

sterilization, as such concentrations caused a waste of ozone as the gas passes through the mixing chambers unconsumed. We have experimented with concentrations ranging from 0.3 to 5.2 g. per cubic meter and have found that under ordinary conditions a concentration of 1 to 2 g. is enough for efficient operation.

The amount of ozone required would vary in different places, as the organic matter present in the water is to a great extent a guide as to the treatment required.

Since the operation of this plant was started, many interesting and instructive facts have been learned with reference to the effect of ozone upon the organic contents of water. Space does not permit us to go into the details concerning these experiments here, but it may be of interest to recite our experience with the action of ozone upon algae.

It was noted that at certain times the ozonized water instead of being bleached was more highly colored. This, as was found out later, was due to the breaking up of certain types of algae and similar organisms by direct oxidation of the ozone and disseminating the chlorophyll matter through the water, the ozone having, as it was later proved, no bleaching

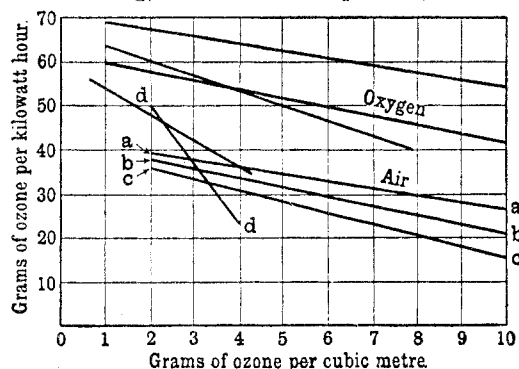


FIG. 8

effect upon this substance. These studies have also shown that the bacterial efficiency of the plant was reduced in proportion to the algae content of the raw water supply.

TABLE I—SHOWING THE EFFECT OF ALGAE GROWTH UPON THE EFFICIENCY OF OZONE STERILIZATION

BACTERIA PER CC.			ALGAE PER CC.			Concentration % O <sub>3</sub>
Raw	Ozonized	% Removal	Raw	Ozonized	% Removal	
1040	390	62.5	210	95	54.7	0.84
950	250	73.6	150	135	10.0	0.84
1500	210	86.0	90	30	66.6	0.92
400	40	90.0	No Algae	No Algae	....	0.84
2720	25	99.1	No Algae	No Algae	....	1.05
1400	14	99.0	No Algae	No Algae	....	0.84

Waters containing excessive turbidity cannot be efficiently treated by this method, unless the turbidity is first removed by filters, owing to the fact that the bacteria may be to some extent mechanically protected from the oxidizing effect of the gas. We can, however, and have for long periods of time, operated the ozone plant at Herring Run with a turbidity of about 40 parts per million, and by proper concentration and mixture have efficiently sterilized such waters. In one particular instance we operated upon a water with a turbidity in excess of 100 parts per million and even under such conditions the bacterial efficiency was about 90 per cent reduction over the raw water count. It is, however, customary to filter waters of

this character before attempting ozonization, although the failure of one plant at least was caused to some extent by disregard of this condition.

From the results that have been mentioned above it is readily seen that the use of ozone as a sterilization agent is considerably more efficient than many of the other sterilizing agents used for water purification at the present time, owing to the fact that it can be used efficiently with water containing turbidities and colors comparatively high, while the other sterilizing agents cannot be guaranteed to maintain their efficiencies under these conditions.

As is well understood, the principal object of ozone treatment is sterilization, particularly the elimination of pathogenic organisms. To accomplish this two conditions must be fulfilled. Ozone must be generated in quantities sufficiently great to oxidize these growths and the gas when so generated must be thoroughly and intimately mixed with the water under treatment. Without attempting to dogmatize, it might be well to review briefly the use of ozone as a water purification agent and its application to this purpose.

If a water contains so excessive a turbidity, or a turbidity in such a state of fineness that it will require filtration at low rates with chemical coagulation, then such a water is not well suited to ozone sterilization, owing to the cost of double treatment.

There are on the other hand many types of surface waters in which the turbidity is never excessive nor do they contain suspended matter in such condition that plain sedimentation or filtration at very high rates will readily remove it. Such waters lend themselves readily to ozone treatment. To this class might also be added highly colored waters, provided the coloring matter is such that it can be bleached by ozone.

