A STUDY OF LIQUIDS THAT WILL NOT ACT ON COPPER, NICKLE OR ZINC, BOILING BETWEEN 20° F and 400° F.

The subject of the boiling point of liquids and their action on metals opens a wide field in chemistry. Almost every chemist has made a study of the boiling point of liquids and some have devoted a large portion of their time to it. The boiling points, and some of the other peculiarities of liquids, are of interest in the construction of thermostatts. The specifications for liquids that could be used in the thermostatt manufactured by the Fulton Company are given by Mr. Fulton as follows:

List of all substances whose boiling points lie between 20° F and 400° F, and which possess the following qualities:

1st: Must not be subject to chemical change (i.e are stable) within a range of 50°F above the boiling point.

2nd: must not attack copper, zinc or nickle within a range of 50 degrees F above the boiling point.

The sources of the information contained in this thesis were, a Dictionary of Chemistry and the allied branches of other sciences by Henry Watts, edition of 1868, and Bloxam's Chemistry, organic and inorganic, edition of 1888 by Charles Bloxam.

The dictionary by Watts is complete on the subject and the knowledge of chemistry up to that time. It naturally contains a large quantity of substances that are not suitable for the list under consideration as compared with the small number of liquids that are suitable.

From the requirements of the thesis all solids and gasses are first eliminated, then all acids, for they are almost all of them active on all three of the metals. Then liquids with too high or too low boiling points are eliminated. Finally the list narrowed down to the liquids given that were gathered from a rather rapid perusal of the aulhorileis mentioned.

The boiling points given in Watts are, most of them quoted from either Dumas, a chemist of the French Academy of Science, or from Kopp, a noted German scientist, who made a special study of the boiling points of liquids. In a great many instances both chemists are quoted.

The process followed was to find a liquid with a boiling point within the range of 20° F and 400°F (-6.7°C and 204.4 °C) and then to investigate to see the probable action of the liquids on the three metals. A glance at the list shows that every substance contains carbon and hydrogen in different proportions, except water H_2O which does not contain carbon. The other elements that occur are oxygen and chlorine. The liquids that contain chlorine are liable to some extent, to attack the metals, since chlorine itself is active on them.

In testing the liquids the greatest difficulty was to obtain them, as the time was not allowed to order them from a distance or to make them. The ones that were obtainable were tested for thin action on the metals and the boiling point was noted, to see iff the liquid acted as it was described in the authority. There are two methods, described in Watts, to find the boiling point. The first one was the one used. The description is in the Dictionary, on page 84, Vol. III, as follows:

The boiling point of liquids being among their most characteristic properties, the determination of them becomes a very frequent and important operation in chemical research. The method recommended by Kopp, in order to insure as much accuracy as possible in these observations is as follows:

"The liquid to be examined is placed in a cylindrical glass vessel, containing a few scraps of freshly ignited platinum foil, the diameter of which, when the quantity of the liquid is small need not much exceed that of the bulb of the thermometer. The vessel is closed by a cork, through the center of which the thermometer is inserted in a way that it can be raised or lowered, so that the bulb may dip either into the liquid or merely into the vapor. It is generally advisable to give the thermometer the latter position, since, as will be seen by what follows, the temperature of the liquid may, under circumstances which not infrequently occur, rise somewhat above the true boiling point; but even in this case a thermometer in the vapor will show the real boiling point of the liquid; under nearly all circumstances the thermometer will stand lower in the vapor than it does in the liquid, if there is a mixture of two or more liquids of different boiling points instead of a homogeneous substance.

Through a second hole in the cork is inserted a glass tube, open at both ends and bent at right angles, as shown in the figure: by connecting this tube with a condenser the loss of the liquid used for the experiment may be prevented. The liquid is heated either by applying a small flame to the outside of the vessel or by means of a water or sand bath, care being taken that the sides of the vessel above the liquid do not become overheated. The indications of the thermometer are observed during the whole time that the liquid is being slowly boiled away."

The description of the second apparatus is given on page 940, Part II of the Third Supplement as follows:

"A simple apparatus for the exact determination of the boiling points of liquids is described by Berthelot. It consists of a long necked glass flask having a capacity of 100 to 200 cubic centimeters. The neck is inclosed in a wide glass tube, closed with two perforated corks; and the tube of the thermometer passes through both, while its bulb is wholly immersed in the vapor. The lower cork is also traversed by a bent tube, which serves to carry off the vapor to a condenser, and thus prevent any excess of pressure in the apparatus."

