Wolf KLAPHAKE

Air Wells

[Thanks to Dr Klaus Neumann, Historian (kneumann@netspace.net.au) for retrieving & sharing this article]

See also: Air Wells, Dew Ponds & Fog Fences

Proceeding of the Society of Chemical Industry of Victoria (Australia), 36: 1093-1103 (1936)

Practical Methods for Condensation of Water from the Atmosphere

by **Wolf Klaphake**, D. Ph, A.A.C.I.

When air is saturated with water vapor, it rains, and one should be inclined to think that the air is saturated, when it cannot take up any more water. This conception is wrong, for air can contain almost any amount of water, providing it is presented to it in the right form. Air, having a vapor pressure of 31.8 mm of mercury, is said to be saturated at 30 C, but we can add water drops of a very small diameter, and they are taken up and transformed into invisible water vapor until the pressure amounts to several times the initial pressure.

It is said that air is saturated with water vapor when the air is above a flat surface of the same temperature, and when the same number of water molecules leave the surface as return to it, but when the surface of the water is convex towards the air --- as it is in water drops --- the saturation pressure is higher. There is no condensation, even at a great supersaturation, unless there are some solid or liquid nuclei, on which combination of the vapor molecules can take place.

Dines mentions on one of his papers that the water content of the air above Europe would yield a rainfall less than one inch per day. The high rainfall of that continent is due to the ascending air currents, for a current saturated at 50 F, ascending at a speed of 1 m/sec, would produce a rainfall of one inch per hour. Such an air current carries with it water drops formed on nuclei, until these drops are big enough to fall quicker than the current rises. This is, however, only one factor in rain-making.

Others are connected with the electric potential of the air, of the earth, of the drops, and of the nuclei.

Considering the conditions on the surface of the earth, condensation there takes place in the form of dew, and the circumstances are very similar to those in higher regions. Dew is condensed humidity and is deposited chiefly on objects which are good radiators, and at the same time bad conductors of heat. The humidity of the air is given either (1) as relative humidity, i.e., the proportion of the quantity of water vapor which the air contains, to that which it would were it saturated; or (2) as absolute humidity, i.e., the weight of the water vapor existing in one cm or one cu ft, given in grams or grains, respectively. Since the relative humidity depends on the temperature as a rule, the absolute one is used.

For a longtime the question as to whether the dew rises or falls was difficult to answer. Aristotle was the first who asked it, and, according to him, the dew fell --- a view which was taken for granted until the end of the 18th century, when Charles Wells made his careful experiments, which he described in his "Essays on Dew" in 1814. His experiments showed clearly that the dew fell, and though later many scientists worked on this question, nothing was added until John Aitken (1) showed, in 1880, that the formation of dew was not quite so simple as Wells had thought, but a complex phenomenon. Aitken proved that the following conditions are favorable to the formation of dew: good radiating surface, still atmosphere, warm moist ground or some other supply of moisture in the surface layers of the earth. The first four conditions he considered to be necessary, the fifth important to obtain a copious deposit. The formation of dew over a moist soil may be of great practical importance, for it can protect plants against night frost. As long as a distillation between the earth and the plant goes on, the water, condensing on the leaves would tend to keep their temperature high, but if this heat lost by radiation were compensated by condensation from the air, then the cooling process would continue.

It was Aitken who called attention to the water drops on the leaves, which one can see glistening in the morning sun. These drops are regarded as the most striking example that dew has been deposited. He is of the opinion, however, that these drops are not condensed from the air but exuded from the pores of the plant. Aitken is usually referred to as the man who proved that dew rises or falls, or travels in both directions, as the conditions may be.

Generally speaking, dew is formed when the dew point curve and the dry bulb cut at the surface of the earth; if they cut above the surface, mist will be formed, and if below, a distillation between the layers of the earth takes place, and thus considerable quantities of water are transported, a process of which our knowledge is still very limited.

There is an important difficulty regarding apparatus measuring the amount of dew per unit area of surface, the drosometer as it is called. The recorded measurements are never absolute, but relative, representing the phenomenon of condensation from the air. Thus the figures for the annual depth of water fallen as dew differ considerably. Loesche estimates the amount of dew for a single night on the West African coast at 3 mm, equal to one-eighth of an inch. On the Desertas, uninhabited islands near Madeira, dew falls so heavily that sometimes rivulets run down the mountain slopes. Dr Marloth, of Cape Town, showed that, from December 1902 to February 1902, Iin56 days, on the Table Mountain, moisture condensed equal to nearly 80 inches of rain; thus, during the dry season about 150 inches of water fall, exclusive of rain. These experiments were doubted, and he made further investigations near Maclear's beacon (3500 ft), and found that, in January 1904, 1.44 inches of rain fell, but his dew gauge collected 48.42 inches of water. In the same month at Woodhead Reservoir (2500 ft), 1.83 inches of rain and 13.73 inches of dew were registered.

