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Certain Physical and Chemical Properties of Methyl Chloride

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THIS paper summarizes the facts about this refrigerant in an interesting way, pertinent to the present uses which have developed for it in this field. The physical properties which concern the heat engineer are first given, followed by a survey of the chemical properties which are most likely to concern him. The basis of this material is experimental.

THE PHYSICAL PROPERTIES OF METHYL CHLORIDE[2]

THE rapid development of the fractional tonnage refrigerating machine has brought out the need of a refrigerant for this kind of work, one that will be safe when the machines are distributed among a class of persons who are ignorant of the refrigerating cycle and its possible dangers, one that operates with an air cooled condenser without excessive condenser pressures, disintegration, corrosion, etc., and one that will have only a nominal piston displacement per ton of refrigeration. The answer to these specifications to a lesser or greater extent has heretofore been sulphur dioxide, apparently because this refrigerant became firmly entrenched before others were investigated to any

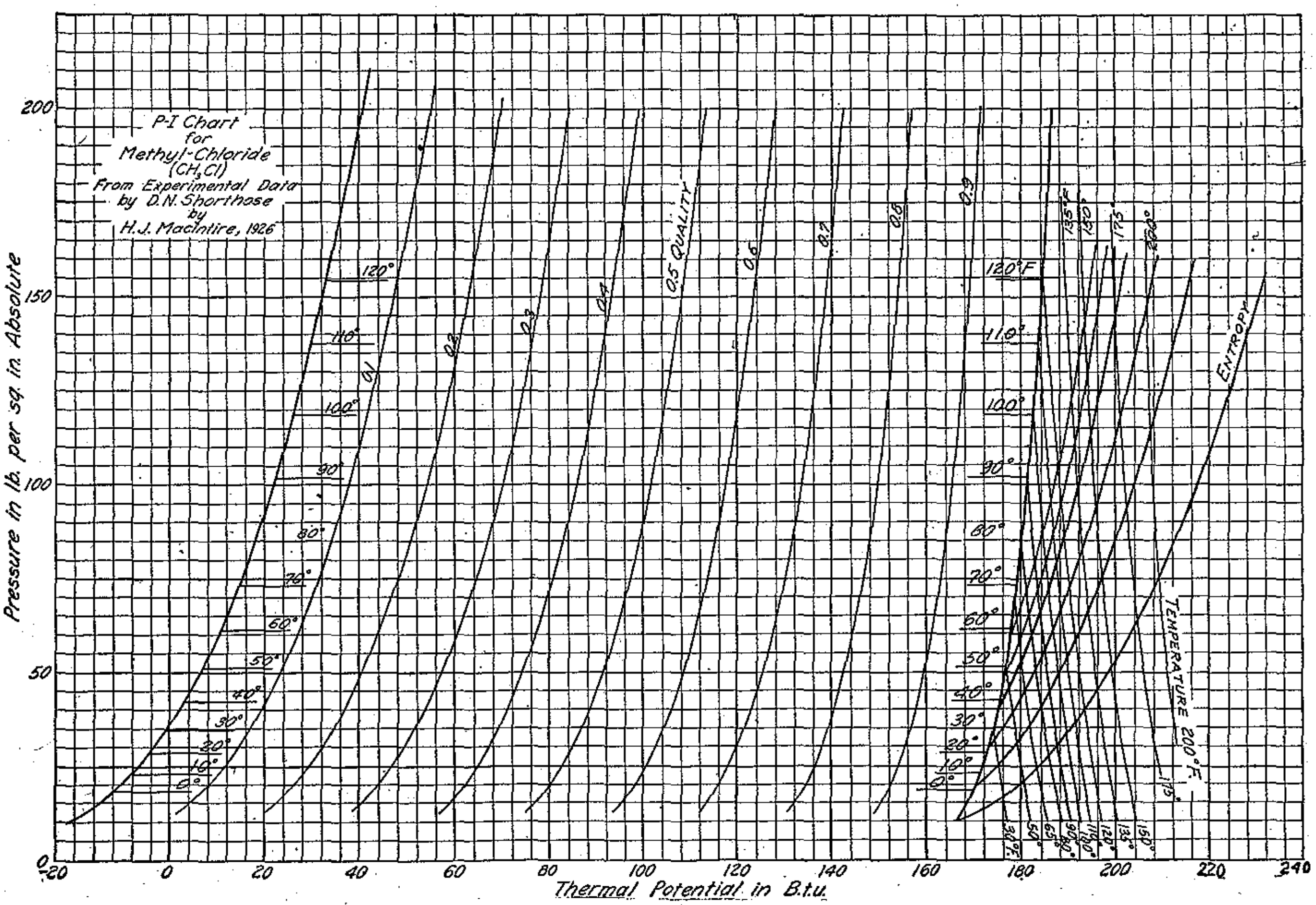

FIG 1 P—I CHART FOR METHYL CHLORIDE

TABLE I.

REFRIGERANT	Thermal potential of saturated vapor at 5° F. B. t. u.	Thermal potential of liquid at 86° F.	Net refrigeration per lb of refrigerant, B. t. u.	Sp. vol. of saturated vapor at 5° F., cu. ft.	Piston displacement per ton per min., cu. ft.	Pres. at 5° F., lb. per sq. in. abs.	Pres. at 86° F., lb. per sq. in. abs.	Piston displacement per ton per min. with that for CO_2 taken as unity.
Ammonia (NH_3)	613.3	138.8	474.4	8.15	3.44	34.3	169.3	4.3
Carbon dioxide (CO_2)	101.0	36.5	64.5	0.258	0.80	32.9	1045.0	1.0
Sulphur dioxide (SO_2)	183.5	42.1	141.4	6.42	9.08	11.8	66.45	11.34
Ethyl Chloride (C_2H_5Cl)	163.5	21.0	142.5	16.18	22.7	4.5	27.4	28.35
Methyl Chloride (CH_3Cl)	171.1	27.7	143.3	4.65	6.49	21.0	95.5	8.11
Butane (C_4H_{10})	165.4	16.0	149.4	10.0	13.4	11.0	42.9	16.75
Propane (C_3H_8)	159.8	17.8	142.0	2.4	3.38	43.9	159.0	4.22

extent. At the present time a number of engineers feel that other refrigerants are preferable to sulphur dioxide and so in the following the reasons for using other refrigerants, especially methyl chloride, will be given consideration, and in particular tests performed on the chemical properties of methyl chloride will be described and the results enumerated.

THE PISTON DISPLACEMENT

