening *c* into the space between *b* and d^1. The major proportion of the solid matter separates out here. The mixture then passes



Figs. 291—294

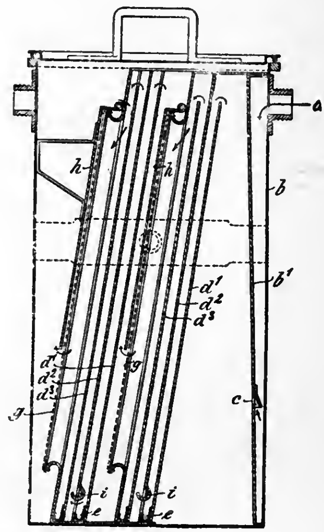


Fig. 295

upwards and downwards between the partitions d^1, d^2, d^3, a further quantity of residue settling out in the pocket *e*. It next passes through the filter-bed *g* which is partly closed by a plate *h*, and after leaving here the operation of settling and filtration is again carried out by plates d^1 d^2 d^3 with pockets *e* and filter-bed *g*. The filtered fluid then passes out of the apparatus, while the solid matter can be afterwards removed from pockets *e* and filter-bed *g*.

No. 163135/12d. **Arrangement for filtering fluids under pressure.** 7-11-02. Samuel Gross and Ganz & Co. Akt-Ges., Budapesth.

This small pressure-filter is very useful for laboratory purposes, and is an improvement on those usually employed. Over the filter-bed 1, (see *Figs.* 296 and 297) a loose piece of filter paper 2 is laid. The residue accumulates on this paper and does not dirty the filter-bed 1. The cleaning of the filter results by unscrewing 6, thus loosening 3, and then removing the filter paper 2. On placing in a new filter paper, the filter is ready for use again.

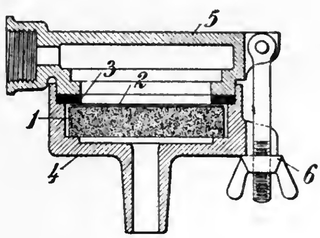


Fig. 296

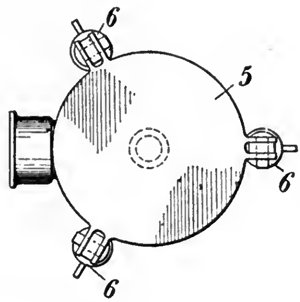


Fig. 297

No. 172183. **Contrivance for removing water from damp material by means of perforated revolving cylinders.** 10-6-04. Hermann Riensch, Dresden.

The separation of fluid and solid constituents from material which contains the larger proportion of the latter, for example wet beet slices, can be conveniently carried out, as is illustrated by *Figs.* 298-299. The filter chamber is formed by three or more finely perforated drums.

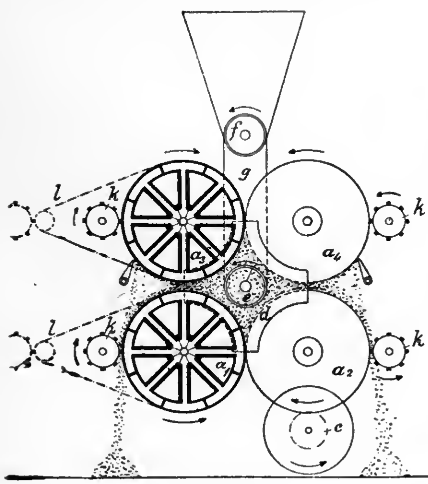


Fig. 298

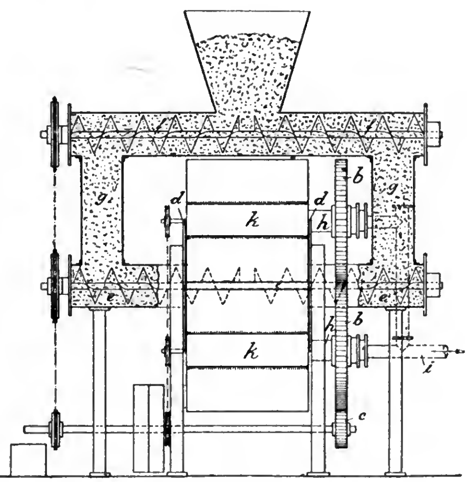
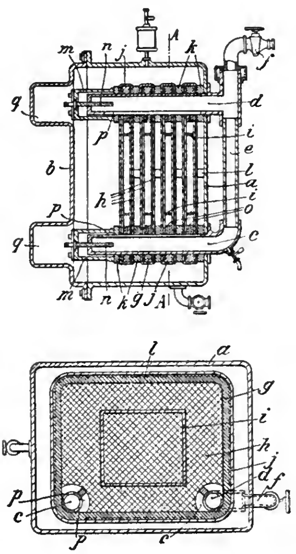


Fig. 299

The drums a_1 a_2 touch one another closely and are fixed ; a_3 a_4 are movable and likewise touch one another closely. All cylinders are coupled to gearing *b c*. The sides of the drums are limited by *d*, so that the press chamber is in connection with the outside only by two small movable slits between a^1, a^3 and a^2, a^4. The material passes through *f* by means of the spiral through *g* and *e* into the press-chamber, and hence from the revolving drums to the outside. The fluid passes through the perforated cylinders and is led away by pipes *h* and *i*. The surface of the cylinders is cleaned by means of scrapers or brushes *k*. For slimy material filter-cloth *l* may be used in addition, the cleaning of which can be carried out in suitable manner.

No. 174368/12d. **Pressure Filters.** 9-10-04. Heinrich Lieberich in Neustadt a. d. H. Germany. (English Patent 13,247, June 27-05.)

The filtering elements consist of frames covered on both sides with a double thickness of woven wire fabric and enclosed in bags *j* (*Figs.* 300 and 301). The frames are provided with rings at two of their corners, and the elements are collected together by passing the rings over outlet pipes *c*, *d*. They are separated at one side by rubber strips having rings to pass over the pipes, and at the other by distance pieces *l*.



Figs. 300 and 301

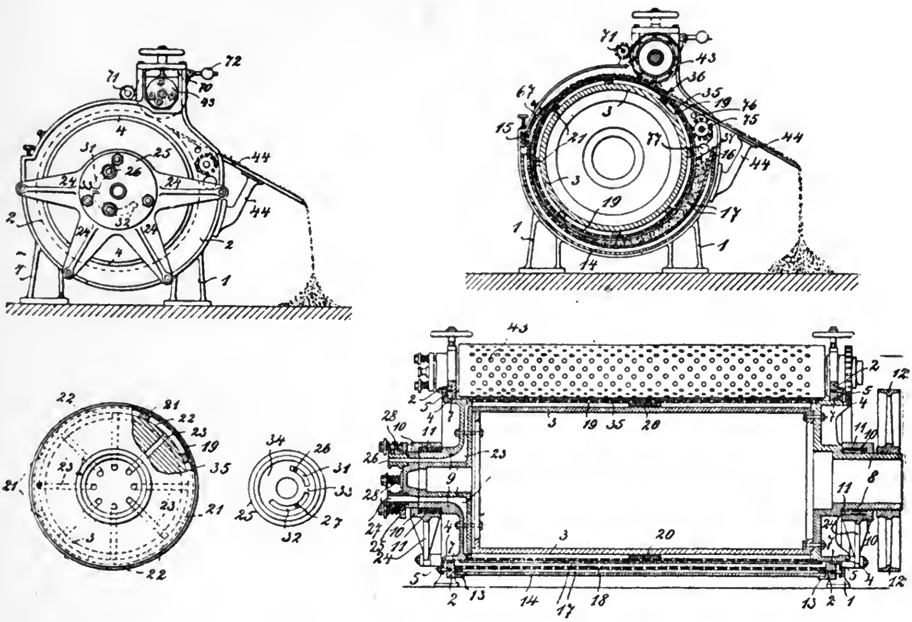
Caps *m* provided with screw spindles *n*, which also pass through the closed ends of the outlet pipes, are screwed against the end rubber rings, being made of such a length that the number of elements used can be varied. The liquid enters the casing by the pipe at *A*, passes into the spaces between the elements, filters into the interiors of the latter, which communicate with the outlet pipes through slots in the frames corresponding with others in the pipes. The filtered liquid is drawn off by the cock *f*, the pipes *c*, *d* being joined by a pipe *e*. The filter may be provided with an air vent, and with a tap, for drawing off the last of the filtered liquid. Frames *i* may be inserted between the two thicknesses of gauze in order to hold them apart.

No. 177764/12d. **Vacuum Drum Filter for separating solids from water or other fluids with arrangement for conveying the residue away.** 19-5-04. Heinrich Hencke, Berlin.

A continuous working drum-filter is shewn in *Figs.* 302-306. The filter works with vacuum, and its characteristics consist in the fact that the vacuum acts at that part of the drum where the residue is taken off from the drum surface.

The filter drum is cased in 14 whose ends 2 are made thoroughly tight by 4. The drum is in connection with 10 in which rollers 11 for the reduction of friction are placed. The parts 8, 9 connect with the outside and pulley 12. The jacket only partly encloses the drum, and contains a curved sieve-plate 17 which between 15, 16 gradually narrows the space between it and the drum. By rotating the drum the rejected matter is pressed out, and the fluid escapes partly through 17, the remainder running forward into the vacuum space formed by 19 and 21, 3 and 20.

The residue will by means of drum 43 with similar contrivance again have some remaining fluid extracted from it and then leaves the drum by means of



Figs. 302—306

36. The filter-bed is cleaned by means of the revolving brushes 71, 75. Through 76 the wash water enters, and through 77 the mixture. The union of the drum cell with suction pump results by means of channel 23 and slit like openings 31 and 32, which through 26 are connected with the vacuum pump.

No. 178931. **Chamber Filter Press to filter acid or alkaline fluids by filter-stones disposed in pairs in a frame and reciprocally supporting each other.** 27-11-04. Golzern-Grimma Engineering Co., Grimma, Saxony, and Wilhelm Schuler, Isny, Wurttemberg.

The special property of the porous filter-stone has led to many attempts to use this material in filter presses. On the one hand disadvantages were encountered because the stones quickly became foul and time was lost in cleansing them, whilst also there were frequent breakages. The last phenomenon arises from the difference in the rates of expansion of stones and metal frames, or also from the friction of stones laid directly on each other. Breakages may be avoided by the interposition between the unyielding frames and the stone itself of an elastic cushion of a substance suitable to the nature of the fluids to be filtered. The filter-press consists of the usual frames with supporting rods and the fastening (*Fig.* 307). The fastening can be of any fashion desired. The top plates can be protected in the interior of the press by acid-proof lining, by clay or porcelain. or by paint of a resisting quality which can be relied upon. *Fig.* 308 shows the disposition of the plates in the majority of cases. The frames *R* are provided on one side with a dove-tailed groove to receive the packing ,and on the other they have a conical surface against which the packing is pressed. In the dove-tailed groove a packing-roll *k* is placed, and inside the frame asbestos packing *c* is introduced and presses directly on *k*, as is plainly shown in the sectional elevation. In each frame there are on both sides two porous filter-plates *P* so disposed that they back each other. The plates have

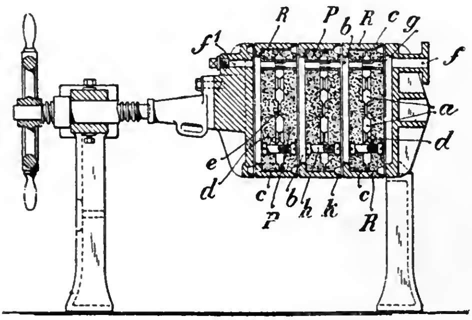


Fig. 307

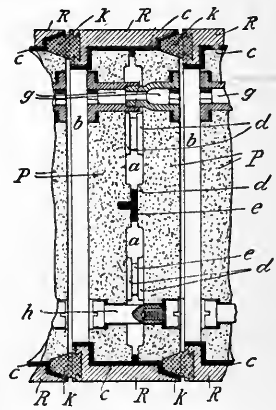


Fig. 308

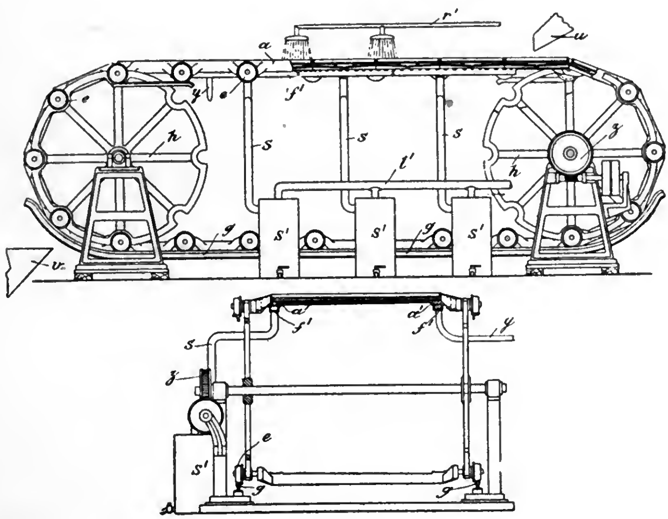
projections *d*, with elastic layers *e* between them, which make the necessary intervals for the filter chambers. The fluid passes in through the tube *f*. In the axial prolongation of the tube there exists a corresponding opening in the plates *P*, and into this opening pass two-part sockets *g* screwing into each other, and which, in conjunction with the screw-coupling *h*, hold the plates together. The filling tube which goes through the sockets *g*, which form it, is fastened to the top plate f^1 by a screw and can consequently, when there is any clogging, be easily cleaned out. The fluid presses out from the filling tube *f* and *g* into the chambers *b*, passes thence through the filter-plates, and escapes through the outlet tube. Washing out the press may be effected by a delivery pipe, the cleansing water passing out of the frame *a* through the stones to the space *b*, and escaping through the tube f^1.

