The Journal of Industrial and Engineering Chemistry

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EDITORIALS

THE INDEX TO CHEMICAL LITERATURE

Under this title, the U. S. Patent Office has published a statement[1] describing the work undertaken by the Classification Division, so as to enable rapid and complete searches to be made on any subject of chemical literature. This is a gigantic piece of work, embracing not merely patent literature, but practically all fields of chemical literature.

Before the chemical card index was commenced, anything like a complete search of the literature was practically impossible, and the validity of chemical patents was more or less in doubt; for, after the most elaborate search possible was made, a five-line paragraph in the files of some little known chemical journal published in Japanese, Russian or other not readily understood language, would be sufficient if cited in court to invalidate the granted patent.

It will be several years before this card index is complete, although much assiduous work is being done on it. In the meantime, enough has already been accomplished that anyone making a search on the literature of a chemical subject, can save much labor and time by consulting the index of the Patent Office. It should be noted that the index is accessible not only to the examiners of the Patent Office, but to patent lawyers practising before the office, as well as to chemists and scientific workers all over the land. Hence, this card index is becoming a national monument to chemical literature.

For those not living too far away, a visit to Washington to consult the index may prove the shortest and cheapest way to make a search in chemical literature. It would be highly desirable, however, if duplicates of this index could be obtained for the more important libraries all over the country. It is true that copying this card index would be rather expensive, but there is no doubt that the enormous value of such a copy would be fully worth the expense. Why could not some of the libraries of the country work together and have several copies printed at the same time, and thus distribute the cost of the task among themselves?

It is interesting to quote from the report mentioned above:

"In planning the chemical card index, since it was manifestly impossible to index all chemical literature, it was decided to cover the work of the past by making a judicious selection of certain works of a general nature, such as the 20-volume work of Gmelin, the annual volumes of the Chemical Society of London, the 4-volume edition of Watts' "Dictionary of Chemistry," Richter's "Lexicon of Carbon Compounds," and other works of that character; by indexing these works the literature of the past would probably be as completely covered as it could be by any plan which the office had the force and means available for accomplishing."

"For the future it was proposed to keep the abstract journals

of the Chemical Society of London, the German abstract periodicals, *Berichte* and the *Centralblatt*, and other works of that character indexed up to date."

"Later when the American Chemical Society, in 1907, commenced the publication of its very complete set of abstracts, it was determined to omit the periodicals in German and other foreign tongues, and retain in the card index only the yearly index volume of the Chemical Society of London in addition to the American abstracts."

The above reference to the usefulness of the abstracts of the American Chemical Society would be decidedly more satisfactory if it were not accompanied by the following statement:

"The question has been raised whether the annual index of the Chemical Society of London is not duplicated by the work of the American abstractors to such an extent as to render it useless to include both publications in the index."

"It is found upon comparing the published lists of the publications indexed by each set of abstracts as follows:

Publications abstracted by the London Society...............................	101
Publications abstracted by the American Society...............................	516
Publications abstracted by the London Society not abstracted by the American....	29

These 29 publications not covered by our American workers include the following *viz.*: German, 8; English, 12; Dutch, Swedish, and French, 2 each; and 1 each of Italian and Japanese.

"Comparing 6 pages of the English Society Index of 1909 with the corresponding American work of the same year it is found that out of 256 articles and monographs indexed by the English workers, 159 of these articles were not in any way referred to in the American Society Abstracts."

"These two facts together seem to fully answer the question, and show the necessity of including both works in the index."

May this criticism stimulate our American abstractors to greater zeal and accuracy, aside from the fact that many justified criticisms have been made that in some instances the abstracts are carelessly drawn up and give a very wrong idea of the originals.

Various difficulties were encountered in outlining a general plan for the index. If chemical bodies each had but one instead of several names, and if in chemical literature one never met with bodies as yet unnamed and therefore referred to by chemical formulas only, then undoubtedly the dictionary plan pure and simple, with the names of the substances alphabetically arranged and the references to literature and patents collected under their proper titles, would answer every requirement, and would be, in fact, the only proper system to use. Practically, however, most bodies known to chemists have a plurality of names, and the names approved and used in prior decades are generally not the names in highest repute nor in ordinary use to-day, nor is it at all sure that the names now in use will in most or even in many cases remain in use in years to come.

Where a chemical compound has several names (as indeed is usually the case), were it possible to decid

now (which perhaps might be done) which one of them is, on good scientific grounds, the most appropriate for index purposes in view of present knowledge, and further (which of course could not be done), could one be assured that such name would remain the approved name for all future time, such title could, without hesitation, be now adopted as the indexing title, under which all references to literature or patents could be entered, and all other titles and names cross-referenced into it; but while this might be done now in certain cases, which and how many of these names now used and approved will remain in use in years to come is something that no one can at present determine. Evidently the dictionary plan, unmodified, was not the best, and some better system had to be devised not open to these objections.

The system adopted was based on the chemical formula. In establishing for the Patent Office a card index to chemical literature, it was therefore decided to use, as an indexing basis, the kind and number of the component atoms of a chemical compound, these being its most unvarying characteristics, being subject only to errors of chemical analysis, and being, therefore, the most stable and unchanging basis for any scheme for the indexing and digesting of chemical literature: a conclusion reached at about the same time independently by Richter, as illustrated in his since published Lexicon der Kohlenstoff-Verbindungen, and by other later workers in this field, the Patent Office system differing from that of Richter in being simpler and of more general application.

It was found that the simplest, most certain, and most direct system, was to rewrite the so-called empirical chemical formula in a particular manner, that is to say, to write the atoms in the alphabetical order of their chemical symbols, upon library catalogue cards of standard size, and place these cards, arranged in alphabetical order, in standard library cases. For example, take the following chemical compounds:

$(CH_3)_2C_2H_2(NO_2)_2$ . . . . Dinitrobutane
$(CH_3)_2CHNO_2$ . . . . Isopropylic nitrite
$KH_3C_2O_4$ . . . . Potassium acetate
CH_3Cl . . . . Methyl chloride
$Cu(AsO_2)_2$ . . . . Copper arsenite

Rewriting them and arranging them alphabetically by formulas instead of titles, they are:

As_2CuO_4 . . . . Copper arsenite
CH_3Cl . . . . Methyl chloride
$C_2H_3KO_4$ . . . . Potassium acetate
$C_3H_7NO_2$ . . . . Isopropylic nitrite
$C_4H_8N_2O_4$ . . . . Dinitrobutane

It should be noted, however, that the compounds containing carbon and hydrogen, and broadly included in the domain of organic chemistry, constitute so large and important a class that it is fully justifiable to depart slightly from the strictly alphabetical arrangement of chemical symbols, and write C always first and H accompanying C always second, in order to bring more closely together in the index bodies more or less closely related in chemical and physical properties.

In practice, therefore, the following general rule has been followed in compiling the chemical card index of the Patent Office: Reject water of crystallization and rewrite the empirical formula in the alphabetical order of the chemical symbols, except that in carbon compounds, C is to be written first and H second. Follow this rewritten formula with the constitutional formula, when given, adding the water of crystallization, if any, but arrange the cards alphabetically by the rewritten formula.

The reason for disregarding water of crystallization may be illustrated as follows: The three bodies, Na_2SO_4 or anhydrous sodium sulfate, $Na_2SO_4 + 10H_2O$ or Glauber's salt, and the heptahydrated salt, $Na_2SO_4 + 7H_2O$, are in this way indexed under the same indexing formula, Na_2O_4S, and are thereby brought together, as they should be, for in solution they are chemically identical. If, on the other hand, water of crystallization were taken into account for indexing purposes, the corresponding indexing formulas would become Na_2O_4S, $H_{20}Na_2O_{14}S$, and $H_{14}Na_2O_{11}S$, respectively, and these three practically identical bodies would, in consequence, be widely separated in the index, which result would evidently be a very undesirable one.

The index was commenced and has been continued on the library-card catalogue plan, using the regular standard card, size $7^1/_2$ by $12^1/_2$ centimeters, or approximately 3 by 5 inches, without rulings except a single colored horizontal line $3/_8$ of an inch below the top of the card—this for typewritten cards and cards upon which printed matter cut from books and periodicals is pasted. A limited use has also been made of cards having ruled lines, where for certain reasons the cards are written by hand.

I believe it would be very desirable to have an exchange of opinions on this subject in the correspondence column of this journal. It is our duty to assist by any helpful suggestions possible, the good work which is now being performed by the Washington Patent Office.

L. H. BAEKELAND

ORIGINAL PAPERS

PRELIMINARY REPORT UPON A PRACTICAL ACCELERATED TEST FOR PAINTS AND VARNISHES[1]

By A. M. MUCKENFUSS

There being comparatively few constants in nature,

it follows that most materials are continually changing their properties with use, though at widely varying rates. In the case of paints, varnishes and some other materials affected by exposure to atmospheric agencies of destruction, this change of properties is quite rapid at first and continues generally at a di-

minishing speed. The coating when fresh is liquid, but soon becomes "tacky," and later firm but elastic, finally descending into a condition of brittleness, chalkiness, and other manifestations of old age. Among the properties of the paint and varnish film might be enumerated: permeability to various liquids and gases, electrical conductivity, elasticity, and hardness. All such characteristics are changing from the moment the coating is applied until it is finally destroyed. What is the internal cause of the alterations and to what extent are they independent of each other? It seems to be generally agreed that there are four classes of changes going on within a protective coating: A–*Chemical:* (1) Reactions between constituents of the air and the vehicle, gum, and in some cases the pigment. (2) Reactions between the coating and the surface covered. (3) Reactions upon each other of the various constituents of the coating. B—*Physical:* (4) Alterations in crystalline form, size of particles, and the like, in the pigment, and physical changes in the vehicle produced by the above chemical actions. The line of demarcation between the physical and the chemical is steadily growing more obscure and nowhere is its haziness more manifest than in such a complex mixture as that of the organic, inorganic, colloidal, crystallic materials of a paint film.

It being self-evident that reactions like the above are the causes of the aforesaid changes in properties, it seems to follow that, with the exception perhaps of the first physical alterations referred to, it is impossible for any one property of the film to gain or lose in value without also a difference becoming manifested in all the other properties. In other words, the variable properties of the paint and varnish coating are dependent and not independent functions. Here we have the foundation for the research outlined below. If the film becomes "flat," there will be an alteration of the density, permeability, hardness, and of all other properties. Theoretically, therefore, it is only necessary to measure one of these characteristics at various periods during the life of the coating in order to obtain an index of the alteration at all other points. Since the coefficient of change with time will be different for each property, the greater the number of these measured, the better; though from a practical view point, it may not be worth while to measure more than one accurately. These variables differ considerably in importance and ease of measurement. Some cannot be measured without injury to the film, as hardness, and some not without unfair treatment, as resistance to chemicals.

Of all these characteristics, permeability is second to none in importance and stands first in ease of measurement. It seems generally agreed among experts that differences in the permeability of the membranes lie at the base of the explanation of the wide contrasts between the durability of protective materials. Many methods, more or less accurate, have been devised for rating the perviousness of the paint film, in recognition of its importance as a distinct property, entirely aside from its periodic measurement as an

index to durability. As to the latter, the panel test is the standard and by its results, slowly obtained though they be, all other processes with similar purpose should be gauged. In the course of the numerous accelerated paint tests described in the literature, little attention has been paid to the age of film, thickness of coat, temperature and humidity of air, amount of sunshine, etc., after coats were applied. As will be shown later, no inferences can be drawn from measurements for the durability of membranes, unless all factors entering into the process of drying and decay are carefully standardized or unless all panels of a set of comparative tests are subjected to practically identical conditions as regards both intensity and duration.

The attempt was made at the outset of this investigation to devise for measuring permeability an apparatus that could be operated as accurately as needed, without in any way subjecting the membrane of the material to unfair treatment. Further
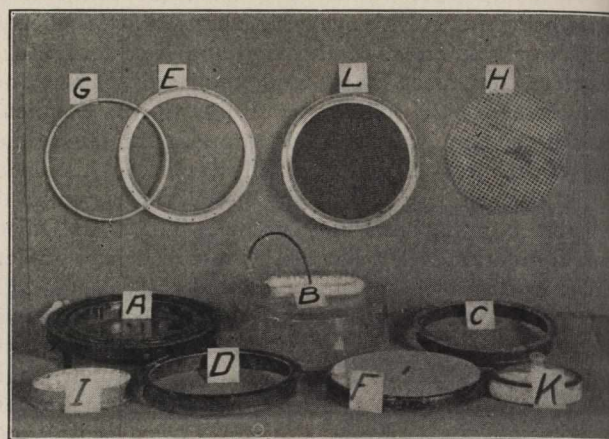
FIG. 1

objects were simplicity, ease of manipulation, a wide range of conditions for measurement, and the possibility of construction in various forms and from various materials. Fig. 1 exhibits several parts of the third and present form of the apparatus and Fig. 2 shows the parts assembled in several units arranged side by side on a shelf. In Fig. 1, *A* is the base; *B*, the general cover; *D*, the convex ring; *C*, the concave ring; *E*,
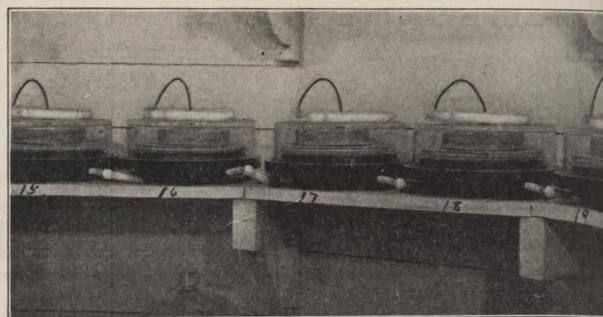
FIG. 2

the clamping ring; *L*, the two latter clamped together with a steel porous surface stretched tightly between them; *F*, the pan; *G*, the wire ring; *H*, the wire screen

disc; *K*, the weighed dish containing the water absorbent; and *I*, the corresponding unweighed dish. The cover to the weighed dish is sealed with a composite wax of proper viscosity. The materials used are cast iron, glass, and painted tin, but there is yet room for many improvements in this regard. When setting up this apparatus, the base is leveled and sufficient mercury is placed in each groove. Sufficient water is also poured into the central trough. Just beyond the water is a tube opening through a plug of cotton to the outside air and across from this is a similar space for placing another tube, if permeability to another gas besides water vapor is to be measured. The general cover of glass permits observation during the interval of a measurement and has a tube which serves both as a handle and as a means of communication with atmospheric pressure, the end of this tube being plugged with water absorbent and cotton to prevent ingress of moisture. The painted surface is prepared by first clamping or otherwise sealing the two rings together or the concave ring to the clamping ring by means of springs or wire through the small holes placed around at equal distances. A porous surface of strength and uniformity is placed between the rings before clamping and is automatically stretched because of the "dovetailing" of the parts into each other. This also minimizes danger of later leakage through points of contact. The porous surface is always of the same material that the paint is intended to cover, steel wire cloth for steel, hardened paper for wood, or cement and sand for concrete. This search for a satisfactory and fair imitation of the actual surface will continue to be the subject of study, commensurate with its importance.

The ring completed forms a "panel," the area of whose surface for painting is 341 sq. cm. The paint or varnish is applied uniformly with a brush just as to any other kind of panel or surface and by weighing before and after, the weight of coating may be obtained as accurately as desired, depending on whether the parts fit well and allow very little "dead" material to creep under the areas of clamping contact and whether or not the weighing is recorded immediately after each coat is spread.

The blank is run as follows: Invert the pan on the base and place on it the wire ring. Upon this place the wire screen disc and then the unweighed dish. Finally put the cover in position. After some hours, when a uniform condition has been reached, note the time, remove cover, replace the unweighed with the weighed dish, remove dish cover, and replace general cover. The next day, at the same time, raise general cover, replace cover of weighed dish and weigh the dish. The increase of weight in milligrams is the "blank" (generally about 50 milligrams) to be subtracted from the number of milligrams obtained in the next step. The pan is now removed and the panel whose permeability is sought is placed in position. After this, the steps are exactly as in the case of the blank. The final result gives the net milligrams for twenty-four hours. If the period is not twenty-four hours, the figure is calculated to that interval, which gives the "actual" permeability of the panel.

An inspection of the construction of the apparatus will demonstrate that, during the measurement, it is impossible for moisture to escape from the trough, except through the paint film of the panel. It is further impossible for it to enter or escape from the apparatus, disregarding any slight leakage, which is canceled by the blank. Both sides of the film are nevertheless open to atmospheric pressure; hence there is no excess in total pressure in any one direction. The area under the film has a humidity of 100 per cent, while that above has a humidity approaching as near to zero as the activity and quantity of the absorbent and the permeability of the film will permit. Under these conditions, the vapor is absorbed by the film on its under side and evolved on its upper side in a steady stream.

The mechanism by which the water or other substance passes through the film will be discussed in a later paragraph, when results bearing upon the point have been presented. Theoretically the standard value for permeability would be that obtained under standard conditions as regards each component that effects the result, or at standard temperature with unit area of film, unit weight or volume of coating, etc. At present, there is no need of attempting to establish such a standard. Practically, however, there is need of adopting a method of comparison by which successive results on the same and on different coatings may be compared with each other. The data to be presented later will indicate that, allowing for errors in spreading the paint already explained, the permeability decreases as the weight of the film increases. Whether the actual results times the weight of film equal a constant for the same coating will be determined by later measurements, but it seems to be true where the divergence in weight of film is not too large. The following proportion is then applicable: Weight of film in grams : 10 :: "weight permeability" : "actual permeability." In other words, the weight permeability represents the result that would be obtained if the film of area given had weighed exactly 10 grams. The major portion of the data presented in this paper is plotted on this basis, largely because the extra calculation involved slight additional labor and afforded the best ready means of comparison. It is true that a film weighing 5 grams would probably not have exactly twice the permeability of one of the same material weighing the standard 10 grams but if 5 grams is the weight of the regulation number of coats for that material, the results on 5 grams should be the basis of calculation. If the densities of the liquids are very divergent some other means of comparison must be adopted before it can be stated that one substance is "high" and another "low" in perviousness. While the "actual" permeability makes comparison on the basis of equal number of coats, yet a "coat" may vary greatly according to the thickness and spreading qualities of the material applied. Of course both the weight and volume of a coating change with time,

but it would appear unnecessary to make more than one determination of these under uniform conditions in order to secure a comparison sufficient for all practical purposes.

One of the first points noticed during this investigation was that successive measurements on the

were reversed, and finally the panel brought to its original position. Thus the moisture passed first from the inside out, and this direction was reversed twice for the white and once for the varnish. This order was changed in the case of corroded lead, with also two reversals.
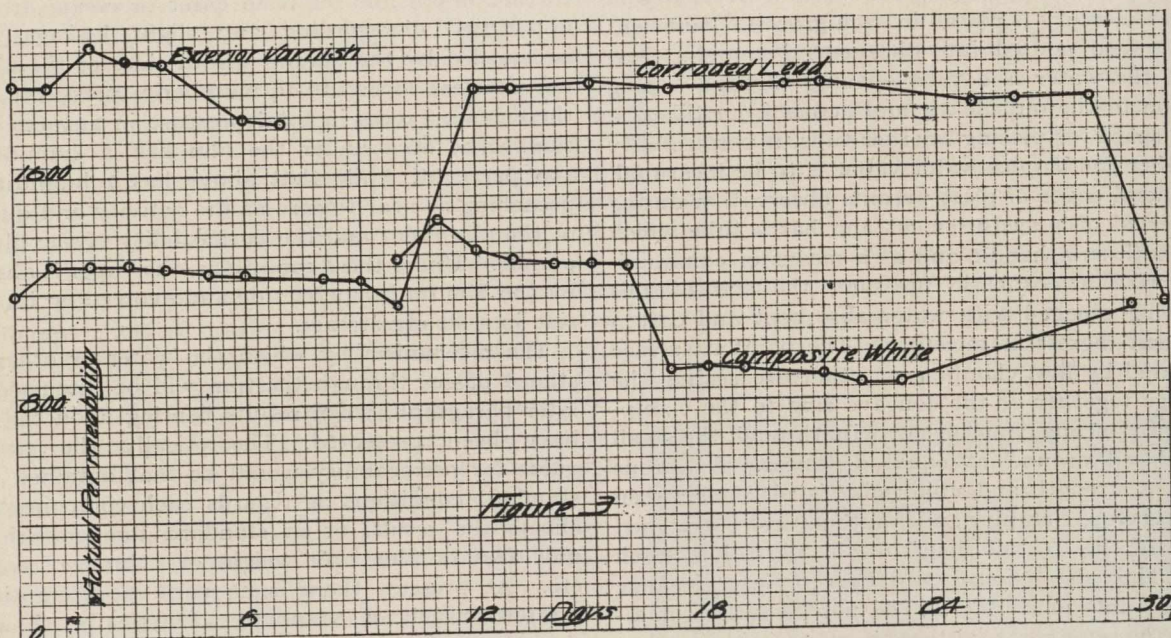
Figure 3

same panels without intervening exposure did not check with each other. This was not surprising since an appreciable temperature coefficient was to be expected. Unless otherwise stated, the results presented in this paper were under conditions of sufficiently uniform temperature, on the average 32.9° C. The exact coefficient under all conditions will be a matter for later determination. The effect of temperature is marked. Thus, it was found that the panel of white (Fig. 3) which gave a permeability of 854 and 853, successively, at 32.9° C., gave two days later, with no intervening exposure, 137 and 139 at 10.9° C., or a drop of 32.52 milligrams for each degree. In this case, the coefficient is 0.0381 per degree C., based on the result at the higher temperature.

Measurements have been made on panels with no water in the trough underneath, with results of about 100 less the blank, representing the moisture actually in the film at the beginning. This is mentioned merely as proof that during the measurements the source of the water is ultimately in the trough of the base.

Fig. 3 is presented as a test of the accuracy of the apparatus under the degree of uniformity considered sufficient for practical purposes. Three panels were prepared at different times from concave and convex rings. Each was placed in a unit of the apparatus and kept there day after day with a dish of absorbent continually drawing water through the film. Generally it was a weighed dish and measurements were made daily, though this was not always convenient. For the varnish and composite white, the uncoated side was at first down; later the sides

RESULTS ON FIG. 3
CORRODED LEAD

Wt. of coat	Meas. No.	Days interval	Actual permeability	Meas. No.	Days interval	Actual permeability	Meas. No.	Days interval	Actual permeability
14.38	1	0	1197	2	1	1298	3	1	1296
	4	1	1292	5	1	1273	6	1	1251
	7	1	1253	8	2	1241	9	1	1223
	10	1	1156	11	2	1894	12	1	1889
	13	2	1896	14	2	1839	15	2	1847
	16	1	1869	17	1	1868	18	4	1812
	19	1	1821	20	2	1830	21	2	1110

OUTSIDE WHITE

	1	0	1302	2	1	1445	3	1	1339
	4	1	1298	5	1	1285	6	1	1285
	7	1	1261	8	1	910	9	1	918
	10	1	903	11	2	884	12	1	854
	13	1	853	14	6	1106	..	..	..

EXTERIOR VARNISH

	1	0	1915	2	1	1911	3	1	2049
	4	1	2001	5	1	1995	6	2	1799
	7	1	1775	..	..	..	..	..	..

It is easily apparent that the lead shows the greatest contrast and the exterior varnish the least, when comparing permeability on either side. Whether this expressed any particular advantage cannot yet be stated. The position of the panel on the base is important, but the length of time elapsing before a measurement is made after the panel is in position is unimportant for a small number of days. The steady decrease in permeability noticed is due doubtless to a slight drying action in progress even while the panel is on the base and in the absence of light. The fluctuations apparent enable one to gauge the degree of error probable for all other measurements to be submitted, which were made with the coated side up.

The most interesting point about Fig. 3 is the apparent fact, suspected by experts, that a paint film is more pervious in one direction than the other. Paint thus may have the advantage of "valve action," offering a greater resistance to water which tends to

same paint on the same surface will not last two years with a succession of bad seasons in a severe climate. In certain areas of the tropics situated on the southern slopes of mountains, we may actually see in nature practically all the extremes of temperature, light, and humidity regularly every twenty-four hours for
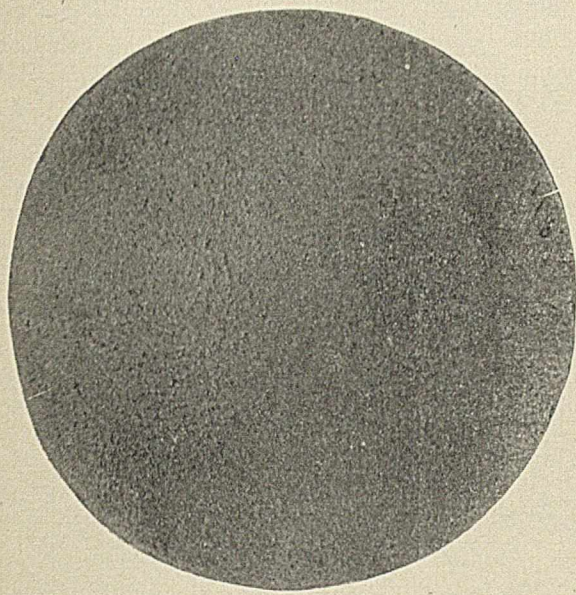
FIG. 4
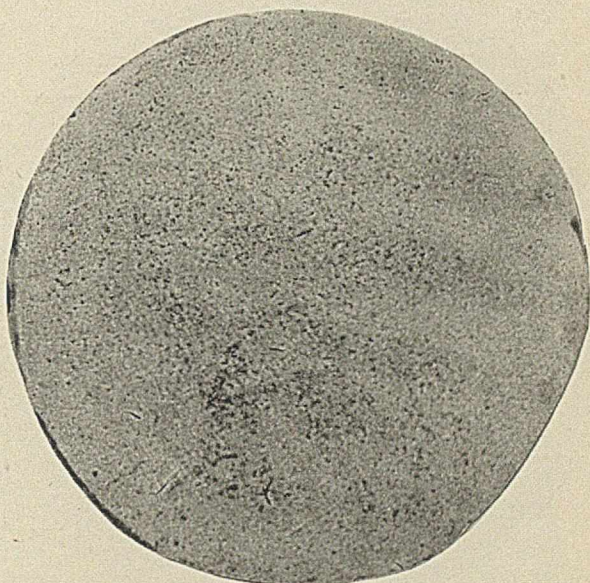
FIG. 5

reach the protected surface than to moisture which at other times and on wooden surfaces must be allowed to escape freely. This point will later receive further experimental trial, too many other phases of the research being more important at present. It may be concluded that the surface covered is probably the chief cause of the contrasts observed. A paint coating is in more intimate contact with the moisture of the under surface than with the moisture of the air (except during a rain). The under surface of wood during a measurement absorbs moisture more rapidly than the paint coating itself; hence, the permeability is higher from this direction.

PRACTICAL RESULTS ON PAINTS AND VARNISHES

It has been shown so far that each of the various components of what is termed "the weather" has its own peculiar effect upon permeability. The next step in this investigation would naturally be to expose panels of various compositions until each is evidently "broken down," measuring permeability from time to time. This has been done, and the results are presented on ten charts below. All of the panels involved were not exposed at the same time nor to exactly the same conditions but those reported together were coated at the same time, measured at the same time, and given the same kind and length of exposure as far as practicable. In order to obtain results more quickly the exposure used was severe. Whether the same comparative results would be produced from a milder treatment, only future experiments can tell. The rate of decay of paint and varnish is well known to differ considerably with the kind and degree of exposure. A good paint under favorable conditions will last perhaps six years, while the

part of the year. Such was the exposure by which the results to be tabulated were obtained. No element in it was more intense than that found in actual service. The panels were not subjected to acid fumes, soaking in water, or any other unnatural condition that could be a source of criticism.

To describe this part of the work properly would double the length of this paper. Suffice it now to state that air-tight cylindrical boxes, sufficiently large (7 ft. in diameter, 4 ft. in height), were used, the weathering force emanating from the axes. The exposure used was indeed artificial, but of the same kind as that acting naturally. Rain was imitated with a whirling garden spray; sunlight, by the use of the mercury vapor and tungsten lamps in combination; and cold weather, by admitting the outside air at night. Plenty of ventilation was afforded by use of a fan while the lamps were in operation. The panels were arranged around the sides of the boxes so as to be easily removed or replaced, care being taken to have those of any one comparative set at the same level in the box. Since the lamps could not be located exactly along the axes of the box and in any event mercury lamps do not radiate equally in all horizontal directions, the lamps and panels were rotated along the above axes for different positions with reference to each other from day to day, so that each panel would receive practically its share of exposure. This illustrates one of the many precautions observed in order to secure valid results. From 7 A.M. to 6 P.M., the panels were subjected to a good imitation of a hot, breezy, summer day, the temperature going up to 60° C. for part of the time. From 6 P.M. to 11 P.M. there was rain, and from 11 P.M. to 7 A.M. cold weather.

Permeability, of course, is simply one of many indications of paint and varnish decay. Nothing more is claimed for the process being outlined in this article than recognition as an additional method of rating protective coverings. The work is at present

FIG. 6

merely in a preliminary stage and only later studies, which will be prosecuted as rapidly as possible, will demonstrate the real meaning and value of the practical results now to be submitted. The finished
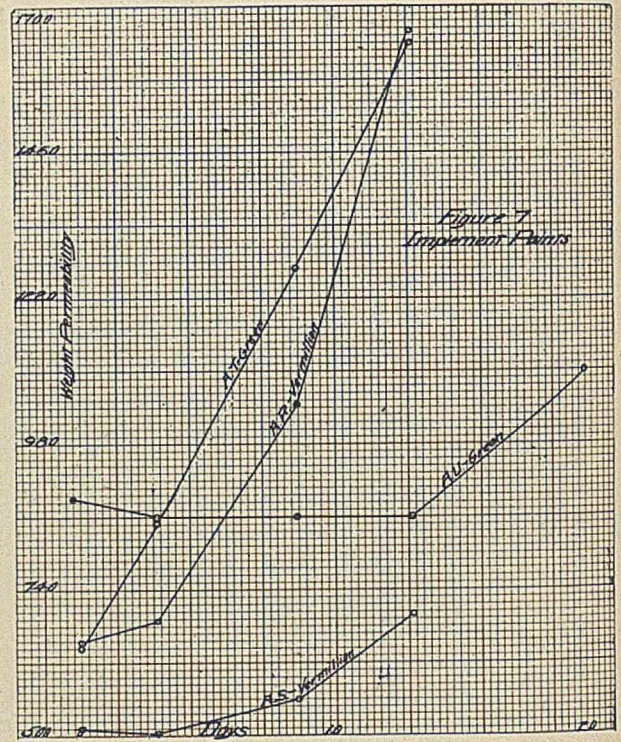
be reported within the proper limits of this paper. Among these should be mentioned the effects of the exposure on several lines of paints for structural iron, spread over steel panels, and on specially prepared mixtures of lead and zinc with various oils and driers.

RESULTS ON FIG. 7—IMPLEMENT PAINTS

	Weight of coat	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight
A R₁	3.41	1	0	2044	697	2	3	2227	759	3	5½	3074	1048
A R₂	3.27	1	0	1871	612	2	3	1878	614	3	5½	3265	1042
Average	..	1	0	..	654	2	3	..	686	3	5½	..	1045
A S₁	2.13	1	0	2374	506	2	3	2323	495	3	5½	2596	553
A S₂	2.14	1	0	2428	520	2	3	2357	516	3	5½	2632	563
Average	..	1	0	..	513	2	3	..	505	3	5½	..	558
A T₁	3.29	1	0	2119	697	2	3	2428	799	3	5½	3239	1066
A T₂	3.08	1	0	1929	594	2	3	2922	900	3	5½	4609	1419
Average	..	1	0	..	645	2	3	..	849	3	5½	..	1242
A U₁	3.78	1	0	2408	910	2	3	2440	922	3	5½	2408	910
A U₂	3.73	1	0	2350	877	2	3	2143	799	3	5½	2155	804
Average	..	1	0	..	893	2	3	..	860	3	5½	..	857
A R₁	..	4	4½	4515	1540	..	..	..	..	..	..	..	..
A R₂	..	4	4½	5574	1823	..	..	..	..	..	..	..	..
Average	..	4	4½	..	1681	..	..	..	..	..	..	..	..
A S₁	..	4	4½	3360	716	..	..	..	..	..	..	..	..
A S₂	..	4	4½	3216	688	..	..	..	..	..	..	..	..
Average	..	4	4½	..	702	..	..	..	..	..	..	..	..
A T₁	..	4	4½	4365	1436	..	..	..	..	..	..	..	..
A T₂	..	4	4½	5967	1838	..	..	..	..	..	..	..	..
Average	..	4	4½	..	1637	..	..	..	..	..	..	..	..
A U₁	..	4	4½	2553	965	5	7	3121	1180	..	..	..	..
A U₂	..	4	4½	2010	750	5	7	2746	1024	..	..	..	..
Average	..	4	4½	..	857	5	7	..	1102	..	..	..	..

products of these tests were either purchased in the open market or mixed under the direction of the writer in the laboratory. The composition is based either on published analyses or determinations in the laboratory. The raw materials were of the best grade and had received the "O. K." of the factory chemist, unless otherwise stated.

Many interesting results were obtained that cannot

One of the first pieces of work completed was on a line of agricultural paints. The samples were from materials in actual use by manufacturers for the coating of their products. The panels were prepared in exactly the same way with the same material as in the painting of a plow or wagon, all coats being applied at dipping consistency. There was first spread on each as nearly as possible to the same thickness

the ordinary "pink primer" consisting of lithopone and some iron and zinc oxides ground to a paste in linseed oil. All panels were given as a final coat as nearly as possible the same thickness of the same short oil (linseed) No. 1 kauri varnish, so the only difference between the panels, disregarding the above sources of error, consisted in the intermediate coat of vermillion or green. Fig. 7 illustrates the great difference noted, and the numerical results are appended

of actual pores evidenced in the appearance or of a decreased thickness of film. This is borne out by the condition of these panels at the end of the testing period; for it is easy to separate them by their marked difference in appearance. Thus a remarkable contrast is shown between these implement coatings. It would be difficult to believe that A S and A U are not more durable than A R and A T.

The next set of tests to be presented is a group of
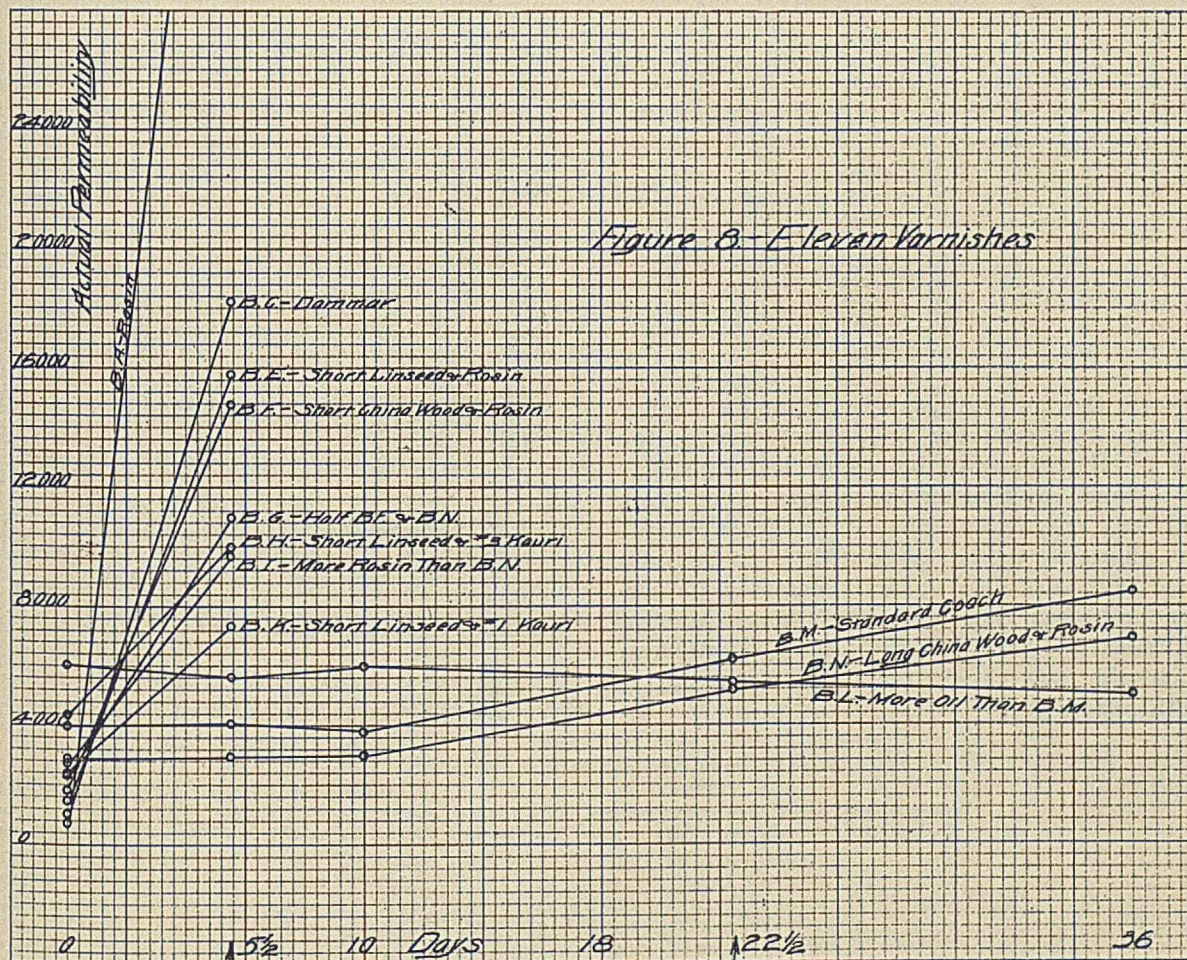
Figure 8—Eleven Varnishes

below. As in all later diagrams presented where duplicate determinations were made, only average results are plotted.

It will be noticed that where a material has slight durability, as A R and A T, the duplicate with the thinner coating shows the greater change in permeability, as might be expected. In the light of later data, it is justifiable to conclude that all of these panels would have decreased in permeability if the second measurement had been made after a sufficiently short period of exposure, $1\frac{1}{2}$ days being too long. Reasoning now once for all, we conclude that as long as permeability is going down, the rate of oxidation is greater than that of dissolving action, hydrolysis, and decreasing elasticity. But when the latter changes have produced a larger effect than the former, the curve of permeability turns up and the film itself soon goes flat, chalks, checks, or cracks. The rise in permeability would thus seem to be finally the result

eleven varnishes, embodied in Fig. 8. The actual data are presented herewith:

RESULTS ON FIG. 8—ELEVEN VARNISHES

Meas. No.	Days interval	Actual permeability	Meas. No.	Days interval	Actual permeability	Meas. No.	Days interval	Actual permeability
B F$_1$.. 1	0	1782	2	$5\frac{1}{2}$	15215	..	...	...
B F$_2$.. 1	0	1898	2	$5\frac{1}{2}$	14365	..	...	...
Ave. 1	0	1790	2	$5\frac{1}{2}$	14790	..	...	...
B E$_1$.. 1	0	1507	2	$5\frac{1}{2}$	16064	..	...	...
B E$_2$.. 1	0	1418	2	$5\frac{1}{2}$	15574	..	...	...
Ave. 1	0	1462	2	$5\frac{1}{2}$	15819	..	...	...
B N$_1$.. 1	0	2978	2	$5\frac{1}{2}$	3090	3	$4\frac{1}{2}$	3008
B N$_2$.. 1	0	2900	2	$5\frac{1}{2}$	2922	3	$4\frac{1}{2}$	2916
Ave. 1	0	2939	2	$5\frac{1}{2}$	3006	3	$4\frac{1}{2}$	2962
B N$_1$.. 4	$12\frac{1}{2}$	5816	5	13	...	..	...	...
B N$_2$.. 4	$12\frac{1}{2}$	4696	5	13	...	..	...	...
Ave. 4	$12\frac{1}{2}$	5256	5	13	...	..	...	...
B G$_1$.. 1	0	2590	2	$5\frac{1}{2}$	12612	..	...	...
B G$_2$.. 1	0	2123	2	$5\frac{1}{2}$	9335	..	...	...
Ave. 1	0	2356	2	$5\frac{1}{2}$	10975	..	...	...
B K$_1$.. 1	0	2465	2	$5\frac{1}{2}$	8119	..	...	...
B K$_2$.. 1	0	2273	2	$5\frac{1}{2}$	6578	..	...	...
Ave. 1	0	2369	2	$5\frac{1}{2}$	7348	..	...	...

RESULTS ON FIG. 8—(Continued)

Meas. No.	Days interval	Actual permeability	Meas. No.	Days interval	Actual permeability	Meas. No.	Days interval	Actual permeability
B H₁.. 1	0	4346	2	5½	9157	..	...	...
B H₂.. 1	0	4363	2	5½	10844	..	...	...
Ave. 1	0	4354	2	5½	10000	..	...	...
B M₁.. 1	0	4170	2	5½	4042	3	4½	4044
B M₂.. 1	0	3804	2	5½	4173	3	4½	3620
Ave. 1	0	3987	2	5½	4107	3	4½	3820
B M₁.. 4	12½	7056	5	13	...	..	...	...
B M₂.. 4	12½	5456	5	13	...	..	...	...
Ave. 4	12½	6256	5	13	...	..	...	...
B L₁.. 1	0	6037	2	5½	5667	3	4½	5802
B L₂.. 1	0	6050	2	5½	5652	3	4½	6300
Ave. 1	0	6043	2	5½	5659	3	4½	6051
B L₁.. 4	12½	5253	5	13	...	..	...	...
B L₂.. 4	12½	5688	5	13	...	..	...	...
Ave. 4	12½	5470	5	13	...	..	...	...
B A₁.. 1	0	826	2	5½	45246	..	...	...
B A₂.. 1	0	688	2	5½	46184	..	...	...
Ave. 1	0	757	2	5½	45715	..	...	...
B C₁.. 1	0	989	2	5½	18295	..	...	...
B C₂.. 1	0	968	2	5½	18100	..	...	...
Ave. 1	0	978	2	5½	18200	..	...	...
B I₁.. 1	0	2974	2	5½	10037	..	...	...
B I₂.. 1	0	2401	2	5½	9412	..	...	...
Ave. 1	0	2687	2	5½	9724	..	...	?...

These were the first varnishes tested and evidently the first period of exposure (5½ days) was far too long; for by that time all but three had "gone to pieces," so much so that in the measurements much absorbent was practically exhausted. Measurements on rosin mixtures to be presented later indicate that these varnishes also at first decreased in permeability and that during the 5½ days interval much interesting history was lost. Nevertheless, it is remarkable how closely the slopes of the curves agree with experience.

	FIRST CHECKING	FINAL CONDITION
B A	7 days, or at the first rain	Practically no coating left
B C	7 days, or at the first rain	Mostly scaled off
B F	13 days	No worse than on 13th day
B E	13 days	Badly checked
B K	17 days	Very slightly checked

None of the others has as yet begun to check, but experiences teaches that they will also act very much in agreement with their permeability changes.

Figure 9
Exterior Varnishes
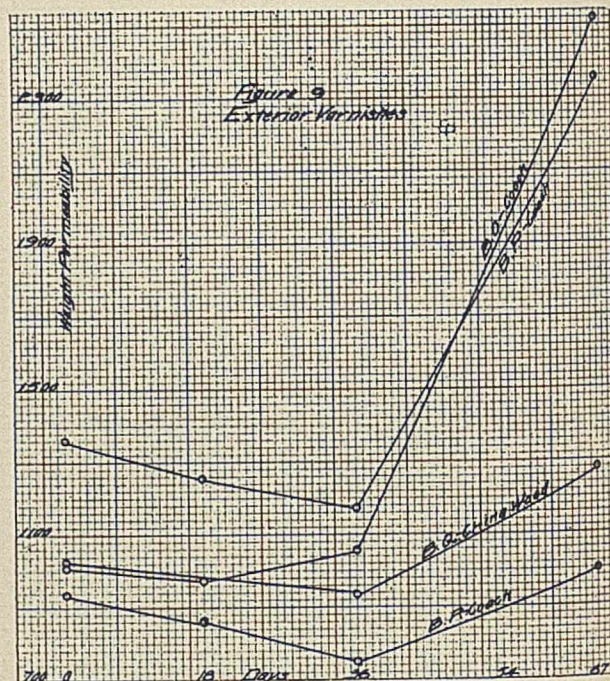
Comparing B K, B H, B F, and B E, we see that No. 3 kauri is less durable than No. 1 but both far more durable than rosin compositions; also that in short oil rosin varnishes, china wood oil is better than linseed. Comparing B N, B M, and B L, it would appear that on long oil varnishes, if the effect of rosin is considered, china wood is more durable than linseed oil and that an increase in linseed oil adds to the permanency, since B L, though it starts higher in perviousness and loses its gloss more quickly, yet outwears B M. Another set of varnishes (exterior) was given a long exposure mainly as a means of testing out the process, for it was impracticable at the outset to expose duplicate panels. The results are worth reporting, as is seen in Fig. 9 and the table appended, because they illustrate well the steadily changing character of permeability. The appearance of these panels corresponds with the weight permeabilities, and as a fact they have been assorted by eye in the same order as is shown in Fig. 9.

RESULTS ON FIG. 9—EXTERIOR VARNISHES

	Weight of coat	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight
B O....................	3.71	1	0	2727	1012	2	17	2620	972	3	19	2836	1052
B P....................	4.13	1	0	3308	1366	2	17	3033	1253	3	19	2832	1170
B Q....................	4.23	1	0	2421	1024	2	36	2212	936	3	31	3025	1280
B R....................	4.46	1	0	2097	935	2	17	1929	860	3	19	1642	749
B O....................	..	4	31	6782	2516	..	..	..	..	..	..	..	..
B P....................	..	4	31	5644	2353	..	..	..	..	..	..	..	..
B R....................	..	4	31	2246	1002	..	..	..	..	..	..	..	..

The composition of the materials is sufficiently described thus:

B A-Gloss oil, consisting of about 45 per cent of rosin and 55 per cent benzine
B C-Dammar in turpentine
B E-Short oil varnish (linseed and rosin)
B F-Short oil varnish (China wood and rosin)
B H-Short oil varnish (linseed and No. 3 kauri)
B I-Same as B N below, but containing more rosin
B L-Contains about twice as much oil as the standard coach varnishes
B N-Long oil varnish (China wood and rosin)
B G-Consists of half B F and B N by volume
B K-Short oil varnish (linseed and No. 1 kauri)
B M-A standard turpentine coach varnish

That these permeability tests agree with well established methods is shown by the results of exposure of these materials placed on regulation wooden panels and exposed on the roof during the winter. The number of days after beginning of exposure when checking first became noticeable is first given: then the condition at the close, after 38 days.

Fig. 4 shows a portion of the panel of B R at the end of the test, having a permeability of 2246. While checked up slightly, the major portion of the coating is still left to view. Fig. 5 is a corresponding portion of B P. This panel has a permeability of 5644 and it is evident that little of the original varnish film has withstood the exposure. The differences between these two photographs show that the numerical data upon which these charts are based have real meaning in expressing the condition of the panels.

All of these are standard coach varnishes, except B Q, which is a china wood oil mixture. B O and B P are seen to be running "neck and neck," if we allow for the lack of check panels and for the thinner coating of B O. B R gains its greater durability from its greater oil content. China wood oil makes its best showing in B Q, this being manifestly a fine varnish.

The evil effect of rosin in an exterior paint is well known, though the word "japan" often covers a multitude of such sins in the paint formula. In order to obtain a graphic representation of this evil, a sample of a standard outside white, B U, was divided into three portions. One part was left unadulterated. Ten per cent. of the vehicle by weight was removed from the second portion and an equal weight of gloss oil substituted. In the third portion, twenty-five per cent of gloss oil was similarly replaced. Panels were then constructed and tested. The records of these measurements are now submitted, accompanied by the striking contrast of the curves shown in Fig. 10.

1, 2, 3. In the cases of more durable coatings, it is sometimes possible to arrange the panels in the order of durability long before the measurements are com-

Figure-10
Effect of Rosin
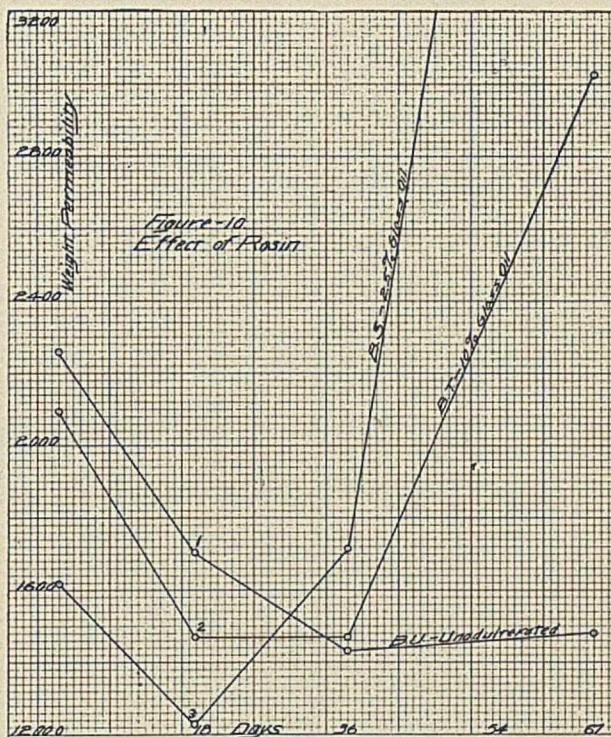
pleted or before any of the films show signs of age.

Fig. 6 gives the appearance of B S, containing 25

RESULTS ON FIG. 10—EFFECT OF ROSIN

	Weight of coat	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight
B U_1	14.22	1	0	1623	2308	2	17	1155	1642	3	19	980	1394
B U_2	14.80	1	0	1491	2207	2	17	1196	1770	3	19	990	1465
Average	...	1	0	..	2258	2	17	..	1706	3	19	..	1429
B U_1	...	4	31	1004	1427	..	...	..	..	..	..	..	..
B U_2	...	4	31	1039	1537	..	..	..	..	..	..	..	..
Average	...	4	31	..	1482	..	..	..	..	..	..	..	..
B T_1	18.73	1	0	1212	2270	2	17	792	1483	3	19	890	1671
B T_2	17.62	1	0	1088	1917	2	17	826	1455	3	19	722	1272
Average	...	1	0	..	2094	2	17	..	1469	3	19	..	1471
B T_1	...	4	31	1667	3122	..	..	..	..	..	..	..	..
B T_2	...	4	31	1660	2926	..	..	..	..	..	..	..	..
Average	...	4	31	..	3024	..	..	..	..	..	..	..	..
B S	13.91	1	0	1163	1618	2	17	883	1228	3	19	1232	1714
B S	...	4	31	4559	6341	..	..	..	..	..	..	..	..

The composition of the gloss oil has been already stated. B T, therefore, contains only about 4½ per cent of rosin, while B S contains about 11 per cent. Doubtless the reader will observe that B S appears to fall in permeability more slowly than either of the other materials at first. If a measurement had been made at the end of 5 days, instead of 17, it is believed that B S would have shown the most rapid decrease. It would appear also to be frequently true, if one reasons from all the data presented in this paper, that the smaller the angle of bend plotted at the points of measurement, not beyond the line where the curve first points upward, the sooner will the curve take an upward trend and the coating break down. This is indicated on Fig. 10 by angles

per cent of gloss oil. The film is quite flat and the cracks shown are large. These cracks began after the second measurement. Probably in no line of protective coverings is there so much waste of money as in the so-called barn paints, in spite of their cheapness. In order to develop this point, three liquid paints belonging to this class were made up on different lines, C A, C B, and C D, and each divided into two portions. One portion, marked x, remained untreated, while in the other portion, marked y, rosin in decreasing quantities was incorporated for the several formulas. Thus, C Ay has more rosin than C Dy, but not more than that found in many commercial barn paints. Duplicate panels were made up for each of the six liquids and the results of their

testing are presented as Fig. 11, with its accompanying tabulation.

In the case of these paints the contrast is evident at a glance. C Ay goes to pieces so quickly that

Figure 11—Barn Paints

RESULTS ON FIG. 11—BARN PAINTS

	Weight of coat	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight
C Dy1	7.81	1	0	2606	2035	2	3	1963	1533	3	1³/₄	1956	1528
C Dy2	8.83	1	0	2731	2411	2	3	2332	2059	3	1³/₄	2002	1766
Average	..	1	0	2668	2223	2	3	..	1796	3	1³/₄	..	1647
C Dy1	..	4	6	1838	1436	5	7	1891	1478	..	...	..	..
C Dy2	..	4	6	1907	1684	5	7	1927	1705	..	...	..	..
Average	..	4	6	..	1560	5	7	..	1591	..	..	..	..
C Dx1	7.25	1	0	2817	2042	2	3	2388	1733	3	1³/₄	2351	1704
C Dx2	6.76	1	0	2838	1915	2	3	2364	1602	3	1³/₄	2363	1599
Average	..	1	0	..	1978	2	3	..	1667	3	1³/₄	..	1651
C Dx1	..	4	6	2207	1600	5	7	2203	1597	..	...	..	..
C Dx2	..	4	6	2283	1543	5	7	2298	1554	..	...	..	..
Average	..	4	6	..	1571	5	7	..	1575	..	...	..	...
C By1	9.07	1	0	2035	1846	2	3	1359	1224	3	1³/₄	1205	1093
C By2	8.93	1	0	1916	1711	2	3	1206	1077	3	1³/₄	1057	944
Average	..	1	0	..	1778	2	3	..	1150	3	1³/₄	..	1018
C By1	..	4	13	6324	5730	..	..	..	..	..	..	..	..
C By2	..	4	13	5430	4850	..	..	..	..	..	..	..	..
Average	..	4	13	..	5290	..	..	..	..	..	..	..	..
C Bx1	5.32	1	0	3932	2087	2	3	3504	1896	3	1³/₄	3357	1786
C Bx2	5.39	1	0	4047	2181	2	3	3637	1960	3	1³/₄	3748	2021
Average	..	1	0	..	2134	2	3	..	1978	3	1³/₄	..	1903
C Bx1	..	4	6	3139	1670	5	7	3098	1648	..	..	..	..
C Bx2	..	4	6	3032	1634	5	7	3063	1658	..	...	..	..
Average	..	4	6	..	1652	5	7	..	1651	..	...	..	..
C Ay1	6.75	1	0	1415	955	2	3	10905	7360	3	1³/₄	18948	12820
C Ay2	6.59	1	0	1438	948	2	3	11715	7720	3	1³/₄	17525	11570
Average	..	1	0	..	951	2	3	..	7540	3	1³/₄	..	12195
C Ax1	4.80	1	0	4498	2164	2	3	4116	1975	3	7³/₄	3429	1649
C Ax2	4.60	1	0	4659	2143	2	3	4728	2175	3	7³/₄	3660	1684
Average	..	1	0	..	2153	2	3	..	2075	3	7³/₄	..	1666
C Ax1	..	4	7	3526	1692	..	..	..	..	..	..	..	..
C Ax2	..	4	7	3806	1750	..	..	..	..	..	..	..	..
Average	..	4	7	..	1721	..	..	..	..	..	..	..	..

even the first three days showed a considerable rise in perviousness. C By broke down before the fifth day, while C Dy held up until the 6th measurement, and then only is just beginning to pass C Dx, having only a trace of rosin. Attention may be called to the first slopes of these curves as another prediction of the fate of a coating, for C Dy points downward farther than C Dx and bends upward sooner. The

with checks at the end of the test. It must, however, be remembered that the exposure was severe, though there was no rain for the first two days. That in milder weather there would be a great contrast between these two coatings should not be asserted at present.

From the very first it was realized that the severest and indeed final gauge of the value of permeability

RESULTS ON FIG. 20—EXTERIOR ENAMELS

	Weight of coat	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight
E C$_1$	5.74	1	0	2168	1246	2	2	2047	1177	3	1	2045	1174
E C$_2$	5.73	1	0	2287	1313	2	2	2186	1252	3	1	2125	1218
Average		1	0	..	1279	2	2	..	1214	3	1	..	1196
E C$_1$	..	4	1¾	2130	1246	5	8	5017	2880	..	..	..	..
E C$_2$	..	4	1¾	2229	1255	5	8	5910	3386	..	..	..	..
Average	..	4	1¾	..	1250	5	8	..	3133	..	..	..	..
E D$_1$	8.53	1	0	2536	2162	2	2	2462	2101	3	1	2276	1940
E D$_2$	8.65	1	0	2794	2419	2	2	2734	2366	3	1	2539	2195
Average	..	1	0	..	2290	2	2	..	2233	3	1	..	2067
E D$_1$	..	4	1¾	2262	1930	5	8	2161	1627	..	..	..	..
E D$_2$	..	4	1¾	2508	2170	5	8	2447	1872	..	..	..	..
Average	..	4	1¾	..	2050	5	8	..	1749	..	..	..	..

same is true notably for C By and x. The two curves of C Ax and C Bx are nearly parallel. Investigation showed that the two coatings represented by these have almost the same composition. While in the process being outlined, coatings are judged by what they "do" rather than by what they contain, yet it is apparent that their conduct under the test is a function of their composition.

FIG. 14

Fig. 14 is a photograph of panel No. 1 for paint C Ay, which went to pieces so rapidly. The illustration is of its condition after three days exposure. It is checked up even worse than the view indicates.

Two exterior enamels were spread on panels in duplicate and tested at frequent intervals for nearly two weeks, at the end of which time they had begun to break down. Fig. 20 and the accompanying table explain the effect of exposure upon them.

The values on duplicates agree very well. E D shows up far better than E C, the latter being covered

as a measure of durability would be upon the best exterior paints. Five representative outside whites were among the first exposed (in duplicate panels) and tested at convenient periods. Fig. 13 is an embodiment of the facts developed in the tabulated permeabilities on page 546:
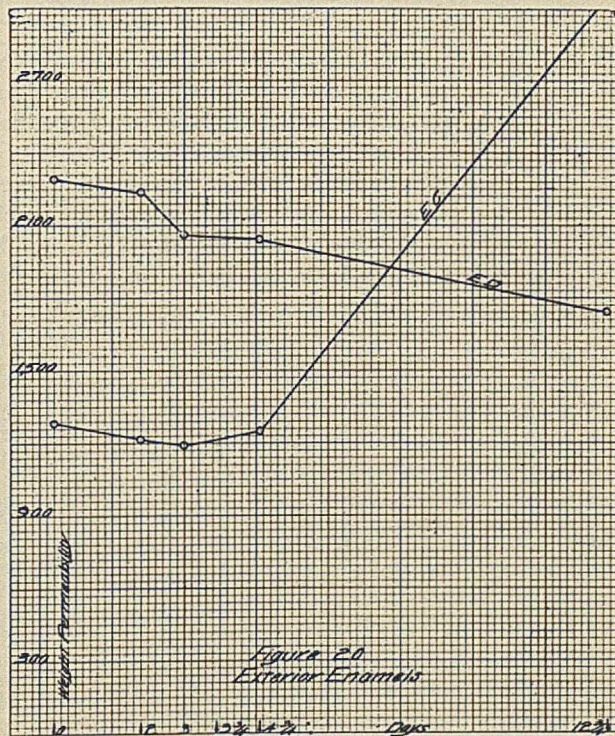
Figure 20.
Exterior Enamels

The composition of these whites corresponds somewhat to their conduct. C K has the highest per cent of lead and of pigment of the five and its curve exhibits next to the greatest bends. One of the panels of C K has a small crack, so that this covering will probably be the second to break down. Generally cracks and checks appear simultaneously on duplicates, and the resulting increased permeabilities agree well. C L contains the highest percentage of

Figure-13
Outside Whites

zinc, and its curve has the least tendency so far to turn upwards. C O is composed of less zinc than C N and possesses a correspondingly greater inclination upwards in change of permeability. C N and C M have about the same composition, and the curves for these are similar up to the thirty-sixth day. Each contains one or more inert pigments but C N holds less zinc and less of the inerts. At the final measure-

ment both panels of C N showed cracks to about the same extent. It is difficult to believe that the explanation for the difference in conduct of these two coatings is to be found in the published analyses. Rather, the writer believes that in the nature of the "japans" used in both cases originates the marked contrast.