The amount of dew collected by different materials is largely due to their nature. W.C. Wells gives a list of materials according to their capacity for collecting dew. By far the highest effect was found with swan's down, then flax and cotton, followed by silk, paper, straw, wool, earth, charcoal, glass-sand, river-sand, chalk powder --- a list which runs roughly parallel to the specific heats of the materials names.

However, it is improbable that the humidity of the air is only condensed on the surface of the earth; it certainly is absorbed in great quantities, too. Beside the plants, which are able to absorb water from the air with their leaves, the soil absorbs it as well. Ginestous (2) has shown that in the northern part of the Sahara desert the moisture of the regularly blowing north-easterly wind gradually decreases with the distance from the sea. At Sousse, the humidity is 17 gr/cm, at Metlauli 10 gr, and at Tamanrasset, which is about 200 miles distant from the sea, 2.5 gr in the summer. In this distance of 200 miles the air loses 14.5 gr water per cm, or about 30 tons of water per square mile, assuming the velocity of the air current to be 3 cm/sec. Ginestous is of the opinion that this water is absorbed by the soil, this giving the necessary moisture to the plants during the rainless season, for it is worth mentioning that the humidity of the air is much greater in the summer than in the winter.

In the Nullarbor Plain, at the border between South and Western Australia, the atmospheric conditions are very similar to those described above. There, too, a regular wind carries moisture from the sea inland; but, unfortunately, there are very few meteorological stations.

As already mentioned, nuclei are essential for the condensation of water from the air, either in form of dew or of rain, but it is no0t yet clear how a nucleus is to be understood and how it works. Aitken invented a simple apparatus by means of which the nuclei present in the air could be counted, and which showed that their number is not increased by blowing coal, coke, or ordinary dust into the air.

Sometimes a difference is made between solid dust particles and hygroscopic substances in the air, but one cannot see why, e.g., a calcium chloride particle suspended in more or less humid air should be more hygroscopic than a carbon particle under the same circumstances. One would rather attribute a different effect of a nucleus and an ordinary particle to a different electric potential. However, this will not be further discussed at present.

Is it possible to make rain? Everybody has heard of the attempts to produce rain by firing shells against the sky, by exploding dynamite, by blowing sand or chemicals, with or without electric charges, into the clouds, and these methods may be effective under appropriate atmospheric conditions; but they certainly are highly expensive and economically unsound. A different method was employed by Graham Balsillie, who experimented in Australia during the Great War. It happens, especially in the inner parts of Australia, that clouds cover the sky day and night, but no rain falls and the clouds dissolve over some other part of the country. Balsillie tried to break these clouds up by using electric waves in order to enlarge the particles, so that rain might fall. He claimed to have caused exceptionally heavy dews, whereas the Weather Bureau proved that there were similar large condensations in districts remote from the place of the experiments. This says nothing against the attempts, and it would be worthwhile to go further into this matter, for it seems probable the water particles could be enlarged by electric power.

One process of making rain may be mentioned, because it is not well known, and is supposed to be effective, though it has not been studied scientifically. Some of the northern parts of

Mexico consist of desert-like plains, partly overgrown with cacti. Under certain conditions, which appear to be great heat, no wind, and a cloudless sky, the Indians set the cacti afire, thus creating a tremendous heat. After a very short time a downpour of rain sets in, which lasts for a few minutes only. This is the description given to the author, and if true the explanation may be that the heat of the fire pushes wet layers of the air higher up, that they get cooled beneath the dew point and drop their water in the form of rain.

Thus the prospect of rain-making is not too encouraging, though there are many places in the world where mankind has made use of the humidity of the air by condensing it, and a number of processes have been developed to draw liquid water from the air.

On the Canary Islands a very primitive way of obtaining water is employed, by shaking the trees in the morning and collecting the dew condensed on the leaves.

