as connected with pressure distribution. We are given to understand that a new Vol. IV is on the stocks, for the double reason that the first issue is already out of print and that there is so much to be added.

Individual effort could hardly accomplish such monumental work and Sir Napier acknowledges fully the ready cooperation of many former official associates, and others, not forgetting proof-readers, pressmen, binders and the manager of the University Press. We take it that all felt a measure of pride in the making of these volumes.

There is not space here to discuss at length new material. One matter of great moment is the practical application of entropy—that elusive something connected with the degradation of heat which college instructors despair of ever explaining lucidly to their classes. It is here regarded as "an index of the dilution of the energy of the working air." In fact, the whole of Chapter VI, treating of "Air as Worker," is a piece of straight thinking on a difficult subject. His tephigram (a combination of temperature and entropy) enables one to plot the heights of successive isentropic surfaces. We are given tables for calculating the entropy of the air, when temperature and pressure are available. We can now regard "an *isentropic surface* as a practical alternative for sea-level or some other *horizontal* surface on which to place the facts about the weather."

Sir Napier of course is a master hand at good English. The nine-page comment on the analogy of medicine and meteorology could well be reprinted as a separate, making a delightful little essay requiring only fifteen minutes to read, but inspiring hours of thinking over. A few lines will make this clear.

> We might indeed have profited by the analogy to which we have drawn attention by giving to this volume the title "The Physiology of Weather," as defining the attitude which meteorologists have to adopt towards experimental physics. We have felt however that to do so might convey the impression that we were proposing to regard weather as the expression of a living organism. Although the weather has many characteristics that are suggestive of vitality, we have thought it best to avoid that impression.

Any forecaster of long experience will appreciate the implication that the weather has a will of its own and like old Joey is deep and devilish sly!

And acknowledging the impeachment that he is not a text-book writer, *i.e.,* one who saves students the trouble of thinking, it is suggested that comprised within the almost unpronounceable name of meteorology there are a large number of subjects quite worth while thinking about. It is in a way unfortunate that the science has been to some extent accepted as a responsibility of government, and this perhaps accounts for much of the indifference of universities, as mentioned above.

It only remains to say that we wonder why a Nobel prize has not come to Sir Napier Shaw. We hope that such recognition will not be much longer withheld.

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BLUE HILL OBSERVATORY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE RATE OF GROWTH OF STALACTITES[1]

IN the summer of 1929 the writer observed stalactites suspended from the roof of the inspection tunnel in the Wilson Dam at Muscle Shoals, Alabama, and later a series of specimens was collected for him by Captain H. D. W. Riley, of the Corps of Engineers. These stalactites are of more than ordinary interest, as their age is known and their rate of growth can be approximately determined.

Fig. 1 is a generalized sketch section of the Wilson Dam. The inspection tunnel is near the base of the dam on the upstream side, its floor 90 feet below the surface of the impounded pool. It is 6 by 9 feet in section and 4,600 feet long. In it are located the valves of the wells for the relief of accumulated hydrostatic pressure in the bedrock beneath the dam. The stalactites hang from the roof of the tunnel along the lines of junction of adjacent concrete segments.

1 Published by permission of the director of the U. S. Geological Survey.

Most of the stalactites ranged between 5 and 9 inches in length (12.7 and 22.8 centimeters) and the

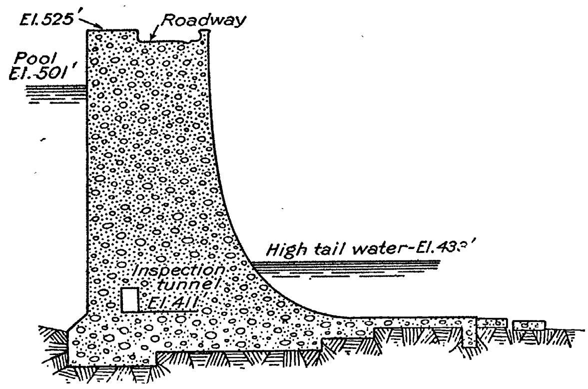

FIG. 1. Cross-section of Wilson Dam at Muscle Shoals, Alabama. The stalactites hang from the roof of the inspection tunnel, eighty-one feet below the surface of the pool.

longest observed was 15.2 inches (38.7 centimeters). The average diameter near the tip was 0.2 inch (0.5 centimeter), and at the base the diameter ranged between 0.5 and 1.5 inches (1.2 and 3.8 centimeters). All had the form of hollow cylindrical tubes whose walls increased in thickness from the tip toward the point of attachment. With two or three exceptions the stalactites were symmetrical.

