ON TRIAL :

(A) *Hydrographic Sextants* (Fig. 3).

These have been found to be most satisfactory and, in fact, decidedly superior to the old pattern. Although their first cost is slightly in excess of the older type, an economy is effected, firstly by their long life and secondly by the saving of spare mirrors usually carried in all British sextants.

(B) *Navigating or Observing Sextants* (Fig. 4).

Here the traditional prejudice against a wholly silvered glass has to be overcome. Many sextants so fitted are still on trial and in the writer's opinion they are just as good, if not better, for observing purposes than the older type, and the advantages of the watertight and almost imperishable mirror should go a long way towards overcoming the above-mentioned prejudice.

If, however, a half silvered glass is still a definite requirement for certain navigators, this can also be provided in an equally watertight case, though strength must necessarily be impaired.

APPARATUS FOR MEASURING THE ABSOLUTE PERSONAL EQUATION IN OBSERVATIONS WITH THE PRISMATIC ASTROLABE.

by

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(Extract from the *Bulletin Géodésique* N° 40 of the Association of Geodesy of the International Geodetic and Geophysical Union : Paris, 1933).

We have thought it necessary for clearness' sake, before discussing this subject, to try to define the notion of the personal equation in observations with the prismatic astrolabe.

We will then describe the method we have been led to adopt for examining the appliances submitted, and how their value may be judged from the results obtained.

We will next make some general remarks on the appliances, with a view to simplifying the detailed description of each. The Memorandum will conclude with the figures they furnished and the conclusions we have drawn from them.

1. *The personal equation in observations with the prismatic astrolabe.*

Determinations of time by the prismatic astrolabe show that the chronometer error deduced from a series of observations is different from the most probable chronometer error obtained by observations on the meridian or by a driven hair-line.

For an observer taking several series, the differences vary a little from day to day, but their mean value remains generally fairly stable ; it may thus be accepted that this

(1) *Members of the Committee appointed by the Bureau of Longitudes to examine apparatus manufactured in France with a view to the International Determination of Longitudes of October-November* 1933, *for measuring the personal equation in observations with the prismatic astrolabe.*

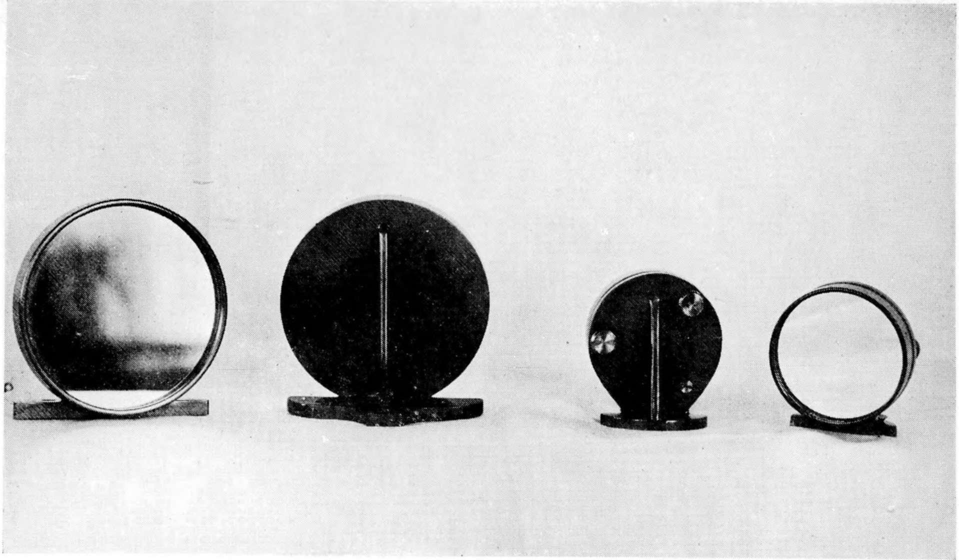

FIG. 2

Watertight circular mirors. — Miroirs circulaires étanches.