There is no reason why the press should not be provided with lixiviating apparatus should it be desired, and the tubes can be disposed accordingly in that case.

No. 191296. **Apparatus for the separation of solid bodies by fluids, e.g., the extraction of gold by cyanide washing.** 10-1-05. Richard Kendall Evans, London.

A constantly working filtering arrangement is shown in *Figs.* 309 and 310. The apparatus is chiefly intended for the extraction of gold by cyanide washing, and substantially consists in a number, independent of each other, of open filter-boxes which are joined to an endless belt and actuated by means of a tube-shaped guide-path alternately by compressed air and suction piping.

Each filter-cell consists of a trough *a* furnished with a suitably adapted filtering layer. The filter-cells are joined in succession to an endless belt and are led at the ends of the machine over guide-wheels *h*. The upper guide-face is tubular-shaped, and connected by a tube l^1 with the suction device. This

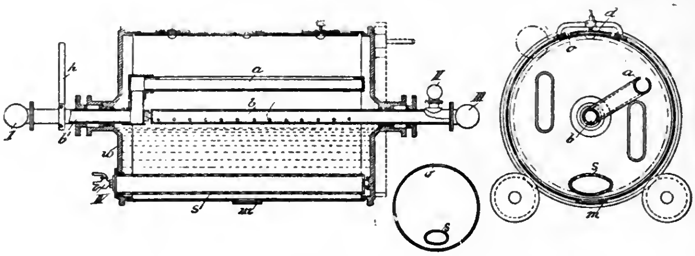


Figs. 309 and 310

tubular guide has on its upper side a slot, and troughs *a* slide on it, having saddle-shaped projections a^1 underneath, which grasp it. The projections a^1 have on their upper part a channel coinciding with the space under the filter layer, so that in a certain time the filter-cells are in connection with the tubular guide f^1. The spraying apparatus r^1 permits spraying with water or fluid solutions, and the pipes *s* conduct the various strong solutions to the receivers s^1. The guide f^1 may be connected for air-pressure with an inlet-pipe *y* to facilitate the emptying of the filter-cells. At the connecting points between the single filter-cells, guide-wheels are disposed which lead the filter-cells during their movement on the lower part of the guide-path.

No. 197495. **Rotating, partially sand-filled, filter drum, with central feed for liquor and wash water** 17-6-06. Franz Wolf, Kuttenberg, Bohemia.

In order to avoid sand and wash water loss in the drum-filter shown in *Figs.* 311-313, it has a slit tube *a* introduced, so placed that it is above the filter-bed and through whose position the height of the liquid in the drum is regulated. The drum is provided with a long opening *o*, which can be tightly closed by cover *d*. Opposite this opening *o* is fixed an oval perforated tube s



Figs. 311—313

which passes through one end of the drum and is suitably fixed at the other. Through cock IV the escape of the filtrate can be regulated. The feed of liquid to be filtered results through tube *b*, and the filtrate runs off by the tube *s* and cock IV. When the filter-bed requires washing valve II is closed and the liquid remaining in the sand displaced by wash water which enters by

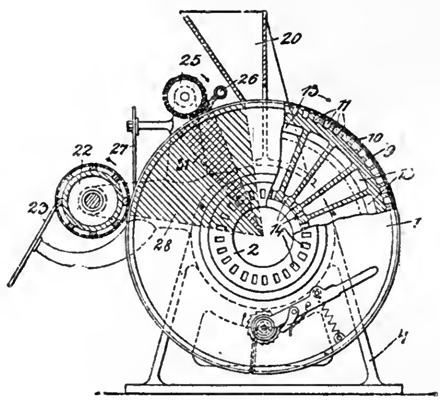


Fig. 314

cock III. The drum is turned through an angle of 180° so that the filter body can be cleaned, and the double angled tube *a* b^1 is turned to its highest position, and the washing process carried out by means of valve I. When the drum is slowly rotated the dirty water passes off by means of the opening in *a* and valve I while clean water streams through the openings in *b*. The height of the water is regulated by the height of *a*. The filter can be partly washed also from underneath by fixing a pipe to IV, clean water running in thus washing away the coarsest part of the polluted matter through *a* and b^1.

No. 211063. **Rotary Filters.** 1-9-06. Heinrich Hencke, Berlin. (English Patent, 19,431. August 31-07.)

Material is supplied to a rotary filter through a hopper 20 (*Figs.* 314-319) and the liquid filters into tapering passages or chambers 11 connected with suction means through the openings 12. The openings 12 are connected with the suction

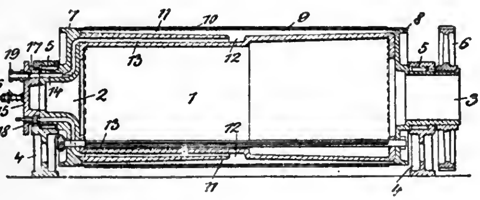


Fig. 315

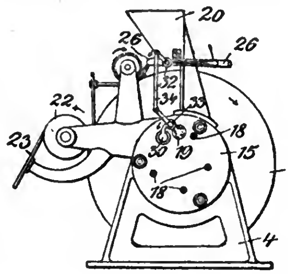


Fig. 316

pipe 19 by passages 13 and an annular passage 17 in a cover 15 which is pressed by springs 16 against the trunnion 2 of the drum. The passage 17 (*Fig.* 317) is provided with adjustable plugs 18, so that, at starting, the area under suction may be gradually increased. The passage 17 is also interrupted in the portion

Fig. 317

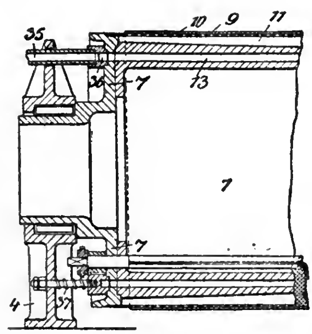


Fig. 318

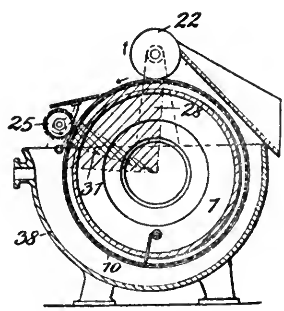


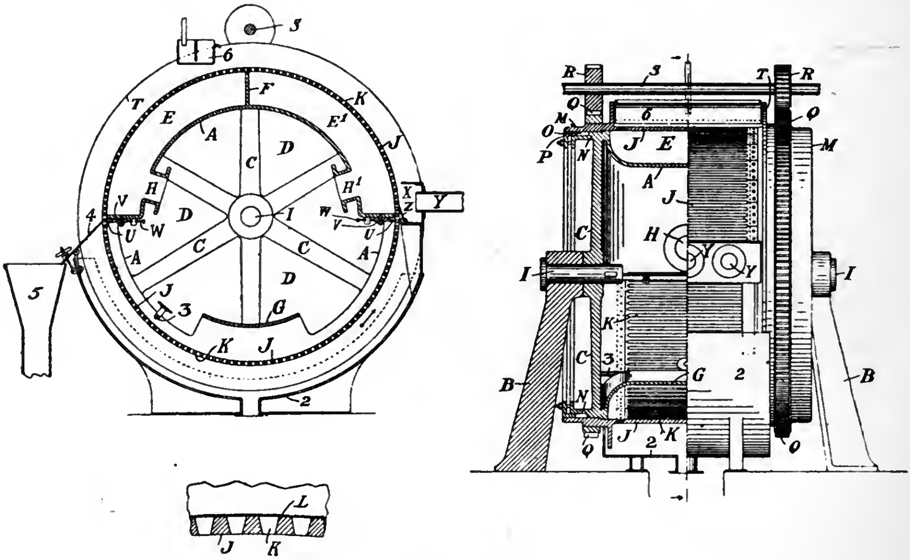
Fig. 319

24 corresponding to the part of the drum shaded in *Fig.* 314, so that there is no suction through the filter where the drum is passing an auxiliary suction cylinder 22 and a scraper 27 which remove the solid layer. In the interrupted portion 24, there is however a slot 29 connected with the pipe 19, so that there is suction under a cleaning brush 25 and a water-spray pipe 26. A valve in the connection between the slot 29 and the pipe 19 may be linked to the valve of the water pipe and the two operated together. The ends of the silk gauze,

felt or other cloth 10 covering the perforated surface 9 are connected to a shaft, which is turned automatically to adjust the tension of the cloth by means of pawl and ratchet gear, the pawl being attached to a lever connected by a spring to the drum head. Jets of compressed air may be used for cleansing instead of the water-spray, the chambers may be of infusorial earth, earthenware, wood or porous stone ; and a steam cylinder for drying the separated material may be used in conjunction with the filter.

No. 221753. **Continuous filtering, washing and drying apparatus.** 11-3-08. Thomas Train Mathieson, Tattenhall, Chester, and John Bebbington, Runcorn. English Patent, 23,221. October 21st, 1907.

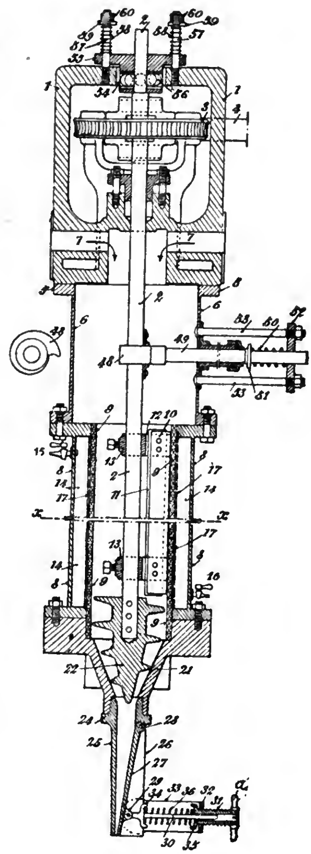
Material to be treated is supplied to a drum *J* by pipes *Y* and a box *X* (See *Figs*. 320-322). As the drum rotates, the contained liquid is drawn



Figs. 320—322

through a flannel and wire-cloth covering and the perforated or grid surface of the drum into a suction chamber E^1 formed by a stationary partition *A* and diaphragm *F*. The chamber E^1 has an outlet connection H^1. Wash water sprayed on to the drum from a tank 6 is drawn into a similar chamber *E* and the dried solids are removed by a scraper 4 delivering into a hopper 5. The filter surface is cleaned by water from a spray 3 which passes outward and is collected and discharged by the trough 2. The drum is rotated from the shaft *S*, pinions *R* on which gear with teeth *Q* on flanges *M*. The flanges *M* rotate over flanges *N* of the partition *A* which is supported by spokes *C* on shafts *I* at each end. The partition *A* does not extend all round but has a portion G at the bottom which serves to strengthen the structure and forms a platform for an attendant. There are annular stuffing boxes between the flanges *M N*, and tight joints are made at the bottom and sides of the box *X* and of the chambers *E*, E^1 respectively by means of rubber flaps *Z* and rubber pieces mounted on adjustable plates *V*. The drum may be provided with outwardly extending flanges *T*. The apparatus is specially intended for the treatment of bicarbonate of soda resulting from the ammonia soda process.

