the glass vessel, if of sufficient concentration, as was the case with new glass apparatus, and in this respect this colloid is like many others, such as platinum and silica.

The ease with which the soluble iron salt is decomposed by heat was well shown in the glass tube connecting the condenser and boiler, the return pipe of the above experiment. Above the stopper of the flask, where this tube was fairly cool, the glass remained clear, but below the stopper where the tube was heated by the steam of the flask, it was covered deeply with a black deposit, probably ferrous oxide. The deposition of this substance at this part of the return tube, commenced almost immediately on starting the experiment.

An experiment carried out in this way where pure water and carbon dioxide were used, where analysis showed the gaseous mixture to contain 11 per cent. carbon dioxide, produced such rapid corrosion of the iron that within a few days nearly a third of the exposed surface had been eaten away to depths of several hundredths of an inch, at which rate an ordinary pipe would not last more than a few months. It is not surprising that carbonic acid should dissolve iron under these conditions, but the fact that this corrosive action is a cyclic one, in which under suitable circumstances even a trace of carbonic acid may dissolve an unlimited quantity of iron without losing its corrosive power, has not received sufficient attention.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

A PROPOSED METHOD OF TESTING WOOD TREATED TO RESIST FIRE.

BY CHAS. F. MCKENNA.

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In the spring of 1902 an effort was made by the Bureau of Buildings of the Borough of Manhattan, New York City, to secure more certitude as to the qualities of the so-called fireproof wood which was being delivered in the city for use in high buildings.

Methods of test which have been in vogue for some time in the Bureau of Buildings were stated to be inadequate for the proper discrimination between well-treated wood and that which was

treated only imperfectly and was presumably at times not fireproof in any sense. These methods included the test, long in use in the Navy Department, of exposing shavings to the influence of heat while they rested upon a wire screen, timing the rate of combustion, as well as estimating its extent; also the splinter test as practiced in the simple expedient of holding a splinter of wood in and across the flame of a Bunsen burner or upon a red-hot iron plate; also, what may be called the cob-work test, by which prisms of wood about 6 inches long and 1 inch, more or less, square, are piled with air-spaces between them and exposed to the flame of a Bunsen burner. There was finally the more meritorious test of Professor Woolson, of Columbia University, which he calls the timber test, in which specimens of wood 1 inch square and 1 foot long are laid in pairs across the top of a 6-inch gas furnace and exposed to a presumably constant temperature of 1700° F. The depth to which the specimens were charred was subsequently measured and the unburned area used as a basis of comparison.

The fundamental fault with all of these methods of test lies in their neglect of the chemical factors involved in the decomposition of wood under the influence of heat. Nor were proper attempts made to standardize the conditions governing the application of the flame, the access of the air, and the surrounding temperatures, etc. Again, no instrumental means of registering the differences in the results obtained were suggested. In the timber test, the accurate measure of the unburned area does not answer this need, and fails of its purpose where the conditions during the test have so varied.

In the course of the discussion upon this subject which took place about the time mentioned in New York City, there was found to be a demand for an "inspector's test"; that is, for an instrumental and simple test giving results measurable and free from guess and which could be carried on at the place of delivery of the timber. The writer approached this subject from the chemist's side, and his first effort was to undertake distillation tests in closed retorts.

Inasmuch as it was early admitted that these fire-proofing processes could not prevent the destruction of wood by fire operating under its worst aspects but could only stay the disintegrating effects long enough to present the hope of gaining some advantage over the demon, it seems strange that the search for

this test did not then take the form of a study of the reactions proceeding during the inflammation and combustion of the wood, as well as of those accompanying its destructive distillation for the purpose of finding facts leading to more certain means of measuring the retarding values of the various treatments to which wood is subjected for this purpose. The writer outlined such a study by means of destructive distillation of samples of natural and of treated woods; for, although combustion and inflammation with free access of air are undoubtedly the most common conditions of a conflagration, yet the breaking down of the cellulose molecule, of the fundamental tissues of the wood, as well as of its allied organic and mineral constituents, takes place from the center of large masses as a distillation without air, just as it does also when timber and planking burn at the back of a hot brick wall, or within a metal-cased door or window frame, or where electric wiring passes over wood encased in concrete flooring or in walls. The prosecution of such studies has been stayed through lack of means, but the initial efforts nevertheless have resulted in this proposed method of testing which, with the apparatus offered, seems to be the means for easily making an extended series of critical observations.

Some early distillations made upon charges of wood shavings in 6-ounce glass retorts heated by a triple Bunsen burner developed the fact that when the temperature reaches 250° C. the volatile products cease to be driven off and temporarily a vacuum is produced if the heat is not promptly raised. This took place in every case in not over three minutes of such heat conditions, and also, under the same conditions, the yield of gas was quite uniform for different woods. To secure higher temperatures in a brief time, the electric wire method was adopted. This led to the invention of an electric test retort, and this in turn, when tried on numerous lots of wood, quickly developed the fact that the little instrument was exactly adapted to meet all the requirements of an inspector's test when the original untreated wood is at hand to compare with the treated, and perhaps also where original samples cannot be obtained. This apparatus is described in my paper presented at this meeting under the title "Electric Test Retort."

