Filter Aid and Carbon Treatment of Prime Steam Lard

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THE use of clarifying and decolorizing agents in present day refining of steam rendered lards, particularly prime steam lard, has become widely adopted in the packing industry. Of the various materials which may be employed for the treatment of lard, diatomaceous silica filter aids have outstanding advantages in accelerating filtration to remove turbidity, ferments, gummy and glue-like substances, etc., without attendant disadvantages of imparting an undesirable flavor to the lard or having a detrimental effect on its keeping qualities. The activated decolorizing carbons have much merit in providing the controlled mild bleach which is desired in refining, with minimum effect on flavor. Combinations of filter aids and carbons are of interest, since the use of many grades of the best decolorizing carbons requires a suitable filter aid for the most satisfactory filtration and removal of the carbon from the treated lard.

The determination of the most suitable filtration and carbon treatment for lard depends on a number of factors, which may be listed as follows: (1) character of lard, (2) degree of clarification required, (3) degree of decolorization or other adsorption effect necessary and (4) filtration equipment available. An analysis of all of these factors would require extensive studies and will not be attempted here. The present study considers only the performance of different filter aid powders, to permit the selection of the most suitable filter aid grade for use with and without one particular grade of decolorizing carbon.

Descriptions are given of the equipment and techniques employed in carrying out the filtration tests and of the instruments and methods employed in making measurements of the color and degree of clarification of the filtered lard samples.

Filter-Cel has been employed for many years as the most suitable type of filter aid for prime steam lard. A more rapid filtering filter aid of the Hyflo Super-Cel type has been employed for a long time for dry rendered lard. More recently, Hyflo and filter aids of the faster flow type have been employed successfully with and without decolorizing carbons for prime steam lard. The advantage of greater production rate which is possible with a faster flow rate filter aid is important in some cases; whereas the shorter filtration period possible is desirable in all cases from the standpoint of minimizing the time of treatment at temperatures above the melting point of the lard.

In this study, a number of different filter aids have been employed. These range in degree of fineness from Filter-Cel, a natural milled diatomaceous powder with extreme clarifying capacity, to Celite 545, which is a relatively coarse particle size flux-calcined product. Celite 545 has found wide application in some filtrations in which the size of suspended particles is large.

The general properties, filtration characteristics and particle sizes of the different filter aids are shown in Tables I, II and III, and Figure I.

The properties of diatomaceous filter aids have been discussed more fully in an earlier paper (1). The lard and the carbon for the present series of tests was supplied by a large packer. The carbon was a finely powdered commercial grade of activated wood charcoal, specially prepared for decolorizing, deodorizing and purifying oils, fats and greases. The prime steam lard was relatively clean and free filtering but was described as a fairly typical product. Tests were run both with filter aid alone and with filter aid plus decolorizing carbon.

It was not feasible to use the same rate of pressure rise and amount of filter aid in the tests with and without carbon because of the wide difference in flow rate. Tests with filter aid only were run at a constant 5-lb. pressure for a one-hour period, using filter aid precoat plus 0.05% filter aid in the batch. Tests with filter aid and carbon were run with pressure gradually increasing to a 20-lb. maximum at 40 min-

TABLE I

General Properties of Filter Aids

	Condition	Color	Density, Apparent Lb./Cu. Ft.	Lb./Cu. Ft. Cake	Character of Particles	General Particle Size Distribution Microns	Approx. Estd. Sp. Surface Sq. Cm./Gram
Filter-Cel	Natural	Gray	8.5	17-22	Mixed forms and fragments of elongated, filiform, and discoid diatoms; many fines.	1-12	30,000
Standard Super-Cel	Calcined	Pink	9.2	17-22	Same, with less fines.	Mostly 2-16	20,000
Hyflo Super-Cel	Flux-calcined	White	9.7	17-22	Same, with microscopic aggregate structure, few fines.	Mostly 4-20	10,000
Celite 503	Flux-calcined	White	10.5	17-22	More microscopic aggregate structure, practically no fines.	5-30	8,000
Celite 535	Flux-calcined	White	11.0	17-22	Still more microscopic aggregate structure, no fines.	8-38	7,000
Celite 545	Flux-calcined	White	11.5	17-22	Pronounced microscopic aggregate structure, no fines.	12-45	6,000
Diatomaceous Earth "A"	Calcined	Pink	8.5	17-22	Mixed fresh water forms principally of disc shape, few fines.	Mostly 4-20	13,600
Diatomaceous Earth "B"	Natural	Yellowish White	8.7	17-22	Mainly fresh water discs, practically no fines.	5-25	18,300
Diatomaceous Earth "C"	Natural	Buff White	14.3	17-22	Melosira (pill-box) type diatoms, no fines.	10-25	11,300

TABLE II

Filtration Characteristics of Filter Aids

(Based on laboratory filtrations; Puerto Rican raw sugar, 0.3% filter aid; regular pressure increase)

	Filtration Rate	Clarification* Ft.-Candles	Clarity Factor
Filter-Cel	100†	8.79	100†
Standard Super-Cel	213	10.33	85
Hyflo Super-Cel	534	15.23	57.5
Celite 503	910	21.09	41.5
Celite 535	1269	25.35	34.6
Celite 545	1830	27.80	31.6
Diatomaceous Earth "A"	518	19.00	46.2
Diatomaceous Earth "B"	383	18.37	47.8
Diatomaceous Earth "C"	211	17.14	51.3

† Standard. * 25-30-minute filtrate.

utes, then continued at 20 lbs. for the remainder of an hour period. Filter aid precoat plus 0.1% each of filter aid and carbon was used. All tests were run at 70°C. (158°F.) in a bomb filter press unit which permitted accurate control of all factors affecting the filtration. This test unit, which has been described previously (2), is shown in Figure II. It consists of four complete bomb presses immersed in a common thermostatically controlled oil bath and connected to a common air pressure supply. Figure III shows the assembly during progress of similar tests. Each of the bombs is provided with mechanical agitation and with a separate reserve liquor tank. Pressure can be maintained either automatically by means of a time-pressure regulator or manually by means of a hand-operated pressure-reducing valve. Each bomb is provided with a precoat chamber for applying a uniform filter aid precoat under pressure at the start of a run. Parts coming in contact with the liquid being filtered are of brass, bronze, copper, or Monel construction.