It would probably take six months under present

RESULTS ON FIG. 13—OUTSIDE WHITES

	Weight of coat	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight	Meas. No.	Days interval	Permeability Actual	Permeability By weight
C K$_1$	22.08	1	0	1466	3237	2	17	1204	2658	3	19	1046	2310
C K$_2$	19.41	1	0	1233	2393	2	17	890	1728	3	19	800	1553
Average	...	1	0	..	2815	2	17	..	2193	3	19	..	1931
C K$_1$	...	4	53	900	1987	..	...	..	..	..	...	..	..
C K$_2$	...	4	53	749	1454	..	...	..	..	..	...	..	..
Average	...	4	53	..	1720	..	...	..	..	..	...	..	..
C L$_1$	11.03	1	0	2349	2591	2	17	1961	2163	3	19	1840	2030
C L$_2$	11.61	1	0	1922	2231	2	17	1633	1896	3	19	1371	1592
Average	...	1	0	..	2411	2	17	..	2029	3	19	..	1811
C L$_1$	...	4	53	1324	1461	..	...	..	..	..	...	..	..
C L$_2$	...	4	53	1116	1295	..	...	..	..	..	...	..	..
Average	...	4	53	..	1378	..	...	..	..	..	...	..	..
C N$_1$	14.03	1	0	1382	1939	2	17	1054	1452	3	19	867	1216
C N$_2$	14.88	1	0	1308	1946	2	17	979	1457	3	19	797	1186
Average	...	1	0	..	1942	2	17	..	1454	3	19	..	1201
C N$_1$	...	4	53	1229	1725	..	...	..	..	..	...	..	..
C N$_2$	...	4	53	1040	1548	..	...	..	..	..	...	..	..
Average	...	4	53	..	1636	..	...	..	..	..	...	..	..
C O$_1$	10.90	1	0	1580	1722	2	17	1204	1312	3	19	1064	1160
C O$_2$	10.91	1	0	1520	1658	2	17	1227	1339	3	19	1070	1167
Average	...	1	0	..	1690	2	17	..	1325	3	19	..	1163
C O$_1$	...	4	53	982	1071	..	...	..	..	..	...	..	..
C O$_2$	...	4	53	888	969	..	...	..	..	..	...	..	..
Average	...	4	53	..	1020	..	...	..	..	..	...	..	..
C M$_1$	14.22	1	0	1623	2308	2	17	1155	1642	3	19	980	1394
C M$_2$	14.80	1	0	1491	2207	2	17	1196	1770	3	19	990	1465
Average	...	1	0	..	2258	2	17	..	1706	3	19	..	1429
C M$_1$	...	4	53	815	1159	..	...	..	..	..	...	..	..
C M$_2$	...	4	53	844	1249	..	...	..	..	..	...	..	..
Average	...	4	53	..	1204	..	...	..	..	..	...	..	..

conditions to secure incontrovertible conclusions. The results, however, check up nicely in rate of change of permeability. The panels have all gone more or less flat. It is gratifying that in eighty-one days one first-class exterior oil paint has been broken down and another has started on the downward grade. Just how far we may speculate as to the relation of these changes to durability is difficult to state. The tale is hardly half told. Practical experience is the
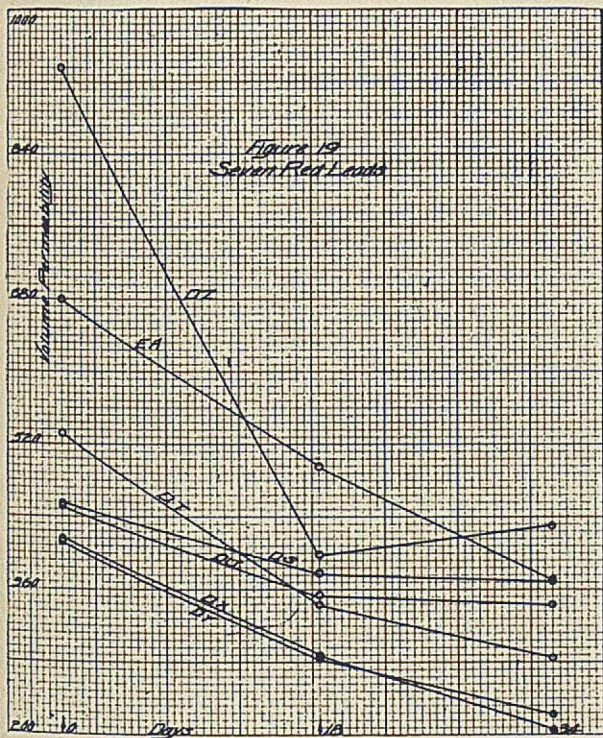

Figure 19
Seven Red Leads

final arbiter, and the process should be compared with the consensus of expert opinion. Should a protective covering, for example, be high or low in permeability in order to afford the highest degree of protection consistent with all the other useful qualities of the paint film? Assertions are easily made, but there are so many variables in a general problem of this kind that a theoretical point of view appears inadvisable. The accomplishment of a practical solution would seem possible by the process being outlined, given a sufficiency of the right kind of exposure. It is a disappointment that eighty-four days of severe

ficial climate that will break down even the best coatings in three months, imitating nature with valid results, but using a greater intensity and variety of weather. Herein lies the "trick" of securing quick results.

We come now to the evaluation of metallic coverings. A great many attempts have been made to improve the time-honored red lead and oil. Seven of such modifications were selected as typical of the trend of improvement, and the mixtures were brushed on steel wire-cloth panels, one being run in duplicate. These paints contained five pigments, which show the variety of coverings placed in comparison. The data below correspond to the curves in Fig. 19.

The results are reported on a basis of volume (weight permeability divided by the specific gravity of the paint) and therefore show within the limits of experimental error the true differences in permeability of these protective coverings. For example, E A is much more pervious than D X and differs from it simply in containing a better grade of red lead. D X and D Y are almost identical in conduct, yet D Y has the greater percentage of pigment. D T carries the least pigment of all and is next to the worst, yet is not highest in permeability, as might be expected. D Z contains a water absorbent, and its curve indicates that it is set apart from all the others. D S and D U differ merely in inert constituents and their changes in permeability are similar. A continuation of the measurements would prove instructive.

The kind of exposure given the panels so far considered was that of a severe tropical climate, ill adapted to interior coatings, though results obtained even on the interior varnishes of Fig. 8 agreed remarkably with experience. In order to secure the intermediate history of such coatings, eight were spread on panels, mostly in duplicate, and given an exposure corresponding to the mountainous regions of our arid southwest. The humidity was high for about an hour each day, but no rain ever reached the coatings. In other respects the exposure was the same as that heretofore described. Fig. 21 explains their conduct under these conditions.

E F is a medium combination oil (linseed, china wood) and manila varnish. E G is short oil (linseed) and No. 1 kauri. E H is short linseed and manila. E K is medium china wood and rosin. E L is dammar,

RESULTS ON FIG. 19—SEVEN RED LEADS

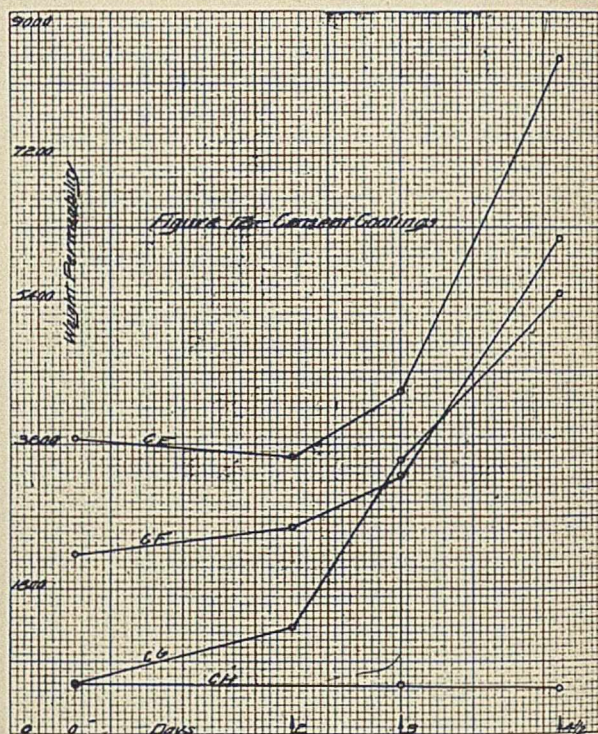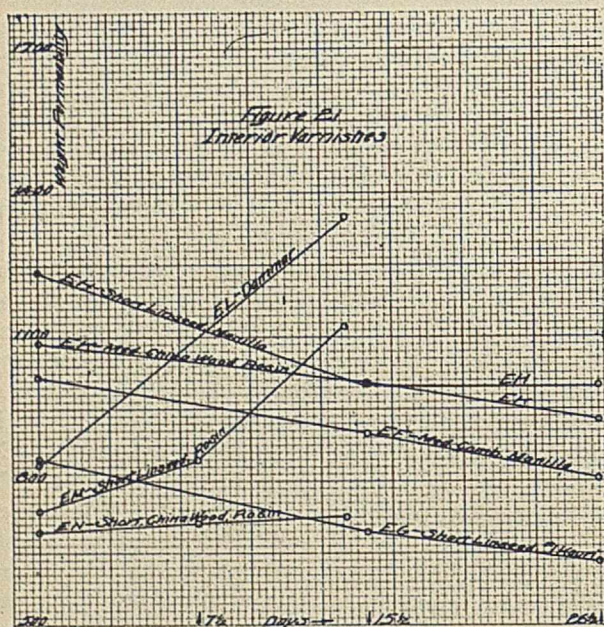|	Weight of coat	Meas. No.	Days interval	Permeability Actual	Permeability Volume	Meas. No.	Days interval	Permeability Actual	Permeability Volume	Meas. No.	Days interval	Permeability Actual	Permeability Volume
D S₁	18.18	1	0	478	422	2	18	317	306	3	15½	250	220
D S₂	15.33	1	0	685	507	2	18	640	450	3	15½	703	522
Average	...	1	0	...	464	2	18	...	378	3	15½	...	371
D T	10.16	1	0	866	532	2	18	558	343	3	15½	463	285
D U	12.20	1	0	626	462	2	18	479	355	3	15½	467	345
D X	11.85	1	0	652	417	2	18	452	289	3	15½	323	207
D Y	14.72	1	0	696	412	2	18	481	283	3	15½	378	223
D Z	14.63	1	0	1307	937	2	18	557	399	3	15½	599	430
E A	10.50	1	0	1076	680	2	18	861	497	3	15½	645	373

exposure should not give greater contrasts, but from another point of view, this is a fine testimony to straight oil mixtures. The writer believes that it is merely a matter of patient search to find the arti-

while E M is short linseed and rosin. E N is the same as E M with china wood substituted for linseed oil. Of course, the term "short oil" does not refer in each case to the same low percentage of oil.

Comparing now Fig. 21 with Fig. 8 and remembering that the former concerns interior and the latter exterior exposure, we see that in general the results are not divergent. The dammar holds up better on the interior, as we should expect. The short linseed

Figure 21
Interior Varnishes

rosin coating in both cases is not so good as that containing china wood oil (E M and E N; B E and B F). E K, the medium combination manila, was not tested with those shown on Fig. 8, but in Fig. 21 it holds its own quite satisfactorily. The No. 1 kauri coating

It has already been observed that among the many possibilities in imitating actual service conditions by the process of testing here presented is the use of

Figure 12. Cement Coatings

the same surface for painting as the liquid is designed to cover. In the following results (Fig. 12) obtained on cement coatings, the porous surface used was $^3/_4$

RESULTS ON FIG. 21—INTERIOR VARNISHES

	Weight of coat	Meas. No.	Days interval	Permeability Actual	By weight	Meas. No.	Days interval	Permeability Actual	By weight	Meas. No.	Days interval	Permeability Actual	By weight
E F₁	3.45	1	0	2716	937	2	15½	2247	775	3	11	2150	741
E F₂	4.02	1	0	2738	1106	2	15½	2550	1025	3	11	2188	879
Average	..	1	0	..	1018	2	15½	..	900	3	11	..	810
E G	3.30	1	0	2566	847	2	15½	2102	694	3	11	1911	631
E H₁	3.46	1	0	3227	1117	2	15½	2620	907	3	11	2554	884
E H₂	3.33	1	0	4058	1352	2	15½	3320	1105	3	11	3358	1118
Average	..	1	0	..	1234	2	15½	..	1006	3	11	..	1001
E K	3.79	1	0	2876	1089	2	15½	2659	1008	3	11	2437	924
E L	4.24	1	0	1568	837	2	14½	2676	1135	..	..	..	..
E M	4.75	1	0	1553	738	2	7½	1772	842	3	7	2368	1125
E N	4.46	1	0	1558	695	2	7½	1615	720	3	7	1634	728

which was broken down in five and a half days on the exterior shows little sign of rising in permeability during twenty-six and a half days on the interior. Thus, some of the history lost in Fig. 8 is now recovered but even here more frequent measurements at shorter intervals would be necessary in order to establish a complete record of the behavior of these varnishes.

inch thick and was composed of 1 part of Portland cement to two parts of sand. The liquids were purchased in the open market, the cans being labeled "damp-proof," "water-proof," "steam-proof," and other like claims. Evidently C E, C F, and C G afford little, if any protection, though C F is the best of the three. C H stands apart from the others, being low in permeability throughout, and justifying

RESULTS ON FIG. 12—CEMENT COATINGS

	Weight of coat	Meas. No.	Days interval	Permeability Actual	By weight	Meas. No.	Days interval	Permeability Actual	By weight	Meas. No.	Days interval	Permeability Actual	By weight
C F	15.49	1	0	1457	2255	2	2	1663	2578	3	1	2073	3209
C F	...	4	1½	3980	6165	..	..	..	..	..	..	..	..
C G	7.51	1	0	914	686	2	2	1778	1335	3	1	4523	3398
C G	...	4	1½	7286	5472	..	..	..	..	..	..	..	..
C E	8.58	1	0	4293	3682	2	2	4007	3438	3	1	4980	4280
C E	...	4	1½	9781	8392	..	..	..	..	..	..	..	..
C H	9.12	1	0	740	680	2	3	697	635	3	1½	640	58

its water-proofing claims. The data are published simply to indicate the possibilities in some such method for evaluating these coverings.

By the resu ts, C F and C G afford tolerable protection in keeping the water out at first, and through the beneficial valve action previously demonstrated, they will let out all excessive moisture in the concrete beneath. C E, however, is nothing else than a sieve, though it retails at $1.75 per gallon.

The basal difficulty in the presentation of this paper is a proper selection from the wealth of experimental and speculative material at hand. The question of the mechanism by which water passes upwards through a panel during a measurement of permeability is important, since the same movement occurs in actual exposure, but space does not permit a complete discussion. Certainly on the apparatus, it is in part at least a phenomenon of gaseous diffusion, for the water is in the form of vapor where it touches the film. The far larger portion of work published on diffusion and osmosis has dealt with the gas or liquid, and very little emphasis has been placed upon any view from the standpoint of the membrane. As far as the paint film itself is concerned, it would seem unwise to presuppose a fundamentally different process for the passage of water through it according to whether this happens to be in contact with it in the liquid or gaseous state. Kahlenberg[1] and others have indicated that "semi-permeability" depends on a chemical similarity between the membrane and the solvent, by which the latter dissolves on one side and escapes on the other through a difference in solution or osmotic pressure, the solute, being far less soluble, passing through much less rapidly. It appears to be thus a question of solution, *little though we understand the term*. A variety of experiments are projected to test this point as regards paint films. If such a coating becomes less soluble in water as it dries, the fact would account for the decrease in permeability due to heating or drying, the latter being true.

The writer has further found that continuous contact of a thoroughly dried linseed oil skin with water causes a steadily increasing absorption up to at least fourteen per cent, as shown by increase in weight of the skin. In other words, a condition of equilibrium between liquid water and linoxyn demand a high percentage of water dissolved in the paint film, but as between aqueous vapor and linoxyn, equilibrium would be reached at a lower percentage, varying with the nature of the substance in contact with the vapor and with the vapor pressure. We have in the latter, one of the components of the marked effect of changing temperature on the results obtained by use of the permeability apparatus. During a measurement on the same, we may imagine the coating to be divided up into a large number of layers. The lower layer contains the highest percentage of water, being in contact with the vapor saturated air. The upper layer holds the lowest percentage of water because of contact with air kept at very low humidity.

[1] *Jour. Phys. Chem.*, **10**, 141.

The actual percentage in both cases will depend on a number of factors, among which is the dissolving power of the coating. Between these two layers there will be a uniform decrease in water content from the lower to the upper, if the affinity for water is the same throughout all layers. These differences in concentration cause corresponding differences in solution tension, resulting in an upward movement of dissolved water through the surface covered and the coating. With gases other than aqueous vapor and membranes other than paint and varnish coatings, the same explanation for permeability as outlined should be postulated, and the apparatus is adapted to such a line of inquiry.

It does not seem necessary to postulate the existence of microscopic or even ultramicroscopic pores in the fresh paint or varnish film, though this theory seems to be generally believed by experts. As the coating becomes thinner through saponification and the resultant formation of more soluble products leaving a chalky upper surface or when it has lost its elasticity and has begun to check or crack, then indeed pores are evidenced by the rise in permeability; the panel has begun to break down.

The foregoing work is believed to be a good start towards an accurate rating of protective coverings. The investigations will be continued by the writer along all lines as rapidly as is practicable with the co-operation of his students and of manufacturers. He desires to express here his thanks to the Patton Paint Company, the Pitcairn Varnish Company, and the Corona Chemical Company for the space in their joint laboratories which has been courteously afforded during this research, and for the stimulating interest and at times assistance of their officials and experts.

MILWAUKEE, WIS.

THE DETERIORATION OF FIREBRICKS DURING SERVICE

By GILBERT RIGG

Received April 15, 1913

The duration of life of a firebrick during service depends upon a multiplicity of factors, physical and chemical, not all of which are by any means understood. These factors may be grouped under three heads, namely:

(1) The manufacture of the brick.
(2) The laying of the brick.
(3) The application of the brick.

Each of these groups of factors has a profound effect upon the value of the other two in determining the life of a brick during service. The third group is to a large extent out of control (but not altogether; for example, carelessness in drying out and starting up a furnace will in many cases shorten the life of the lining). Taking the third group as fixed, then, the problem becomes: How can the other two groups be varied so as to minimize as far as possible the destructive influences in the furnace?

The problem is complicated by the fact that the three groups of factors are controlled by three different sets of men, and to a large extent each of these sets of men understands only the group of factors which he

controls. If the brick manufacturer thoroughly understood the nature of the effects which his bricks would have to withstand, or if the furnace operator knew what method of manufacture would best meet his conditions, the matter would be a great deal simplified. This desirable state of affairs, however, belongs to a large extent to the future.

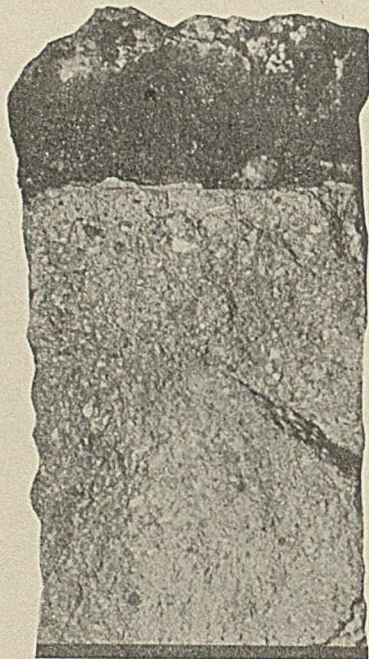Figs. 1 and 2 are photographs of two bricks which

FIG. 1

have been broken across through the layer of slag which has attached itself to one of their surfaces. In Fig. 1, the slag shows a clear line of separation from
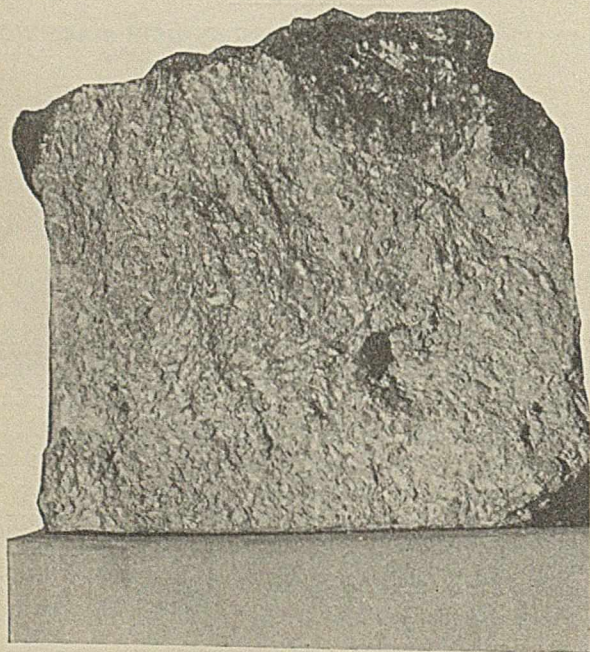
FIG. 2

the brick; in Fig. 2, the slag blends into and penetrates the brick. The first brick will undoubtedly outlast

the second. For this particular purpose brick No. 1 is by far the best article, but I have no doubt that for some purposes brick No. 2 would be perfectly satisfactory. What can be done to standardize brick No. 1 for this particular purpose?

Now I wish at the outset to make perfectly clear that I do not claim to be an expert firebrick maker. I am concerned only with the application of firebrick to certain branches of metallurgy. I have been trying to find out what relation exists between certain types of brick and the duration of life of these brick in certain applications, and the nature of the destructive action which brings about their decay and final failure. Further, I have tried to standardize these types by various tests and methods of examination, and have attempted some work along synthetic lines, to develop masses having certain desirable characteristics. In this paper I am going to define as clearly as I can the destructive influences which I have found to be of paramount importance in determining the life of firebrick and to indicate the type of mass which I have found best fitted to resist them.

I do not propose to deal with such matters as failure by simple fusion of the brick. The remedy for this is obvious. Also within broad lines failure through chemical influences is well understood. Anyone who lines a furnace with silica brick and then exposes it to a strongly basic slag deserves what he gets. I am going to assume that the clay is reasonably well suited both in composition and refractory coefficient for the work it has to do and proceed to discuss its application from that standpoint.

The destructive agencies that come into action in the applications I have been considering may be divided into two groups: (1) Liquid. (2) Gaseous.

DESTRUCTION BY LIQUID MATERIALS (SLAGS, ETC.)

This class of destructive influence is frequently highly effective. Given a refractory mass with pores or openings into which slag can penetrate, it is only a matter of time for the mass to have undergone a more or less complete change in its chemical and physical properties. The extent to which this change may take place, and its effect on the life of the brick depends on certain factors which we shall now consider.

The slag as it enters the body of the brick begins to take up and dissolve fireclay with the result that its temperature of fusion rises. It may happen that by the time the pores of the brick are filled up with slag, or rather a combination of fireclay and slag, the point of fusion of the complex mass is higher than the furnace temperature. This is more likely to happen with dense bricks, of low porosity, than with loose textured ones.

Good examples of this condition are frequently found in spelter retorts. The clay of which these are made will stand a temperature of 1700° to 1800° C., but after being withdrawn from service pieces of clean retort material, free from encrusting slag, may be found to have a fusion point 300° or 400° lower. A thin slice of such a specimen, examined under the microscope, will show numerous cavities, many of which are filled

with slag, and it is doubtless this slag which brings down the fusion point (Fig. 6).

With most, if not all, slags, the vigor of the attack on fireclay appears to be a function of the temperature. Some slags a little above their melting points will lie in contact with the fireclay mass without any serious degree of combination taking place. At a higher temperature, however, the vigor of the attack will increase. The absorption of the fireclay by the slag, as the temperature rises, causes the slag to become more viscous, so that we have the apparent anomaly of the slag stiffening with rise of temperature.

When the slag occurs on the hottest surface of a refractory mass as is the case with a blast furnace lining, the destructive effect is not usually as marked as when the slag occurs on the coolest surface as in a retort or muffle. Under the former conditions the slag as it penetrates into the brick meets with a falling temperature and soon freezes, while under the latter the slag as it penetrates meets with a rising temperature and its destructive effect is enhanced

What is the remedy for this state of affairs? Clearly with a uniform solid mass free from fissures or pores, penetration would be distributed evenly over the entire surface. Whatever destruction took place would be at the surface. In much of the refractory material on the market, however, this condition does not obtain. The mass is non-uniform, contains numerous fissures and pores and irregular penetration is the rule rather than the exception.

Fortunately it is not a difficult matter to determine on a test piece of a refractory brick what are the prospects of a given molten material penetrating and destroying. For some years I have used the following method, which presents certain advantages.

The size of the test piece may vary within a wide range, from a full-sized block down to a cube 2 × 2 × 2 inches according to circumstances. In any case the surface to be tested for penetration should be a natural surface, not one produced by chipping and grinding unless it is specially desired to try out what would happen under these conditions. As an indication of how a given type of brick would behave under the action of a given flux, the natural skin of the brick should always be used for the testing surface.

The slag should also be made into a cube by crushing fine and working up with a little dextrine and water, or glue. With a 2-inch cube of firebrick, a 1-inch cube of slag should be used. In cutting the firebrick cube care should be taken to reject any specimens when cracks have developed in the test surface due to cutting.

The cube of fireclay is placed in a muffle or crucible with the slag cube on top of it, and the temperature raised to that to which the brick will be exposed in the furnace for which it is destined. The slag melts on the surface of the brick and its relation to the latter can be readily studied after removal from the furnace and cooling.

In some cases it is desirable to use the constituents of the furnace charge, powdered and formed into a cube, instead of the slag, in cases where the brick will be exposed to these substances rather than to the slag. In all cases there should be careful regulation of the temperature of the test so that it approximates as closely as possible to the working temperature. If the test temperature is too low, an inferior brick may show up well, and if too high, a satisfactory brick may be rejected.

The appearance of the test piece is frequently highly characteristic, and several type cases may be described. It may be pointed out here that the examination of thin slices of the test piece under the microscope frequently affords valuable evidence as to the resistance of the sample to penetration.

Case 1.—The slag has melted and spread over the surface of the brick like an enamel. On breaking the piece across there is a sharp line of demarcation between the slag and the brick, and no staining of the mass, or veins or particles of slag below this line. The line of separation is approximately straight.

This result indicates a low degree of permeability and a high resistance to penetration on the part of the test piece. Microscopic examination should show the particles of fireclay clear and sharp against the slag.

Case 2.—The slag has melted and spread over the surface, and the fireclay next to the slag is stained or semifused, or otherwise altered. Penetrating veins are absent. The dividing line tends to be convex towards the fireclay.

This usually means a combination between clay and slag, and may indicate speedy destruction of the brick. By repeating the experiment one or more times with fresh cubes of slag, using the same test piece of brick, the discolored layer may increase and tend to blend with the slag layer above, the dividing line being obscured and more and more convex downwards. This means that a compound is being continuously formed by the slag and brick whose fusion point is below the working temperature of the furnace. In some cases, however, successive additions of slag simply pile up on the brick and penetration does not increase in depth, indicating that the lower layers of the compound are too infusible at the temperature of the furnace to penetrate further. In this case the brick has a good chance of standing up under the working conditions. This result is rarely seen, except in bricks whose composition is homogeneous and texture fine. With bricks composed of two or more clays, particularly when one clay is in the form of grains imbedded in a plastic bond formed by the other, the two clays will usually resist to a different degree, the bond clay suffering the most, and the discolored layer will approximate in character to the next case.

Case 3.—The slag has melted and spread over the surface and has sent veins into the clay, these veins penetrating more or less deeply into the brick. When the brick is composed of two or more clays as described in the foregoing case, the veins usually penetrate between the grains of the most refractory clays, and after repeating the experiment several times on the same sample the grains of the more refractory clay

will appear imbedded in a fused matrix composed of a combination of the original slag with the more susceptible clay.

This type of penetration is exceedingly common and is responsible for a great deal of firebrick failure. It is commonly supposed, and with a considerable measure of truth, that brick composed of finely ground clays (say through 10-mesh) are more liable to split when heated and cooled than bricks that are coarse-textured (say through 3-mesh). When a finely ground brick gives way under sudden changes of temperature it does so along one or more well marked lines and as a result pieces frequently come off bodily, and the brick is said to spall. It is a mistake, however, to suppose that a coarse-textured brick does not change at all with sudden changes of temperature. Such bricks often do, but owing to their structure, the strain is relieved by a great number of small fissures ramifying through the mass between the coarse, hard grains, but not sufficiently continuous to cause actual falling to pieces of the mass. It is quite common to find old firebricks of this type (and even new ones also) which, if broken with a hammer, allow the coarse grains to drop out of the matrix like loose teeth. The minute fissures or areas of separation between grain and bond, which permit of this disintegration, undoubtedly facilitate the penetration of slags according to Case 3, and lead eventually to failure.

A striking example of the working of this principle is seen in the arches of the zinc oxide furnaces. The under side of these arches is continually bombarded by minute particles of ore from the charge and zinc oxide smoke. A part of these materials adheres to the arch and forms an incrustation called rock oxide, which may reach a thickness of several inches. The furnaces are exposed to great fluctuation of temperature, as the residuum is drawn periodically and a fresh cold charge put in immediately after.

Now actual experience shows that coarse-textured bricks spall under these conditions far more than fine-textured ones. In the former case pieces of rock oxide drop from the arch from time to time with large pieces of brick adhering to them. In the latter case, the rock oxide will come away leaving the brick behind. I have frequently seen large masses of rock come down bearing the imprint of several bricks on its surface of attachment, showing how close the contact had been, and yet little or none of the brick had come away.

In the case of the coarse brick we have always found that the rock oxide had penetrated into the fissures of the brick, separating the grains and solidifying between them. These penetrating veins are continuous with the mass of rock oxide clinging to the arch, and when the weight of this mass becomes too great to be supported it falls, dragging with it a portion of the weakened brick.

Strictly speaking this is not a case of spalling at all. It is a case of rupture under load, the attachment of the load to the interior of the brick being effected by the penetrating veins. The tendency of a fine-grained brick to split and fall to pieces has, I think, been con-

siderably overrated. But it is quite possible to prepare a close-textured brick containing considerable amounts of coarse material, provided that proper care is taken in sizing the grog. The problem appears to me to be very much on the same lines as concrete mixing, and has been discussed at some length by me in a previous paper.[1] In making concrete, care is taken to mix the different sizes of rock, etc., in such proportions that the interstices between the larger fragments shall be filled as completely as possible by smaller fragments, and this result is achieved by first sizing and then mixing the different sizes in definite proportions. By this scheme the amount of cement necessary to fill up the spaces between the pieces is reduced to a minimum.

Consider now the case of a brick made up of a highly refractory nonplastic flint clay, of low shrinkage capacity, and a plastic bond clay. The former is ground to pass, say, a 4-mesh screen, and mixed up to a stiff dough with the latter. The flint-clay being non-plastic is not affected by the water. The bond-clay being highly plastic, takes up the water and forms a plastic mass in which the grains of the flint clay are imbedded.

During the process of drying, the water evaporates and the mass shrinks. The flint-clay takes no part in this shrinkage. On the contrary it resists the shrinkage strongly, forming a sort of skeleton which tends to maintain the dimensions and form of the brick. The loss of volume due to the evaporation of the water, in so far as it is resisted by the flint-clay skeleton, must be taken up by the bond-clay, and in consequence the latter develops fissures and pores.

During burning the mass shrinks still further. If the flint-clay has a low fire-shrinkage, and the bond-clay a high one (and this distribution of properties is common) the bond clay undergoes a further straining and is consequently rendered still weaker and more open-textured than before.

A parallel case may be quoted here by way of illustration. Both firebrick manufacturers and brick-layers agree that poor bricklaying will spoil good fire brick. By poor bricklaying I mean failure to bring the surfaces of adjacent bricks into the closest possible contact. The clay which is used as mortar between the bricks is a very poor substitute for brick. It shrinks a good deal during the drying and burning and becomes fissured and porous. Consequently if wide joints are allowed, either on account of poor bricklaying, or on account of warped and badly shaped brick, the slag rapidly attacks the clay, eats its way between the bricks, and the structure is soon destroyed.

On a much more minute scale this is what takes place in the case of bricks where the bond clay is badly distributed. Just as in the structure, so in the brick, the bond clay should be reduced to the smallest possible amount which will fill properly the interstices between the grains of grog. If a high refractory coefficient is obtained by cutting down the amount of bond clay regardless of this condition we obtain a weak and

[1] *Met. Chem. Eng.*, **8**, 523.

crumbling brick which is readily penetrated and destroyed. The bond should fill the spaces between the grains as thoroughly as the cement fills the spaces between the rock fragments in the concrete, and what is of paramount importance, the spaces to be filled should be cut down to the smallest possible dimensions.

A single example may be quoted from the paper referred to above:

A grog was used giving the following mechanical analysis:

	Per cent
Through 10 on 16	42
Through 16 on 25	22
Through 25 on 30	9
Through 30 on 50	12
Through 50	15

From this another grog was made up:

	Per cent
Through 10 on 16	24
Through 16 on 30	26
Through 30	50

These two grogs were worked up with bond clay and burned at 1100° C. Seven parts of clay were used

FIG. 3

to nine of grog. The following figures were obtained:

	Original grog	Sized grog
Breaking strain lbs. per sq. in	243	371
Fire-shrinkage, per cent	4.84	5.44

The gain in strength shows a close adhesion of bond

FIG. 4

to grog and greater freedom of the bond from fissures

and pores. This is borne out by the higher shrinkage of the mass with the sized grog.

Figs. 3 and 4 are photos of thin slices of firebrick magnified 40 diameters. In Fig. 3 the grains of grog have separated from the clay bond, as shown by the clear space surrounding them. In Fig. 4 the adhesion of bond to grog is much closer. I may say that slices of brick are very difficult to prepare as the brick substance has a great tendency to crumble. The specimens usually show numerous cracks and holes in consequence.

Fig. 5 is a photograph of another slice showing a cavity in a brick eaten out and filled by slag. In this case the slag has penetrated into and dissolved and absorbed the brick substance, which shows smooth contours surrounding the slag inclusion.

Steam or hydraulic pressing, and re-pressing help very materially in fortifying brick against slag penetration, by closing up the fissures and pores. Fig. 6 shows a slice of spelter retort which has been made in a hydraulic press, after being in service a month.

FIG. 5

The contact between the grains of grog and the bond is very close and perfect.

DESTRUCTION BY GASES

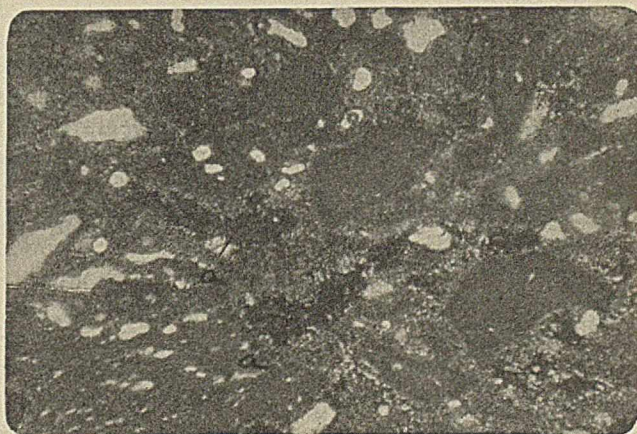This is less general than destruction by liquids but

FIG. 6

nevertheless plays an important part at times. With

the exception of hydrofluoric acid gas, direct destruction of firebrick by gas does not occur to any extent. Where gases are primarily responsible for trouble they usually act as conveyors of the destructive influences which are themselves either liquid or solid.

A familiar example is that of salt-glazing. The articles to be glazed are exposed to the vapors of sodium chloride. In contact with the hot fireclay sodium silicate is formed and the chlorine is liberated. If the operation is unduly prolonged the clay is eaten away by the accumulating glaze. A similar action is sometimes met with in furnaces where alkaline chlorides are found in the furnace gases.

A very curious case of firebrick destruction by gases has recently been described by Prof. Osann ("Reduktion und Kohlung in Hochofen, in Zusammenhange mit Hochofenstorungen," *Stahl und Eisen*, No. 12, 1912). The trouble is usually met with in the top lining of blast furnaces. The bricks weaken and crumble away, more or less rapidly, without exhibiting any sign of fusion. In fact the low temperature at the top makes fusion impossible.

In a case which came under my observation three years ago, the facts were made more striking because, owing to certain furnace troubles, the heat in the top had been excessive and the inner ends of the bricks were burnt hard. The outer ends next the shell appeared to be sheared. They scaled off in laminae, parallel to the shell, and the faces of the laminae were covered with patches of carbon. From the centers of the patches a minute grain could be withdrawn by a magnet. We therefore had the curious phenomenon of the hot ends of the bricks being in good shape and the cold ends destroyed.

Prof. Osann in the paper referred to above explains very clearly what is taking place. It is well known that carbon dioxide in contact with red hot carbon becomes more or less completely reduced to CO, the equation being

$$CO_2 + C = 2CO$$

The completeness of the reduction to CO is a function of the temperature. At 1000° C. the reduction is practically complete. At 500° C., a temperature frequently met with in blast furnace tops, it is very far from complete.

Now the foregoing reaction is reversible, and in the presence of a catalyst, the reaction proceeds rapidly. The composition of the gas coming from the lower part of the furnace corresponds to a temperature at which the reducing reaction is complete. When the gas arrives at the top, and comes in contact with particles of iron oxide contained in the brick, the reaction reverses and carbon deposits. This carbon accumulates in the substance of the brick until the latter is completely disintegrated.

It is noteworthy that this carbon deposition is particularly noticeable in the bond clay which has been used for laying up the bricks. When an old lining is being taken out it is not uncommon to see masses of brick adhering together and showing, where broken across, the bond clay like a geometrical pattern drawn in charcoal.

A somewhat parallel case of destruction by gas is afforded in the case of blast furnaces running on ores containing zinc. Under these conditions the vapors of metallic zinc are liable to enter the brick and, passing to the cooler parts of the brick, oxidize at the expense of the CO_2 and solidify. The veins of crystallized zinc oxide which result from this action have a powerful effect in rupturing the brick and causing crumbling.

Fig. 7 is a photograph of a piece of the upper inwall lining in which a vein of metallic zinc has condensed.
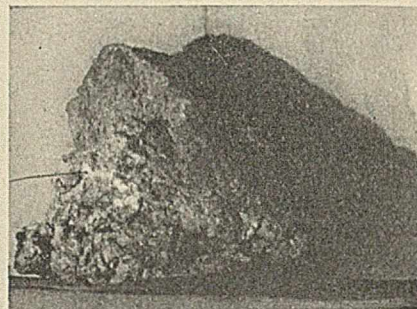

FIG. 7

This is very unusual. As a general rule the vein would be zinc oxide as described above. It is noticeable in these cases of gas destruction that the trouble is set up in the interior of the brick, and in the clay bond in which the bricks were laid. It is by no means confined to the surface; moreover, if the bricks were entirely impenetrable the destructive effects could not occur. The effect is one of penetration by the destructive influences much as in the case of destruction by slags.

Other things being equal I am convinced that the more compact and close-textured a brick is, the better it will stand up against corrosive slags and gases. And the truer it is to shape, the closer it can be laid up in the work; penetration into the bond between the bricks is facilitated by wide joints and is highly destructive to the work. As regards the risk of spalling with changes of temperature in the case of close-textured brick, experience shows that brick of this type can be made to stand up perfectly. If they spall, the trouble is due to unsuitable clay, or poor workmanship, or both.

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THE INFLUENCE OF CINDERS ON THE CORROSION OF IRON IMBEDDED IN CLAY[1]

By WALTER B. SCHULTE

Investigations of electrolytic corrosion of underground structures occasionally reveal examples of marked corrosion under certain conditions which preclude a consideration of stray currents from electric railways as the cause. Filled ground seems to be especially harmful to iron pipes, especially where the filling is composed largely of cinders, coal, and furnace products.

Of the various explanations which have been offered to account for this corrosion the more common are:

that the sulfur, which is a constituent of most coals, probably forms sulfuric acid, with the resultant chemical corrosion; also that cinders and particles of conductive carbon in contact with iron produce a local couple, and the pits which are formed are attributed to this effect.

The objection to the former theory is that after a severe heat treatment the sulfur is usually expelled from the cinder material, and that the latter explanation is not completely adequate is indicated by the fact that the corrosion occurs even where there may be an intermediate layer of clay between the cinder bed and the pipe. Certain cases of deep pitting of iron pipe have been called to the attention of the writer where an overlying bed of cinder filling out of direct contact with the pipe seemed to be in a measure responsible for the damage noted.

It is well known that if a mass of carbon and a mass of iron are imbedded in an electrolytic conductor, such as in moist earth, a difference of potential is established between these two bodies, the iron being electrochemically positive to the carbon. This potential does not establish a flow of current unless metallic contact is made between these two bodies. While a layer of carbon material may be separated from an iron pipe in one locality by a bed of sand or clay, corrosion may be produced at that locality by reason of contact between the iron and the carbon bed at some other position, such for example as occurs where a service pipe or other portion of the underground system may pass through the carbon bed. It is evident, therefore, that contact between the cinders and the iron is not necessary at the exact location where the corrosion is observed in order to account for such corrosion.

An active couple produced by carbon and iron results in the iron being the anode and the carbon being the cathode. Polarization tends to reduce the flow of current but this polarization is minimized if air has ready access to the carbon bed; therefore the nearness of the carbon bed to the surface of the earth is a factor which influences the corrosion caused by such material.

The object of the investigation here described was to reproduce, in the laboratory, conditions which were found in the field and to make laboratory measurements of potential and current flow, and determination of the amount of corrosion. The experiments were carried out in the Chemical Engineering Laboratories of the University of Wisconsin.

APPARATUS

The apparatus, as set up in the laboratory, included a sheet of iron buried in a bed of clay on the top of which rested a layer of granular carbon which represented the cinder bed. Electrical contact between the plate and cinders was provided for by a wire connected between them. The arrangement of the apparatus is shown in Fig. 1.

It is of course evident that the conductive layer of carbon here used has a higher electrical conductivity than that produced by cinder filling, as found in practice, and the reason for using this was to accelerate

the action so as to produce measurable results within a short time.

The iron plate was of No. 24 sheet iron which was pickled, dried and weighed before being placed in the clay which was taken from a fresh excavation and was moist when placed in the box. The layers below and above the plate were well tamped in place. The carbon, which had been used as a resistor in electric furnaces, was granular, the particles ranging from $1/4''$ to $1/2''$ in diameter. A graphite block, with a stem, was placed in the carbon to make electrical contact between the carbon and external connections, and insulated wire connected to the plate was brought out through the clay. The carbon lead was connected to a switch, also connected to the iron plate terminal
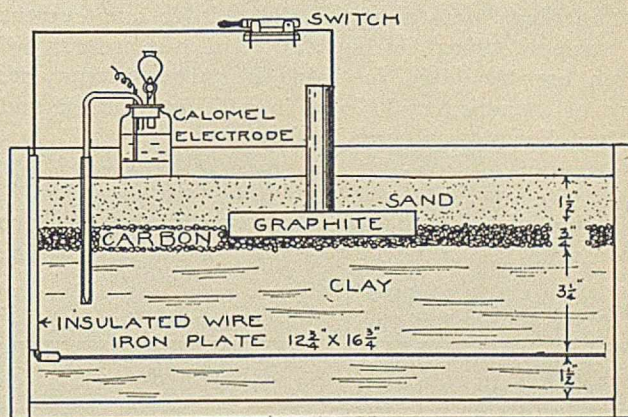

FIG. 1

so that by closing it the cell was short-circuited. The switch was provided with short leads so that an ammeter or voltmeter could be connected to them and measurements be made with the switch open. The carbon was covered by a $1 1/2''$ layer of sand at the beginning of the test but this was removed on the fourth day.

To measure the single potentials of the iron and carbon against the clay a calomel electrode was employed with a long nose reaching down through a glass tube into the clay half way between the carbon and iron. A few drops of normal KCl were poured into the bottom of the glass tube to moisten the clay and assure good contact between the clay and electrode.

MEASUREMENTS

Before closing the switch, the potentials of the iron and carbon against the clay were determined by the potentiometer method, taking —0.56 volt as the potential of the calomel electrode. The results are given below:

Total E. M. F.,   0.842 volt, carbon cathode
Clay to carbon, —0.638 volt
Iron to clay,   +0.204 volt

Total,   0.842 volt
A voltmeter indicated 0.83 volt.

After making the single potential measurements, the circuit was inadvertently closed for a minute or two, after which the voltage, as indicated by a voltmeter, had fallen to 0.72 volt. Further short-circuiting caused the voltage to drop from 0.68 to be-

tween 0.45 and 0.50 after a few minutes. One and one-half minutes after opening the switch the voltage increased to 0.68 volt.

The cell was short-circuited for twenty minutes and the switch then opened, after which single potential measurements were made at various intervals.

After being on short-circuit for seventeen hours, similar single potential measurements were made, during which time the average current, as measured by a milliammeter, was 0.0515 ampere. The data of these measurements, as tabulated in Table I and plotted in Fig. 2, show that the rate of depolarization is decreased after the cell has been short-circuited for the longer time.

The cell was then allowed to stand short-circuited and readings were made of the voltage and current at various times during the run, the results of which are tabulated in Table II. The instruments were of standard make and in good calibration and of the following scales and resistances:

Voltmeter 0–15 volt;   53.5 ohm resistance
Ammeter 0–500 mil-ampere; 0.09 ohm resistance

During the fourth day the layer of sand above the carbon was removed as noted in the table. The

TABLE I—DEPOLARIZATION

Single potentials of carbon				Single potentials of iron			
Short-circuited 20 minutes		Short-circuited 17 hours		Short-circuited 20 minutes		Short-circuited 17 hours	
Time Min.	E. M. F.	Time Min.	E. M. F.	Time Min.	E. M. F.	Time Min.	E. M. F.
..	..	0	...	..	...	..	...
$1/2$	—0.432	1	—0.394	0	+0.184	0	+0.162
1	—0.478	$1^1/2$	—0.424	$1/4$	+0.184	1	+0.160
2	—0.485	2	—0.434	$3/4$	+0.186	2	+0.160
3	—0.508	3	—0.438	2	+0.180	3	+0.160
4	—0.510	4	—0.442	3	+0.182	4	+0.160
5	—0.516	5	—0.452	4	+0.180	5	+0.160
7	—0.524	8	—0.452	6	+0.178	8	+0.158
10	—0.530	10	—0.458	24	+0.180	10	+0.158
24	—0.540	16	—0.468	..	...	16	+0.158
42	—0.564	23	—0.470	..	...	23	+0.156
..	...	43	—0.474	..	...	43	+0.156
..	...	60	—0.484	..	...	60	+0.158
..	...	..	—0.499	..	...	..	...

clay began to dry out, so that beginning with the tenth day about half a liter of water was sprinkled over the carbon and allowed to soak in before a set of readings were made. No readings were taken between the 33rd and 58th days, nor was the cell moistened, with the result that the current on the 58th day was almost nil, and the potential 0.22 volt. Three minutes after the cell had been moistened the observed values increased to 0.0175 ampere and 0.32 volt.

Rough integration of the curve plotted between current and days, with the current as zero on the 58th day, gives 35 ampere hours. If the cell had been moistened regularly each day throughout the test it is fair to assume that the average current would have been 0.03 ampere: 0.03 ampere for 58 days is equivalent to about 42 ampere hours. The average voltage over this period can be taken as 0.35 volt.

The interesting point to be noted is that as long as the clay was moist a current flowed continuously

from the iron to the carbon, the depolarization, due presumably to the action of the air on the carbon, taking place at a constant rate.

The loss of iron by one ampere-year is about 20 pounds so that 0.03 ampere, the assumed average current with the clay moist, would be about 20 x 0.03 = 0.6 pound.

The area of the plate was 1.45 square feet or 2.9 feet total surface, so that the theoretical corrosion per square foot would be 0.23 pound per year or about
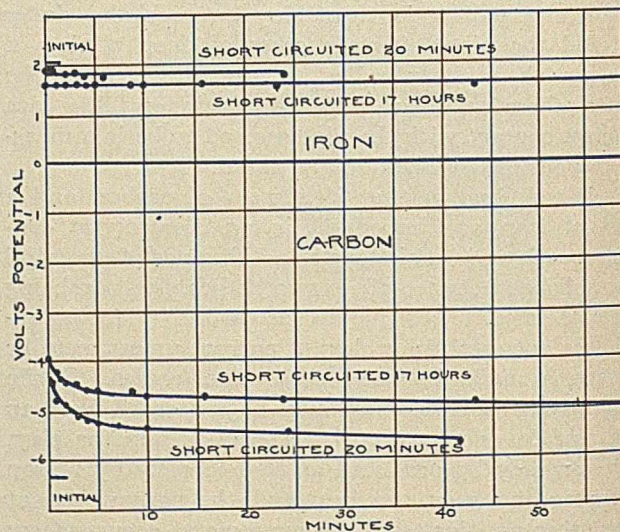

FIG. 2

$1/4$ pound per year. The loss of $1/4$ pound per foot from each surface of a plate would destroy the equivalent of a No. 30 sheet in one year or half of a No. 24 sheet. If this corrosion were concentrated in six square inches area on every square foot, the metal would be pitted to the depth of 0.15 inch which would pierce a three-inch cast iron main in a little over two and one-half years.

TABLE II—CURRENT AND VOLTAGE READINGS

DAY	AMPERE	VOLT	REMARKS
1	0.052	0.45	
2	0.0518	0.50	
3	0.050	0.45	
4	0.051	0.45	Sand removed from top
5	0.051	0.44	
7	0.0495	0.38	
8	0.035	0.40	
9	0.030	0.20	
10	0.040	....	Began wetting
11	0.035	0.40	
12	0.0475	0.42	
14	0.0475	0.42	
15	0.040	0.42	
17	0.041	0.40	
24	0.030	0.35	Dried out since last reading
25	0.0375	0.36	
29	0.023	0.30	
30	0.020	0.20	
31	0.035	0.40	
32	0.028	0.35	
33	0.028	0.35	
58	0.015	0.32	

CORROSION OF PLATE

After the 58th day the cell was dismantled. Examination of the clay near the plate showed that the rust had penetrated into it as much as $1/4$ inch in some places. The plate was spotted with oxide

and greenish iron compounds. Corrosion was noticed both on the upper and lower sides of the plate and the corner diagonally opposite the wire connection was eaten through.

The plate was washed, the greater part of the rust scraped off and the remainder then dissolved off by hot ammonium citrate, after which it was weighed. The data follow:

	Grams
Weight of plate before test	401.6
Weight of plate after test	346.5
Loss	55.1

Thirty-five ampere hours theoretically would corrode 36.4 grams of iron so that the efficiency of corrosion in this case would be about 150 per cent.; that is, it may be said that two-thirds of the loss by corrosion was due to the current produced by the difference of potential between the carbon and the iron.

These experiments were intended as preliminary work for further investigation, which, however, was not undertaken, but a description of this first, rather incomplete work, it was thought, would prove of interest and draw attention to the influence of carbon and cinders on the corrosion of iron and perhaps lead to further experimentation on the subject. Further work along this line should be undertaken with the conditions more closely approaching those actually found; that is, using cinders instead of carbon and putting them, with the iron plate, in the earth. Similar plates not connected with the carbon should also be buried so that the amount of natural corrosion can be determined. Under these conditions, with the higher resistant cinders, it is to be expected that less current would be produced.

An interesting case of corrosion of a gas pipe which may be explained by action similar to that discussed above has been observed recently by the writer. Along a certain street the gas mains were paralleled by a water main buried a short distance beneath. The soil is mainly clay or silt but at the lowest portion of the street the water main dipped into a peaty layer. The gas main lay in the clay above the peat at this point and was corroded through at several places. The main apparently was in a locality not subjected to stray currents from the street railway or grounded power circuits so that the currents causing the corrosion must have come from other sources.

A length of gas main about 400 feet long was disconnected from the adjoining portion. Potential measurements between this disconnected length and an iron rod driven in the black layer showed that the gas main was 0.3 volt positive, and readings between gas and water connections showed that current was flowing from the gas to the water main through the earth. The corrosion can be explained by the fact that peat sets up a different potential toward an iron surface than does clay, and connections between the gas and water services on the consumer's premises makes the couple electrolytically active, thereby producing electrolytic corrosion.

MADISON, WIS.

RECENT ANALYSES OF THE SARATOGA MINERAL WATERS. III

By Leslie Russell Milford
Received April 5, 1913

ACQUIREMENT OF THE GENERAL CARBONIC COMPANY

Following the passage of the "Anti Pumping Act" in 1908, by the legislature of the State of New York, the gas companies situated at Saratoga Springs, which were pumping the mineral water and extracting the gas from it for commercial purposes, were the defendants in a great amount of litigation. One of the largest gas-producing companies was known as the General Carbonic and was situated in the Geysers district. This company derived about one-half of its supply from one spring with natural flow (the Adams) and the remainder from several wells by pumping. This plant continued its operations until the Reservation Commission, in July, 1911, acquired the property which contained about one hundred

ISLAND SPRING

acres of land and 25 existing bores, of which 19 varied in depth from 270 to 533 feet to the bottom of the well. This acquisition was necessary for the control of the large area of the mineral water basin, adjacent to the fault from which the wells and springs have their origin. In order to obtain all of the information possible relating to the condition of the wells upon this property and the effect of pumping on this land and the lands of other proprietors arrangements were made for taking scientific observations while the previous operations of this company were continued without disturbing existing conditions. The General Company continued pumping from July 2, 1911, to July 20, 1911. During this period six pumps worked continually, pumping from wells ranging from 316 to 397 feet in depth, an average of 120,000 gallons of water in twenty-four hours.

Observation of water levels, flow of water, gas pressure, and other physical conditions were noted. Com-

plete chemical analyses of the waters and frequent chlorine and alkalinity determinations were made. On July 20, 1911, the pumping was stopped and since then there has been a constant recovery of the mineral water basin and a rise in water levels of from 80 to 150 feet. A mass of information was thus obtained which showed the effect of pumping, the degree of depletion of the mineral water basin, and the

	1	2	3	4	5
	Adams Spring	Ditch Well No. 2	Flat Well No. 2	Island Spring	Pump Well No. 4
Date of analysis 1912	3/20	9/19	10/19	10/23	7/18

RESULTS IN MILLIGRAMS PER LITER
IONS, RADICLES AND OXIDES AS ACTUALLY DETERMINED

SiO_2	8.95	73.55	56.55	.10.05	9.20
SO_4	2.30	5.35	2.88	8.23	7.52
HCO_3	3983.76	2015.11	4514.67	3242.40	1799.21
NO_3	0.17	trace	trace	0.18	trace
NO_2	trace	trace	trace	trace	trace
PO_4	none	none	none	none	none
AsO_4	none	none	none	none	none
BO_2	trace	trace	trace	trace	trace
Cl	3842.86	1282.60	4230.77	2649.48	894.85
Br	42.28	3.41	26.26	16.37	6.82
I	4.20	0.31	1.45	0.76	1.07
Fe	8.85	9.19	244.96	6.93	5.09
Fe and Al	10.65	21.77	315.28	10.96	10.56
Al_2O_3	3.30	23.72	132.59	7.60	10.30
Mn	none	none	trace	trace	trace
Ca	670.00	378.81	689.01	586.80	350.56
Mg	252.60	214.13	249.27	202.96	83.36
Ba	10.35	1.18	6.59	6.00	3.76
Sr	trace	none	1.53	1.34	trace
K	250.70	42.32	279.34	231.71	82.11
Na	2556.52	711.87	2782.14	1717.99	640.98
Li	7.43	2.35	5.21	4.53	0.97
NH_4	9.82	2.18	19.27	11.40	2.88
Oxygen to form Al_2O_3	1.50	11.14	62.27	3.57	4.84

HYPOTHETICAL FORM OF COMBINATION

Formula					
NH_4Cl	31.12	6.48	57.13	33.82	8.54
LiCl	44.87	14.27	31.63	27.47	5.87
KCl	438.01	77.50	508.48	426.84	149.88
NaCl	5892.90	1802.89	6470.17	3958.48	1339.84
KBr	62.00	5.00	38.50	24.00	10.00
KI	5.50	0.40	1.90	1.00	1.40
Na_2SO_4	3.40	7.91	4.26	12.17	11.13
$NaBO_2$	trace	trace	trace	trace	trace
$NaNO_3$	0.23	trace	trace	0.24	trace
$NaNO_2$	trace	trace	trace	trace	trace
$NaHCO_3$	869.61	...	859.14	572.04	403.41
$Ba(HCO_3)_2$	19.56	2.22	12.44	11.33	7.14
$Sr(HCO_3)_2$	trace	none	3.66	3.66	trace
$Mg(HCO_3)_2$	1533.00	1008.71	1499.91	1221.22	505.99
$MgCl_2$	....	182.43	....	...	...
$Ca(HCO_3)_2$	2713.50	1531.73	2786.01	2372.74	1419.77
$Fe(HCO_3)_2$	28.14	29.27	780.11	22.07	16.20
Mn_3O_4	none	none	trace	trace	trace
Al_2O_3	3.30	23.72	132.59	7.60	10.30
SiO_2	8.95	73.55	56.55	10.05	9.20
Residue on evaporation dried at 105° C	9668.00	3952.00	11572.00	7116.00	3007.00
Total solids in solution (computed)	11654.09	4766.08	13242.48	8704.73	3898.67
Temperature	10° C.	(a)	10.5° C.	11° C.	(a)

(a) = not taken.

1, 2, 3, 4, 5 Files N. Y. State Dept. of Health.

progress of recovery from such depletion. That there is a close underground connection of all these springs has been made clear by these experiments. In a few weeks' time several wells and springs on the General property became active and wells, formerly pumped, became natural spouting springs. These

produced too many outlets of gas and mineral water and in order to conserve the springs it became necessary to check the flow of some of them. A number of wells which showed no energy were packed with clay while those exhibiting signs of life were tubed and allowed to "spout" or else capped temporarily.

The property on which these springs and wells are located is situated east of the Delaware and Hudson Railroad tracks, along the valley and banks of the Coesa Creek. The limestone, from which the springs emerge, is found here at a depth of 275 feet covered with a layer of shale rock of about 200 feet thick, and this covered with a layer of clay 40 to 60 feet thick and this in turn buried beneath a deposit of about 15 feet of gravel. The steep and wooded banks of the Coesa Creek, which flows through this property for nearly a half mile, furnishes unusual opportunities for park development. Several paths, roads and bridges have been built here to enable visitors to enjoy the whole landscape and visit all of the springs.

ADAMS SPRING

The Commission is in hopes of bottling some of these waters, and experiments are now being conducted to determine the fitness of Pump Well No. 4, Flat Well No. 2 and the Island Spring for this purpose.

DESCRIPTION OF THE WELLS AND SPRINGS

The Adams Spring, which has been flowing since it was drilled in 1904, is situated in the Geysers district, on the high embankment rising from the Coesa Creek, being just south and above the Champion Springs and the Clark Well No. 2. It is about one-quarter of a mile northeast of the Coesa Spring and on the opposite side of the Delaware and Hudson Railroad tracks. This spring is 344 feet deep and has a flow of about 10 gallons per minute. It has a large excess of gas, each volume of water giving 4½ volumes of gas, and furnishes approximately 1200

pounds of gas in 24 hours. The waters of the Adams Spring are strongly mineralized and approach very closely to those of the Coesa. This spring is one of the best in the group, but it has not been developed except in connection with the gas industry of the General Carbonic Company.

The Ditch Well No. 2 is a shallow surface well and does not penetrate the rock. In drilling the well a large boulder was struck at about 45 feet below the surface and the tubing was driven to that depth. This well is situated in the bed of a ditch in the Coesa valley about 40 feet east of the creek and 200 feet south of the Pump Well No. 4. It was drilled in 1896 and has a very small flow averaging about one quart per minute. The water is moderately mineralized, resembling that of the Emperor. The analysis of this water shows the presence of magnesium chloride. This substance has been reported[1] only twice before in the published analyses of Saratoga waters. As a great amount of chemical and geological data have been published and various theories have been advanced to account for the origin of these waters,[2]
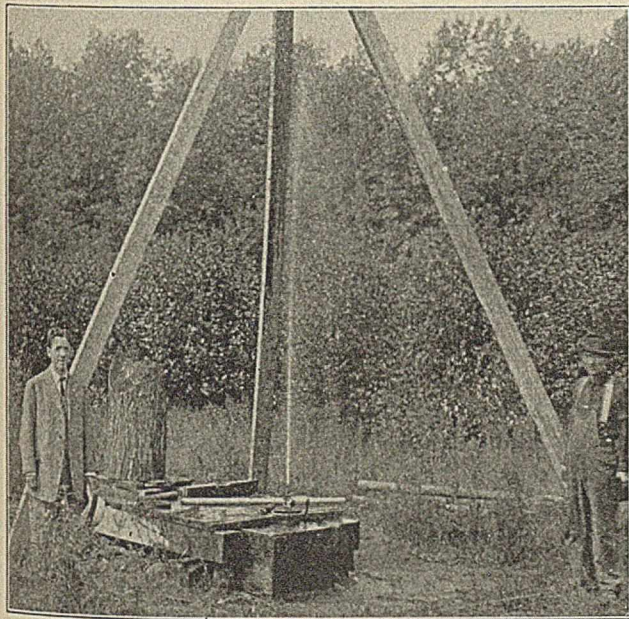
FLAT WELL NO. 2

this presence of magnesium chloride in a shallow well will be interesting to the geologists familiar with this region.

Flat Well No. 2.—This well is situated across the Coesa Creek southwest of the gas company's plant beside the road leading to Ballston Ave. and the Coesa Spring. It is located in the flat land along the Coesa valley and was pumped for the gas. It was drilled in 1904 and is 385 feet deep. When first drilled it had a flow at times of 8 gallons per minute but for a long time previous to its purchase by the Reservation Commission it showed no signs of water. In August, 1912, the well was retubed and immediately

[1] J. R. Chilton, Washington Spring, 1843; Dr. C. F. Chandler, Imperial Spring.

[2] "The Mineral Springs of Saratoga," N. Y. State Education, Dept. Museum, *Bull.* **159**, 1912, by James F. Kemp.

developed into a "spouter," throwing a large stream of water accompanied by great volumes of gas many feet into the air. It shows a static pressure of 42 pounds on the gauge fastened at the top of the casing. The water is strongly alkaline-saline, having a high sodium chloride, alumina, and calcium, magnesium, and iron bicarbonate content. It is unusually high in iron and alumina and shows a natural water containing a large amount of colloids. This water may be termed a natural chalybeate water and is at the head of all known waters of this class in point of strength.

The Island Spring is located on a small island in the bed of the Coesa Creek just below the dam. It was drilled in 1901 and is about 400 feet in depth. This was formerly used as a gas well with no flow of water. In four months after the cessation of pumping, the Island Spring began to overflow with mineral water for the first time in its history. It now has a flow of eight gallons per minute, and spouts many
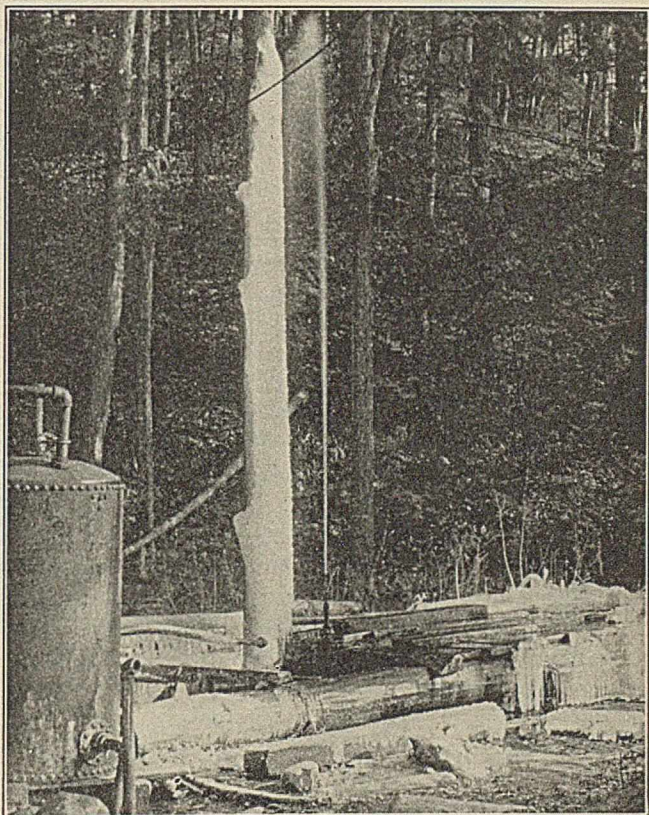
PUMP WELL NO. 4

feet into the air. The water is strongly mineralized and is charged with an abundance of gas. It is an alkaline-saline water and averages with the Hathorn No. 1.

