For the Journal of the Franklin Institute.

Naval Steamers.

Having observed, recently, in several of the public papers, articles extolling the virtues of the U. S. Steamers *Susquehanna* and *Powhattan*, now belonging to the Japan Squadron, and knowing that the reports published were not a fair statement of facts, but were furnished for publication by interested parties, I have thought it worth the trouble to obtain the following facts, so that each may have that credit which is justly their due. The Japan Squadron of steamers consists of the *Mississippi*, of 1800 tons, *Susquehanna*, 2400 tons, and *Powhattan*, 2400 tons; the former has been in commission since 1841; the latter are now on their first cruise. Their total cost, at the time of their first cruise, has been as follows:—

Mississippi,	\$569,670 = \$316.48 per ton.
Susquehanna,	743,044 = 309.60 “
Powhattan,	788,160 = 328.40 “

The machinery for each one cost—

Mississippi,	\$243,784 = \$135.44 per ton.
Susquehanna,	332,766 = 138.65 “
Powhattan,	389,980 = 162.45 “

From this table it will be seen that while the *Mississippi* was built at an early period, (her side lever engines being the first, of any magnitude, made in this country,) when heavy forgings and castings cost much more per pound than at present; yet her *solid* side lever engines cost but a trifle more per ton than the inclined engines of the *Susquehanna*, and much less than those of the *Powhattan*, although the latter form of engine has been claimed to be the best, by those who wish to extol the new at the expense of the old. A few facts will show which is the most to be relied on. The *Mississippi*, up to the latest dates from her, had on this cruise steamed nearly 30,000 miles, and was then in perfect order for service, and at no time since leaving Norfolk had she been out of order, but at all times was ready to go when wanted. The *Susquehanna* has had a series of small mishaps, and at present has two air pump beams cracked, (which have been secured) and will have to be furnished with a new centre shaft before she returns home (which has been sent to her). The *Powhattan* required 10 weeks after she arrived out at China, before she was reported for duty. My object has been to show that our first steamer has been the most efficient; that her machinery, which was well made, has stood the test of time, and been well tried on nearly all our naval stations, and that to-day she is what she always has been, the *most reliable steamer* in the Navy.

FULTON.

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Description of the Interferential Refractometer of Arago.

If two beams of white light, proceeding from the same source, are propagated through the same homogeneous medium, and have followed paths which are very nearly equal, they form, wherever they cross each

other at a slight angle, a compound system of dark and light fringes, easily visible. The central fringe is the least colored; it is nearly either white or black, white between two blacks, or black between two whites, and this character is sufficient for its recognition. In the place which it occupies, the interfering rays have passed over exactly equal distances. Everything, intensity and color are symmetrical on each side of this central fringe. M. Arago determined, many years ago, that the relations of the paths described did not alone determine the place of the fringes thus formed by the interference of the two beams of light. By placing in the air, an exceedingly thin strip of glass, in the path of one of the beams, he found the bands incline towards the slip. This experiment, repeated a great number of times, with all kinds of solids, liquids, and gases, leads to a law which connects, in a very simple manner, the displacement of the fringes with the refracting power and thickness of the transparent body which is thus traversed by one only of the two beams.

So soon as he had discovered this entirely new mode of measuring the refractive powers of transparent bodies, M. Arago was led to apply it to the study of this power in moist air. It was, in fact, very important to know certainly whether the hygrometer was to be taken into consideration, in the calculation of astronomical refractions; it is a question already treated by two illustrious physicists; first, by La Place, by the aid of the general supposition that vapors, and the liquid from which they come, have the same refracting powers,—a supposition very plausible, on the hypothesis of emission, but not confirmed by subsequent researches; afterwards by Biot, by experiments as accurate as the method used admitted of. Fresnel joined Arago in performing the experiment, which he had desired, and the following is the way in which it was tried: two tubes of thin copper, of about a metre in length, were soldered together, like the two barrels of a double-barrelled gun; at each extremity these two tubes were closed by the same plate of glass, with parallel faces. Stop cocks admitted the substances to be experimented on. When the tubes held air of the same density, temperature, and dryness, the beam which traversed the right hand tube, produced, by mixing, as it came out, with that coming from the left, colored fringes, whose place coincided almost exactly with that of the fringes resulting from the reaction of these same beams propagated through free air.