In England two different processes are to be found. In Cornwall, the rustics smooth the surface of the slop of a mountain by means of clay, thus preparing an area of about 40 sq ft, which they surround with a small wall. This are is covered with a thick layer of straw. During the night the straw collects dew as grass does, but the former is said to be more effective. As the climate of Cornwall is damp and the night temperatures in the mountains low, the process works quite well, but the straw has to be renewed frequently as it putrefies quickly, being moist day and night.

The best known process is that of the English dew ponds, mostly in the Midlands and the South of England, which are characterized best by saying that they do not fail to give water when other ponds at low levels have dried up. This fact is indubitable, for many observers, from Gilbert White onward, have confirmed it. The name of dew pond has been used since the beginning of the 19th century, but it appears to be purely a scientific expression, for most of the farm laborers in Sussex, when questioned about dew ponds, rejected the name and called them mist ponds.

It is easy to get information about the construction of these ponds, as many know how to build them, thought there are many different varieties. Generally, such a pond consists of a saucer-shaped mould covered with a layer of straw, on top of which a layer of puddled clay is rammed, the latter being frequently protected by stones or chalk. Martin has given a minute description of the structure of the different ponds. For ramming the clay carefully, and puddling the surface, the rustics used to drive horses round and round and through the pond for a whole day. Martin speaks of a man who remembered that, as a boy, he knew a pond which sometimes contained a little water. When this was so he obtained permission to drive the horses on the way home through the pond in order to cleanse their hoofs. After having done it frequently, the pond commenced to hold more and more water, showing that it ceased to leak by the stamping hoofs of the horses.

The base of dew ponds is covered with grass, and most of them are surrounded by trees or bushes. IF ther is no grass, the pond dries up regularly. Martin has, to a certain extent, put an end to the discussion about dew ponds, by proving that they are not replenished by dew falling on their water surface, as, with few exceptions, the water is warmer than the air, and no dew could be deposited on them. Consequently, either mist condenses on the water as Martin believes, or the grass collects dew which flows towards the center, forming a pond. Both explanations are probably true. Dew ponds are typically English, as they rely on the English climate, and there are very few known in other parts of the world. To give some idea of the amount of water collected in such ponds, Gilbert White may be quoted. He says that a pond near his house at Selborne, west of London, which was never more than three feet deep in the center and not more than 30 feet in diameter, contained about 15,000 gallons of water and was never known to fail, though it afforded drink for 300 sheep and 20 head of cattle every day.

In the Libyan Desert, Northern Africa, the Italians have endeavored, since the Great War, to create a water supply from the atmosphere. They have built high walls of mud bricks with sloping sides, both of which they covered with smooth, condensing surfaces. At the bases of either side, troughs or channels are fitted running the whole length of the alls. Though the desert is arid and barren, the wind carries moisture from the sea towards the land, and water is deposited in the inner parts of the walls. A similar process has been used in Spain for centuries, and the thick walls of stone which are so common in Dalmatia undoubtedly retain a great deal of water.

The so-called Foggaras of the Sahara Desert are elaborate constructions, consisting of subterranean passages many miles long. They are dug by hand into the slopes of the mountains, and are big enough for a man to walk through upright. They are connected with the surface of the earth by an air tube at every 75 ft distance. Some of the foggaras are built on the surface and collect the humidity of the air, whereas those underneath certainly are fed by seepage, too.

These are the processes for condensing water from the atmosphere, as they are known and used today; they are not frequently employed, but the old literature shows that, in the times before the creation of the Roman Empire, whole townships relied on water condensed from the air, and many descriptions are given in old books. And it was by reading Maimonides that the author received the idea of thus condensing water. He was a Spaniard who lived roughly 1000 years ago, and wrote, besides philosophic books, a description of Palestine and its people in the Arabic language. This book contains some hints regarding such a condensation of water as used there.

Shortly after the war experiments on dew were carried out, and, the study being a hobby, it took a good many years to come to a conclusion, for the question was not to condense water from the air simply by cooling it artificially (as this was too easily solved), but to construct a highly effective building which condenses water without or with very low running costs. Gradually it was found that the knowledge of erecting buildings for water condensation from the air was spread all over the world, but that the old Greeks seemed to have had the best knowledge of the process. The usual description of these buildings in our archaeological literature runs like this" Covered troughs or channels were found leading up the slope of a mountain right to the top, where ruins of a great vault were detected, which seemed to have contained water. It is not known how the water got there, but certainly the town possessed a very great supply of water from sources which disappeared". Such descriptions were found for about 50 towns, which obtained their water in this way, and most of which belonged to the sphere of Greek influence, but the old Incas used the same principles and the mystic buildings on some of the Pacific Islands may have served this purpose, too.