No. 224627. **Filter in which the separated matter is discharged continuously.** 21-11-08. Charles Leclaire and La Société A. et G. Héricourt, Paris. English Patent 25,213. 23-11-08.



Figs. 323—324

This patent (*Fig.* 323) relates to the construction of filters in which the separated solids are discharged continuously. The filter is applicable in the manufacture of cement, mineral whites, porcelain and ceramic products, in the treatment of faecal matters, in the drying of cellulose, and in the production of extracts and the like. The filter comprises a casing 8 within which is secured a filtering or straining cylinder 9. The filtering surface 9 consists preferably of a plait of wire, wound in spiral form and surrounded by a sheet of perforated iron or a grating, or by a series of round rods suitably spaced apart. The filtering surface may also consist of suitable filtering material secured between two concentric cylinders of wire-gauze or perforated sheet metal. The liquid is fed through the pipe 7 into the interior of the filter, and the clear liquid which passes into the space 14 is discharged by the tap 15. An additional filter may be arranged in the space 14 through which the liquid must pass on its way to the tap 15, if it is desired to further clarify the liquid. The solid matter that is deposited upon the inner surface of the cylinder 9 is removed by a scraper 10 of india-rubber or the like, secured to the shaft 2 rotated from the shaft 4 by worm gearing 3. The shaft 2 is vibrated periodically, to cause the solid matter to slide down the scraper 10, by means of a cam 48 on the shaft and a spring controlled rod or knocker 49. The solid matter passes into a conical chamber 21 in which a screw 22 on the end of the rotary shaft 2 works, so as to compress the solid matter, and force it through a valved outlet against the action of a spring or other pressure device. As shown in figure the valved outlet consists of a plate 27, hinged at 28 in a three-sided outlet 25 and acted upon by a spring 36, which is fitted between a plate 34 on a rod 30 attached to the plate 27, and a plate 35 on a screw-threaded tube 31 adjustable in a fixed yoke 32. The specification also describes the arrangement of a valved outlet, of the same construction as shown in figure, in an horizontal position radial to the conical chamber 21. The shaft 2, which rests lightly in the chamber 21 and has a tendency to rise, is supported at its upper end by the ball-bearing shown in figure. The balls 56 are arranged around the shaft between a ball race on the

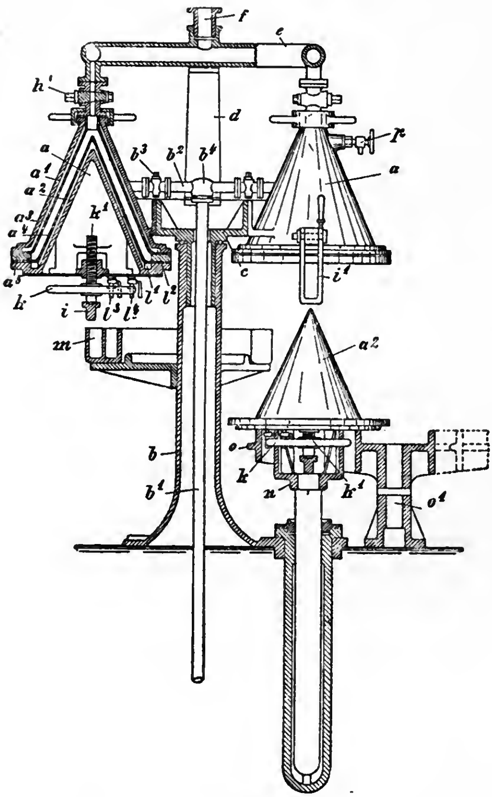


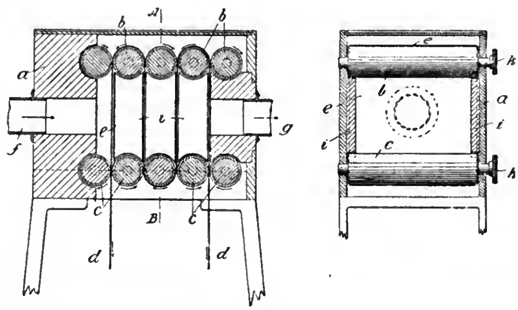
Fig. 325

shaft and a flexibly-mounted cap 55, which is threaded on bolts 57 and is acted upon by springs 58 surrounding the bolts and bearing against washers 59 secured by nuts 60 on the ends of the bolts.

No. 229066. **Continuous working filter consisting of filter chambers which revolve round a circular axis.** 20-2-08. Paul Dehne, Halle a. S., Germany.

By this apparatus, illustrated in *Fig.* 325, it is possible to remove the residue from a particular chamber without interrupting the working of the remaining filters.

Round a column b are fixed four equal-sized conical shaped chambers a which can be rotated by means of the revolving cone c to which they are fixed by means of d. The common feed-pipe f is in communication with each chamber a by means of suitable pipes. The chambers a consist of two hollow cones a^1 and a^2 which fit into one another, and are arranged in suitable manner for filtering, and a tight joint is made between the two by a washer a^5. The two cones a^1 and a^2 are firmly closed together by means of the handwheel k with spindle k^1. The filtrate runs away by means of l^1 and l^2, through the cocks l^3 and l^4 into a circular gutter m fixed in concentric manner to column b. This column also contains the pipe b^1, through which passes the wash water by means of b^2, b^3, b^4. The mixture to be filtered is forced by the pump by means of f, g, e and h into the filter chamber between a^3 and a^4 and displaces the air contained in the chamber, this air escaping by means of the cock p. The residue forms between a^3 and a^4, while the filtrate as described above runs out into m. When the filter is full, the feed is shut off by means of cock h, and the washing water passed in by means of the cock b^3. The filtrate passes away by means of l^1 and l^3. The press is cleaned by lowering the movable cone a^2 by means of a suitable mechanical contrivance which can be worked by hydraulic, electrical or other suitable power.



Figs. 326 and 327

No. 233595. **Contrivance for filtering fluids by means of moving filter-cloths.** 20-9-08. Arnold M. Manski, Almelo, Holland.

A method for the convenient removal of residue from filtering apparatus is shown in *Figs.* 326-327.

The filter-cloth or band d slowly revolves round the rubber rollers b in such a manner that it enters at one end of the press and leaves at the other. The filter-cloth or band d is supported by finely perforated plates e. The liquid to be filtered enters through pipe f, fills the space between b and c, penetrates the filter-cloth and escapes by pipe g. The sides of the chamber are covered with impermeable material i, which with the rubber rollers ensure watertightness. The filter-cloth containing the residue can be cleaned as it leaves the apparatus without interrupting the working of the filter. It is clear that this filter can only be used for the filtration of fluids which contain but a small proportion of suspended matter. The motive power for revolving the rollers b and c is supplied by means of the gearing k.

APPENDIX

PATENTS GRANTED IN THE UNITED KINGDOM RELATING TO FILTERS, FILTER PRESSES, ETC.

SUGAR JUICES AND SYRUPS.

1901—Settling, 4,834. Rotary annular filter, 7,339. Osmotic filter, 7,634. Filter press, removal of cakes, 18,373. **1902**—Closed filter, 7,693. Closed filter, 9,331. Fittings for supply and discharge, 17,491. **1903**—Pressure filter, 886. Flat strainer, 21,009. Filtering media, 27,660. **1904**—Parallel flow filters, supply and discharge fittings, 7,947. Bag-filter, 11,854. Filter press, 15,389. Open filter, 20,857. Revolving drum filter, suction, 29,358. **1905**—Electrolytic clarification, with settling or filtering, 8,661. Flat strainer for massecuite, 10,273. Centrifugal filter, 20,886. Filter press 21,569. Filtering media, 22,942. **1906**—Rotary strainer in purification apparatus, 25,860. **1907**—Settling, 4,620. Filtering media, 13,357. Filtering media, 17,607. Filter-bed, 20,677. **1908**—Discharge of filter-bed, 2,165. Settling, 25,644. **1909**—Settling, 30,080. **1910**—Press with endless band and rollers, for bagasse, 17,550. Settling, 29,581. **1911**—Combined closed filter and dissolving vessel, 133. Settling and filtering, 9,253. Filtering media, 21,204. Filter press, 22,560. **1912**—Pressure or suction filter, with built-up elements, 7,232. Open filter, 8,106. Plates for filter presses, 12,737. Elements for pressure or suction filters, 14,388. Plates for filter presses, 14,429. Multiple funnel filter, 14,764. Pressure filter, with built-up elements, 15,015. Modified filter press, 18,584. Support for filtering medium, 19,317. Multiple bag-filter, 21,200. Closing of filter press, 28,985. **1913**—Revolving drum strainer, with removal of solids, 2,118. Pressure filter, 2,374. Centrifugal strainer, 19,123.

SEE ALSO: Miscellaneous Products of Slimy, etc., Substances; and Syrups.

BEER, WINE, SPIRITS, AERATED WATERS.

1901—Bag-filter, 3,173. Filter for casks, 4,381. Filtering media, 5,529. Plates for filter press, 7,063. Filtering funnel for casks, 7,869. Filtering media for spirits, 10,287. Filter press for grains and hops, 10,813. Filter press for worts, 16,032. Multiple bag-filter for worts, 20,895. **1902**—Plates for filter press, for mash, 8,015. Filter press for worts, tiltable, 8,392. Pressure filter, with built-up elements, 17,694. Pressure filter, 19,027. Apparatus for cleansing filtering media, 19,821. Apparatus for cleansing filtering media, 20,216. Yeast strainer, 20,365. Pressure filter with built-up elements, 22,256. Filtering media for spirits, 25,438. Flat strainer for beer, 25,719. **1903**—Revolving series of open filters, for mash or worts, 1,073. Pressure filter, 6,725. Filtering media, for distiller's refuse, 7,658. Bag-filter, 8,599. Pressure filter, for beer, 8,698. Filter press, for mash, 9,229. Filtering media, 11,223. Filtering media, 15,935. Yeast strainer, 18,739. Bag-filter, 19,796. Discharging distiller's slops from filter presses, 23,230. Strainer, for mash-tun, 25,582. **1904**—Strainer, for mash-tun, 3,080. Pressure filter, for aerated liquids, 10,753. Series of filter tanks for wine and other distilled liquids, 17,772. Filter, for waste beer, 20,342. Frame for filter press, for mash, 24,446. Tun for mashing and filtering, 26,554. Pressure filter, for pot-ales, 29,573. **1905**.—Filter, for beer casks, 6,797. Filter, for waste beer, 7,054. Strainer, for beer-pipes, 7,090. Decanting yeast from vats, 8,370. Pressure filter with built-up elements, 8,984. Apparatus for cleansing filtering media, 12,765. Pressure filter with built-up elements, 18,833. Apparatus for cleansing filtering media, 20,996. Multiple bag-filter, for wine, 21,197. Automatic filter press, for wine, 21,569. Strainer, for beer-pipe, 25,790. **1906**—Strainer, for scum of fermenting tun, 2,198. Pressure filter, 2,992. Mash tun as filter, 4,552. Decanting device, 6,399. Floating decanting device, for backs, 6,655. Pressure filter with built-up elements, 9,502. Funnel strainer, for bottles, 12,015. Centrifugal filter, 13,563. Press, and pressure filter, with built-up elements, 15,046, 24,327 and 29,723. Packing, for plates of filter presses, 15,529. Pressure filter with built-up elements, 17,985. Strainer, for beer-pipes, 20,584. Pressure filter, for aerated liquids, 22,309. Box filter, for mash-tun, 29,484. **1907**—Filter in wort-cooling apparatus, 1,101. Pressure filter, 2,126. Filter-bottom of mash-tun, 4,174. Pressure filter 10,610. Floating (decanting) filter, 13,556. Bag-filter, for waste beer, 21,514. Strainer-bottom of mash-tun, 25,356. Open filter, for malt extract and paste, 26,582. **1908**—Cleansing of fat from filtering media, 3,837. Frames for filter presses, 5,944. Electrolytic filter, 6,969. Pressure filter with built-up elements, 9,207. Pressure filter, with built-up elements, 9,208. Pressure filter, with built-up elements, 12,320. Pressure filter, with built-up elements, 26,661. Decanting and settling of wort, 27,956. **1909**—Bag-filter, for waste beer, 1,906. Pressure filter, 4,297. Filter press, 5,583. Multiple candle filter, 6,760. Tap strainer, 12,129. Bag-filter for casks, 15,220. Bag-filter, for aerated water machines, 21,344. Pressure filter, with built-up elements, and device for compressing filtering media, 28,242. **1910**—Pressure filter, for wine, cider, etc., 4,329. Anti-clogging discharge pipe, 7,278. Pressure filter, for wine and beer, 10,619. Filter press, for cider making, 18,485. Pipe strainer and foam producer, 22,343. **1911**—Bag-filter, for waste beer, 8,494. Closed filter, for waste beer, 12,540. Strainer, for beer pumps, 19,407. Rotary filter press and strainer for hops, 23,829. Screw-compressor strainer, for draff, etc., 26,750. Valve, for discharge pipe, 27,218. Strainer elements, for mash-tuns, hop backs, etc., 29,070. **1912**—Closed filter, for waste beer, 1,766. Filtering funnel, 14,764. Multiple candle filter, for aerated water machines, 15,015. Closed filter, 16,973. Filtering and sterilizing media, 17,472. Pressure filter, 17,559.

