TABLE II—NUMBER OF KILOWATT HOURS REQUIRED TO RAISE ONE TON (2240 LBS.) OF STEEL TO VARIOUS TEMPERATURES AT SEVERAL EFFICIENCIES

Rise in temperature		Percentage efficiency				
° F.	° C.	100	80	70	60	50
950	528	89	111	127	148	178
1050	584	103	129	147	172	206
1150	639	118	147	168	196	236
1250	695	134	167	191	223	267
1350	750	150	187	214	249	299
1450	806	164	205	235	274	328
1500	834	171	214	245	286	342
1550	861	178	223	254	297	356
1600	889	188	235	268	313	376
1650	916	197	246	282	328	394
1700	945	207	259	296	345	414
1750	972	217	271	310	362	434
1800	1000	222	278	318	370	445
2350	1306	272	340	388	453	544

In general, the larger the production of metal in a particular furnace, the greater the electrical efficiency. Too high production, however, usually means difficulties in control and with very high production there is danger of overheating should there be slackening in the production without a corresponding change in the kilowatt input being made. The aim to make a production at a rate equivalent to 4 or 5 k. w. per sq. ft. of hearth and also at 65 to 75 per cent efficiency is an excellent one. When the cost of current is rather high, work which necessitates a production at a lower efficiency than 60 per cent should be transferred to a smaller furnace if the shape of the pieces permits. On furnaces under 30 k. w. capacity these figures do not apply, as the efficiency on such small furnaces is very much less than on the moderate size ones of 50 to 125 k. w.

INSTALLATION OF FURNACES

In order to determine the number and size of furnaces for an installation a careful inquiry into the nature and quantity of the production is necessary. The maximum and minimum productions must be met with as high efficiency as possible for the various productions. Frequently a moderately large furnace to operate all the time, accompanied by a smaller one to be operated as needed, is much more economical from a point of view of current consumption in the long run, than one furnace capable of the maximum production. Care must be observed not to make the furnace too large for the sake of being on the safe side. A furnace so large that it takes 10 per cent more current than a smaller one exactly suited to the work, would waste enough current in the course of six months, or a year at the outside, to pay for a complete new installation. Sometimes the labor requirements determine the size of the units. Two men on a single furnace might not be able to accomplish so much on the one furnace as they would if operating two smaller size furnaces. Here the decreased efficiency in two furnaces must be carefully compared with the saving in labor.

SELECTION OF TYPE OF FURNACE

In the selection of the type of furnace for the particular work, if 10 sq. ft. or more of hearth area are required, a furnace regulated by the resistance method, Fig. III, is certainly to be preferred. This furnace costs about half as much as the furnace equipped with a transformer and has a much more uniform heat liberation in the hearth. Electric furnaces with re-

sistance regulation including all the electrical equipment, cost about the same for installation as a good oil furnace, and frequently are somewhat cheaper if blowing equipment installation charge for the oil furnace is included. As a rule these furnaces operate on a higher voltage than do the furnaces having a special transformer so that a saving in copper for the conductors is sometimes effected. They can be designed to operate on the standard voltages, 220 volts being very satisfactory, and, of course, can operate on either direct or alternating current. The larger furnaces can be built to operate on two- or three-phase lines, but those taking 100 k. w. or less are best constructed for single-phase or direct current. For the small furnaces, such as the one shown in Fig. IV, a regulation by means of voltage is best with a transformer having a secondary with several taps, as mentioned above, either with or without the resistance regulation in conjunction with it.

USE OF ELECTRIC FURNACE FOR HEAT TREATMENT DEPENDENT ON COST OF CURRENT

The extent of use of the electric furnace for heat treating depends quite largely on the cost of current. Fortunately, in this connection, the resistance furnaces have a remarkably steady load. The starting load is somewhat less than the running load. In a large number of cases the mean running load is found to be between 80 and 90 per cent of the maximum demand. Under these circumstances, particularly with operation extended into or through the night, current can usually be furnished for a low figure. The price of one cent per k. w. hr. is frequently sufficient to warrant the employment of the electric furnace in place of oil on the ground of cheaper cost of operation alone. Current for three-quarters of a cent per k. w. hr. frequently proves as cheap as any method of firing when all factors are considered. Among these factors, most of which have been duly considered, might be mentioned the lower labor charge which is usually effected by the introduction of the electric furnace. The furnace is conducive to high production on account of the fact that it is not so uncomfortable for the workmen as the fuel-fired furnaces. Besides the fact that it is relatively cool and the elimination of all smoke and dirt, and the attendant difficulties with the products of combustion, the electric furnace is much more satisfactory from the workmen's standpoint than any heretofore produced.

