THE FRANKLIN INSTITUTE.

Stated Meeting of May 15, 1895.

MR. H. R. HEYL, Vice-President, in the Chair.

[The Chairman announced the paper of the evening, and introduced the speaker.]

THE BALL NOZZLE.

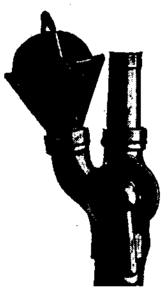
BY ARTHUR KITSON.

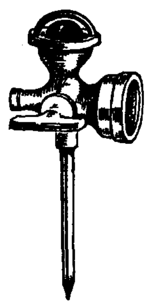
Among the multitude of inventions which, year by year, find their way to the patent office, none attract more attention than those inventions which appear to be of the nature of a paradox, and which the newspapers are fond of describing as "scientific puzzles."

Such inventions as the injector, by means of which water is forced into a steam boiler by the same pressure of steam as that contained in the boiler itself; the down-draft furnace, in which the air for combustion is supplied at the top of the fire instead of at the bottom; the system of heating rooms, by placing the hot-water pipes on the ceiling instead of on the floor—all such inventions which operate on the reverse plan to that with which we are accustomed, at first sight strike us as contrary to the natural order of things, and there is a tendency amongst a certain class to consider the phenomena as marvelous.

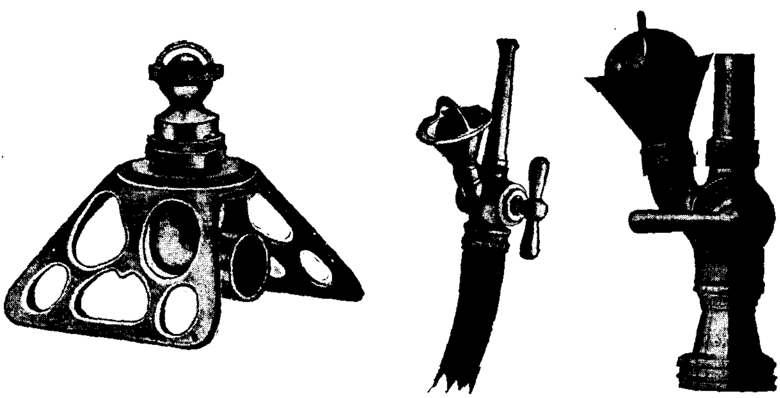
Of the very recent inventions that have in this way excited a great deal of discussion, what is known as the "ball nozzle" is probably the most widely advertised, and the principle governing it the least understood. Because in its operation it presents a phenomenon hitherto unobserved, it has been characterised by the press as contrary to the laws of science. There is, however, nothing of the miraculous or of the supernatural which cannot be explained by well-known scientific principles.

The "ball nozzle" is one of the simplest inventions ever designed. It consists merely of two parts: a bell-shaped or flaring-mouth nozzle, and a ball. The nozzle is connected to a water or air supply, and the ball is placed loosely in the mouth of the nozzle. The ball steadfastly adheres to the nozzle and refuses to leave it, notwithstanding the great pressure of the issuing stream of air or water, and no matter what may be the position of the nozzle, whether vertical or horizontal, or whether the nozzle be turned directly towards the ground. As soon as the pressure is released and the supply of water ceases, the ball, obeying the law of gravity, falls. Variations of pressure from a few ounces to hundreds of pounds to the square inch fail to change the nature of the seeming paradox. In the case of water, the effect of the ball is to divide what would otherwise be a straight stream into a thin, fan-shaped spray, which spreads itself in a circle all around the nozzle. It is in this respect that its