PAPER PULP, CELLULOSE, WOOD PULP, ETC.

(INCLUDING FACTORY EFFLUENTS).

1901—Travelling band filter, 19,237. Travelling band filter, 22,852. **1903**—Open straining tank, with spiral conveyer for discharge of solids, suction, 2,560. Draining tiles, 7,262. Travelling band filter, 8,061. Flat strainer, 21,200. **1904**—Travelling band filter, 10,071. Screw-compressor strainer, 14,484. Oscillating cylindrical strainer, 16,245. Oscillating cylindrical strainer, 29,050 **1905**—Revolving drum strainer, 2,774. Pressure filter, 5,766. Gear for revolving cylindrical strainer, 5,805. Bellows strainer, 12,058. Drainers for bleaching towers, 19,808. Revolving drum strainer, 21,415. **1906**—Jogging and revolving gear, 7,069. Revolving drum strainer, for effluents, 16,009. Revolving drum strainer, for effluents, 17,997. Settling apparatus, 25,116. Settling apparatus, 28,977. **1907**—Jogging and revolving gear, 1,820. Screw-compressor strainer, 8,924. Travelling band strainer, 11,925. Oscillating drum strainer, 14,804. Settling apparatus, for effluents, 19,288. Travelling band filter, 22,732. Screw compressor strainer 25,213. Flat strainer, 26,296. **1909**—Revolving drum strainer, 1,684. Revolving drum strainer, 5,231. Settling apparatus for effluents, 8,593. Travelling band filter, 14,662. Revolving drum strainer, 16,220. Oscillating flat strainer, 19,366. Screw compressor strainer, 23,981. Annular strainer, for effluents, 25,587. Rocking device for strainers, 26,092 **1910**—Flat strainer, and settling, 496. Revolving drum filter or strainer, 2,297. Revolving drum filter or strainer, 2,415. Oscillating cylindrical strainer, 8,599. Revolving drum filter or strainer, 9,865. **1911**—Revolving drum filter, 332. Oscillating device, 13,199. Screw compressor for removing cellulose from pressure filter, 13,512. Travelling band strainers, 21,603. Oscillating flat strainer, 23,892. Revolving strainer for pulp-beating engine, 27,867. Revolving drum strainer, 28,409. **1912**—Revolving drum strainer 3,414. Revolving drum strainer, 4,486. Revolving drum strainer, 6,552. Hydraulic press, 7,893. Revolving and reciprocatory drum strainer, 8,398. Reagent for effluents, 11,614. Settling, for effluents, 12,574. Jogging device for revolving strainer, 13,533. Elements for pressure or suction filter, 14,388. Settling, for waste waters, 14,644. Purifying lye from sulphite cellulose, 19,600. Vibratory mechanism for revolving strainers, 23,191. Chemical method, 25,385. Rotating conical strainer, 26,540. **1913**—Jogging device for revolving strainer, 2,742. Pneumatic joint for revolving strainer, 2,743.

ORES, SLIMES, CYANIDES, ETC.

1901—Travelling band filter, 26,667. **1902**—Settling and bag-filter, continuous discharge, 1,562. Pressure filter, 7,841. Pressure filter, 24,419. **1903**—Strainers, and travelling band filter, 762. Flat strainer, 21,200. Revolving drum filter, 26,391. **1904**—Endless series of boxes, suction, 3,962. Suspended filter, suction, 7,210. Door for discharging oilings, 8,154. Travelling band filter, suction, 8,605. Pressure filter, 8,817. Open tank filter, 9,635. Settling, precipitating reagent, 13,481. Endless series of boxes, suction, 15,776. Travelling band strainer, 24,386. **1905**—Travelling band filter, 149. Filter press, 5,970. Settling, with continuous discharge, and closed filter, 6,534. Settling, and travelling band strainer, 11,237. Open tank filter, 20,941. **1906**—Settling, 994 Settling, 1,004. Revolving series of trays, suction, 11,623. Bag-filter, 20,979. Bag filter, 22,187. Bag-filter, multiple, 27,592. **1907**—Revolving series of trays, suction, 13,569. Continuous discharge of solids from pressure filter, 15,350. Settling, 26,821. **1908**—Multiple candle filter, suction, 1,582. Settling, 2,479. Annular filter, suction, 2,815. Annular filter, suction, 5,830. Settling, and open filter, 6,414. Pressure filter for copper matter, 12,750. Settling, 17,756. Revolving Drum Strainer, 20,400. Revolving series of filter trays, suction, 21,452. Suspended open filter, 21,474. Revolving drum filter, suction, 23,189. Settling, 27,767. **1909**—Revolving series of filter frames, suction, 1,315. Settling, and strainers on travelling band, 2,156. Revolving drum filter, suction, 4,045. Pressure filter, 4,358. Bag-filter, 13,440. Travelling band filter, suction, 14,662. Revolving series of bag-filters, 17,088. Revolving series of boxes, 18,060. Settling, 24,402, 24,403, and 28,509. Multiple bag-filter, 28,625. Revolving drum filter, 28,945. Travelling band filter, 29,360. Revolving multiple filter, suction, 29,445. Settling, 29,755. Revolving drum filter, 30,586. **1910**—Settling, 2,307. Settling, 3,488. Screw-conveyer for settling tank, 6,977. Screw-conveyer for settling tank, 12,062. Settling, and multiple bag-filter 12,471. Revolving drum filter, 16,156. Revolving drum filter, 16,161. Settling, 28,376. Settling, 28,500. Settling, and detecting amount of deposit, 29,383. **1911**—Revolving series of filtering boxes, suction, 608. Filter press elements: 2,800, 2,802, and 2,803. Settling, and open filters, 9,258. Supplying and discharging of filter in copper-extracting apparatus, 12,304. Double travelling band for expression, 20,146. **1912**—Revolving strainer, 6,902. Swinging filter elements, suction, 10,731. Method of supporting woven media, 19,317. Settling, 23,165. Settling and filtering, 24,009. Series of flat strainers, 28,675.

FINE COAL AND COAL WASHINGS.

1903—Strainers, and travelling band filter, 762. **1904**—Travelling band filter, 28,532 Pressure or suction filter, 29,573. **1905**—Settling and revolving open tank filter, 9.464. Settling, and travelling band strainer, 11,237. Settling, 25,135. Settling, and straining-floors, 26,475. **1906**—Travelling band filter, 20,699. Settling, 28,977. **1907**—Pressure strainer, 10,062. **1908**—Straining troughs, 7,369. Removal of solids from settling tanks, suction, 10,303. **1909**—Settling, and strainers on travelling band, 2,156. Pressure strainer, 13,097. Revolving drum strainer, 20,943. **1910**—Travelling band filter, 7,109. Flat strainer, and bucket wheel, 14,160. Pressure strainer, 23,215. Settling, 28,927. **1911**—Settling, 27,528. **1912**—Settling, 5,183. Flat screen, 20,078. Series of flat strainers, 28,675.

POTTERS' SLIP.

1903—Filter press, 1,194. **1904**—Plates for filter press, 2,211. **1905**—Trays for filter press, 26,670. **1906**—Filter press, 8,374. **1907**—Pressure filter, 9,635. **1908**—Screw-compressor strainer, 25,213. **1910**—Pressure filter, 24,543. Plates for filter press, 26,231. **1911**—Pressure filter, 11,163. **1912**—Nozzles and cloths for filter press, 15,503. Fixing of taps to filter press, 18,306.

SEE ALSO: Miscellaneous Products (Clays, Sands, etc.)

MISCELLANEOUS PRODUCTS.

CLAYS, SANDS, &c. **1902**—Flat strainer, 26,572. Flat strainer, 28,788. **1909**. Revolving drum filter, 28,945. **1910**—Revolving drum filter, 10,903. **1912**. Removing solids from settling tank, 18,388. Electro-osmotic filter, 23,545. Revolving drum strainer 25,548. Series of flat strainers, 28,675.

PAINTS, WHITE LEAD, &c. **1901**—Settling and filtering, 11,337. Flat strainer, 14,683. **1902**—Flat strainer, 18,632. Flat strainer, 25,719. **1905**—Automatic filter press, 21,569. **1907**. Mixer and strainer, 4,719. Bag-filter, 7,453. **1908**—Mixer and strainer, 19,858. Screw-compressor strainer, 25,213. **1909**—Mixer and strainer, 79. Flat strainer 4,261. Mixer and strainer, 8,495. Flat strainer, 9,062. **1910**—Revolving filter or strainer, 15,609. **1912**—Flat strainer, 11,334. **1913**—Mixing and straining, 13,391.

VARNISHES. **1905**—Filtering media, 22,942. **1907**—Filtering media, 13,357. Filtering media, 17,607. **1909**—Centrifugal filter with built-up elements, 30,070. **1912**—Filter funnel, 17,674.

INORGANIC CHEMICALS. **1901**—Filtering media, 16,493. **1903**—Filter press, 4,625. Pressure filter, 7,363. Pressure filter, 17,895. Annular filter suction, 28,791. **1904** Multiple funnel filter, 3,428. Pressure filter, 8,817. Pressure filter, 18,899. **1907**—Multiple funnel filter, 3,424. Revolving drum strainer, 23,221. **1910**—Bag and funnel filter, 8,546. Filter for pipes, 8,969. **1911**—Funnel filter, 11,352.

BRINE. **1902**—Strainer for vacuum pan, 20,002. Filter, 28,600 **1906**. Apparatus for supplying reagent, 958. **1910**—Filter, 30,221. **1912**—Open filter, 20,066.

MOLTEN METAL. **1902**—Filter, 13,614. **1904**—Strainer, 23,290.

LIQUID AIR. **1904**—Filter, 14,431.

TAR. **1908**—Open filter, 22,853. Pressure filter, 24,756. **1909**—Bag-filter or strainer, 1,212.

VASELINE. **1901**—Filtering media, 14,329.

WAXES. **1901**—Filtering media, 14,329. **1908**—Open filter, suction, 10,277. **1909**—Multiple bag-filter, 18,120. **1910**—Filtering media, 20,649.

ALCOHOL. **1905**—Filtering media, 22,942. **1907**—Filtering media, 13,357 and 17,607.

VOLATILE LIQUIDS. **1904**—Pressure filter with built-up elements, 10,753.

PERFUMES. **1901**—Bag-filter, 3,173. **1903**—Open filter, 886.

SLIMY, VISCOUS, COLLOIDAL SUBSTANCES. **1904**—Filter press, 15,389. **1905**—Flat strainer, 12,317. **1908**—Combined filter and spinner, 7,600. **1909**—Filter or strainer, 12,739. **1911**—Hollow stone filter, 12,720. Filter press, 22,560. **1912**—Open filter, 8,106. Funnel filter, 14,764. Modified filter press, 18,584.

RESINS. **1905**. Filtering media, 22,942. **1907**—Filtering media, 13,357 and 17,607.

GLUE, GELATINE, GUM. **1901**. Extractor with filter, 24,602, 24,603, and 24,604. **1909**—Flat strainer, 12,739. Open filter, 28,297. **1910**—Open filter. 14,360.

GUN-COTTON. **1905**—Hydraulic press, 108.

SOAP. **1905**—Flat strainer, and mixer, 12,317. **1909**—Revolving drum strainer, and mixer. 79.

GLYCERINE. **1901**—Filtering media, 14,329. **1902**—Strainer for vacuum pan, 20,002. **1904**—Filtering media, 24,100. **1905**—Filtering media, 22,942. **1907**—Filtering media, 13,357 and 17,607.

