

cent for manufacturing fuel, 27 per cent for domestic fuel, and 9 per cent was made into coke.

THE ALCHEMY OF HOAR-FROST.*

By ARTHUR H. BELL.

COOLED surfaces are nature's plates, upon which she etches some of her most beautiful pictures. In this artistic work she employs many materials, but her choicest effects are obtained through the medium of hoar-frost. Commonly, hoar-frost is described as being merely frozen moisture, but this is not an adequate description of an agent that has the power of adorning in a few hours such prosaic objects as gate-posts and dust-bins with all the trappings of fairyland. Moisture is indeed the fabric out of which all this feathery whiteness is built up, but, although it seems sometimes as if it is distributed in a very capricious manner, there are nevertheless certain definite circumstances which cause the hoar-frost to settle down on some surfaces rather than on others.

On any cold and frosty morning it will usually be found that those surfaces that are the best radiators of heat are also those that are most successful in collecting hoar-frost. It is not always realized, however, that all objects are continually radiating heat, so that no matter how much they may receive from the sun, they are constantly trying to get rid of it. A fern leaf, or a stone, may perhaps receive generous supplies of heat during the day, but as soon as night comes it hurries to spend or radiate it, and the object that is quickest at this work will the soonest become covered with hoar-frost. Everyone has observed how the moisture from the air will settle on the outside of a glass of cold water brought suddenly into a warm room. A similar process takes place in the open air, so that as the currents of moist air travel across surfaces that are very cold they pay tribute in drops of vapor, which in warm weather take the form of dew, and in cold of hoar-frost. Moisture, therefore, plays a very important part in the development of these hoar-frost pictures; but there must not be too much of it. Some of the most delicate designs occur during the prevalence of mist and haze, and in towns especially it is no uncommon thing for a choking brumous fog to be in some degree compensated for by a subsequent display of copious hoar-frost. As regards discovering what kind of surfaces are best adapted for collecting hoar-frost it may, in passing, be said that a very instructive and entertaining series of observations may be obtained by exposing to the frost cups, dishes, tumblers, saucers and other glass and china ware, which will be found to accumulate hoar-frost in a varying degree. A brief contemplation of these differences will clearly demonstrate the fact that it is those objects that cool the quickest that make the speediest responses to the alchemy of frost.

In certain parts of the world agriculturists protect their crops from damage by frost by setting light to heaps of rubbish, thus producing clouds of smoke, which check the radiation of heat from the surface of the ground. By this means frosts are warded off and the life of susceptible plants is prolonged. A similar thing happens when real clouds float overhead, it being a common experience that no dew or hoar-frost forms when the night is cloudy. In other words, a canopy of clouds acts toward the earth as an overcoat and prevents the loss of the heat which it received from the sun during the day; for no sooner does this heat attempt to escape into space than the clouds reflect it earthward again, and they form indeed a veritable trap for sunbeams. But when the air is damp and the stars are shining brightly, the thermometer at the same time being ten or more degrees below the freezing point, everything will be dusted over with fragile flowers of frost, and more especially if there happens to be little or no wind.

During very many years it has been a popular superstition that it is injurious to sleep with the moon shining on one's head. From what has already been said as to the way in which moisture promptly settles on all objects that are radiating their heat quickly, it will be gathered that it is not so much the moonbeams that work the mischief as the loss of warmth and the deposition of moisture which falls on all surfaces exposed to the sky on cold and cloudless nights, when dew and hoar-frost are most abundant.

It is, further, not commonly realized that the atmosphere acts as regards moisture very like a sponge. According to this conception of the case the air is not only able to absorb large quantities of water, but it is also able to retain it; and it is only when something happens to squeeze the atmosphere, as the process may be termed, that the hold on this moisture is relinquished. This squeezing of the atmosphere takes place whenever there is a fall in temperature, this being the great agent or force that precipitates the moisture from the air and causes it to take the form of rain, hail, snow, fog, dew, or hoar-frost; these various forms being regulated by the conditions of the atmosphere. Although the air parts so readily with its stores of moisture when the temperature falls, it is to be observed that an increase of temperature greatly enlarges its capacity for moisture. A cubic foot of air having a temperature of 32 deg. can accommodate only 2.13 grains of moisture; but supposing the temperature to be increased to 72 deg. there would then be room for 8.47 grains. It will therefore readily be understood that in looking out for copious displays of hoar-frost, the best pictures will be observed if during moist weather a body of air having a high temperature is suddenly reduced to the freezing point.

One of the best ways of keeping a jar of water cool is to wrap a damp cloth round it; the evaporation of the moisture producing loss of heat. In hot climates this circumstance is, indeed, made of practical service as regards the manufacture of ice, for so intense is nocturnal evaporation of moisture, that it is found that if water is placed in shallow porous pans overnight, there is a welcome supply of ice in the morning. When, therefore, moisture is evaporating into the atmosphere there is always a loss of heat, so that the greater the amount of vapor passing into the air the greater the amount of heat used up.