The testing was done by putting a small quantity of the liquid in a test tube with a piece of the metal, the action on which was to be tested. Then boiling, with the thermometer arranged as in the first description, down to dryness.

The flame was not applied directly to the test tube in any instance. In the case of those liquids with low boiling points, they were put in a warm bath of water without any flame present. Other liquids with higher boiling points were put in a boiling water bath. When the liquids were boiled to dryness the metal was taken out and distilled water was added. HCl was added to make a solution of any metal present. The acid solution was neutralized with ammonia in the case of zinc and nickle, but not in the test for copper. Then H_2S gas was passed through the aquous solution. If copper or nickle were present a black percipitant would result. If zinc were present a white percipitant would be percipitated with the H_2S gas.

The petroleum ether was boiled to dryness in a boiling water bath. There was a brown stain left after the liquid evaporated but no percipitant resulted from the tests on any of the three metals. The boiling point was about 174°F.

The benzine, a coal tar product, was boiled to dryness in a boiling water bath and no percipitant resulted from the tests of any of the three metals. The boiling point was 80°C.

The alcohol tested was the commercial alcohol. A brown stain resulted when it was boiled to dryness which discolored the solution, but no further percipitant or darkening of the color could be observed with the H_2S gas. The boiling point was about 80°C.

The ethel alcohol acted almost exactly as the other alcohol. the boiling point was higher, being 115°C.

The ethyl ether was boiled to dryness in a warm water bath. There was no effect, that could be found, on the metals, as the solution remained clear in all three tests. The boiling point is 34°C.

The benzyne, a petroleum product, was boiled to dryness over a bunsen flame with a wire gauze and a piece of asbestos in between. There was no percipitant from any of the three tests. The boiling point was 117°C.

The Acetone (C_3H_6O) was boiled to dryness in a boiling water bath. There was a good percipitant with the copper and nickle and a small one with the zinc. This was the only liquid tested that gave a percipitant. The boiling point was 56° C.

In Bloxam's Chemistry, Page 736, is given for a difference of one molecule of CH_2 a difference of 19.4°C in the boiling point of the liquid for paraffins and alchols, and a difference

of 26 degrees C in the boiling point of the ethers.

There is a list of mixtures of water and alchol with the boiling points corresponding to the percent of alchol present given in Watts and included in the list that follows. The boiling point seems to be very exact according to the percent of alchol present, as it is recommended by some chemists as a way to determine how great a percent of alchol is present. For use in a thermostatt the alchols do not seem to be very well fitted, for it would be almost an impossibility to keep the alchol from absorbing water and thereby changing the boiling point of the liquid.

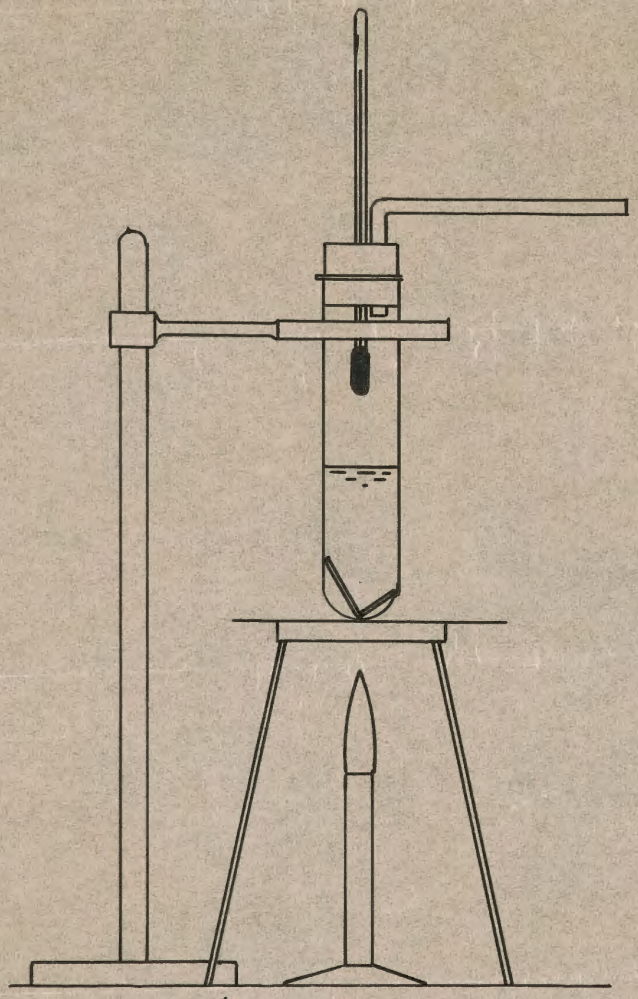
NAME	FORMULA	B.P. degrees C	Page, Vol.	REMARKS
Butane	C_4H_{10}	1		Paraffin
Methyl-ethylic	$CH_3OC_2H_5$	11	551 Bloxam	
Chloride of Ethyl	C_2H_5Cl	11	529 II Watts	
Crolonylene	C_4H_6	18	475 Bloxam	C_nH_{2n-2}
Ethylamine	C_2H_7N	18.7	555 II Watts	
Hydrid of Amyl	C_5H_2	30		
Ethylic Ether	$C_4H_{10}O$	34	551 Bloxam	Tested in Laboratory
Amylene	C_5H_{10}	35	473 Bloxam	
Formate of Methyl	$C_2H_4O_2$	36		
Mercaptan	C_2H_6S	36		
Valerleyne	C_5H_8	45	475 Bloxam	Keytone
Pentane	C_4H_{10}	38		Paraffin
Methyl-allyl	C_4H_8O	46	551 Bloxam	Ether
Methyl-propylic	$CH_3OC_3H_7$	50	" "	"
Acetate of Methyl	C_3H_6O	55		
Dimethyl	CH_3COCH_3	56	546 Bloxam	Keytone
Chloride of Ethylide	$C_2H_4Cl_2$	58	599 II Watts	
Allyl	C_3H_5	59		
Wood Spirits	CH_4O	59		
Ethyl-allyl	$C_2H_5OC_3H_5$	64	551 Bloxam	Ether
Hexane	C_6H_{14}	70		Paraffin
Hexylene	C_6H_{12}	70	473 Bloxam	Olefins C_nH_{2n}
Chomphorone	$C_{30}H_{44}O$	75	733 I Watts	

