What Causes Vibrations in Dams ?

This is a subject which has endangered many an animated discussion among men of science, millwrights, and others, and it seems to be still a mooted question. It has been noticed that natural waterfalls, however great, seldom produce any vibrations in their immediate neighborhoods, while some artificial dams jarr the buildings in their vicinity for several miles around. The cause of this phenomena is worthy of investigation, for it is desirable to build dams that will produce no vibrations. To an inquiry made of us a few weeks since, by a correspondent in Vermont, we gave an answer which has called forth some important information on the subject.

In a letter received from R. Fitzgerald, of New Haven, Conn., he takes the ground that the jarring effect produced by some dams is caused by compressed air, under the smooth sheet of water, and not by the falling of the water. He states that, "forty years ago, there was a dam across the Salmon river, at Malone, Franklin county, N. Y., which had a smooth sheet of water passing over it, and the windows of the houses in the village were kept constantly vibrating by it, until a tree drifted down the river and lodged in the central part of the dam in such a position as to break the sheet of water, when the jarring of the windows ceased." This he attributed to the tree allowing the confined air to escape. Since that period, he has witnessed many similar cases.

Our correspondent has formed his opinion without positive proof as to the cause; he may be right, but our opinion differs from his. In our last number, we intended to publish his letter (but were unable to do so), with the following answer :—"It appears to us that air should act as an elastic cushion to prevent, and not cause, vibrations in waterfalls. Any obstruction which breaks a sheet of falling water prevents the regularity of its vibrations, and stops or modifies jarring sensations, upon the same principle that a body of soldiers walking at random over a suspension bridge prevents it vibrating, whereas, if they keep in regular marching order, they will cause it to oscillate violently, as was done near Manchester, England, in 1831, by which a bridge fell down."

Since we penned the foregoing, we have received a copy of the transactions of the American Academy of Sciences, just published, giving an account of the meeting held at Boston in September last, at which there was a paper read on this very subject, by Charles Stodder, in relation to the dam at Hadley Falls, on the Connecticut River. It seems that the vibrations of this dam are extensive in their influence, and, in fact, are a subject of wonder, being felt at Springfield, seven miles distant, and at Amherst, distant fourteen miles. In his paper, Mr. Stodder states that the only cause he "has seen assigned for this phenomenon is the agitation of the air behind the falling sheet of water"—the same cause as that described by our correspondent, Mr. Fitzgerald. Mr. Stodder, however, entertains a different opinion, and states that such a theory is entirely disproved by a dam at Lewiston, where the water falls over an inclined plane, leaving no space for air under it, and yet the vibrations are very decided.

The dam at Hadley is 1,000 feet long, and it has a vertical fall of 32 feet. The water does not fall in an even stream from the summit of the dam to the surface of the water below, but the upper surface in section presents to the eye a waved outline. This appearance Mr. Stodder has noticed at Hadley, Nashua, Lawrence, and other vertical falls. What is the cause of this ? The following is the answer of Mr. Stodder :—"The phenomena is caused by that property of falling fluids by which they assume the globular form, which may be seen at the Kauterskill Falls on the Catskill Mountains, where the whole body of the falling water is broken into drops. Applying this principle to the fall over an artificial dam, the water at the very commencement of its descent begins to assume that form, and the further it descends the nearer it approaches to it. In passing over a dam like that at Hadley, the water presents a uniform depth throughout the whole length of the dam, and if we imagine the current of water to be an infinitude of small streams of uniform depth in contact with one another, each having the same tendency, the result must be to produce swellings and contractions throughout the whole extent of the dam. When each of these waves strikes the bottom, it gives a blow proportioned in force to the body of water falling from the hight of the dam. Every variation in the depth of the water causes a variation in the size and distance of the waves, each of these causes a concussion in proportionate intensity to the weight of water in it, and in rapidity to their distance apart. These effects of falling water should be expected in general only on artificial falls, such as mill dams." Respecting natural falls, he says :—"As their faces are rarely vertical, but are broken with angular rocks, causing various depths of water on them, and as every variety of depth alters the conditions to form the concussive pulsations, there is no coincidence among them, so that the waves of one part strike the bottom in the invervals of those of another part, and thus the concussion of one neutralizes the other. At Hadley, the dam is one right line from bank to bank, the bed of the river is solid rock, and the top of the dam is level. The waves or pulsations of falling water are uniform, and strike the bottom with sychronous concussion from one end of the dam to the other. It is not surprising that the earth should be felt to vibrate at Springfield and Amherst."

