water, attention is directed to the references given in the footnotes which describe an apparatus which will give a continuous record of sea-water salinity from a moving vessel. This instrument in conjunction with an instrument to record temperature, which has been constructed, would give the three most important physical variables of sea water, namely, temperature, salinity, and density. Such records taken regularly over the same course would show monthly and yearly variations of these physical properties which might be of much scientific value.

ETHER DIFFERENTIAL RADIOMETER.[1]

By W. H. Dines.

[Reprinted from *Science Abstracts*, 1921, 24 : 216.]

The instrument consists essentially of a sensitive differential thermometer formed by two test tubes, each containing a few drops of ether, mounted with their axes in a horizontal line and communicating with each other by a U-tube containing ether to form a pressure gage. A metal shield is placed around each tube, with a horizontal slit to admit radiation. The direction from which radiation is admitted to either tube can be controlled by rotating the appropriate shield about the common axis.

Method of use.—There are two ways of using the instrument. In the direct method radiation from a portion of the sky is allowed to fall on one tube while the other is exposed to a full radiator, a vessel containing water, the temperature of which is altered until a balance is obtained. The equivalent radiative temperature of the sky (i. e., the downward radiation from the atmosphere) is then equal to the temperature of the full radiator. In the indirect method, instead of altering the temperature of the full radiator, the tube exposed to the sky is allowed to receive radiation from a second full radiator, of constant temperature, so placed as to effect a balance. A simple calculation then gives the equivalent radiative temperature of the sky.—*M. A. G.*

551.508.5 (048)

SIMPLE MAXIMUM ANEMOMETER.[1]

By P. L. Mercanton.

(Reprinted from *Science Abstracts*, 1921, 24: § 339.)

It is often desirable to have instrumental evidence as to the maximum force attained by the wind during a gale, and for this purpose a simple, inexpensive maximum anemometer would be useful. The principle of the Pitot tube suggests itself. Three forms of the instrument have been designed. The first two necessitate the employment of a Dines vane communicating with a manometer. In the first this consists of a U-tube containing oil. The difference between the static and dynamic pressure of the air displaces the oil in the tube, and the farthest point reached is marked by a glass index acting like that in a minimum thermometer. In the second form a metallic Bourdon-Richard manometer is used, recording by a light pivoted index. The third instrument is cheaper, but less accurate. It consists of a glass reservior with two tubes leading out of it, one vertically and the other obliquely, and at the top each tube has a shore horizontal extension, in the plane of the two tubes. Tht whole is mounted on a vertical pivot and swings with the wind, so that the horizontal extension from the vertical tube faces the wind. The reservoir contains oil, which also enters the lower part of the oblique tube. During wind the oil is consequently forced up the latter, which has at intervals small pockets. These retain small drops of oil when the main body recedes, and the highest pocket so filled marks the approximate height to which the oil ascended, and hence gives an approximate measure of the force attained by the wind. [The diagram illustrating the instrument appears to be printed upside down.]—*M. A. G.*

[1] Jour. Roy. Metl. Soc., London, Oct., 1920, 46:399-405: discussion, 405-406.
[1] *Archives des Sciences*, 2 : 511-513. Nov.-Dec., 1920.

AMERICAN METEOROLOGICAL SOCIETY MEETING IN WASHINGTON, APRIL 20-21, 1921.

The fifth meeting of the American Meteorological Society was held, amid flag-bedecked surroundings, at the central office of the Weather Bureau on the evening of the 20th and morning of the 21st. There were 21 papers on the program, 3 of which were read by title. One of these papers was published in the March Review, one and abstracts of two others are in this Review, and it is expected that the others will appear in full or in abstract in early numbers of the Review.

Various phases of areological work, particularly (1) making of wind-aloft observations, with free balloons, with kites, and clouds; (2) studying the data; and (3) distributing current aerological information and forecasts for aviators by radio. Some aspects agricultural meteorology, mathematics in meteorology, new instruments, and measurements of sky brightness were presented. Those present were particularly fortunate in hearing Dr. John Paraskévopoulos, of Athens, Greece, tell about the meteorological service in Greece. He was spending two months at the central office studying methods and equipment of the Weather Bureau.

A more complete account of the meeting will found in the May or June, 1921, Bulletin of the American Meteorological Society.—*C. F. B.*

551.509.6 (048)

THE ARTIFICIAL CONTROL OF WEATHER.

By Sir Napier Shaw.

[Abstract reprinted from the *Meterological Magazine*, April, 1921, pp. 60-63; with excerpts inserted from *Aeronautics*, Apr. 7 and 14, 1921. Reprinted also in *Aerial Age Weekly*, May 9, 1921, pp. 203-205.]

On March 9th Sir Napier Shaw delivered a lecture on the artificial control of weather before the Cambridge University Aeronautical Society. A résumé of the lecture is given below.

