copal varnish, this tube must be very secure. For the larger object-glass which you have, zinc was used instead of tinned iron.'

"The Munich tubes appear to be made of two thicknesses of light wooden battens, about $2\frac{1}{2}$ inches wide, and of the same length as the tube itself. These battens are laid longitudinally round a core, the inner thickness breaking joint with the outer; over this is laid a veneer of mahogany, which is finally French polished.

"The relative weights and thicknesses of the different tubes are as follows:—

	Thickness of Tube.	Weight of Tube.	
Brass or iron tube	0·06 to 0·10	3 to 5 lbs.	
		lbs.	oz.
Square deal, corners champered off	1·00	2	8
American tube, paper and zinc	0·20	1	$10\frac{1}{2}$
Mahogany tube, 8 veneers thick	0·37	2	1
Do. 6 veneers thick	0·28	1	$8\frac{1}{2}$"

Specimens of the tubes described accompanied the paper.

On the Angular Disturbances of Ships, as affecting Astronomical Observation at Sea. By Professor C. Piazzi Smyth, F.R.S.E., Astronomer Royal for Scotland.*

"Every one who has used a telescope on shore knows the importance of steadiness in its stand; and nearly every one in this nautical country must have experienced in person how ships roll, and pitch, and lurch at sea; upsetting all ideas of stability, even for the ordinary affairs of life, and much more for scientific requirements. On inquiring, however, from even practical men, I have not found them able to give me numerical particulars of the exact amount, and the manner of the occurrence, of these angular disturbances of position, which occur to a ship while pursuing its onward course; and as some knowledge of this is essential before attempting to devise a remedy, we may with propriety first consider the means of obtaining this information.

"*Measurement of the Disturbances.*—All the various angular motions to which any ship is liable, the translation of the whole ship bodily being of no moment here, are reducible to three, viz., —to *rolling*, a motion from side to side; *pitching*, from end to end; and *yawing*, or deviating in azimuth.

"*Old Ship-Clinometers.*—Very ingenious methods have been contrived to fit pendulums to act as ship-clinometers, as in Captain Becher's horizon; wherein the pendulum swings in a vessel of oil. But the result is not satisfactory; for the oil itself is dis-

* Reduced, by permission, from a paper lately presented to the Society of Arts at Edinburgh. The woodcuts have been very kindly lent by the Society.

turbed, and while the pendulum's tendency to vibration is not got rid of, its sensibility to angular motion is impaired.

"Troughton, again, employed a most elegant method; for, constructing a pendulum of a circular form, like an inverted cup, he set this spinning at a great velocity; and then for a time it seemed to bid defiance to any disturbances in the absolute position of what it rested on, while it showed the angular movements well. Soon, however, the defect predicted by an astronomer became practically apparent, viz., that the forces producing vibration in a simple pendulum were still at work in this rotatory one, and these effects compounded into the spinning movement, at length produced precessional disturbances, which entirely destroyed the accuracy of the indication.

"*New Clinometer.*—For ship purposes, then, we need something that shall be barely influenced by horizontal, but shall be very sensible to angular displacement. Now, this necessary quality of sensibility existing, as is well known, to a high degree in spirit-levels, I first tried modifications of these for naval purposes. The bubbles of air were certainly liable to vibrate after the style of the pendulum by linear movements; but they came to rest almost immediately after the disturbing force had ceased; and a little reflection on the reason of their first movement, immediately made me perceive that it might be reduced indefinitely by decreasing the size of the bubble, and this I found true in practice. But then came the difficulty, that with very small air-bubbles the friction or retardation of their movements greatly increased. A series of experiments, however, on different fluids, indicated that with chloroform the desiderated qualities existed in a sufficient degree for practical purposes, the amount of resistance to movement of small bubbles therein being about $\frac{1}{3}$d of that in ether, $\frac{1}{18}$th of alcohol, and $\frac{1}{100}$th of water.

"*Safety-Level.*—There then remained only to contrive some plan of safety, by which, in a hermetically sealed glass tube (for no other will confine chloroform) a very small bubble might be employed, without a chance of fracturing the glass when the liquid should expand at a high temperature. This object has been attained by introducing a pierced diaphragm into the tube

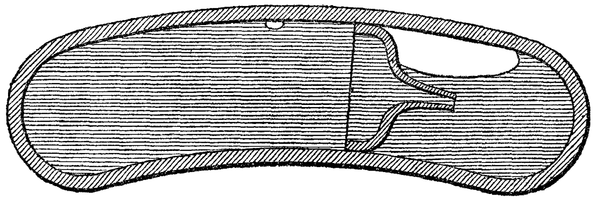

Fig. 1.