One of the important considerations in choosing a refrigerant is that of the piston displacement per unit of refrigeration, especially where space is limited as it frequently is with the fractional tonnage compressors. As a comparison Table I is a theoretical calculation of the piston displacement per ton of refrigeration per minute using 5° and 86° F. for the evaporating and the liquefaction temperatures respectively. The last column shows the displacement using the various refrigerants referred to that of carbon dioxide as unity, whereas the sixth and seventh columns show the suction and the condenser pressures for these operating temperatures. In this table the piston displacement per ton of refrigeration per minute using sulphur dioxide is 9.08 cu. ft. whereas that of methyl chloride is 6.49 so that a compressor using methyl chloride would have a capacity of nearly 50% more refrigeration than a similar one would have using sulphur dioxide. However the methyl chloride condenser pressure (as well as the suction pressure) would be considerably more than that of sulphur dioxide. In no case in temperate climates does the condenser pressure exceed 150 lb. if the condenser is an efficient one and the amount of air circulated through it is sufficient in amount.

CONDENSER PRESSURE

The fact that one refrigerant has a greater condenser pressure than another is of little moment except from the viewpoint of leaks. The work of compression in refrigeration using various refrigerants does vary slightly in amount per unit of refrigeration but the actual amount of this variation is hardly a factor worth mentioning except in the case of carbon dioxide. Where the pressures keep below 200 lb. the difficulty in keeping the system tight is a slight one if the kind of joint used is satisfactory. Small refrigerating machines, where service is frequently of considerable proportional expense, should be designed with short pipe connections, drop forged fittings and the tongue and groove flange. Under these conditions leaks will become a minimum if the condenser is tight and a suitable packing is used on the rod. The ability to detect a leak by the smell or preferably by some indicator—as is possible with ammonia and sulphur dioxide—is convenient but not essential if the design pemits an elimination of leaks. At present no convenient chemical can be used to detect methyl chloride. As will be shown later there is no disintegration of methyl chloride except at high temperatures, and the corrosion due to this refrigerant is as slight as it would be in the presence of other neutrals like benzene, even when such metals as zinc, lead and cast iron are present. Sulphur dioxide, however, corrodes badly in the presence of water so that the charge of refrigerant and the oil must be anhydrous for that reason. Methyl chloride will not mix with water and so if water is present it will freeze at the expansion valve, so that a suitable dehydrator using granulated calcium chloride should be in the pipe line until all danger due to water has been eliminated.