INDIVIDUAL bombs (Figure IV) are of cast brass construction, 5 inches in inside diameter and 11 inches deep, with diameter narrowing to 3 inches at the bottom to reduce dead space around the filter leaf. Mechanical agitation is by means of two three-bladed 1.25-inch-diameter bronze propellers on a shaft driven through a bevel gear box inside of the bomb at the top, and including a Monel universal joint on the shaft just above the propellers. Propeller speed can be adjusted to either 200, 300, or 450 r.p.m. by stepped pulleys on a drive, which is from a common shaft at the rear of the unit and is driven by a ½-horsepower motor. Drive shafts to the bombs, each provided with a clutch, connect to spiral gear boxes on the common shaft. Filter leaf used is 1.5 inches in diameter. When no precoat is employed, a threaded filter plate cap is used, ⅛ to ½ inch deep, depending on anticipated filter cake thickness. Filter leaf head of bronze construction is held in position by four ⅜-inch steel nuts on steel studs. Removal of

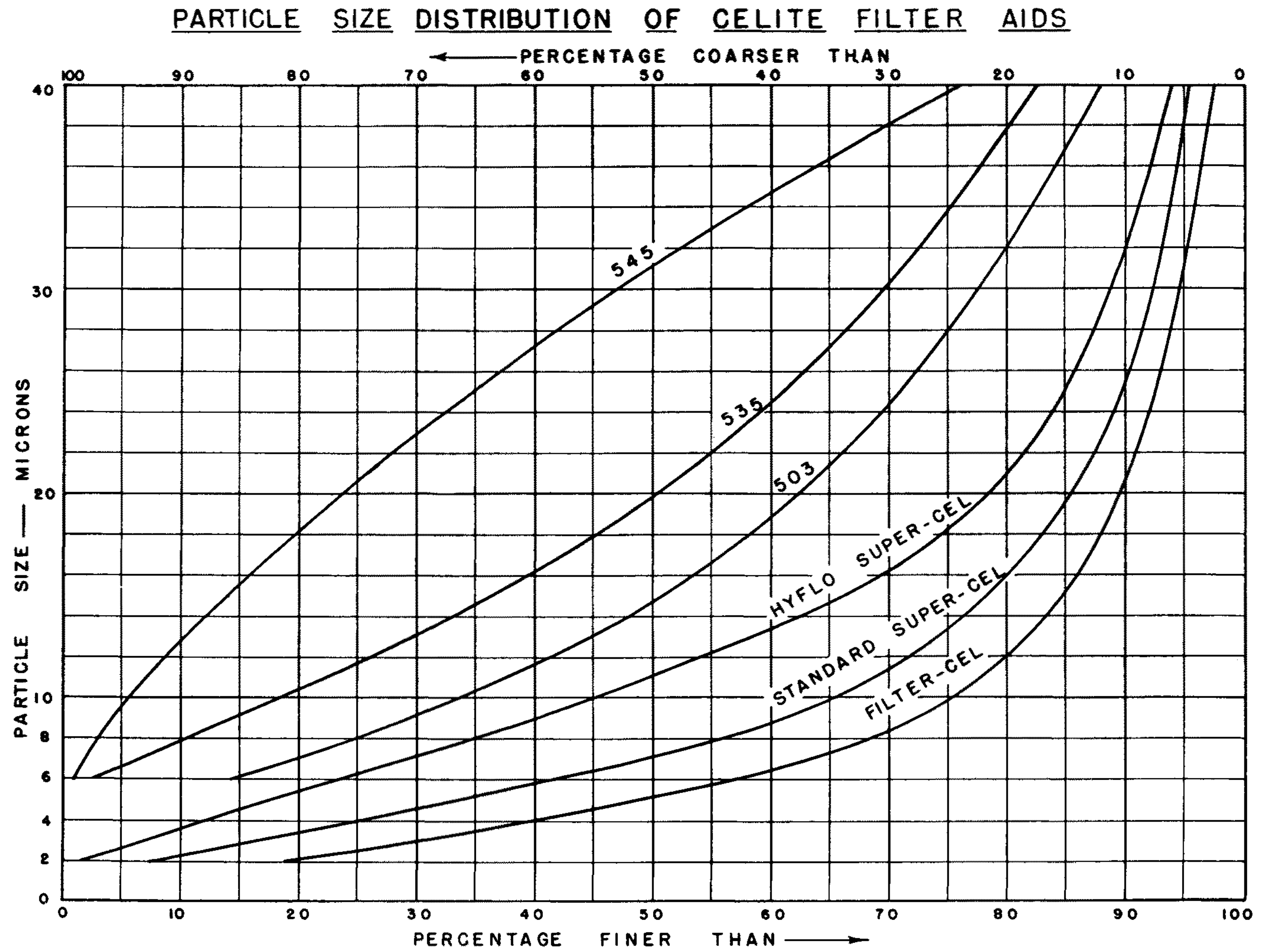


FIG. I. Particle Size Distribution of Celite Filter Aids.

TABLE III

Typical Particle Size Distribution of Filter Aids Obtained by Sedimentation Methods

	Filter-Cel	Standard Super Cel	Celite 512	Hyflo Super-Cel	Celite 501	Celite 503	Celite 535	Celite 545
Coarser than 40 Microns	2.5	4.5	5.0	6.0	9.0	12.0	17.5	24.0
40-20 Microns	8.0	10.0	13.0	15.5	20.5	25.5	32.0	52.0
20-10 Microns	14.0	20.0	27.0	33.5	31.0	29.0	32.0	18.5
10- 6 Microns	19.0	24.5	23.0	22.0	21.0	19.5	16.0	4.5
6- 2 Microns	37.5	33.5	27.5	21.5	17.5	13.5	2.5	1.0
Finer than 2 Microns	19.0	7.5	4.5	1.5	1.0	0.5	......	......

leaf from the bomb requires only removal of these four nuts. Tongue and groove construction at the gasket connection between the filter leaf head and the bomb cover flange enables a tight joint to be easily made with the gasket. The bomb cover flange can be taken off by removing the eight 3/8-inch steel nuts securing it. The 3.5-inch diameter opening in the cover flange, however, is sufficient to permit adjustments inside the bomb and cleaning and inspection of the interior without removing the cover flange. The maximum working capacity of the bomb is 0.687 gallon (2600 cc.), which allows a filtrate volume of 0.555 gallon (2100 cc.).

The precoat chamber, of 0.02 gallon (75 cc.) capacity screws onto the filter leaf and replaces the regular filter leaf cap when operating with precoat. The precoat filter aid is deposited on the filter cloth from suspension in a suitable liquor in the precoat chamber by incoming main batch liquor at the start of the test. When the precoat filter aid has been completely deposited on the cloth, the precoat chamber is raised by pulling up the precoat rod through the stuffing box in the filter leaf head.

The oil bath temperature is maintained by a steam coil in the bottom of the bath. The batch is agitated by a horizontal shaft with two propellers, driven by a 1/12-horsepower motor at one end of the bath. Temperature control is obtained with a Powers No. 14 regulator, which will accurately maintain any temperature within the limits 127° to 216°F. (53° to 102°C.).

Automatic pressure control is obtained with a Foxboro 10-inch, Model 10, time-pressure Stabilog, range 0-70 pounds pressure, with a 2-hour clock driving control cam. Interchangeable cams of soft sheet aluminum can be cut for any desired pressure cycle, and a single cam can be cut for a gradual pressure increase during a 4-hour period or longer. Optional manual pressure control is provided by an Oxweld regulator. By closing a valve in the pressure manifold between bombs 2 and 3, it is possible to operate bombs 1 and 2 with automatic pressure control while running bombs 3 and 4 simultaneously on a different pressure cycle with hand control.

Each bomb filter is provided with a reserve tank of 0.687-gallon (2600 cc.) capacity for supplying additional test liquor under pressure to the bomb when needed during a run. This tank is used when the volume of the test liquor initially filling the bomb is not sufficient for the duration of the run or when it is desired to keep the test liquor hot for as short a time as possible before it is filtered. A gage glass on each reserve tank permits observation of the amount of reserve tank liquor fed to the bomb. Each reserve tank is provided with air agitation.