"The control of weather has been a subject of vivid interest from the dawn of history down to the present day. It is woven into the fabric of every form of civilization. The claims of the rain-maker are in some cases modern; but they are not exclusively modern, and are not to be regarded as one of the many signs of the progress of physical science in civilized nations. * * * Quite deep down in human nature is apparently the feeling that if man can not himself control the weather, at least he knows who or what can; and he can bring influence to bear upon the spirits of the air that will guide the control in the manner desired." Few subjects of speculation are more interesting than the system of control indicated by Greek mythology. Even in the eighteenth century, when as a result of the discovery of the laws of planetary motion the conception of "laws which never shall be broken" was growing on all sides, "the weather was regarded as still at the immediate pleasure of the Almighty Law-giver in Whom had become gathered all the several powers of the Greek immortals." The transition from the mythological position to the theistic position was very gradual, and is perhaps not complete in parts of Europe even to-day.

"In the course of my experience at the Meteorological Office I have had to be responsible for considered opinions on many offers of controlling the weather in some form or other. This was specially the case during the war." Many astonishing suggestions have been made from time to time, but the objects of all of them, good or bad, are curiously limited. "I have never seen any suggestions for beginning where nature begins and turning winter into spring or summer for a particular district by warming the open air or the open sea, or for drying the roads by operating on the humidity of the open air. The objects to which the operations are proposed to be directed are such as the avoidance of hail by the dissipation of thunder clouds. This appeals particularly to the regions which surround the Alps. The production of rain in regions where rain is specially wanted for the maintenance of crops is another object, and, thirdly, the dissipation of fog, and this last has now become transcendently important in flying. The methods proposed are either mechanical or electrical."

The production of noise has always been regarded as influential in controlling the weather, possibly on account of the constant association of rain with the noise of thunder. When firearms were invented their use replaced the ringing of church-bells formerly in vogue among the peasants. The belief in the efficacy of firearms expresses itself periodically in European vine-growing districts. "It was epidemic in a very severe form at the end of last century because somebody had devised a new gun or mortar; pointed upwards it discharged a vortex ring of smoke which could be seen to reach the clouds." The mortars were increased in size until they were 40 feet high, and much money was spent, but the result was indecisive, persons in more northerly latitudes thinking the influence disproved, and those in more southerly ones thinking it proved.

Subsequent French proposals for setting up *paragrêles* "in the form of tall structures carrying metallic points for the discharge of electricity to neutralize the electricity of the thunderclouds" were interrupted by the war.

A variation of the gunfire method is the use of a violent detonation such as is produced by dynamite explosions, heavy gunfire, and so on. "It draws its support largely from the fact that many battles have ended in, or been followed by, downpours of rain. Historically, battles are summer phenomena, and doubtless many summer days of less momentous importance have closed with downpours of rain. * * * There is no ground *a priori* for supposing that concussion would have any effect at all upon the condensation of vapor and clouds And in any attempt to prove the influence by rainfall which occurred subsequently to the explosions we have no means of comparing actuality with what would have happened if the explosion had not occurred. * * * The effect of extensive gunfire may be regarded either as physical, arising from the detonations, or chemical. * * * The direct effect of the detonation is probably nothing at all, and the chemical effect inconsiderable compared with the daily combusion of fuel in the Manchester district."

Mr. Cole, a Canadian airman, suggests rain production by means of liquid air sprayed from an aeroplane. While a certain amount of condensation is thus assured there is a risk that the rain might evaporate before reaching the ground. "A millimeter of rain means 4 tons to the acre, or 2,500 tons to the square mile. To water a countryside would need a good deal of liquid air."

Other rain-making suggestions are even less attractive. The method of throwing dust from an aeroplane on to clouds 5,000 feet high, tried at Pretoria, was unsuccessful, as might be expected, since if cloud is already present dust is superfluous. A similar proposal, using a balloon, was made some years before the war for the dissipation of London fog.

"An electrical installation in Australia for discharging electricity from kites was said to have produced enough rain to fill a large tank in a region that was suffering from lack of rain; but the observations of the time showed that the whole country for hundreds of miles around was uniformly fortunate."