DANGER DUE THE REFRIGERANT

An ideal refrigerant should be a non-combustible or a non-explosive and it should have no bad effects to animal life. Sulphur dioxide is a non-combustible bus it is very painful to breathe even in small proportionl in the air. Its effect on people is more severe than is ammonia, whereas methyl chloride is not harmfuf unless a quantity, or a small amount for a considerable time, is inhaled. There is no particular effect due to methyl chloride should it happen that a large quantity be blown into one's face, provided no liquid is present. Occasionally stories have appeared of sickness caused by relatively small amounts of methyl chloride, due to breathing air in which methyl chloride was present due to leaks. Such accounts are without question occasioned by mixtures of methyl chloride and something else or to impurities in the gas. Methyl chloride will burn and with certain limited mixtures it will explode, but the danger due to this is very small.

A recent paper by H. M. Baker[7] indicates the effect of very high concentrations, of which the temporary effects are bad. No permanent injury from inhalation of the gas has been observed, however.

PHYSICAL PROPERTIES

The most complete experiments on the thermodynamic properties of methyl chloride are those by D. N. Shorthose[3]. These tables (Table II.) have been converted to English units by the author and a P-I diagram has been drawn Fig. 1.

[2] Section by H. J. Macintire, Associate Professor; Mechanical Engineering Dept.
[3] Report, No. 19, Food Investigation Board of Great Britain.
[4] Section by C. S. Marvel, Assistant Professor and Stanley G. Ford, Assistant Department of Chemistry.
[5] *Z. ges. Schiess. Sprengstoffw.* 6, 384; *Chem. Zent.* 1911, II, 1720; *C. A.* 6, 426 (1912).

II.

Chemical Properties of Methyl Chloride[4]

In considering methyl chloride as a refrigerant some properties which need to be known are its stability toward heat, its corrosive action on metals, its effect on the viscosity of oils, the effects of dissolved oils on its boiling point, its toxicity and the tendency of air and methyl chloride to form explosive mixtures. Certain of these properties have been investigated and are reported in the literature.

Saposhnikov[5] has studied various mixtures of air and methyl chloride and has shown that the limits of com-

