THE EFFECT OF AIR PRESSURE ON ANIMAL LIFE.

In our issue of June 20 we described the important discoveries recently made by M. Bert, in relation to the influence which modifications in barometric pressure exercise upon the phenomena of life. M. Bert's investigations have necessarily been directed to two diametrically opposite conditions, the diminution of pressure and the augmentation of the same; and in our former article we explained the results obtained by researches conducted under the first mentioned circumstances. From an industrial point of view, the examination of the effects of compressed air upon the system, which we now propose to follow, is especially interesting because of the many cases, as in bridge building, diving, etc., in which workmen are obliged to labor in such an atmosphere.

A careful distinction, M. Bert says, must be made between the effects of the mere compression itself and those of a sudden decompression. To illustrate the influence of the latter proceeding upon animals, the apparatus shown in Fig. 1 was constructed. This was a large cylinder of sheet steel into which air was forced by the pump, C, actuated by the gearing at A. At D a worm coil was placed in cold water in order to refrigerate the air, and at E a recipient for the condensed moisture in the blast. *b* is a manometer, and *c* a large valve which, on being opened, allows the compressed air to escape, producing a sudden decompression within the cylinder.

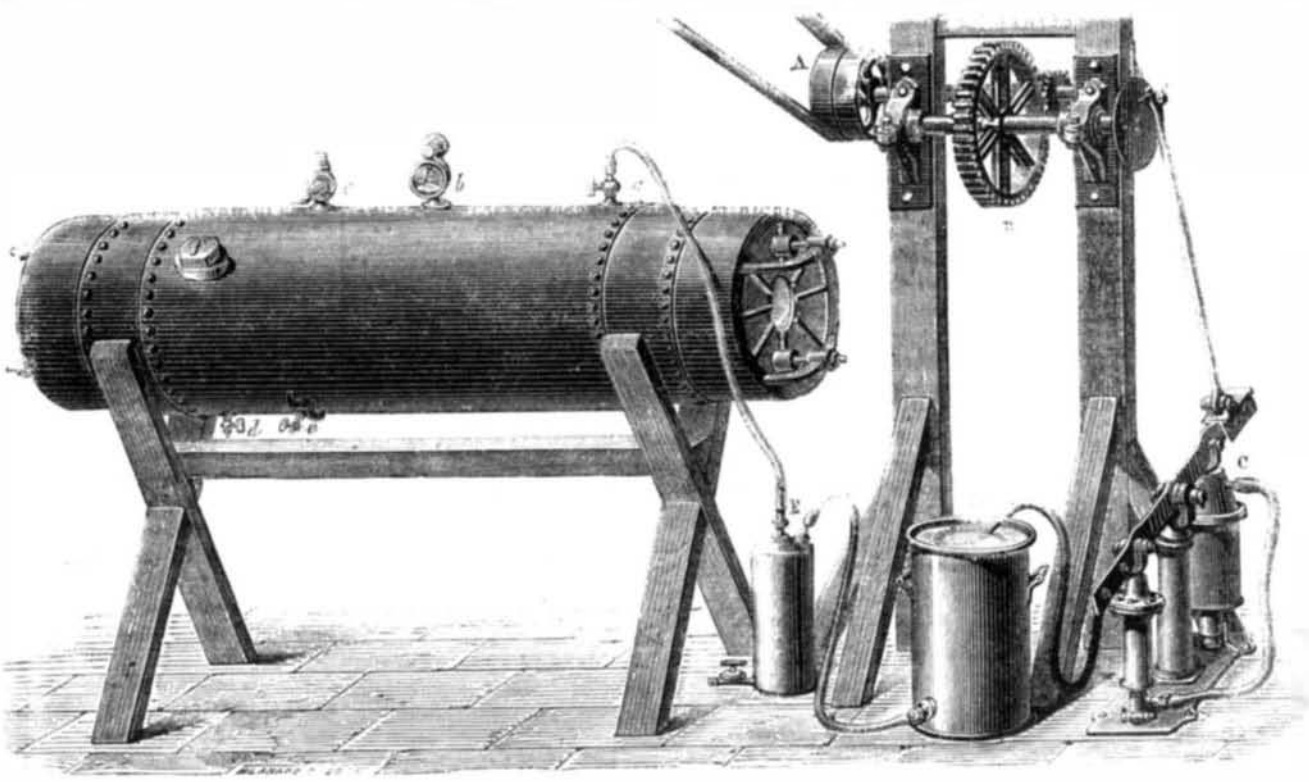

Fig. 1.—APPRATUS FOR SHOWING THE EFFECTS OF COMPRESSED AIR.