"In the present generation not only are the laws of motion of the heavenly bodies regarded as never to be broken, in spite of the fact that Einstein and others may alter the form; but there are many new laws of physics and chemistry which have an equal claim to be regarded as inexorable in the study of weather; and, moreover, the powers of the laboratory and the workshop have become so much enlarged that the new spirit of humanity is not disposed to take the vagaries of the spirits of the air lying down. If we really understand them we ought to be able to direct the operation of the forces of nature; and we find a disposition to ask whether we can not ourselves take over the forces of the air, and if not, why not?" Many opinions of the futility of human effort have been proved to be wrong; all awkward corners may be turned by new inventions. These matters are largely questions of scale; for practical purposes impossibility is reached when the money and material required exceed the limit of what is available. "We can do anything with a quantity of air in a small inclosure in a laboratory. We can, certainly, by artificial means, make cloud or rain in the inclosure and disperse it or evaporate it at will after it has been formed. We could easily find out whether the detonation of a pistol or a small charge of dynamite at a suitable distance would produce any effect upon an artificial cloud, though I have never heard of the experiment being tried. The important question is whether we can extend such operations from the laboratory to the open air. We are here up against the important consideration that a cube of air 10 meters each way weighs more than a ton. If it is foggy it may contain 5 kilograms of water drops, and a millimeter of rain over the same area weighs 100 kilograms. The amount of heat released by the condensation of a kilogram of water is about 600 kilogram-centigrade units, which are equivalent to 2.5×10^{13} ergs, or approximately one horsepower-hour (2.7×10^{13} ergs). Hence evaporating a 10-meter cube of air containing fog is equivalent to 5 horsepower-hours, and a millimeter of rain over the 10-meter square, 100 horsepower-hours; over a square kilometer, a million horsepower-hours.

"I have another proposal of a different character: This time to arrest and prevent the development of fog at sea by pouring oil on to the water and so stop evaporation in the environment of the ship. In this case, it is not merely the scale; the basic theory is probably at fault. The water of an Atlantic fog does not, as a rule, come from the surface on which the fog lies, but from far to the south. It is the cold surface which causes the fog; the temperature of the surface is below the dew-point of the air above it, and dew would therefore be formed on the oil. Even if the theory were correct and we obtained a patch of oil, a clear space, and a ship, we should still have to consider what would be their relative positions at the end of an hour or twelve hours, in view of their relative drifts. An identical method was suggested some years ago for application to the river Rhone, at its junction with the Saone, where warm and cold water join. No news has arrived as to the success of the proposal."

The modern problem of clearing fog from aerodromes has been the subject of several suggestions. The chief of these are local heating by means of coal fires, mechanical driving away of foggy air by propellers capable of giving a speed of 100 kilometers per hour to the propelled stream, and electrical methods. Again it is a question of scale. Both within a laboratory and on the larger scale of furnace flues a brush discharge of electricity will clear away dust, smoke and cloud like magic. Sir Oliver Lodge's experiments in clearing Liverpool from fog were not decisive, and in any case it is not very desirable to have an installation for brush discharge, which comes very near to sparking, in the neighborhood of an aerodrome.

"The most telling example of malevolence of the weather toward the allied forces that I can recall in the course of the war is the development of a rainy cyclonic depression over the western front and southern part of the North Sea during the end of July and the beginning of August, 1917. It began to form on July 28, and reached its climax on August 3, when a well-marked depression, 11 millimeters deep, was exhibited on the map, extending over a nearly circular area, 1,400 kilometers in diameter, and had filled up on August 6. It apparently originated and filled up again in the locality. I reckon that the creation of the depression, which was a very small affair, and on the map looked like gerrymandering, is equivalent to the removal from within the cylinder of 1,400 kilometers diameter of seventy thousand million tons of air. It took six days to accomplish this deportation, and three days to fill the space up again. If the enemy accomplished this feat by artificial means, they must have used some other process than firing shells vertically upward: the question gives me the same sort of tired feeling as the 200-mile jetty, with some other sensations added.

"The most direct means of accomplishing such a deportation of air would be by an underground channel to carry the air from the central region to beyond the boundary of the depression. Let us suppose a channel, 12 feet in diameter, leading from Ostend to Berlin and operated there by a 16-foot propeller giving a full bore stream of 100 kilometers an hour (friction being neglected). The deportation would go on at the rate of 1,200 tons per hour, or 28,800 tons per day. Working without intermission, it would take 7,000 years for the propeller to complete the deportation; and as it had to be done in six days, 400,000 such channels would have to be operated concurrently to get the work done in time.

"What it comes to, then, is that all the suggestions for the human control of weather oppress one, not by any mistaken conception of physical processes, but by the 'scale and effect.' Within our knowledge we are lords of every single specimen of the atmosphere which we can bottle up and imprison in our laboratories, our furnace flues and our greenhouses; but in the open air the ordinary inexorable laws which control the behavior of the atmosphere when we are awake and when we are asleep, have such enormous masses of energy in the form of warmth and water vapor in reserve that our own little reserves are not equal to making any serious impression on the course of nature." The course of the weather may, however, be affected by the explosion of a great volcano, and it would be interesting to consider "how far our reserves of available energy compare with the destruction of Pompeii, the disappearance of the island of Krakatoa, or the eruptions of Mont Pelée and La Souffrière."

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C. Fitzhugh Talman, Professor in Charge of Library.

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