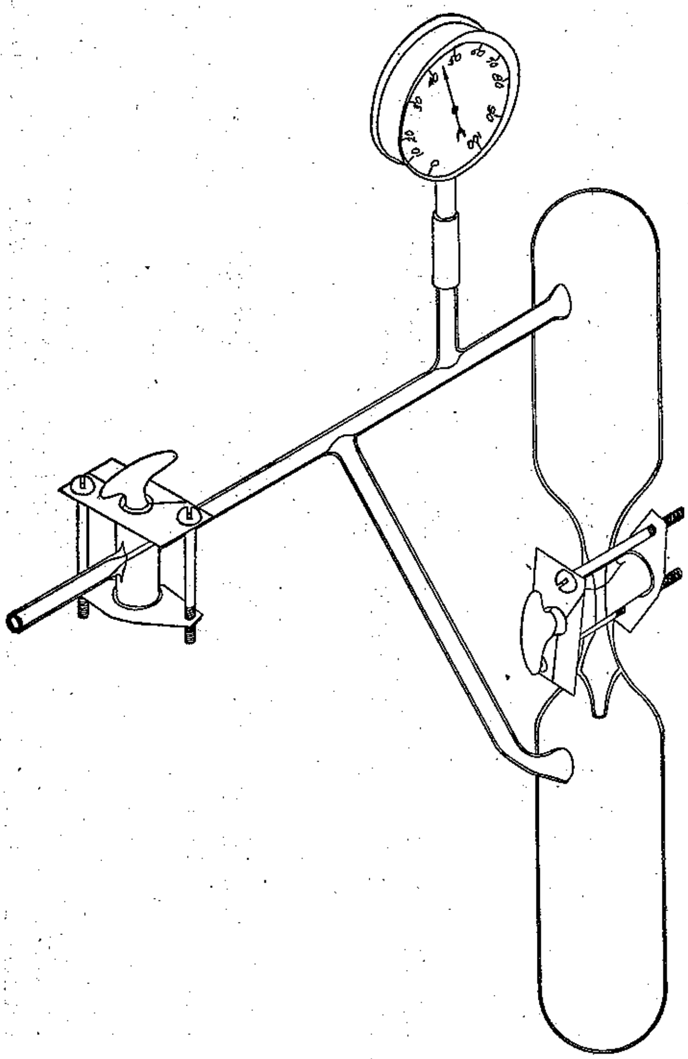

FIG. 2. APPARATUS LAYOUT FOR VISCOSITY TESTS

bustibility are 10 to 15% of methyl chloride in 85 to 90% of air. A flame is extinguished by an air-methyl chloride mixture containing 20% of the latter. An air-methyl chloride mixture containing 12% of the latter can sometimes be exploded by an electric spark but usually does not ignite with a flame.

Several investigators mention that methyl chloride is relatively non-poisonous. Regnauld and Villijean[6] report in some detail on this property. They found that when mixed with air, twice as much methyl chloride as chloroform is needed to produce insensibility and that when the test patient is removed from the exposure to the gas, consciousness returns almost at once. Other statements in the literature place its power of producing anesthesia at one-fourth that of chloroform.

The more important points of stability toward heat and metals have not been so completely studied. Dumas and Peligot[7] report that dry methyl chloride is completely decomposed into hydrocarbon gases, carbon and hydrogen chloride when it is passed through a porcelain tube heated to cherry redness. Very little further information concerning its stability toward heat has been published.

In order to determine more definitely the temperature at which methyl chloride begins to decompose when in contact with metals, a slow stream of the gas was passed through a heated glass tube on the floor of which were placed small plates of the metals commonly used in the construction of refrigerating machines. There is no indication of decomposition below 795 to 800° F. At this temperature decomposition begins and is quite noticeable at 925 to 930° F. This decomposition temperature is much too high to be any source of trouble in the use of methyl chloride in a refrigerating machine.

In order to test the corrosive action on metals, samples of methyl chloride and methyl chloride with ordinary lubricating oils were sealed in glass tubes with single samples of common metals and with several samples mixed in order to provide opportunity for galvanic action, and the tubes heated to about 165 or 175° F. for 24 to 48 hours. On opening the tubes and examining the samples of metal practically no corrosive effects could be determined.

In any form of compressor which might be needed in a refrigerating machine using methyl chloride, there would be an opportunity for the organic compound to come in contact with the lubricating oil used in the machine. As under pressure methyl chloride is very soluble in oil it is desirable to know its effect on the viscosity of an oil. This was determined by devising a viscosimeter in which oil and methyl chloride could be placed under known pressures and then the rate of flow through an orifice measured. All results obtained in this way are comparative since the orifice is not the same as that of standard viscosimeters. An oil with a viscosity of 476 Saybolt at 71.6° was used. The rate of flow of the oil through the orifice was determined at various temperatures and then methyl chloride was admitted until the pressure gauge indicated 30 lb. and the measurements were repeated. At the lower temperatures, 32° F., methyl chloride is quite soluble in the oil and greatly lowers its viscosity. At higher temperatures, 165 to 170° F., the effect is not very great since very little methyl chloride stays in solution at two atmospheres pressure.

Since oil and methyl chloride are miscible, some oil may be carried along with the refrigerant into the expansion chamber. This will have an effect on the boiling point of the liquid in the expansion chamber and thus will have some effect on the temperatures that can be reached in the refrigerator. Pure methyl chloride at ordinary pressures boils at −9.4° F. Addition of oil increases this temperature less than might be expected, since a mixture of 50% each of oil and methyl chloride boils at about −4° F.

