ing the other side, a further portion would be sent back as another echo; if there were many alternate layers of air and carbonic acid gas, this action might take place so often as to quench an entire wave of sound and to dissipate it in echoes. Professor Tyndall here called attention to a small square wooden tube, into the air of which, he said, he could introduce at will seven vertical sheets of carbonic gas through pipes. One of the sensitive flames, which contracted at a shrill sound, was placed at one end of the tube, and a whistle continuously blown by a bellows was placed at the other. When the tube contained air only, the sound passed freely and contracted the flame; when he let seven sheets of carbonic acid gas enter the tube, they broke up the sound into echoes so that its action upon the flame was cut off, being intercepted by layers of invisible gas. He then showed that heated air would have the same effect, by doing away with the carbonic acid, and placing four gas flames below the tube, so as to heat it in four places, and produce four layers of heated air inside. Layers of unequally heated air prevented the sound from passing through the tube, and broke it up into echoes. The lecturer here remarked: "How could it be proved these layers produced echoes?" If they did so, of course he ought to be able to prove it experimentally, so some time since he asked his assistant to solve the problem practically, and Mr. Cotterill had done so. His plan was to take a large hot flame from a batswing burner, which had the power of reflecting sound, for the hotter the flame the greater was the reflection; and he placed this flame in a position to throw back the sound, which it actually did, as proved by the contraction of the sensitive flame.

Strange to say, the flame could reflect sound much better than calico, muslin, and other woven fabrics. Professor Tyndall here borrowed a little boy's handkerchief, and showed that it would not cut off the sound even when folded four times; neither would green baize, nor felt ½ inch thick—so thick that it would entirely cut off the light of the noonday sun. Two hundred layers of muslin in a square pad had but a feeble power in cutting off sound. The lecturer remarked that this was because the air was continuous inside the fabrics. On wetting the handkerchief with water so as to prevent continuity of the air, a single layer of the wet handkerchief cut off the sound. He remarked that, after seeing these facts, the listeners would be quite prepared to understand that a heavy snow storm would have little power in intercepting sound, whereas loud noises might be quickly quenched on a clear day, supposing the air to be heated unequally in different places.

Professor Tyndall narrated how in one of his laboratory experiments he had placed fifteen layers of calico, each an inch or two behind the other and in front of one of his sensitive flames. He discovered that the sound from the whistle would pass through the whole of the fifteen layers, and that each layer would reflect a portion of it so as to act upon the sensitive flame; thus in passing and returning through the fifteen layers, the sound passed through thirty layers in all.

Professor Tyndall here took a large glass cabinet, about the size of a watchman's box, and he caused the sound from the whistle to enter it on one side, and to depress the sensitive flames when it escaped on the other. In the lower part of the cabinet inside he lit two large gas flames, and the hot air from these, rising in the cabinet, intercepted the sound, so that the flame ceased to be shortened. He thus proved that invisible columns of heated air would cut off sound. He then put out the burners and lit a piece of phosphorus placed in a saucer at the bottom of the cabinet; the latter of course was soon filled with a thick smoke of phosphoric acid—so thick was it, that it cut off from view a lighted candle which was placed at the back of the cabinet; yet this cloud, which was so powerful in cutting off the rays of light, did not interrupt the waves of sound at all. Having thus proved that invisible warm air may act as an acoustic cloud, he said that, when such clouds are close to the source of sound, the echoes are immediate, and mix with the original sound; but if the acoustic clouds are further off, then there are prolonged echoes. Further, the length of an echo is a measure almost of the depth of the acoustic cloud whence it comes In the experiments at the South Foreland, he discovered that, when a sound penetrated to a great distance, then the echoes were longest.

At the close of his lecture he argued that the phenomenon which Arago could not explain was due to warm air from the chimneys of Paris, forming acoustic clouds which surrounded the station at Villejuif, while the other station at Monthlery was free from this heterogeneous atmosphere.

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The Micro-Lantern.

Discarding the usual microscopic low powers, we have now adopted, with increased advantages, an objective constructed on the same principle as the well known portrait combination, very short in focus, and with a large aperture in comparison with its focal power. The tube in which the lenses are mounted is very short, so as to permit of the passage of a ray at a great degree of obliquity to the axis. This enables the objective power to cover a large field, or, speaking inversely, to project an image of large dimensions compared with its focal power. But no one who has bestowed attention upon the transmission of large oblique pencils will fail to see that, if the object to be enlarged were mounted upon a flat glass, the astigmation would be so great that, while there would be plenty of light, there would be no marginal definition worthy of the term in the enlarged image. This is quite true; hence we will afford some explanation of the manner by which we so managed that, whereas by one of the usual microscopic objectives only one extended wing of a grasshopper was shown on the screen, we showed not only the one wing, but also the body and the second wing, and not only the whole of one insect or fly, but the whole of three of them which were mounted on one slide, and this with such good marginal definition as to permit the spectators to advance to the screen and examine the details through hand magnifying glasses.