It is an interesting fact that when hoar-frost, or

dew, or any of the other children of aqueous vapor, spring into being, this heat reappears, or as it is sometimes conveniently described, latent heat is set free. As regards rainfall the amount of heat liberated is, of course, greater than is the case with hoar-frost. A fall of one inch of rain means that over every acre of ground a weight of one hundred tons of water has fallen, or 60,000 tons to the square mile. Put in another way, this downpour over such a well-known area as the Thames Valley means that 53,000,000,000 gallons of water have been precipitated from the atmosphere. It has been calculated that the condensation of one gallon of rain gives out enough latent heat to melt 75 pounds of ice, or to melt 45 pounds of cast iron. From these figures the mathematically inclined may work out for themselves the amount of heat set free in some tropical downpour when the rain instead of being an inch in depth, is seven or eight. That this liberated heat has great effect on the temperature and movements of the air goes without saying, but this part of the subject must not here be further pursued. It is now sufficient to say that just in the same way that condensing rain gives out heat, so do hoar-frost and dew, and a recognition of this fact has resulted in the suggestion of a rule for foretelling the occurrence of hoar-frost.

The success of this prognostic depends on the fact of there being an intimate relation between the deposition of hoar-frost and the temperature of the dew point, as it is termed. Reference was made above to the circumstance that the amount of moisture a given body of air can hold depends on its temperature. Thus at a temperature of 52 deg. a cubic foot of air is capable of giving accommodation to 4.39 grains of vapor, but at 32 deg. there is room only for 2.13 grains. If, therefore, a body of air at the former temperature is suddenly cooled, its capacity for moisture is correspondingly reduced and some of the aqueous vapor spills over, as it were, or is condensed. From this it will be seen that there is a critical temperature below which any vapor-laden air cannot be reduced without some of the moisture spilling over; this critical temperature being called the dew point. A glass of cold water (to repeat an illustration), when brought into a warm room, reduces the temperature of the air in contact with it to the dew point, so that drops of moisture form on the outside of the glass. Instruments that give the temperature to which the air is thus reduced are called hygrometers, and during frosty weather, as already suggested, a knowledge of this dew point may become exceedingly useful.

If, for instance, in the evening, the hygrometer shows the dew point to be above 32 deg., in the majority of cases there will be no hoar-frost that night. On the other hand, if the dew point is below 32 deg., and if there is a moderate amount of moisture in the air, plenty of hoar-frost may be expected. From what has previously been said it will be seen that this prognostic is capable of a very simple explanation. Latent heat is set free when condensation of moisture takes place, so that when the dew point is above 32 deg., any deposition of moisture results in a little warmth appearing, which is often quite sufficient to ward off hoar-frost. On the other hand, with a dew point below 32 deg., these hidden stores of heat are not sufficient to hold in check the advance of the icy spicules.

But probably the most interesting fact in connection with hoar-frost is its growth, it being no uncommon thing to see favorable surfaces literally submerged in a frosty mantle. Hoar-frost, moreover, is better suited by an atmosphere where moisture is plentiful than when it is not so abundant, these latter conditions being more favorable for the birth of dew-drops. Another consideration is that moisture may be reduced below the freezing point without congealing. It is a common experiment thus to treat moisture, although the slightest shaking of this cooled liquid is enough to change it promptly to a solid form. Similarly as regards the moisture in the atmosphere, there are excellent reasons for supposing that in certain circumstances the vapor may be a degree or two below the freezing point without actually solidifying, and is only waiting the touch that will turn it into a feathery frond of ice. Supposing, then, that moist air in this condition is gently wafted against a bush, a fence, or a blade of grass, the shock, though slight, is quite enough to work a magical transformation. The greater part of these frost effects are thus prepared in the air, and as each body of chilled vapor floats against an object having already upon it a covering of frost, it is, as it were, roused by the shock, and awakening, promptly adds its load of frozen crystals to the growing picture.

HOW ANIMALS FIGHT.

THERE are no wild beasts in Europe suitable for the combats which Orientals love, or they would certainly have been utilized. Wolves look very promising, and it might be thought that such an ill-tempered animal as the Russian bear could easily be roused to fight a comrade; but we may be sure that the experiment was tried often enough to prove that in neither case was it worth while to make a match. So our forefathers had to be content with the hideous sport of "baiting"—which is not our theme. Had they possessed more ingenuity, however, some diversion might have been obtained from stags. Even antelopes are used in India, though they need training. It is their nature to fight only at the rutting season; to make them eager for the fray at any time they must receive special treatment, and above all they must be kept in practice. But that means a great "consumption" of antelopes, for they battle to the death, and this variety of entertainment, therefore, is not common. Elephants and tigers are the favorite victims, of course; but nothing profitable can be said about their duels and certainly nothing amusing.

A camel fight is rather curious. The brutes have a pair of teeth far back in the jaw, which rival those of a tiger, and an old male is extremely ferocious. Knowing, however, that these, their most terrible weapons, are useless in a front attack—for vast as the camel's gape is, it cannot be stretched wide enough to bring them into action—they never try to grip the head or neck or any vital part of an antagonist. All their strategy is directed to the object of seizing one of his

legs below the knee, and thus overthrowing him by pressure; then the huge back teeth can be brought to bear upon his throat, and he is no better than a corpse. There are those who deny that the camel has any sense at all, and they appeal to everybody who knows the beast by experience. But the rule laid down by Pope is justified in this instance also—

"Its proper power to hurt each creature feels."

