Correspondence.

Electric Fire Pumps.

To the Editor of the SCIENTIFIC AMERICAN:

The general introduction of the electric motor into buildings of all classes suggests an application which might, under certain conditions, prove to be of great value. A fire pump designed to be driven by an electric motor would, it seems to the writer, have many decided advantages. In large manufactories and public buildings, where steam boilers are kept continually under pressure, there is no difficulty in maintaining fire pumps capable of supplying one or more streams with the necessary promptness. There is, however, a large class of buildings, in which may be included private residences, where steam power is not at hand, and where reliance must be placed entirely upon the local fire department, which may or may not be efficient, and which, at the best, must consume a certain amount of valuable time in getting to work. In such cases it is believed that an electrically driven pump would find its most useful application. Such a pump would be in constant readiness for action, and could be instantly started at any time by the simple pressure of a button, or could even be arranged to start automatically in connection with a system of electric fire alarms, or by releasing the air in the discharge pipes, as in the well-known sprinkler systems. It should be provided with relief valves set at the desired pressure, so that, after once being started, it would run at full speed, the amount of water delivered being regulated at will by the hoseman up to the full capacity of the pump. The apparatus should, if possible, be installed in a small detached building or shelter, where it would not be disabled by fire or by the cutting power of wires leading to a burning building. WILLARD P. GERRISH.

Harvard College Observatory, Cambridge, Mass., October 24, 1900.

[The suggestion of our correspondent is a good one. We believe that this method of equipment has already been installed and with success in some buildings in this city.—ED.]

The Relations between Experimental and Mathematical Physics.*

M. HENRI POINCARÉ BEFORE THE CONGRESS OF PHYSICS.

ROLE OF EXPERIMENT AND GENERALIZATION.—Experiment is the only source of truth, and by its means alone can we learn anything new or certain. What place remains then for mathematical physics? The latter has rendered undeniable services, because it is necessary not only to observe, but to generalize; it is this which has been done from all time, only as the remembrance of past errors has made man more circumspect, he has come to observe more and generalize less. Should we not be content with experiment alone? That is impossible, and would be to ignore the true character of science, which is built of facts like an edifice, but is not a mere conglomeration of material. A good experiment teaches us something besides an isolated fact; by its means we may predict and generalize. Thus each fact observed enables us to predict a great number of others, but we should not forget that the first alone is certain and all the rest are only probable. The role of mathematical physics is to guide the generalization so as to increase what may be called the efficiency of the science. It remains to be seen by what means this may be accomplished.

THE UNITY OF NATURE.—All generalization supposes in a certain degree the belief in the unity and simplicity of nature. For the first there can be no difficulty; if the different parts of the universe were not like the organs of the same body, they would not act upon each other, and we have only to ask how nature is one. The second point is more difficult. It is not sure that nature is simple; modern ideas have changed; but those who do not as formerly admit the simplicity of the natural laws are often obliged to consider them from this standpoint, otherwise all generalization and all science would be impossible. It is clear that a given fact may be generalized in different ways. The choice is guided by considerations of simplicity; this is illustrated by our method of drawing a curve between a series of points. To sum up, every law is supposed simple until the contrary proof is given. If we study the history of science, we find two phenomena of opposite character; at times simplicity is concealed under complex appearances, and at others apparent simplicity conceals a series of complicated phenomena. The complicated movements of the planets and the law of Newton is an example of the first, and the kinetic theory of gases and Mariotte's law is an example of the second case. But Newton's law itself has perhaps only an apparent simplicity, and may be due to some unknown and complicated mechanism. No doubt if our means of investigation become more penetrant, we will discover the simple under the complex, then the complex under the simple.

ROLE OF THE HYPOTHESIS.—Every generalization is a hypothesis, and the hypothesis therefore has a necessary role which has never been disputed. It should, however, be verified as often as possible, and if not sustained, should be abandoned, and even in this case renders great service by the new outlook given. Then, under what condition is the use of the hypothesis dangerous? Those which are made unconsciously we are powerless to abandon; a service may be rendered here by mathematical physics obliging us to formulate all hypotheses. We should distinguish different kinds of hypotheses, those which are natural, and a second category which may be called indifferent, as the results of calculations are not changed thereby; for instance, the continuous or the atomic constitution of matter. These are never dangerous if their character is not lost sight of, and they may be useful in calculation or to give a concrete idea. Hypotheses of a third category are veritable generalizations, and should be sustained or condemned by experiment.