For the lard filtrations reported the filter leaves were dressed with cotton cloth (No. 078-DR Filter Media Corporation). Precoating was effected with clear lard, the amount of filter aid being 0.1 lb. per square foot of filter area. The precoating pressure was 3 lb. per square inch.

The degree of clarification in a filtered liquid is an index of the quality of the liquid and its degree of purification. It has been difficult generally to measure accurately and express quantitatively the degree of clarity obtained in filtered liquids. A special instrument for this purpose was developed some years ago in the Research Laboratories of the Johns-Manville Company. This instrument, which has been employed for the present study, is a highly sensitive photometric tyndallmeter. It has been described in some detail elsewhere (2) and (3).

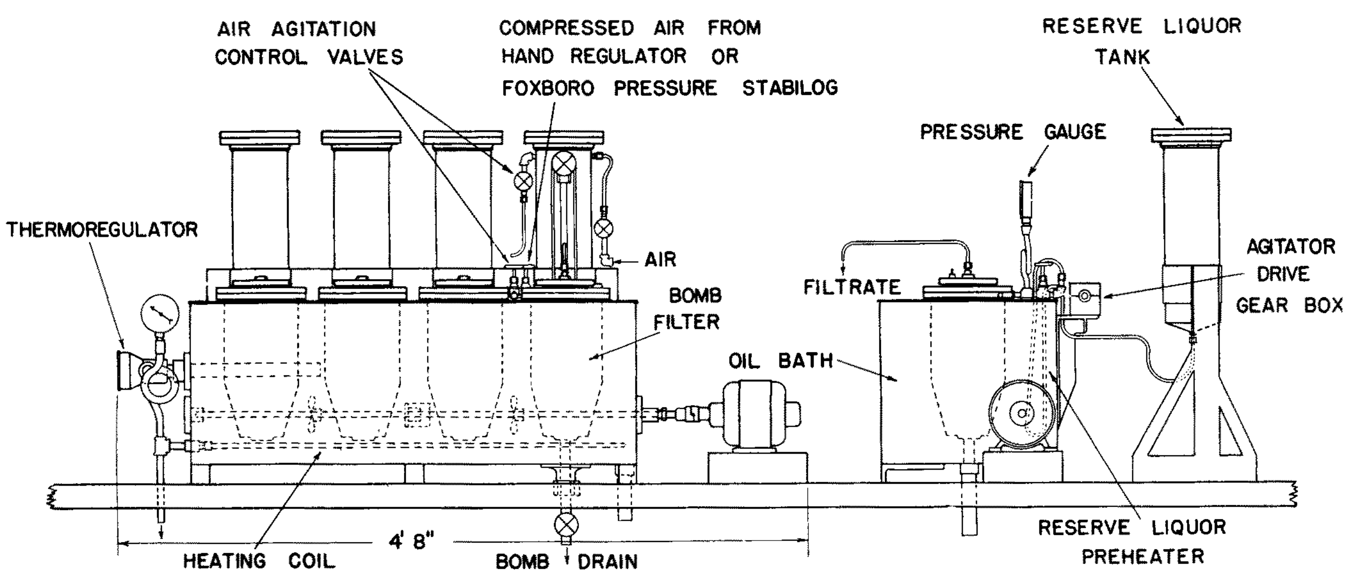


FIG. II. Diagram of Four-Bomb Filtration Test Equipment.

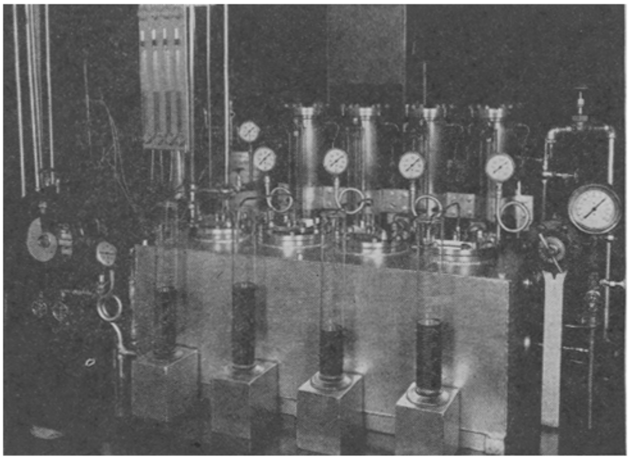


FIG. III. Four-Bomb Filtration Test Assembly in Operation.

THE instrument, shown in Figure V, consists essentially of a primary light source, an incident beam system, the mounting and cell for the test liquid, the emergent Tyndall beam system, the comparison beam system, the photometer unit, the telescopic observation system, appropriate light filters, an optical bench for mounting, and suitable housing for the various parts. A simplified diagram (Figure VI) shows the elements of the assembly.

The test liquid is placed in an observation cell which is constructed with plane optical glass sides cemented to form a cube of 0.65-inch (16.5 mm.) inside dimensions. Highly clarified liquids are centrifuged first to remove all air bubbles. The cell is then placed in position on its mount in the apparatus and the primary light turned on. The superimposed

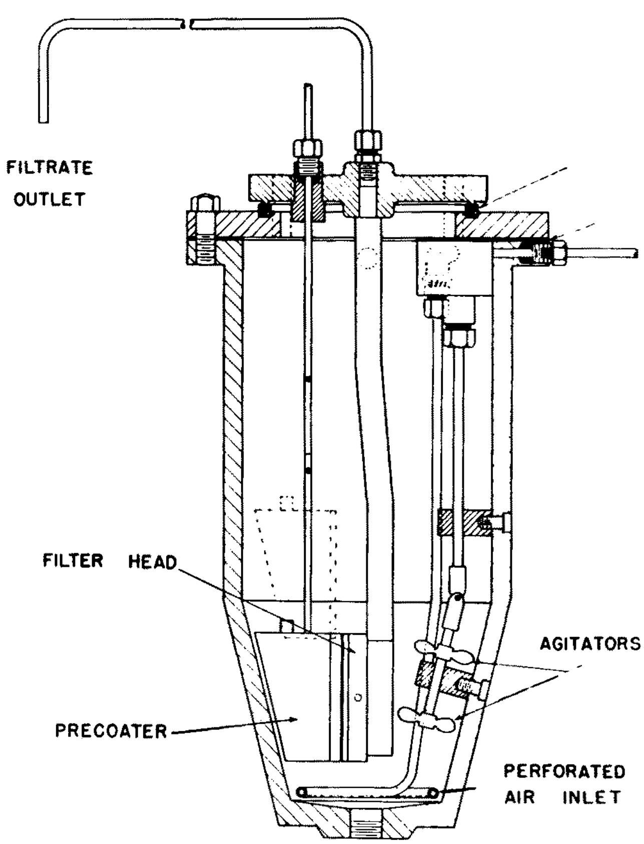


FIG. IV. Individual Bomb Filter Showing Filter Leaf, Precoat Attachment and Mechanical Agitator.