TALLOW, LARD, BUTTER. **1901**—Filtering media, 7,802 and 14,329. **1902**—Flat strainer, 25,719. **1904**—Settling, 28,374. **1906**—Settling and filtering, 4,481. Strainer, suction, for separating stearine, 11,877. **1907**—Screw-compressor strainer, 8,924. **1909**—Screw-compressor strainer, 23,981.

MILK (STRAINERS AND FILTERS). **1901**—21,112. **1902**—18,249, 18,566, 27,245. **1903**—14,969, 22,783, 28,757. **1904**—110, 5,461, 7,201, 17,532, 18,189, 20,292. **1905**—3,159, 7,577, 16,690, 18,255. **1906**—9,006, 9,573, 14,505, 17,607. **1907**—10,764, 14,800, 15,919, 27,191. **1908**—2,287, 2,689. **1909**—28,691. **1910**—16,779. **1911**—27,580. **1912**—93,6, 551, 13,486, 24,027. **1913**—6,762.

CHEESE, ALBUMENS. **1909**—Hydraulic press, 15,028. **1910**—Hand-press, 13,909. **1911**—Filter press, 27,126.

BLOOD SERUM. **1909**—Strainer, 30,224.

SYRUPS. **1903**—Open filter, 886. **1910**—Bag-filter, 3,452. **1912**—Open filter, 8,106.

JUICES, EXTRACTS, ESSENCES. **1902**—Filter press, 8,392. **1903**—Bag-filter, 2,452 **1904**—Revolving drum filter, suction. 29,358. **1907**—Floating filter, 5,489. **1908**—Screw compressor strainer, 25,213. **1909**—Centrifugal filter, 30,070. **1910**—Hand-press 13,909. **1912**—Flat strainer, 13,486

SAUCES, JAMS. **1903**—Open filter, 886. **1909**—Revolving strainer and mixer, 79.

STARCH, FLOUR—Flat strainer, 12,106. **1905**—Flat strainer, 7,483. **1907**—Screw compressor strainer, 8,924. **1909**—Screw compressor strainer, 23,981. **1910**—Centrifugal filter, 28,847.

GRAIN, MALT. **1904**—Revolving drum filter, suction, 29,358. **1905**—Filter press, 21,569. **1908**—Revolving drum strainer, 9,691.

PEAT (INCLUDING CARBONIZED). **1904**—Revolving press, 28,456. **1906**—Hydraulic press, 10,187. **1908**—Double travelling band press, 3,738. **1910**—Revolving filter or strainer, 10,903. Double travelling band press, 13,656. Hydraulic press, 23,215. **1911**—Double travelling band press, and filter press, 4,684. Hollowstone filter, 12,720. Filter trays, suction, 15,326. Double travelling band press, and filter press, 17,610. Hydraulic press, 24,819. **1912**. Electro-osmotic filter, 23,545. Preparation for filter press, 24,639. Chemical method, 25,385.

SEWAGE.

1901—Chemical method, settling, treatment of sludge, 10,838. Open filter, and distributing apparatus, 13,832. Air-domes for creating vacuum, 17,581. Series of filter-beds, 18,405. Series of filter-beds, 21,316. **1902**—Series of filter-beds, 1819. Sloping open filters, 9,920. Series of open filters, 22,213. **1903**—Series of filter-beds, with septic tank, 6,927. Series of filter-beds, with septic tank, 9,151. Filter for testing bacterial action, 9,452. Series of septic tanks, 11,075. Series of filter tanks, with manure extraction, 11,890. Filtering media and method, 14,258. Filtering media, 15,555 Closed filter with ammonia extraction, 15,752. Settling, series of open filter tanks, 16,468. Filter-bed, 16,494. Box strainers, 19,599. Method of aeration, 25,480. **1904**—Method of aeration, 2,808. Straining, filtering and burning, 7,940. Floating filter, 8,857. Series of filter-beds, 8,944. Filter-bed, 9,219. Preliminary straining, 10,539. Siphonic discharge of solids 10,867. Series of septic tanks, 11,900. Settling, straining and filter-bed, 14,003. Series of open filters, 19,444. Revolving series of filtering boxes, 20,889. Filtering media, 22,724. Filter-bed, and septic tanks, 25,591. Open filter tank, chemical method, 28,239 Multiple bag-filter, 28,470. **1905**—Flat strainer, with cleansing brush, 1,101. Settling, 2,520. Filter-trays, 5,251. Pressure filter, 9,523. Septic tank and open filter tank, 10,382. Endless series of flat strainers, 11,231. Pressure filter continuous removal of solids, 12,481.

Settling, and straining, 12,797. Settling and open filter, 15,514. Septic tanks and filter, 17,383. Septic tanks and open filters, 24,322. Revolving drum strainer, 27,155. Septic tanks and filter, 27,275. **1906**—Flat strainers revolving on axle, 1,636. Filtering media 3,240. Settling, and straining (domestic), 5,908. Series of filter-beds, 13,264. Filtering media, 15,922. Filtering media, 16,890. Filtering media, 17,948. Endless series of flat strainers, 19,250. Series of filter-beds, 20,440. Septic tanks and filters, 21,444. Tilting box strainer, 23,455. Open filter tank, with distributing apparatus, 24,172. Removal of solids from settling tanks, 25,116. Series of filter-beds, 28,585. Settling, 28,977. **1907**—Series of septic tanks, 25. Closed filter tank, 8,899. Septic tank, and open filters, 14,704. Series of filter-beds, 14,981. Chemical method, settling, 16,239. Settling, and open filter, 17,325. Filter-bed, 17,389. Cloth-covered filter-bed, 21,647. Septic tank, and closed filters, 25,362. **1908**—Filter-bed or closed filter, 3,357. Rake from sewage screen, 3,623. Settling, and revolving drum or centrifugal strainer, 7,072. Apparatus for scarifying surface of beds, 7,365. Aeration of sewage, 8,722. Septic tank, and open filters, 9,636. Addition of matter to form film on beds, 9,665. Filter-bed, 10,557. Rake for sewage screen, 16,059. Filter-bed to follow septic tank, 16,222. Chemical method, settling, 16,725. Series of filter-beds, 17,244. Revolving drum strainer, automatic removal of solids, 20,623. Series of filter-beds, 26,013. **1909**—Reagent for removing chlorine, 3,023. Open filter tank to follow septic tank, 11,471. Electrolytic method, settling, and filtering, 14,439. Revolving series of curved strainers, 16,837. Filter-bed, 19,483. Filter-bed, 19,734. Filter-bed, 23,978. Filtering media, 24,741. Revolving drum filter, 28,945. Series of filter-beds, 29,032. Vertical strainer, with removal of deposit, 30,328. Revolving drum filter, 30,586. **1910**—Open filter tank, louvred and fluted walls, 1,033. Series of open filter tanks, 2,875. Series of open filter tanks, 12,462. Flat strainer, and travelling band strainer, 18,985. Revolving drum filter, with drying of solids, 22,251. Series of open filter tanks, 25,225. Series of filter-beds, 28,361. **1911**—Series of septic tanks, 3,263. Settling, 9,258. Closed filter tank, 11,123. Apparatus for adding chlorine, 15,430. **1912**—Settling, 2,213. Open basin for sludge fermentation, 3,535. Valve for supply-pipe, 3,699. Collecting nozzle, 4,406. Media, containing components for beds, 5,983. Series of septic tanks, 13,659. Applying heat to beds, for destroying insect life, 14,198. Elements for pressure or suction filter, 14,388. Settling, 14,644. Reagent for entangling and precipitating, 15,243. Yeast fermentation method, filter-beds, centrifugal hydro-extractor, 16,237. Settling, 18,433. Settling, open filter, drying of sludge, 18,502.. Modified filter press, 18,584. Open filter, folded, woven medium, 20,899. Chemical method, filtration, recovery of solids as fertilizer, 24,356. Series of septic tanks, 29,192. **1913**—Settling, 1,840.

See also : Filter-beds, Linings, etc. ; Filter-beds, distributing, etc., Liquid ; Filter-beds, supplying, etc., Liquid ; Filter-beds, removing, etc., of Media.

WATER-CLOSET AND URINAL FILTERS AND STRAINERS. **1904**—23,065. **1907**—10 536, 12,493.

TREATMENT OF SOLIDS FROM SEWAGE, GARBAGE, ETC.

1901—Sludge strainer, 10,838. **1903**—Drying of garbage, includes screw compressor strainer, 2,561. Includes Preparation as manure, 11,890. **1904**—Includes burning, 7,940. **1905**—Filter press, 544. Includes making into fuel, 1,776. Automatic filter press, 21,569. **1907**—Screw compressor strainer, 8,924. **1908**—Night-soil strainer, 1,356. Screw compressor strainer, 25,213. **1909**—Revolving drum strainer for concentrating suction, solids removed by pressure, 20,445. Screw compressor strainer, 23,981. **1910**—Double travelling band for expression, 13,656. Travelling band-and-roller press, 17,550. Includes drying of solids, 22,251. **1911**—Straining and concentrating, 28,328. **1912**—Open basin for sludge fermentation, 3,535. Enrichment with phosphate, for manure, 15,247. Chemical method, removal of water, 25,385. **1913**—Odourless decomposition, apparatus for 9,092.

EXTRACTION OF OIL AND GREASE FROM SEWAGE, GARBAGE, ETC.

1903—2,561, 14,461, **1904**—14,482, 14,483, 14,484, 14,709, 15,235. **1905**—15,514, 23,670, 24,030. **1907**—8,924. **1909**—23,981.

INDUSTRIAL WASTE WATERS, ETC.

1901—(Breweries, etc.), 7,388. Strainer for sludge extracted from water, 10,838. (Paper mills), 19,237. (Woolcombing, dyeworks, etc.), 19,349. Filter-beds, series, 21,316. **1902**—(Sugar-works, etc.), 3,896 Bag-filter, 18,779. (Tinning and Galvanizing works), 22,860. (Wool-washings, etc), 24,482. **1903**—Settling and filtering, 4,430. Media (distilling, dyeworks, etc.), 7,658. (Paper and cellulose), 8,061. (Coal-washings), 15,986. (Bleaching, etc., works), 19,916. (Glucose works, distillers' slops), for cattle food, 23,230. **1904**. (Breweries, Paperworks, etc.), 8,461. (Dyeworks), 11,317. Chemical, settling and filtering, 28,239. **1905**—(Dyeworks), 11,410. (Dyeworks, tanneries, etc.), 12,481. **1906**—(Hatters' sizing water), 11. (Screw-cuttings in oil), 16,996. (Grain washings), 20,773. (Grain washings), 20,780. Pumping sediment from tanks, 25,116. **1907**—(Removal of arsenic), 974. (Removal of arsenic, and for jewellers' washings), 3,557. (Textile factories), 6,562. (Sheep-dipping, washings from), 11,885. Filter-bed, 17,389. **1909**—(Electro-zincing residues), 11,842. (Rubber devulcanizing,) 12,250. (Engraving ink residue), 13,679. Settling and filtering, with sterilizing, 28,360. **1910**—Filter-bed, 579. Filter-tanks in series, 25,225. **1911**—(Dyeworks), 1,327. Settling, filtering (open), 9,258. (Textile works), 19,718. (Rubber factories), 21,566 and 21,567. (Wheat washings), 24,544. (Tan waste, spent grain, and dyework wastes), 26,750. **1912**—(Tanneries), 2,190. Settling, 2,213. Filter-beds, 6,003. (Wool-washings), 7,060. Reagent (paper mills, tanyards, wool-washing works, etc.), 11,614. Settling (paper mills), 12,574. Settling (paper mills) 14,644. Modified filter press (slimy wastes), 18,584. Chemical method, settling, 19,303. Open filter, folded, woven fabric, 20,899. Settling, recovery of grease, 26,362. **1913**—Chemical method, and filtering (soapy water from laundries to be used again), 10,280.

PURIFICATION OF WATER.