ORIGIN OF MATHEMATICAL PHYSICS.—The efforts of scientists have always tended toward resolving the complicated experimental phenomena into a great number of elementary phenomena, and this in different ways. As to time, each phenomenon depending upon that the preceding instant. In space, in an analogous manner, each molecule acting upon its neighbor.

The knowledge of an elementary fact permits us to put the problem into an equation, and integration becomes possible. The reason that generalization takes usually a mathematical form in the physical sciences is that not only are numerical laws to be expressed, but the observed phenomenon is due to a great number of elementary phenomena, similar among themselves, introducing naturally the differential equations.

SIGNIFICANCE OF PHYSICAL THEORIES.—It may be said that scientific theories are of an ephemeral character, but the role of such theories must be taken into account. The theory of Fresnel has given place to that of Maxwell, but the former has none the less its value in the prediction of optical phenomena. If the relations expressed by the equations are known, it makes little difference whether the image we give to the phenomena change or not. The kinetic theory of gases has given place to many objections, but it has, nevertheless, produced valuable results, no matter whether its absolute verity is affirmed or not.

PHYSICS AND MECHANISM.—Most theorists have a predilection for explanations borrowed from mechanics or dynamics. Some of them wish to explain all phenomena by the movement of molecules attracting each other mutually according to certain laws; others wish to suppress attractions at a distance, and the molecules would thus follow straight paths and be deviated only by shocks; still others, as Hertz, suppress also the forces, but suppose the molecules are bound in a system analogous to our articulated systems, thus reducing dynamics to a kind of kinematics. Phenomena may be explained by all these systems. As to the conception of the ether, some regard it as the only primitive, or even the only real matter, and what we call matter as constituted of vortex motions of the ether according to Lord Kelvin, or according to Riemann of points where the ether is constantly destroyed; or with more recent authors, Wiechert or Larmor, of points where the ether has undergone a special kind of torsion. The old fluids, caloric, electricity, etc., have disappeared, not only when it was found that heat was not indestructible, but the unity of nature forbids the creation of such independent fluids.

ACTUAL STATE OF THE SCIENCE.—Two diverse tendencies are observed in the development of physics, that of co-ordination, in which science advances toward unity and simplicity; and that of variation, where, by the discovery of new phenomena, science appears to advance toward variety and complication. If the first of these is to prevail, science becomes possible; but if on account of the multitude of phenomena we are obliged to abandon our classification, it will be reduced to a mere registration of facts; as to this, we cannot reply, but we may compare the present state of science with the preceding, and draw some conclusions. Half a century ago, the greatest hopes were entertained. The discovery of the conservation of energy and of its transformations had just revealed the unity of force; heat was explained by molecular movements; their nature was not known, but the solution of the problem seemed near; for light, the question seemed solved. Electricity, just annexed to magnetism, was farther behind, but no one doubted that it would take its place in the general unity, and for the molecular properties of solids, the reduction seemed easier. In a word, great hopes were entertained. What do we observe to-day? First, an immense progress; the domains of electricity, light and magnetism now form but one. The optical phenomena enter as particular cases of electrical phenomena. While they remained isolated, it was easy to explain them, but now an explanation to be acceptable must enter into the domain of electricity; this is not without some difficulties. The theory of Lorentz is the most satisfactory; Larmor goes still farther and seems to add to the former ideas of MacCullagh upon the direction of ether movements. However, we have not as yet a satisfactory theory. We should limit our ambition and not seek to formulate a mechanical explanation, but show that we could at least find one; we have succeeded in this, owing to the principle of the conservation of energy and that of least action, both constantly verified. The irreversible phenomena are more intractable, but are brought into order by Carnot's principle. The role of thermodynamics has greatly increased, and we owe to it the theory of the pile and of thermo-electric phenomena. To sum up, the old phenomena become better classified, but new ones are constantly coming in, and we must now place the cathodic and X-rays, those of uranium and radium, etc. No one can predict the place they are to occupy, but no doubt they will fit into the general unity. On one hand, the new radiations seem allied to the phenomena of luminescence; above all, it is thought that in these phenomena are found the veritable ions, these being endowed with a great velocity.