ACKNOWLEDGMENT—The writer wishes to express his appreciation of the assistance of his associate, Mr. Richard S. Bicknell, both in the study and design of these electric furnaces, and in the preparation of this paper.

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STUDY OF AUTHENTIC SAMPLES OF GUM TURPENTINE

By A. W. SCHORGER

Received March 11, 1914

VARIATION IN PROPERTIES

Turpentine, spirits of turpentine, or oil of turpentine, is the volatile oil obtained ordinarily by the distillation of the oleoresin of various species of pines.

In recent years a considerable amount of "wood turpentine," obtained by steam or destructive distillation of resinous wood has been placed upon the market. To avoid confusion, the turpentine obtained by distillation of the oleoresin or gum is called "gum turpentine."

Gum turpentine consist largely of the terpene α -pinene, with smaller amounts of camphene¹ and β -pinene.² Camphene is not readily affected by light and air, but α -pinene and β -pinene are soon affected; the specific gravity, index of refraction, and boiling point become higher and there is a pronounced increase in color and non-volatile residue. For this reason the physical properties of gum turpentine will vary considerably, depending upon their age and exposure.

McGill³ collected 48 samples of turpentine on the open market. After eliminating samples of doubtful purity, he defines turpentine in part as follows: Density 0.860 to 0.880 at 15.5° C., being usually about 0.870; density of the first fraction consisting of 10 per cent by volume, between 0.856 and 0.870, being usually about 0.860. The refractive index should lie between 1.4667 and 1.4722 at 20° C., that of the first fraction should not exceed 1.4700; boiling point between 154° and 158° C.; nine-tenths by volume should distil over below 180° C.

Long⁴ found that the specific gravity of pure commercial turpentine varied from 0.8656 to 0.8748. The boiling point was uniformly 155–156° C., and 85 per cent distilled below 163° C.

Veitch⁵ and Donk state that a turpentine of standard or No. 1 quality should have a specific gravity of from 0.862 to 0.870 at 20° C.; a refractive index of from 1.468 to 1.476 at 20° C.; and that 95 per cent should distil below 170° C.

Practically all information previously published on the physical properties of gum turpentine is based on the analysis of samples, the age of which is not stated, and consequently it is not apparent to what extent variations existed in the original freshly distilled oils or to what extent they are due to subsequent changes. Although it has been considered that the conditions of production exerted some influence on the quality of turpentine, the extent of such influences had not been determined.

VARYING CONDITIONS OF PRODUCTION

The oleoresin obtained by systematic scarification of the trees and caught in appropriate receptacles such as "cups" or "boxes," is known as "dip" among turpentine operators, while that portion of the oleoresin which hardens on the face of the tree is called "scrape." Collectively, the dip and scrape are called "gum."

When the trees are tapped by the box system a cavity called a box is cut into the base of the tree. The face immediately above the box is chipped weekly to produce a flow of gum; as a result, the face is ex-

tended and a height of ten to twelve feet is sometimes attained before the tree is abandoned. The height of the face increases from 18 to 24 inches per year, and the gum must travel a constantly increasing distance to reach the box. The dip collected the first year is called "virgin," the second year "yearling," usually "buck" for the succeeding years. Because of the greater distance the gum must flow during succeeding years, which necessitates longer exposure to light and air; the turpentine has a more or less yellow color and is usually supposed to have a higher specific gravity. The proportion of volatile oil in the oleoresin collected decreases as the height of the face increases and the rosin has a darker color.

The employment of the cup and gutter system or cup and apron system reduces the path, over which the gum must flow, since at the beginning of each season the cup is raised to the top of the face chipped the preceding year. The turpentine obtained from this gum is believed to be more uniform in physical properties and is only slightly colored.

The gum is distilled in ordinary copper-pot stills which hold from ten to thirty-five barrels and are heated directly. A small stream of water is allowed to flow into the still from a funnel in the still head after the greater portion of the water occurring in the gum has passed over. The temperature within the still usually does not exceed 160° C. at the end of the distillation, but when old scrape or dip is being distilled a much higher temperature is often employed. The rosin flowing from one still was observed to have a temperature of 194° C.

The species tapped in the South are almost exclusively the longleaf pine (*Pinus palustris* Mill.) and the Cuban pine (*Pinus heterophylla* Ell.); the shortleaf pine (*Pinus echinata* Mill.), loblolly pine (*Pinus taeda* Linn.), and the pond pine (*Pinus serotina* Mich.) are tapped only casually.