In using it for the study of fire-proof wood, it has been my aim to simplify it, as well as the details of the testing, in order that

numerous samples of wood could be examined easily and quickly.

A large gas burette was provided, having with it a large reservoir for leveling, and this in connection with the electric test retort were all that I found necessary for making critical tests of treated woods. Absorption tubes for the pyroligneous products could be provided, but in the work in hand the necessity was obviated as much as possible by the high initial heat and by providing that the water in the gas burette shall absorb the pyroligneous products until nearly saturated with them.

Violette, as quoted by Sadtler[1] in studies devoted to distillation of wood, found that when it is *slowly heated* the water and pyroligneous acids, alcohols, and creosote are all driven off up to and at 280° C. to the extent of 63.8 per cent. of the original weight; a large volume of gas up to and at 350° C.; and up to and at 430° C. a total loss of weight of 81 per cent. is experienced. But *quickly heated* wood placed at once in the retort at 432° C. lost 91 per cent. Senff,[2] in distilling a variety of woods in 100 kg. charges, found that the uncondensed gases in slowly heated samples varied from 17.17 per cent. to 29.23 per cent. with an average of 22.64 per cent. for fifteen examples of different woods; the uncondensed gases resulting from quickly heated samples varied from 24.07 per cent. to 35.56 per cent., with an average for fifteen samples of 31.50 per cent. He found that the charcoal varied from 23.23 per cent. to 34.68 per cent, with an average of 27.59 per cent. in slowly heated samples, and from 20.20 per cent. to 31.59 per cent., with an average of 23.09 per cent., in quickly heated samples. He also found the very important fact that the more common woods, as oak, beech, birch, poplar, and pine, show by the results of the destructive distillation that they resemble one another very much in fundamental composition and give like results in the yield of the respective products.

Hence, we should have in the electric test retort an opportunity to heat quickly to the highest temperature, thus obtaining the maximum gas yield. Fortunately, also, in this test retort, it is not strictly a distillation without access of air; it is really, in a small way, quite a perfect duplication of conditions existing at the beginning of a fire in a closed space, and we have also in this apparatus an opportunity to introduce air in measured quantities, if required.

[1] "Handbook of Industrial Organic Chemistry," second edition, p. 344.

[2] *Ber. d. chem. Ges.*, 18, 60.

In conducting the test, a small charge of wood, cut as a little cylinder about 0.5 inch long and 0.25 inch wide, weighing about 500 mg., is placed within the platinum wire basket, the dome is placed upon the apparatus and clamped tightly by suitable means, and the tube leading off from the dome is connected to the gas measuring burette having the usual reservoir tube attached. A current at a difference of potential of 120 volts and a strength of from 7 to 12 amperes is used. Great precautions are needed to keep the current strength steady, and a 7.5 ampere current is the best strength for this experiment. Tests made with the Le Chatelier pyrometer show that the temperature within the coil with a 7.5 ampere current is 680° C.; with a 10 ampere current the temperature rises at the end of three minutes to 840° C. The charge of wood is subjected to the effects of a current of 7.5 amperes for exactly two minutes, the gas being conducted to the burette. Observations of the glow, if any, and of the amount of smoke and the character of same, can all be made and recorded. At the close of the two-minute interval, the current is shut off, the gas burette stop-cock closed and air admitted to the retort by opening the tubulure at the side. The gas in the burette is cooled, and the volume measured. Or, if a series of tests are being made, the conditions of which are known and invariable, the volume could be read without correction, where so noted. So also, the correction for the volume of air increased by the heat of the contents of the retort can be neglected, for it will be found to be a very constant figure under uniform conditions. Thus, with some experiments in blanks, in heating without the charge with a 7 ampere current for two minutes the results were 23.6, 22.8, 22.8, 22.6, and 22.6 cc. With a 6.5 ampere current for two minutes, the results were 21.6, 21.6, and 21.6 cc. Other experiments gave, with a 7 ampere current for two minutes, 21 cc. average; with a 7.5 ampere current for two minutes, 24 cc. average; with an 8 ampere current for two minutes, 26.5 cc. average; and others with an 8 ampere current for two minutes, 26 cc. average.

The following experiments demonstrate that the gas yield and coal from the distillation of small pieces of some of the more common woods could be used as a criterion of the extent of retardation of fire caused by the proofing processes.

Spruce; 0.500 gram; fireproof; heated for two minutes by 9 ampere current:

	cc.
Gas yield.....	116.5
" "	124.5
" "	117.0
Average	119.3

The same wood leached in boiling water and dried to normal moisture:

	cc.
Gas yield.....	136.5
" "	129.0
" "	136.0
Average	133.8

Birch; 0.500 gram; 8 ampere current for two minutes:

	Gas yield.		
	Untreated. cc.		Treated. cc.
	164		151
	165		160
	171		162
	165		153
	167		...
Average,	166.4	Average,	156.5

The four specimens of char of the treated wood showed an average weight of 147.6 mg., and those of the untreated wood averaged 100 mg. The percentage of charcoal left in the treated wood was 29.5 per cent., and in the other 20 per cent.

