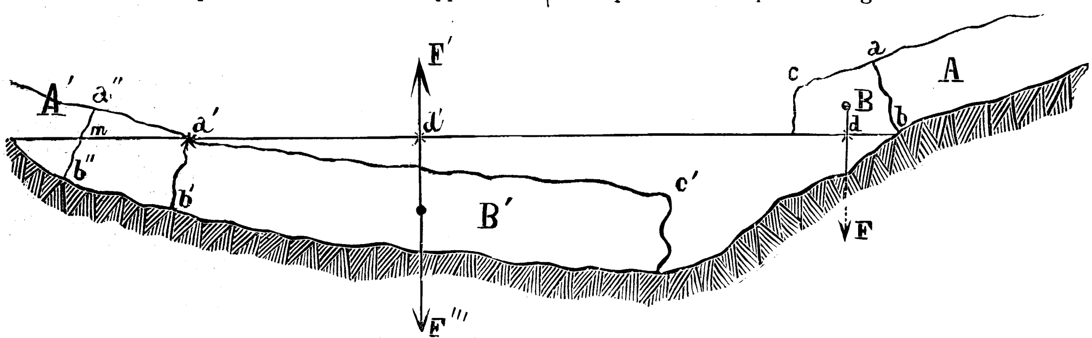
kinds of forces are acting simultaneously upon the same glacier, and while huge icy mountains are at intervals of centuries rising from their dense, watery bed, other and smaller ones are more frequently dropping from its sea-ward face, for those formed by dropping are far smaller than those which rise into the sea, as the following diagram will serve to show. Although about seven-eighths of an iceberg is submerged, it must not be inferred that, when its height has been determined, seven times that height is its depth below the sea level. If of a tabular shape, this proportion becomes more nearly correct; but if of a pyramidal or conoidal cross section, which is far oftener the case, the lineal proportions of height to depth approach each other more closely, while the volumes, necessary to hydrostatic equilibrium, remain invariable. Their great height, as compared with their breadth shows that these lineal proportions do not obtain beneath the sea level, or the mass, if homogeneous could not be in a state of stable equilibrium, and would topple over, which sometimes happens when the conditions of equilibrium are disturbed by the unsymetrical decrease of its different faces.

The height of bergs, estimated or measured by various Arctic voyagers, varies greatly. During the warm months of summer, when they are most frequently encountered by navigators, they are often surrounded by a hazy mist, due to the condensation of the surrounding moisture by their chilly faces, and the effect is to make them appear much higher than they really are, and to render estimates of their height particularly unreliable.

As about seven-eighths of an iceberg is under water, the curious spectacle, which has often been seen in Polar latitudes, of these monsters ploughing their way against a rapid current, loaded with heavy pack-ice, and in the very teeth of a strong gale of wind, can be readily understood on the theory that the surface current is shallow, and the drifting colossus is only obeying the mandates of a deeper and more powerful agent.



ON HEAT CONDUCTION IN HIGHLY RAREFIED AIR.*

By William Crookes, F.R.S.

The transfer of heat across air of different densities has been examined by various experimentalists, the general result being that heat conduction is almost independent of pressure. Winkelmann (*Pogg. Ann.*, 1875, 76) measured the velocity of cooling of a thermometer in a vessel filled with the gas to be examined. The difficulty of these experiments lies in the circumstance that the cooling is caused not only by the conduction of the gas which surrounds the cooling body, but that also the currents of the gas and, above all, radiation play an important part. Winkelmann eliminated the action of currents by altering the pressure of the gas between 760 and 1 millim. (with decreasing pressure the action of gas currents becomes less); and he obtained data for eliminating the action of radiation by varying the dimensions of the outer vessel. He found that, whereas a lowering of the pressure from 760 to 91.4 millims. there was a change of only 1.4 per cent. in the value for the velocity of cooling, on further diminution of the pressure to 4.7 millims. there was a further decrease of 11 per cent., and this decrease continued when the pressure was further lowered to 1.92 millim.

About the same time Kundt and Warburg (*Pogg. Ann.*, 1874, 5) carried out similar experiments, increasing the exhaustion to much higher points, but without giving measurements of the pressure below 1 millim. They enclosed a thermometer in a glass bulb connected with a mercury pump, and heated it to a higher temperature than the highest point at which observations were to be taken; then left it to itself, and noted the time it took to fall through a certain number of degrees. They found that between 10 millims. and 1 millim. the time of cooling from 60° to 20° was independent of the pressure: on the contrary, at 150 millims. pressure the rate was one and a half times as great as at 750 millims. Many precautions were taken to secure accuracy, but no measure ments of higher exhaustions being given the results lack quantitative value.

It appears, therefore, that a thermometer cools slower in a so-called vacuum than in air of atmospheric pressure. In dense air convection currents have a considerable share in the action, but the law of cooling in vacua so high that we may neglect convection has not to my knowledge been determined. Some years ago Professor Stokes suggested to me to examine this point, but finding that Kundt and Warburg were working in the same direction it was not thought worth going over the same ground, and the experiments were only tried up to a certain point, and then set aside. The data which these experiments would have given are now required for the discussion of some results on the viscosity of gases, which I hope to lay before the Society in the course of a few weeks; I have therefore completed them so as to embody the results in the form of a short paper.

An accurate thermometer with pretty open scale was enclosed in a 1½ inch glass globe, the bulb of the thermometer being in the centre, and the stem being enclosed in the tube leading from the glass globe to the pump.

Experiments were tried in two ways:—

I. The glass globe (at the various exhaustions) was immersed in nearly boiling water, and when the temperature was stationary it was taken out, wiped dry, and allowed to cool in the air, the number of seconds occupied for each sink of 5° being noted.