COLLECTION OF SAMPLES

The samples which were taken to study the variation in fresh turpentine were collected by the author at the stills and were obtained at various points in the coastal region from Mississippi to Georgia in order that they might be representative of the turpentine produced throughout this belt. They were taken from barrels which were being filled at the still or from those which had just been filled and rolled into the storage shed. Two lots were obtained, one in the fall of 1910 and the other in the spring of 1911. From each of the samples, as complete a history as possible was secured which covered the source of the gum (whether dip or scrape, from boxes or cups, age of the faces, and other similar information) and the part of distillation from which the sample was taken. A summarized description of the samples is given in Tables I and II.

As soon as the samples were collected they were shipped in sealed, 1-gallon tin cans to the Forest Products Laboratory. Analysis of the samples was begun and finished in such time that not more than a month elapsed between the date of collection and analysis.

To determine what variation might be expected in

¹ Schimmel and Company, *Report*, October 1897, p. 68.

² *Ibid.*, April, 1908, pp. 99–100.

³ Inland Revenue Dept., Canada, *Bull.* 79.

⁴ *Jour. Anal. and Applied Chem.*, 6 (1892), 2.

⁵ *Bur. of Chem.*, Washington, D. C., *Bull.* 135.

large lots of commercial oils, a sample was obtained at monthly intervals from large stock tanks at Pensacola.¹

For studying the effect of storage, two 1-barrel samples of fresh turpentine were obtained² and stored

TABLE I—SPECIFIC GRAVITY, INDEX OF REFRACTION, AND PERCENTAGES DISTILLING UP TO 165° AND 170° OF TURPENTINES COLLECTED IN THE FALL OF 1910

Samp. No.	Kind of gum	Recep- tacle	Year of tapping	Part of run	Sp. gr. at 15° C.	Refrac. index at 15° C.	Per cent distillate to	
							165°	170°
1130	Scrape	Box	1st and 2nd	Last	0.8683	1.4737	92.0	97.5
1131	Scrape	Box	1st	Last	0.8704	1.4743	95.0	97.0
1132	Scrape	Box	4th	All	0.8680	1.4730	95.0	97.0
1133	Dip	Box	1st	First	0.8662	1.4722	97.0	97.5
1134	Dip	Box	4th	First	0.8663	1.4732	94.5	97.5
1135	Dip	Cup	1st and 2nd	First	0.8674	1.4739	91.5	97.0
1136	Dip	Cup	1st and 2nd	Last	0.8673	1.4737	92.0	97.0
1137	Dip	Cup	1st and 2nd	All	0.8683	1.4744	91.0	96.5
1138	Scrape	C & B	2nd	Last	0.8695	1.4744	92.0	96.5
1139	Scrape	Box	2nd	Last	0.8686	1.4737	93.0	96.5
1140	Scrape	Box	5th	Last	0.8678	1.4732	92.5	97.5
1141	Scrape	Box	1st, 2nd and 5th	Last	0.8681	1.4736	92.0	96.5
1142	Scrape	Cup	2nd	Last	0.8683	1.4729	94.5	97.0
1143	Dip	Box	2nd to 5th	Last	0.8682	1.4735	92.5	96.0
1144	Scrape	Cup	2nd	Middle	0.8665	1.4724	97.0	97.0
1146	Dip	Cup	1st	First	0.8669	1.4722	96.0	97.0
1147	Scrape	Box	1st	First	0.8698	1.4724	96.5	96.5
1148	Dip	Cup	1st	First	0.8659	1.4721	96.5	97.5
1149	Scrape	Box	4th and 5th	Last	0.8682	1.4731	93.0	97.0
1150	Dip	Cup	1st	First	0.8666	1.4724	97.0	97.0
1151	Scrape	Cup	1st	First	0.8674	1.4729	95.5	97.0
1152	Scrape	Box	2nd	All	0.8667	1.4723	95.0	97.0
1153	Scrape	Box	4th	Last	0.8695	1.4735	92.5	95.5
1154	Dip	Box	4th and 5th	Last	0.8683	1.4732	91.5	97.0
1155	Dip	Box	1st and 2nd	All	0.8674	1.4723	95.5	97.0
1156	Dip	Box	3rd	Last	0.8688	1.4734	92.5	97.0
1157	Dip	Box	1st and 2nd	Middle	0.8671	1.4726	94.5	97.0
1158	Dip	Box	2nd	First	0.8680	1.4728	97.0	97.0
1161	Dip	Box	1st and 5th	First	0.8699	1.4745	89.0	93.0
1162	Scrape	Box	5th	First	0.8669	1.4732	95.0	97.0
1163	Dip	Box	3rd	First	0.8675	1.4737	90.0	96.5
1164	Dip	Cup	1st, 2nd and 3rd	Last	0.8687	1.4750	87.0	95.0
MINIMUM.....					0.8659	1.4721	87.0	93.0
MAXIMUM.....					0.8704	1.4750	97.0	97.5
AVERAGE.....					0.8680	1.4732	93.6	96.7