There is sold, in the watch glass makers' shops in Clerkenwell, a foreign made watch glass of a peculiar kind, and known in the trade as "concave crystal." The price we paid was at the rate of five shillings a dozen, or more than six times that at which ordinary lunette glasses can be obtained when purchased in quantities. They are stout and strong, the edges finely polished, and they are curved, spherically, to a very slight degree. The diameter of those we obtained were an inch and a half, and, instead of mounting the objects which were intended to be subsequently magnified between two circular but flat glasses as usual, we mounted them between two of these "concave crystals." Here was the whole secret. The two glasses must be placed "spoon fashion," and the object, being between them, is bent in a gentle curve. With objects mounted in this way, and employing an objective of the kind we have just described—what is known by photographers as a "locket portrait combination" will answer well if of short focus—the lime light need no longer be regarded as an indispensable requisite in the showing of microscopic objects; for with a good lamp, burning paraffin oil, a disk of six feet may very easily be obtained.

Hitherto we have spoken of natural objects. But in practice we have also used this arrangement in connection with photography, both in obtaining pictures, with large aperture, which should be microscopically sharp all over the area of delineation, and, conversely, of producing enlargements from pictures thus obtained. As respects the exposure required to produce an absolutely sharp picture, it is, compared with that which is necessary on a flat plate, less than half, because in the latter case a stop must be used to secure intense definition at the margin; hence if proper mechanical contrivances be adopted for effecting a rapid exposure, there will be no difficulty in taking a fully exposed negative of any scene in which instantaneity is a pre-requisite, the picture afterwards bearing a great degree of enlargement. After several trials we can assert with confidence that the manipulation of a circular and slightly concave surface is quite as easy as that of a flat glass.—*British Journal of Photography.*

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THE VOLUME AND WEIGHT OF DISTILLED WATER AT DIFFERENT TEMPERATURES.

BY RICHARD H. BUEL.

In general, water expands when heated, and contracts on being cooled—with the exception that the greatest contraction occurs when the water has a temperature of about 39° Fah., so that expansion takes place whether the temperature is decreased or raised above this point. The precise temperature at which water attains its maximum density has not been accurately determined. The differences between the results obtained by independent investigations are, however, very slight, and the point of maximum density is commonly taken at 39·2° Fah., or 4° on the centigrade scale. At this temperature, the weight of a cubic foot of distilled water, as determined by the best authorities, is 62·425 lbs.; the weight of a United States gallon is 8·379927 lbs., of an imperial gallon, 10·05312 lbs., and of a cubic inch, 252·8787 grains. In French measures, it is usually assumed that a cubic decimeter of distilled water weighs 1 kilogramme. This is not strictly accurate, owing to a slight error, in regard to the weight of water of maximum density, which was made at the time of fixing the measure; and the absolute standard is the liter, which is a volume of a kilogramme of pure water at the temperature of maximum density. In practice, however, the volume of a liter is commonly assumed to be one cubic decimeter, and the error arising from this assumption is unimportant, being less than 0·00002 of a kilogramme. The expansion of water by heat is not regular for equal increments of temperature, but the law of the expansion has been determined by numerous experimenters, the most prominent of whom are Kopp, Matthiessen, Sorby, and Rosetti. The formulas constructed from their experiments are given below, being taken from Watt's "Dictionary of Chemistry."

Let $V =$ ratio of a given volume of distilled water, at the temperature, T, on Fahrenheit's scale, to the volume of an equal weight, at the temperature of maximum density.

$W =$ weight of a cubic foot of distilled water, in pounds, at any temperature, Fahrenheit.

For temperatures from 32° to 70° Fah.: $V = 1{\cdot}00012 - 0{\cdot}000033914 \times (T-32) + 0{\cdot}000023822 \times (T-32)^2 - 0{\cdot}000000006403\,(T-32)^3$.

For temperatures above 70° Fah.: $V = 0{\cdot}99781 + 0{\cdot}00006117 \times (T-32) + 0{\cdot}000001059 \times (T-32)^2$.

$$W = \frac{62{\cdot}425}{V}$$

The table given below has been computed by the aid of these formulas. The experiments on the expansion of water have not been carried beyond a temperature of 412° Fah., so that the results given in the table for higher temperatures have not been verified. It is not probable, however, that they are greatly in error. The highest temperature in the table corresponds to a pressure of saturated steam of more than 1,000 lbs. per square inch. The successive increments of 10° Fah. give such slight changes in the successive differences in relative weights and volumes as to render interpolations by proportion sufficiently accurate for most purposes. The weights given in the tables are for pure water, so that, when water contains foreign matter, it will be necessary to multiply the tabular weight by the specific gravity of the water. For ordinary rain, spring, or river water, the correction is generally so slight that it may be neglected. Below are given the specific gravities of waters from different localities, the most of which have been taken from Professor Chandler's lecture on "Water," published in the thirty-first annual report of the American Institute:

