Atlantic and the efficient condition of her machinery on arrival here ought to remove all doubt as to the practicability of the system.

THERMOMETERS.

The word thermometer means a heat-measure, hence any instrument employed to measure heat should be called a thermometer. When very high temperatures are to be measured, the instruments employed are called pyrometers, or measures of fire. Thermometers do not, of course, measure the quantity of heat in a body, but only tell us the relative temperature. There are several forms of thermometers, all based upon the principle that "heat expands, while cold contracts." Some substances expand unequally for equal increments of temperature, others expand so slightly that they fail to indicate small changes of temperature; both are unfitted for thermometers. It is believed that air expands equally for equal changes of temperature, and as this expansion is quite considerable (1-273d part for each degree centigrade), and as it does not become either liquid or solid under ordinary pressure, at any temperature which we can produce, it is the substance employed for the most accurate measurements of temperature. Any of the difficultly condensible gases, oxygen, hydrogen, marsh gas, might be employed instead of air, but with no advantage and with much inconvenience in their manufacture.

Next to air, the best material we have is mercury, which expands very evenly, does not freeze readily, and boils at a comparatively high temperature. For temperatures below —40° alcohol is generally employed, although it is claimed that glycerine could be used. For temperatures above 300° C. air thermometers alone are admissible; and for very high temperatures, where glass begins to soften, they are made of platinum.

The mercury thermometer, being the one usually employed in the arts, in meteorology, in medicine, and in other sciences, a few words in regard to the manner of making one may be of interest. A glass tube with a very fine bore has a suitable bulb, of any desired form, blown upon one end. At the other end may be a bulb of larger size, blown merely for convenience in filling. Neither bulb can be blown with the mouth, but with a bellows, containing pure, dry air. A small capsule is filled with pure mercury, which is heated to boiling to expel both air and moisture. While still hot the second or temporary bulb is warmed to expel a portion of the air therein; the open end is placed in the mercury, which ascends into the bulb because the air contracts on cooling. When a sufficient quantity of the hot mercury has been introduced into this bulb, the tube and the other bulb are heated to expel a part of the air, and some of the mercury, which must always be kept hot to prevent its chilling and thus breaking the hot glass, enters the real bulb. By repeating the operation the bulb and stem are completely filled with mercury, which is then boiled to expel every trace of air. The tube is now drawn out close beneath the auxiliary bulb to a fine thread and cut off; the thermometer is placed in a bath heated a few degrees higher than the highest temperature which the thermometer is to show; the excess of mercury flows out, and the point is closed with a fine blowpipe flame. As the mercury contracts on cooling it leaves a perfect vacuum above it.

The graduation is effected by putting it into ice or snow, then in the steam from boiling water, marking each of these points, dividing the space between into 100 parts if it is to have a Celsius or centigrade scale, into 80 if a Reaumur, or 180 if a Fahrenheit. This graduation is carried on in each direction to the end of the stem. On the Fahrenheit scale the freezing point is marked 32, on each of the other scales it is marked zero.

Absolute zero is a term applied to a temperature 273° below zero on the centigrade scale, or —460° Fah. If we take 273 cubic inches of air, or any gas, measured at 0° C., it will become 274 at +1° C., or 283 at +10° C., or 373 at +100° C., and at —10° C. it is only 263, at —40° it is only 233, and at this rate it should become only 1 cubic inch at —272°, and at minus 273° it should occupy no space at all, or at least not be a gas any longer. As this temperature is not yet attainable, we cannot positively assert that such would really be the case.

Maximum thermometers are made by placing a little float of steel upon the mercury, and the thermometer placed horizontally or nearly so. As the mercury expands it pushes along the float, which does not, however, follow the mercury when it contracts; hence we are able to ascertain the highest temperature reached during any given interval. To reset the thermometer it is raised to a vertical position and a slight tap given to it, which causes the float to drop down on the mercury again.

A simple and more accurate form of maximum thermometer, employed by Bunsen in measuring the temperature of the Geysers, consisted of an ungraduated thermometer open at the top, such as could easily be made by a person of but little experience. When placed in the spring, of course, a portion of the mercury would flow out and escape. At any subsequent time the thermometer could be placed in an oil bath beside a standard thermometer, and heated until the mercury had entirely filled the tube and was about to flow over; at this moment the standard thermometer is read, and shows the temperature to which the other thermometer had been exposed. The ordinary minimum thermometer contains alcohol instead of mercury, and the float is either of glass or of steel covered with enamel, so that it is drawn back by adhesion, but cannot be pushed forward.