With exercise of more care, similar experiments gave the following results:

Birch; 0.500 gram; 7 ampere current, 125 volts, two minutes:

	Gas yield.		
	Untreated. cc.		Treated. cc.
	125		95
	127		105
	124		105
	126		103
	126		108
	132		104
Average,	126.6	Average,	103.3

	Charcoal.		
	Untreated. Gr.		Treated. Gr.
	0.1037		0.1643
	0.1026		0.1540
	0.1065		0.1595
	0.1025		0.1700
	0.1062		0.1681
	0.1016		0.1661
Average,	0.03541	Average,	0.16366

The following experiment was performed with the assistance of one of the companies practicing the fire-proofing art: A sample of birch, of which I was given an initial untreated specimen, was fireproofed for me in a small test cylinder, using a solution of the density with which they were accustomed to operate on a large scale. Two solutions of less density by one-third and two-thirds of the dissolved salts were also prepared and used on specimens of the same wood on separate runs of the cylinder. I was thus provided with four specimens of wood of the same lot: the first, natural; the second, treated with a dilute solution; the third, with one more dense; and the fourth, with one most dense. These were numbered "0," "1," "2," and "3," respectively. In the test retort they gave the following results:

0.500 gram; 7 ampere current, 125 volts, two minutes:

	Gas yield.			
	"0" cc.	"1" cc.	"2" cc.	"3" cc.
	112	89	99	97
	108	92	97	95
	104	88	92	92
	107	87	99	93
	107	89	95	91
Average,	107.6	88.6	96.4	93.6

Average weight of the charcoal from each:

	Milligrams.	Per cent.
"0".....	103	20.6
"1".....	136	27.2
"2".....	120	24.0
"3".....	133	26.6

If the decomposition into gaseous products and coal measures the value of the treatment, the least dense solution gave the best result, which is probably true, as it was an alum process, and the

penetration of the cell-walls was probably more perfect with the most dilute solution.

Experiments with Yellow Pine, treated by another process and patent than the preceding. This yellow pine gave the following results (as there was no original stock offered, the "untreated" specimens were obtained from scraps of yellow pine in a carpenter shop):

0.500 gram; 8 ampere current, 125 volts, two minutes:

	Gas yield.	
	Untreated. cc.	Treated. cc.
	125	87
	131	86
	128	88
	133	86
	134	86
Average,	130.2	86.6

Average weight of four samples of charcoal:

Untreated.	Treated.
0.0979 gram or 19.58 per cent.	0.1912 gram or 38.24 per cent.

Yellow pine untreated:

(*a*) Dried.

(*b*) With normal moisture, 7.1 per cent. more water than (*a*).

	Gas yield.	
	(*a*) cc.	(*b*) cc.
	139	128
	136	132
	143	134
Average,	136	131

Charcoal, average weight:

(*a*) Gram.	(*b*) Gram.
0.102	0.0963

Yellow pine, treated:

(*c*) Dried.

(*d*) With normal moisture, 3.6 per cent. more water than (*c*).

	Gas yield.	
	(*c*) cc.	(*d*) cc.
	90	92
	91	88
	89	88
	90	85
Average,	90	88

Charcoal, average weight:

(c)	(d)
Gram.	Gram.
0.198	0.1882

Three questions arise: Will not errors be introduced by the moisture of the wood? This is to be met in the same way as in previous methods of test; namely, by the preparation of dried samples subsequently exposed for the absorption of the normal amount of water. Whether it would vitiate the results obtained by inspectors having limited facilities for such work, will have to be determined. Are not the results modified by the superior density of the treated sample over the normal wood that contains no salts? Naturally this should be so in finding the weight of the char residue; but in all experiments it seems to be an unimportant quantity, and in some it would appear that the wood which is heavier from treatment with the dense solution of an inferior fireproofing salt will give a very large gas yield. Would not gases generated from the chemicals also modify the results? The only process where it possibly would, is in using ammonium salts or carbonates and proper provision should be made for the absorption of the gases as each case would require.

It would seem to me to be indicated by the preceding that the degree to which total decomposition without air can be inhibited by previous chemical treatment in wood subjected to a high heat can be definitely measured by subjecting small test pieces to distillation, that this test operation can be easily, quickly, and accurately performed in the small retort as shown, and that the number of such tests which can be made in a short time on small pieces is so great that a good average could be selected in chips from different parts, interior, exterior, etc., of lots of timber as delivered. It seems probable also that in the conditions surrounding experiments in such a retort, an equally accurate measure can be found of the resistance to inflammation of woods before and after treatment, with access of air.

I hope to continue such experiments in the future, if circumstances favor.