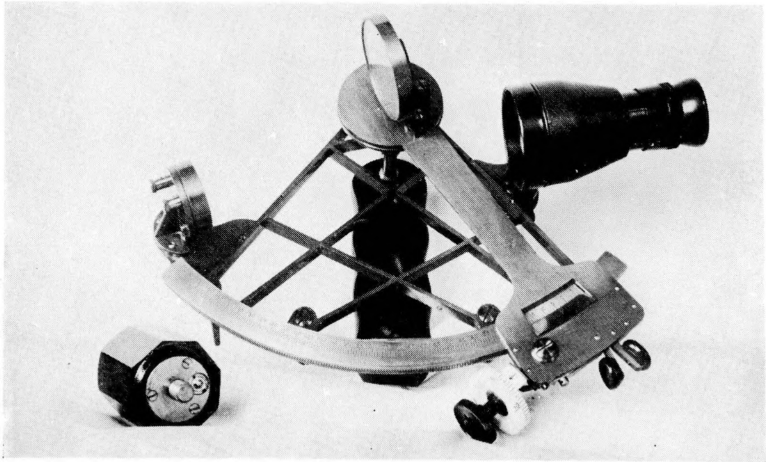

FIG. 3

Hughes Hydrographic or sounding sextant with circular mirrors.

Sextant, type Hughes, pour hydrographie ou sondage, avec miroirs circulaires.

Hughes "Classic" observing sextant with circular mirrors.

Sextant, type Hughes "Classic" pour la navigation, avec miroirs circulaires.

FIG. 4

value is a characteristic of the observer (1), and it has been given the name of *personal equation.*

It probably constitutes the only systematic error hitherto shown to exist in the use of the astrolabe, and it usually corresponds to a time lag on the part of the observer which for some people is nearly zero and for others amounts to 10 and sometimes even 20 hundredths of a second of time.

We take the ***absolute personal equation*** as being the time interval elapsing between the moment when the physical phenomenon to be observed takes place and that at which the pen-point of the chronograph deviates; the duration of this interval is a function of the reaction of the observer and the device which transmits it to the recording stylus.

This reaction probably depends on the physiological condition of the observer and on the speed of approach of the images; it certainly depends also on their brightness.

In addition to this it is possible for error to arise in the actual appreciation of the physical phenomenon. The instant of coincidence of the two images being difficult to detect with certainty, the observer contrives to make them range over a pair of verticals very close to each other, and for coincidence he substitutes a passage across the same horizontal.

The estimation of the horizontal may be more or less falsified by the displacement existing between the images, by the difference in their brightness, and also by the relative positions of the rising and the declining images.

Various hypotheses have been propounded on the influence which the speed, brightness and horizontality of the images may have on the personal equation. Hitherto it has not been possible to verify these hypotheses, for observations of real stars admit too many different factors for it to be possible to isolate the effect of individual ones. Only observations of artificial stars, repeated a large number of times under identical conditions, could make it possible to analyse a complex whole such as a series of real stars constitutes.

The determination of the reaction of the observer as a function of all the variables which may influence him would necessitate a considerable number of measurements of artificial stars. Knowledge of it would obviously enable every real sight to be corrected, and doubtless an improvement would be found in the results of a series thus treated, manifested by a slight diminution of the mean error of observation and by the elimination of the personal equation.

But from a practical point of view it may be asked whether, apart from the elimination of the personal equation, the gain in accuracy obtained would not be somewhat illusory (the value of the corrections applied being more statistical than practical) and whether it would suffice to justify the great number of artificial observations made.

The capital point is to get rid of the personal equation, the importance of which lies in its systematic character. The personal equation as we have defined it, leaving other hypotheses aside, only affects the correction of the chronometer, which is itself deduced almost entirely from the passage of suitable stars.

It may therefore be considered that the personal equation is equivalent to the mean time lag applicable to the observation of these stars.

Also, in this first study of appliances for measuring personal equation, we have confined ourselves to examining merely how they enable that lag to be determined.

2. *Historical account of measuring appliances for the personal equation in the astrolabe.*

Thus, to determine the chronometer correction by the prismatic astrolabe as exactly as possible, it is absolutely necessary to allow for the personal equation of the observer.