A review then of the chemical properties of methyl chloride shows that it is very stable, non-corrosive, not easily inflammable and relatively non-toxic, and hence from the chemical standpoint should be very suitable for use as a refrigerant. In this work the question of hydrolysis was not considered as the conditions, as those of ordinary practice, were anhydrons.

[6] *Compt. rend.* 100, 1024 (1885); *J. Chem. Soc.* 48, 926 (1885).

[7] REFRIGERATING ENGINEERING, 14, 2, 84, August, 1927.

[7] *Ann. chim. phys.*(2) 58, 28 (1835).

TABLE III.
THERMODYNAMIC PROPERTIES OF METHYL CHLORIDE, (CH_3Cl)

SATURATED VAPOR

TEMP.	PRESSURE		VOLUME	DENSITY	HEAT CONTENT ABOVE 32° F.		
°F t	Abs. lb./in.² p	Gage lb./in.² $g\,p$	Vapor ft³/lb. V	Liquid lb./ft.³ $1/v$	Liquid Btu./lb. h	Latent Btu./lb. L	Vapor Btu./lb. H
−20	11.75	*6.1	8.09	63.185	−19.0	186.36	167.36
−18	12.50	*4.8	7.73	63.060	−18.25	185.92	167.67
−16	13.1	*3.2	7.38	62.935	−17.57	185.50	167.93
−14	13.75	*1.4	7.06	62.180	−16.81	185 07	168 26
−12	14.4	*0.8	6.75	62.685	−16.10	184 64	168 54
−10	15.0	0.3	6.46	62.560	−15.38	184.21	168.83
− 8	15.8	1.1	6.18	62.435	−14.68	183.78	169.10
− 6	16.5	1.8	5.92	62.310	−13.95	183.33	169.38
− 4	17.08	2.3	5.67	62.185	−13.20	182.90	169.70
− 2	17.9	3.2	5.41	62.061	−12.50	182.44	169.94
0	18.8	4.1	5.18	62.936	−11.75	181.98	170.23
+ 2	19.6	4.9	4.96	62.811	−11.0	181.52	170.52
4	20.5	5.8	4.75	61.686	−10.30	181.08	170.78
6	21.5	6.8	4.55	61.561	−9.55	180.60	170.05
8	22.4	7.7	4.36	61.436	−8.8	180.12	171 32
10	23.3	8.6	4.18	61.311	−8.06	179.65	171.59
12	24.4	9.7	4.02	61.187	−7.30	179.18	171.88
14	25 34	10.6	3.86	61.086	−6.62	178.70	172.08
16	26.5	11.8	3.70	60.959	−5.85	178.23	172.40
18	27.6	12.9	3.55	60.831	−5.10	177.75	172.65
20	28.8	14.1	3.41	60.702	−4.32	177.27	172.95
22	29.8	15.1	3.28	60.593	−3.60	176.80	173.20
24	31.2	16.5	3.15	60.464	−2.85	176.34	173.49
26	32.5	17.8	3.03	60.365	−2.10	175.87	173.77
28	33.8	19.1	2.92	60.206	−1.38	175.38	174.00
30	35.2	20.5	2.81	60.077	−0.62	174.90	174.28
32	36.57	21.8	2.69	59.914	+0.11	174.40	174.51
34	37.9	23.2	2.59	59.779	+0.87	173.92	174.79
36	39.5	24.8	2.49	59.650	+1.63	173.41	175.04
38	41.1	26.4	2.40	59.521	+2.40	172.91	175.31
40	42.6	27.9	2.31	59.492	+3.15	172.42	175.57
42	44.3	29.6	2.225	59.263	+3.90	171.92	175.82
44	46.1	31.4	2.14	59.134	+4.66	171.42	176.08
46	47.8	33.1	2.06	59.005	+5.41	170.90	176.31
48	49.6	34.9	1.99	[illegible]	+6.19	170.40	176.59
50	51.51	36.77	1.93	58.747	6.88	169.90	176.78
52	53.5	38.8	1.86	58.616	7.66	169.40	177.06
54	55.4	40.7	1.79	58.484	8.40	168.80	177.30
56	57.4	42.7	1.72	58.353	9.20	168.40	177.60
58	59.3	44.6	1.67	58.220	9.95	167.88	177.83
60	61.6	46.9	1.61	58.077	10.70	167.35	178.05
62	63.8	49.1	1.55	57.943	11.48	166.83	178.31
64	66.1	51.4	1.50	57.809	12.25	166.29	178.54
66	68.4	53.7	1.45	57.675	13.00	165.74	178.74
68	70.97	56.23	1.39	57.541	13.75	165.20	178 95
70	73.3	58.6	1.34	57.403	14.52	164.65	179.17
72	75.8	61.1	1.30	57.265	15.30	164.10	179.40
74	78.5	63.8	1.26	57.127	16.08	163.56	179.64
76	79.8	65.1	1.22	56.989	16.83	163.00	179 83
78	82.5	67.8	1.17	56.851	17.59	162.44	180 03
80	85.3	70.6	1.14	56.714	18.36	161.88	180.24
82	89.7	75.0	1.10	56.576	19.12	161.31	180.43
84	92.7	78.0	1.06	56.438	19.88	160.75	180.63
86	95.52	80.78	1.04	56.300	20.64	160.20	180.84
88	98.9	84.2	1.00	56.161	21.34	159.65	180.99
90	10.21	87.4	0.98	56.022	22.13	159.09	181.22
92	10.53	90.6	0.95	55.883	22.90	158.52	181.47
94	108.6	93.9	.92	55.744	23.68	157.98	181.62
96	112.0	97.3	.892	55.605	24.46	157.41	181.83
98	115.3	100.6	.88	55.466	25.27	156.86	182.19
100	118.8	104.1	.85	55.327	26.06	156.30	182.36
102	122.5	107.8	.83	55.188	26.84	155.75	182.59
104	126.2	111.5	.818	55.050	27.63	155.20	182.83
106	130.0	115.3	.79	54.911	28.41	154.62	183.02
108	133.9	119.2	.78	54.772	29.22	154.04	183 26
110	137.6	122.9	.765	54.633	30.03	153.46	183.44
112	141.9	127.2	.745	54.494	30.84	152.90	183.70
114	146.1	131.4	.730	54.355	31.67	152.33	184.06
116	150.5	135.8	.722	54.216	32.50	151.76	184.22
118	155.0	140.3	.712	54.076	33.33	151.19	184.58
120	159.6	144.9	.700	53.936	34.16	150.62	184.74
122	164.4	149.7	.699	53.798	34.99	150.05	185.00
124	169.2	154.5	.689	53.664	35.82	149.58	185.46
126	174.3	159.6	.678	53.530	36.65	149.01	185.62
128	179.2	164.5	.668	53.496	37.48	148.44	185.92

