with a force
~~his tendency being~~ inversely as the diameter
Two bubbles being connected, the smaller will collapse by expelling its contents into the larger.
By employing frames of ~~mica~~ wire, soap bubbles were also made to assume various forms, by which capillarity and other phenomena were illustrated. This subject was afterwards taken up by Plateau of Ghent.

Another part of the same investigation was the study of the spreading of oil on water, the phenomena being referred to the fact that the attraction of water for water is greater than that of oil for oil, while the attraction of the molecules of oil for each other is less than the attraction of the same molecules for water, hence the oil spreads over the water.

This is shown from the fact that when a rupture is made in a liquid compound consisting of a stratum of oil resting on water, the rupture takes place in the oil and not between the oil and water. The very small distance at which the attraction takes place, is exhibited by placing a single drop of oil

on a surface of water of considerable extent, when it will diffuse itself over the whole surface. If however a second drop be placed upon the same surface it will retain its globular form.

XVI Another contribution to science had reference to the origin of mechanical power and the nature of vital force. Mechanical power is defined to be that which is capable of overcoming resistance or in the language of the Engineer that which is employed to do work.

If we examine attentively the condition of the crust of the earth, we find it as a general rule in a state of permanent equilibrium. All the substances which constitute the material of the crust, such as acids and bases with the exception of the indefinitely thin pellicle of vegetable and animal matter which exists at its surface, have all gone into a state of permanent combination, the whole being in the condition of the burnt slag of a furnace entirely inert and capable in itself of no change. All the

changes which we observe on the surface of the globe may ~~we think~~ be referred to action from without - from celestial space.

The following is a list which will be found to include all the prime movers used at the present day either directly or indirectly in producing molecular changes in matter.

Class I { Water power, Tide power, Wind power } immediately referable to celestial disturbance.

Class II { Steam and other powers developed by combustion, Animal power } immediately referable to what is called vital action.

The forces of gravity, cohesion, electricity and chemical attraction, tend to produce a state of permanent equilibrium on our planet hence these principles in themselves are not primary but secondary agents in producing mechanical effects. As an example we may take the case of water-power which is approximately due to the return of the water

to a state of stable equilibrium on the surface of the ocean, but the primary cause of the motion is the force which produced the elevation of the liquid in the form of vapor, namely the radiant heat of the sun. Also in the phenomena of combustion the immediate source of the power evolved in the form of heat is the passage from an unstable state into one of stable combination of the carbon and hydrogen of the fuel with the oxygen of the atmosphere. But this power may ultimately be resolved into the force which caused the separation of these elements from their previous combination in the state of carbonic acid, namely the radiant light of the sun. But the mechanical power exerted by animals is due to the passage of organized matter in the ~~body~~ stomach from an unstable to a stable equilibrium, or as it were from the combustion of the food. It therefore follows that animal power is referable to the same source as that from the combustion of fuel, namely the

developed power of the suns beams. But according to this view, what is vitality? It is that mysterious principle, not mechanical power, which determines the form and arranges the atoms of organized matter, employing for this purpose the power which is derived from the food.

These propositions were illustrated by different examples. Suppose a vegetable organism, impregnated with a germ, a potato for instance, is planted below the surface of the ground in a damp soil under a temperature sufficient for vegetation. If we examine it from time to time we find it sending down rootlets into the earth, and stems and leaves upward to the air. After the leaves have been fully expanded we shall find the tuber entirely exhausted nothing but a skin remaining. The same effect will take place if the potato be placed in a warm cellar, it will continue to grow until all the starch and gluten are exhausted, when it will cease to increase. If however we now place

it in the light, it will commence to grow again and increase in size and weight. If we weigh the potato previous to the experiment and the plant after it has ceased to grow in the dark, we shall find that the weight of the latter is a little more than one half that of the original tuber. The question then is, what has become of ~~that part of the~~ material which filled the sac of the potato? The answer is, one part has run down into carbonic acid and water, and in this running down has evolved the power to build up the other part into the new plant. After the leaves have been formed and the plant exposed to the light of the sun the developed power of its rays decomposes the carbonic acid of the atmosphere and thus furnishes the pabulum and the power necessary to the farther development of the organization.