Inside the last mentioned receptacle a dog was placed, and air forced in to a pressure of eight atmospheres. After maintaining this pressure for three or four minutes, the escape cock was opened, allowing equilibrium with the exterior air. The animal was then removed, but exhibited no distress, running about the laboratory as if perfectly uninjured. In a short time, however, its motions became feeble, its hind portions appeared to be paralyzed and dragged upon the floor, then the other members became similarly affected, and respiration ceased. On opening the body the vessels were found filled with a mixture of gas and blood, and the heart contained clots. The gas, on examination, proved to be nitrogen with a small admixture of carbonic acid.

From this experiment M. Bert concludes that, under the influence of compression, the nitrogen of the air becomes dissolved in the blood in increasing proportions, just as carbonic acid becomes taken up in water in making the so called soda water. On suddenly removing the compressing force, the gas passes to a free state, its bubbles become more numerous, rendering the blood foamy, obstructing the circulation, causing paralysis, and finally death. Nor is the blood alone thus charged with the gas, for the latter penetrates to every humor of the body, even to the tissues, the interior of the eyes, and the liquid which bathes the spinal marrow.

When the pressure is at about seven atmospheres, the results are not so grave. A paralysis of the posterior portions and often sharp pain ensue, but the effects may be passing. If, however, the pressure be stronger, the gas is disengaged so suddenly that death is instantaneous. Thus an explanation is found for the serious maladies which have attacked laborers working in compressed air, and for the paralysis which frequently happens when the pressure is above three and a half atmospheres.

Passing from these results of sudden decompression and compression, we are led to consider those due to compression itself. To this end M. Bert has devised another apparatus, shown in Fig. 2, which consists of a cylinder capable of withstanding twenty-five atmospheres, a bag containing oxygen, a compressing pump, and pipes enveloping the latter, so as to cover it with a current of water. A bird was placed in the cylinder, and air forced in to ten atmospheres, without appreciable effect. When, however, for air, oxygen was substituted, the animal was taken with strong convulsions, and quickly died. To obtain the same result with air, twenty-five atmospheres' pressure was required. Conversely, however, if air at the above pressure was used, deprived in great measure of its oxygen, it became harmless. These experiments, exactly counter to those described in our previous article, tend more conclusively to show that mortal convulsions are due to the tension of the oxygen and not to the degree of physical compression, and that oxygen, in certain quantities, acts as a violent poison, similar in effect to strychnine and like substances, which excite the spinal nerves.