TABLE II—SPECIFIC GRAVITY, INDEX OF REFRACTION, AND PERCENTAGES DISTILLING UP TO 165° AND 170° OF DIP TURPENTINES COLLECTED IN THE SPRING OF 1911

						Per cent distillate to	
Lab. No.	Kind of recep- tacle	Year of tapping	Part of run	Sp. gr at 15° C.	Refrac. index at 15° C.	165° or	170° or
						until 5% re- mains	until 5% re- mains
1671	Box	3rd	Last	0.8718	1.4733	90.0	94.5
1672	Box	2nd	First	0.8696	1.4724	94.0	95.0
1673	Cup	2nd	Last	0.8700	1.4745	90.0	94.5
1674	Cup	2nd	First	0.8674	1.4732	92.0	95.0
1676	Cup	1st	All	0.8675	1.4722	95.0	95.0
1677	Box	1st and 2nd	Middle	0.8704	1.4731	90.5	94.5
1678	Cup	1st	First	0.8678	1.4724	95.0	95.0
1679	Box	7th	Last	0.8703	1.4741	86.0	93.0
1680	Cup	2nd	Last	0.8683	1.4731	92.5	94.5
1681	Box	2nd and 3rd	Last	0.8722	1.4738	87.5	94.0
1682	Box	2nd	First	0.8688	1.4725	93.5	95.0
1683	Box	5th	All	0.8688	1.4724	93.5	94.5
1684	Box	2nd to 5th	Whole	0.8691	1.4726	92.5	94.5
1685	Box	2nd to 5th	Last	0.8707	1.4736	89.0	93.5
1686	Box	1st	Last	0.8692	1.4729	94.0	94.5
1687	Box	2nd to 5th	First	0.8694	1.4732	95.0	95.0
1688	B & C	2nd to 6th	All	0.8680	1.4722	95.0	95.5
1689	B & C	1st to 6th	Last	0.8678	1.4720	94.5	94.5
1690	B & C	2nd to 6th	Last	0.8678	1.4722	94.5	95.5
1691	Box	1st	Middle	0.8668	1.4714	95.5	95.5
1692	Cup	1st	First	0.8670	1.4714	95.0	95.0
1693	Box	2nd	First	0.8675	1.4717	94.5	94.5
1694	C & B	1st to 5th	First	0.8675	1.4730	91.5	93.5
1695	C & B	1st	Last	0.8668	1.4730	88.0	94.0
1696	Box	7th	Last	0.8719	1.4742	86.0	93.5
1697	Cup	2nd and 3rd	Last	0.8690	1.4745	87.5	94.0
1698	Cup	1st	Middle	0.8672	1.4722	93.5	94.5
1699	Box	2nd and 4th	First	0.8697	1.4740	89.5	93.5
1700	Box	2nd and 4th	Last	0.8713	1.4746	87.0	94.0
1701	Box	2nd	Last	0.8688	1.4744	86.5	94.5
1702	Box	5th	First	0.8680	1.4731	90.5	95.0
1703	Box	4th	All	0.8696	1.4737	90.5	93.0
1704	Box	4th	First	0.8684	1.4734	92.0	94.5
1705	Box	1st and 5th	Last	0.8709	1.4734	92.0	94.0
1706	Box	1st and 5th	Last	0.8671	1.4724	93.0	95.0
MINIMUM.....				0.8668	1.4714	86.0	93.0
MAXIMUM.....				0.8722	1.4746	95.5	95.5
AVERAGE.....				0.8689	1.4730	91.5	94.4

at the laboratory; these were examined at intervals

¹ The American Naval Stores Company, from whom these samples were obtained, state that turpentine is constantly added to and withdrawn from their tanks so that the contents seldom remain undisturbed for a period longer than one week.

² From Gillian, Vizard and Company, New Orleans, La.

of four months. The turpentine was distilled from virgin scrape.