fields of the Tyndall beam and the comparison beam in the photometer cube are viewed through the telescope. Photometric match of the two fields is obtained by movement of the calibrated neutral wedge, which varies the intensity of the comparison beam. The reading at the point of photometric match is read from the vernier scale of the wedge. The position of the Tyndall beam in the liquid examined is fixed by settings of two mechanical stage movements which permit the test cell to be moved in the direction of the incident light and also at right angles to it. In this way one reading at standard settings can be made, or a series of readings at different positions of the Tyndall beam can be quickly and accurately taken. A series of readings made of the incident beam and the emergent beam through different

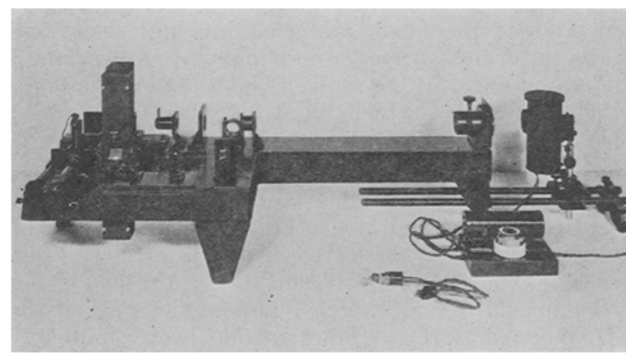


FIG. V. Tyndallmeter for Clarity Measurements (with housing removed to show optical parts).

depths of liquid permits an extrapolated reading to be obtained graphically which corresponds to a reading with zero depth of liquid for both incident and emergent beam. By this method a value is obtained for the intensity of the Tyndall beam which may be considered to be independent of the color of the liquid.

In this study the "clarities" of all filtrate fractions are expressed as actual scale readings of the calibrated wedge. The higher values represent the better clarification. These values can also be expressed as brightness of the Tyndall beam in foot-candles or any other unit desired, such as amounts of standardized turbidity or impurities, etc. This degree of refinement has not been attempted for lard.

Experimental

THE first series of filtering tests was made with filter aids alone. The results are shown in Table IV, which gives values and measurements for each 15-minute period of the one-hour filtering cycles, and for the composited 15- to 60-minute filtrates. These latter represent lards which have been collected after having reached degrees of clarification which may be considered to correspond to those realized in commercial operation after 15 minutes of re-cycling.

Filtration rates show steady increases; and clarifications, steady decreases, in going from Filter-Cel to Celite 545. Average flow rate for the 15-60-minute period increases from 8.0 gals./sq. ft./hr. for Filter-Cel to 45.0 gals./sq. ft./hr. for Celite 545. Filtrates are very clear with the lower flow rate filter aids but are turbid and of unsatisfactory clarity with the higher flow rate products, particularly with Celite 545. A test with Hyflo precoat only shows clarifica-

TABLE IV

Filtration of Prime Steam Lard Without Carbon Treatment

0.1 Lb./Sq. Ft. Filter Aid Precoat Applied at 3 Lbs./Sq. In. Pressure on Cotton Filter Cloth. Filtration at Constant 5 Lbs./Sq. In. Pressure with 0.05% Filter Aid 70°C. (158°F.)

Filter Aid	Filter-Cel	Standard S.C.	512	Hyflo S.C.	501	503	535	545	Hyflo Precoat No Batch Filter Aid	No Precoat No Batch Filter Aid	Diatomaceous Earth "A"	Diatomaceous Earth "B" 5-25 mu.	Diatomaceous Earth "C" 10-25 mu.
Filt. Rate— Gals./Sq. Ft./Hr.													
0-15 Minutes	13.8	21.3	28.1	43.1	54.2	65.3	77.4	93.5	32.2	24.3	37.0	28.8	34.7
15-30 Minutes	9.8	14.6	18.0	25.8	31.8	36.1	44.0	57.6	10.8	3.3	21.8	18.1	18.0
30-45 Minutes	7.8	11.5	14.2	19.6	24.5	26.7	32.5	42.1	7.6	2.4	16.9	13.9	13.0
45-60 Minutes	6.9	10.5	11.6	16.9	20.7	21.6	27.5	36.0	6.3	2.1	13.4	12.1	11.0
15-60 Minutes	8.0	12.3	14.9	20.8	25.7	28.1	34.6	45.0	8.2	2.6	17.3	14.7	14.0
Clarity— Tyndallmeter Reading													
0-15 Minutes	2835	2670	2640	2540	2440	2250	2210	2045	2440	1830	2380	2450	2295
15-30 Minutes	2925	2870	2830	2720	2600	2505	2350	2180	2720	2375	2550	2720	2630
30-45 Minutes	2935	2875	2845	2770	2620	2585	2465	2205	2770	2550	2605	2795	2705
45-60 Minutes	2965	2875	2850	2790	2665	2595	2465	2230	2790	2620	2700	2825	2720
15-60 Minutes	2940	2875	2840	2760	2625	2550	2415	2195	2755	2485	2600	2770	2675
Leifo Color Density per Cm. Depth at 460 mmu.													
0-15 Minutes	.0594	.0750	.0764	.0826	.0890	.1014	.1040	.1468	.0890	.2580	.0930	.0890	.0985
15-30 Minutes	.0586	.0660	.0710	.0790	.0865	.0910	.0994	.1262	.0790	.1000	.0894	.0790	.0875
30-45 Minutes	.0578	.0660	.0702	.0772	.0856	.0880	.0962	.1144	.0772	.0885	.0870	.0760	.0800
45-60 Minutes	.0558	.0650	.0702	.0752	.0812	.0860	.0922	.1104	.0752	.0840	.0795	.0720	.0790
15-60 Minutes	.0576	.0657	.0705*	.0774	.0848	.0888	.0955	.1184	.0774	.0921	.0860	.0760	.0830

* This color corresponds to a value on the Lovibond instrument with 5¼" cell of 15.0 yellow plus 1.9 red.

Note: Original lard showed 1800 Tyndallmeter Reading Clarity.

tion equivalent to that obtained with Hyflo precoat plus batch filter aid but at a considerably reduced filtration rate. With no precoat and no batch filter aid, clarification, except at the start, is in the range obtained with use of the higher flow rate Celite filter aids, but flow rate is very low.

Test results are also shown for three other different types of diatomaceous filter aids. The products referred to as "A", "B", and "C" were prepared from types of diatomaceous earth other than Celite. Preparation "A" consists of mixed fresh water forms, principally of disc shape, of Oregon origin. Preparation "B" is a 5-25 mu classified fraction obtained from Washington diatomite and consisting mainly of fresh water discs. Preparation "C" is a 10-25 mu classified fraction obtained from Nevada diatomite and consists mainly of Melosira (pill-box) type diatoms. All of these preparations show a flow rate in the range of Celite 512 or slightly higher, with clarifications which are inferior to that obtained with Celite 512.

The relationships between filtration rates and clarities are shown in Figure VII. The Celite filter aids, which have all been prepared from a common basic raw material, fall on a curve which shows a clear inverse flow rate—clarity relationship. It is clear from the other points plotted, that not all filter aids or filtration treatments give results which are in line with this empirical relationship. The filtration which affords the maximum degree of clarification together with a reasonably high rate of flow is the desideratum in filtration practice. The positions of preparations "A", "B", and "C" on the graph are the result of particle shape considerations and particle size distributions inherent in these products. The comparatively poor performance of the Hyflo when used as a precoat alone and the complete failure of the test with no filter aid are shown by their positions on the graph.

