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Filter Aids and Materials

Technology and Applications

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FOREWORD

The detailed, descriptive information in this book is based on U.S. patents issued since 1970 that deal with filter aids and materials.

This book serves a double purpose in that it supplies detailed technical information and can be used as a guide to the U.S. patent literature in this field. By indicating all the information that is significant, and eliminating legal jargon and juristic phraseology, this book presents an advanced, technically oriented review of filter aids and materials.

The U.S. patent literature is the largest and most comprehensive collection of technical information in the world. There is more practical, commercial, timely process information assembled here than is available from any other source. The technical information obtained from a patent is extremely reliable and comprehensive; sufficient information must be included to avoid rejection for "insufficient disclosure." These patents include practically all of those issued on the subject in the United States during the period under review; there has been no bias in the selection of patents for inclusion.

The patent literature covers a substantial amount of information not available in the journal literature. The patent literature is a prime source of basic commercially useful information. This information is overlooked by those who rely primarily on the periodical journal literature. It is realized that there is a lag between a patent application on a new process development and the granting of a patent, but it is felt that this may roughly parallel or even anticipate the lag in putting that development into commercial practice.

Many of these patents are being utilized commercially. Whether used or not, they offer opportunities for technological transfer. Also, a major purpose of this book is to describe the number of technical possibilities available, which may open up profitable areas of research and development. The information contained in this book will allow you to establish a sound background before launching into research in this field.

Advanced composition and production methods developed by Noyes Data are employed to bring our new durably bound books to you in a minimum of time. Special techniques are used to close the gap between "manuscript" and "completed book." Industrial technology is progressing so rapidly that time-honored, conventional typesetting, binding and shipping methods are no longer suitable. We have bypassed the delays in the conventional book publishing cycle and provide the user with an effective and convenient means of reviewing up-to-date information in depth.

The Table of Contents is organized in such a way as to serve as a subject index. Other indexes by company, inventor and patent number help in providing easy access to the information contained in this book.

15 Reasons Why the U.S. Patent Office Literature Is Important to You –

1. The U.S. patent literature is the largest and most comprehensive collection of technical information in the world. There is more practical commercial process information assembled here than is available from any other source.

2. The technical information obtained from the patent literature is extremely comprehensive; sufficient information must be included to avoid rejection for "insufficient disclosure."

3. The patent literature is a prime source of basic commercially utilizable information. This information is overlooked by those who rely primarily on the periodical journal literature.

4. An important feature of the patent literature is that it can serve to avoid duplication of research and development.

5. Patents, unlike periodical literature, are bound by definition to contain new information, data and ideas.

6. It can serve as a source of new ideas in a different but related field, and may be outside the patent protection offered the original invention.

7. Since claims are narrowly defined, much valuable information is included that may be outside the legal protection afforded by the claims.

8. Patents discuss the difficulties associated with previous research, development or production techniques, and offer a specific method of overcoming problems. This gives clues to current process information that has not been published in periodicals or books.

9. Can aid in process design by providing a selection of alternate techniques. A powerful research and engineering tool.

10. Obtain licenses — many U.S. chemical patents have not been developed commercially.

11. Patents provide an excellent starting point for the next investigator.

12. Frequently, innovations derived from research are first disclosed in the patent literature, prior to coverage in the periodical literature.

13. Patents offer a most valuable method of keeping abreast of latest technologies, serving an individual's own "current awareness" program.

14. Copies of U.S. patents are easily obtained from the U.S. Patent Office at 50¢ a copy.

15. It is a creative source of ideas for those with imagination.

CONTENTS AND SUBJECT INDEX

INTRODUCTION

Filter media can generally be classified as being one of two types, depth filters and surface filters. A depth filter removes suspended material from the fluid passed through the filter by collecting it not only on the surface of the element but also within the pores. A depth filter has a considerable thickness, and has a plurality of pores of distinct length. The longer the pores, the higher the dirt capacity of the filter, because there is more room for dirt along the pores. Most depth filters are made of masses of fibers, or other particulate material, held together by mechanical means or by bonding. One or several layers of such materials can be employed, and these layers can vary in porosity. In most cases, however, the greater percentage of contaminants unable to pass through the filter is trapped at the surface of the filter.

A surface filter removes suspended material from the fluid passed through the filter by collecting such material on its surface, and the material thus removed forms a filter cake or bed upon the filter. This material naturally obstructs the openings in the surface of the filter, because the fluid must flow through this material, which thus effectively reduces the diameter of the filter openings to the size of the pores in the filter cake. This reduction in effective diameter of pore openings in the filter increases the pressure differential required to maintain flow through the filter.