The same is the case with wheat and all other grains that are germinated in the earth. Besides the germ of the future

plant
there is stored away around it the germ the starch and
gluten to furnish the power necessary to its
development and also the food to build it
up until it reaches the surface of the earth
and can draw the source of its future growth
from the power of the sunbeam.

In the case of fungi and other plants that
grow in the dark they derive the power and
the pabulum from surrounding vegetable
matter in process of decay or in that of e-
volving power.

A similar arrangement is formed
in regard to animal organization. It is well
known that the egg continually diminishes
in weight during the process of incubation
and the chick when fully formed weighs
scarcely more than one half the original
weight of the egg. What is the interpretation
of this phenomenon? Simply that one part
of the contents of the shell has run down
into carbonic acid and water and thus e-
volved the power necessary to do the work

of building up the future animal. In like manner when a tadpole is converted into a frog the animal for a while loses weight, a portion of ~~the~~ its organism has been expended in developing the power necessary to the transformation, while another portion has served for the material of the legs.

What then is the office of vitality? We say that it is analogous to that of the engineer who directs the power of the steam engine in the execution of its work. Without this in the case of the egg the materials left to the undirected force of affinity would end in simply producing chemical compounds sulphuretted hydrogen, carbonic acid &c. There is no special analogy between the process of crystallization and that of vital action In the one case definite mathematical forms are the necessary results, while in the other, the results are precisely like those which are produced under the direction of will and intelligence, &

evincing a design and a purpose, making provision at one stage of the process for results to be attained at a later, and producing organs intended evidently for locomotion and perception. Not only is the result the same as that which is produced by human design, but in all cases the power with which this principle operates is the same as that with which the intelligent engineer produces his result.

This doctrine was first given in a communication to the American Philosophical Society in December 1844 and more fully developed in a paper published in the Patent Office Report in 1856.

The publication in full of three of the series of investigations herein described was made in the Transactions of the American Philosophical Society. Others were published in Dillman's Journal and both these are noticed in the Royal Society's catalogue of Scientific Papers, but the remainder of

them were published in the Proceedings of the American Philosophical Society and are not mentioned in the work just referred to.

In 1846, while still at Princeton, I was requested by ~~ten~~ members of the Board of Regents of the Smithsonian Institution which was then just founded, to study the will of Smithson and to give a plan of organization by which the ~~intentions~~ object of the ~~donor~~ bequest might be realized. My conclusion was that the intention of the donor was to advance science by original research and publication, that the establishment was for the benefit of mankind generally and that all unnecessary expenditures on local objects would be violations of the trust. The plan I proposed for the organization of the Institution, was to assist men of science ~~in different parts of the country~~ in making original researches, to publish these in a series of volumes and

to give a copy of these to every first class library on the face of the earth.

I was afterwards called to take charge of the ~~establishment~~ Institution and to carry out this plan, which has been the ~~the leading~~ policy of the ~~Institution~~ Establishment from the beginning to the present time.

One of the first enterprises of the Am. Instn was the establ. of a system of simultaneous meteorological observations over the United States, especially for the study of the phenomena of American storms. For this purpose the assistance of Prof Guyot was obtained who drew up a series of instructions for the observers which was printed & distributed in all parts of the country. He also recommended the best form of instruments to be used by the observers & finally calculated with immense labor a volume of meteorol. & physical tables for reducing & discussing meteor observations. These tables were published by the Instn & are now in use in almost every part of the world in which the English language is spoken. The system prosecuted by Mr Finally led to the application of the principle in question, established by the predictions of the weather by means of the telegraph to the present system of weather predictions by means of the telegraph.

Prof R. L. McCulloh during his connection with the College made an extended series of observations & experiments on the combination of water & alcohol, in order to determine by the use of the hydrometer the amount of spirits in a given quantity of the mixture for the purpose of collecting duties & these investigations were published by the Govt in a series of tables, which he also made a series of elaborate investigations of the amt of crystallizable Sugar contained in various syrups, also for the ~~Exercise~~ excise operations of the Govt