If, while the elastic force in the two tubes remained equal, one contained chloride of calcium and the other water, the tubes being then filled, one with air completely dry, the other with air saturated with moisture, the bands formed by the interference of the beams traversing each a metre of air in the two tubes, no longer occupied the same place as in free air; the interposition of the tubes caused a notable displacement equal to the breadth of one and a half fringes; this displacement was always toward the side of the dry air.

The direction of the displacement proved, in the first place, incontestably, that dry air had more refracting power than moist air; the ratio remained to be determined. From the law which we explained above, or from experiments made on the reduction of the pressure necessary in one of the tubes, in order that the fringes should be displaced by a fringe and a half toward the opposite side, the ratio of the refractive power of the two

airs might be directly determined. But it was possible that a slight coating of moisture might have been deposited on the internal surface of the two glasses in the damp tube; now, such a deposit, however thin, might be supposed to play an important part in the phenomena, and would mask a great part of the effect looked for. This was the difficulty which deterred Fresnel from giving any numbers in support of the conclusion which he and M. Arago drew from their joint experiment.

This difficulty M. Arago has since entirely removed, by repeating the former experiment by means of two other tubes, the one dry, the other moist, closed at their extremities by the same glasses which had been used before; but this time they were but one centimetre, in place of a metre, in length. The influence of the difference of the refracting power of the two airs being thus almost eliminated, nothing was left but the effect of the film of moisture, precipitated on the interior surface of the two glass plates in the moist tube; this effect was always inappreciable. The displacement, therefore, of a fringe and a half observed in the tubes one metre in length, depended exclusively on the comparative refracting powers of dry air, and air saturated with moisture. The difference at 25° Cent. (77° F.,) was such that if we assume as the ratio of the sine of the angle of incidence to that of refraction, when light passes from a vacuum into dry air, the number 1·0002945. This ratio, when the light passes from vacuum into moist air, (saturated,) becomes 1·0002936. A difference in the seventh decimal place of the indices of refraction is thus shown in experiments in which the ray has been refracted. Let us add, that, as the exactness of the method is proportional to the length of the tubes, nothing prevents us from going much further with it.

This experiment will be completed by another. It is required to know whether heat exercises upon the refractive power of air any influence except that due to its power of dilatation. The doubt merits examination the more, since warm glass refracts more than cold glass. In order to leave nothing undetermined in a question of such importance as that of astronomical refractions, it remains still to study the influence of electricity at rest or in motion. All this is now accessible, and will soon be cleared up.

We will briefly indicate some other applications of which the method of M. Arago is susceptible, and which he has explained to the Academy. Let us conceive of a tube of a certain length, void of air, closed at its two extremities by plates of glass and hermetically sealed. By selecting properly these two pieces of glass, and a third movable plate, intended to be placed in the path of the external ray, we may cause the interference-fringes of the rays passing through the air and vacuum to be formed, by an effect of compensation, exactly as though they had passed through a homogeneous medium. Only, if the external atmosphere changes its refracting power, the fringes will be displaced, their movement being toward the tube when the refractive power diminishes, and the reverse when it increases. Such an instrument might then be employed in observatories, in place of the barometer and thermometer, for the determination of the respective power of the atmosphere. The observation might be made at the height of the object glass of the instru-

ment, and would put an end to the interminable disputes as to the use of the external or internal thermometer in calculating refractions.

The refracting power of air is a function of its pressure and temperature; the pressure remaining constant, if the temperature varies a single degree Centigrade (1.8° Fah.); the fringes in an instrument 11 decimetres (43 inches) long, would be displaced by the breadth of ten entire fringes. This movement may be measured to the tenth of a fringe-breadth.

The instrument described may, therefore, when combined with a barometer, serve to determine the temperature to 0.05° Cent.

This extreme sensibility may be indefinitely increased by increasing the length of the vacuum tube; but this is one of the least advantages of the method. A thermometer, being under the influence of the radiation of the sky, of the ground, and of all surrounding objects, never gives the temperature of the air. On the contrary, the result deduced from a property of the atmosphere, which is a function of its temperature, is completely protected from all these causes of error.