Sand, other inorganic particulate materials and anthracite coal fines are most commonly used as the granular filter medium. Where backwashing is critical, the coal particles are particularly valuable due to ease of fluidization and washing. In recent years, plastic particles, particularly polyvinyl chloride, have been used in deep bed filtration units.

A number of common fibrous materials have also been employed through the years, such as cotton, glass wool and fluffed wood pulp.

In the continuous types of filters one generally uses an initiating medium which may be either woven-mesh metallic or nonmetallic screens or cloths. Many metals and special steel alloys are used, with the choice largely being dictated by the corrosivity of the materials being filtered. Commercially, metallic filter cloths are available in variety of weaves such as plain, twill, corduroy-twilled and stranded.

While cotton and wool are most often used, many synthetic fibers are finding wide use in continuous filters. Thus polyamide, nylon and acrylic fibers are routinely used commercially for highly demanding environments employing continuous filtration.

One of the more stable and inert types of filters is woven from glass yarns to produce cloths of the desired texture and weave. Glass fiber may also be used in combination with asbestos and cellulosics to provide durable filter assemblies.

This book provides an in-depth look at the many filtration processes which have been described in the patent literature in recent years. Many of the processes are general in nature and can be applied to standard industrial filtration requirements. However, an effort has been made to include some of the less commonly considered filtration needs of the industry, which are, in many cases, highly demanding in terms of filter type and construction. Thus there are chapters devoted to processes developed specifically for molten aluminum, bacterial and medical applications, gel filtration chromatography and polymer filtration.

For a detailed discussion of the use of membranes in industrial separation the reader is referred to another Noyes Data book:

P.R. Keller, *Membrane Technology and Industrial Separation Techniques, 1976*

PARTICULATE FILTER MEDIA

CONVENTIONAL FILTER MEDIA

Sand Filter with Thin Precoat Layer

D.R. MacPherson; U.S. Patent 3,680,699; August 1, 1972; assigned to Johns-Manville Corporation describe an improved process for water clarification. A precoat layer containing less than 0.25 pound of porous granular material per square foot is deposited on the top surface of a sand filter. The porous granular material in the precoat layer is selected to consist essentially of particles larger than the effective size of the sand in the sand filter. The water to be clarified is passed through the precoat layer of porous granular material, and subsequently through the sand filter.

When the water to be clarified contains a substantial amount of colloidal solids, a body feed of porous coarse granular material is added to the water to be clarified prior to its passage through the precoat layer. The body feed material, when utilized, also consists essentially of particles larger than the effective size of the sand in the sand filter layer.

Preferably, the sand filter is backwashed when the pressure differential across the filter becomes excessive and the sand filter is then again coated with a precoat layer of less than 0.25 pound of filter aid per square foot of filter area before resuming filtration operations.

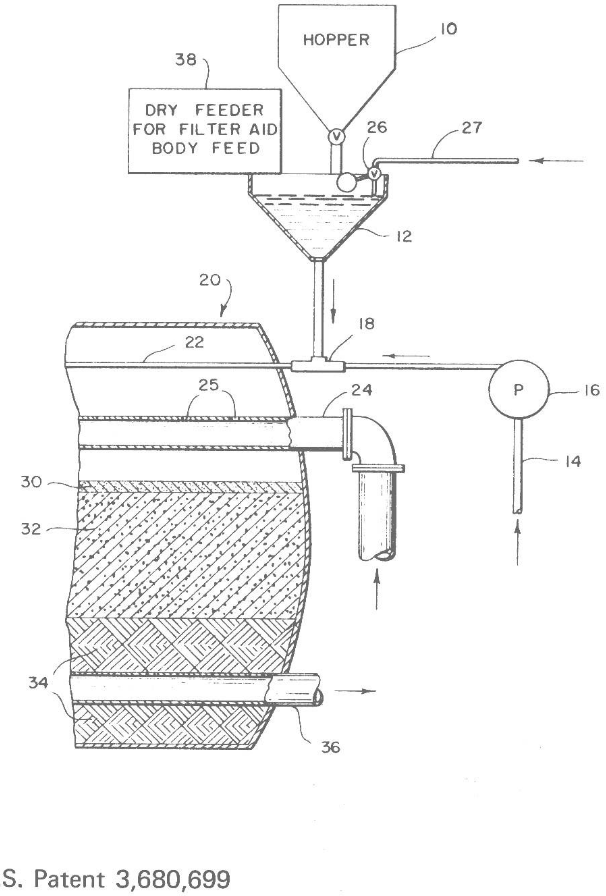
The filter bed comprises a lower layer of sand and a precoat layer comprising less than 0.25 pound of coarse porous granular material per square foot of filter bed. The precoat layer is positioned on top of the layer of sand, and the particles of the precoat layer are larger than the effective size of the sand in the layer of sand.