While waiting for an impersonal astrolabe to be produced, the solution provisionally consists in attaching to the astrolabe some special appliance enabling this personal equation to be measured.

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(1) *We here consider the observer as being associated with his recording material, particularly his registering key* (poire à tops). *Measurements made by the Geographical Service have shown that the registering keys introduce lags reaching* 0.06 *sec. in some cases but much less in others.*

One of us in fact proposed this in 1917, after discussing many series of observations made with the astrolabe at the Observatory of Paris. (1)

In 1921, Ingénieur-Hydrographe L. FAVÉ made an apparatus using a collimator. (2) In spite of the alterations and modifications made to it afterwards, we were unable to get anything out of it during the International Determination of Longitudes.

For this operation in 1926, Captain BOMFORD of the Survey of India made an entirely similar, though larger, instrument at Dehra Dun, which gave reasonably satisfactory results.

In 1927 General BELLOT, Director of the French Army Geographical Service, being anxious to reach a rapid solution, had various types of appliances designed and constructed.

When they were ready, the Bureau of Longitudes appointed a Committee under the chairmanship of M. E. ESCLANGON, Director of the Observatory of Paris, to test them and to decide from the results to what extent they enabled the problem to be solved.

To these instruments MM. CLAUDE and DRIENCOURT added another one, made to their own design by the Société d'Optique et de Mécanique de Haute Précision (S. O. M.) in 1933.

From 22nd February to 17th May 1933, under the control of Colonel VIVIEZ, Chief of the Geodetic Section of the Army Geographical Service, and with the assistance of several officers of that Service, we carried out with these appliances numerous measurements an account of which will be found in the following paragraphs.

Meanwhile, M. DE LA BAUME-PLUVINEL had tried to use the large meridian instrument of the Observatory of Paris for measurements of personal equations with the astrolabe. The telescope, which has a focal length of 3.85 m., served as collimator, and the lighted hole which formed the artificial star was solid with the cradle of the impersonal micrometer, to which the motion is applied by a motor. Time did not permit of our examining this arrangement, which would seen capable of leading to accurate measurements.

3. *Method of carrying out the experiments.*

The method of carrying out the experiments consisted in leaving as stable as possible the quantities whose variations might influence the personal equation ; we adopted an approximately constant size of star (corresponding roughly to the 5th magnitude) and a speed of approach of the images corresponding to that of the time stars seen at Paris in a telescope of × 80 magnification.

Under these conditions a great number of observations were made, combined in such a way as to eliminate the error in appreciating the horizontal if such exists.

Furthermore, the number of observers was multiplied as much as possible.

Each series of observations comprised twenty independent measurements of the personal equation. This number seems to be sufficient. Indeed, the series of observations made with the prismatic astrolabe do not generally include more than about thirty stars, the observation of which is vitiated by numerous accidental errors which do not affect artificial stars ; the personal equations to which our series lead, in comparison with the meridian personal errors, give a satisfactory degree of consistency for any given observer.

The equations obtained were referred to a common registering key, lent by the Observatory of Paris, for all the observers and for all the appliances examined.

The criterion by which the appliances submitted can be judged is the relative consistency of the personal errors obtained by several observers ; the consistency is characterised by the amount of the mean spread.

A single observer does not suffice to enable a conclusion to be reached. If the results he obtains are too scattered, their irregularity may in fact be attributed to his method of observing.

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(1) *We have several times insisted on the importance of such instruments* (Bulletin Astronomique, *Vol.* 34, *p.* 223, *and* Rapport sur l'activité de l'Observatoire de Paris pour 1917, *p.* 9).

We had meant to modify the Wolf apparatus formerly used for the measurement of personal equations in observations of stars' transits ; circumstances did not enable us to carry out this intention. (Note by M[me] CHANDON).

(2) Bulletin Géodésique, 1923, p. 158.

But if the various equations obtained by several observers are irregular for each one of them, it must be concluded that it is the apparatus tested that is at fault.

4. *Principle common to appliances for measuring the absolute personal equation.*

An optical device with movable parts enables an observer to see the same phenomenon as when he looks at the image of a real star in an astrolabe.