In the second series of tests the results with filter aid plus carbon are given in Table V.

Filtration rate shows a steady increase in going from Filter-Cel to Hyflo, then little further change with the faster flow rate filter aids. Clarification shows a slight decrease from Filter-Cel to 512, then a rather sharp decrease between 512 and Hyflo. There

TABLE V

Filtration of Prime Steam Lard With Carbon Treatment

0.1 Lb./Sq. Ft. Filter Aid Precoat Applied at 3 Lbs./Sq. In. Pressure on Cotton Filter Cloth. 0.1% Filter Aid, 0.1% Carbon in Batch. Initial 3 Lbs. per Sq. In. Pressure After 6 Minutes Raised 0.5 Lb./Minute to 20 Lbs. Maximum at 40 Minutes 70°C. (158°F.).

	Filter-Cel	Standard S.C.	512	Hyflo S.C.	501	503	535	545	Hyflo Precoat No Batch Filter Aid	No Precoat No Batch Filter Aid	Diatomaceous Earth "A"	Diatomaceous Earth "B" 5-25 mu.
Filt. Rate—Gals./Sq. Ft. Hr.												
0-15 Minutes	9.5	14.1	15.9	21.8	23.6	24.3	24.8	27.5	12.6	15.0	16.7	14.5
15-30 Minutes	13.6	18.0	20.9	26.7	28.2	27.2	27.1	30.0	13.3	15.8	19.8	19.5
30-45 Minutes	13.9	18.1	21.0	25.9	25.4	25.8	25.8	28.4	12.9	14.8	19.4	19.7
45-60 Minutes	11.3	15.0	17.2	20.8	20.4	20.6	20.3	22.4	10.3	11.6	15.7	16.0
15-60 Minutes	12.9	17.0	19.7	24.5	24.6	24.6	24.4	26.9	12.2	14.1	18.3	18.4
Clarity-Tyndallmeter Reading												
0-15 Minutes	2900	2845	2750	2160	2115	2130	2050	1980	2305	18.25	2210	2390
15-30 Minutes	2975	2920	2875	2500	2440	2430	2390	2260	2705	2550	2505	2675
30-45 Minutes	3000	2980	2930	2635	2590	2605	2610	2520	2820	2725	2680	2810
45-60 Minutes	3040	3005	2970	2945	2955	2965	3000	2980	3010	2940	2920	2935
15-60 Minutes	3000	2975	2920	2640	2590	2595	2580	2470	2815	2690	2660	2785
Leifo Color Density per Cm. Depth at 460 mmu.												
0-15 Minutes	.0516	.0564	.0764	.0812	.0902	.1144	.1262	.1388	.1032	.2266	.0894	.0790
15-30 Minutes	.0502	.0556	.0686	.0776	.0796	.0808	.0832	.0997	.0660	.0890	.0710	.0725
30-45 Minutes	.0480	.0556	.0615	.0696	.0715	.0720	.0800	.0836	.0632	.0700	.0660	.0632
45-60 Minutes	.0464	.0548	.0596	.0636	.0640	.0650	.0660	.0710	.0552	.0630	.0644	.0620
15-60 Minutes	.0483	.0553	.0634	.0708	.0725	.0733	.0774	.0861	.0619	.0751	.0673	.0661

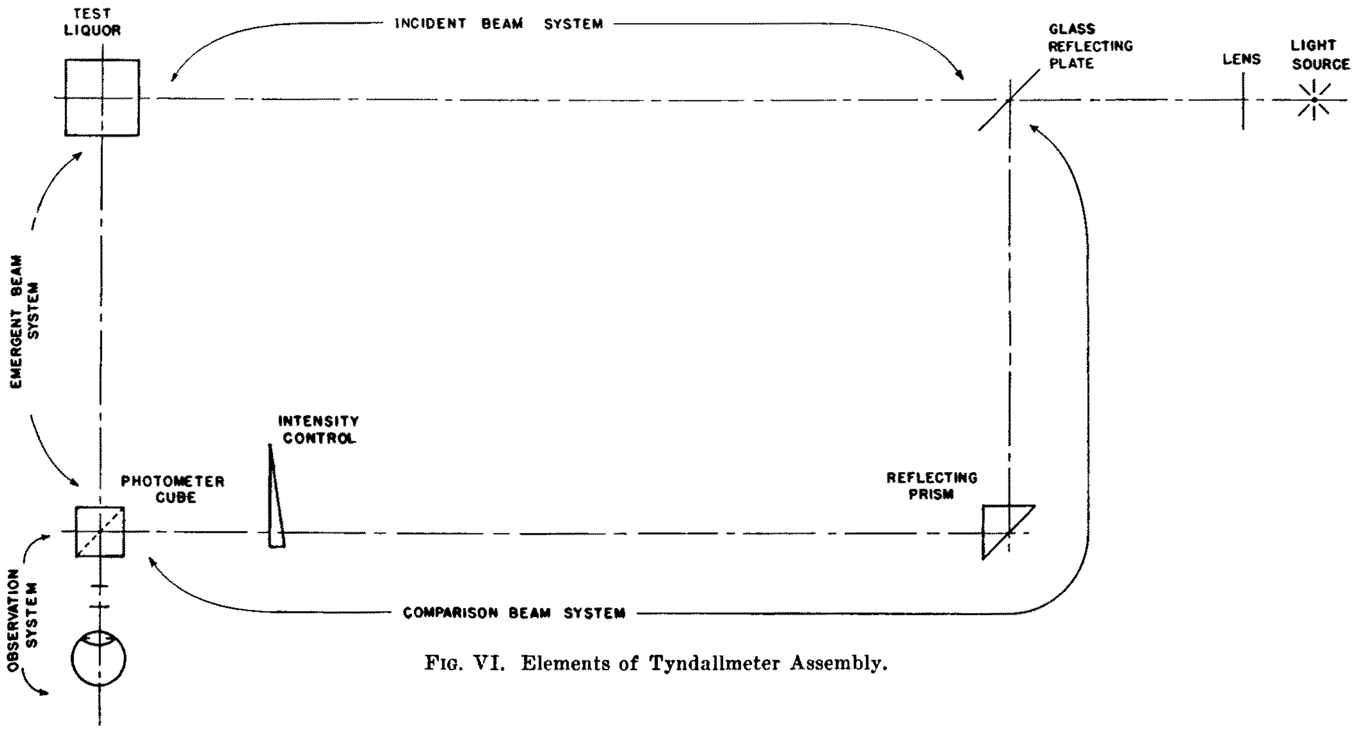


FIG. VI. Elements of Tyndallmeter Assembly.

is relatively little change in clarification, as in rate, between Hyflo and 535, then a rather definite decrease in clarity with Celite 545.

Filter-Cel, Standard Super-Cel and Celite 512 completely retain the decolorizing carbon and show no penetration of carbon to the filter cloth. Hyflo Super-Cel appears to be a filter aid of critical particle size with respect to carbon penetration, for the particular grade of carbon used in these tests. In the one-hour test employed, there was no noticeable deposit of carbon on the filter cloth and no noticeable carbon haze in the filtrate but the marked drop in clarity from 512 to Hyflo in the earlier part of the runs indicates the probability that some slight amount of carbon was passing through the Hyflo cake.