II. The globe was first brought to a uniform temperature in a vessel of water at 25°, and was then suddenly plunged into a large vessel of water at 65°. The bulk of hot water was such that the temperature remained sensibly the same during the continuance of each experiment. The number of seconds required for the thermometer to rise from 25° to 50° was registered as in the first case.

* Abstract of a Paper read before the Royal Society, Dec. 16, 1880.

It was found that the second form of experiment gave the most uniform results; the method by cooling being less accurate, owing to currents of air in the room, etc. The results are embodied in the following Table:—

(Rate of Heating from 25° to 50°.)

TABLE I.

Pressure.	Temperature.	Seconds occupied in rising each 5°.	Total number of seconds occupied.
760 millims.	25°	0	0
	25 to 30	15	15
	30 to 35	18	33
	35 to 40	22	55
	40 to 45	27	82
	45 to 50	39	121
1 millim.	25°	0	0
	25 to 30	20	20
	30 to 35	23	43
	35 to 40	25	68
	40 to 45	34	102
	45 to 50	48	150
620 M.*	25°	0	0
	25 to 30	20	20
	30 to 35	23	43
	35 to 40	29	72
	40 to 45	37	109
	45 to 50	53	162
117 M.	25°	0	0
	25 to 30	23	23
	30 to 35	23	46
	35 to 40	32	78
	40 to 45	44	122
	45 to 50	61	183
59 M.	25°	0	0
	25 to 30	25	25
	30 to 35	30	55
	35 to 40	36	91
	40 to 45	45	136
	45 to 50	67	203
23 M.	25°	0	0
	25 to 30	28	28
	30 to 35	33	61
	35 to 40	41	102
	40 to 45	55	157
	45 to 50	70	227
12 M.	25°	0	0
	25 to 30	30	30
	30 to 35	37	67
	35 to 40	41	108
	40 to 45	58	166
	45 to 50	86	252
5 M.	25°	0	0
	25 to 30	38	38
	30 to 35	43	81
	35 to 40	54	135
	40 to 45	71	206
	45 to 50	116	322
2 M	25°	0	0
	25 to 30	41	41
	30 to 35	51	92
	35 to 40	65	157
	40 to 45	90	247
	45 to 50	165	412

There are two ways in which heat can get from the glass globe to the thermometer—(1) By radiation across the intervening space; (2) by communicating an increase of motion to the molecules of the gas, which carry it to the thermometer. It is quite conceivable that a considerable part, especially in the case of heat of low refrangibility, may be transferred by "carriage," as I will call it to distinguish it from convection, which is different, and yet that we should not perceive much diminution of transference, and consequently much diminution of rate of rise with increased exhaustion, so long as we work with ordinary exhaustions up to 1 millim. or so. For if, on the one hand, there are fewer molecules impinging on the warm body (which is adverse to the carriage of heat), yet on the other the mean length of path between collisions is increased, so that the augmented motion is carried further. The number of steps by which the temperature passes from the warmer to the cooler body is diminished, and accordingly the value of each step is increased. Hence the increase in the difference of velocity before and after impact may make up for the diminution in the number of molecules impinging. It is therefore conceivable that it may not be till such high exhaustions are reached that the mean length of path between collisions becomes comparable with the diameter of the case, that further exhaustion produces a notable fall in the rate at which heat is conveyed from the case to the thermometer.

The above experiments show that there *is* a notable fall, a reduction of pressure from 5 M. to 2 M. producing twice as much fall in the rate as is obtained by the whole exhaustion from 760 millims. to 1 millim. We may legitimately infer that each additional diminution of a millionth would produce a still greater retardation of cooling, so that in such vacua as exist in planetary space the loss of heat—which in that case would only take place by radiation—would be exceedingly slow.

*M=millionth of an atmosphere.

PROFESSOR HUXLEY ON EVOLUTION.

At a recent meeting of the Zoological Society, among the papers read was one by Professor Huxley on the application of the laws of evolution to the arrangement of the vertebrata, and more particularly mammalia. The illustrations adduced were those of the history of the horse, principally, so far as is known, from the work of Professor Marsh on the Eocenes of North America. The announcement of the paper had drawn together an unusually large attendance, as it was expected that the marshalling of the facts in Professor Huxley's hands would have great interest in practically substantiating the theory of evolution, which, though foreshadowed by others, took practical shape in the work of Darwin twenty-one years ago.

Professor Huxley began by saying:—There is evidence, the value of which has not been disputed, and which, in my judgment, amounts to proof, that between the commencement of the tertiary epoch and the present time the group of the equidæ has been represented by a series of forms, of which the oldest is that which departs least from the general type of structure of the higher mammalia, while the latest is that which most widely differs from that type. In fact, the earliest known equine animal possesses four complete sub-equal digits on the fore foot, three on the hind foot; the ulna is complete and distinct from the radius; the fibula is complete and distinct from the tibia; there are 44 teeth, the full number of canines being present, and the cheek-teeth having short crowns with simple patterns and early-formed roots. The latest, on the other hand, has only one complete digit on each foot, the rest being represented by rudiments; the ulna is reduced and partially anchylosed with the radius; the fibula is still more reduced and partially anchylosed with the tibia; the canine teeth are partially or completely suppressed in the females; the first cheek-teeth usually remain undeveloped, and when they appear are very small; the other cheek-teeth have long crowns, with highly complicated patterns and late-formed roots. The equidæ of the intermediate ages exhibit intermediate characters. With respect to the interpretation of these facts two hypotheses