We not only discover new phenomena, but the old ones appear under an unlooked-for aspect. Nevertheless, the relations which we recognized between the supposedly simple objects hold good when we learn their complexity, and this is the essential point. Our equations become more complex, but their form remains. Lastly, the physical efforts have invaded the domain of chemistry, whence the new science of physico-chemistry, which, though recent, enables us to associate phenomena such as electrolysis, osmose and movements of the ions. From this rapid exposé, what are we to conclude? Everything considered, we have approached a unification; though the progress has been less rapid than was hoped for fifty years ago, and the path laid out has not always been taken, we have, in fact, gained considerable ground.

* Abstract by Paris Correspondent of the SCIENTIFIC AMERICAN.

THE AEROSTATIC EXHIBITS AT PARIS.

The aerostatic section of the Champ de Mars contains a centennial collection of great interest; the objects have been loaned by a number of persons who have private collections. The upper illustration shows part of a famous collection which has been loaned by M. Albert Tissandier. These objects, many of which date from the last century, all bear a representation of a balloon, either of the primitive hot air balloon of Montgolfier or the later form inflated with gas. Most of the porcelain and earthenware plaques and other pieces date from the last century, and are decorated with balloons or carry scenes of balloon ascensions more or less artistically drawn. One of these plaques bears the date 1785, and another is dated 1820. A large collection of fans will also be noticed; they all carry scenes of balloon ascensions painted in miniature; and some of these have a considerable artistic value. Two of the fans represent ascensions which were made in the last century at the Tuilleries or at Versailles. In the foreground is a collection of miniatures in round or square metal frames, representing balloon ascensions, and several books with a balloon stamped in gold on the cover. Near it is a collection of miniature boxes in colors or of carved ivory, gold, or enamel, upon all of which a balloon is represented. Most of these boxes date from the end of the last century, and some of them are finely executed. In this collection is a miniature, inclosed in a square leather case, representing "the ascension of Pilatre de Rozier and De Romain at Boulogne, with a balloon filled with inflammable air, on the 12th of June, 1785." Another miniature commemorates an ascension made on the 2d of March, 1784. At one end of the case is a collection of watches, medallions, rings, and like objects, as well as a number of miniatures. Among these is a button of the uniform worn by the military aerostatic corps of 1794; it bears the inscription, "Aerostatier, 1r. Brigade." An interesting relic is a watch with an engraved copper case bearing the representation of a balloon, which was presented to Captain Coutelle in 1794. Another watch of the same period is of steel incrusted with gold, and bears a design of a balloon ascension.

One of the miniatures shows a gas balloon, and bears the date of December 1, 1783, and an engraving in a metal frame, representing an ascension made by Messrs. Robert and Hutin at the Tuilleries on the 19th of September, 1784. In the front of the case is a series of medals which commemorate the different ascensions made during the siege of Paris, 1870 to 1871. In the center is a large medallion in bronze, bearing a figure of the Republic, with a balloon in the background. Surrounding it are a number of small medals which relate to different ascensions. At that time most of the large railroad stations of Paris were turned into balloon headquarters, from which the ascensions were made. The medals bear inscriptions similar to the following, surrounding a balloon in the center: "Depart from the Northern Station—the Torricelli—conducted by the marine Bely—the 24th of January, 1871." The other side of the case contains a large collection of engravings and documents relating to aerostatics. Some of the oldest of these show different forms of Montgolfier balloons, most of which were of a highly ornamental character; among the books and pamphlets is one dated 1784, relating to the experiments of Montgolfier and a copy of the proceedings of the Académie des Sciences of 1828 containing a eulogy of