Pump Well No. 4, formerly known as Hathorn Purchase No. 1, is situated on this same tract of land along an abandoned tail race. It was drilled in 1899 and is 350 feet deep. When this spring was first used for gas it had a large flow but it soon ceased and had to be pumped. A short time after the shutting down of the pumps of the General Carbonic Company, this well developed into a picturesque "spouter" and now gives excellent mineral water at the rate of

11 gallons per minute. The water of this spring is suitably mineralized, being of the mild saline-alkaline class and is the nearest approach to a table water of any.

During the summer of 1912 many of these waters were examined for radium and thorium. Samples of the water were collected and sent to Washington, D. C., where they were tested. The field work of the gases was performed by Dr. R. B. Moore, of the Bureau of Mines, Department of the Interior, a noted authority on radioactivity. His report will probably occur in a future bulletin by him. Sanitary analyses of these waters were made and the results showed free and albuminoid ammonia content with low nitrites and nitrates. No bacteriological examinations have yet been made.

The writer is indebted to John C. Minor, Jr., Secretary of the General Carbonic Company, for information concerning these wells. I also wish to acknowledge the assistance given by Herbert Ant, of this laboratory, who helped me in some of the analyses.

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THE PRECIPITATION OF GOLD BY MANGANOUS SALTS[1]

By A. D. BROKAW

Some interesting occurrences of gold associated with manganese dioxide led to the suspicion that manganous salts, under certain conditions, might react with solutions of gold salts to bring about a mutual precipitation: the gold in the free state and the manganese as hydrated manganese dioxide. A search for literature on such reactions was without avail, and experiments were undertaken with a view to ascertaining if such a reaction is possible, and if so, under what conditions it can take place. The reaction in question is in a sense the reverse of the series of reactions involved in the well-known "chlorination process" of extracting gold from its ores:

$$MnO_2 + 4HCl = MnCl_2 + Cl_2 + 2H_2O$$

and

$$3Cl_2 + 2Au = 2AuCl_3$$
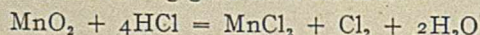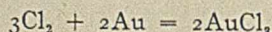
The reaction is doubtless much more complex than the summary equations, but it will be seen that a reversal of the series would lead to the formation of gold and manganese dioxide.

Auric chloride solutions of varying concentrations were mixed with solutions of manganous chloride with concentrations ranging from 0.5 N up to saturation, but no reaction was detected even when the mixture was boiled for several minutes. The addition of a very small amount of alkali to the mixtures, in the cold, caused an immediate precipitation of a dark brown mass resembling manganese dioxide in the hydrated form commonly precipitated. The precipi-

tate was collected, carefully washed to free it from the gold solution, and then treated with standard oxalic acid, containing a small amount of sulfuric acid. The solution thus obtained was divided into equal portions: one was analyzed for manganese and the other titrated for loss of oxalic acid. The results showed that for every equivalent of manganese an equivalent of oxygen had been taken up by the oxalic acid, proving the precipitate to be manganese dioxide. In a check experiment the precipitate was taken into solution with the standard oxalic-sulfuric acid mixture, which was titrated for loss of acid. The manganese in solution was then reprecipitated as hydrated manganese dioxide by a standard method, and the precipitate was again treated with the standard acid mixture. The same loss of acid as before showed the original precipitate to be manganese dioxide.

Gold was left by the solution of oxalic acid and was readily recognized as such.

Gold chloride solutions are notably acid in their reaction, due probably to hydrolysis in part, and in part to the ionization of an addition product with water. Hittorf and Salkowsky showed by electrolytic experiments that gold chloride solution is ionized as follows:

$$\overset{+}{2H} + \overset{=}{AuCl_3O}$$
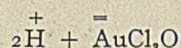
Solutions of gold chloride show marked acid properties toward indicators, and apparently the acidity thus developed is sufficient to suppress the reaction,

$$2Au^{+++} + 3Mn^{++} = 2Au + Mn^{++++}$$
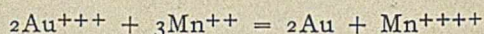
If we postulate the intermediate formation of $MnCl_4$ in minimal amounts, we are justified in assuming that the salt would be largely hydrolyzed, since tetravalent manganese is a very weak base. This hydrolysis would be suppressed by the presence of acids, but on reducing the acidity, hydrolysis might become effective, forming the very slightly soluble hydrated manganese dioxide, and with this removed from the equilibrium system by precipitation, the reaction might proceed until concentrations were diminished to equilibrium conditions.

It is of interest to note that the precipitation began long before the solutions were entirely neutralized as shown by indicator tests. This was shown in another way by placing a crystal of iceland spar in the mixture of gold and manganous chlorides in solution. A slight effervescence occurred, and after a few hours the crystal was covered with a brown coat of manganese dioxide in which flakes of gold were plainly visible. The precipitation of gold was practically complete when an excess of $MnCl_2$ was employed, though this solution had at least the acidity of saturated carbonic acid.

An interesting reaction of similar nature was found to take place between auric chloride solution and manganous carbonate. The precipitated carbonate (doubtless amorphous, in part, at least) reacts at once and is turned to the dark brown hydrated dioxide. The crystallized carbonate, that is, the mineral rhodochrosite, reacts slowly, but, after a day,
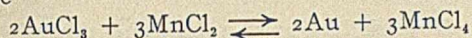
a crystal was coated with dark brown and flakes of gold were plainly discernible.

SUMMARY

If we suppose manganese tetrachloride to be an intermediate product, present only in very minute traces, we may find in it some basis of explanation. Suppose
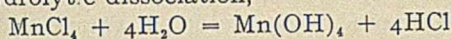
$$2AuCl_3 + 3MnCl_2 \rightleftarrows 2Au + 3MnCl_4$$

Since tetravalent manganese is an exceedingly weak base it should be little ionized, but it may be subject to two other sorts of dissociations, namely:

1. A molecular dissociation,
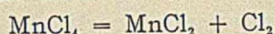
$$MnCl_4 = MnCl_2 + Cl_2$$

2. Hydrolytic dissociation,

$$MnCl_4 + 4H_2O = Mn(OH)_4 + 4HCl$$

Theoretically we should have the hydrolysis constant

$$\frac{Mn(OH)_4 \times (HCl)^4}{MnCl_4} = K$$

assuming hydrolysis according to the above equation. It is obvious that the presence of acid would tend to cut down the hydrolysis and allow the tetrachloride to become sufficiently concentrated to make its molecular dissociation appreciable—the greater the concentration of acid the greater this tendency—and we may, in this way, easily obtain conditions under which free chlorine is liberated, as in the chlorination process.

If, however, the acid concentration is reduced below a certain figure the concentration of the tetrahydroxide will reach saturation. Any further reduction of acidity must result in the precipitation of the hydrated dioxide. It will be seen that such an adjustment may be very delicate indeed—and this seems to be supported by the lack of success in preparing the tetrachloride, subject, as it would be, to both hydrolytic and molecular dissociation.

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SOLUBLE ARSENIC IN MIXTURES OF LEAD ARSENATE AND SOAP[1]

By H. V. TARTAR AND L. A. BUNDY
Received April 7, 1913

There has been some complaint from horticulturists that some difficulty was experienced in keeping arsenate of lead in suspension in water while spraying. It is claimed that the lead arsenate settles out too quickly and it is difficult to keep it stirred up. This seems to be especially true when knapsack sprayers are used. Parker[2] has suggested that a soap solution might be used to aid in keeping the arsenate of lead in suspension. Parker reported results of laboratory experiments which indicate that a soap solution keeps the arsenate of lead in suspension much better than water. He has also stated that the soap would be of value in causing the spray to spread more evenly over the surface of the leaves and, in midsummer spraying, the smooth skin of the apple.

Mr. W. H. Lawrence, Fruit Inspector of Hood River County, Oregon, advised the orchardists in

that locality to try the lead arsenate-soap mixture experimentally. The results of the experiments tried indicated that in some instances considerable injury was caused to the foliage of the trees. It was suggested that this foliage injury, which resulted apparently from the use of the spray, might be due to soluble arsenic compounds formed by the reaction of the soap with the lead arsenate. Consequently, some laboratory experiments were undertaken to ascertain the amount of soluble arsenic in mixtures of soap with the different lead arsenates. While there has never been any extensive use of the lead-arsenate soap mixture, the results obtained are of special interest in showing differences in the behavior of the arsenates.

Three samples of commercial lead arsenate were selected for the experiments. A brand which gave no test for acid arsenate ($PbHAsO_4$) when tried by Volck's test[1] was selected as a neutral (ortho) arsenate of lead [$Pb_3(AsO_4)_2$]. The other two brands were composed mostly of the acid arsenate of lead. The results of the analyses of the three brands were as follows:

	Sample Neutral arsenate Per cent	Sample Acid arsenate No. 1 Per cent	Sample Acid arsenate No. 2 Per cent
Moisture	49.51	47.82	47.39
Total arsenic oxide (As_2O_5)	10.98	15.00	16.73
Soluble arsenic oxide	0.14	0.39	0.28
Total lead oxide (PbO)	37.01	33.92	33.48
Water-soluble impurities other than arsenic oxide	1.01	0.88	0.72

Three kinds of soap were used: "Ivory," whale oil, and ordinary yellow laundry soap. The "Ivory" and the whale oil soaps did not contain any free alkali, while the yellow laundry soap contained a small amount.

The proportions of lead arsenate, soap and water which were used corresponded to those recommended for use in actual spraying practice. In each of the tests, 4.8 grams of lead arsenate, 4.8 grams of soap and 1 liter of water were used. Each sample of arsenate of lead was tried with each of the different soaps. In each instance, the soap was dissolved in about 500 cc. of water, the lead arsenate, after it had been worked up with a little water, was then added and the whole made to 1000 cc. volume. The mixtures were let stand for six hours with an occasional shaking and then filtered. The filtrates were then analyzed for their content of arsenic oxide. The determination of arsenic oxide was made by first digesting the solution with arsenic-free sulfuric acid and potassium sulfate until the solution was clear. The solution thus obtained was neutralized with sodium bicarbonate and titrated with standard iodine solution in the manner used in the modified Gooch and Browning method.[2] Great difficulty was encountered in filtering the solutions for the arsenic determinations. They filtered very slowly and it was found that a small amount of lead passed through into the filtrates.

[1] Paper presented at the Milwaukee meeting of the American Chemical Society, March, 1913.
[2] Montana Agr. Exp. Sta., Bull. 86.
[1] Science, New Series, 33, 866 (1911).
[2] Bureau of Chem., Bull. 107, Revised, p. 239.

It was difficult to ascertain if the lead was actually in solution or merely in suspension and to make the calculations for the amount of soluble arsenic on the safest basis, the lead was determined in the usual manner[1] and the amount of arsenic necessary to combine with the lead present was deducted from the total amount of arsenic found. The results obtained in this way are given in the following table:

Soluble Arsenic in Mixtures of Lead Arsenate and Soap

Material used	Grams of soluble arsenic oxide (As_2O_5)	Grams of arsenic oxide in lead arsenate used	Per cent of the arsenic oxide made soluble
Neutral (ortho) arsenate + "Ivory" soap	trace	0.527	0.00
Neutral (ortho) arsenate + whale oil soap	0.004	0.527	0.76
Neutral (ortho) arsenate + laundry soap	trace	0.527	0.00
Acid arsenate No. 1 + "Ivory" soap	0.173	0.720	24.02
Acid arsenate No. 1 + whale oil soap	0.164	0.720	22.77
Acid arsenate No. 1 + laundry soap	0.184	0.720	25.55
Acid arsenate No. 2 + "Ivory" soap	0.367	0.803	45.70
Acid arsenate No. 2 + whale oil soap	0.280	0.803	34.86
Acid arsenate No. 2 + laundry soap	0.368	0.803	45.82

These results show that in the mixtures of the soaps with the acid arsenates large amounts of arsenic are rendered soluble. The results also indicate that when a neutral (ortho) arsenate of lead is used with soap only a very small amount of arsenic is made soluble. Evidently, the use of a mixture of soap with an acid arsenate of lead for spraying purposes would be a dangerous practice, for the amount of soluble arsenic would be sufficient to badly burn the foliage of fruit trees.

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MINERALOGICAL SOIL ANALYSIS

By Wm. J. McCaughey

The problem of soil fertility and sustained crop production is a difficult one and, as Cameron[2] has pointed out, is a function of many variable factors, all of which are dependent upon each other. The importance of the chemical composition of a soil was recognized by Liebig and since then many analyses of soils have been made for the purpose of indicating the soil fertility. To explain anomalous cases it became necessary to assume that these elements exist in the soil in combinations which are available or non-available to growing plants, and many methods of analysis were proposed and used in determining the amount of these elements available. Such methods, however, are arbitrary and add little to our knowledge of the actual composition of a soil.

The greater part of a soil consists of the residuum from rock disintegration and is composed largely of the minerals constituting the original rock and secondary mineral development due to the alteration of the original minerals of the rock mass. This is more or less modified by geological agencies which bring about the transportation of some of the minerals and the admixture of still other material. It has been the experience of practical soil men that too little is known of the actual composition of soils. A soil examination consists usually in the mechanical analysis which tells only the composition in terms of the size of the soil grains regardless of their nature, and in the determination of the so-called plant foods which are soluble in constant boiling point hydrochloric acid.

Very little work has been done upon the mineralogical composition of soils, though it is obvious that differences in mineral composition will affect their physical and chemical properties. Mitscherlich has indicated that not only the size of the particles has a great influence upon the physical properties of a soil but also the shape of the particles, that is, the amount and *kind* of surface exposed. The recent development in the application of petrographic methods to the study of minerals in fine powder has furnished a valuable and fruitful method for soil work. The microscopic study of minerals has been developed around and practically confined to the study of igneous and metamorphic rocks. Little work has been found in the geological literature to indicate that such examinations have been made on soils. The most important of such examinations have been made by Sorby,[1] Retgers,[2] Schroeder Van der Kolk[3] and Delage and Lagatu.[4]

The chemical and mineralogical study of soil formation and of rock weathering has received more attention from geologists than pure soil work. Mineralogical compositions of wind-blown dusts have been published from time to time. The first attempt to systematically apply petrographic methods for the mineralogical examination of soils was made in 1889 by Steinriede. Since then little work has been done along these lines except by Delage and Lagatu.

The mineralogical composition of a soil bears somewhat the same relation to the chemical analysis of a soil as the petrographic examination of a rock does to its chemical analysis. They each supplement each other. The chemical analysis does not reveal the nature of the chemical elements as they are found in the soil. The mineralogical examination on the other hand is concerned chiefly with the determination of the chemical compounds in which the elements are combined. Should more definite knowledge of the reaction of these minerals toward water be known, a mineralogical examination would be of greater value in determining the chemical properties of a soil. An approximation to the availability of these elements could then be known from their mineralogical combinations. Fortunately from the observation of the chemical alteration of these minerals in the soil a mineralogical examination offers, at least, a comparative estimate of the availability of

[1] Bureau of Chem., *Bull.* **107**, Revised, p. 239.
[2] "The Soil Solution," Easton, Pa. (1911).

[1] "Microscopical Examination and Determination of Minerals in Sands and Clays," *Quart. J. Geol. Soc.*, **1880**, 50.
[2] "Mineral and Chemical Investigation of the Dune Sands of Holland," *Neues Jahrb. fur. Min.* **1**, 16–74 (1895).
[3] "Mineral Composition of Holland Sands," *Der Wandelungen der k. Akad. von Wettenschappen*, **1895**, *et seq.*
[4] "Constitution of Montpelier Soils," *Ann. de Lecols Nationale de Montpelier*, **4**, 200–2 (1905).

these chemical elements in the different minerals.

The presence, in the soil, of certain minerals offers a clue to the identification of the rocks from which the soils were derived. Rocks are often not only characterized by the presence of certain minerals but often by peculiar characteristics in the minerals themselves, as to inclusions, elongation, undulatory extinction, etc., which are preserved in the soil grains themselves. In other words, the physical appearances and characteristics of the minerals are often distinctive enough to indicate their source, as the localities of megascopic specimens are often indicated by peculiarities in habit. Another advantage offered by the mineralogical examination of soils lies in the readiness with which such examinations can be made, the approximation of the chemical composition of soil and, in the latter case, the cheapness of this method of examination where a high degree of accuracy is not necessary. The mineralogical analysis should be of considerable value in the geological mapping of soils as to their origin, etc. In the mineralogical examination of a soil, admixture of soil material is indicated by the differences in the degree of chemical alteration of certain of the minerals, namely, orthoclase and biotite, or by differences in the contour of the mineral grains, notably quartz.

The four common potash-containing minerals found in soils in their order of potash content are: orthoclase, 16.9; microcline, 16.9; muscovite, 10.0; biotite, 9.0. Of these biotite is the one most readily decomposed under soil conditions, due probably to the effect of the iron oxide contained in the molecule. It is perhaps the potash mineral in which the potash is most available. The common potash mineral present in soils is orthoclase, and it is generally present in considerable amounts (3 to 30 per cent). It suffers decomposition less readily than biotite and is perhaps after biotite the mineral which furnishes the potash more readily, in maintaining the concentration of the soil solution.

Muscovite, the potash mica, is quite resistant to chemical disintegration and generally occurs in soils in unaltered fragments which would seem to indicate that this mineral does not materially contribute to the soil solution at least during the presence of biotite and orthoclase. This fact is more or less consistent with the experiments of Johnstone, who found that after one year's treatment with water carrying carbon dioxide, muscovite remained unaltered. Microcline, the triclinic potash feldspar, is very resistant to chemical decomposition and is found in the leached sands of the Coastal plain with the insoluble minerals —quartz, tourmaline, zircon, rutile, etc. It is questionable indeed if this mineral is of great value in the keeping up of the "normal" concentration of potash in the soil solution.

Apatite found in soils has invariably proven to be the fluorapatite and generally is found in slightly rounded prisms with very low birefringence. It is also found in tiny needles as inclusions in quartz and other minerals. At this time attention might be directed to an error in judgment which might be quite easily committed in mistaking epidote on the basal pinacoid for prismatic apatite. These both have low birefringence, parallel extinction, and negative elongation. The epidote may be quite readily distinguished by tapping the cover glass until the mineral rotates about its axis of elongation. If the mineral is epidote, the birefringence will be much higher in this new orientation and the elongation positive. No change takes place in the case of apatite. Complete chemical analysis often shows phosphoric acid which is not available for the maintenance of the concentration of phosphoric acid in the soil solution since these grains are totally imbedded in quartz. There is probably a difference in the rate of solution of chlor and fluorapatites since the latter is the one found in soils. Chlorapatite when found does not show the clear cut appearance of the fluorapatite. These two are distinguished by differences in refractive indices.

Of the calcium minerals, epidote, hornblende, plagioclase and garnet seem to be the commoner ones. Of these minerals, the feldspars are the more available for the maintenance of the "normal" concentration of the soil solution. Hornblende seems to be the next available calcium mineral and then garnet and then epidote. Epidote is a normal constituent of most soils and is present in large, thick grains. Garnet being formed generally by contact metamorphism, is more or less restricted in its occurrence. Hornblende is the common calcium mineral and weathers generally forming chlorite, a magnesium aluminum silicate. In general in soils from the humid regions, even in those derived from limestone the absence of calcite is noteworthy.

In soils derived from limestone, small quartz crystals are so frequently found and so exceptional in other soils that their presence in soils would seem to indicate origin from limestone. The absence of pyroxene as a soil-forming mineral is noteworthy.

Especial attention should be directed to the phytolitharien sponge spicules, diatoms, rhizopoda casts found in some soils. These plant or animal remains indicate, by their presence, low submergence and swamp conditions which have been responsible for the mineralogical depletion of certain soil types. These organisms are of geological importance in the indication of conditions through which the soil has passed. Each of these organisms demand a particular environment for their growth, and their presence in a soil in large numbers indicates this particular condition at least during their time of flourishing. In this matter see Ehrenburg's ' Mikrogeologie."

It may be said that as a general proposition the mineralogical composition of the silts in minerals other than quartz is much higher than in the sand separates, though as a rule, and especially is this so in loam and clay soils, the silt grains are not nearly as well preserved as in the sand separates. It would seem that the smaller the grain the greater the decomposition. It is reasonable to assume that the concentration of the soil solution will vary with the

mineral composition, as each of the minerals probably possesses a distinctive reaction toward water. The concentration of the soil solution will be determined, in general, by the minerals possessing the greater velocity of solution or decomposition. The minerals which furnish the plant food in the soil have their origin in igneous rocks or metamorphic rocks, and it is hardly likely that the reactions occurring in the soil by which the elements pass into solution are reversible; therefore, it is not likely that the soil solution will be of constant composition. These easily soluble or decomposable minerals will furnish the necessary elements to maintain the concentration of the soil solution. There would then be a tendency toward the survival of the more insoluble or the difficultly decomposable minerals which in time would be called upon to furnish the necessary "plant food."

Another factor of importance in considering variation in concentration of the soil solution, is the recovery rate, that is, the time required to attain the normal concentration in the soil solution after rainfall. The rate of recovery will depend not only on the nature of the minerals composing the soil but also upon the percentage composition of the more soluble or easily decomposable minerals. In soils composed of the same minerals that soil which has the greater proportion of the more soluble or easily decomposable minerals will have the quicker recovery to the normal concentration after rainfall. In other words availability as applied to unfertilized soils may be expressed by the mineral composition of the soil and the rate of recovery expressed by the percentage composition in easily soluble or decomposable minerals.

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ON THE INFLUENCE OF THE LIME-MAGNESIA RATIO

By P. L. GILE AND C. N. AGETON

In a recent number of THIS JOURNAL (Vol. 5, No. 1, p. 33) attention was called to the fact that certain Porto Rican soils which are exceptionally productive for citrus trees, pineapples and sugar cane, have exceedingly wide ratios of lime to magnesia. It was pointed out that if Loew's hypothesis of the lime-magnesia ratio holds true for soil conditions, and if this ratio really is a controlling factor in fertility, then those soils with exceptionally wide ratios certainly should not be more than ordinarily productive, and if they are very productive it is evidence of the untenability of Loew's hypothesis.

Loew in commenting on these facts[1] holds that they do not constitute evidence against his theory, since citrus fruit and pineapples "are but other examples of apparent exceptions in regard to the lime-factor. Such exceptions are the lime-loving plants, e. g., the grapevine, as the writer has pointed out repeatedly. These plants are capable of precipitating, as oxalate, the excess of lime carried into the plant by the transpiration process." He further states: "Thus a properly working ratio of lime to magnesia is secured in the cells when the plants grow on soils

[1] THIS JOURNAL, **5**, No. 3, 257.

rich in lime * * * * Hence the view, that the favorable development of these plants on soils very rich in lime and poor in magnesia would be a proof against the influence of a certain ratio of lime to magnesia in soils upon other plants which do not produce oxalates, is not tenable."

It is certainly not our opinion that what holds true for one species of plant necessarily holds true for all plants. But according to our understanding of the hypothesis as Loew has enunciated it, all higher plants are affected by the lime-factor, although lime-loving plants have a higher optimum ratio than others.[1]

Now, pineapples cannot be excepted from the influence of the lime-factor (if such influence exists) on the ground that they are lime-loving plants, for field observations and direct experiments have shown that *pineapples are, on the contrary, strongly calcifuge or "kalkfeindlich."* The intolerance of pineapples for calcareous soils was pointed out in 1911 by one of us in *Bulletin* **11** of this Station. In this bulletin are detailed observations in Porto Rico and other countries, also direct experiments which show that pineapples cannot endure much carbonate of lime in the soil unless a large amount of organic matter is also present.[2]

While citrus trees are not calcifuge, observations in Porto Rico at least would not lead one to classify them as lime-loving. To the knowledge of the writers there have been no direct experiments nor studies showing the tolerance of citrus trees for large amounts of lime in the soil. It is certain, however, that citrus trees in California planted on land with marly subsoils are affected with nutritional disturbances,[3] which would hardly lead one to believe that they are especially lime-loving.

In regard to the formation of oxalates, pineapples cannot be considered peculiar, since the occurrence of oxalates in plant cells is now known to be very common. Kohl states: "Dasselbe [Calciumoxalat] ist in allen Pflanzenorganen und Geweben gefunden worden."[4] In regard to its distribution in plants in general, Coulter, Barnes and Cowles state: "Calcium oxalate is found in every large group of plants except bryophytes."[5] Euler states: "Tritt die Oxalsaure sowohl in niederen als besonders in hoheren Pflanzen sehr häufig auf."[6] Even in the grasses where

[1] Loew, *Landw. Yahrb.*, **1902**, 563, states: "Freilich können viele Pflanzen durch Niederschlagung eines Teiles des aufgenommenen Kalks als Calciumoxalat den Ueberschuss des glösten Kalks unwirksam machen und dadurch des normale Funktionieren im Gange halten. Aber dieser durch Anpassung erworbene Fähigakeit ist eben auch nur eine begrenzte." From this statement one would certainly suppose that the limit of toleration of plants forming oxalates for an unfavorable lime factor would be transcended at a lower ratio than 24/1 to 500/1.

[2] By consulting the data in this bulletin it can be seen that pineapples cannot be called "lime-loving," on account of their growth on soils rich in carbonate of lime (the sense in which this term is usually used), nor on account of the amount of lime which is present in the ash of the plant. Also pineapples thrive on soils which are very poor in lime; see Miller and Hume, Florida Station, *Bull.* **68**.

[3] Hilgard, California Sta., *Circ.* **27.**

[4] F. G. Kohl, "Anatomish-physiologische Untersuchung der Kalksalze und Kieselsaure in der Pflanzen" (1889), cited from *Yahresb. u. d. Agrichemie*, **1889**, 121.

[5] Coulter, Barnes and Cowles, "A Textbook of Botany," **1910;** also see Czapek, "Biochemie der Pflanzen," **1905**, Vol. II, pp. 417–420.

[6] H. Euler, "Grund. u. Ergeb. d. Pflanzenchemie," **1908**, Vol. I, p. 16.

oxalates were supposed to occur very seldom, Montverde has found crystals of calcium oxalate quite widely distributed: of 550 species from 94 families, oxalates were found in 162 species from 92 families.[1] In maize, which Loew states grows best at the lime factor of 2 : 1, Benecke has found calcium oxalate.[2]

The evidence we have offered concerning the untenability of Loew's hypothesis for ordinary soil conditions can hardly be disregarded, then, on the grounds assumed by Loew, since pineapples and citrus trees are not lime-loving plants, nor is the property of forming oxalates peculiar to a few plants.

We also pointed out that a soil where the ratio of lime to magnesia varied from 24/1 to 1461/1 gave an average yield of 60 tons of sugar cane (variety Christalina) last year. The yield obtained is exceptional for Porto Rico and very good for any country. The fact that this soil with an exceptionally wide ratio of lime to magnesia is more than ordinarily productive we take to be further proof that Loew's hypothesis does not hold for ordinary soil conditions.

Loew objects that tankage or cottonseed meal might have been used on this soil as a fertilizer in which case the sugar cane would become almost independent of the lime-factor in the soil, because of the lime and magnesia contained in the fertilizer "in an easily available form." This field in some years has been fertilized with a complete fertilizer at the rate of about 500 lbs. per acre, and we are under the impression that tankage, cottonseed meal and certainly barnyard manure have never been used here. If, however, 500 lbs. of tankage per acre had been applied to the soil in question we fail to see how this application could materially influence the effect of the lime-magnesia ratio if the ratio has any such potent action as Loew in previous articles has attributed to it.

The analyses (given in the previous article) show this soil to contain from 1,044,400 to 1,287,600 lbs. of CaO in the form of carbonate in an acre foot and from 800 to 62,400 lbs. of MgO.[3] From experiments in Japan, Loew concludes that magnesium sulfate is about ten times as effective as the natural magnesium carbonate in counteracting an excess of lime.[4] On this basis, something like 1,000,000 lbs. of magnesium carbonate or 100,000 lbs. of magnesium sulfate per acre would be required to effect the proper ratio. How, then, can the magnesium contained in an ordinary application of tankage or cottonseed meal balance an excess of a million pounds of lime per acre? If it can balance this excess, of what significance is the determination of the original lime-magnesia ratio in the soil?

According to the hypothesis of the lime-magnesia ratio, the injury to plant growth arising from excessive ratios of lime to magnesia *in the soil* is caused by an undue preponderance of lime *in the plant cell.* By the law of mass action the lime, displacing the magnesium, combines with the phosphoric acid in the cell, preventing the assimilation of phosphoric acid and the

plant suffers from phosphorus starvation. Some plants, however, are partially independent of unfavorable ratios in the soil, since they have the power of precipitating an excess of lime as oxalate and so the balance between the "physiologically active" lime and magnesia in the plant cell is maintained. This hypothesis assumes, then, that the amount of lime and magnesia absorbed by the plant is affected more or less by the ratio in which these bases exist in the soil, otherwise how could the injury take place in the plant cell?

Certain results which we have secured in the study of another problem are interesting in connection with this hypothesis. In the course of this work the growth of bush beans (variety Improved Golden Wax) was compared on a soil containing varying amounts of calcium carbonate. The plants were grown in plots which were 10 × 20 ft. in area and 2 ft. deep. The plots were equally and liberally fertilized from time to time so that the plants received sufficient nitrogen, potash and phosphoric acid in all the plots, acid phosphate, sodium nitrate and high-grade sulfate, or muriate of potash being used. There were four plots: Plot I contained the soil with no addition of carbonate of lime, Plot II approximately 4 per cent $CaCO_3$, Plot III 15 per cent $CaCO_3$, and Plot IV 30 per cent $CaCO_3$. The plants were here grown under perfectly normal conditions of root space, moisture conditions, etc.

Table I gives the amount of lime and magnesia in the fine earth soluble in hydrochloric acid of sp. gr. 1.115,[1] also the carbonate content in the four plots.

TABLE I

Plot no.	I Per cent	II Per cent	III Per cent	IV Per cent
CaO......	1.03	4.06	10.90	21.24
MgO......	1.37	1.65	0.79	1.51
CO₂......	0.00	2.18	7.84	15.35

The ratios of lime to magnesia in Plots I to IV were, then, 0.8, 2.5, 13.8 and 14.1 to 1. Loew gives 3 : 1 as the lime factor most favorable for leguminous plants so we should expect the best growth of plants in Plot II and a depression of growth in Plots I, III and IV, if the lime-factor exerts much influence on the growth.

Six crops of beans, namely, Series A, B, C, D, E, and F were grown at different times in the course of three years. In Series A the beans were allowed to mature and their weight obtained. The plants in Series B, C, D, E and F were harvested when the plants were in bloom and had attained their maximum growth without any of the leaves being withered. Samples of these crops were preserved for an ash analysis. In Table II are given the absolute weight of the different crops from the four plots and also the relative yields, calling the yield of Plot I equivalent to 100.

It can be seen that bush beans seemed to do slightly better with increasing amounts of carbonate of lime in the soil, and that the growth on the soil with the lime factor 14 was equal to, or a little better than that made on the soil with the lime-factor 2.5. According

[1] N. A. Montverde, *Botanisches Centralblatt*, **43**, 327.
[2] W. Benecke, *Botanische Zeitung*, **61**, 79 (1903).
[3] Using 4,000,000 lbs. as the weight of an acre foot of soil.
[4] Loew, *Landw. Yahrb.*, **42**, No. 1, 190.

[1] This is practically the method prescribed by Loew for determining the lime-magnesia ratio in the soil. *Landw. Yahrb.*, **1906**, 537.

TABLE II—GROWTH OF BUSH BEANS ON SOIL WITH DIFFERENT AMOUNTS OF LIME

Number of plot	I	II	III	IV
Ratio CaO/MgO in soil	0.8	2.5	13.8	14.1
Weight, seeds from 80 plants, in grams, Series A	.127	123	....	157
Weight, 99 whole plants, in grams, Series B	2086	1913	2112	2855
Weight, 63 whole plants, in grams, Series C	455	510	557	660
Weight, 61 whole plants, in grams, Series D	753	1035	953	954
Weight, 64 whole plants, in grams, Series E	670	740	690	615
Weight, 32 whole plants, in grams, Series F	777	776	695	637
Total weight in grams of Series B to F	4741	4974	5007	5721
Relative yields calling that of Plot I = 100, Series A	100	97	...	124
Relative yields calling that of Plot I = 100, Series B	100	92	101	137
Relative yields calling that of Plot I = 100, Series C	100	112	123	145
Relative yields calling that of Plot I = 100, Series D	100	138	127	127
Relative yields calling that of Plot I = 100, Series E	100	110	103	92
Relative yields calling that of Plot I = 100, Series F	100	100	96	82
Average of relative yields, Series B to F	100	110±3.4	109±4.8	117±8

to the hypothesis of the lime-magnesia ratio, the bush beans grown on the soils with the high percentages of lime and unfavorable lime-factors should contain more lime than the plants grown on the soils with less lime and more favorable lime-factors, although if the growth is unaffected, the plants grown on the soils with the high lime-factors might remove part of the absorbed lime from participating in the physiological processes of the plant by precipitation as oxalate.

The degree to which the varying amounts of lime in the soil has affected the ash composition and quantity of the elements in the dry substance of the plant is better shown in Table IV. Here the amounts of the different elements present in the plants grown in Plot I are given as 100 and the amounts present in the plants grown on Plots II, III and IV are expressed relative to 100. To save space the average, only, of crops B, D and F are given. In calculating the average twice the value was given to the analysis of crops D and F that was given to the analysis of crop B, so the average gives an equal value to each crop grown.

TABLE IV—RELATIVE ASH COMPOSITION OF PLANTS FROM DIFFERENT PLOTS

	Relative composition of ash of plants from different plots. Plot I = 100				Relative amount of elements in dry substance of plants from different plots. Plot I = 100			
Plants from plot	I	II	III	IV	I	II	III	IV
Ratio CaO/MgO in soil	0.8	2.5	13.8	14.1	0.8	2.5	13.8	14.1
Carbon-free ash	..	..	..	..	100	103	101	108
CaO	100	97	97	93	100	100	99	100
MgO	100	107	98	86	100	109	99	93
P_2O_5	100	98	99	93	100	100	100	99
K_2O	100	94	104	104	100	99	106	112
Fe_2O_3	100	81	73	64	100	86	77	72
SiO_2	100	102	89	79	100	105	90	85
N	..	..	..	..	100	94	98	98

It can be seen from Table IV that the percentage of lime in the ash and in the dry substance of the plant is practically constant, irrespective of the amount of lime in the soil where the plants were grown. The same is true of the magnesia, except the results are not quite so uniform.

The degree to which the lime-magnesia ratio in the

TABLE III—ANALYSES OF BUSH BEANS (WHOLE PLANT), GROWN ON SOILS WITH DIFFERENT AMOUNTS OF LIME

	Analysis of carbon-free ash								Ash constituents in dry substance of plant							
	Series B				Series D and F				Series B				Series D and F			
Plants from plot	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Ratio CaO/MgO in soil	0.8	2.5	13.8	14.1	0.8	2.5	13.8	14.1	0.8	2.5	13.8	14.1	0.8	2.5	13.8	14.1
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Carbon-free ash	....	....	....	....	....	....	....	....	10.62	11.48	11.63	12.05	11.20	11.20	10.82	11.73
CaO	35.54	29.95	26.02	28.53	25.91	26.82	28.12	25.57	3.78	3.44	3.02	3.44	2.90	3.01	3.04	3.00
MgO	10.84	12.31	11.15	10.03	7.67	7.90	7.28	6.30	1.15	1.41	1.30	1.21	0.86	0.89	0.79	0.74
P_2O_5	8.14	7.39	7.16	7.02	8.27	8.36	8.67	7.94	0.86	0.85	0.83	0.84	0.93	0.94	0.94	0.93
K_2O	32.98	32.38	31.82	34.45	33.82	31.85	36.82	35.19	3.51	3.72	3.70	4.14	3.78	3.58	4.00	4.13
Fe_2O_3	1.54	1.44	1.22	0.99	1.28	0.96	0.88	0.82	0.16	0.16	0.14	0.12	0.14	0.11	0.10	0.10
SiO_2	12.05	12.85	10.80	8.63	10.11	10.08	8.97	8.38	1.28	1.47	1.26	1.04	1.13	1.13	0.97	0.98
N	....	....	....	....	....	....	....	....	4.03	3.62	3.58	3.76	3.77	3.85	3.62	3.76

In other words, the plants grown on all four soils might contain the same amount of "active or physiological" lime, but those grown in Plots III and IV where the lime factor is 14 should contain in addition considerable calcium precipitated as oxalate. It will be seen that the following analyses do not bear out such an assumption.

In Table III are given the analyses of the beans (cut in bloom) from the four soils, using the whole plant for analysis except the roots. Crop B was analyzed alone, Crops D and F were analyzed together, using a composite sample composed of equal parts of crops D and F. The percentages of the different elements in the ash and the percentages in the oven-dry substance of the plant are given.

plant corresponds to the lime-magnesia ratio in the soil is shown in Table V.

TABLE V

Plot No.	I	II	III	IV
Ratio CaO/MgO in soil	0.8	2.5	13.8	14.1
Ratio CaO/MgO in the plant	3.35	3.08	3.36	3.66

Thus the lime-magnesia ratio in this plant bore no relation to the lime-magnesia ratio in the soil.

Now, bush beans appear to be independent of the lime-magnesia ratio in these soils and also of the increasing amounts of carbonate of lime. This result, of course, does not apply to all plants but it stands for one plant at least, and probably a certain number of plants. Since the lime content of the plants remained constant with increasing amounts of lime in the soil

it does not seem possible that this plant could have adapted itself to the conditions by precipitation of lime as oxalate. It does seem that the independence of the plant to these soil conditions is due to the regulatory power of the root cells in the absorption of nutrients.

While we believe that ratios of different salts, including lime and magnesia, affect plant growth under certain conditions, it does not seem, with our imperfect means of determining the soil nutrients available to or affecting the plant, that the hypothesis of the lime-magnesia ratio should be considered as applying to all soil conditions. Moreover, work on balanced solutions and the regulatory power of plant cells in the absorption of nutrients would seem to indicate that the whole subject is more complicated than was supposed when Loew formulated his hypothesis.

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A SIMPLE METHOD FOR PREPARING NEUTRAL AMMONIUM CITRATE SOLUTION

By A. J. Patten and W. C. Marti
Received April 9, 1913

The necessity of having a strictly neutral solution of ammonium citrate for the determination of available phosphoric acid in fertilizers is recognized by every fertilizer chemist. Methods for preparing such a solution have been discussed by the Association of Official Agricultural Chemists and investigated by many of its referees on phosphoric acid. This subject has also been studied by the Division of Fertilizer Chemists of the American Chemical Society, but to-day there are almost as many methods in use as there are laboratories doing fertilizer work.

Some chemists are still using the corallin method, some the alcoholic calcium chlorid method, some the azolitmin method proposed by Hand[1] and still others use a slight excess of ammonium hydroxid and depend upon the volatilization of the ammonia, upon long standing, to make the solution neutral.

McCandless,[2] when referee on phosphoric acid for the Association of Official Agricultural Chemists in 1908, compared solutions of ammonium citrate made by different chemists. In nine different solutions the ratio of ammonia to anhydrous citric acid was found, by analysis, to vary from 1 : 3.775 to 1 : 4.189. Doctor McCandless commented upon the unreliability of the methods then in use and closed his report with the following words: "While the referee has a strong conviction that the only proper method of making the solution is by analysis and calculation of the exact quantity of ammonia or citric acid to be added to it, still he hesitates to urge it officially, as no work has yet been done by any other referee along this line, and because the referee is himself no longer an official chemist."

Somewhat later the Fertilizer Division of the American Chemical Society proposed that the ratio of ammonia to citric acid should be 1 : 4.25. Such a solution, however, would be distinctly acid and would give higher results for available phosphoric acid than

a solution having the ratio of the tri-ammonium salt.

More recently a method based upon the change in electrical conductivity of a solution as it changes from an acid to an alkaline reaction was proposed by Hall and Bell[1] and later by Patten and Robinson.[2] This method gives satisfactory results and is not difficult of operation, but owing to the expensive apparatus required or for other reasons it has not been generally adopted. Later Bell and Cowell[3] proposed two methods for preparing neutral ammonium citrate solutions but they present difficulties of manipulation that will undoubtedly militate against their general acceptance. There is still, therefore, the need of a method that will be simple, easy of manipulation, rapid and accurate and that does not call for unusual or expensive apparatus.

The method to be proposed fulfills these requirements and is based upon the work of Schiff[4] who found that ammonia unites with formaldehyde to form hexamethylentetramin according to the following equation:

$$4NH_3 + 6CH_2O = N(CH_2.N.CH_2)_3 + 6H_2O$$
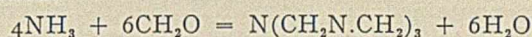
Schiff also found that the same reaction takes place between salts of ammonia and formaldehyde and that the acid may then be titrated with a standard solution of sodium or potassium hydroxid, using phenolphthalein as indicator. Herstein[5] made use of this reaction as a means of testing the purity of ammonium salts, and states that it gives satisfactory results with ammonium chlorid, bromid, iodid, fluorid, sulfate, acetate, oxalate, citrate, thiocyanate and molybdate.

The method as adopted by us is called the "titration method" and is essentially as follows: Fifty cc. of a citrate solution are carefully measured into a 250 cc. flask, made up to the mark with water and thoroughly shaken. Five cc. of the diluted solution are then measured (preferably by means of a burette) into a beaker, 4 cc. of a perfectly neutral 40 per cent solution of formaldehyde added and titrated with $N/10$ NaOH, using phenolphthalein as indicator. The pink color should remain after the solution is brought to boiling. The ammonia is determined in 5 cc. of the diluted solution in the usual manner by distilling with magnesia. The difference between the acid and ammonia titration gives the number of cubic centimeters of $N/10$ NH_3 required to neutralize 1 cc. of the acid citrate solution, from which the amount of a stronger solution of NH_4OH required to neutralize any given amount of the acid solution may be easily calculated.

The titration method was first tried out by us on a solution of ammonium citrate made neutral by the conductivity method and the ratio of ammonia to anhydrous citric acid was found to be 1 : 3.765, the same as for triammonium citrate. We then compared the titration method with the conductivity method for preparing neutral solutions. For this purpose a stock solution of citric acid was nearly neutralized

[1] Bur. of Chem., U. S. Dept. of Agr., *Bull.* **132**, 11.
[2] *Ibid.*, **122**, 147.

[1] *J. Am. Chem. Soc.*, **33**, 711 (1911).
[2] This Journal, **4**, 443 (1912).
[3] *J. Am. Chem. Soc.*, **35**, 49 (1913).
[4] *Liebig's Annalen*, **319**, 76 (1901).
[5] Bur. of Chem., U. S. Dept. Agr., *Bull.* **150**, 47.

with ammonium hydroxid, being careful to keep the specific gravity above 1.09. By the conductivity method it was found that 25.9 cc. of a 5 per cent solution of ammonium hydroxid were required to neutralize 1000 cc. of the solution and by the titration method 25.95 cc. were required. With another citrate solution 35.4 cc. of a 5 per cent solution of ammonium hydroxid were required per liter by the conductivity method and 35.6 cc. by the titration method.

We next determined by the titration method the amount of citric acid and ammonia contained in one liter of a strictly neutral solution of ammonium citrate, of exactly 1.09 specific gravity, with the following results:

> 1 cc. citrate sol. gave 26.34 cc. $N/10$ NH_3
> 1 cc. citrate sol. gave 26.33 cc. $N/10$ $C_6H_8O_7$
> > equivalent to 44.76 grams NH_3 per liter
> > equivalent to 168.57 grams $C_6H_8O_7$ per liter
> > Ratio of NH_3 to $C_6H_8O_7$, = 1 : 3.766.

The three solutions claimed to be neutral by Mc-Candless contained 44.3 grams NH_3 and 168.76 grams $C_6H_8O_7$ per liter, the ratio being 1 : 3.809. The results obtained by us conclusively prove that such a solution would be slightly acid, which fact is further substantiated by the ratio of ammonia to anhydrous citric acid being too wide.

SUMMARY

The titration method of preparing neutral ammonium citrate solutions is accurate and easy of manipulation.

It establishes beyond a doubt that the ratio of ammonia to anhydrous citric acid in the neutral solution should be 1 : 3.765 and that one liter of 1.09 specific gravity should contain 44.76 grams NH_3 and 168.57 grams $C_6H_8O_7$.

The titration method affords a simple means of comparing ammonium citrate solutions made in different laboratories.

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THE FLUIDITY OF BUTTER FAT AND ITS SUBSTITUTES

By GEORGE F. WHITE AND RALPH H. TWINING

The study of the viscosities of butter fat and oleomargarine as a problem of more or less interest, has already been taken up by several investigators with different methods of approach and different types of viscosimeters. Wender[1] worked with an instrument of the Ostwald class, modified so that, according to his statement, it could be cleaned with greater speed and ease. The Reichert-Meissl number of each sample was taken as a measure of purity. The fats were dissolved in chloroform, the viscosity of the solvent being taken into consideration. Wender found that the viscosity of oleomargarine was always greater than that of butter and with both decreased with rise in temperature, but did not change on standing for a considerable length of time. Further, although the viscosities of the butter fats were fairly constant, there were appreciable differences in the margarines from different sources. The amount of mar-

garine added could be approximately determined.

Killing[1] contributed nothing new in his study of the viscosities of butter and other fats, and his apparatus was so crude that no advance was made.

Raffo and Foresti,[2] in an article on a "New Method for the Determination of Margarine in Butter," describe results obtained by an Ostwald instrument. They used butter from two sources and took the viscosities at 50° C. of the fats obtained by melting and filtering from curd and water. The time of flow was found to increase as the percentage of oleo fat increased, different samples giving concordant results. Their data indicate roughly that the viscosity is some function of the composition, but what particular function is not stated.

It is evident that any connection between the viscosity and the composition of butter fats, if it exists, has not been clearly and definitely established. A study of this important relation should therefore reveal by the use of accurate methods of analysis, results of especial value and interest. It is our purpose in this article to present the results of a series of viscosity measurements of various butter and oleomargarine samples, and of mixtures of these of known composition. By utilizing a viscosimeter which enabled us to express viscosities in absolute units, a definite standard of comparison may be adopted. Such measurements are entirely independent of the apparatus employed, and the "times of flow," which are recorded in so many works of this nature and which mean nothing to anyone else than the observer and his particular viscosimeter, do not need to be considered.

We prepared our samples, obtained from various sources, by melting at the lowest possible temperature and allowing to stand for two or three hours in that condition. The curd and water settled to the bottom leaving the clear supernatant fat which was decanted through a filter. The following constants were taken: the iodine number which shows the amount of unsaturated acids present, the saponification number, the percentage of soluble and insoluble acids, the volatile acids, the densities at 40°, 65°, and 90° C., and the viscosities at intervals of 10° from 40° to 90° C. These constants, while by no means representing a complete analysis, give a very definite idea of the purity and the composition of the fat examined.

The iodine number was obtained by treating about one-half a gram of fat with 50 cc. of Hübl's solution (mercuric chloride and iodine in alcohol), and titrating the remaining iodine with sodium thiosulfate solution after three hours' standing to ensure complete absorption. The number is expressed in the percentage of iodine absorbed, i. e., the number of grams of iodine taken up by 100 grams of fat.

The saponification was carried out with an alcoholic potassium hydroxide solution, the mixture being heated on the water bath with a reflux condenser for thirty minutes, and the excess alkali then titrated with half-normal hydrochloric acid. The saponification (Koettstorfer) number is expressed as milligrams

[1] J. Am. Chem. Soc., 17, 719 (1895).

[1] Z. angew. Chem., 1894, 643; 1895, 102. J. Soc. Chem. Ind., 1895, 198.
[2] Gazz. chim. ital., 39, 441 (1911).

of potassium hydroxide required to saponify 1 gram of fat. After the titration, 1 cc. exceeding the exact amount of half normal hydrochloric acid necessary to free the fatty acids was added. The insoluble acids, after cooling, were washed free from the soluble acids and the latter titrated with decinormal alkali, the result being calculated as per cent butyric acid. The cake of insoluble acids was dried and weighed and the per cent calculated.

To obtain the Reichert-Meissl number, which is perhaps the most important of these constants, about 5 grams of fat were saponified by heating under pressure with caustic soda and 95 per cent alcohol. Sulfuric acid in sufficient amount to free the fatty acids was added and the whole again heated under pressure. The flask was then connected with a condenser, the volatile acids distilled off, and an aliquot portion titrated with decinormal alkali after filtering. The result signifies the number of cubic centimeters of decinormal potassium hydroxide solution required to neutralize the volatile acids obtained from 5 grams of fat.

The densities of the samples were taken in an ordinary Ostwald pycnometer, comparison being made with the density of water at 4° C.

Of particular interest to us in our study of the viscosity of these very viscous liquids is the work of Scarpa,[1] who, discerning the sources of error in the viscosimeters of various types, devised one of very great accuracy and which was capable of wide application. In his instrument there was a capillary tube from 5 to 10 cm. long and about 0.2 mm. inside diameter. The lower end of the vertical capillary dipped into a test tube containing oil; the upper end was joined to a series of bulbs of varying volume. At the top it was connected to an apparatus for maintaining reduced pressure, and also with a manometer. The whole was put under diminished pressure and the liquid drawn up to fill one or more of the bulbs, the amount so drawn through the capillary depending on the viscosity. The time t_1 was observed. By use of one or more bulbs the times of flow of liquids of very different viscosities were not widely divergent. The liquid was next allowed to flow back under its own weight and atmospheric pressure, taking the time t_2. The viscosity is proportional to the ratio $t_1 t_2/(t_1 + t_2)$. The constant of proportionality is dependent neither upon the surface tension nor the quantity of the liquid. A characteristic value for the proportionality constant could be obtained by using the instrument under the same reduced pressure. By determining $t_1 t_2/(t_1 + t_2)$ with the same quantity of liquid at the same temperature, relative results could be obtained. Values obtained by the Scarpa and Engler instruments were very widely divergent, the former being by far the more consistent, especially with very viscous oils.

While Scarpa's viscosimeter is evidently one of considerable efficiency, we believe that the instrument described by one of us,[2] and which has been applied to a study of various liquids,[3] presents to a greater degree the advantage of facility of manipulation combined with great accuracy. As do the viscosimeters of Thorpe and Rodger,[1] and Bingham and White,[2] it gives viscosity results in absolute units which are corrected for the gain in kinetic energy involved in the flow of the liquid through the capillary tube. By its symmetrical shape there is only a small correction to the pressure as measured in the manometer. Finally, by varying the pressure, fluid and viscous liquids may be measured in the same instrument and at all temperatures.

Since the viscosimeter has been described in detail in previous articles[3] and has been modified in only one respect for this work, a very brief description will suffice. It consists (Fig. 1) of two vertical glass limbs as nearly alike as possible, except for there being a trap in one, these limbs being connected by a horizontal capillary tube fused into their lower ends. The capillary is of about 0.1 mm. internal diameter and of a length suited to the nature of the liquids to be investigated. On one limb two marks are so placed that, in falling from the higher to the lower, from 2 to 4 cc. of liquid passes through the capillary. This volume is determined before the viscosimeter is put together. Above the higher mark there is a trap. On the other limb, not far above the capillary, another mark is etched. The volume of liquid used is always the amount required to fill the instrument from this last mark to the top of the trap in the other limb.

The modification of the viscosimeters previously used, though only slight, has made the instrument easier to make and to calibrate. In this work, instead of calibrating two limbs, we have taken the time of falling from the higher to the lower mark, then reversing the pressure, taking the time of rising between the same marks. This has proved as satisfactory as the former method and saves the calibration of one limb.

Fig 1

VISCOSIMETER B

The following formula was used in the calibration of the viscosity results:

$$\eta = \frac{\pi r^4 p t}{8vl} - \frac{vd}{8\pi tl}$$

η is the viscosity, r the radius, l the length of the capillary, v the volume of liquid passing through the capillary, d the density of the liquid, p the pressure, and t the time of flow. The constants $\pi r^4/8vl$ and $v/8\pi l$ were determined by taking the time of flow of water at 30° and a suitable pressure, the value of η being taken from the data of Thorpe and Rodger. The correction to the pressure for any asymmetry in the instrument has an opposite effect according to

[1] *Gazz. chim. ital.*, **40**, II, 261 (1911).
[2] *Biochem. Z.*, **37**, 482 (1911).
[3] THIS JOURNAL, **4**, 106, 267, 878 (1912).

[1] *Phil. Trans. London*, (A), **185**, 397 (1894).
[2] *Z. physik. Chem.*, **80**, 670 (1912).
[3] *Loc. cit.*

whether the liquid is rising or falling in a certain (the calibrated) limb. If p_1 and t_1, and p_2 and t_2, represent the times of flow and the pressures when the liquid is rising and falling, respectively, or *vice versa*, the correction to the pressure x may be calculated according to the equation

$$x = \frac{p_1 t_1 - p_2 t_2}{t_1 + t_2}$$

TABLE I

Sample	Iodine number			Saponification number			Insoluble acids			Soluble acids			Reichert-Meissl No.
	I	II	Av.	I	II	Av.	I	II	Av.	I	II	Av.	
Butter I	36.95	37.13	37.04	228.9	229.1	229.0	89.41	89.60	89.51	3.421	3.481	3.451	25.16
Butter II	38.10	37.92	38.01	224.1	225.0	224.6	88.47	88.92	88.70	3.869	3.911	3.890	26.69
Butter III	30.90	31.02	30.96	231.3	231.5	231.4	89.23	89.14	89.18	4.017	...	4.017	27.04
Butter IV	34.07	34.26	34.17	230.4	230.1	230.3	88.71	89.10	88.91	4.026	...	4.026	27.08
Oleomargarine I	58.77	59.17	58.97	194.9	195.3	195.1	94.74	95.04	94.89	0.1	1.1	0.1	0.1660
Oleomargarine II	64.15	64.92	64.54	191.3	190.9	191.1	94.75	...	94.75	Less than		0.1	1.100
Oleomargarine III	67.92	67.92	67.92	136.3	136.9	136.6	93.48	93.41	93.44	Less than		0.1	0.9124
Oleomargarine IV	78.43	78.06	78.25	134.6	133.8	134.2	98.06	97.99	98.03	Less than		0.1	0.4989
Butter II (stale)	40.35	40.19	40.27	227.3	226.9	227.1	89.27	89.33	89.30	4.175	4.163	4.169	9.736
Butter III (stale)	33.44	33.74	33.59	233.4	233.6	233.5	89.48	89.60	89.54	3.749	3.741	3.745	26.01

While one viscosimeter may be used for many liquids, where a long series of measurements are to be made with substances of similar viscosity it is more practicable to construct one which will allow reasonable times of flow. Therefore, for the measurement of these fats, a viscosimeter was constructed with a very short capillary tube, and its constants were determined by using a glycerol-water mixture, the viscosity of which was measured in an instrument adapted to liquids of the viscosity of water, and having a correspondingly longer capillary tube.

Calibration of the viscosimeter used for the fats gave the following results:

Length of capillary (approx.)............................. 1.8 cm.
Volume of liquid passing through the capillary.............. 2.76 cc.
Pressure correction.. ±0.20 cm.
$\dfrac{\pi r^4}{8vl}$ 0.000004916
$v/8\pi l$ 0.03286

The times of flow for the various fats and at different temperatures varied from about ten to two minutes.

The results are given in the tables which follow. Together with the viscosities are presented the fluidities, these latter being calculated by taking the reciprocals of the average viscosities. All viscosity results are expressed in C. G. S. units.

From the results given in the tables several conclusions may be drawn. In the first place, as would be expected from the fact that oleomargarine is more largely made up of the glycerides of the higher aliphatic acids, the margarines are considerably more viscous than butter. Wender[1] seemed to consider that there was but little variation in the viscosity of different butter samples, while the viscosities of margarines from various sources differed widely. This work, however, shows that an accurate instrument can detect variations in different grades of both products, and that slight changes in composition affect the viscosity of these fats to as marked an extent as they do the other constants determined. In general, the lower the viscosity the purer is the butter, and if a high viscosity is found, adulteration by beef or other fats

[1] *Loc. cit.*

may be suspected. Of course an adulterated butter may be made more fluid by the addition of one of many oils possible, and such admixtures could be detected only by a determination of other constants.

That the better grades of butter are the less viscous is evidenced by the constants of the four samples studied. Sample I has the least amount of soluble and volatile acids, and its high viscosity corresponds to the fact that it is the poorest sample. Samples III and IV have the lowest viscosity and are shown to be the best butters by their high content of soluble and volatile acids.[1]

TABLE II—DENSITIES

Sample	40° C.	65° C.	90° C.
Butter I	0.9063	0.8901	0.8745
Butter II	0.9053	0.8896	0.8722
Butter III	0.9026	0.8865	0.8716
Butter IV	0.9026	0.8859	0.8720
Oleomargarine I	0.9026	0.8894	0.8711
Oleomargarine II	0.8989	0.8837	0.8666
Oleomargarine III	0.8997	0.8853	0.8666
Oleomargarine IV	0.9024	0.8867	0.8682
Butter II (stale)	0.9069	0.8890	0.8730
Butter III (stale)	0.9061	0.8992	0.8720

In connection with the change of butter on standing several interesting observations were made. If the butter fat was separated from water and curd, it became rancid very slowly, and after standing for considerable time at room temperature no appreciable change in viscosity could be detected. Consequently some of Samples II and III were allowed to grow rancid before removing the water and curd. The former stood about two months and the latter as many weeks. As shown in Table II, the samples which stood the longer decreased in viscosity, while the others

TABLE III—VISCOSITY RESULTS AT 40°

Sample(a)	Viscosity			Fluidity
	Down	Up	Av.	
Butter I	0.3244	0.3249	0.3247	3.080
Butter II	0.3228	0.3211	0.3219	3.107
Butter III	0.3080	0.3092	0.3086	3.241
Butter IV	0.3024	0.3025	0.3025	3.306
Oleomargarine I	0.3576	0.3605	0.3591	2.785
Oleomargarine II	0.3582	0.3584	0.3583	2.791
Oleomargarine III	0.3476	0.3464	0.3470	2.882
Oleomargarine IV	0.3352	0.3353	0.3353	2.982
Butter II (stale)	0.3177	0.3171	0.3174	3.151
Butter III (stale)	0.3105	0.3111	0.3108	3.218

(a) Butter samples I and II cost 33 cents a pound; III, 38 cents; IV, 30 cents. Oleomargarine samples I, II and III, 25 cents; and IV, 15 cents,

increased. From the Reichert-Meissl number it is evident that Sample II lost considerably more of its volatile acids than Sample III. This seeming dis-

[1] It may be noted that Sample IV, purchased in the same market as Sample III at less cost, is shown to be the *better* of the two.

crepancy may be accounted for in the following manner: The butter which was kept for the shorter interval of time gave off some of its volatile acids due to hydrolysis, and the higher acids remained for the most part unchanged. This would increase the relative per cent of these higher acids and consequently the viscosity. The other sample, which became very stale and of a pasty consistency, lost much more of the volatile acids as shown by the constant and we should expect its viscosity to be so much the

TABLE IV—BUTTER-OLEOMARGARINE MIXTURES—I

Viscosity

100 Per cent Butter

C. temp.	Down	Up	Av.	Fluidity
40°	0.3244	0.3249	0.3247	3.080
50°	0.2289	0.2292	0.2291	4.365
60°	0.1666	0.1667	0.1667	5.999
70°	0.1257	0.1258	0.1258	7.949
80°	0.09817	0.09816	0.09817	10.19
90°	0.07847	0.07857	0.07852	12.74

95 Per cent Butter

C. temp.	Down	Up	Av.	Fluidity
40°	0.3278	0.3262	0.3270	3.059
50°	0.2303	0.2296	0.2300	4.348
60°	0.1677	0.1678	0.1678	5.964
70°	0.1265	0.1264	0.1265	7.905
80°	0.09881	0.09858	0.09870	10.14
90°	0.07863	0.07891	0.07877	12.70

90 Per cent Butter

C. temp.	Down	Up	Av.	Fluidity
40°	0.3268	0.3269	0.3269	3.059
50°	0.2303	0.2302	0.2303	4.342
60°	0.1684	0.1680	0.1682	5.946
70°	0.1275	0.1283	0.1279	7.818
80°	0.09889	0.09847	0.09868	10.14
90°	0.07946	0.07946	0.07946	12.59

75 Per cent Butter

C. temp.	Down	Up	Av.	Fluidity
40°	0.3326	0.3323	0.3325	3.008
50°	0.2340	0.2343	0.2342	4.270
60°	0.1707	0.1709	0.1708	5.856
70°	0.1292	0.1290	0.1291	7.747
80°	0.1009	0.1011	0.1010	9.902
90°	0.08094	0.08088	0.08091	12.36

50 Per cent Butter

C. temp.	Down	Up	Av.	Fluidity
40°	0.3403	0.3381	0.3392	2.947
50°	0.2391	0.2404	0.2398	4.170
60°	0.1756	0.1745	0.1751	5.712
70°	0.1346	0.1350	0.1348	7.418
80°	0.1033	0.1035	0.1034	9.672
90°	0.08310	0.08277	0.08291	12.06

25 Per cent Butter

C. temp.	Down	Up	Av.	Fluidity
40°	0.3484	0.3481	0.3483	2.871
50°	0.2465	0.2475	0.2470	4.049
60°	0.1796	0.1800	0.1798	5.560
70°	0.1369	0.1369	0.1369	7.305
80°	0.1071	0.1062	0.1067	9.371
90°	0.08556	0.08548	0.08552	11.69

100 Per cent Oleomargarine

C. temp.	Down	Up	Av.	Fluidity
40°	0.3576	0.3605	0.3591	2.785
50°	0.2520	0.2522	0.2521	3.976
60°	0.1844	0.1843	0.1844	5.424
70°	0.1398	0.1396	0.1397	7.157
80°	0.1094	0.1093	0.1094	9.139
90°	0.08758	0.08758	0.08758	11.42

If the above inferences are correct, it is very probable that the viscosity of butter increases with time to a maximum, and then decreases on putrefaction. The suggestion is of sufficient interest to warrant further investigation.

