THE ARTIFICIAL DISPERSION OF FOG.

THE SOLUTION OF A MUNICIPAL ENGINEERING PROBLEM.

BY M. M. DIBOS.

Fog is a frequent cause of inconvenience and accident in city and country, and it has occasioned more than one fatal railway collision, but it is still more dangerous at sea and is accountable for the majority of shipwrecks. In recent years a means of communication between fog-bound vessels has been afforded by wireless telegraphy, but comparatively few vessels are yet equipped with wireless apparatus.

Let us examine the conditions of formation of fog. If the temperature falls below the dew point, some of the aqueous vapor in the atmosphere immediately condenses in fine drops which remain suspended because of their lightness and the resistance which the air opposes to their fall. These suspended drops of water constitute fogs and mists.

Maritime regions, such as the eastern coast of America, Norway, the British Isles, etc., the shores of which are washed by the warm waters of the Gulf Stream, are frequently covered by fogs and mists, caused by the evaporation of those waters and the condensation of the resulting vapor by contact with the cooler air. The density of such a fog is proportional to the difference of temperature between the air and the sea or the ground.

Aitken has proved that the presence in the air of solid particles is an essential condition of the formation of fog. The air holds in suspension not only mineral dust, but also organic particles in great variety—infusoria, spores of fungi and other cryptogams, pollen grains, etc. In the course of balloon ascensions I have found that as the elevation increases, the dust in the atmosphere diminishes and disappears entirely at great heights, where the sky is perfectly clear and begins to lose its blue color, which is due chiefly to the presence of water vapor. Both mineral and organic dust, however, are found in greater or less quantity at sea, at very great distances from land, from which the dust is probably carried by violent gales and trade winds. Mineral dust from volcanic eruptions is often found in mid ocean at vast distances from its source.

Large cities and manufacturing towns are covered with fogs of great density and peculiar color, while at sea and in the open country even the densest fogs are colorless. London and the cities of the "Black Country" of England are notorious for the presence of thick black fogs. In France, the fogs of Lyons are especially dense and those of Saint Denis and Aubervilliers, near Paris, are very thick, dark, and fetid.

In support of Aitken's theory, I give a summary of observations of the fogs of a few large cities. Paris, although it can not be classed strictly as a manufacturing city, burns annually 37 kilogrammes of coal for each square meter of its area (7.6 pounds per square foot).

Hence, according to Prof. Gautier's experiments, the production of soot is about 2 grammes per square meter (2.9 grains per square foot), or 160,000 kilogrammes (about 160 tons) in the entire city. This mass of soot settles and forms a grimy coating on all objects.

Similar deposits formed in London and Manchester have been found to contain:

	Percent.
Free carbon	41.5
Solid and liquid hydrocarbons.....	13.1
Various bases	2.1
Sulphuric acid (SO ₃).....	4.6
Hydrochloric acid (HCl).....	1.4
Ammonia in combination.....	1.4
Iron and magnetic oxide of iron.....	2.7
Other mineral substances.....	32.2

The air of Paris contains, in the form of hydrocarbons produced by combustion and soil fermentation, twice as much carbon as is found in country air and one-third more hydrogen, as appears from the accompanying table.

The air of Paris also contains the following combustible gases:

	Parts in 1,000,000 by volume.
Free gaseous hydrogen.....	194
Formene	121
Hydrocarbons of the aromatic series (C _n H _{2n+2}).....	17
Carbon monoxide (with traces of hydrocarbons of the series C _n H _{2n} and C _n H _{2n-2}).....	2

The pollution of the air and the blackening of buildings and monuments are not the worst evils of smoke. Pasteur, Duclaux, Roux, Potain, and others have proved that sunlight is a very active destroyer of microbes, which are killed by the blue, violet and ultra violet rays. Now Tyndall, Gérardin and, in particular, Aitken, have demonstrated that the solid particles of smoke have the singular property of condensing water

	Carbon, Milligrammes in 100 Liters.	Hydrogen, Milligrammes in 100 Liters.	Carbon, Troy Grains in 1 Cubic Foot.	Hydrogen, Troy Grains in 1 Cubic Foot.
Air of Paris.....	12.29	4.32	0.054	0.019
Air of wooded country.....	6.12	3.39	0.027	0.015
Air of high mountains.....	1.19	2.40	0.005	0.0106
Air of the sea	0.02	1.73	0.0008	0.0076

vapor upon themselves and thus forming fogs, which arrest the more refrangible rays, which have the greatest bactericidal power. It has been proved by actinometric measurements that the sun's rays lose from 40 to 50 per cent of their actinic power in the central parts of large English cities and that the light received by the suburbs of these cities is not more than one-third of that which falls at the same season on moderately elevated regions in Switzerland. Depriving large cities of sunlight means depriving them of their most powerful natural means of sanitation. Sir William Ramsay has pointed out the disastrous effects of smoke and the fog which it causes, and English physicians are unanimous in attributing grave diseases, especially tuberculosis, to these agencies.