Atlantic Ocean	1·0275
Dead Sea	1·17205
Great Salt Lake	1·17
Mississippi River	1·00068
Croton (New York Water Supply)	1·00008
Ridgewood (Brooklyn Water Supply)	1·000067
Cochituate (Boston Water Supply)	1·000053
Schuylkill (Philadelphia Water Supply)	1·00006
Delaware River	1·000059
Lake Erie	1·000107
Lake Michigan	1·000113
Genesee River	1·000226
Passaic River	1·000127
Thames, at London	1·000279
Seine, above Paris	1·000151

It will be seen from these figures that, for most cases, it will be sufficiently accurate to use the weights given in the table. If the weight of a gallon of water at any temperature is desired, it may be obtained by dividing the weight of a gallon of water at the temperature of maximum density, previously given, by the relative volume at the required temperature. It may also be obtained by multiplying the weight of a cubic foot of water, at the given temperature, by 0·13368 to find the weight of a United States gallon, and by 0·160372 to find the weight of an imperial gallon. When water contains foreign matter in solution, its rate of expansion by heat is not exactly the same as in the case of distilled water. There has not been a sufficiency of experiments, however, to determine the law of the variation, and no great error will arise from the assumption that the expansion is in accordance with the formulas given above.

With these explanations, the use of the following table will be rendered plain to the reader

VOLUME AND WEIGHT OF DISTILLED WATER AT DIFFERENT TEMPERATURES ON THE FAHRENHEIT SCALE.

Temperature, Fahrenheit.	Ratio of volume to volume of equal weight at the temperature of maximum density.	Difference.	Weight of a cubic foot in pounds.	Difference,
32°	1·000129		62·417	
39·2°	1·000000	·000129	62·425	·008
40°	1·000004	·000004	62·423	·002
50°	1·000253	·000249	62·409	·014
60°	1·000929	·000676	62·367	·042
70°	1·001981	·001052	62·302	·065
80°	1·00332	·001339	62·218	·084
90°	1·00492	·00160	62·119	·099
100°	1·00686	·00194	62·000	·119
110°	1·00902	·00216	61·867	·133
120°	1·01143	·00241	61·720	·147
130°	1·01411	·00268	61·556	·164
140°	1·01690	·00279	61·388	.168
150°	1·01995	·00305	61·204	·184
160°	1·02324	·00329	61·007	·197
170°	1·02671	·00347	60·801	·206
180°	1·03033	·00362	60·587	·214
190°	1·03411	·00378	60·366	·221
200°	1·03807	·00396	60·136	·230
210°	1·04226	·00419	59·894	·242
212°	1·04312	·00086	59·707	·187
220°	1·04668	·00356	59·641	·066
230°	1·05142	·00474	59·372	·269
240°	1·05633	·00491	59·096	·276
250°	1·06144	·00511	58·812	·284
260°	1·06679	·00535	58·517	·295
270°	1·07233	·00554	58·214	·303
280°	1·07809	·00576	57·903	·311
290°	1·08405	·00596	57·585	·318
300°	1·09023	·00618	57·259	·326
310°	1·09661	·00638	56·925	·334
320°	1·10323	·00662	56·584	·341
330°	1·11005	·00682	56·236	·348
340°	1·11706	·00701	55·883	·353
350°	1·12431	·00725	55·523	·360
360°	1·13175	·00744	55·158	·365
370°	1·13942	·00767	54·787	·371
380°	1·14729	·00787	54·411	·376
390°	1·15538	·00809	54·030	·381
400°	1·16366	·00828	53·645	·385
410°	1·17218	·00852	53·255	·390
420°	1·18090	·00872	52·862	·393
430°	1·18982	·00892	52·466	·396
440°	1·19898	·00916	52·065	·401
450°	1·20833	·00935	51·662	·403
460°	1·21790	·00957	51·256	·406
470°	1·22767	·00977	50·848	·408
480°	1·23766	·00999	50·438	·410
490°	1·24785	·01019	50·026	·412
500°	1·25828	·01043	49·611	·415
510°	1·26892	·01064	49·195	·416
520°	1·27975	·01083	48·778	·417
530°	1·29080	·01105	48·360	·418
540°	1·30204	·01124	47·941	·419
550°	1·31354	·01150	47·521	·420

Preparation of Wool before Carding.

Messrs. Whittaker and Ashworth state that this operation effects an economy in oil in the usual process of oiling the wool. The first treatment is in an alkaline bath. The wool is then worked for one or two minutes in an acid bath, at a temperature of about 99° Fah. This bath is composed of 200 gallons water and 3 pounds of commercial sulphuric acid; it serves for the treatment of about 200 pounds of wool. The wool is now carefully washed and dried. Thus prepared, the amount of oil requisite for the oiling process is reduced 50 per cent. The above is the subject of an English patent.