NAME	FORMULA	B.P. Degrees C.	Page.	Vol.	REMARKS
Alchol	C_2H_6O	78	97	I Watts	Tested in Laboratory
Benzene	C_6H_6	80			Tested in Laboratory
Ethyl-propargyl	$C_2H_5OC_3H_3$	80			
Hexoylene	C_6H_{10}	80	475	Bloxam	
Methyl-ether	$CH_3COC_2H_5$	81	546	"	Keytone
Allyl-ether	$C_3H_5OC_3H_5$	82	551	"	
Ethyl-allyl-ether	$C_5H_{10}O$	84			
Chloride of Ethylene	$C_2H_4Cl_2$	84	531	II Watts	
Ethyl-butylic	$C_2H_5OC_4A_9$	92	551	Bloxam	
Propylic-ether	$C_3H_7OC_3H_7$	86	"	"	
Ethyl-propylic	$C_2H_5OC_3H_7$	85	"	"	
Lactone	$C_5H_8O_2$	92	464	III Watts	
Butrate of Methyl	$C_5H_{10}O_2$	93			
Butyral	C_4H_8O	95	689	I Watts	Soluble in Water
Heptane	C_7H_{16}	99			Paraffin
Water	H_2O	100			
Heptylene	C_7H_{14}	100	473	Bloxam	Olofins
Propione	$C_2H_5OC_2H_5$	100	546	"	Keytone
Methyl-propyl	$CH_3COC_3H_7$	101	"	"	"
Glycol-ether	$C_2H_4O_2C_2H_4$	102	551	"	Ether
Valeraldehyde	$C_5H_{10}O$	101			
Tetryl	C_8H_{16}	108			
Butyrate of Ethyl	$C_6H_{12}O$	112			
Enonthylidene	C_7H_{12}	107	475	Bloxam	