The principle is a very simple one. In India and other tropical countries, rooms are found in houses which have very thick walls and small windows right under the ceiling. These rooms are remarkably cool, and that is understandable, for the cool air flows through the windows into the room during the night and is kept there in the daytime, since it cannot escape through the windows, and as these rooms are well insulated by their thick walls. If, in such a room, holes are made near the bottom, so that the cool air can flow out, water condenses on the walls, for the humidity condenses on the cool surfaces.

This process relies not only on the humidity of the air, which is everywhere present, but also on the difference between day and night temperatures --- the greater this difference the more favorable are the conditions --- and this is the reason why the buildings of ancient times were situated on the tops of the hills.

At first the process was tried by insulating a room of a house and making holes at the ceiling and at the bottom, but this method did not work very well, as houses in Europe usually stand in the valleys.

A better method consisted in selecting a mountain slope, smoothing it with cementitious or other material apt to make the surface watertight, and covering it with an insulating material, so that the cover formed over the area a canopy or roof which was supported by pillars or ridges. The sides of the canopy were closed, whereas the upper and lower ends were left open by constructing holes or vents to allow the air to pass under the roof. This construction proved to be very successful, as the cooling surface of the inner part was highly effective. The disadvantage was that the structure was very expensive, and so a return was made to the block house type.

Many types of building were tried, but that finally adopted was a sugarloaf shaped building, about 50 ft high, with walls at least 6 ft thick, with holes on the top and at the bottom, the inner surface being enlarged by a network of walls of a material with great surface. The outer wall is made of concrete to be able to take up a great amount of thermal units, the inner surface consists of sandstone or any other porous material. The building produces water during the day and cols itself during the night; when the sun rises, the warm air is drawn through the upper holes into the building by the out-flowing cooler air, becomes cooled on the cold surface, deposits its water, which then oozes down and is collected somewhere underneath. It is wrong to think that this process works only on days with dew, as the inner surface becomes much cooler than one should expect. In Dalmatia, that day was a rare exception which failed to produce water.

Nearly all the experiments were performed in Yugoslavia, most of them on the numerous islands of the Adriatic Sea, some in the inner parts of Dalmatia. The southern parts of the northeastern coast of Adria have plenty of rain in the winter, but in the summer rain falls only occasionally, and, as the soil consists of pervious limestone, this is one of the dry districts of Europe, though the humidity of the air is high.

The essential principle in obtaining water from the air has thus been shown to be --- a great water condensing surface which must be well protected against the heat of the sun and at the same time it is necessary that the air should pass to the condensing surface slowly, in order that it may cool properly and so deposit its water. The conclusion of this is --- that a big heap of stones would do the same thing as the above-described buildings. The last experiments in Yugoslavia followed this line, where one did produce a small amount of water, though this work was not completed. This process, too, was used by the old Greeks for the water supply of the town of Theodosia on the Crimean Peninsula, where artificial heaps of stones condensed the necessary water on the surrounding hills, whence pipes ran down to the city. These heaps were about 10,000 ft square and 30 ft high, and each of them yielded more than

500 gallons of water per day.

This paper would be incomplete without mentioning that in Paris, Achille Knapen (4) is working on the same line independently of the author. To dry wet walls of buildings, he has invented a tube, closed at one side, which he calls "*siphon atmospherique monobranche*", and it has proven successful, as its use is simple, cheap, and effective. He transferred the principle of this tube to a building, shaped similar to the above proposition, and erected a big experimental "*Puits Aerien*", as he calls it, near Trans-en-Provence in Southern France. He has met with success, though his published results have not yet been seen by the author.

In conclusion, the author feels confident that it is possible to use this process under Australian conditions, and so has decided not to apply for a patent, as this would hinder its application. It would give him much pleasure if one day this process could be seen to have helped those living in the outback.

References ~

(1) *Trans. Royal Soc. Edinburgh* 33: 1885-1886
(2) *La Tunisie Agricole* (18-12-1928)
(3) "*Dew Ponds*", Edward A. Martin (London, 1917)
(4) *Memoire et Compte Rendu des Travaux de la Societe des Ingenieurs Civils de France*, 1928, 1929, 1931.