Celite 501 shows penetration of carbon through the cake and onto the filter cloth. This carbon penetration is shown in increasing degree in going to the still faster flow rate filter aids. The effect of the fine carbon in the cake plus carbon penetration is such that the filtration characteristics show little overall change in going from Hyflo to Celite 535. An appreciable difference is noted between Celite 535 and 545, more carbon passing into the filtrate with this coarsest grade, with an appreciably increased filtration rate and decreased clarification.

With Hyflo precoat only, with carbon but no filter aid in the batch, filtration rate is approximately the same as that obtained in the Filter-Cel run, but with clarification inferior to that obtained with Filter-Cel. With no filter aid precoat and only carbon and no filter aid in the batch, filtration rate is slightly higher than with Hyflo precoat and clarity is inferior.

It is noteworthy that the clarities with Filter-Cel, Standard Super-Cel and Celite 512 are relatively high from the start of the cycles, which shows the excellent retention of carbon, as well as extreme removal of turbidity for the entire filtrations.

With Hyflo and the faster flow rate filter aids, there are marked differences between the clarities for the 0-15 minute fractions and for the later fractions. This is also particularly noticeable for filter aids "A" and "B" and especially for the filtration with carbon only.

The clarity weaknesses of filter aids "A" and "B" are also shown in the composite filtrates. Thus, while both of these products gave filtration rates of about 18 gal./sq. ft./hr., their clarity values are well under that for Celite 512, which has a flow rate of 19.7 gal./sq. ft./hr.

These relationships are shown in Figure VIII.

In comparing the results of filtration of filter aid and carbon with those of filter aid alone, it is apparent that the carbon has a pronounced effect on the filtration. Flow rates cannot be compared directly for the two series of tests, because the amounts of filter aid employed and the pressure cycles were different.

THE curve of Figure VIII shows a strikingly different set of conditions from that of Figure VII. With carbon, there is no substantial difference in flow rates between Hyflo and the filter aids up to and including Celite 545. This means that with the carbon employed, there is such a relationship between the particles of the carbon and the particles of the filter aids that these more open and porous products do not function most efficiently as filter aids under this particular set of conditions. The result is no further improvement in rate of flow, while at the same time there is a tendency toward inferior clarification.

In the test with Hyflo precoat alone the poor clarity of 2305 at the start of the cycle shows that this would be a poor filtration practice, since Filter-Cel with precoat and batch filter aid gives about the same over-all filtration rate of 12.9 gal./sq. ft./hr. and provides a brilliant filtrate almost from the start of the cycle.

With carbon alone, the initial clarity of 1825 shows the passage of carbon haze into the 0-15 minute filtrate. Even for the latter part of the cycle, the need for filter aid with the carbon is shown by comparison with the rate of flow and clarity values for Filter-Cel, Standard Super-Cel, 512 and Hyflo.

The initial poor clarities and the final mediocre clarities for diatomaceous earths "A" and "B" are apparent, and show that filter aids of these types are not best suited for combination filtration with carbon of the type employed in these tests.

In general, the clarity effects observed are parallel with the removal of color. The color measurements were made on all filtrates with two different instruments, the Leifo Photometer and the Beckman Spectrophotometer.

The Leifo Photometer is an optical instrument for visual measurement of the transmission or absorption of a light beam through a definite depth of liquid. Colors of all of the filtrate fractions observed on this instrument are shown in Tables IV and V. Measurements were made with a 460 mmu (blue) filter at a 5 cm. depth. Figure No. IX shows the optical system of the Leifo Photometer.

The Leifo instrument measures optical density which is a combined effect of the color and turbidity. In the earlier filtrate fractions of each run of relatively high turbidity, therefore, and in the more turbid filtrates obtained with the higher flow rate filter aids, optical density values are higher in proportion to the amount of turbidity present. Values at equivalent turbidity are lower in the series in which carbon was used due to the lighter color of the partially decolorized lard.

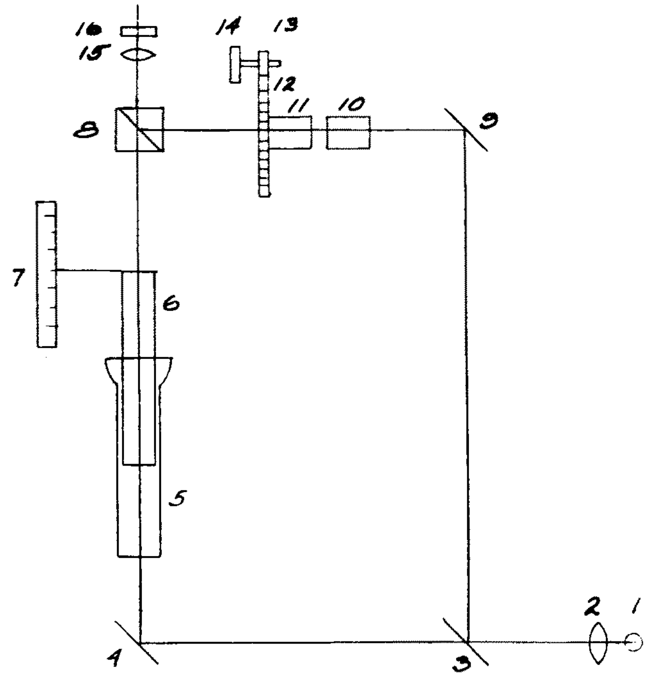


FIG. IX. Optical System of Leifo Photometer.

LEGEND—1. Light source. 2. Collimating lens. 3. Half-silvered mirror. 4, 9. Full-silvered mirrors. 5. Cylindrical test liquid cell. 6. Solid glass cylinder. 7. Scale reading depth of test liquid. 8. Photometer cube. 10, 11. Nicol prisms. 12, 13, 14. Gears and knob for rotating prism "11". 15. Eyepiece lens. 16. Monochromatic filter.