The observer first moves by hand the system which propels the artificial star, until the two images appear as accurately as possible on the same horizontal. He then adjusts an electric contact so as to "make" at this position of the movable system. This contact defines the coincidence of the images; it is introduced into the circuit of one pen of a chronograph, another pen being worked by the observer. Its position, called the *zero of the apparatus*, must be obtained with an accuracy corresponding to about 0.01 sec. with reference to the mean velocity of the artificial star.

The zero must be frequently verified — at the beginning and end of each series of observations if experience shows it to be stable, more often if necessary.

Once the zero has been adjusted, the artificial star is taken out of the field and is then made to cross it at the apparent velocity of a real star; the electric contact makes a pen deviate at the instant of coincidence, the observer on his side notes the phenomenon as well. The time interval separating the two ticks is a single value of the personal equation.

5. *Category of appliances using collimators.*

A collimator directs a beam of parallel rays on to an astrolabe and these give the observer, looking through the glass, the two images which one would ordinarily see. An optical device (which we shall call a *deviator*) enables the incident beam to be displaced, the observer thus experiencing the impression of the passage of a real star.

The electrical contact generally has one pole solid with this device, the other pole being mounted on the frame of the instrument.

This type of appliance calls for the following remarks:

(*a*) By turning the deviator round the optical axis of the collimator, it is possible to displace the beam of light in any plane passing through the optical axis. One can thus represent artificial stars with an apparent movement analogous to that of any real star, circum-meridian as well as for time observation.

(*b*) As the artificial stars are observed in an astrolabe with a mercury trough, the work of installation is relatively important. In fact, for a given position of the deviator (and especially the zero), the beam coming out of the collimator must make an angle with the vertical which does not vary by more than 0.1° during the course of the observations.

The collimator must thus be installed on a solidly constructed pedestal.

It seems however that the use of this pedestal could be avoided by replacing the mercury trough by a nearly horizontal mirror fixed on the frame of the collimator. The whole appliance might move, but the constancy of the angle of observation would be maintained if, for a given position of the deviator, the angle between the mirror and the rays issuing from the collimator did not vary.

(*c*) The zero is adjusted by bringing the deviator into such a position that the two images of the artificial star, as seen in the astrolabe, appear to be on the same horizontal. Thus it is done with the same magnification used for the observation; one cannot make use of a greater enlargement to obtain the adjustment.

Appliances with collimators differ from one another in the nature of the deviator and its position on the trajectory of the light rays.

The appliances by Favé, Bomford and de la Baume-Pluvinel, which belong to this category, do not properly speaking include this deviator, the images being moved by the displacement of the source of light in the focal plane of the collimator by means of a micrometer screw. The use of a deviator enables one to obtain a much greater travel of the contact poles for the same displacement of the images, without recourse to mechanical gearing.

Two instruments with collimators were submitted to the Committee: one by Lieutenant-Colonel Hurault, of the Army Geographical Service, made by the firm of S. O. M., the other by MM. Jobin and Yvon.

Hurault apparatus (1) (*S. O. M.*).

The collimator, with a focal length of about 1 metre, is arranged horizontally on a masonry pedestal. The object glass and source of light are fixed on a frame-work, in the shape of an optical bench, comprising in essentials two solid horizontal steel runners acting as rails for the cradle bearing the deviator. The latter, consisting of a thin prism perpendicular to the optical axis of the collimator, can thus be shifted parallel to this axis between the focus and the object lens. The prism is a light push fit in a cylindrical mounting, so that it can be slewed in its own plane in any direction to within about 1°.

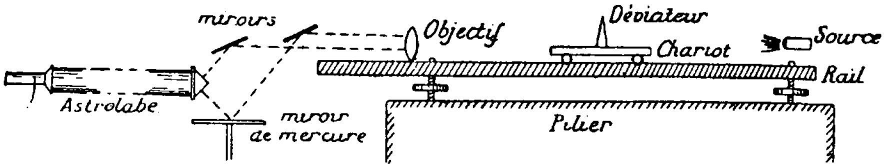

FIG. 1. — *Hurault apparatus (S.O.M.)*

The contact which automatically signals the coincidences is fixed on the frame, along which it can be moved. A finger on the carriage opens it when the deviator is in a given position. There are actually two contacts, one for each direction of movement.