1901—Settling, Pressure-filter, 9,342. Centrifugal, 9,982. Chemical treatment, settling, 11,354. Open tank filter, 14,403. Chemical method, settling, 16,472. Candle filter, 19,840. **1902**—Filter-bed, ozonation, 3,492. Open tank filter, sterilization by boiling, 3,731. Filter-bed, 21,015. Filter-bed, 22,213. Settling, filter-bed, 22,389. Multiple candle filter, 23,548. **1903**—Rotary candle filter, 7,306. Settling, ozonation, 20,163. Settling, use of exhaust steam, 21,668. Pressure filter, 22,570. Settling, 23,483. Filter element, 28,328. Compound open filter, 28,578. Chemical treatment, 28,586 **1904**—Spherical or cylindrical filter for power, 3,050. Pressure filter, 7,080. Settling basin, 13,436. Filtering boat, 16,826. Chemical treatment, settling and filtering (open), regulation of reagent, 18,083. Chemical treatment, settling, 20,984. Chemical treatment, settling, 21,558. Open tank filter, stirring device, 21,644. Chemical treatment, open filter, regulation of reagent, 28,239. **1905**—Candle filter, 6,876. Pressure filter, 9,523 Rotary series of flat strainers, 10,790. **1906**—Filter-bed, with candle filter, 5,256. Settling, filter-bed, 5,751. Chemical treatment, 10,080. Chemical treatment, pressure filter, and for neutralizing and alkalizing, 14,464. Filtering media, 16,890. Settling ozonation, 17,267. Apparatus for removing sediment from settling tanks, 25,116. Travelling open filter for side of reservoir, 26,796. Chemical treatment, settling, open filter, 29596. **1907**—Floating decanting filter, 5,489. Bed of stream, as filter, 7,522. Series of filter-beds, 14,981. Chemical treatment, settling, 16,239. Multiple candle filter, 26,615. **1908**. Suction filter, closed, 7,400. Settling basin, 7,505. Chemical treatment, settling, 16,725. Filter-bed, settling, 17,244. Revolving drum strainer, continuous removal of deposit, 20,623. Chemical treatment, pressure filter, 22,524. Open filter tank, 23,001. Settling tank, 25,644. Candle filter, 27,089 **1909**—Open filter tank, 1,716. Cylindrical filter, pressure, rotates for cleansing, 2,101. Chemical treatment, filtering or settling, 3,023. Open filter, settling, 12,870. Filter-bed, 23,978. Multiple candle filter, 24,811. Pressure filter, 29,863. Filter element, spiral ribbon, 30,303. **1910**—Candle filter, 2,122. Series of open filter tanks, 3,034. Bag-filter, 3,452. Settling, open filters, 9,372. Closed filter, circulation of sand, 14,487. Series of open filter tanks, 16,685. Cleansing device for open filter, 19,425. **1911**—Series of filter-beds, 7,659. Settling, open filter, 9,258. Open and pressure filter, 22,955. Pressure filter, with stirring device, 23,906. Chemical treatment, settling, pressure-filter, regulation of reagent, 24,936. **1912**—Pressure filter, 813. Collecting nozzles for beds, 4,406. Pressure filter, 9,668. Removal of solids from settling tank, suction, 11,137. Air-supplying nozzle for beds, 14,473. Fitting for washing arms in pressure filter, 18,320. **1913**—Chemical method, 1,416. Settling 1,840. Filter for radiators of automobiles, 6,529. Filter-bed, 12,163. Open filter, 16,050. Chemical method, settling, and closed filter, 16,395.

See also : Filter-beds, Distributing Liquid, filter-beds, supplying, etc., liquid, filter-beds, linings, etc. Removing, etc, etc. of media, Water Softening, Regulation of Reagent.

ELECTROLYTIC FILTERS (PURIFYING OR SOFTENING OF WATER).

1901—3,313, 7,806. **1902**—10,874, 14,644, 25,041. **1903**—1,335, 8 175, 10 094 12,191, 12,522. **1904**—17,532. **1905**—9,216, 18,427. **1906**—8,332, 13,023, 25,940. **1907**—13,522, 23,145, 25,222. **1908**—5,774, 6,969, 14,248, 26,477, 27,270, 27,271 27,272. **1909**—14,439. **1910**—1,459, 23,123. **1912**—23,545.

TAP FILTERS AND STRAINERS.

1901—293, 2,975, 8,441, 13,947, 16,364, 18,334, 19,840. **1902**—7,874, 23,909. **1903**—12,297, 28,297, 28,252. **1904**—8,658, 16,652. **1905**—6,876, 6,979, 7,794, 7,810, 17,739.

1906—10,542, 29,477. **1907**—15,256, 19,910. **1908**—5,774, 8,235, 14,155, 14,674. **1909**—66, 9,190, 12,129, 16,259, 17,585. **1910**—25,829, 28,280. **1911**—918, 3,142, 12,355, 19,719, 20,150, 27,423. **1912**—2,543. 20,330.

SERVICE-PIPE FILTERS AND STRAINERS.

1901—19,840. **1902**—7,874. 13,231. **1903**—12,297. **1904**—8,658 21,885. **1905**—6,986, 7,090. **1907**—8,160, 27,435. **1908**—1,846, 8,235, 12,896, 18,716. **1909**—16,259. **1910**—25,829, 28,229. **1911**—28,179.

SUCTION PIPE FILTERS AND STRAINERS (for WELLS, etc.)

1901—16,364, 21,284. **1902**—1,787. **1903**—7,874. **1905**—17. **1906**—19,050, 23,488. **1907**—17,891, 18,871. **1908**—11,536. **1909**—14,656. 23,436. **1910**—3,716. **1911**—7,742 24, 501. **1912**—5,552, 10,653 **1913**—471.

DOMESTIC FILTERS AND STRAINERS (WATER, BEVERAGES, ETC.)

1901—10,712, 18,334, 19,840, 19,841. **1902**—4,470, 23,548, 28,409. **1903**—14,969. **1904**— 13,410, 16,652. **1905**—21,431. **1906**—13,058, 26,160. **1907**—11,447, 16,480, 17,917, 23,569. **1909**—2,034, 15,077, 23,436. **1910**—175, 5,692, 7,653, 16,685, 20,577, 26,456, 28,229, 26,235. **1912**—1,412, 3,247, 17,577, 20,122, 21,608, 22,667, 23,440. 29,549.

PORTABLE FILTERS AND STRAINERS (POCKET, CART, ETC.)

1901—16,364, 22,897, 24,380. **1902**—2,171, 13,680, 14,710, 26,857. **1903**—6,599, 24,149, 26,205. **1904**—16,652. **1905**—22,994. **1906**—7,730. **1907**—6,793, 12,953. **1908** 12,246, 27,089. **1909**—16,259, 23,436. **1910**—8,835, 26,456, 29,965. **1911**—8,414, 16,877. **1913**—3,687, 16,050.

FILTERS, STRAINERS, ETC., FOR MISCELLANEOUS PURPOSES.

HEATING APPARATUS. **1901**—Strainer on radiator, 24,019. **1908**—Water softening filtering, 10,526. Water softening, settling, 24,821. **1910**—Water softening, filtering, 22,923.

HOUSE DRAINAGE. **1901**—Removing fats from dish-water, 14,603. **1907**—Strainer, 1,940. **1908**—Settling and filtering, for basements and cellars, 23,668.

VACUUM CLEANING APPARATUS. **1911**—Water strainer, 9,915.

FIRE-EXTINGUISHING APPARATUS. **1905**—Strainer, 11,780.

STERILIZING APPARATUS. **1904**—Filter, 29,127.

SWIMMMING BATHS. **1903**—Open filters, with aeration, sterilization, etc., 10,865. **1906**—Straining, filtration, aeration, 7,346. **1908**—Open filter, 4,483. Open filter, aeration, and heating, 9,548. **1910**—Open filter, and ozonizing, 10,560. **1912**—Aerating, filtering, heating, 16,945.

RAILWAY CARRIAGES. **1904**—Strainer for heating system, 25,618. **1910**—Strainer for cooling system, 27,738.

WATERING CARTS. **1904**—Strainer for valve, 7,004.

DREDGING BARGES. **1904**—Settling, 22,585. Straining scoop, 17,577. **1905**—Straining chamber, 11,262. **1909**—Baffles, 19,159. **1910**—Flat strainers, 28,062.

RIVER AND MILL-RACE WATER, FOR LEAVES, ETC. **1907**—Travelling band strainer, 23,543. **1911**—Self-cleansing strainer, 9,541. **1912**—Revolving drum strainer, 20,657. Open filter, with folded fabric, 20,899.

WATER-SOFTENING APPARATUS.

(Arranged according to method of separating the solids. *R* = supply of re-agent regulated automatically).

SETTLING. **1901**—6,129, 7,170 R. 11,354, 17,396, 19,125. **1902**—81 R, 11,990 R, 20,913, 25,620. **1903**—498 R, 3,970 R, 7,426, 10,682, 27,517 R. **1905**—1,397, 2,520, 5,332, 19,214, 19,215, 26,527 **1906**—For Laundries, 10,050. **1907**—15,535, 19,005. **1908**—10,531, 16,725, 24,281, for heating apparatus. **1909**—19,413. **1910**—1,231, 11,831, 23,564. **1911**—9,258, 22,351 R. **1912**—2,213, 7,669, 14,351 R, 26,889.

— SETTLING AND FILTERING. **1901**—1,830 R, 6,506, 11,353, 16,366, 16,973 R, 18,825 R, 18,981 R, 19,125 R, **1902**—10,719 R, 13,508 R, 16,965, 26,188 R, 28,162. **1903**—967, 4,430, 7,586 R, 17,456 R, 23,837 R. **1904**—1,467, 6,946 R, 10,355, 17,994 R. **1905**—4,272, 8,336, 15,872 R, 20,277 R. **1906**—7,878 R, 10,066, 18,806. **1907**—6,220. **1908**—19,648. **1909**—15,083, 20,737 R, 26,842. **1910**—24,992. **1911**—5,951, 9,530 R, 18,984, 19,540 R, 24,936 R, **1913**—9,199, 16,935.

FILTERING. **1901**—2,197, 17,649, 18,951, 22,745 R. **1902**—12,303, 16,193, 28,162. **1903**—17,348. **1904**—2,225, 9,038, 9,134. **1905**—5,200 R. **1906**—10,612, 14,339, 18,806. **1907**—28,221. **1908**—2,077, 10,526, for heating apparatus. 17,672 R, 26,477. **1909**—17,984, 20,123, 20,933, 22,920, 26,842. **1910**—22,923 R, for heating apparatus. **1911**—3,870, 5,951, 18,219.

REAGENTS AND CONTACT BODIES. **1901**—6,217. **1902**—7,436. **1903**—6,933, 23,163. **1904**—16,934, 17,920. **1905**—4,182. **1910**—11,938, 26,094, 26,877, 26,878. **1911**—3,870, 19,761, 24,675, 25,633. **1912**—732, 3,057, 13,704.

APPARATUS (SEPARATE) FOR AUTOMATIC REGULATION OF RE-AGENT. **1901**—11,202, 13 069, 13,283, 16,973, 21,231. **1902**—3,516, 7,436, 9,705. **1903**—17,251, 25,262, 27,463. **1904**—6,516, 11,680, 13,368, 17,973, 21,167, 21,777. **1905**—6,785, 15,527, 24,435, 25,016. **1906**—1,158, 10,206, 26,146. **1907**—2,166, 4,348, 11,779, 15,305, 26,648, 28,161. **1908**—909, 3,957, 8,399, 8,548, 12,711, 28,328. **1909**—10,293, 10,643, 17,340, 21,162, 22,193, 27,164, 27,165. **1910**—580, 850, 3,397, 22,153, Automatic valve for apparatus, 22,877, 28,915, 29,322. **1911**—4,634, 7,029, 7,772, 11,251, 13,765, 17,215, 22,977, 27,217. **1912**—3,674, 13,696, 16,861, 29,624. **1913**—1,144.

VARIOUS. **1901**—Strainer for lime-water, 25,880. **1902**—Apparatus for slaking of lime, 13,536. Electrolytic method, 14,644. **1903**—Centrifugal separation, heating method, 22,630. **1904**—Apparatus for admitting steam, 15,904. Circulation of milk of lime, 17,307. House-supply system, 21,325. **1905**—Treatment with gases, 22,148. Vessel for preparing re-agent, 26,773. **1908**—Separation of water for re-agent, 13,362. Electrolytic method, 26,477. **1909**—Vessel for preparing re-agent, 4,786. **1910**—Electrolytic method, 23,123. Valve for measuring tank, 22,153. Heating method, 25,582. **1913**—Method for kettles and boilers, 2,574. Apparatus for preparing re-agent, 5,465.

HARDENING, DE-IRONIZING, ACIDIFYING OF WATER.

HARDENING. **1906**—14,464, 27,700. **1908**—6,363, 24,430. **1909**—25,665. **1910**—26,877, 26,878. **1911**—25,632, 25,633.

ACIDIFYING. **1908**—22,524, 24,430.