I assume, then, that the presence of dust or smoke in the atmosphere is almost necessary to the formation of fog. Each solid particle becomes covered with a minute quantity of water. The drops thus formed continue to float in the air, but they are not in stable equilibrium.

Hence it occurred to me that by producing a mechanical shock, a vibration, a wave, in a stratum of fog, it might be possible to precipitate the suspended drops to the ground, and that these drops, in falling, would coalesce with and carry down with them the drops of lower strata in which no such shock had been produced.

Aitken says that if there were no atmospheric dust neither clouds nor fogs would exist, but the excess of water vapor, causing supersaturation, would condense directly on the ground or melt into the sea. There would be dew but no rain. Thus the hydraulic system of the world would be greatly modified.

It is noteworthy that the conversion of storm clouds into rain is brought about by electric discharges between the clouds. This fact suggests a method of the artificial dispersion of fog.

In 1899 I had occasion to test, during a sea voyage of 48 hours, the damaged and repaired engines of a Norwegian steamer. During the first night we ran into a bank of fog of such density that men standing close together on the bridge appeared to each other like silhouettes. We were then about 65 miles northwest of Calais, in calm weather. Standing near a boiler room ventilator, in order to keep warm, we observed that the fog was partially dissipated in front of the mouth of the ventilator, which discharged a stream of hot air.*

By turning the horizontal funnel of the ventilator in various directions we found that the fog was always dispersed within a conical space bounded by the surface of the funnel, prolonged. We then placed in the boiler room a small blower which forced a strong current of hot air through the ventilating pipe and funnel. When the funnel on the bridge was pointed forward the fog was pierced by a tunnel in which objects as far forward as the foremast could be seen. The limit of visibility was 30 meters (about 100 feet). It occurred to me that a longer clear space might be produced by projecting a stream of hot air under pressure. I concluded from my experiments that a conical discharge pipe mounted on the fore-castle and discharging hot air under a pressure of 4 kilogrammes per square centimeter (about 57 pounds per square inch, or 4 atmospheres) would produce a clear space ahead from 200 to 250 meters (658 to 820 feet) in length. This is twice the length of a steamer of medium size, and sufficient to avoid collision in many cases.

Then I constructed an apparatus consisting of an inner and an outer cylinder of sheet steel about ¼ inch thick, and of diameters in the ratio of 5 to 6. The inner cylinder contains air under a pressure of 4 kilogrammes per square centimeter (57 pounds per square inch) and is provided with a safety valve set to that pressure and a manometer. The space between the cylinders is filled with steam from the boiler and has a manometer and a safety valve set to 6 kilogrammes per square centimeter (85 pounds per square inch) as the pressure in ordinary marine boilers does not exceed 5.5 kilogrammes per square centimeter (78

*A still greater effect must be produced over the smoke pipe, but this would not increase visibility in a horizontal plane. Besides, the fog is simply replaced by equally dense smoke.

pounds per square inch). The outer cylinder is covered with a non-conducting jacket and provided with a blow-off cock. The compressed air is discharged through a copper pipe which passes through the top of the outer cylinder and terminates in a horizontal, conical mouthpiece of bronze, 3 inches in diameter. The pipe is pivoted so that the mouth can be turned in any direction. The pressure of the escaping hot air is sufficient to overcome such light winds as accompany fog as well as the relative wind produced by the motion of the vessel, and to extend the fog-dispersing action to a considerable distance—200 meters (656 feet) in my experiments made in 1899, near Boulogne. To the objection that the benefits of this fog disperser are confined to steam vessels it may be answered that it protects sailing vessels by betraying the proximity of steamers. Furthermore it may be operated by steam from the boiler of the hoisting engine which is now a common part of the equipment of sailing vessels and fishing boats.

On reviewing the experiments of Tyndall, Frankland, Rayleigh, Halley, Saussure, Kratzenstein, Faye, Eiffel, etc., and the statements of Kaemtz, confirmed by Aitken's experiments, it appeared to me probable that Hertzian waves, suitably directed, would be more effective than hot air in dispersing fog.