FIGURE VII

FILTRATION WITH FILTER AIDS ONLY

RELATION BETWEEN FLOW RATE AND CLARITY

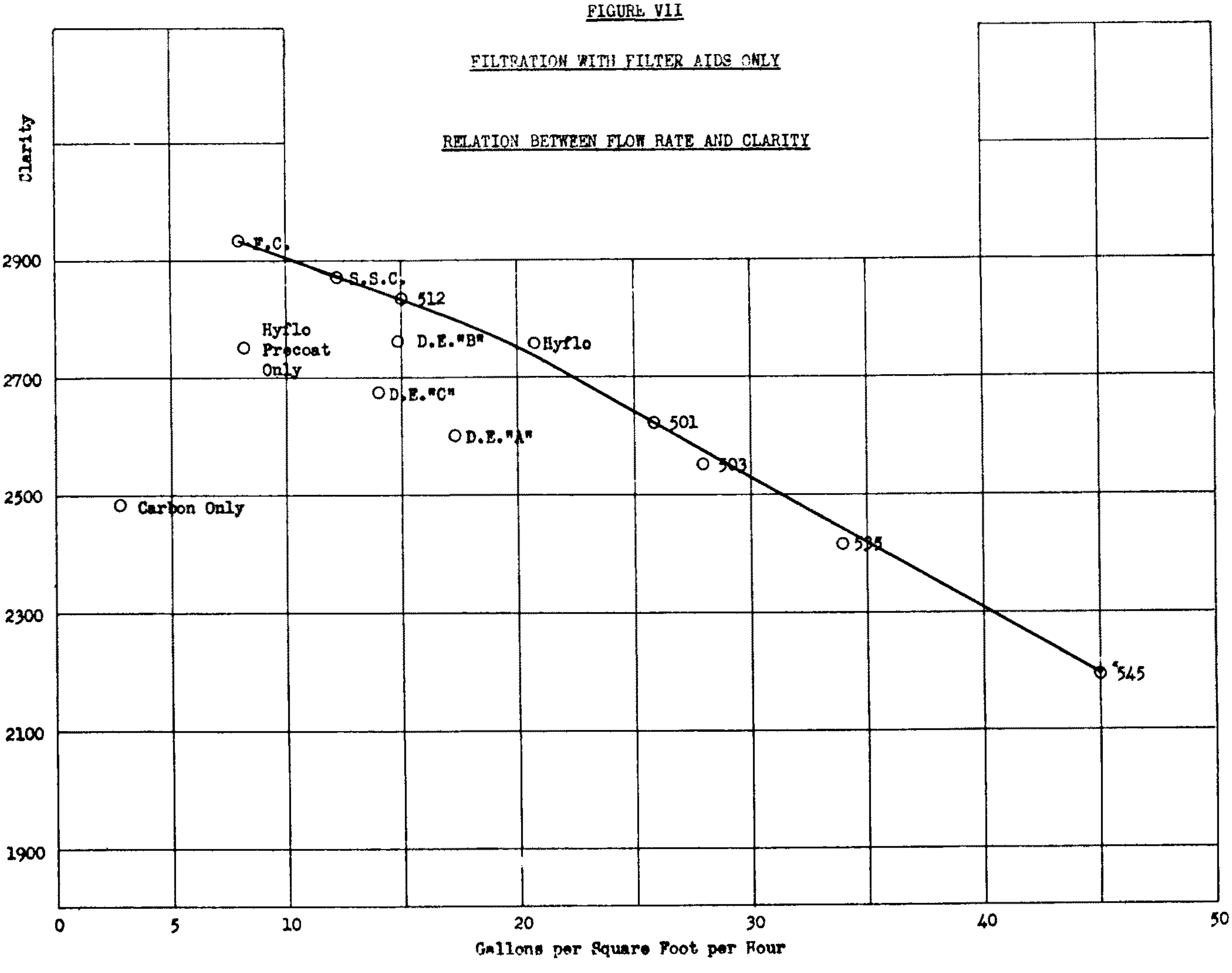
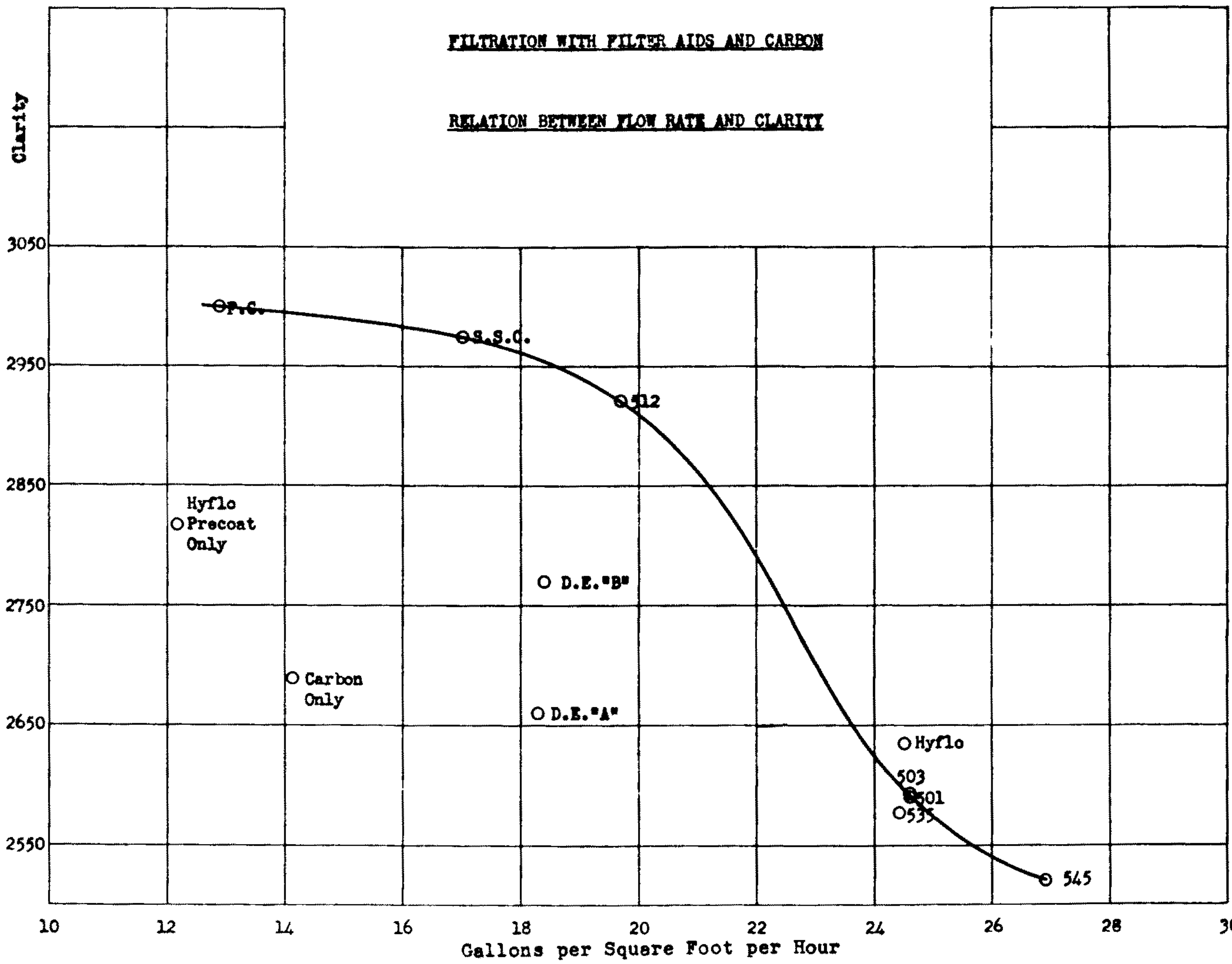


FIGURE VIII



Leifo color measurements were made at one wave length only although it is possible with this instrument to measure density at several wave lengths and thereby obtain a more significant measure of the color. A more complete and satisfactory measurement of color, however, was obtained with a Model DU Beckman Spectrophotometer, which measures the transmission or absorption of any transparent material over a wave length range from 200 to 1000 mmu which includes the ultra-violet and near infra-red, as well as the visible spectrum. Figure X shows the optical system of the Beckman Spectrophotometer.