We have presented a similar idea to this in the case of a body of soldiers marching over a suspension bridge. At the close of the reading of Mr. Stodder's paper, Dr. C. T. Jackson, to controvert the opinions advanced in it, stated that vibrations were noticed at the dam in Nashua, N. H., "only when the wind is in such a direction as to break the fall and permit the air to escape, which is evidently confined behind the sheet of water."

The two opinions here set forth are all that we have ever heard advanced as to the cause of vibrations in dams. We must say that we cannot see how air can cause such vibrations, and the circumstance stated by Dr. Jackson, as an argument against Mr. Stodder's opinion, is one we would construe in favor of it. As the vibrations of the dam at Nashua are only felt when the wind is in a certain direction, in all likelihood it produces the synchronous pulsations of the falling water just in the same manner that it causes suspension bridges to oscillate, and by which peculiar undulations it has caused a number of them to fall. The tree which stuck in the center of the dam over Salmon river may have disturbed the regular undulations of the water, and thus have stopped the vibrations. But, be that as it may, it appears to be a fact which engineers will do well to investigate, as it may afford important information in relation to dams, whereby they may be constructed so as not to produce vibrations.

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[For the Scientific American.]

Fluid Pressure.

A fluid is usually defined to be: "A body whose particles move easily among themselves and to yield the least force impressed." —(*Webster*); but from the true nature of a definition, which should include the sense of the thing defined and exclude everything else, the above does not, strictly speaking, define a fluid.

The "particles" of fine sand, superfine flour, or of any body in a finely pulverized condition, "move easily among themselves and yield to the least force impressed" upon them and to some extent, "when that force is removed, recover the previous condition;" but the substances mentioned are not fluids, and we must look a little deeper into the constitution of fluids, and from an understanding of them thus obtained, frame their definition.

Without regard to the constituents of the atoms or particles of which a fluid is composed when viewed chemically, it is sufficient here to consider each and every one of itself incompressible and surrounded by an atmosphere, so to speak, of heat—that each particle attracts every other, and is itself attracted by a force which we call *cohesion*, and that the atmospheres of heat strive continually to separate the particles from one another.

The modified action of these forces—the attraction of *cohesion* and the repulsion of *heat*—determine the three forms in which all matter is known to exist—*solid*, *fluid* and *gaseous*. When a certain portion of heat is driven from a mass of matter, cohesion draws the particles together, and a solid body is formed; on the other hand, when we add heat to a solid body, it becomes fluid, and a further addition of heat expands it into the gaseous form. It will appear that the less heat a body contains the more permanent is its character. Solid bodies retain their form for years; fluids, though easily placed in vessels, readily evaporate; gaseous are difficult to retain—very evanescent, and when not closely confined, almost immediately expand into space.

But regarding fluids, of which water may be called the type, they may be said to be bodies in which the attractive force of cohesion exactly balances the repulsive force of heat, and thus the particles of which they are composed, still retaining their atmospheres of heat, (all bodies having some heat, and it can never all be expelled,) move among each other, and are separated and brought together with the greatest facility. Here, then, is the definition of a fluid :—*A body in which the force that would draw its particles together exactly balances the opposing force that would drive them asunder.*

It is plain that in solid bodies cohesion preponderates over the repulsive force of heat, as in gaseous bodies the atoms are entirely beyond the sphere of its influence. When investigating the mechanics of a fluid, it is as necessary to omit certain considerations which would be likely to complicate and confuse the process; as when we study the properties of a lever, we pay no attention to the weight of the same, nor of the material of which it may be made.