The position of the cradle may be read with a vernier, carried by itself, working along a graduated scale fixed on the frame.

That the speed of translation of the deviator during the experiments may be known with sufficient accuracy, a blade is so attached to the cradle as to rub against teeth placed every five centimetres along the bench, thus closing, at short time intervals, an electric circuit working an auxiliary pen of the chronograph.

The whole apparatus is borne on four adjusting screws; sensitive levels enable the horizontality of the runners to be verified.

At the end of the latter, two steel plane mirrors are arranged so as to reflect the light rays issuing from the collimator downwards at 30° from the vertical, so that they can be received in an astrolabe. The use of two mirrors makes it possible to cover the prism and the mercury trough without making the objective of the collimator unduly bulky.

Originally the deviator was moved by an electric motor with a controller, turning, through gearing, a horizontal screw parallel to the bearing runners of the cradle. The latter, which was solid with a nut in which the screw turned, thus underwent a uniform translatory movement.

Experience having shown that the travel of the images appeared to be jerky, the screw was done away with and the cradle drawn directly by a belt driven by a pulley from the gear-box.

This transmission made the progression of the images regular, but some trouble must have remained in the translatory movement of the deviator — for the values of the personal equations obtained from the experiments presented much greater anomalies than those deduced from real observations or from the use of other appliances for the measurement of the personal equation.

Perhaps we must also impugn the stability of the pedestal, which, when the assistant leant against it to read the vernier, bent considerably, to the extent of appreciably displacing the images seen in the astrolabe.

Jobin-Yvon apparatus. (2)

This is so assembled as to make it possible to instal it at the actual place of real observations, and to intersperse artificial observations without difficulty during the course of an astronomical series. Only those very few stars cannot be observed which cut the small circle at a zenith distance of 30°, two or three degrees from the meridian.

On the actual pedestal of the astrolabe, below the latter and in the plane of the

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(1) *Manufactured by the Société d'Optique et de Mécanique de Haute Précision* (*S.O.M.*).

(2) *Manufactured by Messrs. Jobin and Yvon.*

meridian, is arranged a horizontal collimator, of a focal length of about 80 cm., bent 90° at the objective end so that the rays leave it vertically upwards.

Above and quite close to the objective is a diasporameter, carried on an arm recessed into a pedestal independent of that belonging to the astrolabe. The two prisms

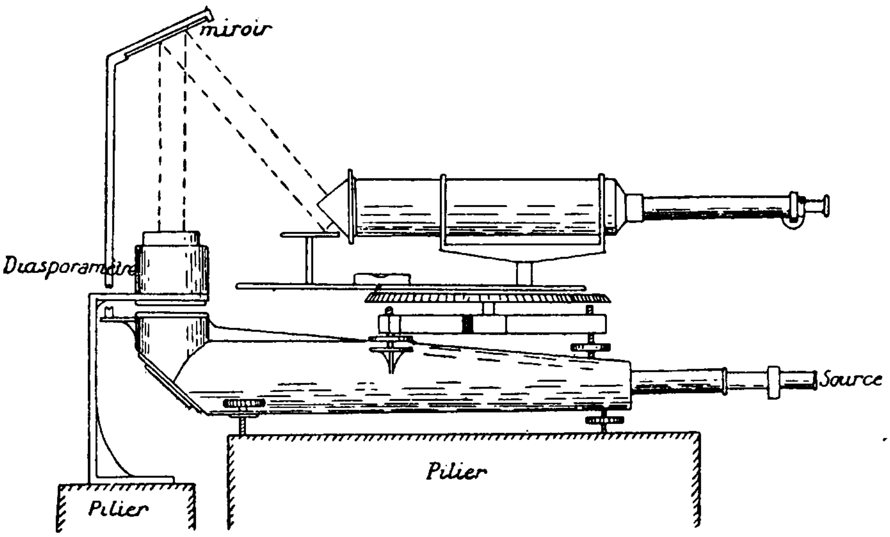

FIG. 2. — *Jobin-Yvon apparatus.*

of the diasporameter are horizontal, and an electric motor with suitable gearing makes them rotate about their common axis, in their own plane and in opposite senses to one another. This rotation displaces the light ray which emerges from the collimator, in the vertical plane passing through the bisector of the angle between the edges of the prisms of the diasporameter. According to the initial orientation given to this bisector, any vertical can thus be swept; that which passes through the plane of symmetry of the whole corresponds to artificial time stars.