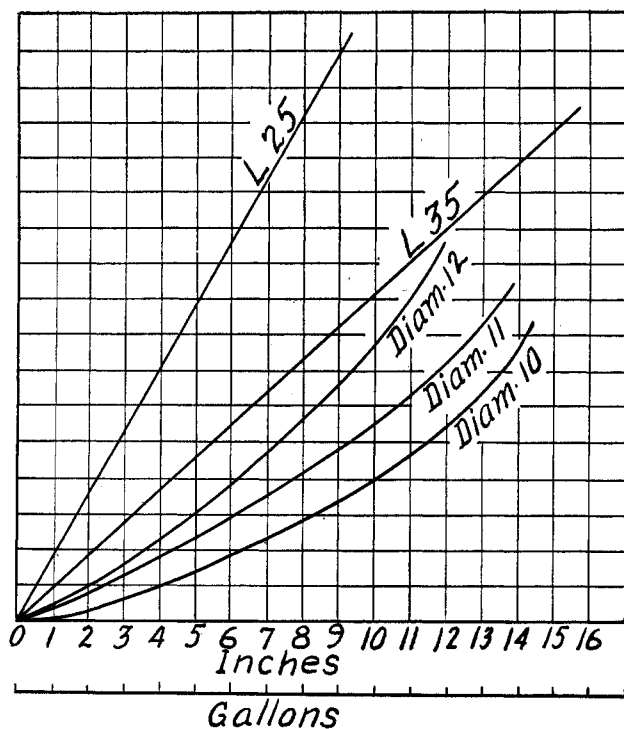
There is no doubt but that the public generally leans towards a method of water sterilization which will efficiently sterilize the supply by means other than the use of chemical compounds. This, of course, is from an aesthetic standpoint, and from the after-effects that have been experienced in chemically treated waters it is not surprising that the layman should take such a stand. A more careful study, on the part of the engineering profession, of this method along these lines might indeed prove fruitful of gratifying results.

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#### A CONVENIENT METHOD FOR RECORDING CONTENTS OF CYLINDRICAL, HORIZONTAL TANKS

By STUART W. MAHER  
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The volume of liquid in a cylindrical tank lying on its side depends on the length and diameter of the tank, and the depth of liquid in the tank. A table giving the volumes corresponding to various values of these variables is apt to be involved and liable to errors in use. The following graphical method of tabulating these values is simple, may be put on a single sheet, and is easily used, with slight danger of error.



The chart is constructed as follows: For a tank of a certain diameter, the areas of the cross sectional segments are calculated for each inch in depth. A curve is then plotted with the inches as abscissas, and the areas as ordinates. Next, for a tank of definite length, a curve is plotted with areas of cross sectional segments as ordinates and volumes in gallons as abscissas. (It may be noted that the curves of "constant length" are straight lines passing through the origin. Hence it is sufficient to determine one point for each of these curves.) It is convenient to give the gallons on a line below that on which the inches rise are given, in order to avoid confusion.

The method of using the chart may be best shown by a specific problem on the diagrammatic curves shown in the figure. Let it be required to find the contents of a tank 25 ft. long, 10 ft. in diameter, and contents 12 in. deep. Referring to the figure, follow the ordinate rising from 12 in. to its intersection with the curve marked diam. 10. Then proceed horizontally to the line L 25, and vertically below is the required number of gallons.

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#### A TABLE FOR VALUES OF CARBON IN CARBON DIOXIDE

By HOWARD LOOMIS

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In the *J. Am. Chem. Soc.*, **31** (1909), 237, in an article entitled "The Weight of Carbon Dioxide with a Table of Calculated Results," by S. W. Parr, there is given a table of values for carbon in carbon dioxide for barometric pressures of 720-770 mm. and temperatures of 10-30° C., calculated in accordance with the formula given and discussed in that article. In making determinations of total carbon in soils in this laboratory recently, it was found that very many

of the barometric readings fell below 720 mm. Consequently, it became necessary to work out a table of values for these lower pressures. The same formula, as given in the article cited previously, was used with the additional factor for converting the results directly to milligrams of carbon, since it was in terms of the element that the final results were desired. The accompanying table is based upon the formula as used by Parr with the addition just mentioned. Values for pressures of 708-716 mm. and temperatures 20-26° C. were worked out entirely by the formula. The remaining values were interpolated from the table of values for carbon published in the pamphlet which

WEIGHT OF CARBON IN MILLIGRAMS PER CUBIC CENTIMETER OF CO<sub>2</sub>  
For Bar. 700 to 718 mm. and 10 to 30° C.