The most reliable form of self-registering thermometer is an upright mercurial thermometer behind which is passed by clockwork a strip of sensitized paper. In front of it is placed a light of sufficient actinic power to blacken the paper above the mercury column. This gives not merely the maxima and minima but all variations of temperature.

Metallic thermometers may be constructed by combining two metals which expand unequally into a spiral, which winds up when heated and unwinds when cooled. One end of the spiral being attached to an index which passes along a graduated arc, the slight motions are magnified so as to be distinctly visible. It is graduated by comparison with a good mercurial thermometer.

For measuring slight changes in temperature a thermo-electric pile, connected with a galvanometer needle, is employed. This is only applicable within very narrow limits and requires great care to obtain satisfactory results.

E. J. H.

HYDRAULIC MORTARS AND CEMENTS.

Certain limestones, which contain upward of 10 per cent silica, possess the property, when burned, of forming a cement or mortar which hardens under water. Such limestone is called hydraulic lime, and the mortar is called hydraulic mortar. This stone, before burning, consists of a mixture of carbonate of lime and silica, or a silicate, chiefly silicate of alumina. The latter is insoluble in hydrochloric acid, hence remains undissolved when the stone is treated with this acid, but in burning this silicate is fluxed by the alkaline carbonates and becomes soluble in acid, the carbonic acid being expelled. When common lime is slaked it swells enormously and develops a great deal of heat; this is not the case in slaking hydraulic lime, which absorbs water without any considerable increase of temperature or of volume.

If ordinary lime be mixed with a suitable quantity of silica or sand, an artificial hydraulic mortar is obtained, to which we apply the name of cement. These cements may be either natural or artificial. The former are found in volcanic regions, having been produced by the terrestrial heat. Pozzuolana, found at Pozzuoli, near Naples, is a natural cement of the following composition: Silica, 44·5; alumina, 15·0; lime, 8·8; magnesia, 4·7; oxide of iron, 12·0 (with oxide of titanium); potash and soda, 5·5; water, 9·3; total, 100·8.

The quantity of lime is, however, so small that it requires to be mixed with ordinary lime to form hydraulic mortar. It was employed in combination with an equal quantity of lime in building the Eddystone Lighthouse.

Artificial cement, also called "Roman cement," because it is *not* made in Rome, has been manufactured in England on the Thames and in the Isles of Wight and Sheppey since 1796. It is made by burning the calcareous nodules which overlie the chalk in that country. A sample analyzed by Michaëlis contained: lime, 58·38; magnesia, 5; silica, 28·83; alumina, 6·40; oxide iron, 4·80. When mixed with water it hardens in fifteen or twenty minutes, and possesses great firmness and strength.

Portland cement was patented in England by Joseph Aspdin in 1824. He took the limestone of Leeds, pulverized and burned it, then mixed it with water and an equal weight of clay to a plastic mass. When dry this was broken up and burned again until all the carbonic acid was all expelled. It was then pulverized and was ready for use. Pasley made it from chalk or limestone with Medway River clay, which contains salt. Pettenkofer suggests that cement is improved by soaking the clay in salt water.

Portland cement is now made, says Wagner, by making bricks of an intimate mixture of limestone and clay, drying them in the air and burning them in a tall shaft furnace from 45 to 100 feet, 12 feet in diameter, with a strong grate 4 feet from the bottom. It is charged with alternate layers of coal and cement stone. The properties of the cement are largely dependent on the temperature employed in burning; a white heat is best, but if the temperature is too high it will no longer unite with water, and may even be melted to a glass. If the temperature does not exceed a red heat it unites readily with water and gets hot, like ordinary lime, but possesses very little strength. The color changes with the burning and forms a criterion for judging the quality. In normal condition it forms a gray, sharp powder, with a shade of green, but not glassy.

The manufacture of Portland cement is now carried on in every part of the world where limestone and clay are to be found. In order to obtain a good cement, not only must the proper heat be employed in burning, but the proper proportion of clay, usually 25 per cent, must be used, and the clay must have certain properties, such as a large proportion of silica, must be very finely divided, and must be very intimately mixed with the limestone. Analyses of Portland cement from various sources show the percentage of lime to vary from 55 to 62; silica, 23 to 25; alumina, 5 to 9; oxide of iron, 2 to 6; soda and potash, usually less than 1 per cent.