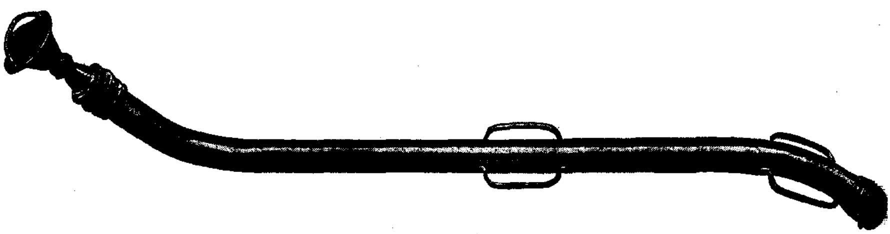


utility arises. One of the essentials of a good water spray for agricultural purposes, or for lawn sprinkling, is the equal distribution of the water, so that an even supply can be furnished without much expenditure of energy. In this field the ball nozzle furnishes an almost perfect machine and seems to be the only genuine "rain-maker" now placed upon the market. With a pressure of 80 pounds to the square inch and a $\frac{3}{16}$ orifice, it is possible to distribute a water supply over a circular area 60 feet in diameter. Such a machine is a convenience and a labor-saving invention which only those who have been accustomed to the old-fashioned lawn-sprinklers can properly appreciate. As a method of distributing fresh air to railway cars or rooms, this invention also seems to fill an important function. But its most useful field, and one in which it comes as a blessing to humanity, is that of a fire-extinguisher. It is one of the glories of science and of invention that, whilst the progress of the human mind in the realm of discovery often brings increased danger to human life, accompanying it—like a guardian angel—are those inventions which act as safeguards to protect life from those dangers to which inventions have given rise. With the ever-increasing dangers which increased speed of ocean travel has occasioned there have likewise arisen increased means and facilities for saving life. The danger attending the use of elevators brought forth the safety catch; and rapid transit, furnished by the trolley system, is soon to be accompanied with the fender,



which will make it almost impossible to sacrifice life in the accomplishment of so desirable an object.

Fire is at once man's preserver and his destroyer, and few things indispensable to him have proved so destructive of life and property as this element. It is estimated that, during the past twenty years, not less than 250,000 lives have been lost, and over $200,000,000 of property destroyed by fire in this country alone. An invention that will in any way mitigate or lessen this awful destruction of life and property must be hailed as one of the greatest benefits that the mind can confer upon society. It is in this field that the ball nozzle will serve its highest function. The large nozzles displayed here to-night are designed for this particular purpose. You will see the end of the fire nozzle has two openings—one consisting of a straight orifice, from which a solid thick stream may be directed, as in the ordinary fire nozzle, and the other consisting of the ball nozzle. A three-way valve serves to direct the water to either of the openings. The *modus operandi* is as follows: A fireman, on reaching a building in which a fire is raging, first directs the straight stream against a window of the building in order to reach the fire with the spray. He then turns his valve and admits the water to the ball nozzle and directs it toward the fire. On entering the building he can proceed at once to meet the fire by placing the nozzle in front of him. He then becomes enveloped with a sheet of water, the force of which is sufficient to drive before him the smoke, at the same time extinguishing the flame. It is impossible for the



smoke to penetrate through the solid sheet of water in front of him. He is thus able to avoid suffocation, on the one hand, and death by fire on the other.

Those who have witnessed large fires and have studied the action of the ordinary fireman's hose, must have been surprised with the apparently slight effect which the water has had upon the fire. The reason is that the whole stream and force of water is directed upon a very small space, not many times larger than the orifice through which the water escapes. To overcome this defect it becomes necessary for the fireman to keep the nozzle moving so as to distribute the water. The result, however, is not satisfactory. Certain parts of the fire get more water than is sufficient to extinguish the flame, and other portions do not get any. Moreover, whilst the water is directed on one small area, the fire is making headway in other portions of the building. It must have occurred to many a man, especially firemen, that if the force could be immediately distributed from one source of supply, sufficient to cover the whole or a large part of a building, that fires could be much more rapidly extinguished and with less danger and loss. This is precisely what the ball nozzle does. Instead of concentrating large volumes of water upon a small area, the nozzle distributes it evenly over large areas, so that all parts of a room or side of a building can be treated equally to the fire-extinguishing element. It is estimated that fifty per cent. of the damage and loss occasioned from fires arises from the excessive use of water. This must be so from the ordinary fire apparatus, and it generally happens that what the water saves from the fire's ravages, is destroyed by the water itself. This evil the ball nozzle must naturally overcome to a large extent. It requires less water to extinguish a fire than by any other system, owing to its equal distribution. Another very important feature is the fact that one fireman can handle a hose with the ball nozzle, where ordinarily it requires three or four men. This seems to be the result of the distribution of the water from the nozzle and the manner in which it comes in contact with the air. A straight stream causes a certain recoil of the hose and necessitates the employment of several men to each hose. Frequent tests of the ball nozzle show that this recoil is much less than in any other, and can be successfully resisted by one man.

In this respect its utility is found to be most valuable.

I refer you to the circulars that have been placed in this hall, containing the endorsement of the various insurance companies and underwriters throughout this country. No institutions are more particular or more conservative about endorsing fire-extinguishing devices than insurance companies, and yet to none are such devices of more importance. Not less than 130 of these companies have endorsed this invention as an improved fire appliance. Judging from the numerous accidents that have occurred recently in private houses from defective flues and exploding lamps, it appears essential that some appliance for extinguishing fire should be provided in every home, and it seems to me that by the aid of this invention the problem may be solved. From twenty-five to fifty feet of hose, attached at one end to the water supply, and fitted at the other with a ball nozzle, may be placed in every bath-room and kitchen, and, in the majority of cases, would serve to extinguish fires in private houses before much damage had occurred.