Bulls push their horns and asses lift their heels." The camel's way of fighting is mean and awkward—the *coup de Jarnac* of quadrupeds. But it is the one best suited to its anatomy. A very strong stomach, however, and a nose which has lost the sense of smell are required to enjoy this spectacle.

Of all combats between beasts, perhaps that between a horse and a tiger is the most thrilling. We have read several descriptions, and always, if we remember right, the horse was the victor. But it must be a stallion, as cunning as brave. To avoid the tiger's spring, in a walled area of limited extent, is impossible. The horse does not try; it is only careful to face the enemy, turning on the same spot as he circles round. At length the spring is made; it sinks its fore-quarters till the knees almost touch the ground, and the tiger lights, unsteadily, upon its haunches. Instantly the hind legs lash out, with such force that the brute is thrown headlong, and if it does not recover its feet in a second the battle is over, so rapid and so heavy are the kicks bestowed. In general, however, there is another "round" exactly similar, and the tiger confesses itself beaten.

Such a match, like a fight of camels, has some interest; but the "hammer and tongs" struggle between two elephants, or an elephant and a rhinoceros, must be always as dull in reality as in description. Lions and tigers are not much more scientific in their methods. Oriental ingenuity, however, has devised some eccentricities in this line. The old Greeks loved a quail fight, and the sport is to be witnessed occasionally in southern Europe. Partridges are used in India. That curious book, "The Private Life of an Eastern King," which made a stir in our grandfathers' time, gives a lively account of the diversion as practised at the Court of Oude. When the table was cleared every evening after dinner two cock partridges were introduced. They trotted about, comfortably and friendly, being familiar with man, until a hen dropped between them.

There is a fable of Lafontaine's, loved by French children, which begins, "*Deux coqs vivaient en paix—advint une poule.*" etc. Its truth to nature was demonstrated by the conduct of those partridges, hitherto friendly, which ruffled their feathers, crowed, and engaged upon the spot. The king would have half-a-dozen "mains" before adjourning for more sophisticated amusements in the "drawing-room." Crows were substituted for the partridges sometimes, but the stupid chronicler only mentions this without giving any details of the proceedings. A crow fight should be droll. But "they went one better" in Manipur. Before the war, while the Maharajah and his noble kin spent all their time in diversion, and employed the public revenue for that object only, the aristocratic sports were polo and pigeon-fighting. The latter does not seem to promise much amusement; but very few of us can judge, for who in this country has seen two doves in mortal combat? Somehow the nobles of Manipur contrived to get up a match, and they found it quite desperately exciting.

Common pigeons there, such as nature designs for pies, fetched three halfpence apiece, while a proved specimen of the warrior class was valued at £3 or £4. But how they bore themselves in fight is a mystery. Mrs. Grimwood often saw a match as she passed along the streets near the palace, but she could never understand how it was going. The birds beat each other with their wings, cooing loudly, and presently the victor was acclaimed—for no apparent reason. But the excitement of the owners and spectators was intense—the betting furious. When Princes of the blood, who were a multitude, lost more than they could pay, as a matter of course, they drew upon the Maharajah. His patience gave way at last, and edict forbade any of the royal line to engage in a sport of such fatal fascination. But a bird almost more unlikely than the pigeon has been induced to fight. Sir Hope Grant witnessed a battle of nightingales or bulbuls, and he says too briefly that "It was amusing enough in its way."

The horse fights of the Northmen must not be overlooked. It was a sport not unworthy of them, for they took part in it themselves, and risked their lives. The owner or a friend attended his stallion to the fray, carrying a short stick, with which he hit it at the psychological moment—that is, at the crisis of the battle. Anyone who has seen well-bred fighting will understand that this would be a service of great danger, the stick being short. But also it was the duty of the champion to "assist" his horse when it rose on its hind legs to attack.

How he assisted it, we cannot tell, but evidently he must have been quite close—sometimes, no doubt, between the furious brutes. Besides these obvious risks, there was a strong probability that he might strike his antagonist's horse, or even the antagonist himself, and, whether this were done by accident or by an impulse of passion, signified little. In either case the blow must be avenged, unless the rivals were personal friends. A certain Eygulf hit his own stallion, and the stick, rebounding, touched Bjarni's shoulder—showing, by the way, how very close they must have been, horses and men, in the heat of the fray.

He instantly apologized, offering sixty sheep if Bjarni would overlook the accident, and the latter replied that it was his own fault; for there was no ill-feeling between them. But, of course, he expected the sheep. In due time Eygulf looked them out, and Bjarni came to receive them. Thermod, Eygulf's father, was present, and remarked, quite mildly, as we should think, that sixty sheep were a "lot." Actually no more than that—but Bjarni struck him dead. A blood feud followed. But if a charge of foul play were made, and the parties concerned were men of influence, all the people of each district would take sides. Odd, "an overbearing fellow," struck Gretti, who, diving under his horse, which was on its hind legs, delivered such a thrust that he knocked Odd into the river,

* Knowledge.