Sectional Elevation of the Adjustable Minim Bubble-Level.

near one end, and confining therein a large quantity of air, which serves as a safety-valve for the fluid from the rest of the tube

B

to press upon when expanding. In ordinary motions of the level, the air does not change its compartment, but when it is held vertical and shaken smartly, small particles of the air may be made to pass from one side to the other of the diaphragm; and thus the bubble may be adjusted in size at pleasure. Mr. John Adie has made many of these levels for me with consummate skill, and finds that to be the best kind of diaphragm or plug which is made of glass and fitted with floss silk.

" *Application to Ship Purposes.*—To apply this principle to a clinometer for use at sea, I have had such a safety chloroform level made to a radius of 6 inches, and an arc of 180 degrees. Being further fitted into a wooden frame with a greyed-glass back, having the angles painted thereon, the smallest bubble is clearly visible, and it will be found to possess, not perfect, but a very high degree of freedom from the effects of horizontal displacement, with, at the same time, an eminent degree of sensibility to angular motion.

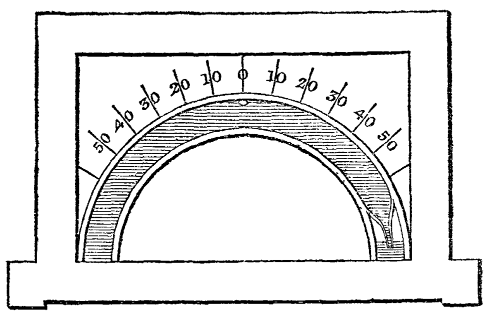

Fig. 2.

Sectional Elevation of the New Ship Clinometer.

" *The Rotation Clinometer.*—The level clinometer, however, does not indicate azimuthal disturbances; and though sufficient and very convenient for most practical purposes, a more perfect instrument is conceivable—one that shall be positively undisturbed by even the most violent lurches, and that shall measure yawing as well as pitching and rolling.

" Such an instrument I have now been able to bring forward, by a proceeding which is equivalent to balancing a Troughton's top, placing it in gimbals, and mounting a second similar apparatus on the top of it with its revolving plane crossing the other at an angle of 90°. But as this machine has resulted from the researches I have been making connected with the *elimination* of a ship's movements, presently to be described, I shall only now say that its action as a *differential* instrument for a short space of time is wonderfully perfect. The rolling is shown on one circle, the pitching on another, and the yawing on a third; and any features in which the level-clinometer may fail, are the strongest points in this instrument. For, while absolutely uninfluenced by horizontal displacement, however quick, or violent, or unexpected, still it has not thereby its sensibility to angular motion injured in the smallest degree; and, in a word, it may confidently be said to be entirely free from the defects which have been described to exist necessarily, to more or less extent, in all pendulums, fluids, or in gravitation appliances generally.

"*Elimination of the Disturbances. Methods hitherto in vogue.* —When an object, for instance a small table, is to be kept level at sea, there is but one method at present employed, viz., to suspend it freely, either in gimbals like a chronometer, or by strings from a hook, as with the trays over a cuddy-table.

"But plainly by such a proceeding we should not have approached the qualities of a table-stand for astronomical instruments; and as long as we have free suspension of any sort above, and a weight below, we may be sure that our arrangement is but a pendulum, which, as described in the case of the clinometer, must, when at sea, be ever oscillating anomalously; and, therefore, being unable to keep itself steady, it can never on ship-board keep a table so. Yet this was the only principle of Nairne's celebrated observing-chair, which, though rewarded by Government, utterly failed in practice.

"*Neutralization of Vibrations.*—Free suspension, however, of some kind we must have, or our table will be carried over bodily and forcibly with the ship; but let us first try to get rid of oscillations, the effect of horizontal displacements, and afterwards we may more successfully cope with the angular motion. To this end, knowing that a pendulum will swing, we shall find it salutary to hang it from its centre of gravity. Then, with a free suspension still, but with as much matter above as below it, the pendulum is changed into a balanced body; and the lurches of the ship, acting on the two halves with an equal force, but in opposite directions, are completely neutralized. In principle this method is simple and perfect; and in practice, with a model apparatus, consisting of a small table mounted on double gimbals and balanced, the correction is so complete that if the fixed frame be taken in the hand, and violently shaken, no vibration or particular disturbance is occasioned. But when a small weight is hung below, the least motion of the outside supporting-frame occasions a pertinacious oscillation of the internal gimbals carrying the table.

"*Elimination of Angular Movements.*—We have thus got rid of the effects of horizontal displacement, and of *lurching*, but the effect of angular motion still remains; for it will be found, on tilting the outside fixed frame above described, that the whole of the internal parts tilt over too, and have no power of themselves to maintain any one position more than another. The human hand is continually needed to put them right. When it is considered that a ship is never at rest, not even for the tenth part of a second, it is plain that we must look to some much more efficient means than the hand of man, to effect our purpose; something that will in fact correct for the motion of the ship while it *is* taking place, and before it *has* taken place.