Experiments on Stability at High Temperatures

A Pyrex glass tube having an internal diameter of a little less than one inch was made into a U tube and a portion about six inches long was immersed in a heating bath (oil for the lower temperatures, lead for the higher temperatures). On the floor of the tube were placed small plates (about 3/8 in. square and 1/10 in thick) of copper, solder, cast iron, galvanized iron, cylinder bronze and forged brass. A gasometer holding methyl chloride was connected with one end of the tube and from the opposite end a tube led the vapors through water to collect any hydrogen chloride that would be formed when methyl chloride decomposed. Three liters of methyl chloride gas (measured at 70° F. and 747 mm.) were passed through the tube during 25 to 30 minutes for each experiment. In case of the higher temperatures duplicate runs were made. The temperatures were measured with glass thermometers up to 480° F. and with a standard pyrometer above that point. A very accurate control of the temperature was not attempted and it may have varied as much as 9°F. for any particular experiment. The amount of decomposition was measured by titrating the acid collected in the water with standard alkali. Table IV. shows the results of this experiment.

The metals showed no corrosion at the lower temperatures. At the higher temperatures the solder melted and no observations on changes in the other metals could be made.

Table IV.

Decomposition Temperature of Methyl Chloride in the Presence of Metals

°F	CC. of 0.1006 N KOH to produce a red color with phenolphthalein
165	0.01
210	0.01
30	0.01
390	0.01
480	0.01
660	0.01
750	0.01
795	0.03
795	0.04
840	0.41
840	0.42
885	1.25
885	1.27
930	2.85
930	2.95
930	2.90

Table V.