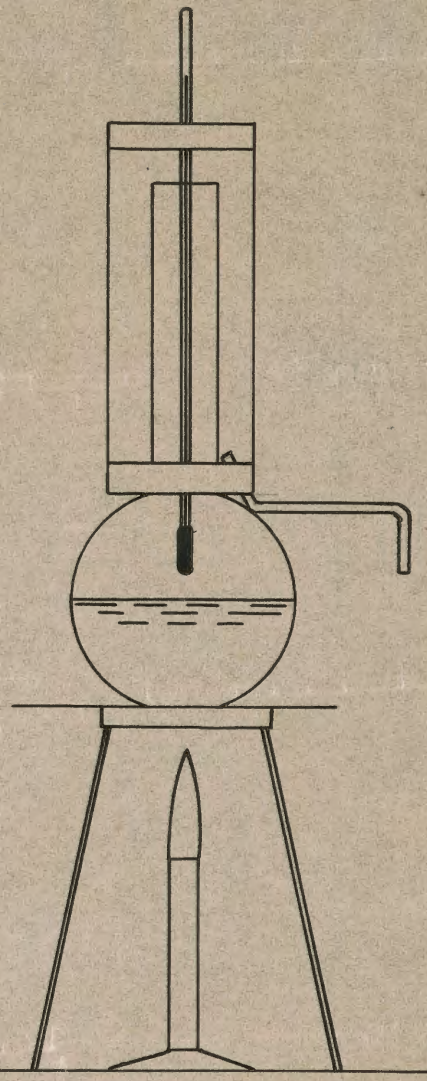
NAME	FORMULA	B.P. Degrees C.	Page, vol.	REMARKS
Tolvene	C_7H_8	114		
Amyl-allyl-ether		120		
Di-ethyl, glycol	$C_2H_4O(C_2H_5)_2$	124	551 Bloxam	Ether
Caprylene	C_8H_{16}	125	473 "	Olofin
Xylene	C_7H_{10}	126		
Carbonate of ethyl	$C_5H_{10}O_3$	126	800 I Watts	
Octane	C_8H_{18}	124		Paraffin
Methyl-butyl	$C_6H_{12}O_o$	127	551 Bloxam	Keytone
Monethyl-glycol	$C_2H_4O_2H_2C_2H_5$	127	" "	Ether
Propyl-ethyl	$C_3H_7COC_2H_5$	128	546 "	Keytone
Aloisol	$C_6H_8O_2$	130		
Acetate of amyl	$C_7H_{14}O_2$	131		
Caprylidene	C_8H_{14}	133	475 Bloxam	C_nH_{2n-2}
Cumene	C_9H_{12}	144		
Butyrone	$C_3H_7COC_3H_7$	144	546 "	Keytone
Xylene	C_8H_{10}	139	1056 V Watts	
Amylic Alchol	$C_5H_{12}O_2$	135	203 I Watts	
Nonane	C_9H_{10}	148	469 Bloxam	Paraffin
Diamyelene	$C_{10}H_{20}$	158	473 "	Olofin
Oil of Terpentyne	$C_{10}H_{16}$	160	921 V Watts	Changes in air
Oxolate of Methyl	$C_4H_6O_4$	162	1009 I Watts	
Methyl-amyl	$CH_3COC_5H_{11}$	155	546 Bloxam	Keytone
Caproate of Methyl	$C_6H_{11}(CH_3)O_2$	150	744 I Watts	

NAME	FORMULA	B.P. Degrees C	Page, Vol.	REMARKS
Caproate of Ethyl	$C_6H_{11}C_2H_5O_2$	162	744 I Watts	
Decenylene	$C_{10}H_{18}$	165	475 Bloxam	C_nH_{2n-2}
Decane	$C_{10}H_{22}$	168	469 "	Paraffin
Methyl-benzylic	$CH_3OC_7H_7$	168	551 "	
Cymene	$C_{10}H_{10}$	175		
Ethylate of Oetyl	$C_{10}H_{22}O$	177	542 II Watts	
Bitter Almond Oil	C_7H_6O	179	147 I Watts	Easily becomes rancid
Valerone	$C_4H_9COC_4H_9$	181	546 Bloxam	Keytone
Tri-ethyl glycerine	$C_3H_5O_3(C_2H_5)_3$	184	551 "	Ether
Ethyl-benzylic Ether	$C_9H_{12}O$	185	579 I Watts also 551 Bloxam	
Oxalate of Ethyl	$C_6H_{10}O_4$	186		
Valerate of Amyl	$C_{10}H_{20}O_2$	188		
Benzyne		117		Tested in Laboratory
Petroleum Ether	$(C_5H_{12}$ $)C_6H_{14}$	174	470 Bloxam	Tested in Laboratory
Ethyl Alcohol	C_2H_6O	115	491 Bloxam	Tested in Laboratory

% WATER	% ALCOHOL	B.P. °C
95	5	96.3
90	10	92.9
85	15	91.0
80	20	89.1
75	25	87.5
70	30	86.2
65	35	85.0
60	40	84.1
55	45	83.4
50	50	83.1
45	55	82.2
40	60	81.9
35	65	81.5
30	70	80.9
25	75	80.3
20	80	79.7
15	85	79.4
10	90	79.0
5	95	78.4



KOPP'S ARRANGEMENT
FOR FINDING THE BOILNG POINT



THE BERTHELOT ARRANGEMENT
FOR FINDING THE BOILING POINT