" *The Spinner, or Free Revolver Stand.*—On clearly making out to myself, two years ago, the nature of this difficulty, it occurred to me to try for its correction the principle that enables the earth so steadily to keep its pole pointed to one invariable part of the sky while it is being annually swung round the sun, and exposed to so many disturbing forces, which are yet not able sensibly to prevail against it. This principle, the persistence of a free axis of rotation, combined with the composition of rotatory motion, was also particularly known to me by Troughton's Top, or Spinning Pendulum, before alluded to, and by the writings of the Rev. Baden Powell.

" Introducing, therefore, into the internal gimbals of the already-described balanced apparatus, a smoothly and rapidly revolving wheel, and balancing it also on the gimbal pivots, and placing its plane horizontal, I had the satisfaction of finding that it was perfectly efficacious in defending the table from any pitching or rolling motion that could be given to its supporting frame, quick or slow, short or long.

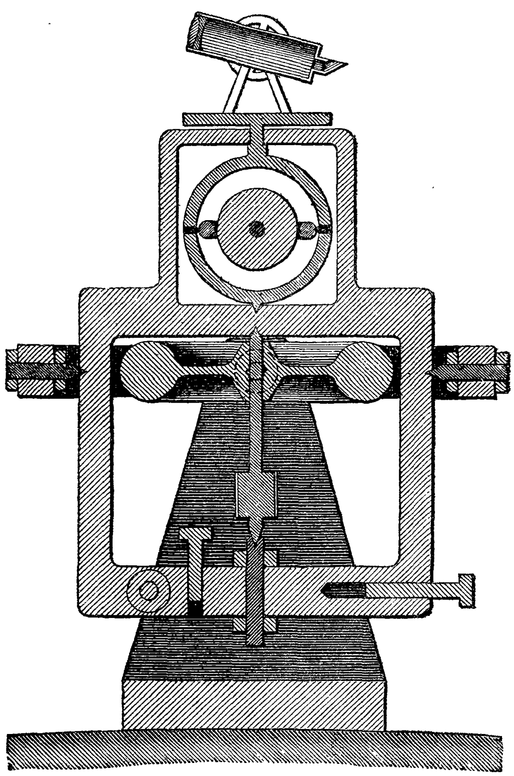

Fig. 3.

Sectional Elevation of Simple Revolver Stand.

" The single spinner apparatus described above, though fully able to protect from all disturbances at right angles to its plane, cannot protect from any that coincide with it. But having, by its means, obtained a small platform, which, once put level by hand, keeps itself so, we may on that erect a second spinner in gimbals with its plane vertical; and balancing this on its own gimbals, and also on those of the first spinner, we may then employ its power to protect from azimuthal movements a table or a telescope placed on its outer gimbal ring.

"Such table will then be entirely defended from all the possible angular movements of a ship; and a telescope once directed on a star, will keep it in the field without hand, though the ship may pitch and roll and yaw to any extent. And if the telescope be moderate in size, and the eye-piece not far from the centre of motion, and its lens large, an observer would have no difficulty in following its apparent motions, with his eye, really rolling with the ship, and so might keep up uninterrupted observation with a high magnifying power.

"*Driving the Spinners.*—Having now a stand with wheels, and it being necessary to make them as large and heavy as possible, something more powerful than a train of wheel-work, impelled by the hand, is necessary to drive them, and to get up a speed, be it remembered, which is unprecedented in mechanics.

"Let it be laid down at once that our driving-power for the wheels must come from a steam-engine, by endless band, or by water, or by steam-pipe.

"With an endless band there will be difficulty in getting up the necessary speed, on account of the slowness of the first mover in a steam-engine. Intervening wheels and pinions multiply expense, vibration, and friction, and, after all, are not so extensively available for multiplying speed excessively as the motion of fluids pressed out of large tubes into small ones; as an extreme case of which may be taken the boiler of a steam-engine with some thousand times the area of the steam-pipe through which all the steam is conveyed away.

"This method I have therefore experimented on in the case of water, air, and steam. The same means employed to utilize one will also suit the others; but air and steam are capable of producing much more velocity than water for the same pressure; and of the two aëriform drivers, steam is the more easily applied, as it can be brought to bear at once out of the boiler by a pipe without the intervention of pump machinery. The steam indeed at first proved troublesome, by its heat and moisture, on escaping after it had done its work, but it was soon found quite possible to carry off all this waste by a second steam-pipe placed in a small wooden chimney communicating with the box in which the driving apparatus was contained.