On journeys, if one was contented to take the atmospheric temperatures such as they are now determined by the thermometer, the vacuum tube might serve as a barometer. A length of tube of one metre (39.4 inches) would permit the appreciation of variations of pressure of from 0.1 to 0.2 of a millimetre (0.0039 to 0.0078 inch). A barometer without a liquid would appear singular enough, but travellers would, especially, remark its small fragility.

M. Arago has shown that his method for determining refractions may be used to determine the state of the atmospheres at all distances from bodies, whether heated or not; to follow the interesting experiments of Faraday upon the atmospheres of mercurial vapors, and their diminution of density as the distance from the liquid increases; perhaps even with tubes sufficiently long, to make sensible the influence of odors. The quickness of the observation permits us, moreover, to conceive the hope that by giving the tube a proper direction in reference to an energetic centre of sound, several properties of sonorous waves may be made sensible to the eye.

As to liquids, it results from observations already made, that by the observation of fringes we may detect, even near the maximum of density, changes of refraction in water corresponding to 0.025° Cent. Who does not see here a new and very precise method of studying the propagation of heat in this kind of bodies, without breaking their continuity by introducing into them the bulb and stem of the thermometer. The same remark applies to the study of the propagation of heat through transparent solids.

Finally, even the increase of the refractive power of water and glass, resulting from the compressibility of these substances, may be detected by the aid of these new instruments. With a tube a metre in length, the compressibility of water for each 0.02 of an atmosphere will be visible; on a tube of glass, of the same length, 0.01 of an atmosphere will become sensible.

This interferential barometer and thermometer would be susceptible of great improvement if we could solve a difficult problem, of which the distinguished physicists, MM. Arago and Babinet, have not yet suc-

ceeded in finding a solution. It is required to bring two luminous rays, separated several centimetres, to conditions of useful interference, without many preceding trials.

In a following number we will give the drawing, description and theory of the instrument as constructed by M. Soleil. We will also add the result of some experiments made under the direction of M. Arago, by MM. Laugier, Soleil and Duboscq, on the refracting form of fog compared with that of pure air.—*Cosmos*, vol. iv, p. 8.

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Veritès Electro-Magnetic Safety Apparatus for Railway Trains.

In a preceding number of the Journal we gave a description of an electric clock, by M. Veritè, of Beauvais, extracted from the Parisian journal, *Cosmos*. From the same journal, for 6th January, we take a notice of another invention, by the same author, for the purpose of guarding against accidents to railway trains, much resembling in its principle the safety switch of Mr. MacRea, described at page 138 of this volume.

“We will suppose, for the sake of fixing our ideas, that it is required to regulate the running of the trains on the Northern Railroad from Paris to Amiens. At each end are placed two connected dials, supported on a small pillar of wood or cast iron, one of them facing Paris, the other Amiens, so placed as to be easily seen by the engine drivers when they arrive at the station. Each of them carries a plainly visible needle, and their circumference is divided into as many parts as there are kilometres* between the two consecutive stations at which they are placed. Each of these spaces is numbered, beginning with this at the upper part of the dial, which is 0.

Let us suppose that a train leaves the Northern Depot, and that the first station is at St. Denis, distant from Paris 8 kilom. The dial at Paris will be divided into eight equal parts, and, at the departure of the train, the needle will be vertical, its point showing 0. When the train has run 1 kilometre the needle will pass from 0 to 1; it will pass to 2 when the train has run 2 kilometres, and so on; so that, if the train arrives at St. Denis without interruption, the needle will have described the whole circumference, and will have returned to 0, ready for the departure of the next train. The first locomotive, on reaching St. Denis, will come into communication with a second dial, (whose index is also at 0,) divided into as many parts as there are kilometres between St. Denis and Enghien, the second station. The train, in its progress, will operate on the dial at St. Denis as it operated on that at Paris, and when it has reached Enghien, the index at St. Denis will have returned to 0. And this operation will take place from station to station, until the train reaches the extremity of the line.

In this way the progress of the train may be followed from station to station, kilometre by kilometre. If any accident should happen, or any

* The Kilometre is the French unit of distance, corresponding to our mile. Its length is about 0.62 of a statute mile.