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J. C. Adams, Esq., President, in the chair.
Dr. Dick, Broughty Ferry, Dundee.
Capt. Ommanney, R.N.; and
G. V. Vernon, Esq., Manchester,

were balloted for and duly elected Fellows of the Society.

An Account of certain Experiments towards increasing facility and certainty in the Use of Mercury in Observations by Reflection and for the Adjustments of Astronomical Instruments.

By the Rev. C. Pritchard.

1. The difficulties and annoyances attending the use of mercury for instrumental adjustments are too well known by practical astronomers to require any description. In the present communication I propose to lay before the Society an account of certain experiments, which appear to disclose the source of these annoyances, and then to explain a method or methods by which I venture to believe they may be fully and with certainty and facility overcome.

2. My first attempt to modify or prevent the well-known tremors to which mercury is liable, consisted in placing a rim of amalgamated copper round the sides of the trough containing the mercury, and in roughening the bottom. I found this process diminished by half the quantity of mercury necessary to cover the bottom, but the tremors still continued, while the surface became dirtier than before.

3. The next expedient resorted to was the amalgamation of the bottom of the vessel, as well as that of the sides; thereby I found the quantity of mercury necessary to cover the bottom was about \(\frac{1}{15}\)th or \(\frac{1}{15}\)th of that required when the copper vessel was wholly unamalgamated. The surface of the mercury was also found to be exquisitely quiescent; the image of the wires in the telescope was decided and motionless, even when the meridian-shutters of the observatory were open, and the wind was blowing with sufficient force to extinguish the flame of gas; still the reflecting surface of the mercury was far from perfectly bright and clean. Attempts to remove the offending matter, either by skimming the surface or by
filtering the mercury through a cone of paper, failed to give a surface satisfactorily free from blemish.

4. Upon examining the mercury in the amalgamated copper vessel, after it had remained there untouched for twenty-four hours, and after gently inclining the vessel, I observed a phenomenon wholly unexpected. The entire surface was found to be covered with a somewhat tough film or pellicle, apparently consisting of long acicular crystals, starting, as it were, from the sides of the copper vessel, and chiefly from the lower parts of it, where the excess of mercury seemed to lift it up. If the vessel were carefully restored to its original horizontal position, the pellicle ceased to be visible: a small amount of violence fractured it, and then the line of fracture presented a permanent silvery line, reflecting but little light; upon further agitation the whole film broke up into minute particles, causing the surface of the mercury to assume somewhat of the appearance of frosted silver.

5. Upon pouring this mercury, thus contaminated, out of the shallow amalgamated vessel containing it, I found this film, or the greater portion of it, adhered so strongly to the bottom, that for a long time all my efforts to detach it were ineffectual. Wiping or gently scraping only served to divide it into smaller portions, and so, by floating on the top of any fresh mercury subsequently poured into the vessel, continued to injure the reflecting surface.

6. At length I devised a means of detaching this obnoxious film, by means of the percussion of a thin stream of mercury as it filtered through a cone of paper upon the bottom of the copper vessel held in a nearly vertical position. The film was thus gradually washed away and removed, and a small quantity of mercury, which was then suffered to remain in the vessel, presented the appearance of beautifully-faultless and highly-polished plate-glass. When this surface was placed under the telescope the reflexion of the wires was tremorless, black, and decided; so much so, that I was at first unable to distinguish the transit or the horizontal wires from their image.

7. This condition of the surface seemed to remain nearly unimpaired for five or six weeks, provided the vessel were permitted to remain undisturbed. Still, upon a closer examination, the existence of the pellicle or film was easily detected, and upon a slight agitation it broke up into the same small silvery portions I had before observed. Here, then, arose a formidable difficulty to the application of mercury thus treated to the observation of stars by reflexion, inasmuch as such observations require the repeated shifting of the reflecting surface.

8. In order to remove this obstacle, I tried the effect of amalgamation without the use of acid, conceiving that by some possibility there had been a formation of nitrate of mercury, inasmuch as the film under the microscope presented much of the appearance of this substance. But the film still made its appearance.

9. I then tried the effect of a vessel made of silver-electroplated copper. The adhesion of the mercury was perfect and in-
stantaneous, and the surface at first beautifully white, and perfect, and quiescent; but after a few hours the film, or a similar film, made its appearance just as before.

10. A copper vessel was then silvered by means of cyanide of potassium and oxide of silver: the surface of the mercury then became contaminated with a yellow film; but upon removing this by cyanide of potassium the reflecting surface was as perfect as in the former instances. Yet, after a few hours, the obnoxious film appeared as before.