DE-IRONIZING. **1901**—6,121. **1903**—12,522. **1906**—6,011. **1908**—18,355. **1909**—12,246, 21,184. **1910**—26,094. **1912**—22,342. **1913**—And for de-fatting, 9,746.

STRAINING, ETC., WATER TO BE USED FOR CONDENSATION OR COOLING.

1903—Revolving series of flat strainers, 3,149. **1905**—Revolving series of flat strainers, 10,790. **1907**—Reciprocating strainers, 15,747. **1908**—Revolving series of flat strainers, 5,776. Settling, 22,184. Revolving series of flat strainers, 22,946. **1909**—Revolving series of flat strainers, 18,094. Revolving drum strainer, 28,573. **1910**—Travelling band strainer, 11,643. **1912**—Strainer or filter for suction-pipe, 10,653.

See also: Filters, Strainers, etc., for Miscellaneous Purposes (River and Mill-race Water).

PURIFICATION OF USED FEED AND CONDENSATION WATER

FILTRATION, ETC., WITHOUT SEPARATION OF OIL. **1901**—Filter, with built-up elements, 5,372. Settling, and filter with loose medium, 6,319. Filter, with built-up elements, 6,769. Settling, and filter with loose medium, 10,497. Filter, with built-up elements, 22,409. **1902**—Filter, with built-up elements, 1,972. Multiple bag-filter, 20,532. Filter, with built-up elements, 22,416. Large filter, loose medium, 22,822. **1903**—Filter with loose medium, 8,656. Filter, with loose medium, 13,978. Multiple filter, with loose medium, 23,428. **1904**—Multiple candle filter, 12,539. **1905**—Multiple filter, loose medium, 17,919. **1906**—Multiple filter, loose medium, 17,190. Filter, with built-up elements, 17,191. **1907**—Large filter, settling, 12,940. Settling, 16,866. Revolving drum strainer, 22,946. Settling, 25,907. Filter, with loose medium, and settling, 28,070. **1909**—Strainer, and settling, 3,593. Multiple bag-filter, 29,902. **1910**—Bag-filter, 8,374. Bag-filter, 12,681. Multiple bag-filter, 21,422. **1911**—Filter, with built-up elements, 5,322. Filter, with loose medium, 11,264. **1912**—Filter, with loose medium 6,290.

SEPARATION OF OIL, FILTER INCLUDED IN APPARATUS. **1901**—Filter, with built-up elements, 9,392. Filter, with loose medium, 11,603. Filter, with loose medium, 22,745. **1902**—Filter, with loose medium, 5,918. Electrolytic, 10,874. Multiple bag-filter, 13,586. Filter, with felted medium, 14,903. Filter, with woven medium, 19,027. Filter, with loose medium, 21,384. **1903**—Filter, with loose medium, 1,522. Filter, with loose medium, 7,217. **1904**—Filter, with loose medium, 5,848. Filter, with loose medium, 15,848. **1905**—Travelling band filter, 12,716. **1906**—Filter, with loose medium, 15,589. **1907**—Filter, with loose medium, 829. Filter, with loose medium, 6,506. Filter, with loose medium, 15,491. Filter, with loose medium, 17,378. **1908**—Filter, with loose medium, 16,713. Filter, with loose medium, 17,262. Filter, with loose medium, 23,289. Filtering medium, 26,228. **1910**—Filter, with built-up elements, 1,353. Multiple bag-filter, 26,482. Filtering medium, 30,004. **1911**—Filter, with loose medium, 9,883. Filter with loose medium, 11,883. Multiple bag filter, 17,638. **1912**—Settling, and filtering, 27,353, **1913**—Closed filter, 9,329.

SEPARATION OF OIL, WITHOUT FILTER IN APPARATUS. **1901**—10,440, 18,305, by Centrifugalling. 20,470. **1902**—12,875. Chemical method. 17,869. **1903**—190, 21,668, 24,415. **1904**—6,657, 29,075. **1905**—7,069, 9,727, 25,336. **1906**—24,286. **1907**—962, 1,272, 6,506, 25,907. **1908**—24,237. **1909**—17,202, 22,857. **1910**—1,977. **1911**—2,388, 6,310, 19,564, 24,312. **1912**—6,290.

SEPARATION OF OIL AND SOFTENING OF WATER. **1902**—28,162. **1907**—6,051, 9,002, 23,365. **1908**—11,952, 24,861.

APPARATUS FOR ADDING DE-GREASING REAGENT. **1909**—17,340.

SEPARATION OF OIL FROM WATER OTHER THAN FEED-WATER. **1901**—Bilge water, 14,603. **1902**—Bilge water, 23,200. **1904**—Used lubricating oil, 17,625. Water from air compressor, 21,436. Used lubricating oil, 29,273. **1905**—Bilge water, 6,117. Bilge water, 11,950. **1909**—Used lubricating oil. 691. Separation of benzine, 19,709. **1910**—Used lubricating oil, 3579. Used lubricating oil, 12,115.

OILS AND GREASES (FILTRATION, ETC.)

GENERAL. **1901**—Open filter, 13,964. Open filter, with built-up elements, 17,213, Filtering media. 14,329. Siphon filter, and decanting, 23,878. **1902**—Funnel strainer 25,719. **1903**—Floating (decanting) filter, 8,732. **1904**—Pressure filter, 16,644. Settling, and decanting, 24,479. **1905**—Pressure filter, 11,957. Multiple bag-filter, 21,197. Filtering media, 22,942. **1906**—Pressure-filter, 10,300. Filtering media, 10,960. Filtering media, 16,890. **1907**—Closed filter, 8,978. Settling and straining, 10,389. Open filter (mineral oil), 11,185. Filtering media, 13,357. Filtering media, 17,607. Open filter, 18,137. Open filter, and straining, 24,455. **1908**—Closed filter, 3,443. Pressure, and suction filter, 8,288. Straining, settling, and filtering, 9669. Suction filter (mineral oils), 10,277. Filtering media, 16,617. **1909**—Bag-filter, and settling, 2,505. Pressure filter (mineral oils), 18,236. Revolving drum filter, 30,070. **1910**—Candle filter, 2,122. **1912**—Pressure filter, 813. Funnel filter, 14,764. Settling, 16,385.

PETROL AND OTHER OILS WITH LOW FLASH-POINT. **1902**—Straining and heating, 2,071. Pressure filter or strainer, 24,041. **1904**—Closed filter (benzine, etc.), 29,319, **1905**—Strainer for automobiles, 1,527. Strainer for automobiles, 7,109. Filter for automobiles, 10,277. **1906**—Filter for carburettor, 807. Strainer for automobiles, 925. Strainer for automobiles, 4,417. Strainer for automobiles, 22,003. **1907**—Filter for automobiles, 594. Collapsible funnel strainer, 3,705. Strainer for automobiles, 5,286. Strainer for carburettor, 8,715. Strainer for petrol drum, 17,377. **1908**—Filter for automobiles, 19,354. **1909**—Strainer for tank, 25,626. Filter for petrol drum, 27,300. **1910**—Filter for automobiles, 8,969. Strainer for carburettor, 18,734. Filter for automobiles, 24,460. **1911**—Strainer for petrol drum, 16,478. **1912**—Funnel strainer or filter, 8,410. Filter for carburettors, 12,598. Strainer for automobiles, 22,861. Filter for automobiles, 23,092. Strainer for petrol tanks, 25,801. Strainer for automobiles, 29,655.

LUBRICATING AND HEAVY OILS. **1901**—Closed filter, 25,420. **1902**—Open filter, 11,149. Open filter and strainer, 16,618. Open filter and strainer, 19,918. **1903**—Closed filter and strainer, 12,359. Open filter and strainer, 16,223. Closed filter and strainer, 16,710. **1904**—Open filter, 14,216. Open filter and strainer, 21,452. Closed filter, 22,238. **1905**—Strainer for automobiles, 1,527. Closed filter and strainer, 21,708. Closed filter, 26,692 **1906**—Closed strainer and settling, 21,086. **1907**—Closed strainer, 2,465. Closed strainer 3,007. Filter for automobiles, 13,187. Strainer for lubricating can, 14,507. Strainer for automobiles, 14,679. Closed filter, 19,022. **1908**—Closed filter and settling, 9,014. **1910**—Open filter, 5,490. Capillary filter, 22,734. **1912**—Settling, 4,243. Closed filter, for vehicles, 8,185. Strainer for grease used in tin-plate works, 11,023. **1913**—Closed filter, 3,647. Strainer, for oil used in metal-rolling mills, 11,871.

FISH OILS. **1904**—Bag-filter, 25,683. **1905**—Automatic filter press, 21,569.

MINERAL, VEGETABLE AND ANIMAL OIL EXTRACTION. **1901**—Boiling, and filtering, 24,602, and 24,603. Boiling, decanting, and filtering, 25,425. **1902**—Filter press, 9,884. **1904**—Hydraulic press, 116,71. Vacuum process, with filter, 25,683. Revolving drum press, 28,456, **1905**—Valve for hydraulic press, 507. Solvent method, decanting, 16,371. **1906**—Hydraulic press, 11,621. Cage for press, 14,075. Plates for press, 16,827. **1907**—Cage for press, 8,253. **1908**—Hydraulic filter press, 4,650. Hydraulic filter press, 22,150. **1909**—Hydraulic filter press, 17,169. Hand press, 26,456. **1910**—Double travelling band press, 13,656. Hand press, 13,909. Press with travelling band and rollers, 17,550. Roller press, 18,485. Cage for press, 19,435. Hydraulic press, 23,215. Double travelling band press, 24,111. **1912**—Hydraulic press with vertical components, 7,364. Plates for press, 13,256. Plates for filter press, 16,167. Plates for press, 18,835. Hydraulic press 22,008. Double drum press, 22,669. **1913**—Screw compressor strainer, 386.

FILTERS, STRAINERS, ETC., WITH USE UNSPECIFIED.

OPEN FILTERS. **1901**—25,824. **1903**—With separate cleansing apparatus for sand, 8,556. **1904**—With stirring device, 23,261. **1908**—3,786. **1909**—With stirring device, 27,599. **1910**—With stirring device, also as pressure filter, 433. With stirring device, 26,480. **1911**—With stirring device, also as pressure filter, 10,413. **1912**—With built-up elements, 22,027.

PRESSURE FILTERS. **1901**—427, with built-up elements, 22,272, with built-up elements. **1902**—9,854, with built-up elements. 25,229, with built-up elements. 27,629, with built-up elements. **1903**—886, 3,938, 10,498, with built-up elements, or as suction filter. 23,772, cleansing method. 27,287, with built-up elements, with stirring devices. **1904**—3,003. **1905**—10,538, with built-up elements. 11,957, 13,247, with built-up elements. **1906**—83, with built-up elements. 8,523, with built-up elements. 10,300, 18,269, 24,548, with built-up elements. **1907**—13,585, 15,350, with continuous discharge of solids. 10,237. **1908**—15,019, method of cleansing. 25,881. **1909**—20,140, with stirring device. **1910**—433, with stirring device, also as open filter. 474, 1,353, with built-up elements. 3,171 with continuous discharge of solids. 14,767, discharging of cake. **1911**—1,337, method of cleansing. 10,413, with stirring device, also as open filter. **1912**—4,318, 7,232, with wedge-shaped, interdigitating elements.

SUCTION FILTERS. **1902**—Floating (decanting) filter, 6,285. **1903**—With built-up elements, or as pressure filter, 10,498.

FILTERS AND STRAINERS FOR POWER OR HAND. **1901**—Medium for travelling band filter, 22,852 **1902**—Travelling band filter, 12,943 **1903**—Revolving drum filter, pressure, 1,336 Annular filter, suction, 7,957 Revolving drum filter, pressure, 16,760. **1904**—Revolving drum filter, 3,859 **1906**—Pressure-filter, with revolving components 22,167. **1907**—Revolving drum strainer, suction, 19,431 **1908**—Revolving drum filter, continuous discharge of solids, 16,047 **1911**—Vertical revolving conical filter, 26,625 **1912**—Revolving drum strainer, 17,216. **1913**—Revolving drum strainer, 2,012.

STRAINING APPARATUS **1901**—For valves, 17,726. **1902**—For valves, 15,529. Flat, 25,719. **1903**—Funnel, 12,223. **1904**—Revolving, open ends, 8,963. **1906**—For bottles, 2,632. Closed, with built-up elements, 7,616. For bottles, 18,240. **1907**—Revolving drum, suction, 19,431. Revolving drum, 27,674. **1909**—For bottles, 8,173. **1910**—Funnel, 29,244. **1911**—Strainer element, 9,228. Funnel, for casks, 24,890

COMBINED PRESS AND FILTER PRESS. **1912**—18,195. **1913**—18,842.