The following examples illustrate the process. All percentages are weight percentages unless otherwise noted. All screen sizes referred to are U.S. Standard Series, unless otherwise noted.

Examples 1 through 3: Turbid water containing ferric hydroxide is filtered through a pressure sand filter using the techniques and apparatus illustrated in Figure 1.1. At the start of the filter cycle, a precoat hopper **10** is filled with a predetermined quantity of filter aid and the filter aid is fed into a flooded funnel **12**. A portion of the influent water is sent through a pipe **14** to a booster pump **16** which boosts the water pressure up to about **90** psi. The water from the pump (about **30** to **50** gallons per minute) is sent through a suitable eductor **18** and then into a pressure sand filter generally **20**. The velocity of the water from pump **16** through the eductor creates a vacuum at the top opening of the eductor which causes the water and filter aid material from the flooded funnel to be drawn into a header pipe **22**.

The header pipe is used to distribute the coarse filter aid throughout the surface area of the sand filter bed, because the velocity of flow in the main header **24** is usually too low to keep the filter aid in suspension. Holes of ⅜ inch diameter are provided on the top of header **22** about 10 inches apart throughout the length of the header which extends the length of filter **20**, and a ⅜ inch hole is provided at the end of the header. This arrangement insures uniform distribution of the coarse filter aid on the surface of the sand.

FIGURE 1.1: WATER CLARIFICATION PROCESS



Source: U.S. Patent 3,680,699

During filtration, the raw influent passes through header **24** and out through holes **25** (about one inch in diameter) in the top of the header. Water is forced under pressure of about 60 psi through precoat layer **30** and sand filter layer **32** to remove solids from the influent water. The sand in layer **32** is considerably finer than AAWU standard fine sand because of repeated backwashing over a number of years. The clarified water passes through a gravel bed **34** and is removed from filter **20** through effluent header **36**.

The filter aid for the body feed is provided by a dry feeder **38** which supplies filter aid at a predetermined rate to flooded funnel **12**. Conventional fittings are provided to backwash the pressure sand filter **20**.

In the installation shown, it is desired to lower the iron content of the effluent from filter **20** to no more than 0.3 ppm from the approximately 3.1 to 3.5 ppm level at which it enters header **24**. The following table compares the cycle lengths and total throughput that are achieved using an ordinary sand filter with the results obtained when the same sand filter is coated with a porous granular material in accordance with the process.

Example	Filter Rate (gpm)	. . . Total Iron (ppm). . . . Influent Average	Effluent End of Test	Cycle Length (hr)	Throughput (gal)
1	244	3.5	0.3	11.25	165,000
2	305	3.1	0.3	15.65	296,000
3	361	3.4	0.3	3	65,000

In the procedure of Examples 1 and 2, the sand filter is coated with 0.17 lb of flux calcined diatomaceous earth per 1,000 gallons of water, about half the filter aid is supplied as a precoat and about half as a body feed. In Example 1, the filter aid has a particle size of from 20 to 60 mesh, as defined in ASTM E11, and in Example 2, the filter aid varies in size from 30 to 60 mesh.

The results of Examples 1 and 2 in which the process produces 300 to 500% increases in cycle length and thoughput compared to the prior art sand filter of Example 3 are typical of the improved results which are obtained by the process.

Examples 4 through 7: Two pressure sand filtration columns (4¾ inches inside diameter, clear heavy-wall Lucite) are set up so that both can be run in parallel. Twenty-six inches of filter sand are placed in each column. This sand contains about 60% by weight of 20 to 30 mesh particles and about 40% by weight of 30 to 50 mesh particles.

A high pressure, six-stage Moyno pump system dispenses a body feed of flux-calcined diatomaceous earth with a portion of the influent into the sand bed. The flow rates through the sand filters are measured with Hagan ring-balance meters. The pressure differentials across each of the sand filters are indicated with a conventional 24 hour recording Foxboro pressure meter placed across the influent and effluent lines for each filter.

In all tests, a filter aid is used in conjunction with one of the sand filters, and the other plain sand filter is run in parallel under identical conditions. Periodically, both sand filters are used for blank runs to determine that each filter is behaving in a similar manner. The filter aid utilized in Examples 4 through 7 is a flux-calcined diatomaceous earth (Celite) having particles in the size ranges listed in the following table. The table below gives the gain in water throughput with granular precoat for parallel pressure sand filters using coarse, flux calcined diatomaceous earth as precoat and body feed at constant filter rate of 12 gsfm.