Corrected for aqueous vapor and barometer readings, glass scale

Calculated from 1.976 = wt. 1 liter CO<sub>2</sub> at 0° C. and 760 mm. at 41° Lat.

P =	700	702	704	706	708	710	712	714	716	718
10	0.4714	0.4728	0.4741	0.4754	0.4768	0.4782	0.4796	0.4809	0.4823	0.4837
11	0.4693	0.4707	0.4720	0.4734	0.4747	0.4761	0.4774	0.4788	0.4801	0.4815
12	0.4670	0.4684	0.4697	0.4711	0.4725	0.4738	0.4752	0.4765	0.4779	0.4792
13	0.4648	0.4662	0.4675	0.4689	0.4702	0.4716	0.4729	0.4743	0.4756	0.4770
14	0.4626	0.4639	0.4653	0.4667	0.4680	0.4693	0.4706	0.4720	0.4733	0.4747
15	0.4603	0.4616	0.4630	0.4643	0.4657	0.4670	0.4683	0.4697	0.4710	0.4724
16	0.4581	0.4594	0.4607	0.4621	0.4634	0.4647	0.4660	0.4674	0.4687	0.4701
17	0.4557	0.4570	0.4584	0.4597	0.4611	0.4624	0.4637	0.4651	0.4664	0.4678
18	0.4534	0.4547	0.4560	0.4574	0.4587	0.4601	0.4614	0.4627	0.4641	0.4654
19	0.4510	0.4523	0.4536	0.4550	0.4563	0.4577	0.4590	0.4603	0.4617	0.4630
20	0.4489	0.4502	0.4515	0.4529	0.4542	0.4555	0.4568	0.4581	0.4594	0.4607
21	0.4465	0.4478	0.4491	0.4505	0.4518	0.4531	0.4544	0.4557	0.4570	0.4583
22	0.4442	0.4455	0.4468	0.4481	0.4494	0.4507	0.4520	0.4533	0.4546	0.4559
23	0.4418	0.4431	0.4444	0.4457	0.4470	0.4483	0.4496	0.4509	0.4522	0.4535
24	0.4393	0.4406	0.4419	0.4432	0.4445	0.4458	0.4472	0.4485	0.4498	0.4511
25	0.4369	0.4382	0.4395	0.4409	0.4422	0.4434	0.4447	0.4460	0.4473	0.4486
26	0.4344	0.4357	0.4370	0.4383	0.4396	0.4409	0.4422	0.4435	0.4447	0.4460
27	0.4319	0.4332	0.4345	0.4357	0.4370	0.4383	0.4396	0.4409	0.4421	0.4434
28	0.4293	0.4306	0.4319	0.4331	0.4344	0.4357	0.4370	0.4383	0.4395	0.4408
29	0.4268	0.4281	0.4293	0.4306	0.4318	0.4331	0.4344	0.4357	0.4369	0.4382
30	0.4242	0.4255	0.4267	0.4280	0.4292	0.4305	0.4318	0.4330	0.4343	0.4355

usually accompanies the Parr Total Carbon apparatus and which is based on the table of values for carbon dioxide as published in the preceding Journal article. These interpolated values were in many cases checked by the formula for accuracy, as were many of the values in the table in the little pamphlet from which the interpolations were made. These values are worked out for Lat. 41°, the same as the original table of values.

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#### A RAPID METHOD FOR THE ACCURATE DETERMINATION OF TOTAL CARBON IN SOILS

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Most methods in common use for the determination of total carbon in soils are not sufficiently rapid to be well adapted to routine laboratory practice. This fact led the writer to attempt an adaptation of the direct combustion method, as now used in the rapid determination of carbon in steel, to the determination of total carbon in soils. The method evolved and successfully used in several hundred determinations is an adaptation with modifications of the method described by Fleming<sup>1</sup> for the rapid determination of carbon in iron and steel. It depends upon the direct combustion of soil in a current of oxygen, the gases being dried by phosphoric anhydride and the carbon

<sup>1</sup> *The Iron Age*, **93**, 64-66.