The viscosity results in general bear out Bingham's[1] views concerning the relations between viscosity and

TABLE V—BUTTER-OLEOMARGARINE MIXTURES—II

Viscosity

100 Per cent Butter

C. Temp.	Down	Up	Av.	Fluidity
40°	0.3228	0.3211	0.3219	3.107
50°	0.2260	0.2264	0.2262	4.421
60°	0.1639	0.1643	0.1641	6.094
70°	0.1243	0.1245	0.1244	8.039
80°	0.09727	0.09686	0.09707	10.30
90°	0.07827	0.07838	0.07827	12.77
40°	0.3225	0.3226	0.3226	3.099

95 Per cent Butter

C. Temp.	Down	Up	Av.	Fluidity
40°	0.3239	0.3227	0.3233	3.093
50°	0.2274	0.2278	0.2276	4.393
60°	0.1657	0.1660	0.1659	6.027
70°	0.1249	0.1253	0.1251	7.995
80°	0.09782	0.09714	0.09748	10.26
90°	0.07791	0.07818	0.07805	12.81

90 Per cent Butter

C. Temp.	Down	Up	Av.	Fluidity
40°	0.3242	0.3255	0.3249	3.078
50°	0.2289	0.2298	0.2294	4.359
60°	0.1667	0.1674	0.1671	5.984
70°	0.1265	0.1266	0.1266	7.898
80°	0.09884	0.09889	0.09887	10.11
90°	0.07900	0.07897	0.07899	12.66

75 Per cent Butter

C. Temp.	Down	Up	Av.	Fluidity
40°	0.3297	0.3315	0.3306	3.025
50°	0.2323	0.2325	0.2324	4.303
60°	0.1700	0.1703	0.1702	5.874
70°	0.1283	0.1284	0.1284	7.787
80°	0.1003	0.0999	0.1001	9.990
90°	0.08049	0.08056	0.08053	12.42

50 Per cent Butter

C. Temp.	Down	Up	Av.	Fluidity
40°	0.3397	0.3401	0.3399	2.940
50°	0.2400	0.2408	0.2404	4.160
60°	0.1751	0.1755	0.1753	5.704
70°	0.1326	0.1327	0.1327	7.529
80°	0.1029	0.1028	0.1029	9.817
90°	0.08282	0.08274	0.08278	12.08

25 Per cent Butter

C. Temp.	Down	Up	Av.	Fluidity
40°	0.3486	0.3488	0.3487	2.868
50°	0.2460	0.2471	0.2466	4.055
60°	0.1814	0.1805	0.1810	5.525
70°	0.1375	0.1383	0.1379	7.251
80°	0.1062	0.1063	0.1063	9.407
90°	0.08576	0.08537	0.08557	11.69

100 Per cent Oleomargarine

C. Temp.	Down	Up	Av.	Fluidity
40°	0.3582	0.3584	0.3583	2.791
50°	0.2535	0.2541	0.2538	3.940
60°	0.1833	0.1833	0.1836	5.447
70°	0.1391	0.1391	0.1391	7.189
80°	0.1087	0.1085	0.1086	9.208
90°	0.08747	0.08743	0.08745	11.43

greater. However, putrefaction of the casein also had commenced with a resulting change in the butter fat which lowered its viscosity without increasing the amount of volatile acids. These products, which do not influence the amount of volatile and soluble acids, may be acids of lower molecular weight than those from which they are derived, but which are insoluble and non-volatile. It should be noted that there is an increase in the quantity of insoluble acids in this last sample considered.

fluidity and composition. Briefly his hypothesis requires that the fluidity of absolutely unassociated liquids, which do not change on being heated, is a linear function of the temperature, and that mixtures of such liquids which do not interact should have additive fluidities. The fluidity temperature curves for one series of mixtures of butter and oleomargarine are shown graphically in Fig. II. It may be noted that they are nearly linear but that the slight curvature

[1] *Z. physik. Chem.,* **66,** 1 (1909).

indicates a certain amount of association in the fats. That this curvature is not a result of chemical change of the fats as they are heated from 40° to 90° is proven by the data in Table V. The viscosity of the pure
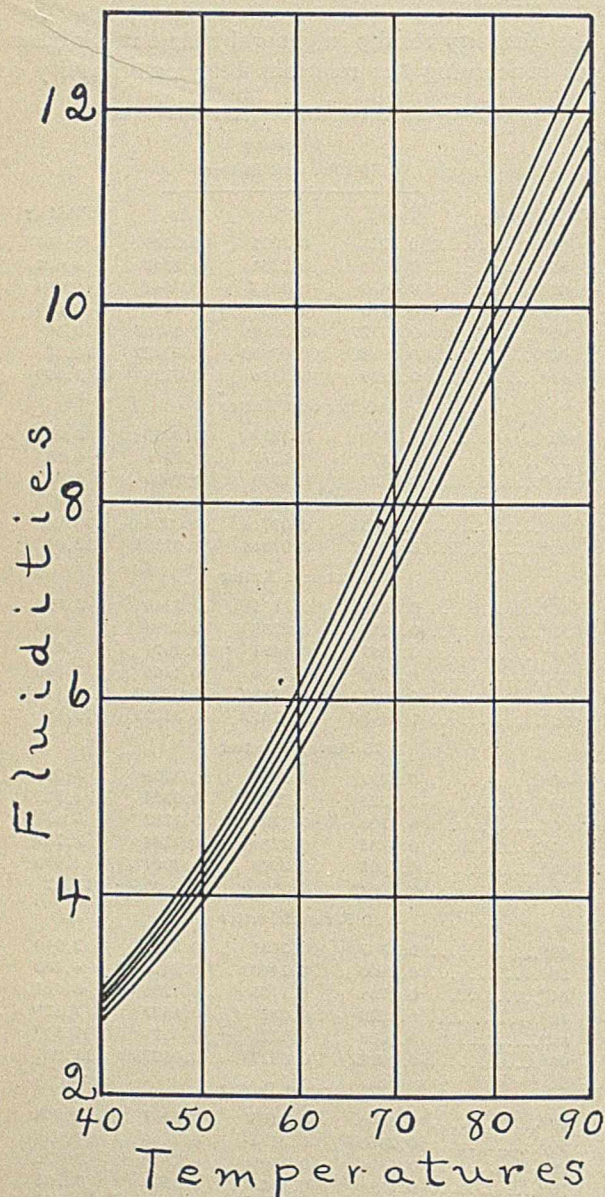

FIG. II. Fluidity Temperature Curves of Butter-Oleomargarine Mixtures—I

butter was determined after it had been so heated, and there is no change except what is well within the experimental error. Such association in the fats is very possible since it has been shown that esters are more or less associated. This same effect has been noted by one of us in work on fish oils.[1] By Fig. III it is seen that in accordance with the second part of the fluidity hypothesis as stated, the fluidities of the butter and oleomargarine mixtures are additive. Evidently then, any such association as was indicated is so insignificant as regards our results and conclusions concerning the additivity of the fluidities of these fats that it may be entirely disregarded. The slopes of the fluidity-temperature curves are practically identical, and it is safe to conclude that, in this case,

[1] *Loc. cit.*

the fluidity is a linear function of the composition at any and all temperatures. Since the fluidity is the reciprocal of the viscosity it would be generally impossible, according to the theory, for viscosities to be additive. The viscosity curves for the mixtures given
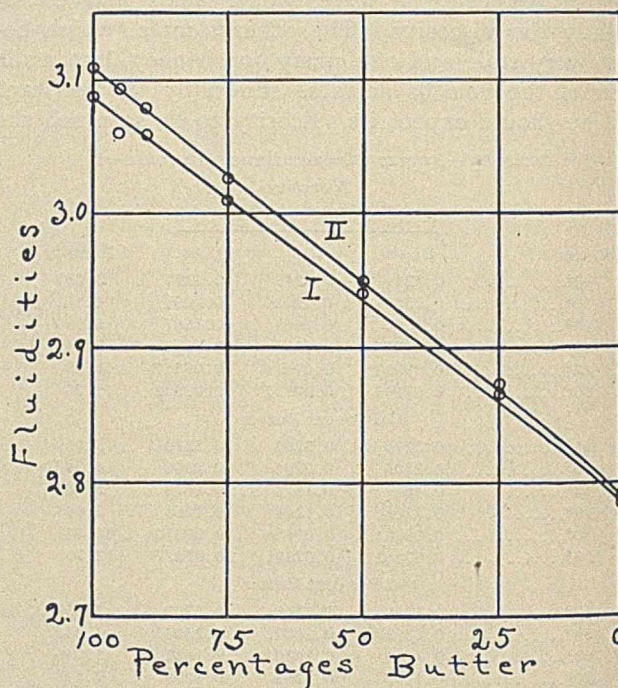
FIG. III.   Fluidity Curves of Butter-Oleomargarine Mixtures, 40°

in Fig. IV show that this is also borne out experimentally, for very evidently a linear curve is not obtained. However, as has been repeatedly shown, when the viscosities of such viscous liquids as these fats are studied, no great divergence from the additive relationship is noticed when the viscosities of the
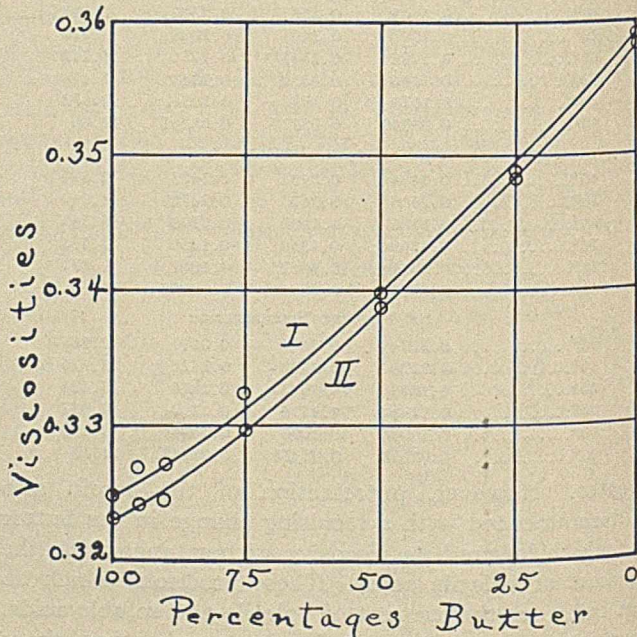
FIG. IV.   Viscosity Curves of Butter-Oleomargarine Mixtures, 40°

components of the mixtures approximate each other.
It was stated above that there was some variation in the viscosities of both butter and oleomargarine,

yet there is a certain reliable mean value for both. These values, with the fluidities, are:

	η	φ
Butter	0.3200	3.125
Oleomargarine	0.3500	2.857

An adulteration of 10 per cent margarine in butter could be readily detected in the apparatus used in any case. Since pure butters from any one creamery vary very little, by finding the mean value for such products, admixture of a foreign fat of different viscosity could be shown if even only 1 per cent were so added.

SUMMARY

1. Oleomargarine fats are always more viscous than butter fats except, of course, where the viscosity of the former is greatly lowered by the introduction of large amounts of liquid fats as indicated by a chemical analysis.

2. On standing, the viscosity of butter probably increases to a maximum due to a loss of volatile acids, and then becomes less viscous as putrefaction sets in.

3. Although the viscosities for both fats vary somewhat in products from different sources, the fluctuation is always about a mean value which might be assumed without great error as a standard.

4. The viscosities of the mixtures are not strictly additive.

5. The fluidities are practically linear functions of the temperature.

6. The fluidities of the mixtures are additive, so that these, and not viscosities, should be the basis for any comparison.

7. Assuming that the fluidity of butter does not vary more than 5 per cent in value, an adulteration of 10 per cent oleomargarine can be detected with assurance by the method of determination used.

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THE PROPERTIES OF WATERED MILK

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Much work in the detection of added water in milk has been done by the usual chemical methods. So far as the authors are aware, no extensive studies have been made of the changes met where hard well water instead of distilled water has been added to milk, or where sucrose has been added to watered milk to build up the refractometer reading, or where additions of sucrose have been made to whole milk serum to build up the immersion refractometer reading.

The standard composition of milk has been well established, and published results of numerous analyses of American cow's milk are well known.[1] In recent years the method of detecting watered milk has been largely a study of the deportment of the given sample of milk when the corresponding milk serum was prepared and examined with the Zeiss immersion refractometer. Various methods have been suggested for the preparation of the milk serum prior to the examination of the refractive power of the serum. Villiers and Bertault,[1,2] as early as 1898, devised a method using acetic acid for the removal of milk proteins. Matthes and Müller,[3] in 1903, made use of the Zeiss immersion refractometer for the examination of the serum which they obtained from spontaneously soured milk. Leach and Lythgoe,[4] in 1904, made use of the immersion refractometer in examining milk serum prepared by the Woodman method. To 100 cc. of milk at about 20° C., 2 cc. of 25 per cent acetic acid were added, well mixed and placed on a water bath at 70° C. for 20 minutes. The mixture was then cooled for 10 minutes in ice water and filtered. The main difference between their method and those formerly used was in the heating of the acid-milk mixture for longer times at lower temperatures prior to filtration. Baier and Neumann[5] used an asaprol-citric acid mixture as the precipitating agent. The serum so prepared was examined with the Wollny milk fat refractometer. Ackermann[6] used calcium chloride as the precipitating agent in the preparation of milk sera. With so many procedures available, it seemed desirable to compare the various methods on samples of known purity. This was done by Lythgoe and Nurenberg.[7] They found some methods had certain advantages over other methods but for ease of manipulation and getting concordant results, the Woodman acetic acid method as used by Leach and Lythgoe was preferred.

Other methods that have been useful in the detection of added water to milk are dependent on the preparation of the milk serum and the using of this serum in various ways such as the determination of the specific gravity, the nitrate reaction with diphenylamine, the determination of the freezing point, the determination of the electrical conductivity and the determination of the index of oxidation.

Using the specific gravity method of examination, Bull[8] found that in eight cases 5 per cent added water was distinguishable, in ten cases 10 per cent added water was distinguishable and in fourteen cases (all examined) 15 per cent added water was distinguishable. Although the method seemed more delicate than the refractometer method, the author felt the refraction method more reliable.[9]

Varying interpretations are given to the estimation of nitrates in milk as indicating the addition of water. They are mentioned here to complete the bibliography. Tillman[10] claimed that water containing 10 mg. N_2O_5 per liter could be detected when added to milk in amounts equal to 5 per cent of the milk. Galvagno[11] claimed that the nitrate reaction was valueless, while

[1] Leach, Textbook, "Food Analysis," 2nd Ed., p. 127.
[1] Reference to Villiers and Bertault, THIS JOURNAL, 1, 38.
[2] Villiers and Bertault, *Bull. Soc. Chim.*, 19, 305.
[3] Matthes and Müller, *Z. oeffentl. Chem.*, 10, 173.
[4] Leach and Lythgoe, *J. Am. Chem. Soc.*, 26, 1195.
[5] Baier and Neumann, *Z. Nahr. Genussm.*, 13, 369.
[6] Ackermann, *Ibid.*, 4, 186; *Chem. Abstr.*, 1, 1588.
[7] Lythgoe and Nurenberg, THIS JOURNAL, 1, 38.
[8] Bull, *Ibid.*, 3, 44.
[9] Woodman, *J. Am. Chem. Soc.*, 21, 503.
[10] Tillman, *J. Soc. Chem. Ind.*, 30, 44.
[11] Galvagno, *Chem. Abstr.*, 3, 2838.

Rothenfasser[1,2] concluded that the nitrate reaction was given too little rather than too much attention.

Fischer[3,4] found the freezing point of whole milk to be fairly constant, and when the watering of milk was not greater than 5 per cent, he was not able to detect with certainty the presence of the added water. With greater degrees of watering he was able to notice differences in the freezing points of the mixtures.

Flohil,[5,6] on the one hand, found that even with 20 per cent added water no marked change in the electrical conductivity sufficient to throw the sample of milk outside of the limit for undiluted milk was noticed, while on the other hand Binaghi[7,8] maintained that the electrical conductivity afforded a valuable indication of the presence of added water.

Comanducci[9,10] devised a method for the determination of the extent of watering or skimming of milk based on the fact that the number of cubic centimeters $N/10$ KMnO$_4$ (H$_2$SO$_4$) necessary to oxidize a given quantity of genuine milk was nearly constant. The author claimed that this method could be used to determine the percentage of water added or the percentage of cream removed, providing the milk had not been both watered and skimmed.

Further, Burr and Berberich[11] have proposed a method for determining the watering of milk by means of examining the ash content of the milk serum. They have found this figure to be in between 0.797 per cent and 0.817 per cent for whole milk and for naturally-soured milk the figure was quite constant.

Richmond[12] has found that the amount of water added to milk can be determined by adding the difference between the specific gravity of the sample and 1000 to the figure representing the percentage of fat in the milk. Unadulterated milk was found to give a value of 36, but 34.5 was considered a safer limit. This method is perhaps of less value.

In the present investigation, the authors have used the acetic acid method for the preparation of the milk serum. This involved treating 100 cc. of milk with 2 cc. 25 per cent acetic acid, mixing thoroughly and heating stoppered in a water bath at 70° C. for 20 minutes. Besides using the whole milk sera, we have used various dilutions of milk and have employed various temperatures for reading the Zeiss immersion refractometer.

Using a number of samples of milk, we have studied the effect of temperature on the readings when they were taken at 15° C. and each respective degree of temperature up through 20° C. The following results will serve as an example; corrected readings are given:

[1] Rothenfasser, Chem. Abstr., 3, 2988.
[2] Rothenfasser, Z. Nahr. Genussm., 18, 353.
[3] Fischer, Chem. Abstr., 2, 1166.
[4] Fischer, Pharm. Ztg., 53, 48.
[5] Flohil, Chem. Abstr., 5, 3598.
[6] Flohil, Chem. Weekblad, 8, 605.
[7] Binaghi, J. Soc. Chem. Ind., 29, 1404.
[8] Binaghi, Biochem. Ztg., 26, 60.
[9] Comanducci, Chem. Abstr., 1, 1588.
[10] Comanducci, Gazz. chim. ital., 36, II, 813.
[11] Burr and Berberich, Chem. Abstr., 2, 3115.
[12] Richmond, Leffman and Beam, "Food Analysis," p. 216 (reference).

DILUTION	15° C.	16° C.	17° C.	18° C.	19° C.	20° C.
Whole milk	46.05	46.0	45.8	45.6	45.3	45.1
20 parts added water	40.4	40.15	39.9	39.65	39.4	39.15
40 parts added water	33.8	33.7	33.55	33.3	33.1	33.0
60 parts added water	27.85	27.7	27.5	27.3	27.15	27.0

We have examined ten samples of milk obtained from a local dairy. The same milk on being diluted with water until the added water amounted to 20, 40 and 60 per cent, respectively, of the mixture was acidified and the serum examined with the refractometer. The following results were obtained at 20° C:

Sample	Whole milk	20 per cent H$_2$O	Diff.	40 per cent H$_2$O	Diff.	60 per cent H$_2$O	Diff.
1	46.45	39.4	7.05	33.3	6.1	27.05	6.25
2	45.6	39.15	6.45	33.0	6.15	27.0	6.0
3	45.2	39.05	6.15	32.8	6.25	26.8	6.0
4	45.8	38.2	7.6	32.8	5.4	26.9	5.9
5	44.1	37.1	6.0	32.5	4.6	26.8	5.7
6	43.5	37.9	5.6	31.5	6.4	26.4	5.1
7	40.9	35.4	5.5	30.3	5.1	25.3	5.0
8	44.2	38.2	6.0	32.2	6.0	26.2	6.0
9	42.5	36.8	5.7	31.0	5.8	25.7	5.3
10	43.1	37.4	5.7	31.3	6.1	25.8	5.5

The average differences in refractometer reading for each 20 parts of added water as shown by the above table was 5.88° on the scale of the Zeiss immersion refractometer.

In order to ascertain what differences there might be when well water instead of distilled water was used for dilution of the milk, a number of samples of milk were diluted with well water and distilled water, respectively. The following table shows the readings with the different waters:

DILUTION	Distilled water	Well water
Whole milk, 42.6		
20 parts added water	36.7	36.7
40 parts added water	30.9	31.0
60 parts added water	25.9	26.0

The well water used contained 0.030 gram of total solids per 100 cc. From the table it is evident that there is but little difference in the readings. From the different samples examined it seemed that with a water containing 0.030 gram solids per 100 cc. there was an increase of about 0.1° above the refractometer reading observed when using distilled water. This difference is scarcely large enough to exceed the error possible in making the readings.

SAMPLE A

Amount of sugar per 100 cc. Grams	Whole milk readings	Difference per gram of sucrose
0.0	42.8	...
1.0	46.6	3.8°
2.0	50.6	4.0°
3.0	54.6	4.0°

SAMPLE B

Amount of sugar per 100 cc. Grams	Whole milk readings	Difference per gram of sucrose
0.0	44.15	...
1.0	48.00	3.85°
2.0	52.05	4.05°
3.0	56.1	4.05°

In studying the influence of sucrose added to milk, whole milk was adulterated with 1.0, 2.0, and 3.0 gram portions, respectively, of ordinary granulated sugar per 100 cc. of milk and treated in the usual way to prepare the corresponding sera. Great care was exercised in getting all the sugar dissolved and the solution well mixed. Fourteen samples of milk

yielded an average increased reading of 3.98° on the immersion refractometer scale for each gram of sugar per 100 cc. of milk. The average difference per gram of sucrose was approximately the same whether 1.0, 2.0 or 3.0 grams per 100 cc. of milk were used. The above will serve as representative samples.

Seventeen samples of milk were adulterated by additions of sugar and water. The samples were prepared by filling 100 cc. flasks with milk, withdrawing 20 cc. by means of a pipette, adding 1.0, 2.0 and 3.0 grams, respectively, of ordinary granulated sugar, dissolving and mixing the sugar solution carefully and then filling to the graduation mark with water. The samples were then heated with acetic acid as usual for defecation. In 17 samples, an average difference of 4.02° instrument reading per gram of sugar added was obtained. Following this, samples of whole milk were diluted to contain 60 parts milk and 40 parts of added water. Five samples gave an average difference in reading of 4.1° instrument reading for each gram of sugar added per 100 cc. of milk. Five samples of milk containing 40 parts of milk and 60 parts of added water yielded a difference of 4.04° (average) for each gram of sugar added.

The average difference in reading produced by a gram of sugar added per 100 cc. of milk calculated on the total 41 samples including whole milk, milk containing 20 parts added water, 40 parts of added water and 60 parts of added water, respectively, per 100 cc. of milk-mixture, was 4.03°. From these results it seems that 1 gram of granulated sugar added to 100 cc. of milk raises the refraction of the serum about 4° and no great difference is observed when either whole milk or watered milk is used. If this increasing figure is used together with the decreasing figure (2.9°) representing the refractometer reading produced by 10 per cent added water, one should be able to adjust the two figures so that the refractometer reading on the serum would come near that observed for unadulterated milk. Thus by adding the proper amount of sugar, the serum of the watered milk should be capable of yielding a refractometer reading approaching the normal milk before adulteration. We calculated with this in view and found that for every 10 per cent of water added, 0.725 gram granulated sugar (commercial grade) such as we were using had to be added to each 100 cc. of milk in order to make the adulterated sample of milk give the same refractometer reading as the original whole milk.

The following data was obtained from an actual sample of milk that showed a refractometer reading of the serum to be 44.15° and contained total solids amounting to 14.48 per cent. On watering this sample of milk until we had a mixture containing 80 parts of milk and 20 parts of added water, and adding 1 gram of granulated sugar, by calculation, we should have had a mixture yielding a serum with a refractometer reading of 42.35°. By actual experiment, we found 42.15 as the observed reading. Adding 2 grams of sugar per 100 cc. of milk-mixture should have yielded a refractometer reading of 46.35°. By observation, the actual reading was 46.1°. Adding 3 grams of sugar

to 100 cc. of the milk should have given us a serum with a refractometer reading of 50.25°. Exactly this figure was found by experiment.

The experimental part checked fairly well with the calculations. Other samples of milk with which we worked varied from the calculated value as much as 0.5° but the majority of the samples gave readings within closer range of the calculated values.

The sample of milk just described in detail although watered and sugared (1.0 gram per 100 cc.) yielded a refractometer reading safely above the standard usually associated with whole milk. The total solids in the diluted milk, after treatment with sugar, would have been 12.58 per cent, a figure exceeding the usual standard. The milk originally mentioned contained 5 per cent fat. Even on dilution this resulting figure would have been above the standard for butter fat. It is evident that the milk in question when diluted so as to contain 20 per cent added water and 1 gram of granulated sugar for every 100 cc. of watered milk, on being examined in the usual way would have given results that might have baffled the chemist in detecting the added water. Unless the sucrose tests had been applied, the sample might have been passed as unadulterated milk.

It can be shown that this form of milk adulteration is a profitable thing. At the rate of 1 gram of sucrose to 100 cc. diluted milk containing 80 parts of whole milk, one quart of the milk would require 0.025 pound of granulated sugar to bring the refractometer reading up to its original value. With sugar at 6 cents a pound and milk at 8 cents a quart, 0.15 cent spent for sugar would yield a return of 2 cents. The adulteration can be thus carried on profitably by the milk dealer if he is able to escape the chemist's sucrose tests.

CONCLUSIONS

1. The Zeiss immersion refractometer method of testing milk serum is doubtless the most practical method for the detection of water addition, but this method is far from infallible when used alone.

2. This work indicates that for every 10 per cent of water added to milk, the serum when prepared by the acetic acid method gives a refractometer reading about 2.9° lower than the unwatered milk.

3. The addition of 1 gram of granulated sugar to 100 cc. of milk, watered or unwatered, will raise the refractometer reading of the serum about 4°.

4. The adulteration of milk by watering and sugaring can be profitably carried on by adjusting the amounts of the adulterants and adding them to the milk that is well above the standard in solids and fat.

5. This work was carried out to find the actual importance of the desirability of detecting cane sugar as a milk adulterant. It seems that in examining commercial samples of milk it is well worth the chemist's trouble to look out for the presence of this form of adulteration.

CHEMICAL LABORATORIES
UNIVERSITY OF INDIANA
BLOOMINGTON

THE DETERMINATION OF NITROBENZOL IN PEANUT OIL[1]

By H. J. LUCAS

Received March 18, 1913

In the regular routine work of this laboratory, it became necessary to determine the amount of nitrobenzol present in certain varieties of peanut oil on the market. Because of its cheapness, a very large amount of this oil is consumed by the people of Porto Rico, especially the poorer classes, as a substitute for olive and other higher-priced oils. Inspection showed that a considerable percentage of the oil on the market was adulterated by the addition of nitrobenzol, which has been added for the purpose of giving a pleasant odor, and of deceiving the purchaser into thinking that the product was oil of bitter almonds. An examination of these products led to the working out of the following method.

Nitrobenzol is easily volatile with steam, and can be distilled from an oil by this means. However, experiments showed that there is considerable loss from this procedure: (1) because, it is very difficult to remove the last portions, and (2) because there is a continual, although slight loss by volatilization as is evidenced by the pronounced odor of the distillate Since the distillation must be carried on for some time this continual volatilization causes an appreciable loss.

Nitrobenzol is easily reduced to aniline in hydrochloric acid solution by such reducing agents as stannous chloride, and metals. Attempts were made to recover this aniline by distillation with steam, but the same difficulties were encountered, as mentioned above. However, by the use of suitable immiscible solvents it was found that the aniline could be separated from the oil, evaporated to dryness from a hydrochloric acid solution, and weighed as aniline hydrochloride. Although the method does not give a complete recovery of nitrobenzol, it is so nearly so that for practical purposes it may be considered as quantitative.

To peanut oil, free from nitrobenzol and aniline, were added varying amounts of nitrobenzol, giving mixtures containing from 0.125 per cent to 1.000 per cent of the latter. These were then analyzed according to the following method: Thirty grams of oil containing nitrobenzol are weighed into a counterpoised, glass-stoppered Erlenmeyer flask of 150 cc. capacity. Five grams of zinc dust are added, and the oil gently agitated in order to distribute the finely divided metal throughout the mixture. Ten cc. of concentrated hydrochloric acid are then poured in, and the whole mixed quickly and thoroughly by three or four rapid whirls. Finally, 10 cc. of water are added, and the entire contents shaken vigorously, care being taken to avoid loss, since the heat development may cause the stopper to loosen.

Should the odor of nitrobenzol disappear within a few seconds, the amount of same present is very small, and but little more shaking is required for complete reduction. If, however, it persists for over three minutes, the amount is so large that continual shaking for fifteen minutes is necessitated. In either

event, at the end of this time the liquid contents of the flask are transferred to a separatory funnel by means of 50 cc. of ether and 25 cc. of water, care being taken to leave behind in the flask as much of the undissolved zinc as possible, which is washed into a second separatory funnel with 25 cc. of ether and 25 cc. of 5 per cent hydrochloric acid solution. The aqueous layer from the first separatory funnel is filtered through a wet filter into a third, and that from the second into the first. The contents of the second are then washed with 25 cc. and 10 cc. of 5 per cent hydrochloric acid, in two successive portions, which are, in turn, used for washing the oil-ether mixture in the first. The separate extractions and washings should be performed by shaking for two minutes, cautiously, as an emulsion is very liable to form if the shaking is done vigorously. The filtrate is a perfectly clear solution of zinc chloride and aniline hydrochloride in dilute hydrochloric acid, with traces of oil which passed through the filter.

This is now allowed to run slowly into 50 cc. of strong sodium hydroxide solution (100 grams of sodium hydrate to 150 cc. of water) which must be kept cool and shaken constantly. It was found very convenient to have the alkali in another separatory funnel. The resulting solution should be clear, or nearly so. The aniline separates as an oily layer, if the amount present is considerable, and the zinc remains dissolved as sodium zincate. Extraction with ether is made, using 60, 40, 30 and 20 cc., and pouring off from the top into a perfectly clean and dry separatory funnel. If, after standing for half an hour, small drops of water should be visible on the inner wall, the ether must be transferred to another, thus securing a solution of aniline free from inorganic salts. Final extraction is now made, using 4, 3, 2 and 1 cc. of 10 per cent hydrochloric acid solution successively, and shaking each time for 2 minutes. The acid extractions are evaporated on the water-bath in a tared platinum dish, which is kept covered until all the ether has boiled away and danger from loss by spattering has ceased.

	SAMPLE TAKEN			PEANUT OIL RECOVERED					
No.	Grams oil	Per cent $C_6H_5NO_2$	Gram $C_6H_5NO_2$	Gram $C_6H_5NH_2$ HCl	Gram $C_6H_5NO_2$	Per cent $C_6H_5NO_2$	Per cent recovery	Weight non-volatile residue, Mg.
1	30	1.000	0.3000	0.3030	0.2879	0.960	96.0	0.2
2	30	0.500	0.1500	0.1521	0.1445	0.482	96.3	0.0
3	30	0.250	0.0750	0.0728	0.0692	0.230	92.2	0.7
4	30	0.250	0.0750	0.0729	0.0693	0.231	92.4	0.0
5	30	0.125	0.0375	0.0371	0.0352	0.117	94.0	0.6
LARD OIL								
6	30	1.000	0.3000	0.2960	0.2812	0.937	93.7	
7	30	0.500	0.1500	0.1486	0.1412	0.471	94.1	

The evaporation must be watched very carefully at the finish, the dish being removed just before dryness is reached, at a point where the whole mass will just crystallize when allowed to cool. If carried further, there is danger of loss by volatilization. The residue is dried to constant weight in a soda lime desiccator: this requires from 16 to 35 hours, depending upon the amount of residue. On ignition at a low red heat,

the amount of inorganic material is obtained, which, when subtracted from the total residue, gives the weight of aniline hydrochloride.

The accompanying table gives the results of analyses of mixtures of peanut oil and nitrobenzol of known strength, and also two of lard oil and nitrobenzol.

CHEMICAL AND BROMATOLOGICAL LABORATORY
SAN JUAN, P. R.

THE DETERIORATION OF SODA WATER DUE TO MICRO-ORGANISMS

By N. P. SHERWOOD AND C. C. YOUNG
Received June 2, 1913

During the last two years many letters have been received at this laboratory from soda water bottlers asking for information relative to the cause and prevention of the so-called "diseases" of soda water. In a few instances, at least, bottling works have been forced to close down their business, owing to the fact that the product put out by them continually "went bad." As it is of economic importance to the various soda water manufacturers throughout the country and indirectly of interest to the consumer, an invitation was extended to various bottling works in the state to send in to the laboratory samples of spoiled soda water whenever found. Accordingly, a large number of samples were received and examined. It was found that the spoiled beverages may be classified into three groups, namely: *First*, stringy pop; *Second*, pop with sediment and turbidity; and *Third*, pop in which sufficient fermentation had developed to blow off the caps or break the bottles. The authors have been unable to find records of any previous work on this subject.

A microscopical examination of several samples revealed the fact that stringy pop, in these particular cases, was caused by the presence of a one-celled algae, "Tetraspora." Data on file in the water laboratories showed that the water supply used in the manufacture of the soda water was infested with an excessive growth of this algae. The stringiness was due to the mucilaginous nature of the cell walls which hold the cells together in large colonies. It can readily be seen that any algae-infested water, used directly, will give the manufacturer trouble. The use of distilled water is the best and easiest solution of this difficulty. Filters will not protect the bottler from this trouble entirely as the algae grow through the filters.

Those samples of soda water, showing only sediment and turbidity or in many cases sediment alone, were shaken, carefully opened and portions of the contents plated out on agar and other portions were inoculated into saccharose and dextrose broth fermentation tubes. Microscopical examinations were also made of the sediment settling to the bottom of the bottle. The agar plates showed the presence of 30,000 to 45,000 yeasts per cubic centimeter while the microscopical examination of the sediment established the fact that it was made up, in every case, of yeasts. Several strains of bacteria were isolated along with the yeasts and kept for further study as will be described presently.

While many bottlers reported losses due to blowing off of caps to bottles no samples thus affected were obtained, but instead a successful attempt was made to produce this effect by inoculating various kinds of soda water under normal conditions, with three laboratory strains of saccharose fermenting colon organisms, which had been isolated from polluted water and sewage. The yeasts and bacteria isolated from samples showing sediment and in some cases marked turbidity were separately inoculated each into a respective set of samples to check up the cultural and microscopical findings mentioned above. A set of controls was also carried. Two varieties of soda water were used in these experiments, Cocoa Cola and Cream. These were inoculated in sets of four bottles each with the following organisms:

Set	Lab. No.	
1	101	Saccharose fermenting colon organism.
2	102	Saccharose fermenting colon organism.
3	107	Saccharose fermenting colon organism.
4	5428	Yeast (from ginger ale).
5	5429	Saccharose fermenting bacillus. Acid. No gas (from cream pop).
6	5432	Yeast (from lemon soda).
7	5426	Saccharose fermenting bacillus. Acid. No gas (from ginger ale).
8	5427	Saccharose fermenting bacillus. Acid. No gas (from ginger ale).
9		Controls.

NOTE: These experimental samples were bottled under normal factory conditions, with the exception that all bottles were sterilized.

When soda "goes bad" it does so almost invariably in hot weather, hence these bottles were placed in an incubator and kept at 37° C. for a week and then placed at room temperature and kept for several months with the following results:

SET	ACTION
1	Developed slight turbidity only.
2	Developed slight turbidity only.
3	Developed slight turbidity and sufficient gas produced to lift caps.
4	Heavy sediment produced, made up of yeast and cap from one bottle lifted.
5	Turbidity only.
6	Sediment yeast.
7	Turbidity only.
8	Contaminated with yeasts, probably from bottling machine.
9	Normal pop. No sediment or turbidity.

NOTE: Active-gas producing colon organisms and yeast were found.

It would seem from the above that while not all strains of saccharose fermenting colon organisms will produce sufficient gas to lift the caps on the bottles, yet an extremely good gas-producing strain may bring this about and also that some strains of yeast will produce this result. Hence the use of polluted water might, in addition to endangering the health of the consumer, render the produce unsalable owing to presence of large numbers of colon organisms.[1] In a previous paper by the authors, it was noted that when a certain strain of *B. coli* was inoculated into pop it rapidly died out; this, however, was a non-saccharose fermenting organism and did not produce turbidity in the pop.

It is also evident from these experiments that sediment may be produced in pop owing to presence of certain wild yeasts, and also that any bacteria which ferment saccharose with the production of acid but no gas may render the pop turbid and unsalable.

Inasmuch as it is an established fact that algae grows only in the light it is important that all distilled

water stored in the bottling plants should be kept in the dark.

We wish to suggest to bottlers that they discard wooden kegs as they have been found to be carriers of yeasts and undesirable bacteria even after attempts have been made to sterilize them with hot water. Salt-glazed pottery, where substituted for wooden receptacles, are very easily sterilized and have given excellent results in practice. Every effort should be made to keep all materials covered to prevent the entrance of these organisms from the air.

BACTERIOLOGICAL LABORATORIES
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LABORATORY AND PLANT

SOME PROJECTION EXPERIMENTS WITH SPECTRA[1]

By H. E. HOWE
Received May 3, 1913

The development of projection apparatus within the last few years, producing forms with which work of precision can be done, naturally led to the use of such instruments in fields where projection heretofore has not entered. The mention of projection apparatus recalls to the minds of most people simply the process of projecting lantern slides, but the physicist has for a long while used projection in lecture experiments and laboratory work. Of late the biologist has found it most useful for lantern slides, opaque ob-

A lecture given by Dr. C. E. Kenneth Mees on the "Nature of Color" before the Rochester section of the American Chemical Society suggested these simple experiments, for in that address Dr. Mees used the Zeiss complementary color projection apparatus, the principles of which are used in the instrument I have here.

However, the Zeiss instrument is too difficult to set up and has other objections which made a simplification very desirable for our purposes. Mr. W. L. Patterson, of the Bausch & Lomb Optical Co., therefore undertook the construction of a complementary color apparatus which would have the form of a con-
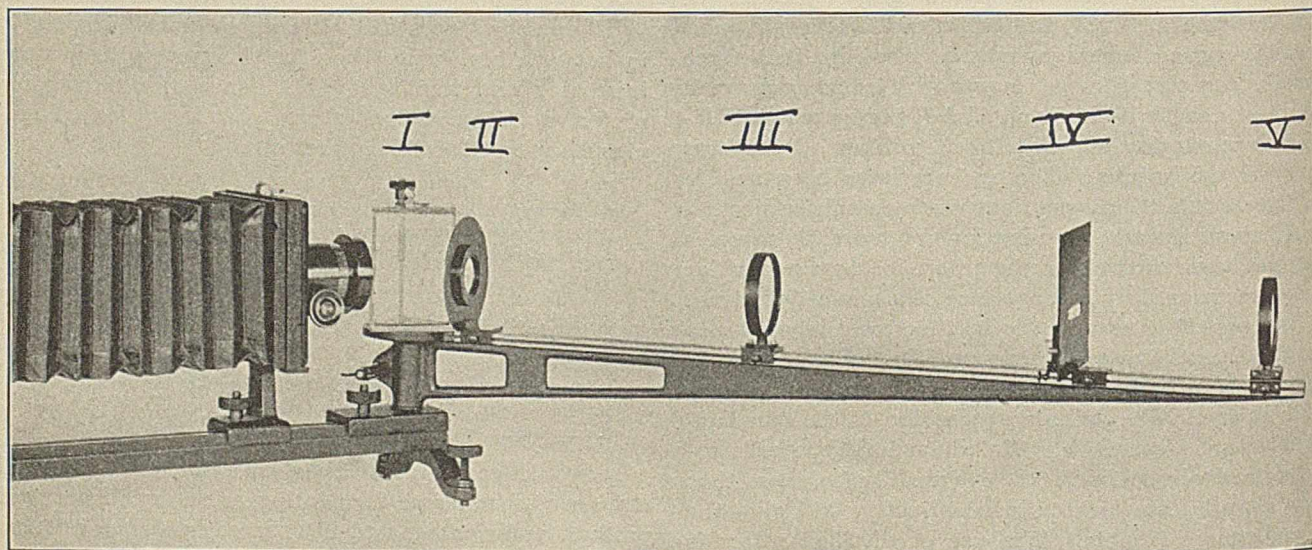
FIG. 1

jects, and for microscopical projection, not to replace the table microscope but as an accessory. It has always seemed to me that the chemist could use projection (more especially in lectures) profitably and to a large extent if he would but work out a few experiments as a beginning, and add to them as his familiarity with the projection suggests other experiments. The first of these chemical experiments with the aid of projection were given by Dr. Frank B. Kenrick, of the University of Toronto, and myself, at the general meeting of this Society at the Washington meeting, and the few experiments I now have to offer are more in the line of physics but have an application to the teaching of chemistry especially in qualitative analysis where the spectroscope is used for the identification of certain elements.

venient attachment which can be used on any of the well-known Balopticons possessing a lathe bed. The result was a light and easily adjustable apparatus which is shown in Fig. 1.

The projection apparatus consists of a Balopticon set up for lantern slide projection but with an extra standard, upon which the adjustable slit is carried, placed between the condenser system and the projection lens and to the bed of this Balopticon, the complementary color apparatus is attached as illustrated. This instrument consists of a short optical bench which may be adjusted to any angle with reference to the bed to which it is attached and which supports the following accessories:

I. A bottle prism for holding carbon bisulfide or any other liquid.

II. An Iris diaphragm and light shield.

III. Lens which images Iris diaphragm on the projection screen.

IV. A screen with rectangular opening and supporting slides having both cross and vertical movements.

V. A lens which may be swung in or out of the optical axis, depending upon whether a disc in which the spectrum is reunited is desired or the spectrum itself.

The optical bench is turned about the axis of this support until the angle of minimum deviation of the prism is found when it is clamped in its position. When set up we obtain a brilliant spectrum of the carbon arc in rectangular form just as the student sees it in the spectroscope.

The screen IV has a vertical and cross slide with clips for holding small deflecting prisms. By moving these prisms to any point desired that portion of the spectrum can be deflected so that with V in position we get two images of the Iris diaphragm, II, on the screen. One of these images will be the color of that portion of the spectrum which has been deflected while the remainder of the spectrum is shown in the other disc; where the discs overlap we see white light. By using two prisms, one of which deflects the light downward and the other upward from the normal we can obtain three discs of light. The prism carrier may be moved across the spectrum by means of the cross slide and complementary colors clearly demonstrated. (This was then shown.)

The absorption spectra of colored glasses or of solutions can be satisfactorily shown by placing the colored glass or cells of the solution in the path of light just
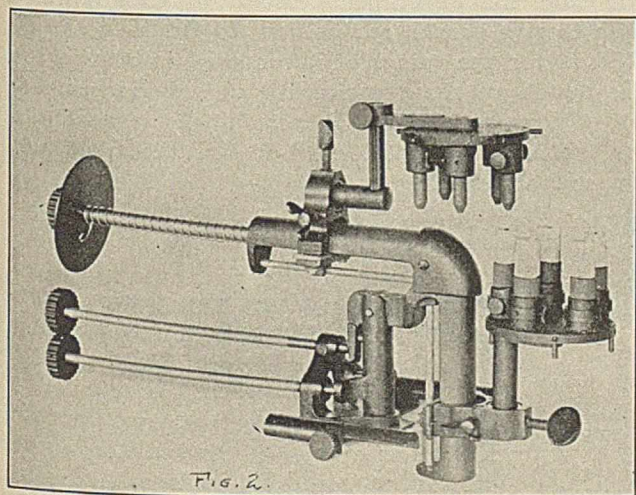
FIG. 2

back of the slit; that is, between slit and the light source, near the slit. Any spectroscope cell can be employed. Those which I use are twenty-five millimeters in thickness, provided with a glass stopper to prevent evaporation and consist of a glass ring cemented between two square plates which act as a support. With these cells I have found the following concentrations to be satisfactory: uranium sulfate 15 per cent, potassium bichromate $2^{1}/_{2}$ per cent, potassium permanganate $1/_{32}$ part per 1000, copper and ammonium sulfate $2^{1}/_{2}$ per cent, didymium

nitrate 30 per cent. These salts were chosen at the suggestion of Dr. Mees as six which gave very characteristic absorption spectra, and it is obvious that the absorption spectrum of any solution can be quickly demonstrated to an entire class in this manner.

The emission spectra of elements is shown with the same apparatus by introducing salts into the carbon arc as is well known. The old method of changing carbons for each element to be projected must be followed if pure spectra are to be obtained, but the inconvenience of changing hot carbons is overcome by the holder in Fig. 2.

Revolving holders for the carbons carrying the salts are not new, but in this design we have the revolving holder for the negative as well as the positive carbon, since if both carbons are not changed sufficient oxide is deposited on the negative carbon to give an impure spectrum with the next salt demonstrated. With work with direct current the best results are obtained by having the positive pole on the lower carbon which carries the salt. To eliminate the spectrum of the carbon arc, a vertical arc is used and the carbons separated until the image of the arc and the spectrum of the arc fall above and below the rectangular opening in the screen IV, Fig. 1. In this position the vapor of the salt becomes the source of illumination, and we have upon the screen the characteristic spectrum of the salt just as we see it in the spectroscope. In this form of holder one passes successively to each of the five different salts with the minimum inconvenience and by turning the upper carbon holder each time the lower one is turned, has in reality a fresh pair of carbons for each demonstration.

The question of the best manner in which to introduce the salts in the arc next confronts us. The way in common use is to employ a carbon of the flaming arc type or to drill out the core of the soft-cored carbon A, Fig. 3, and then fill this hole with asbestos cement made up with the fluoride or chloride of the element. I have found this to give good results when sufficient care had been exercised in preparing the
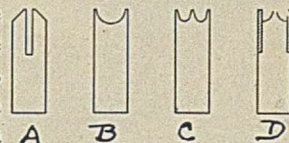

FIG. 3

carbon, but very frequently the substance melted and ran to the bottom of the cavity, leaving insufficient material for the arc to give a brilliant spectrum. There is also trouble in preparing a number of carbons if one wishes to demonstrate any number of salts. A solid carbon turned out as in B, Fig. 3, was next tried but in this case the arc would form at the edge of the crater and run around the carbon, making it impossible to keep it centered. This led to C, Fig. 3, in which it was hoped the arc would remain at the center where the little projection of carbon was left for the purpose, but this did not prove successful for the reason that the arc in following the line of least resistance would sometimes jump to the circumference. It, therefore, was little better than B.

Next a solid carbon was turned to the shape shown in D and a cup formed by placing a short piece of porcelain combustion tubing in the place indicated

by the shaded portion. While this process was successful in so far as keeping the arc centered was concerned and gave an easy method for introducing any salt into the arc, it had the serious objection that the glaze of the combustion tubing gave the sodium line in all spectra. Finally, fused quartz was substituted for the porcelain and the result is a satisfactory cup for the process. By using a carbon of small diameter in the upper holder there is no difficulty in striking the arc, even after the original carbon projection has been burned away. Any salt can be quickly introduced and the silica tubes serve for a number of burnings. Spectra of barium, strontium, calcium, lithium, and silver were found to be satisfactory for demonstration. (These spectra were then shown.)

The spectra of gaseous elements have not been projected, owing to the fact that sufficient illumination could not be secured. The transformer type of spectral tube, Fig. 4, as designed by Dr. P. G. Nutting overcomes this difficulty for, owing to its construction in which a large capillary is employed with correspondingly large electrodes, a light 100 times as intense as that produced by the old tubes is secured. This type of transformer tube uses about 10,000 volts which I secure by means of a Clapp-Eastman transformer operating on an alternating current of 110 volts. This is an inexpensive and excellent transformer and together with the tube described gives us good illumination without noise. The holder for these tubes consists of a suitable piece of asbestos wood supported on a clamp which fits the optical bed. There is an asbestos wooden block on this which holds the tube supported by a brass plate in which the slit is cut. The plate
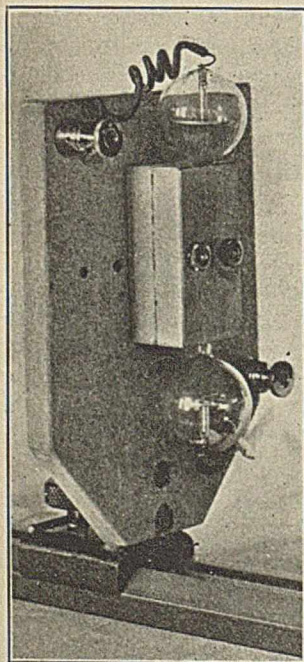
Fig. 4

is held in position by two posts with nuts. The holder also carries two binding posts so that connections with the platinum wires of the transformer tubes can be carefully made at leisure, leaving any hurried changes to be made with the feed wires at the large binding screws. The holder with the tube is placed in the same position as the slit for the other experiments. The helium, hydrogen, and neon tubes used were loaned by Dr. Nutting. (Spectra of the three elements were then shown.)

For the arc spectra a similar holder, Fig. 5, is provided, but in this case of slate since the resistance is such that the 10,000 volt current from the condenser will flow from one terminal to the other through asbestos wood. A porcelain hood with brass cap in which the slit is cut is mounted to prevent light falling into the room and the metallic electrodes are fitted with pins as illustrated so that in changing from one set of electrodes to another it is only necessary to insert them as far as the pin will allow them to go and secure them with the set screws. The electrodes have chisel points.

Connections with the current are made at the binding posts. So far we have not been able to obtain a suitable screen for demonstrating the ultraviolet spectra of these arcs to any considerable number of people but hope to accomplish that later. In observing the spark spectra of metals in the ultraviolet, the projection lens is replaced by one made of quartz and the bottle prism of carbon bisulfide by a quartz Cornu prism.
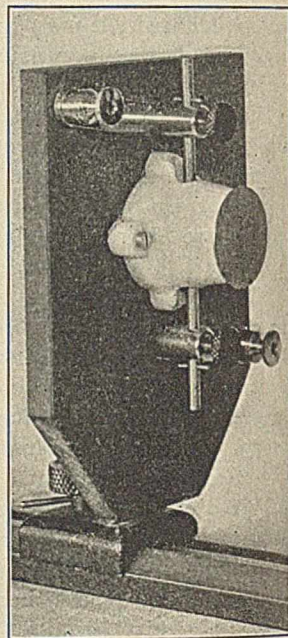
Thus, we have simple devices for certain spectrum experiments which can be carried on so that an entire class may view the results simultaneously and also used as a supplement to the table spectroscope.

Fig. 5

It is hoped that those interested in the subject will find the experiments useful in their work. I wish to give proper recognition to Dr. Mees and Dr. Nutting for the valuable aid rendered in working out the details of the experiments and offering valuable suggestions and to Mr. Patterson who is responsible for the designs of the special apparatus, carbon holders, supporters, etc.

BAUSCH & LOMB OPTICAL CO.
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A SHORT METHOD TO DETERMINE THE EFFICIENCY OF OXIDES FOR GAS PURIFICATION

By A. F. KUNBERGER

The gas engineer as a rule is not as much interested in how much total iron oxide is contained in a given batch or shipment of oxide as he is in how much hydrogen sulfide can be removed per ton or per bushel of oxide before it is saturated and requires renewal.

That the regular chemical analysis does not give him this required information is evident from the fact that one oxide containing almost twice as much Fe_2O_3 as another, may absorb but $1/10$ of the amount of H_2S absorbed by the latter, and it is the object of the present communication to describe the method developed and employed in this laboratory for the estimation of the efficiency of purifying oxides.

To determine the quantity of H_2S a given oxide would be able to decompose, the water formed by the reaction was absorbed in a weighed tube containing

fused $CaCl_2$, as a preliminary experiment. It appeared evident, however, that these results must be incorrect unless the amount of moisture in the oxide could be correctly estimated before and after the test, so as to correct for the moisture originally contained in the oxide, and carried along by the water formed by the reaction. This is difficult, and requires time, and, owing to the rapidity with which some oxides revivify, it is almost impossible. Without this correction the method would be lacking in accuracy to such an extent that it would be of little value, and to avoid this the entire products must be weighed.

The results obtained were very satisfactory, and the method has been in use for over a year with good results. It enables one to determine in a very short time (about 1 hour), whether an oxide to be used, is very active, active, or indifferent.

The procedure is as follows:

A glass tube with a bulb at one end (see C in sketch) is most suitable to hold the oxide to be tested, but a
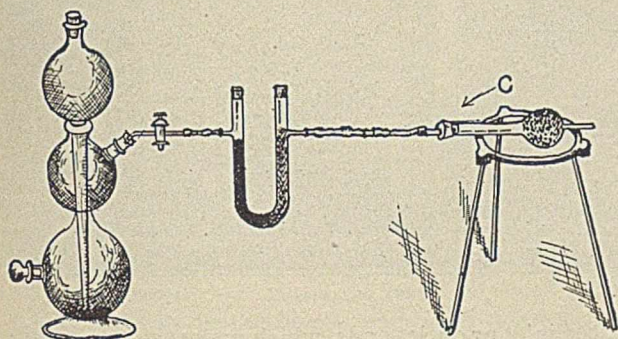
U-tube or almost any other tube compact enough so that it can be weighed on an analytical balance will answer.

In tube C a ayer is placed over the outlet to prevent any of the contents from passing through the little outlet tubing. On this cotton is placed enough small granular calcium chloride to fill the bulb; it is then covered with a thin layer of cotton to hold the calcium chloride in place.

Five grams of the oxide to be tested are next mixed with about 2 grams of coarse sifted sawdust and placed in the tube, and covered with another layer of cotton to prevent any of the contents from falling out at the stopper end of the tube. The stopper is then inserted. The entire tube is accurately weighed and the total weight noted.

A U-tube filled with calcium chloride to dry the hydrogen sulfide issuing from the generator is connected with the test tube by means of a piece of rubber tubing and the whole connected with the generator. A small piece of glass tubing closed at one end so as to leave only a hole the size of a small pinhole and placed between the U-tube and the generator regulates the flow of gas.

The hydrogen sulfide gas generated in the Kipp generator, and dried by passing it through the calcium chloride in the U-tube, is decomposed by the iron oxide in the test tube C, forming iron sulfide and water. The water formed is absorbed by the calcium chloride in the bulb of the test tube.

The test is carried on for 1 hour, after which time the test tube is disconnected and weighed. The gain in weight represents the amount of hydrogen sulfide absorbed, or rather decomposed, by the oxide. By dividing the amount of oxide taken, into this weight, the percentage of hydrogen sulfide decomposed can be determined, and from the latter the sulfur calculated.

The following analysis and fouling tests made with some oxides will illustrate how much more satisfactory results can be obtained by the fouling test than by chemical analysis alone.

Sample No.	No. 1 Per cent	No. 2 Per cent	No. 3 Per cent	No. 4 Per cent	No. 5 Per cent
Iron oxide	47.36	64.00	65.92	72.32	76.90
Total H_2S absorbed in 1 hour	22.01	19.85	10.80	2.66	2.80
Total H_2S absorbed per unit of Fe_2O_3	46.5	31.0	16.4	3.7	3.6
After revivification	21.34	3.5	3.34	1.66	1.58

Since the above fouling tests were borne out by results obtained on a large scale in the works, one is encouraged to believe it will greatly reduce the work of the chemist, and at the same time give information that usually can not be obtained from chemical analysis alone.

Some oxides are very active at the first fouling (when new), but revivification is slow and incomplete, and on second fouling they give far lower results. For this reason it is sometimes desirable to carry the test far enough to determine the total absorbing capacity of an oxide. This is particularly the case where a new oxide is to be introduced, as well as where new shipments are to be received. In this case it is advisable to keep the $CaCl_2$ and oxide in separate tubes, but they should be weighed together.

After the first fouling, the oxide tube is disconnected from the $CaCl_2$ tube, and air passed over it until completely revivified. To prevent an oxide which has the tendency to revivify very rapidly from getting too hot and consequently burning, thus becoming more or less inert, it is advisable to pass the air used for revivification over water so as to saturate it with water vapor.

After complete revivification, the tubes of oxide and $CaCl_2$ are again weighed and connected with the Kipp apparatus, and fouled a second time. This second fouling as a rule is sufficient to show how active the material is, for if the results of the second fouling are very close to those of the first, the material is very active, but the test can be repeated the same number of times as the oxide is revivified in practice: thus the entire capacity of the oxide can be determined before it is placed in service.

CHEMICAL LABORATORY
UNITED GAS IMPROVEMENT CO.
PHILADELPHIA

THE ELIMINATION OF RUBBER STOPPERS FROM THE VITRIFIED CLAY COMBUSTION TUBE BY MEANS OF TAPERED CLAY INLET AND OUTLET

By CHAS. MORRIS JOHNSON

In THIS JOURNAL, **5,** 488, the writer published an account of a vitrified clay combustion tube with

tapered outlet designed by the author and manufactured at this works. The tube has been in successful operation for six weeks of twenty-four hour working days and is still in commission. Several more are now in use and mark a considerable reduction in cost of carbon determinations as the material from which the tubes are made costs less than 1 cent per tube.

The advantage of the tapered outlet very soon suggested the making of a tapered clay inlet which is shown at K in the illustration and also at L-M.

The clay part of the inlet is a duplicate of the outlet end. The tube is charged and discharged by re-

pierced by the cylindrical surface of the combustion tube which makes only a single circle of contact between the stopper and the tube. The slip-over gives a tangential contact which provides innumerable circles of contact.

Further superiority of the tapered clay and rubber sleeve inlet is that, should the bore of the combustion tube tend to be elliptical instead of a true circle, the elasticity of the rubber sleeve will still give a pressure-tight connection on account of the large surface of contact.

Again, many combustion tubes offered by dealers are rejected because of grooves in the interior walls,
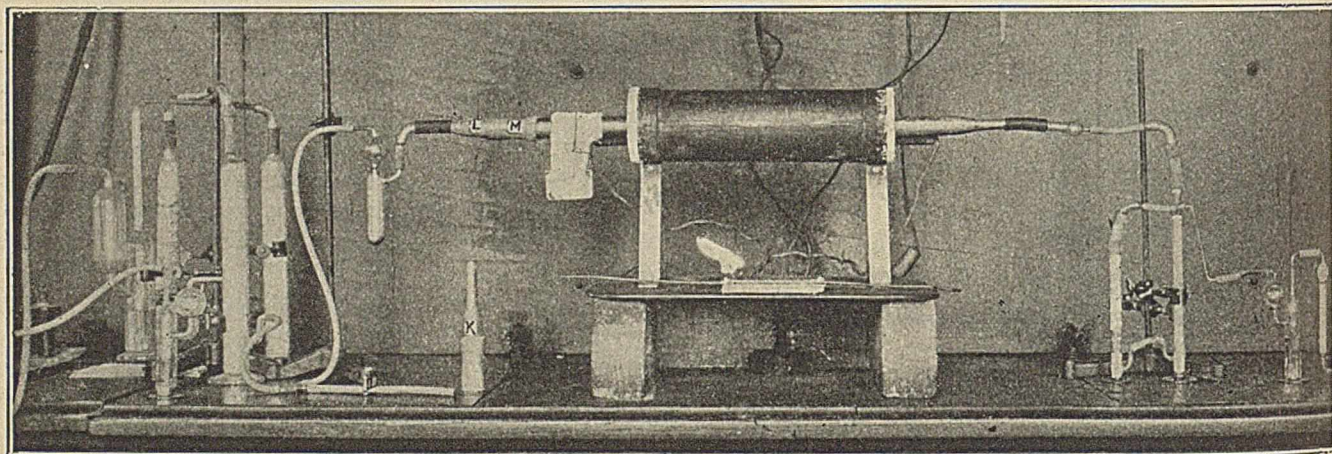
moving L-M which is connected to the main part of the combustion tube by means of the rubber sleeve M. This connection is a piece of $3/4$ inch bore, $3/16$ inch wall and $2^1/4$ inches long, pure rubber tubing. This sleeve is more easily handled than a rubber stopper. The operator grasps L-M at the clay part L and slips it over the main part of the combustion tube and twists it firmly in place. The clay part L offers a substantial hold for one's hand and is absolutely safe. A glass taper would be dangerous as it might be crushed when grasped, causing a wound.

The slip-over connection is geometrically a tighter connection than a rubber stopper, for the reason that the latter affords an example of a conical surface

at the inlet or outlet ends, which make tight connections with rubber stoppers impossible. The tapered slip-over connection renders such tubes perfectly satisfactory.

The entire apparatus with the single exception of the little mercury valve tube attached to L-M is the author's design and shows but one rubber stopper at an unimportant point in the little KOH drying tube at the extreme outlet end of the combustion train. This could also be eliminated by a small glass taper or clay taper.

LABORATORY OF THE PARK WORKS
CRUCIBLE STEEL CO. OF AMERICA

ADDRESSES

EXPERT TESTIMONY—ITS MATERIALITY—CAUSES FOR ITS DISCREDIT—AND REMEDY[1]

By Judge J. T. Ronald

Expert testimony does not always consist entirely of opinions. The bacteriologist *knows* whether microbes are in the water and whether germs are in the food; the toxicologist *knows* whether poison is found in the tissues; the metallurgist *knows* that certain clays contain aluminum and that it will bubble forth under certain heat; the chemist *knows* the results to follow certain conditions; the doctor *knows* the causes of many diseases and conditions; the constructive engineer *knows* the tensile

[1] Address delivered by Judge Ronald, of the King County Superior Court, before the Puget Sound Section, A. C. S., March, 1913.

strength of various materials; the civil engineer *knows* levels, curves and volume of cuts and fills. All this is expert testimony, but this paper deals only with that class of expert testimony which consists entirely of opinions on questions of science or skill, given by persons learned or experienced therein. It constitutes the exception to the general rule of law, that opinions are not admissible in evidence.

Eminent jurists are on record in favor of the abolition of this exception and the rejection of all opinions as evidence. This, in my opinion, would be a serious retrogression, and would result, in many cases, in excluding from courts of justice material truth, and the consequent rendition of unjust judgments based on falsehood.

The field of judicial investigation, requiring the assistance

of experts, is illimitable. Questions relating to human anatomy, diseases of the human body, derangement of the functions of the brain, the genuineness of handwriting, valuation of or damage to property, compliance with technical requirements of contracts, infringement of patents, causes of death, existence of mineral veins, customs of marine traffic, causes of this or that chemical, electrical or some other natural phenomena, of which the average lawyer, juror and judge possess no knowledge, are, in some form or other, subjects of daily investigation in our courts.