Gain in Water Throughput

	. . . . Raw Raritan River Water			Alum Floculated Water
Example	4	5	6	7
Column designation				
A	Sand	Sand	Celite	Celite
B	Celite	Celite	Sand	Sand
Celite filter aid used	30/45	30/45	30/45	30/45
Influent				
Pressure psi	40	40	80	80
Turbidity ppm*	5-7	3-7	2-5	0.5-2
Length running hour				
To breakthrough sand**	6.5	6.5	6.0	3.6
Total	23.2	16.5	16.0	9.6
Diatomaceous earth used				
Precoat psf	0.54	0.54	0.18	0.18
Body feed psf	2.08	1.24	0.84	0.18
Total per 1,000 gal	0.157	0.149	0.091	0.052
Throughput gsf				
Sand up to break-through	4,650	4,650	4,310	2,590
Diatomaceous earth	16,700	11,900	11,500	6,910***

*Measured with Hellige turbidimeter. Water quality of effluent as measured by turbidity through column including filter aid was 50 to 100% better than through sand.

**Pressure differentials at breakthrough varied from 0 to 3.0 psi.

***This test could have been continued much longer than 9.6 hours.

The results of this table show the significant increase in throughput that can be achieved by the process while actually producing an increase in water quality.

Granulated Walnut Shells

G. Hirs; U.S. Patent 3,780,861; December 25, 1973; assigned to Hydromation Filter Company describes a method for filtering contaminants from suspension in liquids by utilizing, as a filter medium, granulated shells of black walnut (*Juglans nigra* L.).

The shells of black walnuts are light in weight, with a specific gravity of 1.3 to 1.4. The shells also are relatively strong, having a modulus of elasticity of 170,000 psi, and the shells are relatively nonabrasive when compared to sand or anthracite. This last property is somewhat surprising in view of the common use of walnut shells as a blasting grit for metal finishing. However, black walnut shells are utilized as soft grit which does not cause pitting of the metal part to be cleaned.

To illustrate the utilization of granular black walnut shells as a filter medium, the following table is presented. In obtaining the figures in this table, liquid containing a standard test dirt consisting of Fe_3O_4 dirt in the indicated amount was passed through 12 inches of 20 to 50 mesh granular black walnut shells. The dirt was added at a rate of 250 mg/l. The filter flow rate was 10 gallons per minute per square foot of cross sectional area of the shells. The following results were obtained:

Gallons of Filtered Liquid	Pounds of Dirt Added per Cubic Foot of Media	Filter Effluent Clarity (mg/l)
20	0.5	0.24
40	1.0	0.36
60	1.5	3.2
80	2.0	9.9
100	2.5	14.5

The above table illustrates that granular black walnut shells have a dirt holding capacity which is substantially equivalent to that of silica sand.

Other favorable characteristics of black walnut shells when utilized as a filter medium are that they are oil and water resistant, they have a hardness in Mohs of 3, and are for all practical purposes chemically inert. Also, granular black walnut shells are commercially available in all practical mesh sizes for use in deep bed filtration at a cost which is about one-sixth the cost of many inexpensive plastic materials.

Anthracite Coal and Walnut Shells

A process described by *G. Hirs; U.S. Patent 3,900,395; August 19, 1975; assigned to Hydromation Filter Company* involves the use of granular black walnut shells in combination with anthracite coal as a deep bed filter method and apparatus. The granules of black walnut shells are larger than the fines of anthracite coal in the filter and, having a specific gravity of approximately 1.4 (as compared with a specific gravity of from 1.5 to 1.7 for anthracite), intermix with the anthracite coal fines after initial backwashing of the filter bed.

The presence of the three-dimensionally angular and larger sized granular walnut shells on the surface of the flaky anthracite coal fines opens the surface of the anthracite coal bed for more effective penetration by dirt particles, resulting in less surface loading and longer filtration cycles. This particular mixture of granular walnut shells with anthracite coal results in a synergistic effect, with the combination producing more effective filtration than either walnut shells or anthracite coal alone.

In addition, the intermixed granular walnut shells break up the flat, impervious surface of the fine, flaky particles of anthracite so that they can also be effective in the filtering process. Without the intermixed walnut shells, the anthracite fines tend to lay flat much as the slats of a venetion blind. The walnut shells open these blinding fines to take full advantage of filtration surface phenomenon, which predominates in most deep bed filtration.

Black walnut shells have certain inherent features which make them a particularly adaptable and unique material for use in a filter bed in combination with anthracite coal. First, the material is a low-cost waste by-product, as are some of the anthracite coals used in the filtering field. Further, the material has an ideal specific gravity for use with anthracite coal since it will tend to float or stay on top of the larger anthracite granules and not intermix therewith. Further, it fractures into an ideal three dimensional angular shape for effective inter-