METHOD OF ANALYSIS

The method of analysis, which consisted of fractional distillation and the determination of the physical properties of the fractions, is fully described in *Forest Service Bulletin 105*.¹ The fractionating apparatus consisted of a twelve-inch Hempel column filled with glass beads. The sample consisted of 500 grams of oil and the fractions collected amounted to approximately 10 per cent except for the first 5 per cent of distillate. For the first lot of samples (Nos. 1130 to 1164, inclusive) about 2 per cent was taken for the first fraction and the distillation was continued until a temperature of 170° was reached or the distillate ceased to pass over. The other samples for which detailed analyses are given (Nos. 1671 to 1705) were distilled in a slightly different manner. The first two fractions amounted to about 2.5 per cent each; the specific gravity of the first fraction was taken separately; then the two fractions were combined and the specific gravity of the mixture was determined. Also it was aimed to leave a residue of 5.0 per cent in the distilling flask. These changes seemed advisable because of the great variations in the properties of the first fraction when it was as small as 1.5 to 2.0 per cent. Furthermore, when either the first fraction or residue is less than 5 per cent, their specific gravities cannot be taken with the Westphal balance in general use in chemical laboratories, and when it is attempted to distil more than 95 per cent of the turpentine, polymerization takes place to a considerable extent; this has the effect of increasing unduly the specific gravity and index of refraction of the residue.

ANALYSIS OF FRESHLY DISTILLED OILS

Table I gives the specific gravities, indices of refraction, and percentages distilling to 165° C. and 170° C. for the dip and scrape turpentine collected in the fall of 1910; similar determinations on the turpentines collected in the spring of 1911 are given in Table II. The specific gravity of the turpentines ranged from 0.8659 to 0.8722, with an average of 0.8685 for all conditions of production. The index of refraction of the same samples ranged from 1.4714 to 1.4746, with an average of 1.4730. The specific gravity values are fairly evenly distributed throughout the range indicated, except in the upper portion, where they are more scattered.

Boiling Point—The samples collected in the fall of 1910 had a range of boiling point of 155° to 157.6°, the average being 156.1°. The boiling points of the samples collected in the spring of 1911 ranged from 154.1° to 156.9°, the average being 155.8°.

First Fractions and Residues—The first fraction amounting to 2.5 per cent had the following properties: specific gravity at 15° 0.8630–0.8655, the average being 0.8645; refractive index 1.4674–1.4708, the average being 1.4691.

The first fraction amounting to 5.0 per cent had the following properties: specific gravity 0.8641–0.8663,

¹ "Wood Turpentines, Their Analysis, Refining, and Composition," by L. F. Hawley.

the average being 0.8652; refractive index 1.4691-1.4710, the average being 1.4698.

As anticipated, the residues showed the greatest variation. The properties of the 5 per cent residues were as follows: specific gravity 0.8873-0.9723, the average being 0.9121; refractive index 1.4837-1.5082, the average being 1.4920.

EFFECT OF CONDITIONS OF PRODUCTION ON PROPERTIES

Season of Year—The "dip" turpentines collected in the spring had an average specific gravity of 0.8689 while the specific gravity of those collected in the fall was 0.8676. The difference shown by the average values appears fairly consistent in the individual samples, notwithstanding that the lower range is identical for both classes. Of the 35 samples collected in the spring, 19 had a specific gravity higher than the average for all samples, while of the 17 dip turpentines collected in the fall only three fell above the mean value

from first- and second-year faces. The average for all samples of the former class is 0.8691, and of the latter 0.8678. The age of the face seems to have little or no influence on the properties of turpentine distilled from scrape gum.

Method of Collecting Gum—The turpentines from boxes have an average specific gravity 0.0012 greater than those from cups, but when individual samples are compared there is little regularity in the values. The average index of refraction and range of refractive values are practically identical for both classes of turpentine.

Part of Distillation—The part of the distillation run from which the sample is taken has a very evident influence on its specific gravity. The average gravity of all samples from the first part of the run and of those representing the middle part of the whole run is practically the same, but the samples from the last part

FIG. 1

FIG. 2

FIG. 3

for all samples. The average index of refraction, as well as the range of refractive values is practically identical for the two classes of turpentines.