11. Mercury placed in a tinned vessel presented a surface worse than any other observed.

12. It now became necessary to discover, if possible, what the pellicle was, and what was its origin. Hydrochloric acid was found to have no effect upon it; the film, therefore, did not consist of the oxide of a metal. Nitric acid entirely dissolved it, and upon applying the usual tests, the film appeared to consist entirely of metallic copper and metallic mercury, or of metallic silver and mercury, according as the vessel was either copper or silver. The mercury used was originally pure, but after standing in the shallow amalgamated vessels it was found to contain either silver or copper, but these metals only to a very slight extent, and in quantity by no means approaching the proportions in which they existed in the films. The source of these films now, therefore, appeared to be evidently the gradual floating up of the amalgams formed at the bottom of the vessels through the supernatant mercury. The existence, therefore, of these films seems to be an inherent and necessary consequence of amalgamation.

13. In this state of things I resolved to try the effect of a vessel made of platina. In order to effect the amalgamation of this metal, I in the first instance, adopted the very ingenious process pointed out by Mr. Grove, in an admirable paper printed in the Philosophical Magazine for August 1839, viz. that of making the platina dish, while in contact with mercury, the negative electrode in a voltaic circuit. Subsequently, however, I found that, provided the surface of the platina had been previously acted upon by nitro-muriatic acid, I could amalgamate the metal as perfectly and easily as I could copper, and that by simple friction only, without the intervention of the voltaic circuit. I had entertained the hope that the film of platina amalgam would now, on account of its density, remain at the bottom of the vessel, but it made its appearance at the surface of the mercury just as readily as in the case of a copper or silvered vessel, and with this additional disadvantage, that the film when broken up by agitation reflected less light than in the cases of copper or silver.

14. Thus the hopes I had entertained from the use of platina were not realized, but the object of these experiments had been so far attained that I could at any time procure a perfectly bright and comparatively tremorless surface of mercury, by means of the amalgamations and mercurial washing or percussion already described: this surface would remain effective for several weeks if undisturbed,
but did not, after a few hours, admit of unlimited removal from place to place.

15. Upon detailing these experiments to that very accurate philosopher, Professor Miller of Cambridge, he informed me that a paper upon the subject of the artificial horizon had appeared in Poggendorff's *Annalen*. On referring to p. 156 of the 79th volume, I found that M. Oertling, of Berlin, had there proposed an artificial horizon, constructed on the following principles:—1, a very shallow copper vessel was to be made, of a depth not exceeding $\frac{3}{2}$ th of an inch; 2, this vessel was to be amalgamated by means of mercury and hydrochloric acid; 3, this exceedingly shallow vessel was to be placed upon a stand, supported by three adjusting foot-screws; 4, mercury was to be amalgamated to a very great extent with tin; 5, this amalgam of mercury and tin was to be poured into the shallow amalgamated copper vessel, and then the excess of mercury carefully skimmed off, leaving thereby a bright and tremorless surface. This surface, however, M. Oertling observes, is liable upon agitation, or from the access of wind, to become exceedingly foul. Of these five conditions, omitting or modifying four, and retaining only the fifth, viz. that of skimming off the surface, I now propose a construction of vessel, which I venture to regard as fulfilling all the requisites sought for in a perfect, and permanent, and movable reflecting surface. The surface itself is very easily obtained or renewed, and appears to be as applicable for the reflexion of stars as it is for the reflexion of the wires of a telescope. No adjusting-screws are necessary, no admixture of tin, no acid, nor any vessel of inconvenient shallowness, but such an one as may without difficulty be conveyed from place to place. The construction which I propose is as follows, admitting, however, such modifications as circumstances may require.

16. Upon a board of mahogany, or other wood, about $1\frac{1}{2}$ inch thick, is to be placed a perfectly flat rectangular plate of copper. On this copper is to be placed a flat rectangular rim, about $\frac{3}{2}$ th or $\frac{1}{2}$ th of an inch thick, and $\frac{1}{2}$ an inch wide. Thereby is formed a shallow rectangular vessel of copper, $\frac{3}{2}$ th or $\frac{1}{2}$ th of an inch deep. On three sides of this rim is to be placed a rim of iron or wood, $\frac{1}{2}$ ths of an inch wide, and provided with a vertical flange $\frac{3}{2}$ ths of an inch high; these three pieces of metal are to be screwed closely upon the mahogany. The section of the vessel thus formed is represented by the figure

![Diagram of the vessel](https://academic.oup.com/mnras/article-abstract/13/3/61/2602573)

Where A B C D represents a section of the copper vessel, the depth $A C = \frac{1}{2}$ th inch.
G E L is the iron or wooden angle-iron, forming a comparatively deep edge for the whole vessel.