Weight Changes in Metals Treated Separately with Methyl Chloride

Metal	Wt. in g. of sample	Wt. in g. of sample after heating with CH_3Cl	Change in g.	Appearance
Copper	0.7081	0.7083	+0.0002	Unchanged
Solder	1.8827	1.8829	+0.0002	Surface slightly dulled
Galvanized Iron	1.5375	1.5380	+0.0005	Ungalvanized surface darkened
Cast Iron	1.3068	1.3075	+0.0007	Surface darkened
Cylinder Bronze	1.4684	1.4684	– – –	Unchanged
Forged brass	1.6651	1.6653	+0.0002	Unchanged

Experiments on Corrosion with Methyl Chloride

Test plates of the various metals mentioned in the tables were sealed in glass bomb tubes with liquid methyl chloride, with methyl chloride and lubricating oil, and with oil alone. The tubes were heated in a water bath at 165 to 175° F. for different periods of time varying from 24 to 48 hours.

Tables V, VI and VII give typical results.

A rather interesting fact is that these samples described in Table V. did not change weight further when treated with methyl chloride a second time.

Experiments on Viscosity of Lubricating Oil-Methyl Chloride Mixtures

A sample of lubricating oil with a viscosity of 476 Saybolt at 71.6° F. was used in these experiments. The apparatus[8] is shown in Fig. 2. The oil was placed in the upper bulb up to a definite level. The stop cock was opened and the time taken for a definite amount of oil to run into the lower bulb. The orifice is smaller than the bore of the stop cock so that if the cock was not opened to exactly the full extent this would not effect the results. The temperature was maintained within about one degree in a large thermostat. After the standardization runs were made the stop cocks were clamped in place by two brass clamps and methyl chloride was introduced under pressure until the gauge showed a pressure of 30 pounds. Then the experiments were repeated. The results are recorded in Table VIII.

Table VI.

Weight Changes in Metals Heated in Contact with each other with Methyl Chloride and Lubricating Oil

Metal	Wt. in g. of sample (previously used)	Wt. in g. of sample after treatment	Wt. in g. of sample (not previously used)	Wt. in g. of sample after treatment
Copper	0.7083	0.7083	0.7294	0.7295
Solder	1.8829	1.8829	1.7363	1.7364
Galvanized Iron	1.5380	1.5380	1.3598	1.3595
Cast Iron	1.3075	1.3075	1.2944	1.2940
Cylinder Bronze	1.4684	1.4682	1.7546	1.7546
Forged brass	1.6653	1.6651	1.5356	1.5356

Table VII.

Weight Changes in Metals Heated in Contact with each other in Lubricating Oil

Metal	Wt. in g. of sample	Wt. in g. of sample after heating in oil
Copper	0.7261	0.7260
Solder	1.6248	1.6248
Galvanized Iron	1.3076	1.3075
Cast Iron	1.2689	1.2683
Cylinder Bronze	1.7220	1.7220
Forged Brass	1.4712	1.4713

Experiments on Effect of Lubricating Oil on the Boiling Point of Methyl Chloride

Samples of methyl chloride with varying percentages of lubricating oil were placed in open test tubes and stirred with a toluene thermometer until active boiling was noticed and this temperature was recorded. The temperature measurements are accurate to about 1° C. and the concentration to about 0.2%, hence no great accuracy is claimed for these experiments. The results in Table IX show that there is no great elevation of the boiling point by as much as 50% of oil.

TABLE VIII.

EFFECT OF METHYL CHLORIDE ON THE VISCOSITY OF LUBRICATING OIL

°F	Time for flow of oil, sec.	Time for flow of oil-methyl chloride solution, sec.
32	136.5	39
32	130	40
77	32	26
77	31	27
122	14	8.5
122	13.5	8.5
167	11	8
167	11	8.5

TABLE IX.

EFFECT OF LUBRICATING OIL ON THE BOILING POINT OF METHYL CHLORIDE

Oil % by volume	Boiling Point °F.
0	−9.4
5	−9.4
10	−8.5
20	−8.5
50	−4

SUMMARY

Methyl chloride has been found to be stable up to 800° F. even in the presence of metals.

It does not corrode the ordinary metals used in construction of refrigerating machines.