Kind of Gum—The samples collected in the fall of 1910 included turpentines from both dip and scrape gums. The average specific gravity of the scrape turpentines was 0.8683 and of the dip turpentine 0.8676; the maximum and minimum values were also higher for the scrape turpentines than for the dip turpentines by about the same amount as the average values. The average index of refraction for both classes of turpentines was precisely the same, but the range for the scrape turpentines was a trifle narrower than for the dip turpentines. The average specific gravity of the first fractions and the average values of both the specific gravity and index of refraction of the residues are slightly higher for the scrape than for the gum turpentines.

Age of Faces—The dip turpentines from 3- to 7-year faces had a slightly higher specific gravity than those

of the run have higher gravity than those from the first and middle. This variation is fairly consistent among the various classes of samples. The index of refraction of the samples from the last part of the run is also higher.¹

Summary—Turpentines vary in specific gravity with the conditions under which they are produced. The average gravity is higher for scrape than for dip turpentines, higher for turpentines collected in the spring than for those collected in the fall, higher for old faces than for new, higher for boxes than for cups, and higher during the last part of the distillation run than during the first part. These differences are very small; but that they are real and not accidental is in-

¹ The barrel into which the water and oil run from the still and where the separation of water and oil is effected, usually remains from one-half to three-fourths full, the turpentine being gradually dipped out to prevent overflow, consequently the samples are more uniform than it would appear since a sample taken from the last third of the run is not taken from the last third that actually runs from the worm. Furthermore, since the turpentine is distilled in the presence of water vapor there would be no sharp separation into light and heavy fractions.

licated by the fact that the variations are fairly consistent among individual samples, and that the effects are most pronounced when several factors are combined. The highest average gravity for any group of samples occurs for three which come from the last part of the run on gum collected in the spring from old faces by boxes; the lowest occurs for four samples from the first part of the run on gum collected in the fall from first- and second-year faces, by cups.

The index of refraction varies to some extent for the individual samples, but the average values for the different classes are practically the same.

Although the physical properties of turpentine vary with the conditions of production, the variations are comparatively small and the range of values for normal turpentines is likewise comparatively small. The range for percentage distillation and specific gravity and index of refraction of normal gum turpentines is shown graphically in Figs. 1, 2 and 3. These curves show the extreme limit of physical properties for authentic samples.

FIG. 4

ANALYSES OF SAMPLES FROM STOCK TANKS

The analyses obtained at monthly intervals from stock tanks are given in Table III.

The average specific gravity, 0.8689, and refrac-

TABLE III—ANALYSES OF TURPENTINES OBTAINED AT MONTHLY INTERVALS FROM STORAGE TANKS

Lab. No.	Date received 1912	Date examined 1912	Sp. gr. at 15° C.	Ind. of ref. at 15° C.	95 per cent distilled up to ° C.
1967	Jan. 8	Jan. 25	0.8696	1.4726	167.5
2216	Feb. 5	Feb. 20	0.8697	1.4726	166.5
2230	March 6	March 8	0.8694	1.4725	166.0
2315	April 8	April 10	0.8694	1.4726	167.5
2115	May 3	May 7	0.8692	1.4726	167.5
2170	June 6	June 10	0.8684	1.4728	167.0
2207	July 8	July 10	0.8685	1.4727	167.0
2417	Aug. 6	Aug. 8	0.8682	1.4727	167.0
2447	Sept. 5	Sept. 10	0.8688	1.4729	167.0
2501	Nov. 4	Nov. 7	0.8687	1.4730	166.5
2546	Nov. 19	Nov. 22	0.8685	1.4730	166.0
2594	Dec. 14	Dec. 17	0.8683	1.4729	166.5

tive index, 1.4727, of these samples agree well with the corresponding average values for the samples examined in the preceding series of tests, namely, 0.8685 and 1.4730. The ranges for percentage distillation, specific gravity, and refractive index for the samples obtained from stock tanks are given in Fig. 4, and are much narrower than those given in Figs. 1, 2 and 3. This greater uniformity is to be expected in the samples taken from bulk quantities. Since it is not known what class of turpentine predominated in a tank at any time, such variations in physical properties as appear cannot be fully explained. However, the higher specific gravity of the samples taken the first months of the year may be accounted for since the first dipping of the season is not distilled until April or May, and scrape turpentines from the previous season would predominate during the winter months.

EFFECT OF STORAGE

The two barrels of turpentine secured for storage at the Forest Products Laboratory were distilled the middle of December, 1910. Sample No. 1559 was stored in an iron drum, while No. 1560 was left in the original container. Both samples were first examined March 30, 1911, at which time sample No. 1559 was transferred to the iron drum, and were subsequently examined at periods of approximately four months each. The results of examination are given in Tables IV and V.