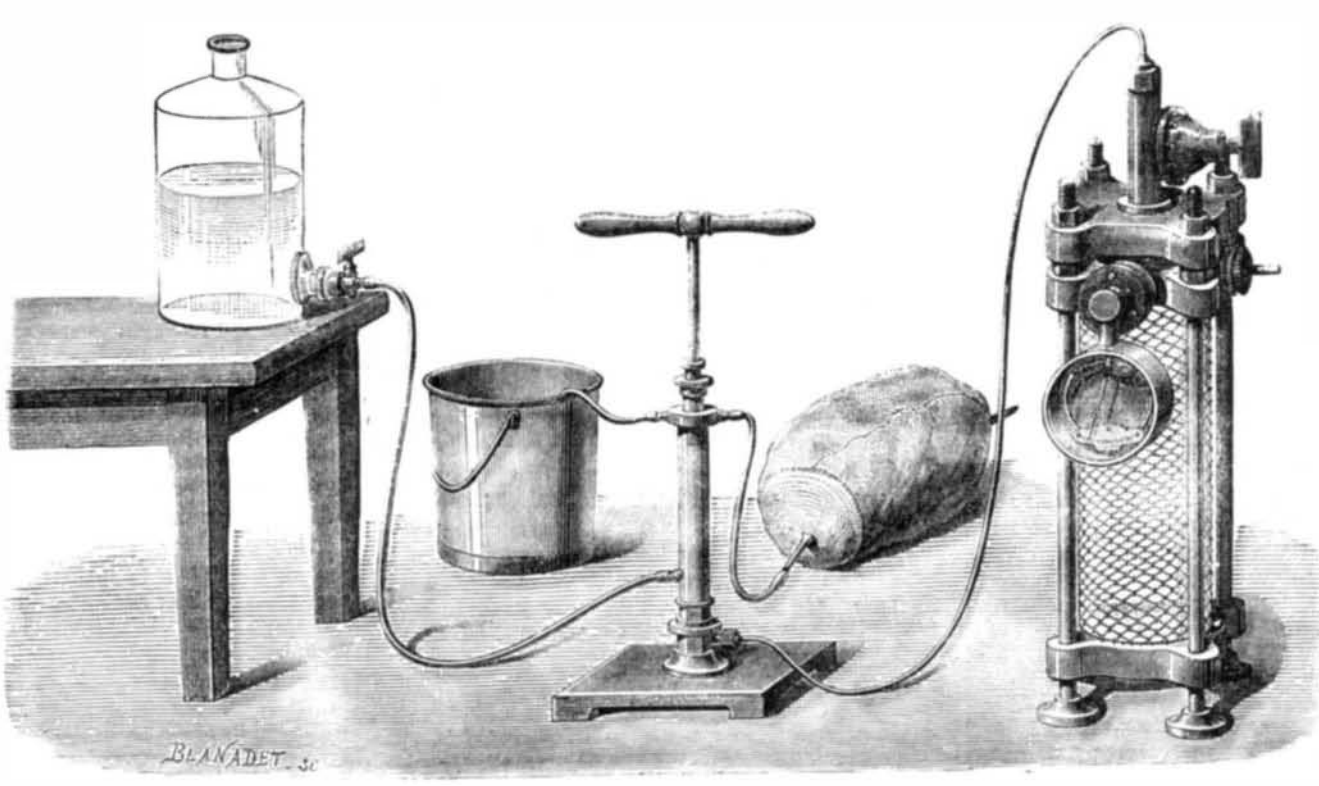

Fig. 2.—APPRATUS FOR SHOWING THE EFFECTS OF OXYGEN AND AIR.

This is not because the quantity of oxygen undergoes a notable augmentation in the blood, for M. Bert's analyses have shown that, from the normal pressure, but little more than 1 volume of oxygen to 100 volumes of blood is added by each additional atmosphere of compression. Hence the first cause of the deadly effect does not lie in alterations of the blood. Nor, in fact, are the results only observable upon larger animals; not only are creatures, both cold and warm blooded, having diffused nervous systems, as articulates or mollusks, thus affected, but even the vegetables do not escape. The terrible action controls microscopic animalculæ, infusoria, and the *mucedinæ*, which cause certain fermentations. The effect is only explained by the supposition that the oxygen acts upon the elementary particles of the body so as to arrest or modify injuriously the chemical functions of which they are the agents. Hence the general accidents, convulsions, and death.

It would seem that the phenomena produced by overdoses of oxygen would consist in strong oxidations; that the tissues of the body, in other words, would be burnt up. Strange to say, just the reverse takes place. Animals become rapidly cooler, and produce little carbonic acid and urea; and, in brief, oxygen in excess arrests oxidation.

The practical industrial utilization of M. Bert's discoveries readily suggests itself. Divers, it has been noticed, experience pains in the chest when some 160 feet beneath the surface, and the same sensations are felt by laborers working under a pressure of five atmospheres. These troubles are incontrovertibly due to an excess of oxygen, and it only remains to supply air poor in that gas. The mechanical arrangements to this end are easily constructed for caissons and fixed structures, but some ingenuity will be needed to devise apparatus for divers who work under constantly changing pressures. Hydrogen or nitrogen could be used to dilute the air.

The author deduces from his investigations a number of interesting conclusions regarding the past and present conditions of life upon the earth, which may be briefly summarized as follows:

1. Temperature being left out of consideration, there is for animals and vegetables upon high mountains an impassable limit, which varies with the species. This is one of the causes of geographical distribution governed by latitude. 2. There would exist a like limit at shallow depths in the water of the ocean, if the same contained oxygen and nitrogen in solution, according to Dalton's law. A stream of air rushing from the bottom would extinguish all life met on its upward course. The varying richness in oxygen of the different currents, at different depths, has perhaps some influence on submarine geographical distribution. 3. At primitive geological epochs, when the pressure of our atmosphere was much stronger than it now is, the conditions of life were very different from those at present; and if, as is asserted by geologists, our atmosphere, by the cooling of the interior of the earth, tends to penetrate into the substance of the latter, then we are approaching a condition when beings like ourselves will be suffocated, exactly as we now are at very high elevations. 4. It is wrong to teach that vegetables appeared upon the globe before the animals, in order to purify the air of its carbonic acid. Germination, of mold even, cannot take place in air sufficiently charged with carbonic acid to be mortal to warm-blooded animals. 5. It is equally erroneous that, for some such similar reason, reptiles first appeared, or that they could breathe air which warm blooded animals could not. The exact reverse is the case, as the reptiles fear carbonic acid, more than the birds, and much more than the mammifers.

Finally, the gist of M. Bert's investigations may be thus briefly summed up:

1. Modifications in the manometric pressure of air act but in proportion to the tension of the oxygen contained in the latter. 2. Above the normal pressure there is an increasing tendency to poisoning by oxygen, characterized by the determination of inter organic oxidations, which may be opposed by employing deoxygenized air.

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LUTECINE OR PARIS METAL.—MM. Le Mat, Picard, and Bloch give the following proportions for this alloy: Copper 800, nickel 160, tin 20, cobalt 10, iron 5, zinc 5. Total 1,000.