Impounding of the reservoir was accomplished early in 1925, and the stalactites were measured early in 1930 so that their present size represents five years' growth. Roughly the linear growth rate of the average specimens was between 1 and 2 inches a year. As pointed out by Allison,[2] the factors affecting stalactitic growth are rate of drip, air circulation, relative humidity, temperature and concentration of the mineral content of the water. As each of these factors has a wide range in different places, it is obvious that the rate of stalactitic growth in the Wilson Dam inspection tunnel is peculiar to the exact conditions there prevailing and is not generally applicable.

Recently Mr. F. E. Matthes, of the U. S. Geological Survey, showed the writer a tubular stalactite 3.5 inches (8.9 centimeters) long, 0.5 inch (1.3 centimeters) in diameter at the base and 0.25 inch (0.6 centimeter) at the tip, which he had collected from the arch of a concrete culvert in Rock Creek Park in Washington. The culvert was constructed in 1927, and the stalactite had attained the dimensions given two years later.

In connection with the stalactites already described two exhibits at the National Museum are of interest. One (U. S. N. M. No. 39089) is a group of tubular stalactites 0.5 inch (1.3 centimeters) in diameter and 4 inches (10.2 centimeters) long, which were formed under one of the old arches at the west side of the center of the Capitol. Although the time of formation is not exactly known, it is on the order of tens rather than hundreds of years.

A second exhibit (U. S. N. M. No. 68342) is a pint whisky bottle which was left for five years under a small drip in Weyers Cave, near Shenandoah, Virginia. The bottle is coated with a crust of calcium carbonate which has a maximum thickness of 0.25 inch (0.6 centimeter).

Allison[2] noted stalactites in a coal mine growing at the rate of 0.1 to 1.44 centimeters in length a month. Curtis[3] observed aragonite aggregates growing in drops of water at the rate of $\frac{3}{8}$ inch in three months.

Mr. E. T. McKnight,[4] of the U. S. Geological Survey, observed calcium carbonate stalactites as much as 2 feet in length and several inches in diameter suspended from old timbers in a lead mine in Arkansas. The maximum age of these stalactites is probably 30 years.

The observations cited indicate that the formation of stalactitic and stalagmitic deposits of calcium carbonate in caves can proceed at a fairly rapid rate when the essential conditions are favorable.

More soluble salts permit greater concentration of the solutions, and stalactites of such salts often grow very rapidly. A copper sulfate stalactite 27 inches (67.5 centimeters) long and 1 inch (2.5 centimeters) in average diameter on the 1,400-foot level of the Briggs mine, at Bisbee, Arizona, was formed in 17 months.[5] On the assumption that the conditions were constant this represents a rate of 1.68 inches (3.95 centimeters) a month. Photographs showing the stalactites of chalcanthite and limonite hanging from mine timbers at Butte, Montana, have been widely reproduced.[6]

William Drumm Johnston, Jr.
U. S. Geological Survey

[2] V. C. Allison, "The Growth of Stalagmites and Stalactites," *Jour. Geology*, 31: 106–125, 1923.

[3] J. S. Curtis, "Silver-lead Deposits of Eureka, Nevada," U. S. Geol. Survey Mono. 7, pp. 56–58, 1884.

[4] Oral communication.

[5] G. J. Mitchell, "Rate of Formation of Copper Sulfate Stalactites," *Am. Inst. Min. Eng. Trans.*, 66: 64, 1921.

[6] W. H. Weed, "Geology and Ore Deposits of the Butte District, Montana," U. S. Geol. Survey Prof. Paper 74, pl. 8, 1912.

BLACK PAPER FOR CAMERA LUCIDA DRAWINGS

In the use of the camera lucida some difficulty is frequently experienced in seeing clearly the object when white drawing paper is used.

Quite accidentally, the writer discovered that the object stands out much more definitely when a black surface is the drawing medium.

Black drawing paper (charcoal paper) may be secured in any store that carries a good line of drawing materials, and it is very satisfactory. Some difficulty was experienced in getting a pencil that was, in the first place, hard enough to take a good point, and, in the second place, of a color that would stand out well on a black background. An Eversharp carrying yellow lead was found best for the purpose. This lead can be sharpened to a needle point on fine sandpaper and is sufficiently hard to hold this point.

A controllable source of illumination on the drawing paper has been found beneficial in making the point of the pencil stand out more clearly. This is particularly true if the work is being done in a dark room or at night.

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