FILTER PRESSES. **1901**—Plates for, 7,063. Apparatus for removal of cake, 18,373. **1902**—Plates for, 19,619, 21,782. **1904**—Filtering, elements for, 11,978. Automatic, 15,389, 21,569. Plates for, 23,942. **1906**—Packing for joints, 2,991, 6,363, 15,529. Composition protecting elements against chemical action, 16,460. Constant pressure, 25,649. **1907**—Forcing by steam or air, 3,650. Filtering, elements for, 9,285. Composition for coating elements, 10,447, 20,375. Tightening gear, 20,809. **1908**—Tightening gear, 5,943. Packing for joints, 5,944. Hydraulic, 14,444. **1909**—Tightening and releasing gear, 6,211. Hydraulic opening gear, 16,615. Tightening gear, 21,660. **1910**—Plates for drying cake, 10,610. Discharging of cake, 14,767. **1912**—Plates for, 12,737. Elements for, 14,429. Taps for, 22,294. Elements for, 23,867. Closing gear, 28,985. **1913**—Electro-osmotic method, 10,873.

CANDLE FILTERS. **1901**—Multiple, 25,606. **1902**—Joint for, 3,096. Multiple, 4,598. **1904**—Joint for, 27,180. **1908**—Joint for, 25,861. **1909**—Cleansing of, 9,248. **1910**—Cleansing of, 29,814. **1911**—Cleansing of, 28,909.

SETTLING APPARATUS. **1902**—18,830. **1905**—5,108. **1906**—28,977. **1907**—17,793 **1911**—And decanting device, 3,654. **1912**—Removal of solids, 11,137. Removal of solids, 18,388. **1913**—Outlet for, 7,499.

BAG FILTERS. **1901**—Multiple, 3,294. 12,586. **1902**—For barrels, 4,190.

FILTER-BEDS, LININGS, FLOORINGS AND PACKING (SPACING) ELEMENTS. **1901**—Porous blocks, for forming channels, etc., 9,365. **1902**—Arched tiles, 24,974. False floor, expanded metal, 25,988. False floor, 26,081. **1903**—Arched tiles, 15,546. Moulded spacing blocks, 16,851. Arched tiles, 23,132. **1904**—Arched tiles, 3,945. Arched tiles, 7,455. Moulded spacing blocks, 15,829. Arched tiles, 15,957. Arched tiles, 25,067. Interlocking tiles, spaces between, 28,937. **1905**—False floor, 1,143. Channelled tiles, 9,148. False floor, 13,947. Moulded spacing blocks for settling basin, 16,851. Arched tiles, 17,837. Bricks for walls, 19,693. **1906**—False floor, 4,141. Arched tiles, 5,850. Arched tiles, 7,633. Channelled tiles, 14,542. Conduit system, 20,440. False floor, acid and alkali resistant, 23,049. Arched tiles, 27,232. **1907**—False floor, 4,118. Flat tiles, only perforated, 13,500. Arched tiles, 15,391. **1908**—Arched tiles, 1,873 Arched tiles, 8,590. **1909**—False floor, 24,011. **1911**—Acid resistant tiles, 1,336. Arched tiles, 25,336. Raised tiles for settling tanks, 26,927. **1912**—Media—containing packings for beds, 5,983. Moulded spacing blocks, 7,232.

FILTER-BEDS—DISTRIBUTING (SPREADING, SPRINKLING, ETC.), LIQUID. **1901**—Rotary, 517. Rotary, 1,070. Nozzle, 10,402. Stationary piping, 18,365. Rotary, 21,882. Rotary, 22,923. Spiral trough, 23,553. Notched troughs, 23,907. Rotary, 26,187. **1902**—Travelling, 2,155. Rotary, 4,029. Rotary, 9,179. Rotary, 9,747. Stationary piping, 12,635. Travelling and rotary, 14,366. Travelling, 15,086. Rotary, 15,646. Notched trough, 23,750. Rotary, and water-wheel, 24,278. Rotary, 24,680. Rotary, 26,974. Rotary, 28,653. **1903**—Rotary, 158. Travelling, 1,087. Rotary, 6,181. Rotary, 7,412. Open gutters, 11,424. Rotary, 23,936. Travelling, 24,838. Rotary, 28,165. Travelling, 28,375. **1904**—Rotary, 5,653. Rotary, 7,754. Screen, 14,929. Rotary, 15,494. Stationary piping, 19,216. Travelling, 22,235. Rotary, 25,147. Rotary, 27,948. Travelling, 29,203. Travelling, 29,544. **1905**—Rotary, 65. Rotary, 276. Travelling and rotary, 3,121. Nozzle, 3,228. Trough and wires, 4,192. Perforated plate, 8,944. Rotary, 10,224. Rotary, 14,920. Rotary, 15,576. Rotary, 17,518. Rotary, and water-wheel, 17,992. Rotary, 21,892. Rotary, 26,660A. Rotary, 27,154. **1906**—Rotary, 1,802. Travelling, 3,073. Rotary, 4,132. Travelling, 5,445. Rotary, 5,649. Rotary, 6,162. Travelling drums, 10,375. Nozzle, 10,627. Rotary, 10,940. Notched trough, 16,989 Rotary, 19,268. Rotary, 20,205. Rotary, 20,206. Notched Tray, 21,990. Rotary, 22,052. Spraying coil, 24,172. Trough with wires, 24,878. Spreading plate, etc., 28,258. Notched trough, 28,541. **1907**—Rotary 25. Rotary, 488. Rotary, 4,694. Travelling, 6,274. Rotary, and water-wheel, 7,074. Rotary, and water-wheel, 7,074A. Rotary, 8,595. Nozzle, 12,416. Travelling, 13,221. Rotary, 13,847. Travelling, 18,127. Rotary, and revolving drum, 18,694. Travelling, 23,861. Rotary, 24,924. **1908**—Nozzle, and spreading plate, 140. Rotary, 1,039. Rotary, 1,485. Stationary pipes, with sprays, 3,542. Travelling, 4,542. Travelling, 6,803. Troughs, 7,454. Perforated sheets, 9,656. Rotary, 12,394. Clearing perforations in pipes, 15,167. Spreader, 16,317. Rotary, 17,644. Rotary, 18,151. Travelling, 23,293. Trays, and spreading-plates, 23,651. Rotary, 24,948. Prevention of choking of perforations in pipes, 25,896. **1909**—Prevention of choking of perforations in pipes, 7,468. **1910**—Rotary, 1,033. Troughs, with bundles of fibres, 13,877. Rotary, 25,682. Clearing perforations in pipes, 27,227. **1911**—Coating for inside of pipes, 3,651. Notched pipes, 8,461. **1912**—Stationary piping, 2,009. Underground piping, 3,815. Nozzle, 21,218. Wind compensator, 23,236. Rotary, 26,229. Travelling, 27,736. **1913**—Cleansing of nozzles, 1,991.

FILTER-BEDS—SUPPLYING, REGULATING, DISCHARGING LIQUIDS.

1901—Siphonic, 25. Siphonic, 903. Clock valve, 5,388. Float valves, 5,834. Float valves, and siphonic, 7,550. Siphonic, 10,782. Float valves, 16,368. Float valves, 12 287. Float valves, 17,670. Float valves, and siphonic, 25,893. **1902**—Balanced buckets, 5,847. Siphonic, 9,623. Siphonic, 10,571. Float valves, 16,271. Siphonic. 25, 897. **1903**—Float valves, 2,434. Float valves, 3,013. Tilting table, 9,151. Float valves, and siphonic, 16,320. Float valves, 19,920. Siphonic, 23,146. Siphonic, and float valves, 26,466. **1904**—Siphonic, and float valves, 4,730. Float valves, 10 923. Siphonic, 14,993. Float valves, 16,199. Balanced buckets, 20,547. Float valves, 23,747. Float valves, and siphonic, 26,144. Float valves, 29,037. **1905**—Float valves, 1,800. Tilting tray, and siphonic, 6,389. Float valves, and siphonic, 7,284. Tilting valves, 8,041. Float valves, 12,957. Float valves, and air bells, 13,653. Float valves, and siphonic, 17,627. Float valves, 18,718. Tilting valves, 25,548. Float valves, 25,831 Water-level indicator, 27,111. **1906**—Float control, 578. Float valves, 13,062. Float valves, 15,139. Tilting, etc., buckets, 18,759. Tilting vessels, and float valves, 20,583. Tilting vessels and float valves, 21,291. **1907**—Automatic discharge valve, 3,341. Rising and falling bucket, 6,534. Siphonic, 8,899. Siphonic, 10,418. Float valve, 11,032. Tilting bucket, 25,362. **1908**—Rising and falling bucket, 2,989. Float valves and siphonic, 8,070. Siphonic, 18,974. **1909**—Tilting and float valves, and siphonic, 7,464. Tilting tray, 13,488. Float valves, and siphonic, 18,064. **1910**—Tilting bucket, 13,969. Float valve, 18,823. Air-bell, and siphonic, 28,250. **1911**—Siphonic, 2,564. Air-bell, and siphonic, 10,985. Apparatus for constant supply, 16,331. **1912**—Float valve, 411. Time-element valve, 3,699. Time-element valve, 4,021. Siphonic flushing apparatus, 6,689. Float valve, 15,512. Tilting tanks, 16,233. Electrically controlled, 19,203. Rotary, 20,380. Float valve, 21,248. Rotary, 21,249.

INCLUDING DISTRIBUTING APPARATUS. **1901**—Tilting vessel, 517. **1903**—Siphonic, 6,181. **1904**—Float valve, 19,216. **1905**—Float valve, 10,170. Siphonic, 14,920.

FILTER-BEDS, ETC.—REMOVING, CLEANSING, DISTRIBUTING OF FILTERING MEDIA. **1903**—Travelling apparatus for cleansing sand of filter-bed, 12,481. Travelling apparatus for cleansing sand of filter-bed, 24,229. **1904**—Revolving drum for cleansing sand of filter-bed, 10,701. Travelling apparatus for cleansing sand of filter-bed, 14 536. Cleansing device for pressure filter, 29,512. **1905**—Apparatus for cleansing media from filter-beds, etc., 17,278. Travelling apparatus for cleansing media of filter-beds, 23,393. **1906**—Travelling apparatus for distributing media, 28,919. Travelling apparatus for removing media, 29,319. **1907**—Travelling apparatus for cleansing media, 18,852. **1908**—Travelling apparatus for removing, cleansing and distributing media, 15,041. Cleansing pipes for filter-beds, 16,036. **1910**—Travelling apparatus for removing and cleansing media of filter-bed, 15,508. Travelling apparatus for removing and cleansing media of filter-bed, 15,714. **1912**—Jigging screen for cleansing media, 16,036. Revolving drum strainer, 18,681.

ACCESSORY DEVICES FOR FILTERS.

1901——Automatic flow of wash-water when filter clogs, 7,550. Air-valve, 12,741. Valve, 20,229. **1902**—Fixing filter-cloths, 464. Discharging wash-water rapidly, 585. Bars to obtain uniform compression of media at all depths, 19,644. Apparatus for cleansing fibrous media, 19,821. Apparatus for cleansing fibrous media, and sterilizing, 20,216. Purifying media by bacterial action, 20,303. **1903**—Bars to obtain uniform compression of media at all depths, 15,948. Discharge pipe of cleansing device, 27,007. Fixing of asbestos element, 28,328. **1905**—Current divider, 5,537. Bearing for stirring device, 22,645. **1906**—Contrivance for lifting filter-cells, 20,695. **1909**—Shock absorbent for pipes, 11,785. **1910**—Discharge pipe, avoidance of clogging, 7,278. **1911**—Stirring device, 146. Device for obtaining constant discharge, 24,344.

INDEX

SUBJECT MATTER

NAMES

BRISTOL : BURLEIGH LTD., AT THE BURLEIGH PRESS

H
Er .td.

s,

ow,

Su ists.

MA
EV ERY
FOR

SUGAR INDUSTRY

COMPLETE
SUGAR FACTORIES
AND REFINERIES : : :

EXPERT ADVICE given in connection with the **ENLARGING** and **MODERNIZING** of **EXISTING PLANT.**

ESTIMATES UPON APPLICATION.