It lowers the viscosity of lubricating oil but not to the extent that the oil is not useful as a lubricant.

Solutions of lubricating oil in methyl chloride boil at very little higher temperatures than pure methyl chloride.

In general it can be said that methyl chloride has chemical properties which make it very well suited for use as a refrigerant.

DISCUSSION—MR. MACINTIRE introduced his paper with a few remarks as to the characteristics of the refrigerant under discussion, pointing out its unique advantages. He spoke of the fact that he had noted that there were 29 companies in Germany manufacturing refrigerating machines using ammonia, 27 manufacturing CO_2 machines, and 19 making SO_2 machines. He also found that SO_2 was quite popular in Great Britain as well as in this country for the small machine. The arrangement of the characteristic chart presented in the paper was discussed briefly, the author pointing out that volume lines were not included in order to make for simplicity, but stating that they could be readily calculated.

MR. B. H. COFFEY inquired whether any investigation has been made on the effect of oil upon the latent heat of methyl chloride. MR. L. A. PHILIPP, on this same subject, maintained that he did not think that oil could be returned from the evaporator to the compressor since oil and methyl chloride are completely miscible. According to him, if oil is returned it must be by mechanical entrainment. MR. HENRY TORRANCE thought that it was entirely a question of how large the pipes are, and how great the velocity of flow of the gas, whether or not oil comes back. It was pointed out by the chairman that there must be a possible distillation, but MR. PHILIPP maintained that this would be unlikely because of the wide difference in boiling point between oil and methyl chloride.

In replying to these inquiries the author said, first, that he had not investigated the effect of oil on latent heat, assuming that it would be very slight in any event, except as far as the boiling point was changed. With respect to the carrying over of oil, he thought various theoretical explanations were possible but said that he spoke from a practical view based on experience with this material.

MR. PHILIPP criticized the use of the term potential to describe the characteristic symbolized by the letter "i". From the point of view of theoretical chemistry, this term should be applied only to two free energy's. It was pointed out by the author, however, that he had adopted the notation of Goodenough who defined the use of this word very definitely, in preference to the term total heat. MR. D. L. FISKE asked about the method of drawing the diagram with respect to the data, inquiring as to the entropy lines in particular. MR. MACINTIRE replied that the chart was drawn from experimental data directly, without the use of an equation.

PRESIDENT CARRIER remarked as follows: In the case of a refrigerant of this character, if it becomes saturated with oil, where it is beyond a certain point, the viscosity is such that there is a foaming. Oil is to a certain extent carried over bodily and separated as bubbles. It cannot be separated before compression. You can carry it right through a separator, because of its foamy nature, but it will separate after compression. There is a critical point of saturation where entrainment cannot be suppressed and the question is, how much is the boiling point affected when it reaches the point of saturation?

MR. MARVEL presented the second part of this paper. MR. L. A. PHILIPP was the first one to discuss it, commenting on the excellent work of the author. He suggested that an important consideration which should have further investigation is the possible hydrolysis of methyl chloride with water, inasmuch as these form an equilibrium mixture. On one side of an equation you have methyl chloride and water, on the other methyl alcohol and hydrochloric acid. According to him if any mixture is there there is certain to be hydrolysis in spite of the fact that the solubility of methyl chloride in water is very small. The hydrochloric acid obviously would have a bad effect. This speaker also wondered whether a mild intoxicant such as methyl chloride would have decided practical advantages over a more violent refrigerant poison such as SO_2. The addition of chlorine groups to any chlorinated hydro-carbon increases the anesthetic properties of the compound. MR. PHILIPP continued by inquiring as to the use of 30 lbs. pressure in determining the viscosity. He wondered whether there was a possible reaction of methyl chloride with rubber gasket material to form mercaptans.

(Continued on page 138)

The above paper was presented at the spring meeting of the Society on May 23, 1927, by H. J. MACINTIRE together with C. S. MARVEL. The first author needs no introduction to readers of this journal. On the staff of the University of Illinois he is connected with instructional as well as research work, and is the author of recognized texts. The first collaborator is an Assistant Professor at this institution, and the second, S. C. FORD, an Assistant, both of the Department of Chemistry.

[8] The glass apparatus was made by Paul Anders, Urbana, Ill.