The further advancement of sciences in new and unexplored regions, supplanting last year's contested theories with this year's established facts, and evolving from last year's unlocked dark mysteries the dawning light of this year's progressive theories, thereby appreciably magnifying the importance of enlightening the trial tribunal with the best evidence which advancing science can produce, makes the testimony of the expert more and more a material aid to the ascertainment of truth. Nor must it be supposed that the expert in the scientific field deals altogether with mere theories.

While it is true that many of Nature's laws are not understood; that many conflicting systems of some of her branches of science have not been reduced to uniformity or exactness— thereby affording an ever fruitful source for conflicting theories, or for disagreements among contentious exponents, however sincere, yet, in the words of an eminent writer: "No one who is borne along by the irresistible current of modern inductive thought, can escape the conviction that in the realm of Nature, all things—all activities—conform to definite and immutable laws; that many of these laws scientists now understand and have formulated in terms of mathematical precision. The astronomer has scanned the heavens and read the glories of infinity; the geologist has studied the earth and found 'tongues in trees, books in running brooks, sermons in stones and good in everything.' Old ideas have perished in the retort of the chemist. A new world has been discovered by the microscope; everywhere has been found the infinite. In every direction man has investigated and explored, and nowhere on earth or star has he found the least interference with the external reign of Nature's laws."

A practical chemist can tell whether stains are of blood or rust, and if of blood, whether of man or beast. The experienced toxicologist can determine whether death be the result of poison; yet, upon true answers to these and many similar questions, justice itself, stern and exacting, or a human life may depend.

Such testimony is often the only means of arriving at the truth, and "When delivered with caution and without bias in favor of either party or in aid of some speculation and favorite theory, it becomes a salutary means of preventing intelligent juries from following a popular prejudice, and deciding a cause on inconsistent and unsound principles."

Yet, material as expert opinions are to the administration of justice, the courts are confronted by a condition where, whatever the causes, the evidence of the paid expert has very little, if any, value with judge or jury. It is admitted because the law allows such, and because nothing better can be had, but it is a common occurrence, after such testimony has been elaborated and at great expense introduced, to see juries who, instead of being enlightened and aided, are but bewildered and perplexed, and show their contempt by absolutely disregarding the whole mass thereof. "They do not attempt to weigh honors, learning, experience or standing of one expert contradicted by another. They do not attempt to compare relative value or reasonableness of conflicting expert testimony."

While conceding its importance, it is condemned by judges in general, by respectable legal text books and journals. It meets no praise in any recent decision—finds no welcome in any existing court. One author says: "There is a growing tend-

ency to look with distrust upon every form of skilled testimony."

An eminent writer and lawyer in an address before the Pennsylvania Bar Association in 1898 said: "It is patent to any one who chooses to inform himself that expert testimony, as now received in our courts, is looked upon by the public as an unmitigated farce and a nuisance."

The Supreme Court of Michigan (29 Mich. 4) says: "The experience of courts with the testimony of experts has not been such as to impress them with the conviction that the scope of such proofs should be extended. Such testimony is not desirable in any case when the jury can get along without it."

The Supreme Court of the United States (1 Curtis 439) says of it: "This species of evidence is less satisfactory than any other."

Nowhere is this state of affairs more deplored than among members of the profession themselves. *The Medico-Legal Journal* of June, 1912, of medical opinions, says: "The value and efficiency, and public utility of medical expert testimony has fallen into great disfavor among all classes of our people in a lamentable degree."

A well-known alienist, writing in the March number of the same journal, said of his own profession: "No class of specialists in any profession has been as bitterly assailed and severely criticized as the alienists. * * * They are the victims of public suspicion, of newspaper condemnation, and of the criticism of their own colleagues in the medical profession. * * * The shadow of suspicion universal and disquieting falls athwart the reputation of the alienist and, like a freak of the unreasoning elements, descends alike upon the just and the unjust."

Now, it is a bad condition of affairs when testimony so material, and in many cases absolutely indispensable, to the cause of truth and justice, should go upon its mission so tainted and discredited. There are underlying causes for this degradation, and before this class of evidence can have its due weight and effect it must regain public confidence; to do this the underlying causes must be removed.

Among lawyers generally, and judges and thoughtful writers on the subject, there exists great unanimity as to the principal causes responsible.

One contributing cause is often found in the lack of qualification of the expert himself, or in the ignorance of counsel, and sometimes in both. Courts are often too lax in applying the tests of qualification. Instead of requiring the proffered expert, as a pre-requisite to giving his opinion, to *show* he possesses special knowledge and skill concerning the particular subject under investigation, all that is generally required of him is to *say* he possesses some knowledge of the subject, whereupon the Court indulges the presumption that he is entitled to exploit his theories. My mind recalls an instance related by a prominent lawyer, where the "whole construction of a railroad was shown to be wrong from beginning to end by the testimony of a man who had been a section foremen until he had reached a point of inefficiency even for that job."

I have known expert surgeons to be totally discredited by glib and voluble doctors whom no intelligent man would trust to sew up a cut finger.

Average professional knowledge does not supply proper qualifications in all cases; yet average doctors often testify without any investigation or experimentation, in cases involving chemical or microscopical examination. I have, on more than one occasion, witnessed the spectacle of an ordinary doctor who never saw the defendant until the day of trial, and then only for a few minutes when the prisoner knew he was being watched, setting up his opinion with an air of greatest confidence, against the experienced alienist who had been observing by night and by day without knowledge or suspicion on the part of the prisoner.

Again, it is not uncommon to see the old successful practi-

tioner, with presumptuous pride, relying entirely upon his learning—his reputation—without making the least investigation of the precise matter in dispute, in face of the well recognized fact that "experiment and discovery are so constantly changing theories on scientific subjects that the books of last year may contain something which this year everybody rejects as absurd," and when such an experiment is made by another, discovers the error of his position.

And often when the expert is well qualified, the lack of knowledge of examining counsel deprives court and jury of the expert's science.

The more counsel knows of the science under investigation the more easily can the whole truth be extracted from the scientist. It is not always easy, under our rules, for an expert, however skilled and unbiased, to state the whole truth clearly in answer to questions propounded by uninformed lawyers, and if the expert, perceiving the lawyer's lack of information, and noting the defects in his questions, suggests the needed elements to elicit the whole truth, he is called down by the other side for volunteering, and required to confine his answers to the senseless questions propounded.

Ofttimes an illustration designed to bring out the whole truth plainly, is spoiled by confusing interruptions of the examining counsel, or technical objections of his opponent. Often on cross-examination a paragraph from some book is read to the expert witness conflicting with the opinion he has advanced.

Now it is a well-known fact that writers on science, and especially medical science, have their various and conflicting theories which are sustained or combatted with great ingenuity. The other lawyer, and perhaps the expert himself, does not know that the theory supported by the quotation read may have been "vigorously contested or perhaps triumphantly overthrown by other authors."

Another contributing cause is the "Hypothetical Question." This judicial "Hydra" has been long tried, fairly weighed and, to the detestation of all fair-minded experts and the abhorrence of all broad-minded courts, has been found to be a useless vampire which, in practice, devours the very truth it was, in theory, designed to convey. Whatever the theory of the rule requiring it, in practice a vast majority of hypothetical questions do not, and from the nature of the case ordinarily cannot adequately and, therefore, impartially present either the actual or most probable state of the case. Seldom is, and, assuming the fairest intention in the examining lawyer, rarely can the question be so framed as to embody a full and fair submission, or to embrace a completely comprehensive view of all the relevant facts or elements in the case. Therefore, the opinion of the expert, who has not himself heard all that was to be heard, nor seen all that was to be seen, must necessarily cover only a part of the ground and be misleading. The fact that other and new elements are injected, or brought out on cross examination, eliciting apparent modifications or qualifications of the opinion in chief, tends to develop a seeming inconsistency and to create in the mind of a juror an impression that the expert is a partisan, who in his original answer attempted to mislead the jury and who, finally contradicting himself, is unworthy of belief. This method has been aptly characterized by one writer as the "Hypotheses abomination—a lamentable method, vicious, misleading and subversive of every attempt at fairness." Concerning it and its answer, another has written: "It is perhaps the most abominable form of evidence that was ever allowed to choke the mind of a juror, or throttle his intelligence."

Another contributing cause lies in the fact that there is no limit, except the arbitrary discretion of a court, as to the number of expert witnesses a party may call, and it is rare when one party will content himself with a less number than his opponent had. This practice, besides producing a "motley collection of conflicting opinions" leaving confusion worse confounded, tends to disgusting prolixity and entails an expense far beyond the value of any results realized.

Concerning this practice a Justice of the Supreme Court of the United States (29 How. 101) said: "Experience has shown that opposite opinions of persons professing to be experts may be obtained to any amount; and it often occurs that not only many days, but even weeks, are consumed in examinations to test the skill or knowledge of such witnesses and the correctness of their opinions, wasting the time and wearying the patience of both court and jury, and perplexing instead of elucidating the question involved in the issue."

Another member of that high court in 1 Curtis 439 said: "It is common remark that when there is any room for a difference of opinion, experts in about equal numbers will generally be found testifying on each side."

Justice Miller, one of the ablest members who ever graced that august bench, said (4 Dill 488): "My own experience, both in the local courts and in the Supreme Court of the United States, is that whenever the matter in contest involves an immense sum in value, and when the question turns mainly upon opinion of experts, there is no difficulty in introducing any amount of them on either side."

But chief above all causes, and far more disastrous in its results, is the partisanship of the experts themselves. I do not wish to be understood as intimating that experts, as a rule, are dishonest. Far from it. No class of experts have suffered so much in reputation among jurors and the public generally as medical experts, and yet to say they all, or even generally, are dishonest is to utter an infamous libel against the most unselfish profession in the world. But there are dishonest men in all professions. I am impressed with the conviction that some make a business of furnishing expert opinions to order. Sometimes in their partisan zeal to further the interest, right or wrong, of the party employing them, they will not hesitate to inject into a case, not only an immaterial, but a dishonest element. Time and again have I heard a physician, driven to the wall for an excuse for his opinion that a litigant's injuries were not the result of accident, defend his untenable position by delivering a supposed "knock out" to the effect that he had found upon the person of the party, scars which might have been (not that they probably were) caused by syphilis—thus injecting into the case a false theory or possible defense never testified to by a single witness or suggested by any inference from the pleadings.

In a certain personal injury case in this county some years ago, plaintiff's expert testified to permanent injuries; defendant's experts testified to the contrary. At one period during the trial the medical gentlemen finding themselves together in my present chamber, fell to discussing the merits of the respective theories. One of them, at the time of the highest standing in his profession, was overheard to say: "I am an expert for the plaintiff and must necessarily hold up the plaintiff's cause of action. You are an expert for the defendant, and you must necessarily testify in favor of the defendant."

The public have not forgotten an episode occurring during an inquiry about two years ago into the sanity of Harry Thaw, where a certain prominent alienist swore that Thaw had no incurable mental disease; whereupon being confronted with a report he had made before the famous trial to Thaw's counsel, to the effect that Thaw was burdened with a "hereditary malady with a sequence of aberrations that amounted to a chronic ailment," he attempted to explain his contradictory statements with the statement that these anti-trial opinions were merely a "medical brief" for the use of Thaw's counsel during the trial.

It is just such exhibitions as the foregoing by exponents of science that provoked from a learned writer the following severe arraignment of science: "If Science, for a consideration, can

be induced to prove anything which a litigant needs in order to sustain his side of the issue then Science is fairly open to the charge of vena ity and perjury, rendered the more base by the disguise of natural truth in which she robes herself;" and that caused Professor Himes, a writer in the *Harvard Law Journal*, to say: "It is often surprising to see with what facility and to what extent their views can be made to correspond with the wishes or interests of the parties who call them."

This language can apply only to dishonest experts, for it is not correct to say, in all instances, that experts shape their views to correspond with the wishes of the employer. The honest expert refuses to conform his views to any interest save what he believes to be the truth. As a lawyer cannot be expected to employ an expert whose opinion is against the interest of his client, so a scientist, who finds his views happen to conform with the view of the employer, violates no rule in engaging, for a consideration, to testify his sincere opinion. But when an expert, sincerely believing in the correctness of his views, finds himself employed to defend them because they accord with the theory which his employer seeks to establish, there naturally springs in the most honest breast a zeal to prove, in this battle between contesting theories, the soundness of his own opinion. And the stronger his convictions, the more natural it is—however honest and unpurchasable he may be—that he should become the earnest advocate of his theory, and, unavoidably, a zealous and loyal assistant of the attorney paying him to establish that theory. It is too much to expect an expert, who thus looks upon the contest as a battle between the true and the false, in which he is engaged to aid in the triumph of the true, to be entirely unprejudiced. He will not sit calmly and see his theory, which he believes to be the truth (and which he is paid to establish), overthrown by what he believes to be the false. The greater his sincerity, the more earnest his advocacy. The experts then become the contending parties in a contest of theories. They align themselves into classes—each becoming a champion of his own class theory, and assuming the attitude of the advocate rather than that of a scientist. The expert is then truly biased. It is a purely scientific bias due to his peculiar views. It may be likened to the religious bias of the sincere and zealous minister favoring the theory of hell fire for the sinner. "Against such a bias no amount of self-restraint, nor the most sensitive conscience will fortify a man." Such a man is often an upright, learned, conscientious man, deserving and commanding the greatest respect and profoundest admiration—all of which only tend the more to confuse the jury and bewilder and perplex the court. Time will not permit citation of numerous instances of record verifying this statement.

The field of the engineer, comprising as it does questions of drainage, dyking, dams, adjustments, etc., affords a most prolific source of some most fallacious theorizing, and of some rank partisanship. As samples of the former I recall an instance where the question before the court was the feasibility of the present system or plan now happily in operation for the drainage of our White River Valley in this county. The establishment depended, by statute, upon the findings of the court of its feasibility. The farmers were hopelessly divided. Some were actively urging the system as the only means of reclaiming and utilizing that part of the valley subject to overflow; others were bitterly opposing it as a menace carrying certain destruction to the whole valley—the reclaimed as well as the unreclaimed. Engineers were aligned in support of the opposing theories. One class contended that the overflow of the valley, which occurs for a short period yearly following our chinook winds, would result in diverting and shifting the united waters of the White and Green Rivers to the channel of the proposed canal, scouring out and irreparably damaging the whole of that fine valley. The court, however, adjudged the plan to be feasi-

ble. Several miles of canal, reaching almost the entire length of the valley, were dredged. Instead of the channel below the junction of the two rivers shifting to the canal, the White River above their junction changed its course entirely from the north to the south, and now finds its outlet through the Stuck and Puyallup Rivers to the Sound forty miles to the south, while only the waters of the Green River now flow north through the original channel, of what, before the shifting, was called White River; and for years abundant crops have been produced where for ages before there existed only marshes and duck ponds.

Again I recall where a jury in my division of the Superior Court was assessing damages for the present regrade of Fifth Avenue in this city. As all know, this avenue runs along the face of the hill. The owners of property on the east or uphill side of the street were basing claims for damages on the liability of the whole hill sliding down as a result of the new and deeper cutting. Again engineers were aligned—some on behalf of the city and others on behalf of different property owners. Both sides were familiar with the character of the soil and its different substrata, and each expert became an earnest advocate of his class theory. The jury put greater credence in the opinions of the city's engineers and awarded damages on the theory that there would be no sliding. Less than three years have elapsed. The whole face of the hill has been sliding. Costly buildings have long since toppled, a mass of ruins, while a large area of the hillside is continuously shifting, requiring the constant work of teams to keep the regraded streets free from the moving earth, to the enormous damage to the city.

But a field wherein the engineer witness becomes the partisan advocate is in cases for the assessment of damages for adjustment of property to regrades, etc. All are familiar with the rule allowing damages for buildings wholly taken or partially damaged by regrades. Where there is no means for adjusting such buildings to the regrade, they, of course, are totally lost, and then the amount is easily ascertained; but where the conditions are such that the buildings or plants affected may be adjusted, the statute allows the estimated cost of making a reasonable and proper adjustment with reference to the new grade. Here is where I have seen the engineer become a real artist. There are many different ways of adjustment; but what the law requires is the most feasible and practical adjustment, all things considered, with reference to the new grade, and for the allowance of the reasonable cost thereof. It has been, and is, the practice of some owners to employ engineers to devise plans of adjustment. Many times I have noticed that the plans were presented and advocated by the engineer witnesses with the greatest earnestness and plausibility, not with a view to procuring recoupment for actual loss, but with a view to putting the property owner in a better position than he was before. Instead of being made whole for his actual loss, he was to profit off the city.

The Supreme Court of Ohio, concerning this partisan tendency of experts, says (12 Ohio 483): "Whenever they have enlisted on the side of either party or of some favorite theory, the difficulties are greatly multiplied, and however honest or renowned for professional character the witness may be, such will be the conflict of their testimony in nine cases out of ten, that it will be utterly unsafe for a jury or court to follow or adopt the conclusions of either side."

And the Supreme Court of California (40 Cal. 396) declare: "It must be painfully evident to every practitioner that these witnesses are generally but adroit advocates of the theory upon which the party calling them relies, rather than impartial experts upon whose superior judgment and learning the jury can safely rely. Even men of the highest character and integrity are apt to be prejudiced in favor of the party by whom they are employed. And as a matter of course, no expert is called until the party calling him is assured that his opinion will be favorable.

Such evidence should be received with great caution by the jury, and never allowed except upon subjects which require unusual scientific attainments or peculiar skill."

An expert is defined in 27 A, L. Reg. 3, to be: "A man who is paid a retainer to make a sworn argument."

Elliot, in his "Work of the Advocate," says of this definition: "Bitter as this definition is, it is not entirely inaccurate. Expert witnesses usually do, with swiftness and avidity, seize every opportunity offered them to put forth an argument in the form of an opinion, and such an argument is the more hurtful because of the guise it wears. As an argument and nothing more it would do little mischief, but as an apparent opinion it may do much."

"Some experts do not realize their tendency to partisanship. Others are badgered into it by unfair efforts of cross-examiners to throw doubt and obscurity upon their direct testimony. These efforts are often instigated and directed by the expert advocate f r the other side."

A prominent attorney writing in the *Yale Law Journal* a couple of years past, said: "To the jury an expert is an expert—a kind of intellectual prostitute ready to sell his opinion and enlist in the service of the side that pays him."

From "Best on Evidence" I quote: "There can be no doubt that testimony is daily received in our courts as scientific evidence to which it is almost profanation to apply the term."

The Maine Supreme Court (65 Me. 74) characterizes it as the "Vain babblings and oppositions of science falsely so-called when the hopes of a party depend rather on mystification than enlightenment."

The evil is of long standing, and of increasing gravity. The subject of a remedy is being discussed by various State Bar Associations, and by numerous writers in legal and scientific journals, but there is no unanimity as to any remedy. Six of the states have enacted laws on the subject, but there is no uniformity, and but little effectiveness in the laws thus far adopted. Of the proposed remedies up to date, the two apparently most favored provide: One for the appointment of expert jurors as triers of scientific issues, while the other proposes the appointment by the court of all expert witnesses; that their compensation shall be paid from the public treasury. Various details are prescribed, such as providing for the reimbursing of the public treasury by the litigants, and for preventing the experts from knowing at whose instance, or expense, they are appointed.

The first method is not new. It has been tried. It originated in the old Roman practice (Dig. Lib. XXV. Tit. 4) and was one of the modes selected by our English ancestry away back in early times, before trial by jury was much developed, for the trial of issues relating to certain classes of facts, and so strictly was the mode adhered to that we find, even in that misty age, one instance at least of a jury exclusively of *matrons de ventre inspiciendo*. This mode of trying scientific causes by expert juries continued with much regularity, as a part of the English practice, during the thirteenth, fourteenth and fifteenth centuries, and even, but with waning regularity, up o the eighteenth century.

Riley's Memorials contain numerous instances of specially qualified juries called to try such issues as: Fishing nets with meshes smaller than those required by the trade; improper tanning of hides; false tapestry; improper hats and caps; false pewter vessels; false gloves; false wine; putrid victuals; malprac ice by surgeons; etc., etc.

However well this mode may have worked as a system applicable to a large and densely settled population, with many branches of science either unknown or but little understood, it is sure that under the theory of jurisprudence prevailing in our American colonies and later adopted as a part of the government of our states, recognizing the common law jury

as an integral part of our system, with our sparse population and limited number of scientific exponents of any particular branch of science, this method of calling experts as jurors was found inapplicable and gave way to our present method of allowing the respective parties to call experts as witnesses before our common law jury. And whether, in this age of advanced science, and with its numerous scientific experts and our increased population, it would be practical at this time to provide for a jury of purely scientific experts on every particular branch of science is, in my opinion, very problematic, but it is certainly very questionable whether such a law would not be violently opposed as contravening the whole theory of our jurisprudence.

And it is seriously questioned whether the other proposed remedy of placing the appointment of experts exclusively in the power of the courts would not be depriving a litigant of his constitutional right to call witnesses and produce evidence material to his case. It is, however, certain that any legislation on the subject must meet the approval generally of the bar; and it is equally certain that the bar will never approve any legislation which will enable the courts to create a privileged class of experts. A practice has latterly grown up for the court, at the instance of one litigant, to appoint one or two disinterested medical experts to examine the opposing litigant. This practice has now given rise to the charge, very extensively entertained among the bar, that the experts appointed by the court are not impartial, but are endowed with a leaning one way or the other; and when it is considered that judges are not infallible, that every judge generally has his family, or some other physician in whom he has greater confidence than in some others, and which doctor, notwithstanding, may be a charlatan in the profession, or under regular salary from some interest, there is some ground for this complaint.

An attempt has been made in some states to meet this by legislation requiring the judge to make appointments from lists selected by the parties, but in practice there has been found no way to compel the parties to agree on selections. The truth is, no legislation will afford a complete remedy. Something in addition to legislation is required. The right kind of laws can, however, do some good. If I were recommending any legislation I would propose a more liberal rule or policy for the admission of expert opinions. I see no objection to the judge appointing the experts from lists selected by the parties when they agree, but in case of failure to agree, I would not deprive a litigant of the right to call, at his own expense, his expert witnesses, but I would limit the number he should call. The party thus limited will be disposed to call only the ablest experts. This makes for economy in time and reliability in quality. In all cases where a litigant expects to rely upon expert testimony he should be required to file in the case notice of such intention, stating the subject, or scientific inquiry on which he proposes to offer expert evidence. Thereupon the court should have the authority, at its discretion, to appoint two experts, skilled in the same branch of science, to be paid out of the public treasury and to sit in the court room during the trial and hear all the evidence bearing upon the subject of expert inquiry, and to be called by the court, or by either party, after examination of the parties' experts, to give their opinions and to be subjected to cross-examination by both parties. Provision can be made for recoupment.

I would not restrict counsel to the hypothetical question, but would allow the expert witnesses for both sides, and the court's experts, sufficient latitude, by way of illustration, explanation or otherwise, to enable the jury to understand and comprehend exactly, if possible, the experts' positions. When the judge or juror knows the reasons for an expert's opinions he will be better able to weigh that opinion, and the court's experts will be better able to approve or disprove the same.

Such in brief are some of the benefits we might derive from

legislation, but I venture the suggestion that no legislation will make an unlearned witness competent, or a dishonest one honest, or a biased one impartial. Something besides legislation is necessary to prevent our present practice putting its premium on perjury, or reducing the honest expert to the level of the charlatan.

The real remedy, the true reform, in the final test, rests with and must come from the persons largely responsible—the professions themselves, comprising the expert witness and the lawyers. So long as it is profitable to use or to give faked or biased expert testimony, so long as it can be bought and sold without loss of professional standing, so long will it be a commodity hawked in the trial courts.

"In nearly every city of importance," writes a thoughtful observer, "there is a doctor notorious among lawyers as 'plaintiff's expert' who can be relied upon to give plaintiff what he wants. The lawyers who use him on a contingent fee retain their standing at the bar," and I might add, on the other hand, there are in such a city one or more doctors under stated salary for employers of labor, and who are known among lawyers and jurors as "defendant's experts."

The result is that doctors have largely become known or classed as "plaintiff's experts" and "defendant's experts." One class magnifies symptoms and injuries, the other minimizes and makes them imaginary. To quote from one of the aptest writers on the subject: "The plaintiff's expert has argued and reasoned himself into a frame of mind that sees in the given case just what the plaintiff's attorney needs. On the other hand, the defendant's expert sees a malinger in every man who asks damages. It is the old story of bringing to the market what the market demands. If deformities are the fashion, deformities are cultivated. We are not talking of charlatans. The doctors who are doing this are the leaders in their profession, who qualify with respectable medical degrees, professorships in leading medical colleges, and membership in the principal medical societies. Now, as long as these men can do this and remain leaders in their profession, just so long is any chance at real reform postponed. Just as long as a leading physician can accept a general retainer from a street railway company and appear day after day, in case after case as 'defendant's expert' and retain his professional respectability, just so long will you have 'plaintiff's experts' and 'defendant's experts.'"

It is not against a physician that he is under a salary from a railroad company, but this relationship makes it unprofessional for him to act, at the same time, as expert witness. His place is beside the counsel and as a medical advocate, not witness. The doctors can so frown upon the practice of acting as medical counsel and witness as to stamp it out.

When the professions "set a moral standard that demands that a member testifying under oath in court must state his opinion fairly and fully without bias and without regard to the side that calls him, neither suppressing nor overemphasizing any aspect of the case, then and only then will you have real expert testimony."

"When you have that standard established the charlatans and fake experts will be driven from the courts, because what they have to offer can not be successfully used."

Having exposed the shortcomings of other professions, I now turn to my own, and charge the legal profession with its share of responsibility. The lawyers have done as much as the experts to create a demand for "plaintiff's experts" and "defendant's experts." If the lawyer would refuse to buy, the expert could not sell. Lawyers whom no motive would induce to suborn an ordinary witness will offer a premium for the biased expert. Attorneys who would scorn to pass counterfeit bills will not scruple to palm off fake expert testimony on a jury.

There will always be lawyers who will look upon "lawsuits as games to be played and won by any means that the rules allow" and this seems to one of the rules of the game. If the honest expert will not give him what he demands he vigorously searches in the open market for what he wants.

"If he cannot get the real article he furnishes up the counterfeit and passes it off on the jury. If he finds that the genuine expert opinion is against him, he may, at least, deliberately play the game with the counterfeit to disgust the jury with all expert testimony and even up things by leading the jury to disregard it for both sides."

"As long as the standards of the profession countenance this abuse, so long will it continue. Whenever the good lawyers will not, the shysters cannot continue to misuse expert testimony."

I cannot resist the temptation, at this point, to relate the instance of a certain lawyer in a case in one of the eastern states, who after having introduced expert evidence and finding himself confronted with outweighing contradictory expert opinions, and realizing overwhelming defeat if reliance were to be placed upon such evidence, in addressing the jury said: "Gentlemen of the jury: There are three kinds of liars—the common liar, the d—d liar, and the scientific expert."

The legal profession can reform itself. The ambulance-chasing lawyer is becoming extinct before the frowns of the profession. The present code of legal ethics came in response to the general demand of the profession. The good sense of all the professions must adopt standards in the use of expert witnesses which will make such witnesses useful and their evidence effective in the interest of truth. If the professions will establish the standards, the court will enforce them.

A scientist in the classroom aims to teach truth, and when in the court room, where a life may depend upon his words, he should be equally as impartial. He should advance nothing before a jury he would not advance before a learned society or before a class.

An expert witness should be in practice what he is in theory —an adviser of court and jury. The judgment of a scientist based upon partial facts is as unjust as a judgment of a court similarly based. No lawyer expects a biased judgment from a court. He has no more right to expect one from an expert. The expert who is the sole repository of this scientific knowledge, the sole possessor of this peculiar skill, owes it to his position as a true scientist to declare the truth as he sees it; just as the judge possessing the knowledge of the law, owes it to his position to declare the law as he sees it. A scientific man is not a concealer of truth, but a searcher after concealed truth, and, unlike the habitues whose existence depends upon concealment, he should come into court with clean hands and a pure heart, with sincerity of purpose, with a tendency and desire to ascertain and recognize truth wherever and whenever it may be found— whether in the silent meditations of his library, or after the soul-burning and anxious experimentation of his laboratory, or whether brought out by the disputes, disagreements and discussions in the court room; to conceal nothing, ever mindful of his oath which requires him to speak, not a partial, but the whole truth; or, in the language of Dr. Walton: "His testimony should be the colorless light of science brought to bear upon the case * * * To the true expert, in that responsible position, the utterance of half truths should be simply impossible."

THE SMOKE NUISANCE; A QUESTION OF CONSERVATION[1]

By Raymond C. Benner and J. J. O'Connor, Jr.

INTRODUCTION

Neither for those who live in nor for those who even visit an industrial centre which burns a large quantity of bituminous coal, is a definition of the smoke nuisance necessary. Its effects

are apparent on every side and no man, woman or child escapes them. The smoke nuisance is truly a modern plague.

It is only within the last few years that any serious study has been given to the various phases of the problem other than to the engineering. However, a remarkable change has taken place. There is not a city in the country that has the smoke nuisance in an acute form that is not aroused to the seriousness of the problem and is not attempting in one way or another to abate it.

It is rather appropriate that the city of Pittsburgh which, with its sobriquet "The Smoky City," has long been held up as the shining example of the smoke nuisance should be the center of an investigation which claims for itself comprehensiveness of plan if no other merit. It leaves no phase of the smoke problem untouched. The donor of the fund for this investigation was actuated by the belief that a thorough investigation would reveal not only the nature, extent, and precise cause of the smoke nuisance, but also the remedies that would make its abolition possible and practicable. To carry out this investigation, he placed $40,000 with Professor Robert Kennedy Duncan, Director of the Department of Industrial Research of the University of Pittsburgh.

In this paper we endeavor to present the various phases of the problem as they have come to our notice in our work in the smoke investigation.

THE CHEMISTRY OF SOOT

When one considers the very different conditions under which coal is burnt, it is obvious that the character of soot must vary. All conditions in the furnace greatly affect the amount of carbon lost in soot, but the fact stands out that where equal amounts of coal are consumed domestic installations are worse offenders than boiler furnaces. Loss of efficiency through the escape of soot itself is small. This is, however, an indication of a far greater loss in the shape of unburned, invisible gases, which loss may be as high as 10 per cent.

Soot consists of:

(1) Carbon in a finely divided state. This, as is well known, is lamp-black, the basis of most black paints and has a great covering power. It has the power of absorbing the corrosive acids which are produced by the combustion of coal containing sulfur.

(2) Tar. It is common coal tar which makes the soot cling tenaciously to everything with which it comes in contact. Tar contains carbolic acid and a large number of other compounds of an injurious nature.
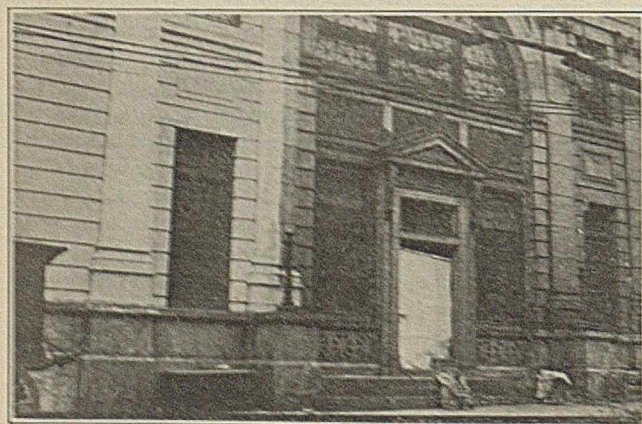

FIG. I—A PITTSBURGH BUILDING PARTIALLY CLEANED

(3) Acids. Sulfurous acid; sulfuric acid; hydrogen sulfide; hydrochloric acid together with a number of organic acids.

These acids corrode and tarnish all of the common metals. They attack many of the stones and building materials, especially limestones. Draperies, paper, paints and other decorative

materials suffer to no less extent. In burning the sulfur in the coal, the relatively inactive sulfurous acid is for the greater part produced, but this soon becomes oxidized in the air to the far more active and corrosive sulfuric acid. These acids are also poisonous and detrimental to health.

(4) Ash. This is the least injurious of all the constituents of smoke and may be, for all practical purposes, considered as common dirt.

(5) Ammonia is found in soot only in very small quantities and is of less importance than the other corroding agents.

(6) Arsenic. This poisonous substance has been found in small quantities (generally less than 0.1 per cent. of the soot).

The amounts of these constituents of black smoke vary between the widest possible limits, depending upon the composition of the coal, methods of firing, amount of air, temperature of the furnace, etc. The following analysis of soot taken from Cohen and Ruston's "Smoke, a Study of Town Air" gives a good general idea of what one must expect.

INDUSTRIAL SOOT—SOOT FROM BOILER FURNACE

			Boiler chimney		
	Original coal	Bottom	13 feet from base	70 feet from base	Top of 110 ft. chimney
Carbon....	...69.30	19.24	16.66	21.89	27.00
Hydrogen.....	4.89	2.71	0.86	1.44	1.68
Tar..........	1.64	0.09	0.28	0.80	1.14
Ash..........	8.48	73.37	75.04	66.04	61.80

DOMESTIC SOOT

			Dining room flue	
Constituents	Coal	Kitchen flue	Bottom 5 ft. from grate	Top 35 ft. from grate
Carbon..........	76.80	52.34	36.45	37.22
Hydrogen.........	4.90	3.68	3.51	3.51
Tar.............	0.88	12.46	34.87	40.38
Ash............	1.80	17.80	5.09	4.94

THE PER CENT OF FREE ACID IN SOOT

Sources of sample	Base of chimney	Top of chimney
Brass foundry.................	0.00	0.65
Study flue....................	0.50	....
Kitchen flue..................	0.0	....
Boiler chimney...............	1.62	0.56
Fireplace.....................	0.37	0.00

Dr. Russell found that the rain water did not contain acid unless it also contained soot. The amount of free acid in nine samples calculated as sulfuric acid was found to be: 1.4 per cent., 0.5 per cent., 7.2 per cent., 0.0 per cent., 4.9 per cent., 0.8 per cent., 1.2 per cent., 2.3 per cent., 0.0 per cent.

From the above analyses it is seen that the amount of tar and carbon in the soot from domestic fires is much higher than that from boiler furnaces, while in the case of ash the reverse is true. Domestic soot is thus by far the more objectionable and is produced in greater quantities from the same amount of coal. The amount of acid depends more upon the amount of sulfur in the coal than upon any one factor and is given off with the products of combustion whether smoke is produced or not. When, however, soot is produced, a large percentage of the acid is occluded in the soot, where it is more injurious than if allowed to escape alone into the air. The soot coming in contact with metal, stone, decorations, etc., is made to adhere firmly by means of its tar content, in reality covering the surface with a coat of black paint. The acid is not readily washed away by the rain, but continues to act until it is all used up. This acid absorbed from the air by the rain water would be more injurious if it did not drain off from most surfaces before its action was completed.

DETERIORATION OF BUILDINGS AND BUILDING MATERIALS

After considering the various phases of the chemical composition one can readily understand why houses in a smoky atmosphere look grimy and miserable and why the use of skylights is in many places made impossible, while in others it is necessary to so arrange them that they may be readily cleaned.

Otherwise they would soon become unsightly because of the accumulation of soot. Again, changes in design to make a different arrangement of drain pipes, etc., are, at times, necessary in order to prevent the splashing of rain water containing soot upon the building.

In a smoky city, too, much more glazed tile and vitrified brick are used for the outside of buildings, as it makes the cleaning a comparatively simple matter, washing alone being necessary. Building stones, such as limestone, marbles or sandstones with calcareous binding material are rapidly disintegrated by the acid in the soot and air. Therefore materials such as granite, sandstone (with a siliceous binding), brick, etc., which are not readily attacked by the sulfurous and sulfuric acids in the soot, should be utilized. But unfortunately, that stone which is most easily affected, disintegrated by the atmospheric acid and decolorized by soot, is the one which it is easiest to work into the desired shape for building purposes. Granite and similar stones which are practically unattacked by acid and impervious to moisture, and which are readily cleaned, are extremely expensive because of the difficulty in working. Thus the architect finds himself confronted with monetary as well as esthetic considerations. Stone may be cleaned but to say the least, it is but a temporary expedient and represents a periodical tax on the owner. The logical thing is to make cleaning unnecessary by water-proofing the stone and doing away with the smoke. The sulfuric acid acts on the calcium carbonate (the principal constituent of stones most easily corroded by the acid in the soot), forming calcium sulfate (gypsum) which is more soluble in water than the calcium carbonate but, at the same time, causes the stone to undergo a physical change, making it swell and become porous and friable and easily disintegrated, also roughening polished surfaces, thus making them more readily attacked by acid and moisture and affected by weather. Dr. Angus Smith has found mortar to contain as high as 28.33 per cent. of sulfuric acid, equivalent to 48.16 per cent. CaSO$_4$ caused by the action of the sulfuric acid in the air on the calcium carbonate.

The effect of the sulfuric acid on most metals is rather marked and greater than the action of a like amount of acid in the rain water or air. It would seem from observations taken in Pittsburgh, that where soot containing acid is made to adhere to the metal by means of its tar content, an electrolytic action is set up, making corrosion much more rapid. In case of iron and aluminum, the oxide and basic sulfate are produced, at least in part, from the sulfate, and the acid is used over and over again. To experimentally verify these observations, duplicate sets of various metals were fastened to two boards. One set was protected from the soot in the air by means of cheese-cloth, yet still exposed to the air and rain. The other set was left unprotected. The pieces of metal left unprotected from the soot show a greater amount of corrosion than those which were protected. I wish, here, to call your attention to the following figures obtained by Messrs. W. B. Worthington and A. Rattray, showing the corrosive effect of the acids in the air. Quoting from Cohen, "A number of rails were placed in suitable positions by the side of the line, and weighed at intervals and the loss in weight recorded. The rails were of the ordinary railway section weighing 86 lbs. per yard. The annual loss of weight from corrosion was as follows:"

	Loss in wt. in lbs. per yd. per average year	No. of years of observations
1. In the center of the town	1.04	17
2. In dry place in smoky tunnel	1.48	13
3. In a wet place in same tunnel	1.71	8
4. On the seacoast among sand hills	0.18	17

The question of exterior and interior decoration is one affected as much by the amount of smoke in the air as by the tastes of the owners of the buildings.

Interior draperies and paper are soiled much quicker in a smoky city than elsewhere. If light paper is used in papering the rooms, it must be cleaned every six months and new paper put on every year to keep it looking only half as well as one would wish.

The acid in the soot attacks draperies, rendering them useless in a short time. The extra wear of cleaning shortens the life markedly. On interior painting the effect is not as marked because cleaning is done about every so often anyway. But the problem of interior decoration and keeping the outside of a building clean are problems, indeed, and next to an impossibility in some smoky places. The statement has been made to us by a number of painters that they have done jobs which looked really as bad after two or three days as they did before they were painted. Soot certainly destroys the esthetic value of paint very quickly. The time it takes to accomplish the pollution is, of course, dependent upon the amount of soot in the air, the color of the paint, tar in the soot, etc. The number of paintings necessitated to keep the same building as presentable as in a smoke-free city will naturally vary greatly. Cases can be cited where it is necessary to paint three or four times as often as would be required for protection. In the majority of cases in smoky cities the number of paintings required is probably doubled. Sometimes it is necessary to remove the soot and tar and to wash the building before applying the next coat of paint. This washing also removes the paint, often making necessary two coats in place of one for a proper covering. After the wood has received ten to twelve coats it is customary to burn off the paint. This is an additional expense and likewise endangers the house with fire. The action of soot on the wearing qualities of the paint also depends on many factors involving the chemical composition of the paint and soot. The soot may be acid, neutral or even slightly alkaline. Places are known where the soot is thought by some to act as a protective coating, while in others it is corrosive to the painted surface, destroying the gloss and rendering it much more easily weathered. The latter is probably true in those cases where the coal burned contains a lot of sulfur and the soot is consequently quite acid.

SMOKE AND THE WEATHER

From a preliminary study of available data and a perusal of the literature concerning the meteorological branch of our work, Dr. H. H. Kimball arrived at the conclusions:

(1) That city fogs are more persistent than country fogs, principally because of the increased density due to the smoke which accumulates in them.

(2) In consequence of the fog prevalence there are fewer hours of sunshine in the city than in the country.

(3) The sunshine is less intense than in the surrounding country, the light of short wave length of blue light suffering the greater depletion.

(4) Daylight, which often depends entirely upon diffuse daylight from the sky, is depleted by smoke in greater proportion than direct sunlight.

(5) Minimum temperatures are markedly higher in cities than in the country, in part, of course, because of city heating, but principally because the smoke acts as a blanket to prevent the escape of heat at night.

We find when using a chemical method for determining the intensity of daylight that on some days there is two or three times the light as measured by chemical action, ten miles from the center of Pittsburgh as there is in the city proper.

The amount of soot in the air varies greatly, depending upon the direction and strength of the wind, etc. We have found variations between 0.0015 to nearly 0.2000 gram per 1000 cu. ft. We have many more times the soot in the air on some dark days that we have on clear, bright days.

Visibility determinations (the distance one can see) vary

greatly from day to day. With the accumulation of more data we hope to trace a relationship between these determinations and the amount of soot in the air.

The soot-fall (the amount of soot which falls on a given area in a given period of time) is of interest to us from many viewpoints. A large number of determinations have been made, and although they vary greatly in different parts of the city, those made at the same stations remain remarkably constant. The total fall varies between 720 and 2280 tons per square mile per year for the cleanest and dirtiest parts of the city, respectively. These figures represent the entire dust-fall, which is jet-black and is considered here, as elsewhere, to represent the soot-fall. Analyses are, however, being made for tar, organic and inorganic matter.

HOW VEGETATION IS AFFECTED BY SOOT

Trees, shrubs, etc., are utilized in a city as adjuncts of beauty, rather than a source of income, and as the smoke nuisance, as a rule, is prevalent only in cities of some size, its effect is not felt on the crops in the country district. Therefore, the effect of soot on vegetation would be considered more particularly a question of esthetics. Yet it makes felt its injurious action, both directly and indirectly. The smoke clouds limit the available daylight in two ways:

The amount of sunlight as well as diffuse daylight is not nearly as great in a smoky city as it normally should be.

If the amount of light cut off by the deposit of tar upon glass can be considered in any sense as a measure, the tar deposit on the leaf is by far the most important factor in light absorption.

The tarry matter contained in the soot coats the leaves and chokes the stomata. This injury is mechanical. Its destructive action does not, unfortunately, stop there. Like all other forms of finely divided carbon, soot has the power of occluding other substances. The tar, acids, etc., are all poisonous to plant growth and greatly lower the vitality, the acids in particular limiting the activity of the soil organisms, especially those of nitrification.

Cohen and Ruston find that the relative assimilations of laurel leaves in districts where the air contains different amounts of soot, etc., vary from 11.6 to 100. Crops of radishes and lettuce grown in different sections of the town show the possibility of correlation of the known atmospheric impurities with the yield of the crops. Trees automatically keep record of the presence of any inhibiting factor by the narrowing of their annual rings. In one case the cross section of a tree plainly showed evidence of the building of a smoke-producing factory near at hand.

We find that such flowers as roses, carnations, etc., will not thrive within the city limits of Pittsburgh, and that for this reason many greenhouses have been forced to move beyond this deleterious influence. Furthermore, many of our trees are injured if not entirely killed by the smoke.

SMOKE AND DISEASE

The effect of smoke on health has always been a much mooted question. At the present time in the city of Pittsburgh it has assumed a very practical form. The city has appropriated considerable money for a tuberculosis hospital and a dispute has arisen as to its location. Some contend that it should be placed outside the city limits, while others hold that more intensive work can be done if it is located in that part of the city where the disease is most prevalent. The advocates of the first location, as part of their argument, assert that the smoky atmosphere is detrimental to those suffering from the disease or at least that it retards their recovery. The weight of opinion seems to be against this view.

Dr. William Charles White, in a paper read before the Fifteenth Congress of Hygiene and Demography said: "As a result of our clinical study we have come to the conclusion that the general death-rate from tuberculosis in Pittsburgh is low, that there is nothing in the smoke content of the air which in any way stimulates the onset of tubercular process or militates against the rapidity of recovery from tuberculosis when once this disease has been contracted."

Dr. White's studies along this line, however, led him to declare that from his study of the air content of Pittsburgh and of disease that smoke has an important bearing on the pneumonia death-rate, in fact that it is nearly proportional to the soot-fall. Dr. White is in favor of a popular crusade for the prevention of pneumonia like that which has been waged against tuberculosis. Of course, in such a campaign serious attention would be given to the smoke problem.

Dr. Louis Ascher, of Königsberg, who has made an extensive study of the effect of smoke and dust on disease maintains that in Germany a smoky atmosphere is responsible for the increased mortality from lung diseases other than tuberculosis. He holds that not only is this increase taking place, but that persons who are the subjects of pulmonary tuberculosis die in smoke-
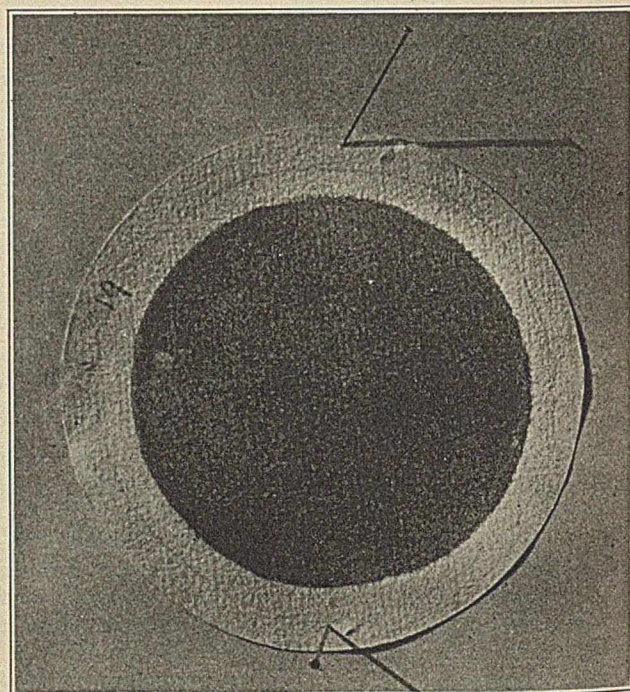

FIG. II—FILTER PAPER THROUGH WHICH THE AMOUNT OF AIR BREATHED BY A MAN IN ONE DAY HAS BEEN FILTERED

laden districts more rapidly than those persons similarly affected, but living elsewhere.

Of the fact that carbon makes its way into the lungs of those who live in a smoky city, there is no doubt. Dr. Oskar Klotz finds large amounts of it in the lungs of Pittsburghers; 10.6 grams were found in the lungs of a street peddler 28 years of age.

According to Lehmann, while the sulfur dioxide contained in the soot is absorbed by the nasal mucous membrane, the particles of carbon are carried further into the respiratory passages. Finally reaching the lungs, they are deposited there having meanwhile in their descent given up to the bronchial mucous membrane and the lining membrane of the lungs some of the acids they retained.

Dr. W. L. Holman finds that soot acts as a disinfectant, the moist being more active than the dry. (Water seems to dissolve the disinfecting agents in the soot, making them more active.) Carbon floating in the air seldom if ever carries bacteria unless it has lodged on the ground and is again blown into the air. Soot acts as a very effective blanket, protecting the bacteria and giving them a chance to grow.

Dr. E. W. Day finds that diseases of the nose and throat are not appreciably more prevalent in smoky cities, but that they are more severe and harder to cure. This is probably due as much to the cracking of the mucous membrane by the dry atmosphere in the houses and subsequent irritation by dust as by the smoke. Singers, on visiting Pittsburgh, usually get Pittsburgh sore throat, which lasts about seven days, when they become acclimated for the time being. Unfortunately though, the same thing occurs on each succeeding visit to the city.

THE COST OF SMOKE

We are coming more and more to look at the smoke problem as fundamentally an economic problem. We have been told time and time again that smoke and soot are the products of imperfect combustion which means a waste of fuel, and a waste of fuel means an unnecessary expense. But there is more than this to the question; smoke is not only a cause of expense to the maker of it, but it is a cause of expense to every man, woman and child in the community.

Various estimates of varying degrees of accuracy have been made of the financial damage due to smoke and soot. In 1905 the Hon. F. A. Rollo Russell estimated the damage in London to be $26,000,000. The largest single item of this amount was $10,750,000 for extra washing and wear and tear of linens. The Cleveland Chamber of Commerce in 1909 placed the per capita loss for that city at $12.00 or $6,-000,000 for the entire population. Mathew Nelson, Chief Smoke Inspector of Cincinnati, asserted that the loss there was $100.00 per family. Mr. Paul Bird, in his report as Chief Smoke Inspector of Chicago, declared that the loss in Chicago was at least $17,600,000 or $8.00 per capita. In a paper read before the American Civic Association, Herbert M. Wilson, Chief Engineer of the United States Bureau of Mines, stated that a careful government inquiry into the toll paid by the people of the United States showed a total of over $500,000,000 or a per capita toll of $17.00 a year for every man, woman and child in the larger cities.

These figures startle. It is the task of those who are engaged in the economic phase of the smoke investigation to make estimates for Pittsburgh as accurate as possible by inquiring into the various items that go to make up the total. They are attempting to deal not in sweeping generalizations, but in what Mr. Wood, in speaking of the work of the Pittsburgh Survey, termed, "Piled-up actualities."

About 25 per cent. of the cleaning expense of office buildings in the city of Pittsburgh is due to smoke. When you realize that the cleaning bill of some of our office buildings is $75,000 per year, you know well what a toll is placed on them. To cite a single item—it costs a certain building in Pittsburgh $320.00 more a month for window cleaning than if the building were located in New York or Philadelphia. The lighting bills in office buildings are increased by half because of the conditions of the atmosphere in Pittsburgh.

The damage to goods in wholesale, retail and department stores runs up into the thousands, amounting to as much as $30,000 a year in the case of one store. We have found that it costs from 33 per cent. to 50 per cent. more to conduct a hospital in Pittsburgh than in other cities. For instance, in the matter of extra cleaning force, one hospital could save $3,000 a year, and another $1,200 if the city were cleaner. You have noticed, no doubt, the number of buildings in large industrial cities that are washed down or painted once or twice a year. To one firm in Pittsburgh this means an extra expenditure of $700.00 and in the case of another firm, of $500.00.

Census reports on laundries show that Pittsburgh pays more than most comparable cities and that it costs the laundry-men more to do the work. These figures when compared with the report of smoky days in various cities seem to indicate that atmospheric conditions and not custom determines, in a large measure, the per capita amount of business done.

The schedules of men who now live in Pittsburgh but who come from other cities show that they pay from one-third to a half more in Pittsburgh. They wear at least two more shirts and two more collars per week which means an extra expense, at the lowest, of $16.00 each year. Schedules of women who have lived in other cities show that they pay $24.00 each more a year in Pittsburgh than elsewhere. The toll paid to steam laundries alone amounts to something like $800,000. The extra expense in labor, time and effort in home laundry work is much greater than that of steam laundries. As a minimum estimate Pittsburgh pays a toll of $1,500,000 in laundry and home washing bills.

Dry cleaning is found necessary far more frequently in Pittsburgh than in other cities because of the atmospheric conditions. Because of this a greater supply of clothing is required and clothes wear out sooner. Moreover, Pittsburghers are limited in the selection of colors of clothing. Especially is this true of woolen goods, furs, hats, trimmings, etc. The average annual bill of a man in Pittsburgh who sends his clothes to a dry cleaner is $18.00; a woman's bill is about $20.00. This is half more than the man or woman would pay in a cleaner city. The total extra cost of dry cleaning in the city of Pittsburgh is about $750,000.

In October, 1912, the Philadelphia assessors, in answer to the appeal of the property owners in the 24th and 44th wards of that city, who declared that recent sales in their vicinity were at prices far below the assessed valuation because of the smoke nuisance, reduced the assessed valuation of each from $500 to $2,000 on some three hundred properties. A preliminary survey of conditions in Pittsburgh showed that the same facts were here true. In some sections there has been a depreciation of fully 50 per cent. in sale price. Such property is near mills or railroads or, as is often the case, near both. Houses in such neighborhoods are very difficult to rent and in order to rent at all, there must be a reduction in the rental price of at least 20 per cent. Sometimes people rent these houses and move as soon as they become acquainted with the nuisance.

To all these losses—and there are many others—must be added the cost of the fuel wasted through imperfect combustion. In 1881, when a little less than 3,000,000 tons of coal were being used in Pittsburgh, William Metcalf, an eminent engineer and mill owner, estimated the cost of the coal that was sent, wasted, out of the tops of the stacks at $1,063,000. At the present time Pittsburgh burns in the neighborhood of 15,000,000 tons of coal annually, the cost of which is about $19,000,000. It has been estimated, on the basis of efficiency tests, that there is a loss of $4,000,000 annually which could be saved by proper furnace operation.

FACTORS TO BE CONSIDERED IN THE ABATEMENT OF SMOKE

As a problem the smoke nuisance presents many and various phases. In the method of attack in the different cities there are a number of factors which must be taken into consideration.

1. The topography of the country is an important factor in the mitigation of the evil. A hilly country, such as we have in Pittsburgh, confines the smoke to the valleys, so that it is not readily carried away by the wind as it is in Chicago and other cities built on a flat country.

2. The location of the smoke-producing plants with reference to the residence district must be taken into consideration. In many places this proves a source of great annoyance, in others tends to simplify the problem. In Pittsburgh the mills are situated along the Ohio, Allegheny and Monongahela rivers, which run through the city, bounding at least three sides of our best residence districts. Recalling the topography of the city you can see that this does not facilitate abatement.

3. The necessity for burning soft coal in private dwellings is a great bane, the methods for burning it without smoke not being nearly as well perfected as in case of large installations. About 6 per cent of the coal burned in fireplaces and other domestic installations escapes through the chimney as soot,
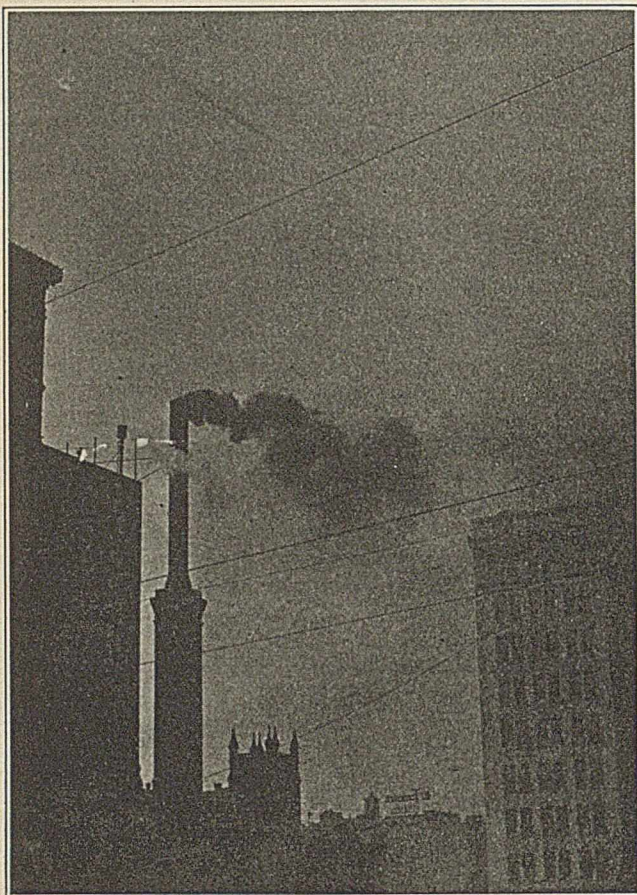

Fig. III—A Low Stack among High Office Buildings

while only about 0.5 per cent of that burned in power plants is thus wasted; that is, weight for weight, the coal burned in domestic installations is twelve times more a nuisance than that burned in a hotter furnace under a boiler. Cities which have at their disposal a supply of natural or other cheap gas are greatly favored.

4. Cities, such as Philadelphia, which have access to cheap hard coal, should have very little need of consideration in connection with our problem. Anthracite coal is a smokeless coal. In fact, soft coals vary greatly in the ease with which they are burned without smoke. Different types of mechanical stokers and other kinds of installations are required in many cases. Each district presents new engineering problems. An installation which gives perfect satisfaction with one kind of fuel will not of necessity do so with another.

5. Smoke abatement is not a difficult task in non-manufacturing towns where power plants are the exception rather than the rule. In manufacturing towns, on the other hand, long-continued campaigns of education are necessary before even the enforcement of an ordinance is possible.

After a thorough perusal of smoke literature and a general survey of the smoke-producing plants in this district, a number of facts were firmly imbedded in our minds:

(1) That the production of smoke was in most cases unnecessary and could be prevented with economy to the power plant operator.

(2) No thoroughly practical method is known for abating the smoke in roundhouses, coke ovens, brick kilns and one or two special furnaces.

(3) However perfect a smoke preventing device has been installed, it will not be of much value for the prevention of smoke unless intelligently operated, *i. e.*, the fireman must be educated to do his work in a proper manner.

(4) The public in general were of the opinion that in order to be prosperous the city had to have smoke, *i. e.*, that it meant industry and prosperity.

(5) No investigation of the subject as a whole had been made by the coördinated efforts of a group of men.

We find that certain types of installation are notorious smokers while others are practically free from smoke at all times.

Furnace Type	No. of stacks observed	No. violating the city ordinance
1	45	26
2	21	3
3	8	0
4	23	15
5	15	0
6	1	0

The human element must not, however, be neglected in this connection. It is possible for a skilled fireman to operate a hand-fired furnace without objectionable smoke even if it is not constructed in the most approved manner. But given an unskilled or careless man in charge, the most modern of plants may become an objectionable smoker.

To do away with smoke and increase efficiency one must bear in mind three things:

1. The mechanical contrivance for burning the coal must be suited to the purpose.

2. The fireman must be trained to do his work in a proper manner.

3. Some method of furnace control should be employed (CO_2 recorders, pyrometers, etc.) so that the efficiency of the furnace, amount of smoke, etc., may be known both to the fireman and superintendent.

Fig. IV—Hand-Fired and Stoker-Fired Stacks

THE QUESTION OF LEGAL REGULATION

As legislation follows rather slowly the agitation for and need of certain reform measures and as the question of smoke abatement in the United States is of comparatively recent date, we need not be surprised to find that the passage of ordinances on the subject, especially of ordinances that are in any way effective, has taken place in only the last ten years. This is not true, however, of England where the law took cognizance of the smoke nuisance as early as 1273, when the use of coal was prohibited in London as prejudicial to public health. There is in existence a statement that one John Doe was, in 1306, tried, condemned and executed for burning coal in the city of London. Since 1273 there have been numberless proclamations, parliamentary commissions, laws and ordinances on the smoke nuisance.

It was about thirty years ago that cities of the United States began to pass smoke ordinances. However, as early as 1856 an ordinance was introduced in the council of Cleveland to prohibit the use of soft coal in manufacturing plants, and some time prior to 1869 Pittsburgh passed an ordinance which con-
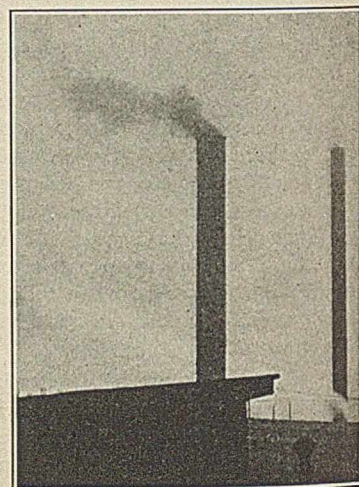
tained the provision "that no bituminous coal or wood should be used in the engine or any locomotive employed in conducting trains upon any railroad." Chicago and Cincinnati were the first cities to pass general ordinances on the subject, the first ordinance in Chicago being passed in 1881. Pittsburgh did not have an ordinance until 1891 and then it was for only a section of the city.

At the present time all of the cities having over 200,000 population, with a few exceptions—and in these cities the problem is not acute—have smoke ordinances, as have many of the smaller cities which are far-sighted enough to be on their guard, lest this modern industrial plague come upon them in its full wrath.

The source of power of governmental authority to abate the smoke nuisance is the police power of the state. We are always tempted to think of this as extending only to the protection of life and property in its narrow sense and the maintenance of public order, but more and more we are coming to know that its great sphere is public health and general welfare. This police power may be delegated by the state legislature to municipal corporations, and this is the power under which municipalities declare certain acts nuisances. While a municipality may be authorized in general terms to declare what shall constitute a nuisance, it may not declare that to be a nuisance which in fact is not. In common law "dense" smoke was not a nuisance *per se* though some courts have held it to be so in a populous city.

The Pittsburgh ordinance of 1906 was held void for two reasons, one of which was "that the Legislature of Pennsylvania had likely not given the city sufficient authority to pass an ordinance upon the subject." The city at once sought and secured the power. Thus it can be seen that in order to deal with the smoke nuisance, cities should seek specific authority from the legislature.

When a municipality is thus empowered it is then in position to pass an ordinance. It is a difficult matter to say what the
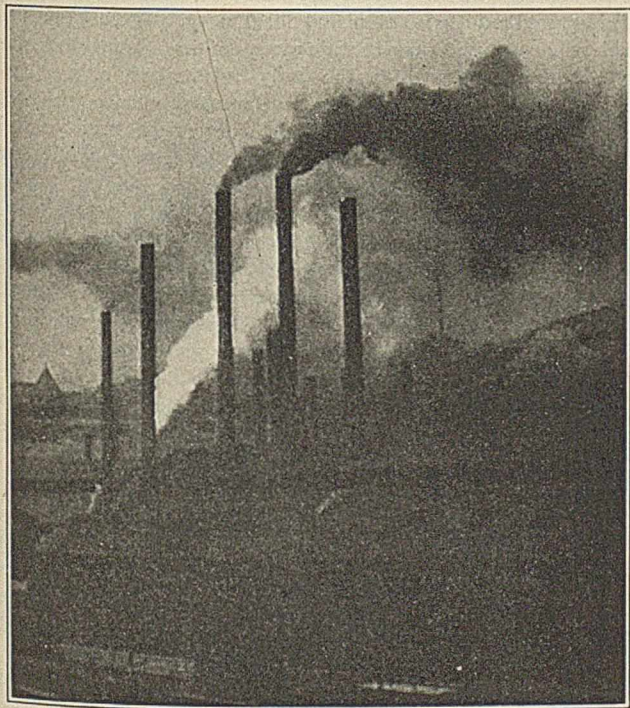

Fig. V—A Steel Mill—One of the Worst Offenders

essential provisions of a smoke ordinance should be and yet from the experience of the different cities we are able to select certain features that are necessary if the ordinance is to accomplish any notable results.