It was necessary to devise special apparatus as the arrangement commonly employed for wireless telegraphy is not suitable for the dispersal of fog. My first apparatus was set up in the winter of 1904 on the roof of a house at Wimereux on the English Channel. An antenna bearing a comb with copper points was maintained at a positive potential of 140,000 volts. The top of the antenna was about 80 feet above the ground, and 180 feet above sea level.

In fog so thick that persons could not be distinguished at a distance of 5 or 6 feet clear spaces from 100 to 120 meters (328 to 394 feet) in diameter were obtained after an average period of emission of 40 minutes. The clear space increased when the faint southerly breeze brought, with the fog, the smoke of Boulogne, 2½ miles away, while with a southwest or west wind, laden with sea fog, the diameter of the clear space did not exceed 100 meters. This seems to show that an admixture of smoke makes fog more sensitive to electric waves and facilitates its dispersion. In the autumn of 1905 I obtained similar results with both static and dynamic sources of electricity.

A priori, a Wimshurst machine appears most appropriate for the production of high potential. Static machines, however, do not work well in damp weather which is precisely the condition in which their highest efficiency is required. Hence dynamo-electric generators, already common on land and on vessels, combined with resonators, furnish more practical means of producing electric waves.

Ashworth has proved that air laden with carbon dioxides, hydrocarbons, exhalations of living organisms or dust is always ionized, and that in air thus contaminated the spark of a static electrical machine is longer than in pure air. Hence it may be inferred that near factories, in cities, over cultivated fields and over certain parts of the sea, the propagation of electric waves is promoted by a pre-existent ionization of the air.

While I was endeavoring to construct a practical fog-dispersing apparatus the distinguished English physicist, Sir Oliver Lodge, had also been attempting to disperse fog by the action of electric waves, and had produced clear spaces from 100 to 110 meters in diameter.

Other things being equal it would appear that intermittent impulses should be more effective than a continuous current. This fact, however, was not manifest at the commencement of the experiments. It is evident that there are atmospheric vagaries which require careful study. I venture to suggest the following plan for the installation of a fog dispersing station. The primary current, produced by accumulators or by a dynamo, traverses the primary circuit of a very large Ruhmkorff coil, giving a spark of about 1 meter. A rotating interrupter and a condenser are intercalated, in parallel, in the primary circuit. The current induced in the secondary circuit is converted from an alternating into an intermittent current by passing through two series of four mercury vapor rectifiers of the Cooper Hewitt type, whence it goes to the inner coatings of two large Leyden jars, of which the outer coatings are connected together. The knob of one jar is connected to earth. From the other (the positive electrode) a wire leads to a crown of points on the top of the antenna mast.

The function of the two series of rectifiers is to maintain constant the direction of the secondary cur-

rent and yet produce positive and negative discharges. The Leyden jars are successively charged and discharged and the resulting electric oscillations are conducted to the antenna. Lodge's apparatus has no earth connection and the discharges are produced between opposing groups of insulated points.

A clear space of 100 meters would be very useful in

harbors, straits, canals, etc., but at sea the desideratum is clearness for 400 meters in every direction from every vessel. On railways even a small clear space around signals would be very valuable. Hence the Northern Railway Company has taken great interest in my experiments, and has installed an experimental apparatus at its Paris terminus. The disper-

sion can be extended indefinitely by a chain of stations. Antennæ of the netting type spread below signals are also to be recommended. The electric waves employed in dispersing fog do not appear to interfere with the ordinary electric signals.—Abstracted for the SCIENTIFIC AMERICAN SUPPLEMENT from Bulletin des Ingénieurs Civils de France.

METEOROLOGICAL PHENOMENA ON MOUNTAIN SUMMITS.*

BY S. P. FERGUSON.

MUCH of our knowledge of the upper air has been obtained from observations made on the summits of mountains. With the single notable exception of the Prussian Aeronautical Observatory near Berlin, where, for several years, daily observations at great heights have been obtained with the aid of kites and balloons, we are still dependent upon the mountain observatories for information concerning annual and seasonal changes in the upper air at different heights, and for other data not easily secured except by means of continuous observations made at the same place. The chief error arising from any general application of such observations is caused by the unknown influence of the mountain itself upon the meteorological conditions in its vicinity. The results from observations in the free air do not show the same vertical changes that are observed on mountains, the diurnal periodic change of temperature noticeable on all mountains disappearing at a height of 1,000 meters in the free air.