Sample No. 1559 shows but a slight change after storing for 1½ years, while the specific gravity of

TABLE IV—SUCCESSIVE ANALYSES OF TURPENTINE STORED IN IRON DRUM (SAMPLE NO. 1559)

Date of examination	Age Months	Specific gravity at 15° C.	Refractive index at 15° C.
March 30, 1911	3½	0.8685(a)	...
July 26, 1911	7½	0.8682	1.4723
December 6, 1911	11½	0.8681	1.4723
April 4, 1912	15½	0.8684	1.4724
August 8, 1912	19½	0.8688	1.4724

No. 1560 has increased but 0.0025 during the same period. The latter sample had to be frequently transferred from one barrel to another because of leakage and was more exposed to the air than the sample in the iron drum which was practically air-tight.

TABLE V—SUCCESSIVE ANALYSES OF TURPENTINE STORED IN WOODEN BARREL (SAMPLE NO. 1560)

Date of examination	Age Months	Specific gravity at 15° C.	Refractive index at 15° C.
March 30, 1911	3½	0.8682(a)	...
July 26, 1911	7½	0.8680	1.4719
December 6, 1911	11½	0.8681	1.4719
April 4, 1912	15½	0.8691	1.4721
August 8, 1912	19½	0.8715	1.4724

(a) A Westphal balance was used for determining the specific gravities on March 30, 1911, while the succeeding determinations were made with a Gay-Lussac pycnometer to secure greater accuracy. This accounts for the higher specific gravity of the first determinations.

The extent to which sample No. 1559 had changed is shown in Fig. 5, where the distillation data obtained on December 6, 1911, before any appreciable change in specific gravity occurred, are compared with the last distillation made (August 8, 1912). Coincident with the change in specific gravity there is a slight increase in the amount of high boiling constituents and an increase in the index of refraction of these constituents.

FIG. 5

Fig. 6 shows the change that took place in sample No. 1560 during the same length of time. The original specific gravity had changed 0.0034 and a considerable increase in high boiling constituents was anticipated. It will be noted, moreover, that the boiling point, index of refraction, and specific gravity show a decrease in the lower part of the curves; the difference is especially large for the specific gravity. The boiling point of the last fraction could not be accurately determined, since the mercury continued to drop gradually, although the distillate came over regularly. An explanation that may be offered for the changes occurring in this sample is that a selective oxidation had taken place at the expense of the higher boiling

terpenes. To examine this point further, a three-liter green glass bottle with a narrow neck was filled to within one-half liter of its capacity with turpentine from the same barrel and allowed to stand open to the atmosphere in the laboratory. The average temperature was about 20° Centigrade. The exposure lasted from October 23, 1912, to February 5, 1913, approximately 3½ months. The specific gravity of the oil when set out for exposure was 0.8725 and at

FIG. 6

the end of the test 0.8848, the index of refraction being 1.4746. The curves obtained on distilling 500 grams of the aged oil are compared in Fig. 7 with the curves obtained December 6, 1911. The original oil showed no turbidity and no apparent change in color by aging. The initial boiling point of the oil after exposure was about 145° C., and upon distillation 10 per cent. of water was collected in the first fraction. The amount of water present in the distillate decreased gradually to fraction No. 6—the only clear fraction obtained—and increased from this point to the end of the distillation. In the case of fraction No. 9, the temperature dropped gradually to 135°, the oil distilling regularly until this temperature was

reached, when distillation ceased. Parallel distillations were run and it was found to be impossible to prevent the drop in temperature at this point, even by doubling the rate of distillation. Nearly the full power of the Bunsen burner was required to obtain fraction No. 10, amounting to 1.95 per cent and containing about 10 per cent water. The residue amounted to 12.3 per cent with a refractive index 1.5265 and a

were combined and allowed to stand twelve hours. Considerable water and a yellow sediment deposited. The layer of turpentine was decanted off clear and shaken with anhydrous sodium sulfate and 500 grams were taken for distillation. The results of this distillation are again compared with the original turpentine in Fig. 8. There is a noticeable decrease in boiling point and refractive index, and especially in

specific gravity.

From our present knowledge, α -pinene, camphene, and β -pinene are to be considered the chief terpenes present in gum turpentine. α -Pinene has a specific gravity of about 0.863 at 15° and boils at 156° Centigrade. Camphene has a specific gravity of about 0.870 and boiling point 160°, but it is one of the most stable of the terpenes towards air and light. β -pinene has a specific gravity of about 0.868 and a boiling point of 164–166°. A greater oxidation of the β -pinene in preference to the α -pinene would account for the decrease in the values for the physical properties of the fractions.