In our day and generation we are looking to preventative rather than remedial legislation for telling achievement. This thought leads us to one of the fundamental functions of a smoke ordinance: that it should make provision for prevention as far as possible of the installation of improperly designed furnace equipment. For this purpose the ordinance should provide that plans and specifications for all construction work on furnaces be submitted to the smoke inspector and approved by him before the work is started.

This feature leads us to the point that since it is so important a provision, the ordinance should state the qualifications of the man whose duty it is to pass on these plans and specifications. Surely it should provide that he be an engineer, "qualified by technical training and experience in the theory and practice of the construction and operation of steam boilers and furnaces."

An ordinance, of course, should state the density of smoke that is to be permitted and provide a standard of measurement. On the first point, care should be taken lest the provision be somewhat vague, for this has been the rock upon which many ordinances have been wrecked in courts. In speaking of this feature—the fixing of the density—Mr. S. B. Flagg, of the United States Bureau of Mines, says: "The requirements should represent the best practice, the standard set should not be an impossible nor an impracticable one, neither should it represent ordinary or poor practice. In some ordinances a stack well within the limits as set by the ordinance may be responsible for the discharge into the atmosphere of many times as much soot as another stack which violates the ordinance.

The mere enactment of a reasonable, efficient and enforceable smoke ordinance is not enough. The ordinance must be enforced. At this point most of the cities have fallen short. Sometimes the wrong methods are used in the enforcement of the ordinance. Most of the time the methods employed are altogether too lax and feeble to secure even mediocre results. To remedy this situation there is one great weapon—public opinion. However, in order to educate, concentrate and focus public opinion, a league or union of civic and commercial organizations should be formed in each city. Such organizations seem imperative in American cities until better results are secured by way of enforcing smoke ordinances. Eternal vigilance on the part of the public is the price of a smokeless atmosphere, but to those who enjoy such a blessing the price is not a whit too high.

Enough has been said to suggest that the smoke nuisance is an economic question and that the people who are most concerned are not those who make the smoke but those who suffer because it is made. It is necessary, therefore, to educate the public as to the evils of the nuisance, that an active and intelligent public opinion may be brought to bear on those who are responsible for it. As has been pointed out, even with the smoke makers this problem is an economic one. The abolition of the smoke nuisance, therefore, unlike many other social nuisance against which outcry has been made, would result in direct and immediate gain both to the public-at-large and to those who are chiefly responsible for the nuisance itself.

Department of Industrial Research
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THE CHEMIST AND SCIENTIFIC MANAGEMENT[1]

By H. W. Gillett

Your secretary asked me to speak to the section on some phase of what the chemical engineer gets up against in commercial work. The most interesting thing I met in commercial work was scientific management. This is a comparatively new thing in the industrial world, but I believe it has greater possibilities for our individual and national good than any industrial

[1] Paper presented before the Cornell Section of the American Chemical Society, February 25, 1913.

development since the beginning of the introduction of labor-saving machinery.

It is a scientific development in which we have for once outstripped the Germans. Perhaps it is because it is of American instead of German origin that chemists, though eminently fitted by their training to understand and make use of it, have so far been far behind the mechanical engineer in taking it up.

Popular interest in scientific management is, however, growing rapidly; the appointment of President Taft's commission on economy and efficiency, the comments of the daily press and the formation of two national societies for its advancement, testify to this. The *Saturday Evening Post* ran a series of popular articles on it last fall, and at about the same time *The Outlook* dealt quite fully with it in regard to housekeeping. The Department of Home Economics of the Cornell Agricultural College gives lectures on it, as applied to housekeeping. Vassar College is applying it in its business office, and you can hardly pick up an engineering magazine that does not record its progress. It is time for the chemist to get into the game. I am glad to see that the February JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY has a good editorial on it.

But why, you ask, should the chemist be interested in management of any kind? Perhaps the best answer will be to call to your minds the recent recipients of the Perkin Medal,—Acheson, Hall, Frasch and Gayley. Is it not because these men had not only scientific ability, but the executive ability that can take a process out of the laboratory and make it work on a large scale, that they stand forth as the highest type of successful chemists?

Without scientific ability they would have been nowhere, but it is equally true that without executive ability they would never have won great fame and wealth. The chemist who gets the big rewards is the one who can bring to bear both scientific and executive ability, while the one with scientific ability alone may get his name mentioned in Erdmann or Bernthsen.

Our industries are drawing more and more from the ranks of technically trained men for their superintendents and managers, and there are many cases where the works laboratory is the best training school for what we may call the technical type of executive and that is the coming type.

Let us, then, take for granted the chemists' interest in executive problems; in management. What is there in scientific management for him? To answer this, let us see what conditions exist that make a place in industry for what we call scientific management.

A man starts a business on a small scale and to make it a chemical industry, let us say he makes a new kind of scouring soap. At first he is his own foreman, inspector, purchasing agent, and sales agent. He sees to the ordering of material and keeps track of the stock on hand. He hires all his men himself, oversees them, works with them and keeps them occupied with work, shows them what to do and how best to do it, sees to the weighing of the batch, the firing of the kettles, the salting out, watches that the cakes are correctly made and properly wrapped. He sees that orders are filled promptly and that quality is maintained. In short, he has the whole thing in his head and is on the job all the time.

Let us say that he has a good product and it finds a ready sale. He enlarges his field of operation, builds an addition to his factory, employs more men, and has to have a foreman, and a shipping clerk. Time goes on and he has all the departments of the large, modern factory, then some fine day he finds out that the cost of production per cake of soap instead of going down, as it should because of large production, is standing still or increasing, while raw materials are going up and selling price, through competition, is going down.

He studies the situation, or calls in an efficiency engineer to do it for him, and finds that the plant is held up because the stock of alkali has run low because the foreman neglected to notify the purchasing department that it was needed; he finds that the new men hired in the expansion period have not been taught to work as well as the old ones he taught himself, that the men are not making any more cakes with new machinery than they did with that of obsolete design, that packing boxes have not been provided and orders for which customers are calling cannot be shipped. Probably he finds that only one man knows how to salt out the soap, and he's "off on a tear," so things are hung up again.

In short, the business has grown too large for one man to control all the details, and his organization cannot cope with the situation as he himself used to handle it when the shop was small. When an emergency arose, he had said to the superintendent: "You must get Smith and Jones' order for 50,000 cakes of Bonolio out this week." The superintendent passed the word to the foreman, the foreman told the kettle man and he put it up to his helper. Instead of planning and directing the work in detail, the older or "military" type of management tends to put the responsibility on the workmen themselves, the part of the organization least fitted to handle it.

To cope with such a situation, whether in making soap, laying brick, running a machine shop, making ladies' suits, or any industry whatsoever, there are certain principles and methods, which we call "scientific management."

It is the aim of scientific management to provide means for running the plant with the same thoroughness, planning and attention to details that the old boss used in the small shop.

Let me give you a few definitions of Scientific Management.[1]

"The art of management has been defined 'as knowing exactly what you want men to do and then seeing that they do it in the best and cheapest way;' also, 'the principal object of management should be to secure the maximum prosperity for the employer coupled with the maximum prosperity of each employee."

Mr. K. H. Hathaway says:

"For its objects Scientific Management has the saving of energy, materials, and time, or in other words, the elimination of waste, and the increase of the world's wealth resulting from greater productivity of men and machinery. These it aims to achieve, in each industry to which it is applied, through bringing to bear upon each problem the analytical methods of investigation employed in the sciences; developing a science with well defined and codified laws, in place of uncertain tradition and rule-of-thumb opinion. This is a broad statement of the first principle of Scientific Management."

Theodore Roosevelt says:

"Scientific Management is the application of the conservation principle to production..... the time, health and vitality of our people are as well worth conserving, at least, as our forests, minerals, and lands. And Scientific Management seems to do even more for the workman than for raw materials. It studies him at his task. Of the motions he makes and the efforts he puts forth, it determines by patient observation, which are the ones that get the result. It experiments to see whether these cannot be further shortened, or made easier for him.

"When the right way has been worked out in every detail, Scientific Management sets it up as a standard for that job, then instructs or trains the workman until he can accomplish this standard, and so on, with all other workmen and all other jobs. The individual is first made efficient, his productive capacity is raised 25 per cent or 50 per cent, sometimes doubled. From these efficient units is built up an efficiency organization. And when we get efficiency in all our industries and commercial ventures, national efficiency will be a fact."

Mr. Brandeis says: "In Scientific Management nothing is left to chance. All is carefully planned in advance. Every operation is to be performed according to a predetermined schedule under definite instructions, and the execution under the plan is super-

[1] Gilbreth, "Primer of Scientific Management," pp. 1-3

vised at every point. Errors are prevented instead of being corrected. The terrible waste of delays and accidents is avoided. Calculation is substituted for guess; demonstration for opinion."

I quote also from the editorial in the February number of This Journal.

"Modern industry was brought about by the change from handicraft to manufacture, and early British economists held that the application of the principle of *division of labor* was the basis of manufacture.

"It appears, however, that another principle is the basic one in the rise of industry. It is the *transference of skill*. The transference of skill from the inventor or designer to the power-driven mechanism brought about the industrial revolution from handicraft to manufacture.......Except in rare instances, no effort was made to transfer the skill of the management to the production department and to the employees, or to undertake the division of executive thought. Very little consideration was given to the workmen as a producing unit.............

"Another tendency has as its object the improvement of the personal relations between the employees themselves and between the employee and the employer. It is the effort to establish the best of factory working conditions, to develop and maintain a shop atmosphere free from all harassing and hindering influences. It is an attempt to make use of the results of experimental psychology in improving working conditions.

"But the most important change and one that comprehends the others, is in the mental attitude toward the problems of production. The tendency is toward an attitude of questioning, of research, of careful investigation of everything affecting the problems in hand, of seeking for exact knowledge and then shaping action on the discovered facts. It has developed the use of time study and motion study as instruments for investigation and the planning department as an agency to put into practice the conclusions drawn from the results of research, and methods of wage payment which stimulate coöperation.........The skill of the management is consciously transferred to all of the operations of the factory—the prominent element in present-day industrial management is through the mental *attitude that consciously applies the transference of skill to all the activities of industry.*

"Here emphasis is placed upon the word *all*, for the restricted application of this principle to machines and tools has been highly developed for a long period."

I have gone thus briefly into the situation that creates a need for scientific management, and into its definition, to try to indicate to those of you who are not yet familiar with industrial plants, the reason for its importance at the present day.

Now let us briefly consider the mechanism of scientific management, labor-saving devices, or, we might call it, *Quantitative Management*.

It includes:

(1) Standardized conditions and methods   } Scientifically planning
(2) Standardized operations   } your work.
(3) Planning
(4) Instruction   } Scientifically working
(5) Inspection   } your plan.
(6) Efficiency reward

First of all we must have standardized conditions, that is, find out the best way to do a thing. This involves studying the passage of material through the shop and routing its passage so that it goes in a straight line from one operation to another without doubling on its path. It involves balancing the equipment, the floor space and the number of workers, so that every man and every machine is busy all the time without being held up by the failure of some previous man or machine to do its part.

This brings up the very important point of *dependent* sequence. Take the big generator that supplies current for our electric furnace work here. The 2200 volt induction motor has an effi-

ciency of 90 per cent. The generator run by this has an efficiency of 85 per cent. The efficiency of the set is then 90 × 85 or 76.5 per cent. The same principle applies in manufacture. If the efficiency of each of five operations is 90 per cent, the over-all efficiency is only 59 per cent. So we see the importance of getting *each* detail right.

Standardized conditions may involve such factors as the use of high-speed steel and the consequent higher speed of feed and greater depth of cut that are revolutionizing machine shop practice. It is interesting to note that the discovery of high-speed steel by Taylor and White was a chemical by-product of Dr. Taylor's research work on standardizing machine shop conditions, when he was first working out scientific management. Factory machinery, dictaphones, adding machines, and improved labor-saving and "system" devices, shop forms and operation symbols[1] are often shown to be worth while, but these improvements are not the vital part of scientific management. Those who consider that improved machinery is a synonym for scientific management mistake the part for the whole. As was pointed out in the editorial already referred to, machinery has been highly developed for a long time. In fact most plants are overmachined rather than undermachined, and the aim of the organizer, or efficiency engineer, is first to secure the best use of the present equipment, keeping down the investment in new machinery to a minimum, and confining it to cases where the outlay is really imperative. Too many managers have installed expensive automatic machinery in order to halve the production cost per piece, only to find that in a couple of hours per week it would provide all the pieces used in the whole week, and that in interest and overhead charges it was eating its head off, costing in the long run more than the old way. The balance of the factory had not been taken into consideration. Such an investment is not scientifically planned.

In the standardization of raw materials, buying on specifications, and the standardization of the product, the chemist and metallurgist are called in. As an example, in one paper mill where one chemist was formerly employed, they found it necessary to hire seven as soon as scientific management was started.

As an example of standardization, consider the blueprints used in a scientifically run shop. Every dimension shows the "tolerance," or limits between which the piece will serve. Where the length of a shaft can vary $1/2$ inch either way, the worker does not spend time trying to get it down to $1/100$ of an inch. Where it must be within $1/1000$ in diameter he knows it and does not measure it with rough calipers and get it off $1/100$ of an inch or more, thus spoiling it.

Standardization also comes in in scientific hiring—fitting the man to the job. Failure on the part of a worker to attain high efficiency, if the man makes an honest effort, is looked upon, not as incompetence, but as due to bad placing or to bad instruction, both of which are functions of the management, not of the man.

Standardizing methods involves recording them. For instance, instead of the old workman who could harden steel because long practice had trained his eye to tell temperature roughly, and whose death, disability or absence threw the tool-room into chaos, we have a little slip attached to each lot of tool steel, giving the temperature and length of time required to harden that lot; thus, with the aid of a pyrometer an unskilled man can do even better work than the old skilled workman. After a difficult job in the foundry has had the proper pouring temperature and proper gating worked out, and the job finished, a card filed with the pattern tells just how best results were obtained. Then six months after, when the pattern again goes in the sand, instead of relying on the overtaxed memory of a

[1] Parkhurst, "Applied Methods of Scientific Management," p. 70. "The Science of Management in Practice," *Industrial Engineering*, Mar., 1912, p. 187; April, 1912, p. 272; May, 1912, p. 365.

foreman, or failing that, working the whole problem out again we can start where we left off. This is a part of what is meant by "transference of skill."

After our conditions are made right, we can go on to the next step, standardizing operations. Under this system all the head-work is done by the management, the workers follow instructions. Before we can issue instructions, we must be sure that we know what to do and the best way to do it.

The first thing in deciding what a man is to do is to know to whom that man is responsible; organization charts are hung in conspicuous places throughout the shop to show graphically the relation of each man to the whole organization. An organization record, accessible to all, gives the duties of each man down to the rank and file of workers, who know to what gang bosses and foreman they are responsible.

The instructions vary in their nature, from rather general ones in cases where the nature of the work involves initiative, through fairly detailed ones to workers such as shipping clerks and janitors whose work is of the same general daily nature but not absolutely repetition work, down to the detailed instruction sheets issued for the guidance of the workers on repetition work in the factory itself. I have here for your inspection samples of all three kinds (see p. 600), the first being the instructions I worked under at a foundry using scientific management, taken from the organization record, the second taken from an instruction sheet for a machine operation, and the third a part of the janitor's instructions in another plant.

The second shows the exact time for each detail or sub-operation in a whole job, divided into those that have to be done only once for the whole lot (such as studying the blueprint) and those for each piece.

I have chosen a short one here, but often a seemingly simple job may involve hundreds of sub-operations. The way the expert in scientific management divides labor into its elements and studies the interrelation of each variable constantly reminds me of the classical work of Harcourt and Essen on the reaction of permanganate and oxalic acid. It seems to me that the mechanism of scientific management is very analogous to quantitative analysis and to the methods of physical chemistry, and that the chemist should therefore grasp the principles of this new science even more rapidly than the mechanical engineer.

The janitor's instructions show a rest period included as a part of regular work. This is from Parkhurst's book on "Applied Methods of Scientific Management" (p. 301). When this came out skeptics jeered at the idea of instructions for a janitor. As a matter of fact, standardizing this work saves 20 cents per hour each day the shop runs.

The time study by which these standard times, on which these instructions are based, are obtained, is the mainspring of the whole mechanism of scientific management. A man skilled at his work and willing to coöperate with the management is chosen, and taught how to do the particular piece of work we are studying. One is chosen who is suited to the job, and he is timed, with his consent, when working at his best average gait, not on a spurt. He is paid extra for "working under the watch." *Concealed* stop-watch work is rarely or never justified. Tact must be used in choosing the man and explaining to him the object of the work, when time study is first started. After time study and bonus pay become well started in the shop, there is no trouble, the men often asking that jobs not yet put on bonus be studied by the watch and put on bonus pay, so that they can share in the benefit they see coming to their fellow-workers who are already on standardized, bonus jobs.

Each sub-operation is noted and timed. For instance, in filtering a dozen samples of iron ore from silica, after getting standard conditions, such as weight of sample, volume of acid used, temperature of wash water, standard angle of funnel, standard length of stem, standard filter paper, etc.; folding the

filter, picking up the funnel, placing the filter into the funnel, wetting filter from wash bottle, filling funnel with solution, each operation of washing, etc., etc., would be timed. In this case one would take just enough samples so that the solution in the first filter had run through by the time the solution had been poured into the last, and would use a wash bottle of such size that washing this number of samples could be finished without having to refill the wash bottle. Many of these sub-operations are standard. Folding the filter for filtering a gelatinous precipitate would take the same time as for the silica, though other sub-operations would take different times. After making time studies on a lot of filtrations of various materials, one could analyze the filtration of a new one into its elements. Most of these would already be standard, and a short study would give the other sub-operations so that we could readily get out standard time.

The time-study man is really making a labor assay, as it is often called, and one noted authority says that a chemist makes the best time-study man.

Time studies are usually made to hundredths of a minute with a decimal stop watch and recorded on a standard form. Often a seemingly simple operation will contain hundreds of sub-operations, and duplicate observations are made on different men. Twenty observations of each element on five different men, or a hundred observations in all on each sub-operation is the usual minimum. As the time study progresses, it is easy to see where false motions are being made, and methods of eliminating them are devised. When the false motions and the waits are cut out, we find that, in general, an operation can easily be done in about one-third the time the man does it when left to himself or merely hounded on by the foreman. This is true in almost any industry or operation you wish to name. It has been found that $1/100$ of a minute is not close enough for some time studies, so that very recently a scheme for getting it down to $1/50$ of a second has been devised. A dial a foot and a half in diameter with a hand making a revolution every 6 seconds, electrically driven, and graduated in its circumference to correspond with fifteenths of a second is set up beside the workman and motion pictures taken of the operation and of the dial. These can then be run slowly on the screen, and studied at leisure. Finally the films involving waste motions may be cut out, and the revised film used as a method of instruction to new workmen.

When this point is reached in the discussion of scientific management, the question is always asked "Doesn't time and motion study make the workman into a mere automaton, and destroy his initiative?" The most convincing answer to this is to take the questioner through a plant working under these principles and let him talk to the men on the subject. We have not time to go into this now, but I refer you to pages 49–56 of Gilbreth's "Primer." One point should, however, be brought up:

"The employee is provided the incentive of promotion. If his work could not be quickly turned over to another without fear of demoralizing or at least crippling temporarily the organization, he might be denied such an opportunity of promotion. There are many men to-day experiencing just this injustice because they have become necessary parts of a business machine which cannot be disabled even for the short time required to replace a perfectly good part by one which may need some adjustment."[1]

Gilbreth is making a life-work of time and motion study. He is now working on hospital practice. The results of his investigations enable him to declare, among other things, that scientific management applied within the time-limit of actual surgical operations will cut down the ether-minutes of a patient

[1] Parkhurst, "The Science of Management in Practice," *Ind. Eng.* Mar., 1912, p. 189.

from ten to thirty per cent. What this means in terms of lives is apparent. And even in other lines "to save time is to lengthen life."

Time study can be applied to anything. For example, one of our colleges has tried to get Mr. Gilbreth to apply it to their football formations, so that they can get by actual *measurement* the most expeditious and satisfactory method of passing the ball.[1]

When the time study is complete, the time needed for each operation and sub-operation is noted opposite them on an instruction sheet which goes to the workman as a guide. About 90 per cent of this maximum speed forms the standard time, or as it is often called, "the *task*." The 10 per cent deduction, more or less, is made in order not to drive the man too hard, but to allow proper rest periods to prevent fatigue. In many cases, the instructions show when, and for how long, rest periods shall be taken. Psychology is drawn upon heavily for data on the science of fatigue, for use in this connection. The influence of temperature, humidity, lighting, ventilation and general sanitation on the efficiency of the worker is studied, with the invariable result that the worker gets better conditions and in turn makes more money for his employer through added efficiency.

Now we have standardized both conditions and operations and are ready to consider planning.

Under scientific management all production orders pass through the planning department, from which the order-of-work clerk allots the work to each machine, or man. The relative importance of different pieces of work is decided upon, the work of the different departments is kept in proper balance, and the records of the work in hand and the schedule of the work ahead shows whether men are to be hired or laid off, whether the sales force is to be notified that the factory is working up to capacity and cannot work on new orders till a certain time, or whether it is not up to capacity in a certain line, and that orders for that product should be gunned for.

A planning board is provided with two pockets for each work bench or machine, in one of which are next-work order cards indicating the work ahead of that bench or machine, in proper order. In each department of the shop is a duplicate of that particular section of the board, which controls that department. Duplicate job order cards are in this in order, and as fast as the jobs are completed, these cards are placed in the other pocket from which they are taken by the "move material" boss, who finds on them his instructions as to where the material on which one operation is finished, is to go for the next. When he has moved it, the card is placed in the other pocket, and is taken back to the planning room by the factory mail boy who makes his rounds every fifteen minutes. Hence the planning department knows within 15 to 30 minutes the exact state of every piece of work in the shop.

It is up to the planning department to see that orders are issued to the stock room for the proper materials for these jobs and that everything is in readiness for the job to start at the scheduled time. It issues the proper drawings, instruction sheets and bonus sheets with these next-work orders.

When there is no work for a bench, or a machine, a red card is put in that pocket, and the red areas show vividly where there is overhead expense and no production, and act as a guide to the sales force.

The planning department would be called "non-productive labor" by many old school managers, but it is merely doing in a large plant the sort of head-work that was done in our one-man-controlled soap factory. Under scientific management, instead of only one foreman trying to oversee 50 or 100 men, we have numerous "gang bosses," each overseeing a half dozen or a dozen men working together on the same sort of work.

He gives instructions showing how to cut out waste motion and how to keep up to the standard time. The men are not given standard instructions and then thrown on their own resources, but are constantly shown how to work. The gang bosses are paid a bonus based on the bonus earned by the men under them, and a still larger bonus if *each* man under them earns his bonus, so that they do not neglect any man through personal dislike. The men do not "grow into" the business, Topsy-fashion, in a hit-or-miss way.

Under scientific management, instead of making an error in the first operation on a piece and not finding it till the whole thing is finished, when all the work is wasted, we have inspection at every point, so the same mistake is not made on a second piece or second lot. Under inspection, also, we shall class cost and production records, for they constitute an inspection of the management. Proper records under scientific management have been defined as "immediate and adequate," or still better, they are to work like an "instrument of precision," accurately and without lag, *i. e.*, they must reflect wrong conditions and deviations from the standard before it is too late to remedy them. Records again, while essential, are not Scientific Management, but merely a part of a larger whole. Emphasis should be laid on this, as there are too many half-baked accountants, who, seeing the interest in scientific management, advertise themselves as "efficiency engineers," delude the board of directors into hiring them, put in a cumbersome system of forms and records, collect their fee, and leave the plant in worse chaos than before. The accountant, while useful, bears about the same relation to the real organizing engineer as the mere analyst does to the chemist.

Now the efficiency reward. If no incentive be given for the workers to go at the pace the time study has shown is proper, and we merely try to drive the men, all the work of standardizing conditions and operations is wasted. This is not the time nor place to discuss methods of pay in general, nor of different schemes for rewarding the man for doing the task as instructed and in the proper time. Suffice it to say that the best scheme is the differential bonus,[1] by which the man receives his flat day rate no matter what happens, as long as he is considered good enough to keep on the working force, and in addition, a small bonus when he begins to approximate a fair day's work, the bonus increasing steadily with increaseed output till, when he reaches the output fixed as the standard task or full day's work, he gets a bonus of from 25 per cent to 100 per cent of his day rate, the percentage being greatest with the work that is physically hardest, such as working over hot furnaces, for there the incentive has to be greater.

Straight piece work rates have no place in the scheme of Scientific Management.[2] The bonus is always paid in a separate envelope from the day rate to emphasize the fact that the added wage is paid, not for time spent, but for doing things right and as directed.

Now for some of the results obtained by scientific management. I am going to cite cases merely from the plants I have myself seen, using the new management. I visited one plant in which I picked out at random from their perpetual inventory, cards showing the cost of production of stock parts for some three years of old line management and some five of scientific management. They showed in no case less than 50 per cent reduction in cost, and in some 400 per cent.

The foundry with which I was recently connected had some dozen plants. One plant, the most modern of the lot, had always been at the bottom of the list on cost of production, though several men well skilled in the trade had unsuccessfully tried to improve its operation. An expert in scientific management who was not an expert in this particular trade, took hold

[1] Nock, "Efficiency and the Highbrow," *American Mag.*, Mar., 1913, p. 50.

[1] Parkhurst, "Applied Methods of Scientific Management," pp. 166–180.
[2] See Gantt, "Work, Wages and Profits."

of it, and in six months that plant was at the head of the list instead of at the foot, and the costs were less than $^2/_3$ what they had previously been. And this with no other change than the use of the principles of scientific management. And at that, they have hardly gotten started on it. A few weeks ago I saw their "lost ground" chart, on which the jobs that did not show improvement over past conditions, either in cost of production or rate of production, were marked in red. Out of some fifty jobs on which they have time studies and installed bonus pay, as I said, they are hardly started, *one* cost and *one* rate were in red, and there were special reasons which fully explained these. The rest showed improvement of 25 per cent to 400 per cent.

Still later reports from this plant show that 115 operations are now on bonus, which show an average increase in production over that under former methods of 122 per cent, an average cost reduction of 31 per cent, an average decrease in defective castings from all causes of 40 per cent and an average wage increase, in bonus, of 26.3 per cent.

Take some specific instances:

A pile of waste sand had to be taken away to allow excavating for a new building. The best bid any contractor would make for the work was $450.00. A little time-study and the establishment of proper methods and bonus pay allowed the plant to do it for $162.00.

Take the job on which this bonus chart was issued:

BONUS CHART 32
10/17/12

Differential Bonus for molding gang on Four Cylinder Crank Case No. ——. The following prices will be paid as *bonus* in addition to hourly wages for time consumed on the job based on good castings. Losses not due to the molding gang will not be deducted. These prices will not be lowered no matter how long the job may run from this pattern and equipment.

Cope and drag rammed in floor; 1 molder; 3 helpers

Good castings	Bonus per casting	Bonus each molder	Bonus each helper
25	$0.020	$0.50	$0.38
26	0.023	0.60	0.45
27	0.026	0.70	0.52
28	0.029	0.81	0.61
29	0.032	0.93	0.70
30	0.035	1.05	0.79
31	0.038	1.18	0.89
32	0.041	1.31	0.98
33	0.044	1.45	1.09
34	0.047	1.60	1.20
35	0.050	1.75	1.31

THE .... COMPANY

This is a bonus chart for the molding of the crank case that goes in a well-known automobile. Note particularly the statement in black and white that these prices will not be cut.

Under old methods the average number of good castings per day was 18.2, the labor cost per piece was 59 cents. The molder got $3.25 and each helper $2.50, making the labor cost per piece 59 cents. Under instruction and bonus the average is 33.3 castings per day. The molder gets $4.75 and each helper $3.63, the labor cost per piece being 47 cents, or a 20 per cent decrease in labor cost, a 45 per cent increase in wages and 83 per cent increase in production.

The firm not only makes a bigger profit, but makes it on many more pieces, so that the cost of the time study, the inspection and the planning is repaid many fold. As to the workman, well, you're not going to have much labor trouble with your men getting 45 per cent more than the regular day rate for their class of labor. As to the consumer, he is getting castings nearly twice as fast as he was before (and he wants all he can get) without supplying more than one pattern, and that pattern cost about $600, where under the old conditions he would have had to supply two to get the castings he wants.

Take a case in coremaking at this foundry. This job had been run under day work from 75 to 85 cores a day, and in the judgment of the foreman 90 cores could be made in nine hours. A time study on this job was made, and the result was that the job figured 0.83 minute per core and making an allowance of about 10 per cent, the maximum bonus production was figured on a basis of 0.9 minute per core. This means a production of 600 cores per day for one man at the bench. Bonus was started at 70 per cent of this production (420) and the chart above referred to was issued on this basis. It is a pretty radical proposition to take a 75 to 90 a day job, based on the best judgment of the man in charge of that department and attempt to jump it to 420 before the men earn any extra remuneration. The man who had been working on this job refused to work under bonus and walked out. A strange man was put on the job and for the first day's work made 460 cores and the second day 537, and since that time has continually averaged very close to the 600 mark. This example is recorded here as a good illustration of the apparent radicalism of some of the results under new methods.

Here is still another example:

MEMO OF A MOLDING JOB UNDER DIFFERENTIAL BONUS
Aluminum crank case weighing 79 pounds
4 duplicate sets of equipment—38 days' run

Pat. No.	Av. good No. per days	9 hr. day	Mold-ers good	Daily day wage	Wage bonus	Molding cost per good case
1	37.72	27.55	28.6	$23.27	$9.121	1.175
2(a)	36.31	31.40	32.2	25.64	12.926	1.228
3	37.64	27.70	29.1	23.06	9.607	1.180
5	36.77	26.75	28.3	24.06	8.832	1.230
Averages of four patterns...	28.35	29.55	$24.005	$10.121	1.203

(a) Gang on pattern No. 2 was a picked gang considered the fastest and best workers in the shop; they always worked together and received extra high wages, owing to their efficiency.

NOTE:

Old average good production under combination of day and premium.............................. 15.15 cases

Old average good production cost under combination of day and premium.............................. $1.196 per case

Bonus average production increase................... 87.2 per cent

Bonus average cost increase....................... $0.007 per case

Old foundry defective from all causes when netting 15.15 good cases per day was 25 per cent.

Foundry defective from all causes under intense bonus production when netting 28.35 cases per day was 9.72 per cent.

Foundry defective loss under intense bonus production and Scientific Management methods was reduced 60.7 per cent.

Average bonus equals 42.2 per cent over regular day wages.

This shows an increased molding cost of nine one-hundredths of a cent a pound, but the cost of the material and labor used in melting and handling the metal and in making the cores lost in the greater number of defective castings obtained before, throws the cost balance far on the side of the new methods, even disregarding for the moment the increased profits and decreased overhead due to the large increase in production.

In another plant that I have visited, they were machining 10 pieces of a certain sort per day. Large demand for that product made it necessary to get some work done outside. The best they could get an outside firm to do was 2 per day, so the firm sent its own men and applied its own methods to the outside shop, and got 8 per day in a strange shop on an antiquated lathe.

Now for the workman's point of view. Where scientific management has been installed, the hours have been decreased and the pay largely increased. Our foundry went from 10 to 9 hours, and the production increased. I asked an old workman in one plant I visited whether he would be willing to go back to the old methods. He said "No, Sir! We do more work, but things are fixed so we can do it easier, and we get more pay-

I always tried to do a day's work for a day's pay, but what I like about this shop now is that there are no loafers who get the same pay I do and don't do half as much."

Following is a partial list[1] of the industries in which some form of labor-saving management has been installed:

Bookbinding	Machine tools	Food products
Building construction	Molding machines	Furniture
Carriage and wagon-building	Pumps	Flour
	Pneumatic tools	Glass
Chains	Sewing machines	Lumber products
Hardware	Typewriters	Pianos
Tanks	Wood-working machinery	Paper and paper pulp
Construction and repair of vessels (navy yards)	Metal and coal mining	Rubber goods
	Metal working	Soaps
Firearms and ordnance	Bolts and nuts	Shoes
Rifles	Valves and pipe fittings	State products
Gun carriages	Miscellaneous manufacturing	Printing and lithographing
Machinery building	Beer	Railroad maintenance of motive power
Automobiles	Beet sugar	Steel manufacture
Agricultural implements	Boxes (wood and paper)	Textile manufacture
Coal-handling machinery	Tin cans	Woolens
Electrical machinery	Buttons	Bleaching and dyeing
Founding iron and brass	Clothing	Velvets
General machine work	Cordage	
Gas engines	Cottons	
Locomotives		

This shows how universally applicable these principles are.

In fact I have been wondering how the chemical departments of our universities would strike an efficiency engineer. As university departments go, they rank well, but looked at from the point of view of efficiency, they are probably in the same class as all industries, a certain amount of work done in a difficult way, when, applying the principles of scientific management twice as much could be done in the same time, in ways easier for both student and teacher.

I know you will say: "Oh, scientific management is all right in a machine shop or a foundry, but it wouldn't do in a university—conditions there are different." That is exactly what every one says of his own business at first. It is exactly what I said at first when I was told to look into scientific management and see what was in it for our foundry. But, as I studied the question, I saw that it *was* applicable, and after the right expert was secured, it was applied with the results I have given you.

Gilbreth says, in reference to his hospital work,[4] "A hospital *is* a factory, a health-and-happiness factory; and it ought to be governed by the supreme principle that governs any other factory—the principle of maximum efficiency in relation to the output."

I look at a school of chemistry as a manufacturing plant, with its product either embryo superintendents or managers of plants or else pure research men, whether employed as such in the industries or as teachers. The principles that apply to our factories will apply here.[2]

Parkhurst says:[3]

"Scientific Management applied to our public and preparatory schools, colleges and industrial and manual training schools will be the remedy for much, if not all, of the present inefficiency. ....The greatest handicap to the remedy of this efficiency will be the opposition of those directly involved and who are to be directly benefitted by a radical change."

F. W. Taylor says:[4]

"The illustrations chosen in this book are such as, it is believed, will especially appeal to engineers and to managers of industrial and manufacturing establishments, and also quite as much to all of the men who are working in these establishments. It is

hoped, however, that it will be clear to other readers that the same principles can be applied with equal force to all social activities: to the management of our homes; the management of our farms; the management of the business of our tradesmen, large and small; of our churches, our philanthropic institutions, our universities, and our governmental departments."

How do other university graduates who, like myself, meet Scientific Management in after life, feel about it? Let me quote again from Gilbreth:[1]

"I am building a fairly large job at the present time on which I have a number of young college men, most of them from a few months to a very few years out of college. They come from the best colleges in this country, and they have formed themselves, without any suggestion from anybody, into the first Canadian Society for the Promotion of Scientific Management......Now the question of academic efficiency I am not prepared to debate, but I will say this however; these young men came from different colleges, the University of Illinois, Yale, Brown, Lehigh, Massachusetts Institute of Technology, and I don't remember what other colleges, and every one of them said, 'I regret exceedingly that our professors have not taken this thing seriously, and given it to us while we were in school.' "

This year one of our largest universities has 177 working days in the college year. Allowing for Sundays and holidays, including Founders' Day, and allowing thirty days' vacation besides (though the man of college age who has to work for a living is mighty glad to get two weeks), there should be 275 working days. That gives a time efficiency of 63 per cent. Then look at the laboratories that are occupied, say 25 per cent of the time that college is in session, and you get floor-space efficiency on the line of dependent sequence, of 16 per cent. Look at the lines waiting at the stock room windows. Look into the laboratories and see the time wasted in setting up apparatus, talking things over, waiting for balances, etc., and if you get a real working efficiency of 50 per cent in any chemical department of any university, I shall be surprised.

Let us grant that producing chemists is a different sort of industry than making molding machines for example, and that the universities do not, like a manufacturing plant, get more money for giving their students more and better training, the student gets the money in the form of a more rapid and a higher rise than he would were he less well trained. Yet is there any reason why the university should not be willing to learn from any source, even though not an academic one, how to "make the best use of the present equipment?" Every one at first naturally has the idea that his industry is run as well as it possibly can be, that scientific management is something for the "other man."

We quote again from Gilbreth:[2]

"It's a mystery to me why the medical men take themselves for granted as the ones to manage a hospital. They seem to think that a training in a specialty is a training in management. Nothing of the kind. Management *is* a specialty. A doctor's training is not of the kind that would make him a manager. The surgeon is just like the old-style shop foreman, it's the instinct with him to resent suggestions from anyone outside the trade and he wouldn't work in a plant where 'non-professional' orders or instructions are tolerated. So from the standpoint of scientific management, the hospitals are back in the Dark Ages."

Does not the same thing apply to chemical schools? How many educators could qualify as up-to-date executives in a manufacturing plant? Yet are they not really forced to *be* executives in what is really a manufacturing plant? If our teachers of chemistry will study deeply the science of management, as they do their own science, with the thought constantly present that possibly some of the principles *might* apply to their

[1] *Industrial Engineering*, December, 1912, p. 239.

[2] Cf. M. L. Cooke, *Bull.* **5**, Carnegie.

[3] F. A. Parkhurst, "Science of Management in Practice," *Industrial Engineering*, Feb., 1912, p. 113.

[4] Preface to "Principles of Scientific Management."

[1] Report of Dartmouth Conference of Oct., 1911, p. 358.

[2] *American Magazine*, March, 1913, p. 50.

work, and not solely to the other man's, there might sometime be created a scholastic environment that in turn would create in our chemical students an attitude of mind which would largely span the gulf that now exists between the college and the works in which the student is to use his college training. Why need we look back at our college days, in comparison with our works experience, as a period of hard mental endeavor, but of little actually accomplished?

It is not the hard mental work that counts in brain development, but the *efficient* work. The university deals with impressionable brains. To impress on those brains the need of planning work in advance, of setting a standard of work and then of living up to it, is vital.

I believe that a course in chemical engineering run on the lines of scientific management would teach as many chemical facts as the present courses, and might also teach a greater number of students how to think.

But whether the universities take up scientific management is not for us to decide. What each one of us *can* decide, is whether he cannot apply these principles which have brought such results in so many and so varied fields of endeavor, to his own work—to his own study in his college course, to the planning and execution of his own research work, to the lay-out and routine of his own laboratory, and to his own daily life.

If I have succeeded in awakening any interest in your minds in this new American industrial development, I shall be glad. If I have not, the fault lies with the speaker, and not with the subject.

I. INSTRUCTION FOR MANAGER OF RESEARCH DEPARTMENT

1. The Manager of the Research Department is under the direct charge of, and solely responsible to, the General Superintendent; his hours are those of the office at Plant No. 1.

2. He shall make his headquarters in the laboratory located at Plant No. 1. While he is not under the orders of any one at Plant No. 1, his location at that plant makes it advisable that he work in close harmony with the officers of that plant, since most of his observations and tests on actual foundry practice must be made at that plant. When such work is to be done, the authorization of the Superintendent of Plant No. 1 must be obtained. This is to prevent hampering the production of Plant No. 1 by the research work. In all such work no orders shall be issued to any foremen or workmen that are not fully authorized by the Superintendent's approval of the work.

3. He shall have charge of the maintenance of the laboratory, and its equipment.

4. He shall make such routine analyses and tests of materials purchased by this Company and received at any plant as shall be required by the General Superintendent.

5. He shall have charge of the pyrometer equipment at all plants and shall keep the same in working order. All new pyrometers or repair parts for them shall be ordered by the Research Department and supplied by it to the various plants on their order.

6. He shall be in general charge of all pyrometric control of core ovens, furnaces, and pouring temperatures at all the plants.

7. He shall have general charge of the preparation of specifications for the purchases of material, but such specifications must be approved by the General Superintendent and the Purchasing Agent.

8. He shall have general charge of all alloy mixtures at all plants and shall see to it that such directions are furnished the various plants as, when properly executed by the plants, will result in the alloys put out meeting the physical and chemical specifications demanded by the customer. He is thus in a general way responsible for the quality of the output at all plants.

9. He must work in close touch with the Sales Department, on the matter of customers' specifications. A customer's specifications should be O. K.'d by the Manager of the Research Department before the order is booked.

10. He shall keep full and accessible records of all analyses, tests, experiments or investigations of any kind conducted by his Department.

11. He shall read the various technical and scientific journals that contain information of value to the aluminum, brass and bronze casting industry, these to be furnished for his Department at Company expense, and shall maintain a complete file of references to such information contained

therein, so as to be able to answer promptly and accurately inquiries on technical and foundry problems.

12. As opportunity offers, he should attend meetings and conventions of societies dealing with the chemical, technical, engineering and foundry problems of this business. He should make every effort to keep abreast of current scientific and technical progress in his line of work.

13. He shall collect data from the various plants, or from other sources, on foundry problems, and shall make his Department a clearing house of technical information for all the plants. When a piece of work has shown how savings can be made, or quality of output improved, this information is to be reported to all plants.

14. He shall carry on such scientific or technical investigations and researches as may seem advisable in order to solve problems that come up, or to acquire needed information. The problems may originate with him, or be suggested by the Officers of the Company, by the various plants, or by customers. Before undertaking such investigations, a statement shall be made to the General Superintendent, stating the problem, the reasons why it might be worth while to investigate it, an estimate of the time and expense attached to it, and a general outline of the methods to be used in the investigation. The work shall be undertaken only after securing the approval of the General Superintendent. In rare emergencies where problems are sent in by plants, or by other Officers than the General Superintendent, which will not admit of delay, the work may be started without waiting for his approval, but he must be at once notified of the situation.

15. No analyses or tests outside of the regular routine authorized by the General Superintendent, or by these instructions, shall be made without the approval of the General Superintendent.

16. Weekly reports of the progress of the work in hand shall be made to the General Superintendent, President, and Vice-President. Copies of all letters written of any importance shall go to the General Superintendent. Where customers or sales are affected, copies shall also go to the Vice-President. Where letters concern any plant or plants in particular, copies shall also go to the Manager or Superintendent of the Plant in question, depending on the nature of the subject. In cases where the letters

II. INSTRUCTION CARD FOR A MACHINE OPERATION

<div>

........MACHINE Co.
INSTRUCTION 680

NOTE

All time is expressed in   Form F. A. P. 35*a*
Hours and Decimals   1 SHEETS, SHEET 1 DATE 5–9, 1912

ARTICLE OR JOB—Pl–2–3–4–5–6 Treadles
OPERATION—dlcs

</div>

		Hand or Machine—7-D	Sketch or Drawing—10169
Quantity 1	Material—Iron Castings		
TOTAL	TOTAL		BONUS
LOT TIME 0.061	PIECE TIME 0.05		CHART 680

SUB OPERATION	DETAIL INSTRUCTIONS	TOOL	CUT	FEED	SPEED	PIECE TIME	LOT TIME
1	Preparation..................						018
2	Study drawing................						008
3	In drill.....................					002	
4	Treadle from floor to table.......					001	
5	On jig......................					001	
6	Drill C.....................			Hand	40'	006	
7	Change drills................					004	
8	Drill D.....................			Hand	37'	005	
9	Off jig.....................					001	
10	Change drills................					004	
11	Drill E.....................			Hand	40'	005	
12	Out drill...................					003	
13	In countersink...............					002	
14	Change speed................						002
15	Countersink C & D............			Hand	70'	005	
16	Treadle to floor..............					001	
17	Dismantle and work order to desk					033	
	Carried Forward or TOTAL					040	061
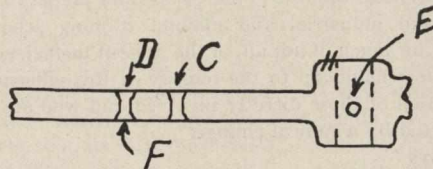
WHEN MACHINE CANNOT BE RUN AS SPECIFIED, GANG BOSS MUST REPORT AT ONCE TO
L. NICHOLS   INSTRUCTION 680

are of sufficient interest or importance, copies shall also go to the President.

17. Strict attention must be paid not only to the accuracy of the work done but to the promptness with which it is done and reported. In cases where there is doubt as to the relative importance of several pieces of work that call for prompt attention, special instructions shall be secured from the General Superintendent.

III. From Janitor's Instructions

Afternoon work, Monday to Friday inclusive

		Minutes	Hours	Bonus
17	Empty wash trough in locker room, thoroughly sweep and scrub same including floor..........	15	0.25	0.0125
18	Remove ashes (based on an average of five loads each afternoon)...	36	0.60	0.03
19	Sweep the north bay of the machine shop between the east wall and store room, and remove chips..	48	0.80	0.04
20	Sweep main press shop including erecting floor and part west of the dead line, and remove chips; includes twelve minutes rest period......................	189	3.15	0.1575
21	Prepare water in the locker room prior to the quitting whistle at 6 p. m......................	12	0.20	0.01
		300	5.00	$0.2500

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MORSE HALL
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THE INTERPRETATION OF U. S. P. ASSAY PROCESSES[1]

By Frank O. Taylor

The alkaloidal assay methods of the United States Pharmacopoeia have been plentifully criticized and volumes have been written concerning changes of greater or less importance deemed necessary by various analysts. Many entirely new methods have been suggested and improved methods finally evolved from this mass of work, for use in the next Pharmacopoeia, will doubtless be more efficient than those now employed. However much we may blame defective processes for the lack of uniform results obtained by different men in the assay of fluid extracts, tinctures, etc., I am convinced that the trouble is frequently not in the method *per se*, but in the details of applying it, or in other words, in the individual interpretation of the method as stated in the U. S. P.

Now, I am perfectly willing to concede that few, if any, assay methods are given in any fuller detail than those in the Pharmacopoeia for the estimation of alkaloids and on casual reading it would seem that the methods are so explicitly stated that even an inexperienced chemist could hardly err in carrying them out, and yet if you give the same fluid extracts to several different and equally expert chemists, you are extremely liable to get some widely different results. If placed in the hands of chemists who are not thoroughly familiar with the eccentricities of alkaloidal assays, he would be a rash prophet who would attempt to foretell the variation in results obtained. This condition of affairs is one of grave importance alike to retail pharmacist and manufacturer since, with the greatly increased attention to this work during recent years, many chemists have taken it up who have not had the opportunity of acquiring the necessary experience to confer expertness and thorough reliability. This is in no wise a reflection upon individual ability or general knowledge of chemistry and pharmacy as all who have had long experience in drug assays will agree, but is simply a chemical application of the old saying that "practice makes perfect," and this peculiarly difficult variety of assays requires a great deal of practice.

As a homely illustration, suppose the pharmacist reads the instructions for the assay of Henbane, for example, he will most probably say "Surely that is so explicit that any chemist ought to be able to get accurate results," but he would not think of taking a cook-book home to his wife, expecting her to make a

[1] Paper presented at the Milwaukee Meeting of the American Chemical Society, March, 1913.

cake exactly like that made by Mrs. Smith by following the recipe unless she was a very experienced cook and had made numerous similar cakes before.

With the existing and increasing number of legislative enactments concerning standards of strength for drugs and their preparations, any errors in assay may bring about confusion and legal complications for which there is no basis in fact. Chemists working under the authority of Federal or State Governments and those responsible to individuals or corporations are equally interested in seeing that the desired standards are maintained and that conflicting analyses do not throw discredit upon analyst or producer.

It is the purpose of this paper to direct special notice to possible misinterpretation of the U. S. P. assays and in some cases to emphasize again facts that have already been published by others, but to which little attention seems to have been paid.

The adoption of uniform methods of assay for alkaloidal and other drugs is a very necessary thing, but the standardization of these methods is a very different thing from the standardization of the operations of a machine, and the literal applications of the U. S. P. methods may often give results never contemplated by the authors of the processes. As in the meting out of real justice under the terms of a law, regard must be had for the obvious intention of its originators, so in the carrying out of these somewhat intricate directions for the estimation of alkaloids we must keep in mind the evident intention of those who devised the methods and interpret the minor details in the light of this knowledge. You will recall that the eighth revision of the Pharmacopoeia became official on September, 1905, but supplementary notes and corrections were later made which were embodied in correction sheets official from May, 1907, and a few additional notes were made official from June, 1907. Copies of the Pharmacopoeia printed subsequent to this time contained all these corrections in the text, but it is quite likely that these emendations have not everywhere received due attention.

The writer's attention was recently called to a typical example of how discrepancies in assays may occur when two different chemists failed to get anything like concordant results in the assay of the same tincture of aconite, and consideration of the details of this method of assay will show how the confusion occurred and how it might happen in other cases.

In the process as described, after evaporating 100 cc. of tincture aconite to dryness, the Pharmacopoeia provides that the residue should be dissolved in a definite amount of tenth-normal sulfuric acid and distilled water and then says: "When the extract is dissolved, filter the liquid into a separator, washing the dish, and filter with about 25 cc. of distilled water." Now, there is a certain amount of extractive matter not soluble in the acid water and it is the obvious intention that this residue, the dish and filter shall be washed entirely free of alkaloid so that no loss may occur. If the washing is carried out rapidly or carelessly, it is quite possible that some of the alkaloid will not be washed out with 25 cc. of distilled water, and the washing ought by all means be continued until the alkaloid is completely transferred to the acid solution. It is next required that the acid solution, after being made alkaline with a definite amount of ammonia, shall be shaken with successive portions of 25, 15, 10 and 10 cc. of ether, the total being 60 cc. Here again the evident purpose is to entirely remove the aconitine from the aqueous solution to the ether, but, as we will see later, this will not be accomplished by this treatment and the extraction with ether should continue until this is done, which may be demonstrated by evaporating one or two cc. of the last ethereal washing, taking up the residue with a few drops of acid water and testing for the presence of alkaloid with Mayer's reagent. Certainly the exact wording of the process does not require this, but here again it is the obvious intention that this should be done and is

authorized by the Pharmacopoeia under one of the notes of correction to the article on "Alkaloidal Assay" given at the foot of page 579 in those copies printed since June, 1907, which reads as follows: "If extraction is incomplete, the process must be repeated with additional solvent. The completion of the shaking out processes may be tested in most cases by evaporating a small portion of the solution, dissolving the residue in acidulated water and adding mercuric potassium iodide, T. S., when the absence of turbidity indicates exhaustion."

From a careful comparison of the method of applying the U. S. P. assay by the two chemists in the instance mentioned above, it seemed very probable that the difference in results was due to this incomplete extraction, and in order to demonstrate the truth of this theory, a quantity of tincture of aconite was divided into different portions and submitted to four different chemists for assay with instructions that the U. S. P. process be followed literally in every particular, and after making the assay by this means the aqueous liquid should be again shaken out with successive portions of ether until the test with Mayer's reagent indicated complete extraction. The results are shown in the table below:

	Grams per 100 cc. of Tincture			
	Chem. No. 1	Chem. No. 2	Chem. No. 3	Chem. No. 4
Using 25–15–10 and 10 cc. ether for final extraction..........	0.0352 0.0352	0.0372 0.0372	0.0345 0.0333	0.0358 0.0358
Per cent of U. S. P. Standard...........	78.2%	82.6%	75.3%	79.5%
Extraction continued with 25–20–20 cc. ether..............	0.0098 0.0098	0.008 0.008	0.012 0.012	0.0084 0.0090
Per cent of U. S. P. Standard...........	21.8%	17.8%	26.6%	20.0%
Final result of assay....	0.045 0.045	0.04522 0.04522	0.0465 0.0453	0.0444 0.0448
Per cent of U. S. P. Standard...........	100.0%	100.4%	101.9%	99.5%

It will be noted above that when the process of assay is carried out exactly as outlined in the Pharmacopoeia, using separate portions of 25, 15, 10 and 10 cc. of ether, the alkaloid extracted amounted to from 75.3 per cent to 82.7 per cent of the quantity required by the U. S. P. When the extraction was continued by the use of a further quantity of ether and the total amount of alkaloid estimated, the results were very uniform, ranging from 99.5 per cent to 101.9 per cent, which is well within the practical limit of personal variation in applying an assay process of this kind. In carrying out this work, Chemists 1 and 4 each used different volumetric solutions while Chemists 2 and 3 employed the same volumetric solution, but different from either of the others.

These experiments demonstrate conclusively that complete extraction cannot always be obtained by the use of the exact quantities of solvents specified in this assay process, and the same thing is equally true of many other of the methods laid down in the U. S. P., particularly the various mydriatic drugs and physostigma, but, as indicated in the note we have quoted above, it is the intention of the Pharmacopoeia to have such extraction complete and it is necessary, therefore, to take a common sense view of the assays and be guided accordingly.

Taking the aconite assay again as an example, the separation of the ethereal and aqueous liquids is stated as follows: "Draw off the lower layer into a flask and filter the ether solution into a beaker. Return the contents of the flask into the separator ...." Now, nothing is said about rinsing out the flask with water when pouring its contents back into the separator, but as otherwise some loss would occur, the careful chemist

would unquestionably do this and be carrying out the spirit of the Pharmacopoeia in so doing. Details of manipulation such as these may appear trivial and do not have a place in the pharmacopoeial statement of the assay process as they can be covered to better advantage in a general article such as appears in the back of the Pharmacopoeia on alkaloidal assay, but they must not be overlooked in actual work.

As a specific instance of this kind, Salway (*Trans. Chem. Soc.*, **99**, 2149 (1911)) states that "a representative sample of Calabar beans........when assayed by the method of the U. S. Pharmacopoeia yielded 0.091 per cent of alkaloid. The method referred to, however, was found to give results which were much too low since the amount of physostigmine isolated when working on a large scale........was equivalent to 0.179 per cent........ The low result of the above method of assay has been ascertained to be due to the fact that three extractions with ether (as required by the Pharmacopoeia) are quite insufficient to remove the alkaloids completely from a solution which has been rendered alkaline with sodium hydrogen carbonate."

The same remarks concerning incomplete extraction are likewise true as applied to the transfer of alkaloid from its solution in ether or chloroform to an acid aqueous liquid, as in the assay of coca, cinchona, pilocarpus and the mydriatic drugs.

Turning now to still other sources of variation, attention may be directed to the methods of shaking employed. In the various assay methods the Pharmacopoeia gives definite statements as to the length of time which the powdered drug should be shaken with the solvent used for extraction as, for example, in Belladonna leaves it says: "Shake the flask well at intervals during one hour" or, when it gives the time for shaking the immiscible solvent with the aqueous solution as further in the same assay process, the statement is made: "Shake the separator well for one minute." The continuation of the shaking in the first case beyond an hour, or by shaking at frequent intervals by hand, or continuously, in a mechanical shaker, all are intended for the purpose of completely extracting the alkaloid from the drug, or rather for producing a uniform distribution of the alkaloid in drug and solvent, which practically amounts to the same thing, and if the extraction process is not carried far enough an error may creep in here, so that it is decidedly preferable to exceed the time limit of the U. S. P., especially if the shaking is done by hand at intervals, rather than to run chances of following the instructions literally and getting a low result. Scoville (*Proc. A. Ph. A.*, **1910**, p. 820) has made brief reference to this same point, and others have probably done the same thing, but additional emphasis is by no means uncalled for.

In another paper (*Proc. A. Ph. A.*, **1910**, p. 874) Scoville has pointed out a very serious source of error in the assay of fluid preparations of the mydriatic drugs in that these have the very peculiar characteristic of being less easily extracted when old than when freshly made if the U. S. P. process is strictly followed. He has shown that fluid extracts of belladonna, hyoscyamus, scopola and stramonium, when freshly made, may usually be extracted completely by following the U. S. P. process, but after they have aged for one or two years it is impossible to extract the full amount of alkaloid present by the strict use of the U. S. P. process, and the same difficulty sometimes occurs even in freshly made extracts. The addition of a small portion of alcohol to the chloroform used for the preliminary extraction permits of the complete and much more rapid removal of the alkaloid from the aqueous liquid. It may seem that this is going beyond the bounds of the U. S. P. process, but I do not believe this is the case since in the pharmacopoeial note on the alkaloidal assay (page 579), it states that if an emulsion forms which cannot be easily broken, it is permissible to use a "slight amount of alcohol to assist in breaking this emulsion, and as emulsions are specially liable to form in the assay of the mydriatic drugs, alcohol would

very likely be used in many cases, and it is certainly not overstepping the bounds of the assay to use it in every case. In fact it was in the use of a little alcohol for breaking emulsions that the great advantage of its presence was originally determined. If this trace of alcohol is not employed, a fluid extract which is fully up to standard strength might very easily be condemned as having deteriorated to a great extent.

After the alkaloid has been isolated and its exact quantity is to be determined by titration, as with coca, ipecac, belladonna, henbane and stramonium, another error may creep in, especially with the mydriatic leaves and their preparations. The residue left by evaporation of the ethereal or chloroformic solution is to be dissolved in an exact quantity of standard acid and the excess titrated by alkali, but sometimes if much care is not taken, all the alkaloids will not be dissolved even with the excess of acid present and the result of the assay will be too low. To be sure of completely dissolving the alkaloid as is intended in the assay process the addition of 2 or 3 cc. of neutral ether or alcohol is always desirable; not because the alkaloid itself is so difficultly soluble in the acid, but because a certain minute quantity of other substances not easily soluble in very dilute acid is carried through the various stages of the assay and, being incorporated in the final residue, offers more or less protection to the alkaloid against the action of the acid and water. Having effected complete solution by this means it is best to evaporate the ether by brief warming on a water bath, subsequently cooling before titration with the standard alkali; if alcohol is used it may remain in the solution.

Other details in the U. S. P. methods of assay might be cited as possible sources of variation in the results of different chemists as, for example, the apparently very simple process of filtering aqueous or ethereal solutions, but such instances will occur to you from your personal experience in this work and could be multiplied to a great extent.

SUMMARY

Conditions surrounding the assay by different men cannot always be the same and variation may occur for the following reasons:

First and chiefly, because of incompleteness of extraction either of the drug or of the aqueous liquids by immiscible solvents.

Second, by too great haste in carrying out this work, for in chemical assays, as in everything else, the old aphorism that "haste makes waste" is most certainly true.

Third—With particular reference to the fluid preparations of the mydriatic drugs, there is evidence of a peculiar condition in old preparations and sometimes in new ones that prevents the complete extraction of the alkaloid without the use of a trace of alcohol in connection with the chloroform.

Fourth—The question of shaking by hand or by mechanical means at any point in the process may make some difference, but particularly will there be difference in results if sufficient time is not allowed, and it is well to exceed the pharmacopoeial time limit, which is most evidently intended for a minimum statement of time necessary, so that in either case complete extraction will be assured.

Fifth—The solution of the alkaloidal residue in standard acid before final titration may not always be complete, and a little carefully neutralized ether or alcohol should be used as an aid to this end.

Sixth—The individual method of reading end points by various indicators in the titration of alkaloids, while not specifically mentioned above, will have some effect upon the results.

The U. S. Pharmacopoeia has come to be a legal authority and as such will be construed more strictly than ever before, but we must keep in mind that good law is also good common sense, and to apply the pharmacopoeial requirements in any other manner is warping it away from its true purpose.

The carrying out of its assay methods must be done with a clear vision of the end to be attained and a thorough understanding of the many pitfalls in the way of the chemist.

LABORATORIES OF PARKE, DAVIS & CO.
DETROIT

WATER SUPPLY FOR THE MANUFACTURER[1]

By W. M. BOOTH

Before locating a new plant or industry, a large amount of preliminary information is necessary. Having decided that market conditions, transportation, labor and power are available and acceptable, a thorough study of water conditions must be made. This should determine the quantity, quality, and cost of this material necessary in the production of power, for strictly manufacturing operations, for drinking, for cleaning and for fire. Sum up all possible requirements and add from 50 to 100 per cent for emergencies and for growth.

If possible, two independent sources of supply should be obtainable.

Information of the character demanded can be obtained from a commercial laboratory that has specialized in this direction, or from a consulting engineer who has a laboratory at his disposal. Such a study should be begun at least a year in advance of building operations. Seasonal changes are such that both quality and quantity of water may vary greatly form month to month, if the proposed source is a river, small stream or spring.

Having employed a man or company to make the necessary observations and analyses, the proposed sites can be visited and the requirements pointed out and discussed. If water is to furnish the power of the mill and maximum and minimum flow data are not available, they must be obtained from the government or from original experiments conducted with a weir. Special forms of this device are now sold with recording gauges that read in cubic feet per second. If records have not been kept and the expense of the instrument is more than is thought necessary, actual velocity and depth studies can be undertaken at stated dates each month. If the minimum of these readings shows the passage of the required volume of water, the questions of quantity are dismissed for power, fire and cleaning.

Such water is rarely exactly fitted for power and technical purposes. There is, however, a considerable area of granite or related rock in the United States, the run-off from which is soft and clean. The Adirondacks, the White Mountains, and the Catskills all afford an abundance of soft water. The plants along the streams running from these highlands have many advantages due to this kind of water supply. I have found the hardness to average about fifty parts per million.

Shale rock areas in New York state at an altitude approximating 1400 feet also afford very good water, with a hardness between 100 and 120 parts per million. Limestone areas generally produce *hard* water. Such a belt runs through the United States from eastern New York to the Mississippi river and south; hardness 150–2000 parts per million. Before use in a power house, this class of water should be softened by chemical means. The cost of treatment varies from a fraction of one cent to twenty cents per thousand gallons.

The quality requirements for manufacturing purposes vary with the nature of the business. Textile mills demand a great volume of soft water, free from iron and sediment. Canned goods concerns need a water under a hardness of 170 parts per million, clean and sanitary, low in organic nitrogen. Power producers and steel plants need large volumes of soft water, free from sediment and oil, and cold for condensing purposes.

Many industries use water for rinsing. Laundries must avoid water containing iron; in addition it should be soft and clean. Nor can iron tanks be used in storing water for laundries; but wood and concrete are always available.

In fact, very few operations of manufacturers require hard water and in such cases, the necessities are generally well understood.

If a stream cannot be appropriated for a site, a lake may be considered. The Great Lakes serve hundreds of plants. The water has a hardness of from 90 to 100 parts per million. As cheap sources with enormous volume, they are unexcelled. All lake water carries sediment which can be treated according to the needs of the business. One grain of alum per gallon cleans the usual run of lake water at a cost of less than $2.00 per million gallons.

Smaller lakes in the eastern states are usually on high ground and necessitate a water works system between the source of supply and the plant on the railroad. New York state includes within its borders hundreds of such natural reservoirs. The water has a hardness of approximately 100 parts per million.