A few approximate comparisons have already been made, of Ben Nevis (1,343 meters high) in Scotland by Mr. Dines, and of the Brocken (1,100 meters high) in Germany by Dr. Assmann, but in both instances the kite or balloon observations apparently were made at a distance exceeding 90 kilometers from the mountain observatory. Also, Mr. Clayton has compared the temperature on Blue Hill with that of the free air.

The data obtained indicated that the temperature on mountain summits is lower than that of the free air at the same height. No information as to differences of humidity or wind velocity is available, although it appears quite probable that the wind velocity is higher on mountains than in the free air at the same height.

During the last week in August, 1905, I was able to make a comparison of the weather conditions on Mount Washington, N. H., with those of the free air, by means of kites flown in the Ammonoosuc Valley 16 kilometers west of and 1,500 meters lower than the summit of the mountain. This valley is open toward the west, whence come the prevailing winds, and there are ample open spaces suitable for kite flying.

The meteorological data were obtained from four meteorographs constructed as nearly alike as possible in order to secure uniform action, all having the same scales and each recording the temperature, atmospheric pressure, humidity and velocity of the wind upon a paper-covered cylinder rotated once in twelve hours by a clock. The time-scale was about 25 millimeters an hour and data could be obtained every two minutes. Two of these instruments were employed in recording the conditions on the summit of Mount Washington and at the kite station near Twin Mountain, and two were adapted for use in the kite experiments, being a modified form of the kite meteorograph devised by me for use at the Blue Hill Observatory. All the instruments were carefully compared with standards.

The meteorograph on the summit of the mountain was exposed in the north window of the office of the newspaper Among the Clouds, the editor, Mr. Frank H. Burt, very kindly volunteering to keep it in operation during the experiment. The exposure, so far as temperature, humidity, and pressure are concerned, was very good. The anemometer, which recorded electrically, was placed on the roof of the office near the western end and was well exposed to the winds from all directions except those between northeast and southeast, which were obstructed by the other buildings on the summit.

The kites employed were two Eddy kites respectively of 1.67 and 3.20 square meters area, and two "Blue Hill box" kites, each having a lifting surface of 2.0 square meters. A "hand" windlass containing 3,400 meters of No. 11 music wire, and provided with accurate devices for indicating the length of line employed and for recording the pull of the kites, was employed in flying the kites. The heights reached were chiefly determined from altitudes obtained by means of a transit, though intermediate heights could be obtained from the record of atmospheric pressure.

It was intended to keep one of the kite meteorographs as nearly as possible at the same height as the

summit of Mount Washington, and the other about half as high, and in this way obtain a vertical section of about 1,500 meters; the Twin Mountain station being 427 meters and the summit 1,916 meters above sea level.

The instruments at the summit and kite stations were compared with a standard thermometer three times each day and comparisons of the kite meteorographs were made at the beginning and end of each flight.

After the apparatus was installed there remained but five days for the actual work of observation, and to my surprise, the wind was so exceedingly light throughout the entire period that but two flights could be obtained; during one of which, however, the upper meteorograph was carried to within 60 meters of the height of Mount Washington. An accident to one of the kites prevented more than one observation at this height; but since this appears to be the first time such observations have been made so near a mountain observatory, it may be worth while giving the results in detail.

AUGUST 24, 1905.

Time, P. M.	Conditions at Kite.				Conditions on Mt. Washington, 1,489 Meters Above Valley.			
	Height, Above Valley, in Meters.	Temperature, Deg. C.	Relative Humidity, Per Cent.	Wind Velocity, Meters, per Sec.	Temperature, Deg. C.	Relative Humidity, Per Cent.	Wind Velocity, Meters, per Second.	
3:15	0	22.2	90	6	7.2	52	19	
3:26	267	19.4	90	6	7.2	52	19	
4:11	456	15.6	85	6	6.1	49	20	
4:17	618	14.4	100	13	6.1	30	18	
4:38	970	11.7	80	14	5.6	25	17	
5:02	1,135	11.1	75	12	6.1	28	17	
5:31	1,224	11.0	65	13	6.1	30	15	
5:41	1,408	10.0	65	13	6.1	30	16	
5:43	1,418	9.4	65	13	6.1	33	16	

At 5:44 P. M. one of the two supporting kites collapsed and the other, not being sufficient to support the meteorograph and line until they were reeled in, fell into the forest on the north slope of the "Three Sugar Loaves" (a small mountain 300 meters higher than the kite station) and the flight came to an abrupt end.

Allowing for the difference of level of 61 meters, the observations indicate a decidedly lower temperature and a much higher wind velocity on Mount Washington than are found in the free air. The hygrometers had not been tested below 40 per cent and the comparison of humidities, while indicating a lower humidity on the mountain, is not considered trustworthy.