It is true that fluids are affected by gravitation, and have weight in common with matter of all kinds; but we can imagine a fluid—water for instance—ceasing to possess weight without ceasing to lose its peculiar properties as a fluid. Such a body would act very strangely—it would neither fall nor flow from a vessel; being perfectly passive in its nature, it could be moulded into any form, separated into parts and put together again; but the most remarkable property it would display next to its incompressibility, would be that of equally transmitting pressure in all directions. Suppose it was contained in a vertical cylinder of say one hundred inches area, and on it was resting a closely fitting piston. If the piston have no weigbt, it is clear the fluid experiences no pressure, and if the bottom or the sides of the cylinder or if the piston were pierced with an orifice, no portion of the fluid would escape; but, if we load the piston with say 100 pounds, it will tend towards the bottom of the cylinder, and, of course, will press upon the fluid, the particles of which having perfect mobility, the mass would at once conform itself to the shape and size of the cylinder, and would sustain the piston; not, however, unless it, in turn, is snstained by the bottom of the cylinder. Being incompressible it may be regarded as a solid body, and then the transmission of the 100 pounds to the bottom of the cylinder is easily understood. Now, as the whole pressure of the piston is borne by the whole area of the cylinder's base, it is evident that one-half of the base sustains fifty pounds, and that any square inch of surface on the base sustains one pound. So far, this imaginary fluid does not differ from a solid in the transmission of pressure, but the peculiar characteristic of a fluid is that the same effects are produced upon the sides of the cylinder, and against the under side of the piston. The fluid being under pressure as before, and its particles free to move in any direction which is consistent with the nature of all fluids, if an opening be made in the side of the cylinder, it will spout out, and if the piston be perforated, the fluid will spout upwards. If these openings are one inch square each, it will require one pound pressure to prevent the fluid from escaping; if fifty inches, fifty pounds, and so on proportionally.

Admitting these facts to be true, it must be evident that *fluids transmit equally and in all directions the pressures exerted upon them.* Again, let us suppose we establish a direct communication at the bottom of this cylinder with a small cylinder of one inch area, also fitted with a piston, from what has been shown, it is plain the small piston must receive an outside pressure of one pound to keep it in place against the outward thrust of the fluid. If we force the small piston in its cylinder against the fluid, say a distance of one inch, the large piston must be raised, but it need not move only one hundredth part of that distance to make room for one cubic inch of fluid, because that cubic inch must spread over 100 square inches of surface; we have really raised 100 pounds by the movement of one pound, but we have only raised it a hundredth part of the distance—what we have gained in power we have lost in distance. Thus we have a simple machine, which, like all others, depends upon the principle of *virtual velocities*, and is to all intents and purposes the hydrostatic press, known in mechanic arts and appliances to possess extraordinary advantages over the wedge, lever or screw, especially where immense pressures are required.

If we now confer weight—the attraction of gravitation—upon the fluid in question, it must be evident that it can in no wise alter the property of equality of pressure, except so far as the additional pressure arising from the gravitating tendency of the fluid is concerned. The fluid by no means exists as such by virtue of gravitation, but is only modified in its mere mechanical performances by it, and under the influence of this force finds the lowest position possible for its parts, and seeks a level for its surface.

Considerations of this character seem to clear up the apparent anomaly which is inseparable from the ordinary method of statement regarding the equality of pressure. We say the pressure is equal in every part of a vessel containing fluid, and in all directions, and every one knows that in a vessel containing water, the heaviest pressure is on the bottom; that the pressure on the sides is greatest at the bottom, and least at the top, and if the vessel be full and have a lid, the lid would experience no pressure at all. We must understand that equality of pressure is due to fluidity only, and that the inequality of pressure which every vessel containing fluid experiences is due to gravity; the one is determined by estimating density and altitude, the other is the active principle of fluidity.

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Ores.

This term is applied to any form in which metals occur naturally and from which they can be extracted by subsequent metallurgic processes. Metals are always found in one of the following states: either pure as native metals or combined with others forming natural alloys; combined with sulphur, forming sulphurets or sulphides; in combination with oxygen producing oxyds, or with acids forming metallic salts, as carbonates, sulphates, phosphates and numerous others. They are found in lodes or veins, which are cracks in rocks filled up with ore, or in beds, where the ore takes a place in the strata of the country as a regular geological deposit.

Sometimes the more precious metals are found in streams, to which they have been brought by the water breaking off pieces of the parent vein and carrying these down the current, gradually rounding off the sharp angles and breaking them up into powder, as found in the gold fields of California and Australia. In some situations gold has been found in a fibrous condition.