Next to lakes, small streams and isolated springs may be considered. The annual maximum and minimum supply must be definitely determined before any plans are made to use such water. Large streams with a large average flow fifty years ago are often dry in midsummer now.

Perhaps the industry does not need a large volume of water daily, or must be situated in a town or city. When there is no choice of location, bad water must be corrected mechanically or chemically. If there is a choice between two or more towns, the question from the water investigators' standpoint is what kind of a supply and what equipment exists at each place.

A complete history of the water works company, plant and equipment should be worked up, short, but showing location and extent of water-shed, storage capacity, piping, pumping plant and the financial standing of the company itself. The quality from a sanitary, mineral and bacteriological standpoint should be made a part of the record, the result of personal investigation and not from published records.

No modern mill superintendent can tolerate a scant supply or a poor distribution system. We all know of towns where the water pressure varies from 20 pounds to zero. Insurance rates are unduly high and fire losses are numerous. Few small towns afford supply in quantity sufficient for big business. My clients operating canning factories require from 50,000 to 100,000 gallons of good water per day for special uses; woolen and cotton mills from 2,000,000 to 5,000,000. Canals and rivers flowing through such towns are the only inducements for large users. City water costs from 3 to 15 cents per 1000 gallons; 10 cents is not unusual. The bill for this item alone may amount to $30 to $50 per day. Such a fixed factory cost is not unheard of but it cuts down profits with regular and insistent demands.

If a town will furnish clean, soft water at 10 cents per thousand gallons to a concern using not more than 50,000 gallons a day, the chances are that the use of such is desirable rather than an attempt to find other sources with certain overhead expense and uncertain results.

This statement applies also to wells, fully discussed in my previous paper before the Institute.

DRINKING WATER

No two sanitarians will agree concerning the standard to be set for potable water. In this paper I suggest three types with possible limits of purity. Many thousands of people are drinking each of the three grades daily, with apparently no ill effects. These tentative standards are as follows:

	Parts per million		
	I	II	III
Free ammonia.........	0.02	0.05	0.10
Alb. ammonia.........	0.08	0.10	0.15
Nitrates..............	1.00	2.00	2.50
Nitrites..............	0.000	0.005	0.01
Chlorine.............	2.00	10.0	20.0
Oxygen consumed......	1.00	2.00	3–5
Total solids..........	100.0	500.0	500–4000
Colonies per cc........	100.0	500.0	1000–20,000
B. Coli..............	0.00	Presence 10 cc. amts.	Presence 1/10 cc. amts.
Sediment.............	none	slight	heavy
Color................	none	slight	yes
Odor................	none	yes	yes
Temperature........	winter above 45° F. summer below 60° F.	40° F. 80° F.	very cold very warm

With increased attention to sanitary details everywhere, the manufacturer can well afford to add a clean, pure supply to his factory equipment. If it is impossible to obtain potable water, it should be prepared. In case the supply is muddy, it should be filtered; if polluted it should be passed through sand and charcoal or distilled and then passed through charcoal. It must be remembered that water distilled from an impure source, organically, carries ammonia and sometimes other gases. Charcoal gives such water a pleasant taste and removes odor. Do not attempt to condense steam from an ordinary boiler for drinking purposes. Rather pass steam through a copper coil in a tin-lined kettle. Condense also in tin. Such water must be cooled before drinking.

When a manufacturing corporation can afford to do so, it should build and operate its own water works. Ten, fifteen, or twenty miles is not a prohibitive distance to go for a good supply. The initial expense will be small compared with the additional resources of the plant that has all of the clean, soft water needed.

To accomplish such a purpose, it may be necessary to buy several hundred acres of cheap land. This should be fenced and all people and animals kept out. Having an abundant supply, a corporation may add to its income by selling water.

If water of a poor quality, but soft, is available near the concern, a purification plant on a large scale can be built to good advantage. Here water may be filtered or softened to the degree required by the average use to which it is put.

DILLAYE BUILDING
SYRACUSE, N. Y.

CURRENT INDUSTRIAL NEWS

By W. A. HAMOR

THE EYNON-EVANS FLANGED BLOW-OFF VALVE

A Philadelphia concern has placed on the market an angle flanged blow-off valve, an illustration of which is shown below. The principle involved is that of protecting the packing inside the shield before the grit, scale and other blow-off products are permitted to pass through the valve from the boiler. The lower end of the shield also acts as a valve, thereby permitting of the removal and inspection of the packing while the blow-off valve is in service with full boiler pressure.
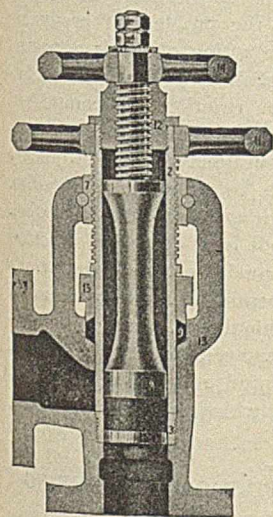
The body and yoke 13 are cast in one piece, and are made extremely heavy. A nickel ring, 3, is secured in the iron body, the interior diameter of which is the same as that of the interior of the bronze shield 2, forming a continuous surface for the reception of the packing. This packing is so placed in the ring 3 and shield 2 that it prevents leakage from the inlet to the outlet and around the stem; it can be adjusted or compressed by the nuts to the desired density while the valve is in service. The hand wheel 14 withdraws the pistons with packing from the ring 3 into the shield 2. The shield 2 is operated by the wheel numbered 11.

Rotating the small wheel 14 causes the packing with its piston to rise or open until the shoulder on the follower piston strikes the bottom of the hub 12. The packing is now inside the shield 2, protected from the blow-off products. Rotation of the wheel 11 causes the shield 2 to rise until the shoulder, just below the thread, strikes the bottom of the threaded bushing 7. After having rotated the wheel 11 to open the valve, and it is now desired to close it, the shield is rotated until it strikes the ring 3. The small wheel 14 is then rotated and the packing is returned to fit inside ring 3, making, it is claimed, the valve absolutely tight. To open, the small wheel is raised first; to close, the large wheel is lowered first.

THE INFLUENCE OF SULFUR ON THE STABILITY OF IRON CARBIDE IN THE PRESENCE OF SILICON.

The value of the heat treatment of the iron-carbon alloys depends mainly upon the manner in which the cementite and pearlite carbide are affected. Especially is this so in connection with the alloys richer in carbon, such as the various cast irons, and Hatfield (*Eng.*, 95, 683) therefore endeavored to make a thorough study of this phase of the subject, as a result of which he recorded some experiments made to ascertain the manner in which sulfur affects the stability of iron carbide.

The influence of sulfur has received considerable attention from the time of Percy onwards, and it is now accepted that, providing the other constituents of normal cast irons remain constant, any considerable increase in sulfur results in an increase in the combined carbon content—in other words, the presence of carbon prevents the entire breaking down of the carbides during the cooling of the iron. It is generally understood that in ordinary cast irons the amount of sulfur present (rarely exceeding 0.06%) has little influence upon the carbon. Wüst has published the results of some experiments which, however, showed that the influence of sulfur was increased by any decrease in the silicon content of the iron. These experiments are considerably amplified by the data contained in a quite recent paper by Coe (*Brit. Foundrymen's Assn.*, 1912).

Hatfield concludes from his experimental investigations that:

(1) Sulfur increases the stability of iron carbide at high temperatures.

(2) It is most probably the small percentage associated with the carbide crystals that accomplishes this action.

(3) Coe's deduction that the sulfur separates as sulfide at the freezing point is not strictly correct, as a small and essential proportion is apparently retained in the cementite carbide.

(4) The action of sulfur is of a chemical nature, and Levy's suggestion that the action is mechanical and is attributable to the existence of sulfide films does not receive support.

(5) Silicon in a large measure neutralizes this action of the sulfur, probably by forming a silicon sulfide.

(6) Manganese neutralizes the action of the sulfur present in such materials as mentioned.

THE ALUMINUM INDUSTRY.

The report, recently issued by the Aluminum Industrie Gesellschaft, which owns the large works at Neuhausen, Switzerland, shows net profits for the year of $717,000, against $448,000 in 1911; dividends were 20%, against 14% in 1911. The very low prices which prevailed for some time resulted in many new uses being found for aluminum, which favorably influenced the development of the industry and enabled the whole Swiss production to go into consumption. A new agreement has since been entered into by the various manufacturers of aluminum. The subsidiary industries conducted by the Neuhausen works, namely, the manufacture of calcium carbide and nitric acid, have justified expectations, and extensions are being carried out in several directions. The present capital amounts to $2,500,000 and there are loans to the amount of $2,070,000.

As to the aluminum industry in the United States, it may be said that the market during the latter part of 1912 was brisk; later the demand has exceeded the supply. The Aluminum Company of America has been making serious efforts for some time past to increase its production, but has been confronted with difficulties in securing an adequate source of supply of electric power. It has, however, secured certain riparian rights in North Carolina and Tennessee. The development of this water power is contemplated. Until its own power development is completed, the Company will use power supplied by the Tennessee Power Company from their development on the Ocoee River, near Chattanooga; this new aluminum plant will, it is planned, be in operation by the middle or latter part of 1913. In addition to its extensions in the South, the Aluminum Company is engaged on an extension to its Massena, N. Y., plant, which, when completed in 1914, will make that plant the largest of its kind in the world. A large supply of electricity will be brought to Massena from the development on the St. Lawrence at Cedar Rapids.

The Aluminum Company of America has recently embarked in the manufacture of powdered aluminum, which is employed in explosives, lithographing and printing, and as a paint pigment; the concern has in operation at New Kensington, Pa., one of the most complete aluminum bronze plants in the world. This plant was recently moved from Dover, N. J. Tanks, cooking vats, and similar vessels are also being made at the New Kensington plant; a considerable extension has been made to the cooking utensil factory located at this point, and a thoroughly modern boiler house is also being installed.

The most notable growth in the industry during the past year has been in extruded forms, tubing and aluminum foil. The Aluminum Company is planning a considerable extension to its tubing plant at New Kensington, and is erecting an aluminum foil plant at Arnold, Pa.

ELIANITE.

The electrochemical works of Rossi in Legnano has, for some time, been conducting experiments on the production of acid-proof alloys, and it is now announced that it has succeeded in obtaining one cheaply. The new alloy—"elianite"—is produced in an electric furnace and is to be used in the manufacture of nitric acid from the air; it is said to differ from similar alloys known in that its resisting power is not limited to certain acids, and it is a good conductor of heat. The composition of "elianite" is kept secret.

THE INDUSTRIAL USES OF CALCIUM CARBIDE AND ACETYLENE.

In an address on the industrial uses of calcium carbide and acetylene, and their influence on the development of other industries, delivered before the Verein österreichischer Chemiker (Z. angew. Chem., 26, No. 36, 318), Fraenkel referred to a paper read by him before the same society five years ago. At that time, most of the calcium carbide was consumed in the production of acetylene for illuminating purposes, while very little acetylene was used for autogenous welding; now, however, as much calcium carbide is employed for the production of acetylene for welding purposes as for use as an illuminant. The latter application has nevertheless opened up new fields for the use of calcium carbide and acetylene, particularly in mining and on railroads and steamers.

The development of the autogenous welding industry has led to a great increase in the consumption of oxygen. According to Linde, the German production of oxygen from liquid air amounted to 30,000 cubic meters in 1903, while about 2,000,000 cubic meters were produced in 1910; Vogel estimates that 5,000,000 cubic meters were manufactured in 1912. The successful application of acetylene and hydrogen in autogenous welding led to the employment of a number of other compressed gases and liquids (illuminating gas, oil gas, Blau gas, ethane, benzol, benzine, alcohol, etc.) for the same purpose. Fraenkel considers, however, that the results obtainable are inferior.

The production of cyanamide from calcium carbide induced the establishment of a nitrogen industry. Nitrogen is obtained from liquid air by the process of Linde and Claude. Fraenkel discussed the production of cyanamide, and predicted still further development to the production of ammonia with the simultaneous manufacture of formic acid (a suggestion from Sulzer). He further anticipated development of the processes of Hubou, Machtolf and Morani, for the decomposition of acetylene into carbon and hydrogen, and of the method of Frank and Caro for the preparation of carbon. Machtolf's process is being operated by the Carbonium Gesellschaft in Friedrichshafen, the pure hydrogen obtained being used by the Zeppelin Gesellschaft and the carbon in the manufacture of inks and varnishes, especially in Russia.

Fraenkel touched upon the production of chlorine derivatives of acetylene and appeared to be enthusiastic concerning the future of trichlorethylene as an industrial solvent. He pointed out that the technical solution of the problem of producing acetaldehyde from acetylene by the action of water appeared to have been successfully accomplished by the Griesheim-Elektron A.-G. and Grünstein. The reaction is accomplished best in sulfuric or phosphoric acid solutions, mercury salts serving as catalysts. The aldehyde-paraldehyde must be quickly removed from the solution in order to avoid polymerization. The aldehyde may be oxidized to acetic acid or reduced to alcohol.

In order to obtain cyclic compounds from acetylene, Fraenkel recommended the Richard Mayer modification of Berthelot's pyrogenic condensation; he also commended the process of Steinkopf for the preparation of thiophene. Finally, he predicted that acetylene would be employed in the synthesis of caoutchouc: a mixture of acetylene and ethylene may be condensed at a red heat into butadiene, which can be transformed, by methylating, into isoprene.

THE EMPLOYMENT OF LIQUEFIED GASES IN MINING AND METALLURGY

It is reported in Echo des Mines, 1913, 476, that liquid air and liquid oxygen are being experimented with in Germany as mine explosives. Liquefied oxygen, mixed with aluminum powder, and detonated, forms, it is said, an explosive about $2^1/_2$ times as powerful as black powder, from which there is no production of deleterious fumes.

The same journal comments favorably upon the use of liquid air to attain high temperatures in metallurgical operations. It is stated that a Thomas furnace is being worked at Ougree-Maripaye by injecting liquid oxygen, under pressure, into the hearth, where it raises the temperature to 2000° C. The claim is made that large quantities can be treated, as with coal or coke,

much more easily than in an electric furnace; that the reactions occur quickly without any change in the *modus operandi* usual in steel-making; and that the fusion time is reduced one-half and a furnace can double its output. Some trouble has, however, been experienced in maintaining the furnace walls, owing to the high temperatures.

THE STORAGE OF INFLAMMABLE LIQUIDS

At the Seventeenth Annual Meeting of the National Fire Protection Association, held in New York, May 13-15, 1913, about one-half of the report of the Committee on Laws and Ordinances was devoted to a suggested complete ordinance to regulate the use, handling, storage and sale of inflammable liquids, etc. It was explained that this was the completed work of several former committees and that the ordinance was much desired throughout the United States. Inflammable liquids were classified in accordance with their flash-point. Class 1, the most dangerous, included ethyl ether, carbon disulfide, gasoline, naphtha, benzole, collodion, "hydro-carbon" ("gas-drips"), and liquefied petroleum gas. Class 2 embraced acetone, alcohol, amyl acetate, and toluol. Class 3, the least dangerous, included kerosene, amyl alcohol, turpentine, whisky, and brandy. Severe restrictions were placed on the storage of Classes 1 and 2, although in a few minor ways Class 2 was to be treated similarly to Class 3.

Strong objection to the classification on the basis of flash-point alone was raised by those interested in the manufacture and sale of alcohol for commercial use. It was claimed that the actual fire hazard was not in proportion to the flash-point, which placed alcohol in Class 1, but that it was greatly reduced through the lightness of alcohol vapor and its rapid diffusion in air to a non-inflammable and non-explosive mixture, together with its miscibility, which prevented the burning and vaporizing liquid from being scattered by water. These disputed points are to receive investigation by the committee.

[It may be stated on the authority of von Schwartz ("Fire and Explosion Risks," 1904, p. 270) that "in point of general fire-risk, alcohol is far below ether, benzol, carbon disulfide, and similar liquids." Alcohol between 60 and 99.5% strength is more inflammable than ordinary petroleum; but the vapors are far less explosive, since, in order to attain this condition, they require to be strongly heated and placed in contact with a flame or spark. Special danger attaches to alcohol by reason of its high diffusibility; the stronger the alcohol, the more rapid is the dispersion.—W. A. H.]

FUEL BRIQUETTING IN THE UNITED STATES

Fuel briquetting in the United States in 1912 is discussed by E. W. Parker in an Advance Chapter from *Mineral Resources of the United States for* 1912 (U. S. Geological Survey, 1913). Although the quantity of briquetted fuel manufactured in the United States in 1912 did not show any material gain over the preceding year, the industry may be considered as passing out of the experimental stage and assuming more of a substantial and permanent character. The total quantity of briquetted fuel made in this country in 1912 was 220,064 short tons, valued at $952,261, as compared with 218,443 tons, valued at $808,721, in 1911. There were nineteen plants which contributed to the production in 1912; of these, 9 in the Eastern States produced 107,181 tons, 7 in the Central States produced 89,714 tons, and 3 on the Pacific Coast produced 23,169 tons. Seven plants used anthracite culm, 9 used bituminous or semibituminous slack, 1 used carbon residue from gas manufactured from oil, 1 used mixed anthracite culm and bituminous slack, and 1 used peat. Two plants, 1 at Detroit, Mich., and 1 at Point Breeze, Philadelphia, Pa., which were constructed for the purpose of principally utilizing coke breeze, were not operated in 1912,

the abrasive action of the coke dust being so destructive to the molds and machinery that the plants have been closed.

Among the indications of the interest taken in the briquetting industry as promising future development are the following:

1. The organization of the Malcolmson Briquet Engineering Co., of St. Louis, Mo., for the purpose of designing, building, and equipping briquetting plants, but not for the purpose of engaging in the manufacture of briquets.

2. In contemplation, the construction of a plant for the manufacture of boulets by the Devillers or Belgian process at Grafton, W. Va., which shall utilize bituminous slack from the mines of the Grafton district.

3. In contemplation, the construction of a plant at Cambridge, Mass., by the Atlas Coal Briquet Co., with headquarters in Boston. It is reported that the contract has been closed for the construction and equipment of a plant similar in design and character of output to the one in Brooklyn, N. Y.

4. Under construction, the plant of the Northern Briquetting Co., at Minot, N. Dak., for the purpose of utilizing lignite, of which ample supplies are available. The plant is expected to be in operation in August, 1913.

5. In contemplation, the Pacific Coast Coal Co., Seattle, Wash., expects to have a plant completed by October, 1913. The character of the fuel and the binder to be used are not stated.

"PAROL"

A new fuel for use in internal combustion engines has recently attracted attention in Johannesburg, South Africa. This gasoline substitute, now being marketed under the name of "Parol," is said (*Chem. World*, 2, 175) to be made from paraffin by a chemical process and without the use of heat. It is claimed by the manufacturers that, by means of the chemical process employed, the property which creates carbon in the cylinders and forms soot around the sparking plug is eliminated; the paraffin used in all the tests so far is of 150° fire test. The manufacturers contemplate going to England in the near future to compete in the tests to be conducted by the Royal Automobile Club for fuels other than petrol.

SOLID ALCOHOL

The methods used in the preparation of solid alcohol may be classed in three categories (*Chem. News*, 107, 257).

The first consists in fabricating a solid soap into which alcohol is mechanically incorporated; in this manner a translucid product is obtained containing 60 per cent of alcohol. Instead of employing soap as a vehicle, the alcohol may be enriched with collodion; the process is more expensive than the preceding one, but it gives a more satisfactory product, because of much easier combustion and of a more engaging exterior aspect. Usually alcohol soaps are delivered by trade in the form of a paste enclosed in a metal box made in one piece, which can be used as a warmer, the cover of which has openings that can be regulated, so as, if need be, to act as moderator to the flame; on the contrary, the collodions of alcohol are arranged for sale in the form of pills or ovals, almost transparent. Both soaps and collodions are too expensive to be practically utilizable as industrial combustibles; their employment is restricted to applications of luxury, such, for example, as being burned in toilet-lamps, traveling spirit lamps, etc. However, it is not the same for the little bricks of sawdust impregnated with alcohol and agglutinated with coal-tar that are just now being brought out in trade at a low price, and which may turn out to be a practical combustible.

BENZOLE AS A MOTOR FUEL

We learn from *The Chemical Trade Journal*, 52, 569, that the committee appointed by the Automobile Club and kindred

associations is working in a very energetic manner to popularize the use of benzole as a motor fuel and also to stimulate its production. Toward the end of May, Lord Montague of Beaulieu brought together a number of people interested in gas undertakings, for the purpose of hearing the proposal of H. L. Doherty, of New York, relative to the extraction of benzole from coal gas. Briefly stated, the proposals were to extract the benzole from the coal gas for use as a liquid fuel and to supply gas having no illuminating power. To quote from the same source: "Now that the calorific standard for town's gas is being more extensively adopted, and also having regard to the fact that the illuminating power is not of itself an important point, the presence of benzole in the gas is not essential, but whether it would pay to extract it from coal gas is quite another matter . . . . . .no one seems to know how much benzole is contained in coal gas as produced under existing conditions. If the quantity is anything less than two and a half gallons per ton of coal, ...it will be seen that very little margin for profit will accrue to the gas works."

Brewer (*Idem*, **52**, 572) showed, at the meeting of the Institute of Inventors, that his experiments with benzole proved it to be a suitable carburant.

A NEW PRODUCT FROM WHALE OIL

A German-Norwegian company, capitalized at about $833,500, organized to work a new German method for hydrogenating whale oil, commenced operations at Fredrikstad, Norway, in May. The Hafslund Falls are being utilized to generate the electric power required by the works and also to manufacture by electrolysis the hydrogen required for the hardening process to which the purified whale oil is submitted and converted into a solid neutral fat. The daily consumption of oil is about 300 barrels.

[Bömer and Leschly-Hansen (*Chem. Rev. Fett. Ind.*, **19**, 218, 247) hardened whale oil by the method of Wilbuschewitsch, according to which the oil is mixed with the catalytic agent (nickel reduced on kieselguhr) and heated in an autoclave under pressure while a current of hydrogen is introduced. The product possessed a melting point of 45.1° C.; a solidifying point of 33.9° C.; an acid value of 1.2; a saponification value of 192.3; an iodine number of 45.2; and a refractometer reading at 40° C. of 49.1.—W. A. H.]

THE COMPOSITION OF SOME SOLE LEATHERS

Investigations conducted by Veitch and Rogers (*Bull.* 165, Bureau of Chemistry, U. S. Department of Agriculture, 1913) show that weighting of leathers with useless or harmful materials is largely practised in this country, with the result that resources in leather materials are wasted and the public is defrauded. A large majority of the samples examined contained an unnecessary quantity of uncombined tanning material; in fact, Veitch and Rogers estimate that but little less than $1,000,000 worth of tannin is wasted annually in this way. Sixty-three per cent of the leathers examined were weighted with glucose, with Epsom salts, or with both. The amount of loading varied from 1 to 7.3 per cent of Epsom salts, with an average of 3 per cent; the maximum quantity of glucose in the loaded leathers was 10.4 per cent, and the average 5.5 per cent. The maximum amount of these loading materials found in any leather was 16 per cent and the average where both were present was 8 per cent. The results obtained indicate that not less than 12,000,000 pounds of glucose and Epsom salts are sold annually in sole leather to the American people. With regard to the weighting of leather, Veitch and Rogers conclude that the materials add absolutely nothing to the wearing value of the leather and where present in large quantity may positively decrease its wear. Shoes made from these leathers are readily penetrated by water. Loading makes leather more

costly, consequently an inferior leather is more expensive than a good leather.

A NEW HORN SUBSTITUTE

A process which combines leather and celluloid has been devised in Germany for the production of a horn substitute. The hide is depilated and then extracted with amyl acetate and acetone, to remove fleshy matter and to produce a hardening effect. Subsequently it is coated with a solution of celluloid in amyl acetate and acetone. When the solvent has evaporated, the hide is placed in a bath of shellac dissolved in alcohol. It is said that hide thus treated is not only similar to horn, but also possesses its elasticity and strength; the product is strong and light, and is suitable for the manufacture of trunks, boats, and insulating materials.

SOME INDUSTRIAL USES OF SUGAR

A list of the industrial applications of sugar, which illustrates the great diversity of manufactures in which this product appears quite apart from food economy, was contributed by Rolfe to *The Chemical News*, **107**, 217.

French writers, especially Vivien, have recently made pleas for the use of sugar as the cheapest form of pure carbohydrate, since it replaces, in many cases, glucose, starch and dextrin. The French Government imposes a tax on sugar and glucose products used as human foods, but "denatured" sugar is exempt from taxation. As in alcohol denaturation, the substance added is, if possible, some ingredient in the special process using the sugar. In France, an excellent quality of sugar known as No. 3 white sugar and polarizing over 99 per cent sells, when denatured, at a lower price than does starch, glucose or dextrin, approximating what the refiners pay here for raw sugar.

Sugar is a common ingredient of many compounds for removing and preventing boiler-scale, and as these usually contain alkali, this is used as a denaturant. The shoe-blacking industry uses sugar and molasses to a considerable extent. In Europe there seems to be a tendency to use blackings of this older type as less injurious to leather than the newer wax blackings, owing to the solvents used in the latter. These shoe-blackings are made by the carbonization of sugar with sulfuric acid, neutralizing the product, and then incorporating boneblack, oil, etc. Many tons of sugar are now used by manufacturers of transparent soaps; sugar soaps are less sticky than glycerin soaps. There are over thirty patents for explosives in which sugar is a component to the extent of from 6 to 40 per cent. This use of sugar has become so important in Germany that a special provision is made in that country for denaturing sugar employed in the manufacture of explosives, paraffin being used. In the color and dyeing industries sugar is used as a reducing agent in indigo and chrome work, as a base for the manufacture of organic chromium salts, and as a vehicle or "filler" for solid aniline colors, giving them an attractive appearance. The European tanneries use large amounts of sugar in "filling" leather and, to some extent, in removing lime from the hides in dehairing. This solvent action of sugar on lime, and the easy recovery of the sugar by carbonization, has suggested its use in several processes where it is desirable to remove excess of caustic lime from calcined minerals, such as phosphates, magnesium oxide, etc. Tannin extracts are also "filled" with sugar, as they are in the United States with glucose. Sugar is also used in several chrome tanning processes as a reducer, and, as in dyeing, for making acetates and formates. Still other uses are in the manufacture of copying inks, printers' rolls, hektograph pads; silvering of mirrors, hardening of mortar and plaster; as a source of pure carbon for use in the manufacture of pure carbon monoxide or sulfurous acid; and as a source of sucrose octonitrate, or nitrosaccharose, a product analogous

to guncotton, sucrose acetate, a substitute for cellulose acetate, and sucrose benzoate.

PAINTS FOR INDICATING THE USES OF PIPES

Engineering, **95**, 607, states that in 1911 German engineers and metallurgists came to a preliminary understanding that it was desirable to mark pipes carrying certain fluids by certain colors, so as to avoid confusion. The question has since been discussed by technical institutions and chemical manufacturers. It was natural that conflicting wishes should be expressed, for in each works some particular kinds of pipes may predominate or coexist, and the managers naturally desire to make certain distinctions particularly easy. The majority of authorities have, however, now agreed that the following colors should be used for the following purposes: Water, green; gas, yellow; air, blue; steam, white; acid, pink; lyes, violet; oils, brown; tar, black; and vacuum, gray. It is recommended that pipe conduits for high tension electric currents be marked red, like acids, as red would be the danger color; the forked-lightning arrow might be added as a distinctive mark. It is proposed that an ordinary steam-pipe should be white; a red ring would indicate a pressure of more than 2 atmospheres; 2 red rings, high-pressure superheated steam; and a green ring would distinguish the exhaust-pipe. A dark red ring on a pink or violet acid or lye pipe would intimate that the acid or lye carried was concentrated. A black ring would stand for carbon or an impurity; a tar-oil would be brown with a black ring; a refuse-water pipe green with a black ring. Pipes for ordinary gas or for purified blast-furnace gas would be painted yellow; the red ring might indicate coke-oven gas, the black ring blast-furnace gas not purified, the green ring water-gas, the blue ring producer-gas, etc. In blue air-pipes the red ring would indicate high pressure, a white ring hot air. Potable water pipes might be green with white dots; pipes carrying slimes, green with black dots. Letters might be employed to distinguish different gases and liquids. Small iron labels or rings a few inches in width, properly colored and then varnished or enameled, would cause much less expense. It is the opinion of German engineers that enameled rings, directly clamped around the pipes, are most convenient.

A SELF-EQUALIZING EXPANSION JOINT

The "Badger" self-equalizing expansion joint is a corrugated copper joint having external rings and is designed to take up changes in length of pipe lines conveying steam, water or air. The external rings on the corrugations distribute the strain and by thus bringing many corrugations into service no one of them is called upon to take more than its share of the strain. The rings force a part of the strain to the next corrugation, and, as each corrugation has only a slight movement, the joint is said to last almost indefinitely. The number of corrugations depends upon the pressure and upon the length of the joint. For high pressures and superheated steam the change in length is considerable, and, therefore, more corrugations are used; for very low pressures, as in exhaust piping, 2 or 3 are sufficient for the slight alteration in length. In some cases where the expansion is small but the vibration must be taken up, the joint does not require any external rings; these, however, add strength and also stiffen the exhaust pipe against collapse. This new joint is said to require no packing and to take up no more room than a pipe fitting.

A NEW TYPE OF PULVERIZER

A German firm has placed on the market a pulverizing machine with conical cylinders, and constructed in such a manner that it is dust-proof and perfectly automatic. It is designed to grind substances to a fine state of subdivision and to simultaneously produce intimate mixtures. The construction is shown in the accompanying figures.

This pulverizer is claimed to be more efficient than any other type for the following substances: chemical products, mineral colors, dyes, feldspar, barite, ores, chalk, gypsum, clay, white lead, lithopone, ultramarine, resins, saltpeter, salt, lime, coal,

Fig. 1

Fig. 2
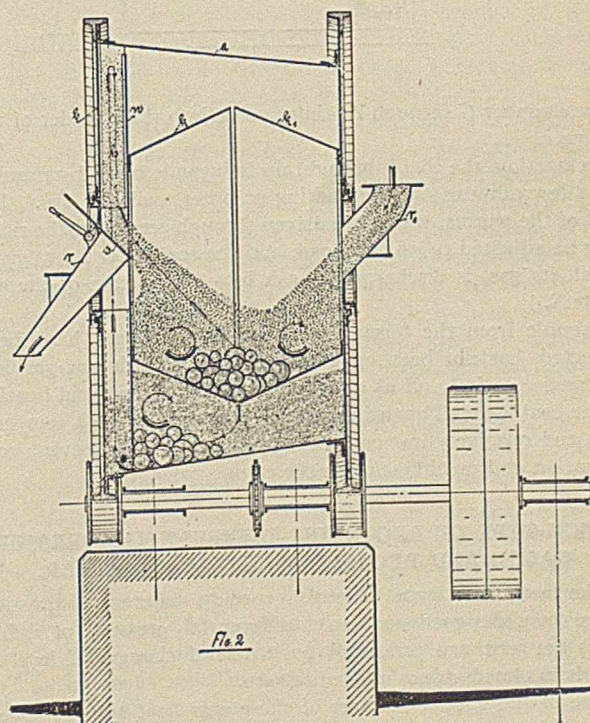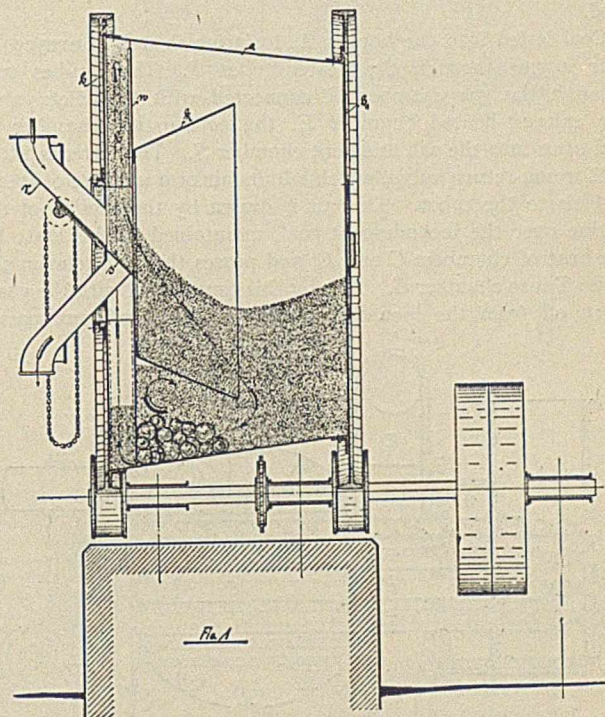
cement, sand, coke, cork, flour, manure, graphite, chamotte, etc. It is claimed that the machine is particularly useful for mixing aniline dyes with vegetable dyes.

The material is charged into the conical drum by way of a fixed hopper. At the base of the drum is a scoop which returns the material to the drum at every revolution, thus effecting intimate grinding and mixing. A man-hole is provided on the side for cleaning the interior of the drum.

THE LOW GAS PRODUCER AND ENGINE

A. M. Low has invented a self-contained unit for the direct conversion of coal energy into work; it is essentially a producer-gas engine with a compact gas producer attached to the end of the cylinder. The illustration shows a 100 h. p. unit, which is said to have developed a brake horsepower-hour on $1/2$ lb. of coal.

Coal is fed into the hopper A, from which it is conveyed by four worms through the heater tubes *T*. These tubes pass through the gas chamber *G*, connected with the inlet valve, the exhaust-heated chamber *E*, the combustion chamber *C*, and open into the ash and soot chamber *S*. The latter is fitted with a non-return valve, which admits air or a mixture of steam and air to the tubes. This air is drawn by the suction of the engine over the incandescent coal, maintained in this state by the heat of chambers *C* and *E*, and passes through holes in the tubes *T* into chamber *G*. It is by this time mixed with the gases given off from the incandescent coal, and the mixture passes
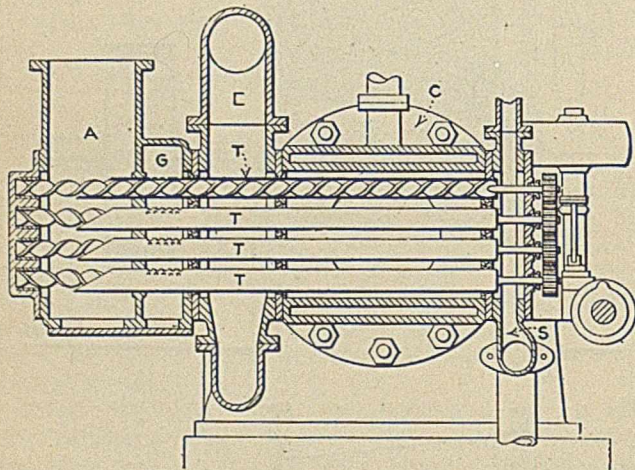
from chamber *G* through the inlet valve into the cylinder of the engine.

In starting, the coal is brought up to incandescence by running for a few minutes on illuminating or other available gas. The feed of the worms, which are driven through gearing at the right, may be adjusted to suit the load, and the coal, after it has given off all its gas, is discharged as ash into the bottom of the ash chute *S*.

Trouble from the formation of tar, which might have been expected, has not been experienced, as the tar is not gasified, but passes entirely off as a fine yellow dust. The rapid heating of the coal in small quantities causes this, and the high temperature and relatively low compression, about 90 lb., prevent condensation and precipitation in the engine passages.

A NEW TYPE OF RECORDING DIFFERENTIAL PRESSURE GAUGE AND RECORDING FLOW-RATE METER.

The new float type Bristol recording differential pressure gauges are designed to record differential pressure or differences between two pressures, or to record changes of level of liquids in closed spaces under pressure.

One of the special features of these new float type recorders is that they can be constructed to accurately record on charts having scales graduated uniformly in terms of velocity or volumes of air, gases, steam or liquids flowing. Another special feature is their ability to withstand sudden fluctuations of differential or static pressure and at the same time produce accurate records of rate of flow of volumes or quantities of liquids or gases flowing. These float type recorders are made for both high and low ranges of differential pressure, and may be subjected to either heavy or light static pressures.

Among the numerous applications for recording differential pressure gauges, some of the most important are for recording rate of flow of air, gases, steam, water and other liquids, in connection with Pitot tubes, Venturi meters, orifices, nozzles, and combinations of Pitot tubes and orifices or nozzles.

The extreme simplicity of construction and the absence of
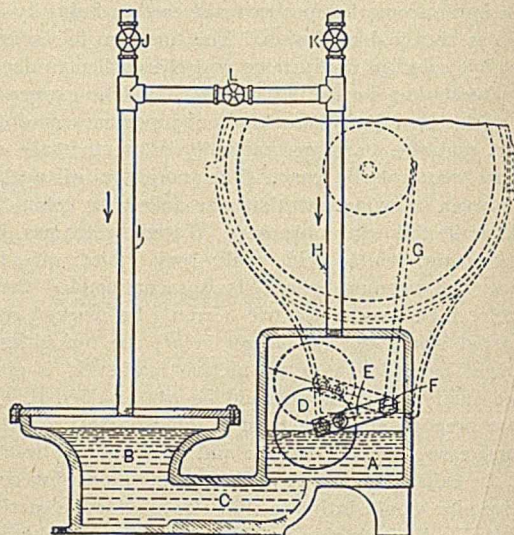
multiplying devices and all other complicated mechanisms make these recorders especially suitable for practical service under ordinary operating conditions in manufacturing plants and industrial works, such as steel works, blast furnace plants, power plants, gas works, by-product coke plants, water works, natural gas systems, chemical works, etc. The accompanying figure shows a cross-sectional diagrammatic sketch outlining the fundamental principles of construction and operation of one model of float type recording differential pressure gauges. It will be noted that there are two pressure chambers, A and B, intercommunicating through the connection C. In this way the pressure casing forms a U tube, and the liquid employed for low ranges of differential pressure is sometimes water and the liquid employed for high ranges of differential pressure is usually mercury. In the pressure casing A, a cylindrical float, D, is outlined, and this is connected rigidly by arms to the shaft F, to which the pen arm G is rigidly fastened. The rise and fall of the liquid in the pressure chamber A, therefore, causes the float and pen arm to move about F as an axis. The dynamic or high static pressure is applied to the surface of the liquid in the compartment B through the pipe I and the low static pressure is applied to the surface of the liquid in the compartment A through the pipe H. When the static and dynamic pressures are to be applied, the by-pass L is first opened, and then the valves J and K are opened, and later the by-pass L is closed, so that the difference between the two pressures acting on the liquid in the compartments A and B will produce corresponding differences of its level in these compartments, thus causing the pen to record the differential pressure.

By making the cross section of the pressure chamber B of certain proportions, as indicated, it is possible to produce a scale whose graduations are uniform for equal increments of flow of volume. The Bristol-Durand Radii Averaging Instrument may be used on chart records obtained from this instrument for integrating the total flow during a period of 24 hours.

THE STATUS OF THE CERESIN INDUSTRY

The present condition of the ceresin industry is discussed by Lach in *Chemiker-Zeitung*, **37**, No. 56, 573.

Owing to the high price of Galician ozokerite, the ceresin industry is in a serious position; the market price of ceresin has

advanced and accordingly the consumption has decreased. Recently two innovations having a technical bearing upon the ceresin industry have appeared. One is a variation in the process of manufacturing potassium ferrocyanide; the other is the introduction of magnesium hydrosilicate as a decolorizing agent. It has been demonstrated at the "Frankonit" works of the Pfirschinger Mineralwerke G. m. b. H., at Kitzingen on Main, and at the "Tonsil" works of the Tonwerke Moosburg, A. & M. Ostenrieder, in München, that the ceresin bleached with silicate is superior to that decolorized with bone-black; this may be accomplished at one-half the cost. Partially refined ceresin is treated only once with concentrated sulfuric acid, and a finished product is obtained by treatment with 3 to 5 per cent of "Tonsil," instead of subjecting ozokerite to two treatments with sulfuric acid, thereby occasioning a loss of 20 per cent.

HORTON GAS-ENGINE PACKING

A new packing for large gas-engines has been designed by James Horton, of the Carnegie Steel Co. It is claimed that excessive friction and wear on the piston rod is eliminated by preventing the closing of the collapsible ring under excessive pressure.

As shown herewith, the packing rings proper *C* and *D* are in contact with the rod. They are placed in grooves, the walls *A* and *B* of which are free to move in line with the rod and thus

bind the packing rings against forcible closing at the time of the highest pressure in the cylinder. In practice it is found that this side clamping of rings does not affect the sealing quality
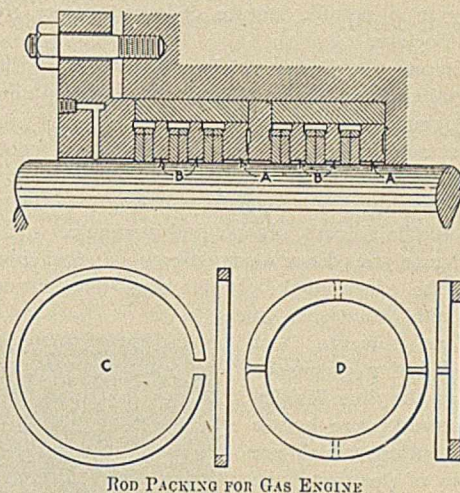
ROD PACKING FOR GAS ENGINE

of the packing, as contact with the rod is sufficient to prevent the passage of gas, but yet so light that wear cannot be detected on the rod. All rings and corresponding parts of the packing are interchangeable.

SCIENTIFIC SOCIETIES

PROF. DR. PAUL WALDEN, PRESIDENT OF THE NINTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY

By George Frederick Kunz

At the Eighth International Congress of Applied Chemistry, held in New York, last September, the celebrated chemist Prof. Dr. Paul Walden, of Riga, was selected to serve as president of the Ninth Congress to be held in St. Petersburg in 1915. No more fitting choice could well have been made, for the great and important services rendered by Prof. Walden to the progress of chemical science are universally acknowledged in the scientific world.

Born near Riga in the province Livonia, July 27, 1863, the new president is by birth a Russian, although of German blood. His early education was obtained at the Real-school in Riga, and later at the Riga Polytechnicum. Here he had the privilege of studying under the great Ostwald, then professor of chemistry at this institution, and he was soon recognized to be one of the most apt and brilliant pupils of his master. In 1885, he was appointed assistant in the department of physics, and in 1888 in that of chemistry. The year 1892 saw him privatdocent, and two years later he became professor of analytical and physical chemistry. He is now, and has been since 1896, assistant professor of inorganic and physical chemistry and a director of the Riga Polytechnicum. On Ostwald's resignation of the professorship of chemistry there, Walden became his successor, and he still holds this position. His degree of Doctor of Philosophy was given him at Leipzig in 1891; in 1893 the degree of Master of Chemistry was conferred upon him at Odessa. Then followed the degree of Doctor of Chemistry from the University of St. Petersburg, and that of Doctor of Engineering from the Riga Polytechnicum. He has laboratories both in Riga and in St. Petersburg.

Russia has not failed to honor the attainments of one of her greatest citizens, Walden having received many important Russian decorations. He is commander of the Order of Vladimir as well as of those of St. Anne and of Stanislaus. The Russian Academy of Sciences has elected him one of its

members, and he is also an honorary member of the London Chemical Society. He was the Imperial Russian delegate to the Eighth International Congress of Applied Chemistry.

Prof. Walden's thorough command of a number of spoken languages will greatly facilitate the performance of his duties as presiding officer of the International Congress. Russian, French, German and Livonian he speaks fluently, and he is thoroughly familiar with English and Italian as well. His quiet, dignified manner, coupled with a large share of mental and physical alertness, can also count as an important asset. Some five feet eight inches in height and weighing about 175 pounds, with blue-gray eyes and fine teeth, and wearing his hair brushed high up on his forehead, his appearance is very prepossessing. When addressing an assembly, his words come readily and his forceful, direct delivery brings them home to his hearers. His thought seems to clothe itself spontaneously and naturally in well-chosen and effective words and phrases; there is no touch of ambiguity in his clear-cut sentences and they always convey to his auditors the strictly logical sequence of his ideas and deductions, convincing them that his statements are the outcome of ripe reflection and dictated by sound judgment.

It is for his extended investigations in the field of stereochemistry, and for his more recent epoch-making work on non-aqueous solutions, that Prof. Walden is best known. He began his scientific career, under the inspiration of his great teacher, Ostwald, with a series of investigations directed to the determination of the constitution and molecular weights of salts in aqueous solution by means of electrical conductivity measurements.

After Ostwald left Riga for Leipzig, Walden turned from physical chemistry to organic chemistry. First in collaboration with his teacher and colleague, Bischoff, and later independently, he carried on a long and important series of researches in the field of stereochemistry. Conspicuous among the achievements of Walden during this period may be mentioned his collaboration with Bischoff in the preparation of the well-known "Handbuch der Stereochemie," the discovery of the important phenomenon since known as Walden's inversion, and

the recognition of the bearing of the optical activity of natural petroleums on their origin and mode of formation. In 1904 Walden summed up the then state of knowledge of stereochemistry in a notable lecture delivered before the German Chemical Society.

More important, however, than his work in the fields of stereochemistry are his investigations upon non-aqueous solutions. Beginning in 1900 with the discovery of sulfur dioxide as an electrolytic solvent, his work in this field continued uninterruptedly to the present time and has included a detailed study of the physical properties of solutions in practically every available solvent, organic and inorganic.

The electrolytic dissociation theory of Arrhenius had its origin in the exceptional behavior of water solutions as contrasted with solutions in non-aqueous solvents, and while certain non-aqueous solvents at the time Walden began his work were known to form solutions which are conductors of electricity, the data at hand could not be brought into harmony with the general laws which had been developed in connection with the study of aqueous solutions. Indeed, it was pretty generally believed that these laws did not apply to non-aqueous solutions.

It is to Walden, more than to any other contributor to the knowledge of solutions, that credit is due for showing that instead of being limited in its scope, the electrolytic theory of Arrhenius is applicable to all electrolytic solutions without exception, non-aqueous as well as aqueous.

Walden has given his exceptional talents almost exclusively to the development of pure chemistry. He has contributed little or nothing directly to applied chemistry.

Aside from his purely scientific activity Prof. Walden has found time to write several biographical sketches and memoirs of noted scientists of our day, these studies being marked by keen and critical insight, by a thorough comprehension of the special endowments and qualifications of the men, and by a luminous exposition of the great scientific truths which they proclaimed and illustrated. Berthelot and thermochemistry, Pasteur and the germ theory of disease, the Russian Mendeléeff and the periodic system of the elements, have all been brought nearer to the reader's understanding by Walden's biographical memoirs.

The most important and significant of these studies, however, is that devoted to the life and work of his venerated master and friend, the widely-famed physical chemist and philosopher, Wilhelm Ostwald. Here it was indeed a labor of love that Walden performed, and so well has he done his work that Ostwald himself has been heard to say that a full half of his great

PROF. DR. PAUL WALDEN

reputation could be justly ascribed to the influence exerted by this sympathetic study of his career and activities.

In addition to the very extensive original work of Prof. Walden, he has enriched Russian scientific literature with several translations of noteworthy scientific productions into that language. Such, for instance, as Fischer's "Anleitung zur Darstellung organischer Präparaten," and the "Lowell Lectures" delivered by the renowned chemist J. H. van't Hoff.

Possessed of such wide and varied attainments as is Prof. Walden, he seems to be an ideal choice for president of the Ninth Congress. Many qualifications not often united in the same individual are most essential for success in such a position. The delegates, coming as they do from all the principal countries, represent not only the scientific culture of these lands but also the diverse endowments and characteristics of many nationalities and races. To bring about among them a harmonious interaction in the true interest of science is not always an easy task, but it is one that may perhaps be best accomplished by a scientist having the intimate knowledge of the art of combining chemical elements possessed by Prof. Walden, and we are fully confident that all the delegates of the coming congress will find in him one whose devotion to pure sciences has in it no touch or stain of national partiality or prejudice. The question as to the number of official languages, whether three or four, to be used in the Ninth Congress, came up before the Eighth Congress and the decision favored the recognition of the four languages, English, French, German and Italian.

Of great importance to the scientific world was the recommendation by the Eighth Congress that an agreement should be reached providing that the atomic weights recognized by one of these triennial Congresses of Applied Chemistry should be regarded as standards until changed by a succeeding congress. This would be a means of securing uniformity in all industrial and scientific uses. A standard governmental examination of ores, metals and fuels was also strongly advocated as of prime importance for mine owners, as well as for all distributors and consumers of mining products.

When the Ninth International Congress assembles in St. Petersburg in 1915, a number of questions touching the organization and management of this assembly will come up for consideration, such as the proper placing of the international delegates and the proper assignment of the papers to be read, in order to determine the due attribution of priority to one nation or another in reference to scientific or industrial discoveries of which so many are constantly being announced in this age of feverish activity in all departments of science and industry.
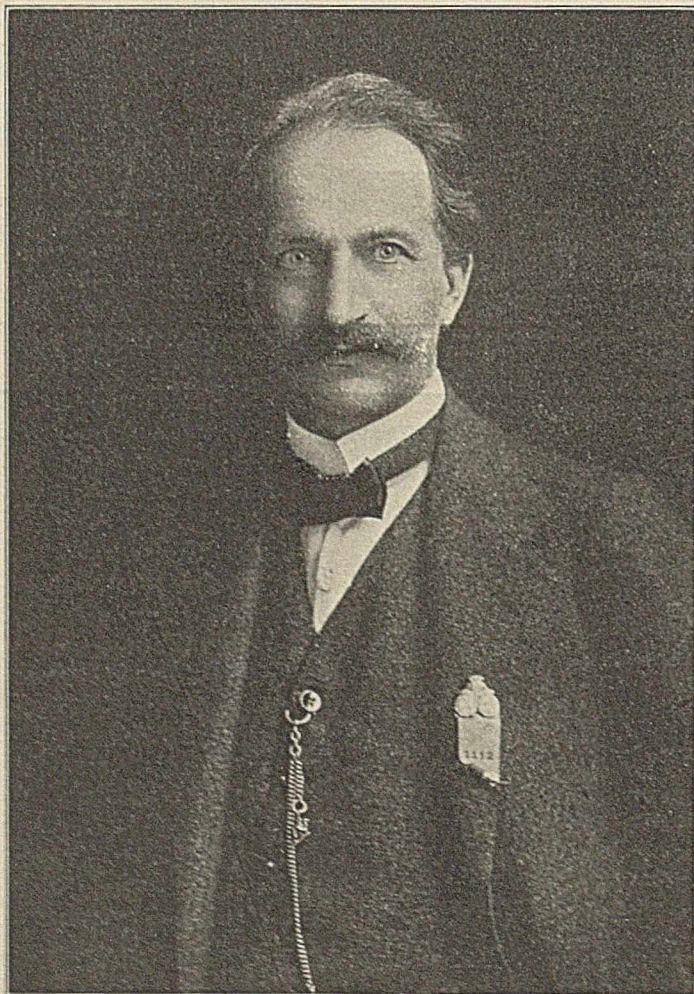
Another subject for consideration will be the founding of a Congress of Congresses with its headquarters at the Hague.

In accepting the presidency of the Ninth International Congress Prof. Walden spoke (in German) as follows:

"The choice which has just fallen upon me is a distinction of an altogether exceptional kind, and also a task of an exceptional kind. On behalf of Prof. Konovaloff, who is absent, and who will assuredly regret his inability to take part in our common celebration, I can express to you only his thanks and his undoubted acceptance. In my own case, however, I realize mixed emotions. I say to myself: 'Much honor, much work; many disappointments, many gray hairs!' In accepting this choice, we are fully aware that our powers will prove insufficient to do full justice to the duties entailed, but we see therein an honor rendered to our fatherland and to the great men, the great chemists of our country. I need recall to your minds only a few names; that of Lomonossoff, who 160 years ago laid the foundation of modern chemistry; that of Grotthus, a Russian chemist of a century ago; that of Hessen, also a chemist; and finally I name to you our great fellow-countryman, recently deceased, Mendeléeff, the creator of the periodic system of the elements. I assume that the honor you have just accorded to our fatherland is also addressed to these great men. We are the inheritors of the deeds these men accomplished. It is not the mind alone that rules congresses, the heart also must have its say. Of the scope of my mind, I am, naturally, not qualified to speak, but in what concerns my heart, in what concerns my ardent wish to do my best to give you the best possible reception, as to this I believe I can safely speak, as to this I shall willingly and gladly compete with the gentlemen who have received us in former congresses, and if three years hence, in transmitting my office into other hands, I may perhaps be able to speak in my turn with the sunny humor of our president of to-day, then I shall be content. I thank you."

The following list embraces the principal works and articles published by Prof. Walden, and testifies to his tireless activity in the domain of physical chemistry:

"Die Affinitätsgrössen einiger organischer Säuren." (Dissertation), 73 pp., 8vo, Leipzig, 1891.

"Versuch zur Untersuchung der osmotischen Erscheinung" (Magisterial dissertation in Russian), 66 pp., Riga, 1893.

"Handbuch der Stereochemie," Frankfurt a/M, 1894, [3] + 16 + 1060 pp., ill., 1 port., 8vo. (In collaboration with Carl Adam Bischoff.)

"Louis Pasteur" (biography in Russian), 24 pp., 8vo, Riga, 1896.

"Materialien zum Studium der optischen Isomerie" (dissertation in Russian), 134 pp., 8vo, St. Petersburg, 1898.

"Wilhelm Ostwald," vii + 120 pp., post., 8vo, Leipzig, 1903.

Translations into Russian

W. Ostwald: "Wissenschaftliche Grundlagen der analytischen Chemie, 160 pp., Riga, 1896; "Ueberwindung des wissenschaftlichen Materialismus," 26 pp., 8vo, Riga, 1896; "Tabellen zur qualitativen Analyse," 24 pp., 8vo, Riga, 1897.

E. Fischer: "Anleitung zur Darstellung organischer Präparaten," 83 pp., Riga, 1897.

J. H. van't Hoff: "Acht Vorträge über physikalische Chemie," 87 pp., 8vo, 1903.

Development and Activity of the Chemical Laboratory at the Riga Polytechnicum (in Russian), 12 pp., 8vo, Moscow (from the "Lomonossonskij Sbornik").

Articles in Periodicals

Berichte der deutschen chemischen Gesellschaft:

"Isomerieverhältnisse in der Stilbengruppe" (with A. Kernbaum) 4 pp., Vol. xxiii, 1890.

"Tetrinsäure, Oxytetrinsäure und ihre Homologie," 14 pp., Vol. xxiv, 1891.

"Vermeintliche optische Activität der Chloralsäure, und über optische-active Halogenbernsteinsäure." 5 pp., Vol. xxvi, 1893.

"Ricinolsäure und Derivative," 8 pp., Vol. xxvii, 1894.

"Optisch-active Hologenverbindungen," 10 and 7 pp., Vol. xxviii, 1895.

"Gegenseitige Umwandlungen optischen Antipoden," 47 pp., Vols. xxix, xxx, and xxxii.

"Characteristik optisch-isomerer Verbindungen," 16 pp., Vol. xxix, 1896.

Vol. xxx, 1897. "Krystallform optisch-activer Körper," 6 pp. "Stereoisomerie Chlorbrombernsteinsäuren," 6 pp. "Neues, die Drehungsgrösse steigerndes Mittel," 7 pp. "Optischer Verhalten des Tannins," 6 pp.

Vol. xxxi. 1898. "Autoracimisirung," 7 pp. "Vermeintliche Identität des Tannins mit der a-Digallussäure," 8 pp.

Vol. xxxii, 1899. "Spaltung racemischer Verbindungen in ihre activer Bestandteile," 3 pp. "Verhalten der l-Aepfelsäure beim Erhitzen," 15 pp. "Neues, anorganisches ionisirendes Lösungsmittel," 9 pp. "Optische Drehung der Aepfelsäure im freien und gelösten Zustande," 13 pp.

Vol. xxxiv, 1901; "Basische Eigenschaften des O," 17 pp.

Vol. xxxv, 1902; "Das mehrwerthige O," 9 pp.; "Basische Eigenschaften des C," 14 pp.; "Nitroaepfelsäure- & Nitroweinsäureester," 8 pp.; Vol. xxxvi, 1903; "Sogenannte Dinitrowein säureester," 3 pp.; "Die Ester der Ricinolsäure," 12 pp.

Liebig's "Jahresbericht der Chemie."

"Optische Isomerie," 80 pp., 1896–97.

Lorenz's "Zeitschrift für anorganische Chemie."

"Zusammengesetzte Rhodan- und Cyanverbindungen," 5 pp., Vol. xxxiii, 1900.

"Anorganische Lösungs- & Ionisirungsmittel," 43 pp., Vols. xxv and xxix, 1900, 1902.

"Flüssiges SO$_2$ als Lösungsmittel" (with M. Centnerszwer), 106 pp., Vol. xxx, 1902.

Meyer, "J. praktische Chemie."

"Einfluss der Elementen auf die optische Activität des Amylalkohols," 4 pp., Vol. lix, 1899.

Ostwald, "Zeitschrift für physikalische Chemie."

"Bestimmung der Molekulargrössen von Salzen aus der elektrischen Leitfähigkeit ihrer wässerigen Lösungen," 50 pp., Vol. I and II, 1887, 1888.

"Affinitätsgrössen organischer Säuren und ihre Beziehung z. Constitut.," 71 pp., Vol. viii, 1891.

Vol. x, 1892, "Tricarbonsäuren," 17 pp.; "Monocarbonsäuren," 27 pp.; "Diffusionserscheinungen, und Niederschlagsmembranen," 34 pp.

Vol. xv, 1894, "Optische Drehungen der Ionen," 13 pp.; "Optische Drehungen einiger Derivate des activen Amylalkohols," 28 pp.

Vol. xvii, 1895, "Optisch-active Derivate der Bernsteinsäure," 22 pp.; "Idem, der Phenylessigsäure und Optische Superposition," 20 pp.

Vol. xx, 1895, "Optische Drehungen stereoisomerer Verbindungen," 12 pp.; "Einfluss der Bindung auf das optische Drehungs-Vermögen," 17 pp. "Flüssiges Schwefeldioxyd als Lösungsmittel" (also in Bulletin de l'Académie Impériale des Sciences de St. Petersburg, Vol. xv, No. I, 1901), with M. Centnerszwer, 84 pp., Vol. xxxix, 1902. "Verbindungen des Schwefeldioxyds mit Salzen" (with M. Centnerszwer), 37 pp., Vol. xlii, 1903.

"Ueber abnorme Elektrolyte;" *Z. physik. Chemie*, Vol. xliii, pp. 385–464, Leipzig, 1903.

"Ueber organische Lösungs- und Ionisirungsmittel," Pt. I, *Z. physik. Chem.*, Vol. xlvi, pp. 103–188; Leipzig, 1903; Pt. II: "Messungen der electkrischen Leitfähigkeit," op. cit., Vol. liv, pp. 129–230, 1906; Pt. III: "Innere Reibung und deren Zusammenhang mit dem Leitvermögen," op. cit., Vol. lv, pp. 207–249; Pt. IV: "Ebullioscopische Messungen," op. cit., Vol. lv, pp. 281–302; Pt. V: Lösungsvermögen," op. cit., Vol. lv, pp. 683–720; Pt. VI: "Lösungswärmen," op. cit., Vol. lviii, pp. 479–511, 1907; Pt. VII: "Lösungs- und Dissociationswärmen," op. cit., Vol. lix, pp. 192–211, 1907; Pt. VIII: "Lichtbrechungsvermögen und elektrolytische Dissociation," op. cit., Vol. lix, pp. 385–415; Pt. IX: "Elektrostriktion," op. cit., Vol. lx, pp. 87–100; Pt. X: "Lösende Kraft und Dielektrizitätskonstante," op. cit., Vol. lxi, pp. 633–639, 1908.

"Ueber abnorme Elektrolyte," *Z. physik. Chem.*, Vol. xliii, pp. 385–464, Leipzig, 1903.

"Ausdehnungsmodulus, spezifische Kohäsion, Oberflächenspannung und Molekulargrösse der Lösungsmittel," *Z. physik. Chem.*, Vol. lxv, pp. 129–225, Leipzig, 1908.

"Ueber den Zusammenhang der Kapillaritätskonstanten mit der latenten Verdampfungswärme der Lösungsmittel," *Z. physik. Chem.*, Vol. lxv, pp. 257–288, Leipzig, 1909.

"Beiträge zur Kenntnis der Dielektrizitätskonstanten von Lösungsmitteln," *Z. physik. Chem.*, Vol. lxx, pp. 569–619, Leipzig, 1910.

"Ueber die elektrolytische Leitfähigkeiten nichtwässerige Lösungen bei tiefen Temperaturen," *Z. physik. Chem.*, Vol. lxxiii, pp. 257–268, Leipzig, 1910.

"Ueber einige abnorme Temperaturkoeffizienten der molekularen Oberflächenenergie," *Z. physik. Chem.*, Vol. lxxv, pp. 555–577, Leipzig, 1910.

(With R. Swinne) "Beiträge zur Kentniss der Kapillaritätskon-

stanten von flüssigen Estern," *Z. physik. Chem.*, Vol. lxxix, pp. 700–758, Leipzig, 1912.

Riga, "Correspondenzblatt," Journal of the "Naturforscher-Verein," Jubilee Volume, 1895.

"**Elektrochemie in der Technik,**" 16 pp.

Sklarek's "Naturwissenschaftliche Rundschau:"

"**Fünfundzwanzig Jahre Stereochemischer Forschungen,**" 16 pp., Vol. xv, 1900, St. Petersburg;

"Zhurnal Russkavo Fisico-Khimicheskavo Obshchesvta" (Journal of the Russian Physicochemical Society).

"**Vergleichende Untersuchung der Reactionen welche zur Entdeckung der Salpetersäure vorgeschlagen sind,**" 13 pp., Vol. xix, 1887.

"**Constitution von Demargay's Säuren,**" 20 pp., Vol. xxiii, 1891.

"**Resultate der Untersuchungen der Derivaten von mono- und disubstit. a-Oxysäuren**" (with C. A. Bischoff), 15 pp., Vol. xxvi, 1894.

"**Optische Isomerie,**" I: "**Active Derivate der Chlorfumarsäure und das Drehungsvermögen des Tannins,**" 20 pp. II: "**Optische Aktivität der Halogenverbindungen,**" 43 pp. III: "**Method der Umwandlung optischer Antipoden,**" 34 pp. IV: "**Hypothese von Ph. A. Guye,**" 28 pp., Vol. xxx, 1898.