CONCLUSIONS

I—There is a tendency for the specific gravity to be higher for scrape than for dip turpentines, higher for turpentines collected in the spring than for those collected in the fall, higher for old faces than for new, higher for boxes than for cups, and higher for the last part of the run than for the first. However, the differences between the turpentines from these various sources are slight.

II—The properties of bulk quantities composed of turpentines produced under various conditions should

approach the average values given below.

III—Turpentine stored with reasonable care for a period of one year will show little or no change in physical properties.

IV—Aged turpentines will contain varying amounts of oxidation products of the terpenes, depending upon the degree of aging or exposure and should not be considered normal turpentines.

V—The range and average values for the physical properties of normal, freshly-distilled, gum turpen-

FIG. 7

specific gravity of 0.993 at 25°. The low boiling points of several of the fractions must be due to steam distillation caused by the presence of water. The water doubtless results from the breaking up, on heating, of the hydrates formed by aging.

Owing to the presence of water, the distillation of the oil altered by age did not give satisfactory information in regard to the changes which may have taken place in certain of the constituents. Accordingly, the first nine fractions of the two parallel distillations

tines, based on the analysis of 67 samples, are as follows:

1—The specific gravity at 15° C. will fall between 0.8659 and 0.8722, with an average of 0.8685. The index of refraction at 15° C. will fall between 1.4714 and 1.4746, with an average of 1.4730. The initial boiling point will not be lower than 154° or higher than 157.6°, and will average about 156°.

FIG. 8

2—The first fraction by the method of distillation used, amounting to 2.5 per cent, will have a specific gravity not lower than 0.8630, and will average about 0.8640; the index of refraction will be not lower than 1.4675 and will average about 1.4690. If the first fraction amounts to 5 per cent, the specific gravity will be not lower than 0.8640, with an average of 0.8650; the index of refraction will be not lower than 1.4690, with an average of 1.4700.

3—At least 86 per cent, generally 91–93 per cent, will distil up to 165°; and at least 93 per cent, generally 97 per cent, will distil up to 170°.

4—The residue of 5 per cent will have a specific gravity not lower than 0.8875 and it will average about 0.9140. The last fractions should show a steady

increase in specific gravity. In no case should the specific gravity of any fraction be lower than that of the previous fraction.

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THE HYPOCHLORITE OF LIME TREATMENT OF A MUNICIPAL WATER SUPPLY AND A STUDY OF CERTAIN RESISTANT BACTERIA

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Received April 9, 1914

INTRODUCTION AND HISTORY

On March 27, 1909, the Council of the City of Bethlehem, Pa., passed an ordinance appointing a committee to investigate conditions and decide upon a site for a new water supply for the city. This was the first official act taken that contradicted the idea that Bethlehem was being supplied with pure water. Until a few months previous the city was supposed to have one of the best water supplies in the State of Pennsylvania. While the cistern has been more or less in vogue in this community always, yet as a municipality Bethlehem may be said to have probably the oldest public water system in the United States. The old pumping station back of the Eagle Hotel is an historic landmark, ranking in age with the Moravian Chapel and some of the rest of the city's pre-Revolutionary buildings. When one considers the length of time that this source has supplied the city with water, it can readily be seen how some of the citizens objected to a seemingly enormous outlay of money for a new supply.

On July the fourteenth, 1909, Council authorized the purchase of Illick's Mill site and gave permission to the committee to spend the necessary money for drilling wells. A bond issue was then placed before the people and in the fall of that year it was passed. There were objections raised, however, and the case was taken to the Supreme Court. The Court decided that the ballot had been defective and that the bond issue was defeated. Work on the Illick's Mill plant was necessarily suspended and Bethlehem saw no chance for a change in water supply.

The city had grown enormously in the last decade in the vicinity of the old spring and it was well known that the water was badly contaminated. The spring and well were down in a hollow surrounded by buildings. Theoretically, one could not look for a worse place from which to draw a public water supply. Practically, the water was being polluted as badly as could be conceived of.

It might be well to state here just what constitutes a "good" water supply and wherein the Bethlehem water failed to fulfill the requirements. Savage (Savage—Water Supplies, page 2) classifies bacteria found in water into three divisions.

1—Normal inhabitants, as *B. fluorescens liquifaciens*. This class comprises all bacteria which find water a suitable medium for their growth and multiplication. This class may be present in large numbers without necessarily indicating contamination. It would mean,