A calcareous marl found near Kufstein forms a natural Portland cement on burning without any other admixture. The analysis shows that it contains 21·77 per cent of insoluble substance containing 16 per cent of silica. The portion soluble in hydrochloric acid consists of 70·64 carbonate of lime; 1·02 carbonate of magnesia; oxide of iron, 2·58; alumina, 2·86. These figures lead us to expect that a marl containing from 20 to 25 per cent of insoluble matter, with 70 of carbonate of lime, will probably furnish a good cement when burned. The presence of much magnesia seems to have in all cases an injurious effect; all excellent hydraulic lime contains very little magnesia.

Erdmenger, who has studied the constitution of Portland cement very carefully, concludes that it is not a definite chemical compound. He considers it rather as water glass, in which the alkali is replaced by lime.

A consideration of the use of Portland cement in the manufacture of artificial stone would exceed the limits of our present article.

H.

GENERAL GRANT AS PRESIDENT OF THE WORLD'S FAIR COMMISSION.

General Ulysses S. Grant was chosen permanent President of the World's Fair Commission, at a meeting of the Commissioners held in this city January 13. It was announced that he had consented to serve.

General Grant's ability as an executive officer is known the world over; and probably no other name would have carried so much influence at home and abroad. With a leader so well known, popular, and capable, the Commission should be able to raise promptly all the money needed to secure at Inwood, in 1883, an exhibition worthily representing the progress of the world since 1876.

SOLAR CLOUDS AND SUN SPOTS.

Some recent studies of solar spectra in connection with sun spots and other features of the sun's envelope have led Mr. Charles S. Hastings, of the Johns Hopkins University, to form a somewhat novel theory of the sun's constitution and the conditions producing the more notable phenomena familiar to solar students.

Mr. Hastings finds, contrary to the received opinion, that the spectra of the center and the outer edge of the sun's disk are not precisely alike, though the differences are so minute as to escape all but the most perfect instruments and all methods which do not place them in close juxtaposition. Certain of the Fraunhofer lines, the thickest and darkest in the spectrum, notably those of hydrogen, magnesium, and sodium, which appear with a haze on either side in the spectrum of the center of the solar disk, are sharp and distinct in the spectrum of the limb. Certain very fine lines are stronger at the limb, while other very fine lines are stronger at the center. The ordinarily accepted theory of the solar constitution and the origin of the Fraunhofer lines fails to explain these phenomena. The probable reasons for this failure Mr. Hastings discusses at considerable length in the January issue of the *American Journal of Science*, and then proceeds to frame a theory of the sun's constitution, which, he thinks, will satisfactorily explain all the observed phenomena. The limit of our space forbids more than the briefest summary of his conclusions.

His theory differs from that of Faye chiefly in localizing the phenomena of precipitation instead of regarding it as proper to all portions of the photosphere, and in supposing the precipitation confined to one or two elements. He attributes the granular appearance of the solar surface to ascending currents directed generally from the center of the sun. About these currents are necessarily currents in an opposite direction, which serve to maintain a general equilibrium in the distribution of mass. The ascending currents start from a level where the temperature is probably above the vaporizing temperature of every substance. As they move upward the vapors are cooled, mainly by expansion, until a certain element (probably of the carbon group) is precipitated. This precipitation, restricted from the nature of the action, forms the granules. The precipitated material rapidly cools, on account of its great radiating power, and forms a fog or smoke, which settles through the spaces between the granules till revolatilized below. It is this smoke which produces the general absorption at the sun's limb, and the "rice grain" structure of the photosphere. The reasons for supposing the precipitated element to be of the carbon group (carbon or silicon) is simply that no other substances present the properties indicated by the cloud masses of the photosphere. It is pretty clear that the substance has a boiling point above that of iron, for iron vapor at a lower temperature exists in its immediate neighborhood. The element is not a rare one, and its molecular weight cannot be great, for though precipitated below the upper natural limit of its vapor there are few elements found in abundance above it, and those in general of low vapor density. It is possible that the light coming from the sun is radiated from solid or liquid particles of carbon just at the point of vaporization; but Mr. Hastings is rather inclined to suspect that the photospheric material is silicon. There is also good reason to suppose, he thinks, that carbon is precipitated at a higher level, possibly along with the less common element boron.

The clouds of carbon or other smoke would naturally be drifted into spaces of downward flowing currents, thus forming sun spots, the characteristics of which are readily accounted for by the necessary behavior of smoke clouds sinking into regions of higher temperature. This explanation of sun spots and their allied phenomena is certainly plausible, and we shall look with interest for what older students of the sun shall have to say about it.

THE MATANZAS INTERNATIONAL FAIR.—Mr. Benjamin Giberga, general agent for the United States of the approaching Cuban World's Fair, announces that the opening day has been definitely fixed for February 10, 1881.