Unusually clear, fine weather prevailed throughout the time that could be devoted to the experiments and the summits of the mountains were seldom hidden by clouds. On two successive days (August 25 and 26) the average wind velocity on Mount Washington was less than three meters per second, and on several other days it was almost as low. The conditions for kite flying may not be more difficult near mountains than in other places, but the consequences of accidents to the kites, and the fall of the line and apparatus into the dense forests in these regions, demand that unusual precautions be taken to avoid mishaps. A small gasoline motor for quick manipulation of the line during periods of light wind is almost a necessity.

These experiments have also demonstrated the great value of a simple and compact meteorograph in obtaining data at a place like Mount Washington. The time required for changing the records of the instrument employed was about five minutes, or less, each day, the construction of the recording mechanism of the anemometer being such that this operation could be performed at any time convenient to the observer, or even omitted for a day without loss of records by superimposing. After the meteorograph was installed, on August 20, continuous records of the four elements already referred to were maintained until the close of the season on the summit. It was not practicable to record the direction of the wind on this meteorograph except by means of a device indicating only the eight principal directions; and while such approximate

data are useful in studies of climate they are of small value in other meteorological researches.

THE COLUMN OF TRAJAN.

By COMMENDATORE BONI.

UP till recently it has been believed by archæologists that the column was erected to indicate the height of a hill cut away in order to level the area for the Forum Ulpium, but that view does not seem to accord with the writings of ancient writers. Ancient writers state that three years after the column had been built Trajan left Rome for an expedition and died, and was cremated, and his ashes were collected and placed in a golden urn and buried in a sepulchral column. Looking at the bas-reliefs around the base of the column they seemed to represent the acts of a people after the funeral of a hero. Modern topographers have said that the column could not be sepulchral, as there were no traces of a funeral chamber, but last year my attention was attracted to the loophole window on the southern side of the pedestal, like those admitting light into the spiral staircase, and on examination I found that this had been walled up inside. I noticed also that part of the base, which was decorated with a beautiful wreath of laurels, had been broken away; and on closer examination it appeared as if a violent blow had been given to the top of the base. We know that a bronze statue of Trajan formerly stood at the top of the column, and that in the XVIth century a colossal head of Trajan was found, but which has since disappeared; and the conclusion I arrived at is that in early mediæval times the statue shared the fate of many statues which stood on the summits of the arches, and of other monuments of Rome which were pulled down and taken to Constantinople, or put into the melting-pot and made into church bells or pots and pans. Following out this hypothesis, I searched the foot of the pedestal to see if I could discover any fragments of the torus. A grotto had been excavated at the base of the column, probably in the Middle Ages, for the purpose of searching for hidden treasure, and on searching I found the missing fragments of the torus. Afterward I penetrated the grotto and discovered a number of human skeletons, the skulls being like those which came out of the Catacombs. From other indications there was no doubt that buildings existed before the column was built. In the eleventh century also a church was built against the column. There is curious documentary evidence of this in the grant of the monks of land to peasants. Having filled up the grotto, I turned my attention to the entrance, and in the inner vestibule at the base of the column found there were still visible traces of a door which had been walled up and plastered over. I removed the plaster and cut away part of the masonry, and found that the door led into a small atrium, turning to the right, where a second door was discovered. This second door led into a chamber, 10 feet long, 5 feet wide, and 6 feet high, which was the funeral chamber. On the outer wall of the chamber were the bricks which closed up the loophole which had first attracted my attention on the outside. Within this chamber were the remains of a funeral-table 2½ feet high and 4 feet wide, and just above the table in the marble wall of the chamber holes had been drilled in such a way as to suggest that clamps going out from the wall had supported on the table two urns, one toward one end and one toward the other end of the table. An inscription still preserved in the Vatican Lapidarium stated that Hadrian had erected a temple *parentibus suis*, in honor of his parents Trajan and Plotina. This temple had stood close to the column, and as it was the custom to erect such temples close to the burying-place of the persons in whose honor they had been erected, the natural conclusion is that the chamber was a sepulchral chamber, and that the table had supported two urns, containing the ashes of Trajan and his wife, the parents of Hadrian. My conclusion is that the main object of the column is plainly that of a sepulchral monument. Now we have to deal with the inscription, the old interpretation of which was that it indicated the height of the hill which by so much labor had been cut and carried away. The inscription read: "AD. DECLARANDVM. QVANTAE. ALTITVDINIS. MONS. ET. LOCVS. TANTIS. OPERIBVS.

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