The bottom A B, and the copper edges A C, D B, are to be carefully amalgamated by the friction of mercury with water and rotten stone, or pumice-stone, and then carefully washed with abundance of water, and dried by means of a piece of very clean linen. Pure mercury, free from lead or tin, is to be poured upon the bottom A B, and above the edges A C, B D. A flat piece of copper, with its edge amalgamated and cut so as to fit exactly the section G E C A D B F H, is to be drawn somewhat rapidly from the one end of the vessel to the other end, where there is no flange, so as to remove all the mercury, together with its floating impurities lying above the horizontal line C D, bodily into an iron box, placed in a suitable hole cut in the mahogany just under the extremity of the copper edge of the vessel. The whole is then to be tilted, until so much additional mercury has run out of the shallow vessel into the iron box as shall leave a depth of from \( \frac{2}{9} \) of an inch. The surface will be found to be perfectly quiescent, and free from all blemish, and may be carried with facility and without risk to any suitable position, and there placed upon a bed of sand. The sand I regard as very important, because it will at once facilitate the placing of the vessel in a horizontal position, and will also serve to destroy the propagation of tremors. It is evident, also, that the surface can, by means of mercury in the iron box, be renewed with the greatest facility in a very small space of time.

17. For ordinary purposes, it will be sufficient to form the vessel solely of flat copper turned up at the edges to the extent of about \( \frac{1}{8} \) of an inch. This vessel is to be amalgamated according to the method directed, and then placed on the top of any vessel, such as a common saucer inverted in a large plate, as here represented:

\[\text{Diagram of vessel setup.}\]

Mercury can then be poured into the shallow amalgamated vessel, filling it above the brim; the excess of mercury, together with its floating impurities, can then be skimmed bodily into the plate, and any additional quantity afterwards be tilted out until a sufficient quantity only remains in the vessel.

18. The quantity of mercury required for an amalgamated circular vessel, five inches in diameter, is under two ounces troy. If unamalgamated, the least possible amount is about twenty-one ounces.

19. The mercury after continued use will ultimately become very dirty and contaminated with copper, but I have found that the impurities may be wholly removed by the agitation of the impure mercury in a bottle containing a very little water. The impurities assume the form of a dark spongy mass, and while floating on the surface of the wet mercury can be with facility removed. The
mercury itself can then be dried with bibulous paper, and after being gently heated becomes pure and bright.

20. I will only add, that the modifications which these experiments suggest in the construction of the common portable artificial horizon are very obvious. With regard to the ingenious arrangements which, after the completion of these experiments, Colonel Sabine informed me had been adopted some years ago by M. Schumacher for the artificial horizon, I found the form of the vessel, viz. the segment of a sphere, peculiarly objectionable, on account of the depth and the quantity of mercury employed; moreover, there is no possibility of easily cleaning the surface, or of removing the obnoxious film of amalgam so often alluded to.

On the Determination of the Orbit which a Satellite describes around its Planet. By M. Sawitsch, Professor of Astronomy in the University of St. Petersburg.

When there exist a great number of observations of a satellite, we may employ various combinations for finding with facility the elements of the orbit which the revolving body describes around its primary. It appears, however, that no method has yet been assigned for determining these elements from the smallest possible number of observations. The general theory which we owe to the illustrious Gauss, relative to the calculation of planetary orbits, undoubtedly applies also to the problem under consideration. This theory first leads to an approximate solution; after which it puts us in the way of obtaining such a degree of accuracy as the excellence of the observations demands. The provisional results, however, necessarily imply that the intervals between the times of observation are small, relatively to the complete revolution of the celestial body in its orbit. Such a supposition cannot be admitted when the question refers to a satellite, for in that case a single day may form a considerable part of the entire period of revolution. It is proposed, according to the following method, to determine the elements from three observations, the interval between the first and third being supposed not to exceed a few days.

Let \( t, t', t'' \), denote the times of the first, second, and third observations; \( \Delta, \Delta', \Delta'' \), the observed distances of the satellite from the planet; and \( Q, Q', Q'' \), the angles of position referred to the circle of the geocentric latitude of the planet. Moreover, let \( l, l', l'', b, b', b'' \), denote the geocentric longitudes and latitudes of the planet; and \( R, R', R'' \), its corresponding linear distances from the earth.

All these quantities are supposed to be given either by observation or calculation; but the following are to be determined, viz.:

\[ R \left(1 + \delta\right), R' \left(1 + \delta'\right), R'' \left(1 + \delta''\right), \]

the linear distances of the satellite from the earth, corresponding to the times \( t, t', t'' \).

\( \tau \), the period of the revolution of the satellite.