FIGURE XI shows the curves obtained with four samples of lard in the Beckman Spectrophotometer analysis. Optical density is plotted against wave length, using the octaval system (4). Curve 3 was obtained with Hyflo Super-Cel filtrate without use of carbon. Curve 4 was obtained on the Hyflo filtrate using carbon, the difference between Curves 3 and 4 representing the effect of the carbon. Using the method for calculating color according to the standard observer and colorimetric coordinate system recommended by the International Commission on Illumination and applying to Curves 1 and 2 in the visible region (400 to 700 mμ), color removal of approximately 25% by the carbon is indicated.

Curve 1 shows the absorption values for the unfiltered lard (centrifuged to remove coarse particles)

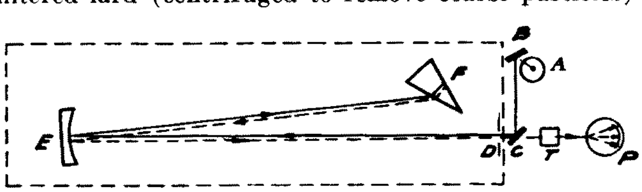


FIG. X. Optical System of Beckman Spectrophotometer. LEGEND—A. Light source. B. Condensing mirror. C. Plane mirror. D. Plane of entrance and exit slits. E. Collimating mirror. F. Quartz prism with back face silvered. T. Test liquid cell. P. Phototube.

and Curve 2, the values for lard filtered through filter paper. Both of these curves show the same shape as the Hyflo filtrate curve, but greater absorption due to the turbidity present.

The benefit of filter aid and filter aid plus carbon in removing color and turbidity is shown by the divergency of the curves in the range of 400-700 millimicrons.

General conclusions which may be drawn from this study, as to most suitable Celite filter air grades for lard filtration, are as follows:

(1) With the use of filter aid alone, without carbon, each successively coarser filter aid grade gives a successively higher filtration rate with correspond-

ing measureable decrease in degree of clarification. Hyflo or at most Celite 503 are probably the coarsest grades to be recommended for this use inasmuch as the still coarser grades yield filtrates which are of rather definitely turbid appearance. Selection of the most suitable grade will depend on the specific flow rate or clarity requirements.

(2) With the use of filter aid plus carbon of the type tested, Hyflo Super-Cel is the coarsest grade which will satisfactorily retain this carbon and prevent a carbon smearing of the cloth. Hyflo appears to be of a critical particle size with respect to carbon retention and might not satisfactorily retain a finer carbon than that used. Celite 512 appears well suited for this use. In the range from Filter-Cel to 512, each successively coarser filter aid grade gives an increased flow rate with only slight decrease in clarification. Hyflo Super-Cel, however, shows a more marked decrease in clarification, particularly in the earlier part of the run.

The study shows the general advantages of diatomaceous filter aids in lard filtration in increasing filtration rate, in improving clarification and in preventing carbon smearing of the filter cloth. The effect of color removal is indicated to some degree.

The methods and apparatus employed for carrying out the filtration tests and for making the clarity and color measurements are described as of interest and for consideration by the lard and oil refining industries.

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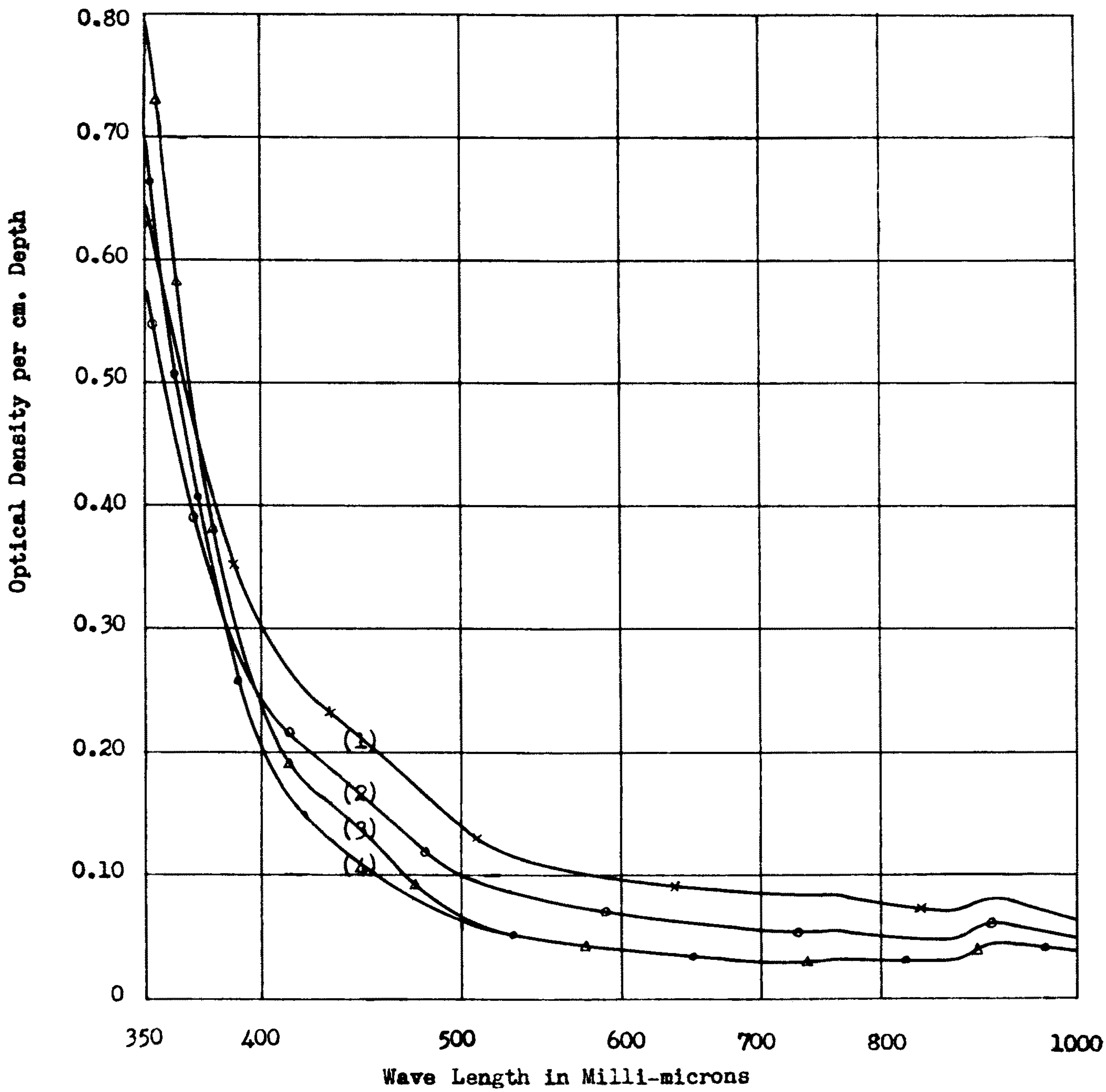

FIG. XI. Effect of Filter Aid and Carbon Treatments on Color of Lard (as determined with Beckman Spectrophotometer).

(1) × Centrifuged to remove coarse particles; 1830 clarity. (2) ○ Filtered through filter paper; 2040 clarity. (3) △ Filtered with Hyflo. (4) ● Filtered with Hyflo plus carbon.