I have briefly described this invention and its most useful applications and have left the explanation of the phenomenon for final discussion. The problem connected with this invention may be put thus: Why does the ball adhere to the nozzle when there is behind it a force aggregating as high as hundreds of pounds pressure? The explanation usually given is that the atmospheric pressure holds the ball in its place and prevents it from falling or leaving the mouth of the nozzle. To this others answer that the pressure behind the ball far exceeds the atmospheric pressure; for instance, there is an exhibition given daily in New York with one of these nozzles where the water pressure equals 100 pounds per square inch, and as the atmospheric pressure is only about fifteen pounds, it would at first sight seem that the excess of pressure on the under side of the ball was eighty-five pounds, and ought, therefore, to expel the ball. The error, however; in this argument arises from failure to distinguish between the pressure of the water when confined in the pipes and when issuing around the ball. It is very certain that if 100 pounds pressure were acting directly upon the ball, it would be blown out of the nozzle, but it does not appear to me to act in this way. When the ball is confined to the mouth of the nozzle and pressed against it, it is undoubtedly subjected to the pressure of the water, but the moment it is raised slightly from the mouth, it is no longer subjected to this pressure, since the water is escaping all around it. In this respect it resembles the lid of a tea kettle when the water is boiling. By plugging the spout, the lid will be raised by the steam pressure sufficiently to allow the steam to escape at the sides. The explanation that seems to me to be the correct one is as follows: The ball is acted upon by three forces: first, gravity; second, atmospheric pressure; and third, the force of the issuing stream. At first, the atmospheric pressure is the same at all points, and hence gravity has free play; but as soon as the stream passes through the nozzle, the atmospheric pressure from the under side is counteracted by the momentum of the issuing water, and the ball rising to a point where the water can pass freely around the sides, without pressing materially upon the ball, we have the full pressure of the atmosphere on the under half-side of the ball resisting the force of gravity. The ball, therefore, simply serves as a deflector to divert the current of water or to spread it out, and the resistance of the atmosphere against the ball suffices not only to perform this operation but also to sustain its weight.

It is possible that the density of the air may also be somewhat increased under the ball by the action of the spray. With a heavy pressure, the ball is further removed from the nozzle than with a light pressure. The same holds good respecting a heavy ball and a light ball. Most of these so-called paradoxes may be attributed to momentum or inertia. Take, for instance, the phenomenon of the injector. "If a 1-inch opening in a boiler, carrying 15 pounds pressure above the atmosphere, be made, if there is no reduction by friction, steam will issue from it at a velocity of about 1,440 feet per second, and the steam which would issue from it would be 10 cubic feet per second, which would weigh $\frac{2}{3}$ of a pound. When this steam is condensed to water, it maintains its velocity but is reduced in volume from 10 cubic feet to $\frac{1}{90}$ of a foot, or in other words, the stream of steam of 1-inch area, which issued at 1,440 feet per second, is reduced to a stream of water $\frac{1}{32}$ of an inch in diameter, having the same velocity—1,440 feet per second.

"The laws of hydraulics show that water will issue from a vessel under a pressure of fifteen pounds per square inch, with a velocity of forty-five feet per second, and that any stream having a greater velocity than forty-five feet per second, if directed against the orifice in the vessel, will enter it, notwithstanding the pressure inside the vessel.

The jet of condensed steam has a velocity of 1,440 feet per second, or more than thirty times that necessary to re-enter the boiler. This velocity is, therefore, reduced by mixing it with 900 times its weight in water, and this mixture will still enter the boiler."* This, of course, is merely theoretical and is largely reduced by friction; but in practice it is well known that steam will carry many times its own weight in water into a boiler from whence the steam is itself derived. We have, therefore, in the ball nozzle, the momentum of the moving stream of water which overcomes the atmospheric pressure on the under side of the ball, and the inertia of the ball which serves to keep it from moving, aided by the atmospheric pressure on its top side. This is my own explanation of a phenomenon which seems to puzzle a great many people, but which is strictly soluble by the well-known laws of physics.

In conclusion, I believe this invention, simple as it is, is destined to become a very great friend of society, particularly as a protection against the scourge and devastation of fire, and a means of saving human lives as well as very much of the wealth which annually disappears in smoke.

HAVING THE LOGARITHMS OF TWO NUMBERS, TO FIND THE LOGARITHM OF THEIR SUM OR DIFFERENCE.

BY NATHANIEL HILL.

For the solution of this problem, *addition* and *subtraction* logarithms were devised; Zech's seven-figure tables being published in the year 1849, and the five-figure tables of Gauss presumably quite as early, as his name is often used to identify this kind of logarithm. Newcomb's five-figure tables, Pierce's, Wheeler's and Macfarlane's four-figure tables are more recent, and are also American publications.

* Appleton's Cyclopædia.