"*Elemental Driving applied directly to the Spinner.*—To gain this end I have made many experiments, and have concluded with a small turbine on a pin which is fixed into the lower spinner pivot, and projects through its bearings. In the normal position of the apparatus the turbine hangs down in the inside of the supporting-stand or table; the steam or water pipe, fitted with a peculiar nozzle, is then raised so as to enter the void centre of the turbine, and flashes out the fluid in a horizontal sheet through the curved and open sides. The vanes forming these sides are purposely set nearly at right angles to the radii, in order to make the speed of revolution surpass the rate of efflux, and appears in a transverse sectional plan, as in fig. 4.

Turbine Driver.
Sectional Plan.

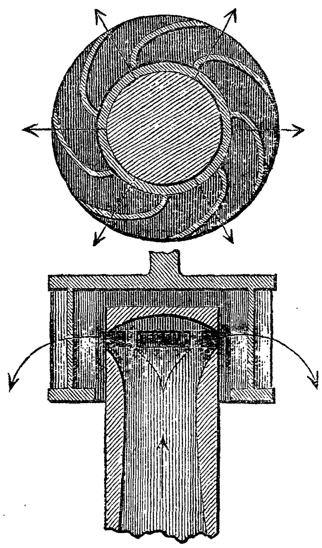

Fig. 4.
Sectional Elevation of the above.

"The power of this method is so great that the wheel moves the instant the steam is applied, the full velocity is obtained in but a few seconds, and the addition of the 10 lb. spinner hardly affects the rate of revolution of the 4 lb. turbine, which is about 70 to 80 per second.

"*Conclusion.*—With these powerful elemental methods of driving, and with large wheels at high velocities, there seems no reason why platforms should not be constructed for use on ship-board capable of carrying both the observer and his telescope.

"Tremor might be feared, because we find it more or less wherever we find mill-wheels revolving; but that is because their centre of gravity is not adjusted symmetrically to their axis of motion. In our case we do employ accurate methods of effecting this important correction, and we may expect, therefore, the large wheels to revolve as smoothly and as silently as the small ones."

The following paragraph appears in the *Boston Daily Evening Traveller* of October the 22d:—

"We understand that George P. Bond, Esq., who was recently appointed by the President, with the consent of the Senate, Chief Astronomer of the United States, under the Act of Congress of August 11th, 1856, to carry into effect the first article of the Treaty of June 10th, 1846, between the United States and Great Britain, by running the boundary line between America and British Oregon, has declined the appointment.

"Mr. Bond is the first assistant at the Astronomical Observatory of Harvard University at Cambridge, and by this decision meets the strongly expressed wishes of the friends of the Observatory, and of its Director.

"We also understand that this nomination was made by the

President, without any consultation with Mr. Bond, and solely on account of the high reputation he has acquired as an Astronomer. It was, therefore, an appointment equally honourable to the President and (to the) recipient thereof."

Extract of a letter from Mr. G. P. Bond, dated November 7, 1856:—

"We are preparing, on a large scale, for renewing experiments in lunar photography.

"Before this reaches you, you will probably have received Part i. of vol. i. of our *Annals*, completing the first volume . . . The subject of Part i. vol. ii. will be mostly *Saturn*, of which we have eight years' observations of physical aspect," &c.

At the conclusion of the ordinary business of the meeting, Mr. Carrington gave a verbal account of a recent short tour of inspection into the present state of some of the German observatories; premising his statement with the remark that it would greatly tend to keep our information of what other observers are engaged in up to date if other Fellows of the Society would, after autumn travels, in like manner communicate what they had had opportunities of ascertaining. The observatories visited were those at Bonn, Bilk, Göttingen, Gotha, Leipsic, Halle, Dessau, Berlin, Hamburgh, and Altona. Mr. Carrington was requested to put his remarks into a form suitable for the *Monthly Notices;* and will, in this paper, endeavour to comply with the wish expressed.

Woodcut representations of several of the above-named observatories will be found in a little tract entitled *Deutschland's Vorzüglichste Sternwarten*, written and published by Carl von Littrow, as an appendix to his Calendar for the year 1848, and sold separately. A copy was presented, and laid on the table.

At Bonn, Dr. Argelander, and his assistants, Drs. Schoenfeld and Kreuger, are now principally engaged upon a large series of zone observations of stars for basis-points of an extensive system of charting. The whole northern hemisphere has been divided into zones of two degrees width by one hour in length, to be gone over twice, the zones of the second series overlapping those of the first by one degree. The positions are being observed with a small equatoreal of less than three inches aperture, with a species of comb *painted* on a plate of glass in the focus; and the work is much of the quality of the Markree observations made with a similar object. Of about 2000 zones required, 1300 are completed, and a trial-chart (scale double the Berlin) lithographed. The Professor confines his own attention more particularly to the continuation of his researches connected with variable stars,