"**Ueber anorganische Lösungen und Ionisirungsmittel,**" *Z. anorg. Chem.*, Vol. xxix, pp. 371–395, Hamburg, 1902.

"**Ciekly dwutlenik siarki jako rozpuszczalnik**" (Sur l'anhydride sulfureux et son action comme dissolvant); **Wiadomosci matematyczne** (*Gazette of Mathematics*), Vol. vi, pp. 213–243, Warszawa, 1902.

"**Flüssiges Schwefeldioxyd als Lösungsmittel,**" *Z. anorg. Chem.*, Vol. xxix, pp. 513–596; Vol. xxx, pp. 145–250, Hamburg, 1902.

"**Ueber das Drehungsvermögen optisch-activer Körper**" (address), *Deutsche chem. Ges.*, Vol. xxxiii, pp. 345–409, Berlin, 1905.

"**Zusammenhang zwischen der inneren Reibung und Ionengeschwindigkeit, bezw. Diffusionsgeschwindigkeit,**" *Z. Elektrotech.*, Vol. xii, pp. 77–78, Halle, 1906.

"**Ueber das Drehungsvermögen in Lösungen,**" *Deutsche chem. Ges.*, Vol. xl, pp. 2463–2491, Berlin, 1907.

"**Ueber das Wesen des Lösungsvorganges und die Rolle des Mediums,**" *Rev. Sci.*, Vol. ii, pp. 256–278, Bologna, 1907.

"**Ueber die Schmelzwärme, spezifische Kohäsion und Molekulargrösse bei der Schmelztemperatur,**" *Z. Elektrotech.*, Vol. xiv, pp. 713–724, Halle, 1908.

"**Zur Geschichte der kolloiden Kieselsäure,**" *Z. Kolloide*, Vol. vi, pp. 233–235, Dresden, 1910.

"**Einige Molekulargrössen in Phosphoroxychlorid als kyroskopischen Solvents,**" *Z. anorg. Chem.*, Vol. lxviii, pp. 307–316, 1910.

"**Die Lösungstheorien in ihrer geschichtlichen Aufeinanderfolge,**" *Samml. chem. u. chem. tech. Vorträge*, Stuttgart, 1910, Vol. xv, No. 8/12, pp. 277–454, 8vo.

(With C. A. Bischoff). "**Bisubstit. Bernsteinsäure,**" *Deutsche chem. Ges.*, 6, 4 and 1 pp., Vol. xxii, 1889.

Physikal Const. d. substit. Aethenyltricarbonsäureester, 5 pp.; **Leitverm. d. substit. Bernsteinsäuren and Glutarsäuren,** 8 pp.; *Deutsche chem. Ges.*, Vol. xxiii, 1890.

Glycolid and seine Homologen, 4 pp.; **Anwendung d. dynam. Hypothese auf Ketonsäurederivate,** 9 pp.; *Deutsche chem. Ges.*, Vol. xxvi, 1893.

Anomalien bei Verkettungen, 4 pp.; **Aethylenester d. Glycol- and Oxalsäure and d. Anhydride a-halogenisirter Fettsäuren,** 13 pp.; *Deutsche chem. Ges.*, Vol. xxvii, 1894.

Deriv. d. Glycolsäure, 26 pp.; **Idem d. Milchsäure,** 29 pp.; **Idem d. Aepfelsäure,** 8 pp.; **Idem d. Weinsäure,** 15 pp.; **Die 1- and 2-bas. a-Oxysäuren,** 35 pp.; Liebig's *Jahresber d. Chem.*, 1894.

A LIST OF UNITED STATES PUBLIC DOCUMENTS PERTAINING TO PULP AND PAPER

The remarkable development of the pulp and paper industry within comparatively recent years has attracted considerable attention, and there is an increasing demand for specific and detailed information in regard to the technical, commercial, and economic features. Much information of this character can be obtained from the public documents or reports of the United States Government, a number of which are specifically devoted to pulp and paper subjects. These particular publications, however, have not been of the greatest usefulness, due, first, to their having been issued at various odd times and by many different branches of the government and, second, to the fact that there was no special catalogue or index bringing them all together for ready reference. On this account, the list of titles below will be found of much advantage.

The publications listed vary widely in subject matter, depending on the character of the investigations conducted by the different branches of the government by which the reports were issued. However, these investigations do not cover every feature of the pulp and paper industry so it must not be expected that all desired information can be obtained from government publications. For the particular subjects considered the reports are quite thorough since the scope of government investigations usually is far greater than could be attained by independent investigators.

Aside from being readily accessible in many public libraries, most of these publications may be secured by purchase from the Superintendent of Documents, Government Printing Office, Washington, D. C., at very small cost. Many of them also are available for gratuitous distribution by Members of the Senate or House of Representatives and by the respective Departments and Bureaus from which they were issued. The ease with which they may be obtained, combined with their authoritative and impartial nature, renders them especially valuable as sources of information.

It is believed that with the following exceptions the list contains the titles of all government publications pertaining more or less directly to pulp and paper subjects. The principal exceptions are the decisions and reports of the Interstate Commerce Commission and the Monthly Consular and Trade Reports of the Bureau of Manufacturers (later the Daily Consular and Trade Reports of the Bureau of Foreign and Domestic Commerce) of the Department of Commerce and Labor. The former often have reference to particular cases before the Commission in which pulp and paper figure merely as articles of shipment, and the points at issue are such as freight classification, tariff rates, shortage of cars, and similar transportation subjects. The Consular and Trade Reports frequently contain short articles by American Consuls dealing with paper products in foreign countries, together with suggestions for home manufacturers. The Geological Survey of the Department of the Interior and the two Statistics Bureaus of the Departments of Agriculture and of Commerce and Labor have each published certain information (other than that indicated in the list below) on subjects relating to pulp and paper-making but this has generally been included in reports in a form not particularly applicable to this industry alone.

The branches of the government from which the several publications were issued are indicated in the headings.

AGRICULTURE DEPARTMENT

BRAND, CHARLES J. The Utilization of Crop Plants in Papermaking. 12 pp., illus. 8°. 1911. (Dept. Agr., yrbk., separate, **1910.**)

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constitute the customs regulations (in effect November, 1911), pertaining to the importation of pulp-wood, wood pulp and paper.

The author would appreciate having his attention called to any omissions or errors in the above list.

HENRY E. SURFACE.

FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN
FEBRUARY 1, 1913

AMERICAN CHEMICAL SOCIETY—NEW DESCRIPTIVE DIRECTORY OF THE DIVISION OF INDUSTRIAL CHEMISTS AND CHEMICAL ENGINEERS

It is desired to issue a new descriptive directory of the Division of Industrial Chemists and Chemical Engineers in December, 1913. In order to do this the members of the division are requested to notify the secretary of changes of address, occupation, etc., and to contribute one dollar each toward the expenses of the division. It is absolutely necessary that the list of members should be corrected and brought up-to-date and it is hoped that each member will attend to this immediately.

Any other member of the Society wishing to enroll in the Division should send his name, address, occupation (title and business connection) and lines in which he is most interested to the Secretary, together with one dollar as a contribution toward the expenses of the division.

[S. H. SALISBURY, JR., *Secretary*

LEHIGH UNIVERSITY,
SOUTH BETHLEHEM, PA.

OBITUARIES

WILLIAM McMURTRIE

In September, 1872, I left my home in Indiana for the purpose of taking a post-graduate course at Harvard University. Never having been in the National Capitol, I took occasion to visit Washington en route. At that time Dr. R. T. Brown, one of the old-fashioned scientists who had been professor of chemistry in the medical college which I attended, was chemist of the Department of Agriculture. I visited the Department for the purpose of paying him a friendly call. On entering the laboratory, I found one assistant at work: a young man with jet-black hair and pleasing appearance, seated on a high stool, before a desk, attending to some of the details of an analysis. On inquiring of him for my friend, Dr. Brown, I was told that he was not in, and the young man introduced himself as William McMurtrie, assistant. This was my first meeting with Dr. McMurtrie, and the beginning of a friendship which continued unabated until the time of his death. The impression made upon me by Dr. McMurtrie at that time is indelible. The picture which I have just described is as vividly before me now as it was forty-one years ago.

Dr. McMurtrie's career in the Department of Agriculture was signalized by the usual activity which he always displayed in every position that he filled. Within the next two years from the time of which I speak, Dr. Brown retired from the position of the chief chemist of the Department of Agriculture and Dr. McMurtrie took his place. He was at that time, though only twenty-one years of age, well trained in chemistry, as training was regarded in those days. It is stated that even in his boyhood he displayed a remarkable liking for chemistry. At the age of fourteen he attended some lectures given to young people by the minister of the neighborhood and gladly paid the fee of five cents which was necessary to cover the costs of the materials for each of the lectures. When he entered Lafayette College there was no special course of chemistry, so he took mining engineering because in that he could have the best chemical training which the college afforded.

The story of how he was selected for the succession to Dr. Brown reveals one of the characteristics of his whole life, namely, unselfishness. Judge Watts was at the time Commissioner of Agriculture. When Dr. Brown retired, a number of applications for this position came in. Commissioner Watts called young McMurtrie into his office and asked him what he thought of the qualifications of the applicants. He said that he did not think any one of them was properly qualified for the position. Commissioner Watts then asked him if he thought he could do the work and would like the position. He replied that the idea of succeeding Dr. Brown had never entered his mind, but he thought he could do better than any of the men who were being considered. The Commissioner replied: " You have not made any application." It was not long, however, before the application was made out and he continued to hold the position of Chief Chemist until 1877.

The story of his retirement from this position is most interesting. During the term of President Hayes, Mr. Le Duc was Commissioner of Agriculture. He evidently had some political debts to pay, for among other things he wanted Dr. McMurtrie's place for Dr. Collier. Commissioner Le Duc had a very fine opinion of Dr. McMurtrie's ability and services and frankly told him the predicament he was in and asked if he could give him something else, would he be willing to step aside. With his well-known devotion to others Dr. McMurtrie readily consented. He retired from the position of Chief Chemist of the Department and went to Paris in 1878 as a representative of the Department of Agriculture. In addition to discharging his special duties as representative of the Department he made a thorough and extensive study of the beet industry and of the wine industry of France. His report on the sugar industry laid the foundation of the scientific beet sugar industry of this country and is one of the most valuable contributions Dr. McMurtrie made to science.

After his return from Europe, he continued his relations with the Department and carried on a very elaborate investigation

on the subject of fibers, especially of wool and cotton. He continued these investigations after he accepted the position of Professor of Chemistry in the University of Illinois. It was my good fortune to know something of the details of his fine work. It was a work of monumental proportions and carried out with all the devotion to detail which Dr. McMurtrie brought to the study of every problem. His microscopical and physical study of fibers occupied much of his time and that of several assistants, whom he employed for a number of years. For some reason the valuable manuscripts which he prepared for the Department of Agriculture have never been published in full. It would be a great tribute to his memory as well as of great value to science if these unpublished manuscripts could be made public.

Dr. McMurtrie discharged his pedagogical duties with distinction and at the same time kept up his laboratory studies. An investigation into an alleged case of poisoning by baking powder led to his coming into contact with the officials of the Royal Baking Powder Company; in 1888, he resigned his chair of chemistry in the University of Illinois, and became consulting chemist of that company. He continued his connection with that company first as chemist, then as manager and later as vice-president, until the time of his death.

My most intimate association with Dr. McMurtrie in an official way, was in the reorganization of the American Chemical Society. We were members of the committee which formed the present constitution and made possible the useful activity of the society. In the early nineties, the American Chemical Society numbered scarcely more than two or three hundred members. The journal was a matter of no consequence and the meetings were confined to New York City. The committee on reorganization realized that the only avenue of prosperity lay in the direction of popularizing and localizing the activities of the society. The plan of forming local sections appealed to the committee as the only solution of this difficult problem. To this plan Dr. McMurtrie devoted his services with his customary zeal and enthusiasm. The wisdom of the reorganization is apparent at the present time. There are 42 local sections scattered throughout the country and a total membership of around 6,000. Dr. McMurtrie's services in this line were recognized by his fellow chemists, in his election as president of the society in 1896-8, the duties of which position he discharged with great credit to himself and benefit to the society.

Dr. McMurtrie's later years were devoted to executive rather than laboratory work, and for this reason the number of his contributions to scientific literature in later life was not numerous. In spite of this, however, his love of his chosen profession never waned. In the three years prior to his death, in which he was an invalid, he manifested a most lively interest in all things relating to the prosperity of the American Chemical Society and the advancement of chemistry. Not only was he an extensive reader of chemical literature during these three years of invalidism, but he carried on a most extensive correspondence with his old friends and new ones in matters relating to chemistry. He will be known professionally to the succeeding generations by his contributions to agricultural chemistry, most especially his work in laying broad and deep the foundations of the sugar beet industry of this country. His great work on fibers is known to only a few of his intimate friends. In his connection with a great manufacturing company, he, doubtless, was restricted to some extent in his publications by the code of ethics governing such positions. While this code is to be regretted from a scientific point of view, it is probably the only one which could exist in the present condition of commercial operations.

In his relations to his fellow workers, Dr. McMurtrie was the ideal *persona grata*. His wit, his humor and his geniality illuminated every function he attended. He died peacefully on the 24th of May, 1913, as the victim of apoplexy, his arteries having hardened altogether too early, largely perhaps by reason of devotion to his profession.

Friend, counsellor, co-laborer, *vale*.

HARVEY W. WILEY

BIOGRAPHICAL DATA

WILLIAM MCMURTRIE

Born March 10, 1851, near Belvidere, New Jersey.

Degree, M.E., Lafayette College, 1871.

Degree, M.S., Lafayette College, 1874.

Degree, Ph.D., Lafayette College, 1876.

Married—Washington, D. C., to Helen Douglas.

His wife and son Douglas C., survive him.

Died—May 24, 1913, result of apoplexy.

Buried—Oak Hill Cemetery, Washington, D. C.

DR. WILLIAM McMURTRIE

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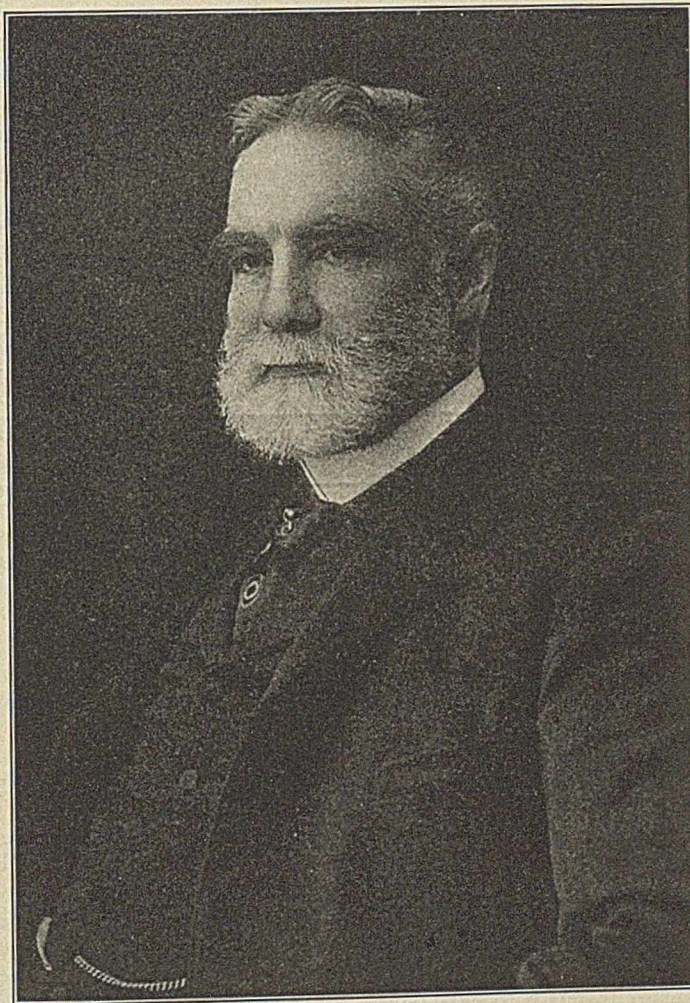
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NOTE: The above is as complete a list as could be obtained at this writing.—DOUGLAS C. MCMURTRIE

NOTES AND CORRESPONDENCE

THE SAMPLING OF RUBBER GOODS[1]

Investigations have been made at various times to show the great importance of sampling such material as coal, sugar, alloys of various kinds, etc., and a great deal has been written on this subject, showing that the value of the chemical analysis made depends largely on the care expended in sampling. With regard to the sampling of rubber goods very little has been said, and if we may judge by the experience of this Bureau, little attention has been paid to this important subject. Yet it must receive the most careful consideration from all who are interested in the chemical analysis of rubber, if we are to expect analyses made in different laboratories to reach even fair agreement.

Inasmuch as rubber compounding is merely mechanical mixing of solid material of varying natures, it is obvious that a fair average sample can be obtained only by taking pieces from different parts of the finished material.

As a rule, the matter of sampling is left to a corps of inspectors, to whom rubber is only one of many materials to be handled. Too much must not be expected of them. In such cases, it is always the manufacturers who have most at stake, and it would seem that they are the ones who should insist that the sampling be done properly.

For example, some months ago, this Bureau had occasion to test a sample of suction hose. A small strip was taken from the end of one length, and another sample, one foot in length, was sent by the manufacturer, with the guarantee that it was made of the same material, and vulcanized under the same conditions. The analysis of the inspector's sample showed it to be much inferior to the one submitted by the manufacturer. The material was rejected, and considerable annoyance and expense was caused, until the manufacturer proved that the hose was capped

with a somewhat inferior compound. If the manufacturer, who knew all the conditions, had made this statement at the time the sample was taken, much delay and expense in re-testing would have been saved.

Furthermore, samples should not be subjected to any treatment whatever before they are sent to the testing laboratory. Recently, we received a sample of insulated wire, which, on examination, proved to contain a variety of materials. Part of it was a piece of wire just as it came from the reel, some of it the rubber stripped from the wire, and the largest part material that had been stripped from the wire and worked through a mill, "to give an average sample" as the inspector explained. The rubber on the wire showed a free sulfur content of 0.79 per cent, whereas the specifications allowed only 0.50 per cent. The other material, however, showed a free sulfur content as low as 0.42 per cent. Analysis of samples of this nature is a waste of time and money, since there can be no assurance that the results obtained bear any relation to the material which the contractor is offering.

Still another sample has been received recently, consisting of rubber which had been ground to pass through a No. 20 sieve. This was sent in a paper envelope, not sealed. The absurdity of the analysis of such material is apparent to all who have given any time and thought to the question of the chemical analysis of rubber. Suffice it to say that practically all analytical methods require the analysis to be started within 24 hours after the grinding of the sample.

Care of the sample after taking is equally important. A testing laboratory can analyze a sample only as it is received, and it is to the manufacturer's interests that this sample be received in a satisfactory condition.

This subject should come under the jurisdiction of the rubber section of the American Chemical Society and we would recommend that some action be taken. This Bureau is now insisting

[1] Published by permission of the Director of the Bureau of Standards. Paper presented at the Milwaukee meeting of the American Chemical Society, March, 1913.

that material for analysis should meet the following requirements:

Samples shall be taken directly from the finished material. These samples should be sealed, and marked with maker's name, date of sampling, kind of material, and sufficient other data to ensure easy and complete identification. The sample should be of such size as to permit of part being taken for analysis and the remainder stored for future reference, should the occasion for such arise. Every precaution must be taken to prevent contamination of the samples by any foreign material, and they must always be stored in a cool place. The object of these precautions is to insure that the sample shall be received in exactly the same condition as it is offered by the contractor.

The following table will show the minimum amount of material required for making the various tests, leaving a sufficiency for supplemental chemical check tests if these are needed. The amounts specified are intended to show the size of sample required on what might be considered relatively small lots. The samples should be made up of a number of pieces taken from several parts of the delivery, and from these a composite sample will be made for chemical analysis. It should be noted, however, that the pressure test on hose requires a four-foot length. Large lots should be represented by samples of corresponding size. In such cases, it may be advisable to make two, or more, composite samples for chemical analysis.

PHYSICAL TESTS ONLY

Hose of all kinds, up to 3 in. diameter	2 feet
Hose of all kinds, over 3 in. diameter	1 foot
Pressure test on hose	4 feet
Packing	1 sq. ft.
Insulated wire	4 to 6 feet
Other mechanical goods,	
sufficient material to give at least 6 pieces 1 in. × 6 in.	

CHEMICAL TESTS ONLY

Hose of all kinds, up to 3 in. diameter	1 foot
Hose of all kinds, over 3 in. diameter	6 inches
Packing	1/4 sq. ft.
Insulated wire	2 to 3 feet
Other mechanical goods,	
sufficient material to give at least four ounces of rubber.	

ELECTRICAL TESTS ONLY

Insulated wire	6 feet

JOHN B. TUTTLE

BUREAU OF STANDARDS
WASHINGTON, D. C.

BAKELITE PATENT RECOGNITION

As a result of negotiations between the General Bakelite Company and the Condensite Company of America, the suits brought by the former against the latter and its customers for alleged infringement of the Bakelite patents, have been withdrawn, and the Condensite Company, recognizing the pioneer character of Dr. L. H. Baekeland's work, has acknowledged the validity of the Bakelite patents in suit and some others, and will pay substantial royalties thereunder.

The General Bakelite Company will continue the manufacture of Bakelite under its numerous patents, and the Condensite Company will manufacture Condensite under the Aylsworth patents, as well as the license just granted for such of the Baekeland patents as are broad enough to cover Condensite.

This recognition of the force and validity of the principal Baekeland patents by the only other manufacturer of condensation products is a confirmation of the Bakelite Company's claims for the broad scope and pioneer character of these patents.

There is much that is old in the art of making phenolic condensation products, but Dr. Baekeland was the first to make practical application of what theretofore had been chiefly laboratory experiments.

NOTE ON THE STANDARD VANILLIN SOLUTION FOR THE COLORIMETRIC METHOD FOR THE DETERMINATION OF VANILLIN IN FLAVORING EXTRACTS

Since the publication in THIS JOURNAL, 4, p. 670, of "A New Colorimetric Method for the Determination of Vanillin in Flavoring Extracts," by Otto Folin and W. Dennis, the method has been used in the Kansas State Board of Health Food Laboratory in the analysis of over sixty extracts and a number of samples of known vanillin content.

The method has worked well and has given sufficiently accurate results for judging vanilla extracts but some experiments with the standard vanillin solution seem important enough to be reported.

The directions call for a solution of vanillin of which 10 cc. contain 0.001 gram of vanillin. Experiments have shown that this solution increases, on standing, in its power to produce a blue color when treated with the phosphotungsticphosphomolybdic acid reagent so that after a month it increases to such an extent that determinations on solutions of vanillin of known strength showed only about 75 per cent of the true vanillin content. Such results are illustrated by the following estimations:

Date	Fresh standard	Old standard
1–18–13	20.0	15.4
2–24–13(a)	0.501	0.356
Duplicate	0.498	0.362

(a) This was a solution 0.5000 gram of Merck's refined vanillin (same as used in standard) and 25 cc. of 95 per cent alcohol in 100 cc.

A very satisfactory standard solution may be prepared by dissolving 2.0000 grams of vanillin in 200 cc. of 95 per cent of alcohol and diluting to one liter and then using 10 cc. of this solution to make 200 cc. of standard solution when it is needed. Such a solution was made January 18, 1913, and standards made by diluting the strong solution were compared with fresh standards with the results shown in the following table:

Date	Fresh standard	Standard made by dilution
1–18–13	20.0	20.2
1–22–13	20.0	20.1
1–25–13	20.0	20.3
1–29–13	20.0	20.1
3–21–13	20.0	20.1

These results show that the strong solution will keep for at least two months without showing an appreciable change. It is much easier to make the dilution than to make up a fresh standard each day.

OSCAR E. HARDER

UNIVERSITY OF KANSAS
LAWRENCE
MAY 16, 1913

DETERMINATION OF SULPHATE IN AMMONIUM SULFATE SOLUTIONS, ETC.—A CORRECTION

Through a clerical error in the paper under the above title, THIS JOURNAL, 5, 469, no reference was made to the paper published by H. F. Muer, "The Determination of Sulfur in Coal by Means of the Jackson Turbidimeter," THIS JOURNAL, 3, 553. Muer's paper was carefully consulted in connection with our work, and the reference made to it on the original manuscript was omitted by a clerical error in the Bureau offices. The apparent discrepancies in the results reported in the two papers were not discussed by us, because the differences in the methods of precipitation used were sufficient to account for all, except Muer's preference for tablets of solid barium chloride instead of a barium chloride solution as a precipitant, and for only a limited amount of agitation after precipitation. As no definite results were given in support of these conclusions, we could not, of course, discuss them fully. The differences found only serve to emphasize the fact that the method used

in calibrating the turbidimeter must be carefully followed in all subsequent determinations. No originality is claimed for the turbidimetric method described in our paper; it is merely an account of the results obtained in an effort to adapt the method to a new use.

R. S. McBride
E. R. Weaver

Bureau of Standards
Washington, D. C.

THE CHEMICAL CONSTITUTION OF RESINOUS PHENOLIC CONDENSATION PRODUCTS—A CORRECTION

In my article under the above title, THIS JOURNAL, 5, 506, there is an error in the last line, page 511: "hexamethylen-tetramine" should read "hexamethylentetramintriphenol."

L. H. Baekeland.

BOOK REVIEWS

A Dictionary of Applied Chemistry. Second edition, revised and enlarged. By Sir Edward Thorpe and other eminent contributors. To be issued in five volumes. Volume III, 789 pages. Price of complete set when issued, $67.50. Price per volume, $13.50. Longmans, Green and Company: London and New York.

This book is the third of the five volumes of the set. Volumes I and II were reviewed in This Journal, 4, 550 and 698. Volume III closes with the chapter on Oils and Fats, following the usual alphabetical sequence. The same careful selection of eminent authors obtains in this as in the previous volumes, and a number of new names appear among the contributors. A comparison of the subject matter with that of the older edition shows careful revision and extension of the more important topics. A large amount of new matter has been added, for example, new chapters on Grape, Grape-seed Oil, Greases, Guaiacol, Guanidion, Gypsum, Halogen Acetic Acid, Helium, Hordenine, Hydantoin, Hydrolysis, Indigo (natural and artificial), Invertase, Iridium, Isoprene, Lacquer, Lactic Acid, Lactones, Lard, Leucine, Liquefaction of Gases, Liquors and Cordials, Meat Extracts, Mercerizing, Metallography, Monazite, Monel Metal, Neodymium, Utilization of Atmospheric Nitrogen.

The book is excellently printed on a paper well adapted to reference use. The binding is strong and substantial as in previous volumes.

It is hoped that the additional two volumes to complete the set will appear promptly. In this revised form the set will be a welcome addition to the working equipment of every works office, laboratory and reference library.

M. C. Whitaker

Methods for the Analyses of Iron and Steel, Used in Laboratories of the American Rolling Mill Co., Middletown, Ohio. pp. 62. Illustrations 7. The Republican Publishing Co., Hamilton, Ohio.

The preface states that this bulletin is issued on account of the numerous requests received for copies of the methods used in the laboratories of the American Rolling Mill Co., especially those referring to the analysis of American Ingot Iron. The methods given for the ordinary elements are those of common use in iron and steel laboratories, and no claim is made for originality. The bulletin is intended as an aid to experienced chemists, thoroughly conversant with the standard methods for the analysis of iron and steel. For detail of method the reader is referred to standard text books with the exception of the determinations of nitrogen, hydrogen, and oxygen in steel, which are given in detail. Criticism and suggestions are invited in reference to new or modifications of old methods.

William Brady

Coal, Its Composition, Analysis, Utilization and Valuation. E. E. Somermeier. 167 pages. Illustrations and tables. New York: McGraw-Hill Book Co. 1912. Price, $2.00.

This book contains a very complete and readable presentation of coal testing, including sampling, analysis, calorific determinations, flue gas analysis, boiler test calculations, coal washing tests, etc. It is written with a view to meeting the demand of the mechanical engineer, chemist, as well as the practical business man whether a seller or purchaser of coal, on all subjects relating to same. Tables of analyses of coals from all parts of the United States are included.

The book is particularly valuable to the chemist as it goes into details relating to methods of coal and flue gas analysis and calorimetric determinations, giving ample details of procedure, and points out many possible causes of errors, their relative importance, and means of obviating or correcting for same. Much of this data is original and is so important that every chemist who has to do with coal analysis should consult this work.

The book appears to be a little weak on a few points where the author has expressed opinions or made statements that are not in accordance with the most recent research work on the subjects without presenting any data or proof to substantiate same. This is especially so in connection with "Sampling Coal and Fusibility of Ash." Also in connection with calorimetric work and thermometer calibration, the author rather minimizes the work of the U. S. Bureau of Standards, while the advantage and need of referring all standardization work to them should have been emphasized.

E. G. Bailey

Electroplating. A treatise on the Electro-deposition of Metals with a chapter on metal coloring and bronzing. By William R. Barclay and Cecil H. Hainsworth. Longmans, Green & Co. pp. 399. Price, $2.10, net.

This volume is probably the most up-to-date book in English that we have on this subject. The first 116 pages are devoted to accessory knowledge in chemistry and electricity, which every electroplater should know, but of which few have any understanding. Thus we have short chapters on fundamental principles of chemistry, electrochemistry, electricity, primary batteries, the lead storage battery, the dynamo, etc. While this information is available in many other sources it is probably an advantage to have it included in a book on electroplating, thus bringing it directly to the attention of the electroplater.

In the discussion of voltage calculation on pages 67 and 68 according to the Kelvin equation, the shortcomings of the method are not mentioned, which is unfortunate.

Chapters VII and VIII describe the details of the plant for electroplating, construction of vats, rheostats, electrical measuring instruments, cleaning, scouring, sand blast, etc. All of this is well treated and considered in a practical manner. The rest of the book deals with the electro-deposition of silver, copper, nickel, gold, zinc, brass, iron, cobalt, tin, platinum, etc., in a very thorough way. The control of the baths is described and analytical methods given. The formulas for the different baths appear to have been carefully chosen. References are given in many cases, and some of these refer to recent work in this line. For example, Field's admirable work on brass is referred to, and also Kern's copper, nickel, and zinc baths.

The last chapters are devoted to metal coloring and finishing. Taken as a whole the book is excellent and should prove extremely useful.

S. A. Tucker

Food Inspection and Analysis. For the use of public analysts, health officers, sanitary chemists and food economists. By Albert E. Leach, S.B., late Chief of the Denver Food and Drug Inspection Laboratory, Bureau of Chemistry, U. S. Department of Agriculture. Third Edition. Revised and enlarged by Andrew L. Winton, Ph.D., Chief of Chicago Food and Drug Inspection Laboratory, Bureau of Chemistry, U. S. Department of Agriculture. New York: John Wiley & Sons. Large 8vo. xxi + 1001 pp., 120 figures, 40 full page half-tone plates. Cloth. Price, $7.50 net.

This very popular treatise is so well known that a detailed description of it is unnecessary. "The period since the appearance of the second edition has been, in America, one of steady progress in food science as compared with the period of special activity, stimulated by federal legislation, immediately preceding and the pioneer period, in which the author was a prominent figure, that led to the publication of the first edition. Without changing the general plan of the work, which ought ever to remain as a monument to the author's remarkable grasp of the subject, new matter equivalent to about 80 pages, not including some 40 pages changed in the last thousand of the second edition, and 12 new cuts, have been added. The size of the work, however, has been increased but 47 pages, as much antiquated matter has been replaced by new, thus performing a double service to the reader."

The text of the book is divided into twenty-one chapters as follows:

Chapter I, pp. 1–13, discusses Food Analysis and Official Control.

Chapter II, pp. 14–38, The Laboratory and Its Equipment. A cut showing the Freas electric drying and constant temperature oven is a new addition to the discussion of laboratory equipment.

Chapter III, pp. 39–52. While this chapter is called Food, Its Functions, Proximate Components, and Nutritive Value, the major part consists of the classification and discussion of the proteins. The small part devoted to nutritive value of foods is very inadequate; it is rather strange that the old Rubner physiological fuel values have not been replaced by the more correct figures of Atwater which are so generally used at the present time.

Chapter IV, pp. 53–80, General Analytical Methods. The reviser has improved this chapter by giving a more complete discussion of the modern methods for the detection and determination of arsenic than was to be found in the old edition. Apparatus for drying in an atmosphere of hydrogen and the Hoskins electric furnace for ashing are illustrated and described.

Chapter V, pp. 81–99, The Microscope in Food Analysis.

Chapter VI, pp. 100–103, The Refractometer. These chapters remain unchanged.

Chapter VII, pp. 124–210, is on Milk and Milk Products. This chapter shows careful revision—cuts illustrating new forms of Babcock apparatus are substituted for the old ones and the discussions of the methods, e. g., in the case of the detection of nitrates, have been augmented in order to include improvements which have appeared since the publication of the second edition. The sub-chapters on condensed milk, cream, and ice-cream have been very much improved, a process for the detection of foreign fat constituting a new and valuable addition.

Chapter VIII, pp. 211–269, is headed Flesh Foods. The sub-chapter on meats contains the discussion of the composition, wholesomeness and effect of treatment as in the earlier edition; the number of analytical methods, however, has been increased by methods for the determination of ammonia in meat and of acidity of fat. A paragraph on the effects of floating of shell-fish is new to this chapter.

Chapter IX, pp. 261–270, Eggs.

Chapter X, pp. 271–364, Cereals and Their Products, Legumes, Vegetables and Fruits. This chapter has been rewritten and improved in several places, especially the part devoted to flour. A method for the determination of sugar in cereal products is a noteworthy addition; the sub-chapters on yeast and baking powders contain some new material.

Chapter XI, pp. 365–407, Tea, Coffee and Cocoa. The sub-chapter on tea contains the new methods for detection of "facing." The determination of sucrose and lactose in cocoa products assumes a new form.

Chapter XII, pp. 408–470, Spices. Several parts of this chapter have been rewritten.

Chapter XIII, pp. 471–564, Edible Fats and Oils. No important change.

Chapter XIV, pp. 565–652, Sugar and Saccharine Products. The description of several of the analytical methods in this chapter have been revised and brought up-to-date; Munson and Walker's lactose table has been corrected and more accurate tables of the relation between density and percentage of sugar solutions supplant the old one on pages 617 to 620.

Chapter XV, pp. 653–758, headed Alcoholic Beverages, has undergone a couple of slight changes. The Bureau of Standards table for the calculation of the percentage of alcohol-water solutions from the densities is not to be found.

Chapter XVI, pp. 759–781, on Vinegar has been enlarged in order to contain a method for the determination of glycerol in vinegar.

Chapters XVII, pp. 782–820, Artificial Food Colors. In addition to the extensive schemes for the separation and identification of the various dyestuffs used in sophistication of food material contained in the old edition, there are presented Price's scheme for separating the seven permitted colors and Mathewson's method for the quantitative separation of acid coal tar colors.

Chapter XVIII, pp. 821–849, Food Preservatives. A sub-chapter on a new food preservative, formic acid, has been added.

Chapter XIX, pp. 850–856, Artificial Sweeteners.

Chapter XX, pp. 857–899, Flavoring Extracts and Their Substitutes. The section devoted to vanilla extract has been revised to include several new methods, tests and a "summary of the analyses of authentic samples of vanilla extract." The lemon extract sub-chapter contains a new section devoted to the methods of analysis of lemon oil (also applicable to orange oil). Ginger extract is given place in this chapter.

Chapter XXI, pp. 900–964, on Vegetable and Fruit Products, has been completely revised and widened in scope to embody, according to the revising author's preface, "new sections on tomato ketchup, dried fruits, preserves (including maraschino cherries), fruit juices, and non-alcoholic carbonated beverages." "In the final chapter are included descriptions of recent methods for the determination of tin, vegetable acids, and habit-forming drugs, and for the detection of saponin, also microscopic methods for the detection of spoilage."

Following the final chapter there is an appendix containing the amended Federal Pure Food Law and the Meat Inspection Law. The 40 excellent photomicrographic plates are conveniently placed at the back of the book as in the past editions.

The reference lists following the chapters do not seem to have been so carefully revised as the general text of the book. While the recent work published in the government bulletins has been included in these reference lists, it is to be regretted that much that has appeared in the general chemical literature since the publication of the second edition of Leach's book has been omitted. Dr. Winton's revision, however, has greatly strengthened and improved the text of the treatise making it a valuable addition to the libraries of "public analysts, health officers, sanitary chemists and food economists."

A. W. Thomas

NEW PUBLICATIONS

By D. D. Berolzheimer, Librarian, Chemists' Club, New York

Alloys and their Technical Utilization. By A. Ledebur. 4th edition. 8vo. 214 pp. Price, $1.00. M. Krayn, Berlin. (German.)

Asphalt Construction for Pavements and Highways. By Clifford Richardson. Sm. 8vo. 155 pp. Price, $2.00.

Boilers, Modern Steam. By W. D. Wansborough. 8vo. 168 pp. Price, $1.25. C. Lockwood, London.

Chemistry, General Crystallography and Mineralogy. By E. von Meyer and Fr. Rinne. Lex. 8vo. 650 pp. Price, $5.50. B. G. Teubner, Leipzig.

Colloidal State of Matter, The. (Translation.) By Leonardo Cassuto. 8vo. 247 pp. Price, $2.00. Theodor Steinkopff, Dresden. (German.)

Colors, Oils and Varnishes, A Manual of Painters'. By George H. Hurst and Noel Heaton. 5th edition. 8vo. 528 pp. Price, $2.75. Charles Griffin & Co., London.

Dictionary of Applied Chemistry, IV: Oilstone Soda-Nitre. By Edward Thorpe. Vol. 5. Revised edition. 8vo. Price, $12.00. Longmans, Green & Co., New York.

Dyeing, Chemical Products for Use in. By P. Heermann. 2nd edition. 8vo. 444 pp. U. Hoepli, Milan. (Italian.)

Electrochemical Practice. By Erich Mueller. 8vo. 221 pp. Price, $2.00. Th. Steinkopff, Dresden. (German.)

Electrochemistry, Yearbook of, and Applied Physical Chemistry, XIII, 1906. By H. Dannel and Julius Meyer. 8vo. 823 pp. Price, $8.00. Wilhelm Knapp, Halle. (German.)

Engine, The Gas, Petrol and Oil. By D. Clerk and G. A. Burls. Vol. 2. 8vo. 838 pp. Price, $7.50. John Wiley & Sons, New York.

Finishing, Manual of Cloth. By Editors, Dyer and Calico Printer. 8vo. 300 pp. Price, $6.50. Heywood & Co., London.

Gas Analysis. By L. M. Dennis. 12mo. 434 pp. Price, $2.10. The Macmillan Co., New York.

Gas Analysis Laboratories, Apparatus for, at Coal Mines. By Geo. A. Burrell and Frank M. Seibert. 8vo. 24 pp. U. S. Bureau of Mines, Technical Paper 14.

Gas Companies, Directory of American. By E. C. Brown. L. 8vo. 768 pp. Price, $5.00. The Gas Age, New York.

Gas Engineers and Managers, Handbook for. By Newbiggings. 8th edition. 8vo. Price, $4.50. Walter King, London.

Gas Mantles, Illumination by Means of. By C. Richard Boehm. 8vo. 62 pp. Gustav Heydenreich, Charlottenburg.

Gas Power. By C. F. Hirschfeld and T. C. Ulbrecht. 8vo. Price, $1.50. Chapman & Hall, London.

Illuminating Gas, Quality Standard for. By Joint Committee on Calorimetry. 4°. 94 pp. Empire State Gas & Electric Association, New York.

Inorganic Chemistry for Engineers. By F. Dupré. 8vo. 173 pp. Oskar Leiner, Leipzig. (German.)

Inorganic Chemistry, Textbook of. By A. F. Hollemann. 11th edition. 8vo. 463 pp. Price, $2.50. Veit & Co., Leipzig.

Inorganic Chemistry, Handbook of the Working Methods of. Vol. 1. By A. Staehler. Vol. 2. 8vo. 742 pp. Price, $7.00. Veit & Co., Leipzig. (German.)

Iron, The Metallurgy of. By Paul Domner, et al. 8vo. Price, $2.00. Vinbert, Paris. (French.)

Iron, Using the Etching Process for the Testing of, by Means of the Microscope. By E. Preuss. 8vo. Price, $1.50. Julius Springer, Berlin. (German.)

Liquid Air, Production, Use and Storing. By Oscar Kausch. 4th edition. L. 8vo. 463 pp. Price, $2.50. Carl Steinart, Weimar. (German.)

Metal Casting. By E. A. Schott. 8vo. Price, $3.50. Bernh. Friedr. Voigt, Leipzig.

Metallic Alloys, Their Structure and Constitution. By G. H. Gulliver. 2nd edition. Cr. 8vo. 438 pp. Price, $2.75. C. Griffin & Co., London.

Metallurgy, Introduction to the Study of. By Henry Le Chatelier. 8vo. Price, $2.25. Dunod & Pinat, Paris. (French.)

Metallurgy and Assaying, Textbook of Experimental. By A. R. Gower. Cr. 8vo. 178 pp. Price, $1.00. Chapman & Hall, London.

Natural Gas, Wastes in the Production and Utilization of, and Means for their Prevention. By Ralph Arnold and Frederick G. Clapp. 8vo. 29 pp. U. S. Bureau of Mines, Technical Paper 38.

Petroleum: Production, Industry and Commerce. By L. Wenger. 8vo. Price, $1.25. A. Rousseau, Paris. (French.)

Petroleum, A Treatise on. By Boverton Redwood. Vol. 3. 3rd edition. 8vo. 1000 pp. Price, $12.50. C. Griffin & Co., London.

Producer-Gas Power Plant, The Commercial Trend of the, in the United States. By R. H. Fernald. 8vo. 93 pp. U. S. Bureau of Mines, Bulletin 55.

Radium (New Journal). 8vo. Monthly. About 14 pp. Began with April, 1913, number. The Radium Publishing Co., Pittsburgh. Forbes & Meyran Aves.

Rubber Tree. By W. F. de Bois Maclaren. 8vo. 300 pp. Price, $3.00. Maclaren & Sons, London.

Service Chemistry. By Vivian B. Lewes. 4th edition. Cr. 8vo. 576 pp. Price, $4.20. Longmans, Green & Co., New York.

Sewage: Trade Waste Waters and their Nature and Disposal. By J. Maclean Wilson and H. T. Calvert. 8vo. 331 pp. Price, $5.00. J. B. Lippincott Co., New York.

Steel, Standard Specifications for. By Committee on Standard Specifications. 8vo. Price, $1.50. American Society for Testing Materials, Philadelphia.

Textiles, The Vegetable. By J. Beauverie. 8vo. 290 pp. Price, $4.50. Gauthier-Villars, Paris. (French.)

Tin Working, The Technic of. By F. Georgi and A. Schubert. 8vo. 160 pp. Price, $1.25. M. Jaenecke, Leipzig. (German.)

Waters and Water Supplies, The Examination of. By John C. Thresh. 2nd edition. 8vo. 644 pp. Price, $4.50. J. & A. Churchill, London.

Water Supplies, The Purification of Public. By George A. Johnson. 8vo. 84 pp. U. S. Geological Survey, Water Supply Paper 315.

Zinc and Cadmium and their Production from Ores and By-products. By R. G. Max Liebig. 8vo. Price, $7.50. Otto Spamer, Leipzig.

RECENT JOURNAL ARTICLES

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Alkaloid Silicotungstates. By Harold R. Jensen. Pharmaceutical Journal, Vol. 90, 1913, No. 2586, pp. 658–660.

Barite, The Technical Manufacture of. By L. Marino and D. Danesi. Gazzetta Chimica Italiana, Vol. 43, I, 1913, No. 5, pp. 416–439.

Catalysis by Oxidation and Reduction. By H. Heinrich Francke. Zeitschrift fuer angewandte Chemie, 26 Aufsatzteil, 1913, No. 43, pp. 313–316.

Copper, The Sulfid Ores of. By L. C. Graton and Joseph Murdoch. Bulletin of the American Institute of Mining Engineers, 1913, No. 77, pp. 741–811.

Dyes, Vat, Their Uses, Properties and Methods of Applications. Anonymous. Textile Colorist, Vol. 35, 1913, No. 413, pp. 113–138.

Efficiency Bibliography. By N. H. B. Meyer, Bibliographer of the Library of Congress. May issue of Special Libraries. Nearly 1200 titles. Price, $0.25. Special Libraries Association, 93 Broad St., Boston.

Ethyl Alcohol, New Method of Determining. By Geo. B. Frankforter and Francis C. Frary. Journal of Physical Chemistry, Vol. 17, 1913, No. 5, pp. 402–473.

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Furnaces, Some Fundamental Faults of Present-Day, and their Remedies. By Alleyne Reynolds. Engineering, Vol. 95, 1913, No. 2471, pp. 646–651.

Gas Engines and their Applications. By William H. Edmondson. The Gas Age, Vol. 31, 1913, No. 11, pp. 551–555.

Gas, Some Notes on Carbonization. By Ernest A. Franks. Journal of Gas Lighting, Vol. 122, 1913, No. 2612, pp. 667–669.

Heating Apparatus, Electric, for Laboratories. By Charles Fribourg. International Sugar Journal, Vol. 15, 1913, No. 173, pp. 219–222.

Lipochromes, or Fat-Soluble Coloring Matters of Natural Origin, Recent Advances in the Chemistry of. By G. W. Monier-Williams. Chemical World, Vol. 2, 1913, No. 6, pp. 179–181.

Nitrogen, The Fixation of, by Mixtures of Barium Oxid and Charcoal. By Thomas Ewan. Journal of the Society of Chemical Industry, Vol. 32, 1913, No. 9, pp. 467–474.

Oil Analysis, Methods of. By Charles Eachus. Journal of the American Leather Chemists' Association, Vol. 8, 1913, No. 6, pp. 237–243.

Paints, Leadless, Lead and Zinc Pigments Compared. By R. Claude Bussell. Paint, Oil & Drug Review, Vol. 55, 1913, No. 23, pp. 10–13.

Precipitation, Electrical, of Suspended Particles. By Linn Bradley. Proceedings of the Engineers' Society of Western Pennsylvania, Vol. 29, 1913, No. 3, pp. 111–134.

Rubber Solutions, Determination of the Degree of Viscosity of. By P. Schidrowitz and H. A. Goldsbrough. India Rubber Journal, Vol. 45, 1913, No. 17, pp. 16–17.

RECENT INVENTIONS

By C. L. PARKER, Solicitor of Chemical Patents, McGill Building, Washington, D. C.

Portland Cement. T. A. Edison, April 22, 1913. U. S. Patent 1,059,661. This is a process intended for use in making Portland cement in localities where the conditions as to raw material are unfavorable for working by the usual methods.

The cement-making material with coal or coke in the proper amount to effect the fusion are introduced into the water-jacketed furnace 1. Quartz may be employed as the source of silica and clay as the source of alumina. A small percentage of oxid of iron is employed as well as limestone to permit fusion at a low temperature. The temperature necessary for fusion is from 1800° to a little below 2500° F. and there is produced an extremely liquid, non-viscid slag containing approximately 50% of lime. This is subjected to a powerful blast which chills and finely subdivides it. To this, sufficient limestone is added to give the proportion of lime desired for the cement and the mixture is then calcined.
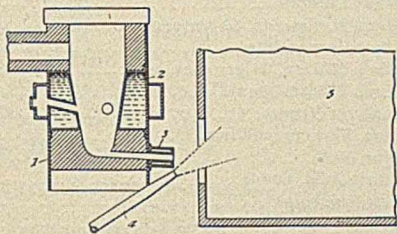
Potash and Cement Clinker. S. Gelléri, April 8, 1913. U. S. Patent 1,058,686. Silicates containing alkali metal compounds are burned with a salt of an alkaline earth metal. The residue is subjected to the action of ammonium carbonate vapors under high pressure in a closed chamber to render the alkali soluble. The alkalies are then leached out and the residue again burned.
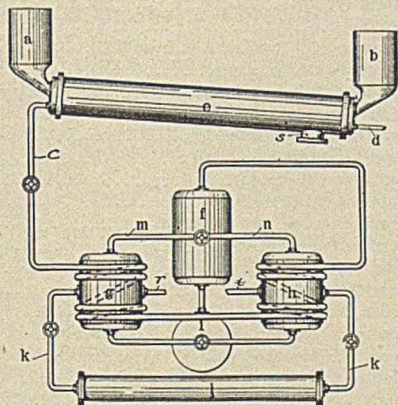
Persulfates. G. Adolph and A. Pietzsch, April 22, 1913. U. S. Patent 1,059,809. A bath containing ammonium sulfate and undissolved potassium sulfate is subjected to electrolysis, fresh supplies of solid potassium sulfate being added from time to time to reconvert the persulfate of ammonium produced into the sulfate.

Aluminium Nitrid. O. Serpek, April 29, 1913. U. S. Patent 1,060,509. In this process aluminium nitrid is produced by heating alumina and carbon in a current of nitrogen in a stationary furnace. The heating is effected by means of electrical resistance, the nitrogen being supplied in the immediate neighborhood of the resistance and forming a cavity between the resistance and the nitrid produced.
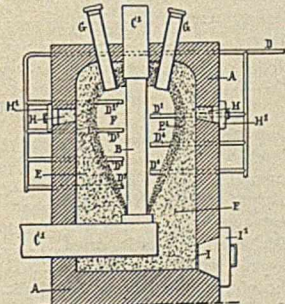
Catalyzer for Hydrogenating Oils and the Like. C. Ellis, May 6, 1913. U. S. Pat. 1,060,673. The material consists of finely granular active charcoal coated but not substantially impregnated with reduced nickel.

Automatic Gas-Analyzer. A. Mertens, May 6, 1913. U. S. Pat. 1,060,996. This apparatus is particularly designed for measuring the percentage of carbonic acid in the products of combustion of a furnace. In the illustration, a indicates the smoke flue which is connected by a pipe, b, having a dust filter, c, with a gas measuring chamber, d, which is in turn connected with a gas-absorbing chamber, f, by pipe e.

The suction of the gas into the measuring vessel d is effected by the automatic emptying of the gas-measuring vessel through the medium of the siphon g. The forcing of the gas into the absorber f is effected through the feeding of the vessel d with water conducted from a receptacle, h, through pipe i. This operation is entirely automatic, the liquid flowing from the receptacle h into the vessel d until the moment when the siphon g automatically fills and causes the rapid emptying of the vessel d, which emptying is accompanied by a suction of gas which
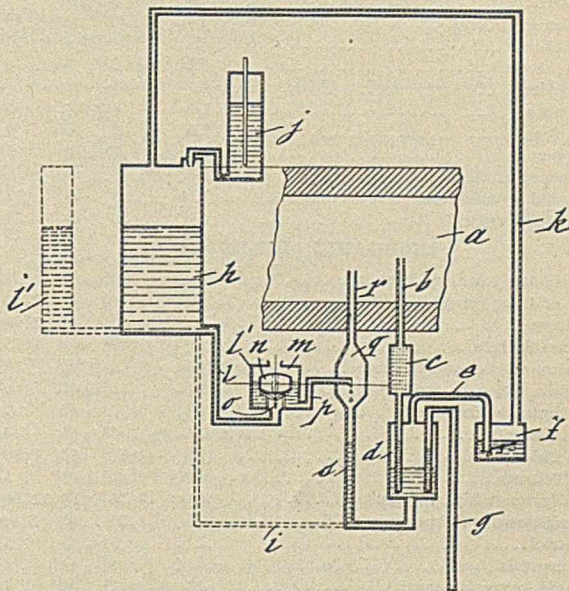
stops when the siphon empties itself and the forcing of the gas sucked in recommences by a fresh arrival of liquid from the receptacle h.

The receptacle h is a closed vessel connected to a Mariotte bottle, j, regulated so as to cause the flow of a certain quantity of liquid from the receptacle h directly a depression is produced therein. Moreover, the absorber f is connected by a pipe, k, to the receptacle h so that the non-absorbed gas is forced into the receptacle h. The Mariotte bottle j, as well as the receptacle h, is provided with a graduation allowing of easily ascertaining the volumes of liquid which have flowed therefrom. Consequently when, at the end of a given time, it is desired to learn the mean proportion of carbonic acid contained in the products of combustion it is only necessary to take note of the quantity of liquid which has run from the Mariotte bottle j as well as the quantity of liquid which has run from the receptacle h. This latter quantity is easily determined by adding to the volume V indicated by the graduation as having flowed from the receptacle h, the volume v of the liquid which has flowed from the Mariotte bottle j. The ratio $v/(V + v)$ then immediately gives the proportion of the gas absorbed with relation to the total quantity of gas treated.

The apparatus is also provided with means which may be used if desired, to cause the volume of gas analyzed in any period of time to vary with the draft of the flue.

MARKET REPORT

AVERAGE WHOLESALE PRICES OF STANDARD CHEMICALS, ETC., FOR THE MONTH OF JUNE, 1913

ORGANIC CHEMICALS

Item	Unit	Low		High
Acetanilid	Lb.	21	@	23
Acetic Acid (28 per cent)	C.	2.00	@	2.15
Acetone (drums)	Lb.	15¾	@	16
Alcohol, denatured (180 proof)	Gal.	37	@	39
Alcohol, grain (188 proof)	Gal.	2.46	@	2.48
Alcohol, wood (95 per cent)	Gal.	49	@	52
Amyl Acetate	Gal.	2.35	@	2.55
Aniline Oil	Lb.	10⅛	@	10⅝
Benzoic Acid	Lb.	23	@	27
Benzol (90 per cent)	Gal.	21	@	23
Camphor (refined in bulk)	Lb.	42½	@	44
Carbolic Acid (drums)	Lb.	12	@	14½
Carbon Bisulfide	Lb.	6½	@	8
Carbon Tetrachloride (drums)	Lb.	8	@	8½
Chloroform	Lb.	25	@	35
Citric Acid (domestic), crystals	Lb.	41½	@	42½
Dextrine (corn)	C.	2.80	@	3.40
Dextrine (imported potato)	Lb.	6	@	7
Ether (U. S. P., 1900)	Lb.	14	@	20
Formaldehyde	Lb.	8½	@	9½
Glycerine (dynamite)	Lb.	19	@	19½
Oxalic Acid	Lb.	7⅞	@	8
Pyrogallic Acid (bulk)	Lb.	1.20	@	1.40
Salicylic Acid	Lb.	29	@	31
Starch (cassava)	Lb.	3¼	@	4
Starch (corn)	C.	2.02	/	2.50
Starch (potato)	Lb.	4¼	@	5
Starch (rice)	Lb.	8	@	9
Starch (sago)	Lb.	2⅜	@	2¾
Starch (wheat)	Lb.	5	@	6¼
Tannic Acid (commercial)	Lb.	35	@	35
Tartaric Acid, crystals	Lb.	30¼	@	31

INORGANIC CHEMICALS

Item	Unit	Low		High
Acetate of Lead (brown, broken)	Lb.	7¾	@	8
Acetate of Lime (gray)	C.	2.50	@	2.60
Alum (lump)	C.	1.75	@	2.00
Aluminum Sulfate	C.	1.40	@	1.75
Ammonium Carbonate, domestic	Lb.	8	@	8½
Ammonium Chloride, gray	Lb.	6¼	@	6½
Aqua Ammonia (drums) 16°	Lb.	2¼	@	2½
Arsenic, white	Lb.	3⅜	@	4
Barium Chloride	C.	1.70	@	1.80
Barium Nitrate	Lb.	5¼	@	5½
Barytes (prime white, foreign)	Ton	18.50	@	22.50
Bleaching Powder (35 per cent)	C.	1.25	@	1.40
Blue Vitriol	Lb.	5¼	@	5½
Borax, crystals (bags)	Lb.	3¾	@	4¼
Boric Acid, crystals (powd.)	Lb.	7	@	7½
Brimstone (crude, domestic)	Ton	22.00	@	22.50
Bromine, bulk	Lb.	30	@	35
Calcium Chloride, fused	C.	85	@	1.10
Chalk (light precipitated)	Lb.	4	@	5
China Clay (imported)	Ton	11.50	@	18.00
Feldspar	Ton	7.00	@	9.00
Fuller's Earth, powdered, Foreign	Ton	14.50	@	15.00
Green Vitriol (bulk)	C.	55	@	60
Hydrochloric Acid (18°)	C.	1.15	@	1.55
Iodine (resublimed)	Lb.	3.05	@	3.10
Lead Nitrate	Lb.	8⅛	@	8¼
Litharge (American)	Lb.	6½	@	7
Lithium Carbonate	Lb.	65	@	70
Magnesia (powdered)	Lb.	5½	@	6
Magnesite (raw)	Ton	30.00	@	31.00
Nitric Acid, 36°	Lb.	3⅞	@	4¼
Phosphoric Acid (sp. gr. 1.75)	Lb.	21½	@	25½
Phosphorus	Lb.	35	@	90
Plaster of Paris	Bbl.	1.50	@	1.70
Potassium Bichromate, 50°	Lb.	6¾	@	7
Potassium Bromide	Lb.	39	@	40
Potassium Carbonate (calcined) 80 @ 85%	C.	3.40	@	3.65
Potassium Chlorate, crystals	Lb.	8¼	@	9¾
Potassium Cyanide (bulk) 98–99%	Lb.	19	@	24
Potassium Hydroxide	C.	3.75	@	4.75
Potassium Iodide (bulk)	Lb.	2.60	@	2.65
Potassium Nitrate (crude)	Lb.	5	@	—
Potassium Permanganate (bulk)	Lb.	9¾	@	11
Quicksilver, Flask		40.00	@	—
Red Lead (American)	Lb.	6½	@	7
Salt Cake (glass-makers')	C.	55	@	65

Item	Unit	Low		High
Silver Nitrate	Oz.	37¾	@	39
Soapstone in bags	Ton	10.00	@	12.00
Soda Ash (48 per cent)	C.	65	@	70
Sodium Acetate	Lb.	4	@	4½
Sodium Bicarbonate (domestic)	Lb.	1	@	1½
Sodium Bicarbonate (English)	Lb.	2¾	@	3
Sodium Bichromate	Lb.	4½	@	4⅞
Sodium Carbonate (dry)	Lb.	60	@	80
Sodium Chlorate	Lb.	8¼	@	9½
Sodium Hydroxide, 60 per cent	C.	1.57½	@	1.62½
Sodium Hyposulfite	C.	1.30	@	1.60
Sodium Nitrate, 95 per cent, spot	C.	2.40	@	2.45
Sodium Silicate (liquid)	C.	65	@	1.50
Strontium Nitrate	Lb.	6⅞	@	7⅝
Sulfur, Flowers (sublimed)	C.	2.20	@	2.60
Sulfur, Roll	C.	1.85	@	2.15
Sulfuric Acid, 60° B	C.	85	@	1.00
Talc (American)	Ton	15.00	@	20.00
Terra Alba (American), No. 1	C.	75	@	80
Tin Bichloride (50°)	Lb.	14¼	@	14½
Tin Oxide	Lb.	48	@	50
White Lead (American, dry)	Lb.	5¼	@	6
Zinc Carbonate	Lb.	10½	@	11½
Zinc Chloride (granulated)	Lb.	4½	@	5
Zinc Oxide (American process)	Lb.	5⅜	@	6⅜
Zinc Sulfate	Lb.	2½	@	2¾

OILS, WAXES, ETC.

Item	Unit	Low		High
Beeswax (pure white)	Lb.	42	@	45
Black Mineral Oil, 29 gravity	Gal.	13½	@	14
Castor Oil (No. 3)	Lb.	8⅞	@	10
Ceresin (yellow)	Lb.	12	@	22
Corn Oil	C.	5.70	@	6.00
Cottonseed Oil (crude), f. o. b. mill	Gal.	47	@	—
Cottonseed Oil (p. s. y.)	Lb.	7⅝	@	7⅞
Cylinder Oil (light, filtered)	Gal.	21½	@	32
Japan Wax	Lb.	9⅛	@	9¾
Lard Oil (prime winter)	Gal.	94	@	98
Linseed Oil (double-boiled)	Gal.	48	@	49
Menhaden Oil (crude)	Gal.	27	@	28
Neatsfoot Oil (20°)	Gal.	98	@	1.10
Paraffine (crude, 120 & 122 m. p.)	Lb.	3½	@	3¾
Paraffine Oil (high viscosity)	Gal.	26	@	28
Rosin ("F" grade)	Bbl.	4.80	@	5.00
Rosin Oil (first run)	Gal.	30	@	34
Shellac, T. N.	Lb.	21	@	22
Spermaceti (cake)	Lb.	30	@	35
Sperm Oil (bleached winter), 38°	Gal.	72	@	74
Spindle Oil, No. 200	Gal.	18	@	19
Stearic Acid (double-pressed)	Lb.	9½	@	10
Tallow (acidless)	Gal.	64	@	67
Tar Oil (distilled)	Gal.	30	@	31
Turpentine (spirits of)	Gal.	39½	@	40

METALS

Item	Unit	Low		High
Aluminum (No. 1 ingots)	Lb.	24½	@	25
Antimony (Hallet's)	Lb.	8¼	@	8¾
Bismuth (New York)	Lb.	2.10	@	2.15
Bronze powder	Lb.	50	@	3.00
Copper (electrolytic)	Lb.	14¾	@	15
Copper (lake)	Lb.	14⅞	@	15⅛
Lead, N. Y.	Lb.	4.32½		
Nickel	Lb.	50	@	55
Platinum (refined)	Oz.	46.00	@	—
Silver	Oz.	58⅜	@	60
Tin	Lb.	45.10	@	46
Zinc	Lb.	5.10	@	5⅛

FERTILIZER MATERIALS

Item	Unit	Low		High
Ammonium Sulfate	C.	2.95	@	3.00
Blood, dried	Unit	2.85	@	—
Bone, 4½ and 50, ground, raw	Ton	27.50	@	28.00
Calcium Nitrate (Norwegian)	C.	2.40		
Castor meal	Unit	nominal		
Fish Scrap, domestic, dried	Unit	nominal		
Mowrah meal	Ton	nominal		
Phosphate, acid, 16 per cent bulk	Ton	7.00	@	7.50
Phosphate rock; f. o. b. mine:				
Florida land pebble, 68 per cent	Ton	3.00	@	3.25
Tennessee, 70–80 per cent	Ton	5.00	@	5.50
Potassium, "muriate," basis 80 per cent	Ton	38.55	@	
Pyrites, furnace size, imported	Unit	0.13½		
Tankage, high-grade	Unit	2.75	&	10