The light ray which emerges from the diasporameter, and which is directed upwards, is reflected on to the astrolabe by an adjustable mirror attached to the collimator.

The contacts that mark the coincidences are two in number, for a complete turn of the diasporameter corresponds to two coincidences. They are fixed on the mounting of the diasporameter; a finger carried by each of the rotating plates causes the corresponding contact to function. These are make-and-break contacts; they have been carefully designed to obtain the maximum of accuracy, in spite of the comparatively slow displacement of their actuating fingers.

The source of light, in the focal plane of the collimator, is the reduced image of a brilliantly illuminated small hole.

A micrometer arrangement enables the source to be moved in the focal plane, so as to bring the images into coincidence when one of the fingers is in the act of breaking the contact which it governs.

For the other finger, the images are brought into coincidence by moving the diasporameter by hand; the finger, unclutched from the diasporameter, is then displaced until the contact breaks; at this stage the finger and the plate are once more rigidly connected.

We have insisted on this adjustment because it is not the same for the two coincidences obtainable by turning the plates, in which the direct image is in one case rising and in the other case descending. If the results finally obtained in the use of this appliance show a slight difference between the two cases, this difference is rather to be explained by the method of adjustment than by the optical conditions presented to the observer.

The effective measurements, as we have already seen, were made in series of some twenty sights each, corresponding to ten turns of the diasporameter.

At the end of each series, the initial adjustment was verified as far as possible.

In general a slackness of about 0.04 (maximum 0.06) sec. was found, from unascertained causes.

The personal equation was corrected by one half of the amount of this play whenever it could be measured.

The following are the results obtained :

TABLE I. (1)

DATES.	E. CHANDON.			R. DE VOLONTAT.			A. GOUGENHEIM.		
	Lower.	*Upper.*	*Mean.*	*Lower.*	*Upper.*	*Mean.*	*Lower.*	*Upper.*	*Mean.*
	s	s	s	s	s	s	s	s	s
31st March......	—0.02	+ 0.07	+ 0.03				+ 0.13	+ 0.08	+ 0.11
3rd April.......	+ 0.05	+ 0.02	+ 0.04	+ 0.20	+ 0.23	+ 0.21	+ 0.15	+ 0.12	+ 0.13
5th April.......				+ 0.16	+ 0.20	+ 0.18			
7th April.......	+ 0.02	+ 0.06	+ 0.04						
MEAN...........	+ 0.02	+ 0.05	+ 0.04	+ 0.18	+ 0.21	+ 0.19	+ 0.14	+ 0.10	+ 0.12

They are very satisfactory. The mean difference for an isolated point is equal to 0.06 sec.

6. *Category of visual appliances.*

In the appliances which do not introduce the astrolabe, the two star images are represented by two points of light which can be displaced with equal speeds and in contrary senses on very closely spaced verticals.

The dimensions are calculated in such a way that the operator experiences the same impression of speed of approach, of brightness, and of lateral spacing of the images, as when he observes real time stars with the astrolabe.

The observation is made with the naked eye through a low-power glass; so these appliances have been given the name of *visual appliances.*

The movable parts on which the artificial stars are fixed carry one pole each of the electric contact which automatically signals the coincidences.

In appliances of this kind, a very accurate adjustment of the zero is obtained, for the observer can regulate the horizontality of the images by making the latter approach very closely, this corresponding to a magnification much greater than that of the observation.

The constructors have not attempted to make oblique trajectories available; it has been shown that the consideration of time stars appears to be sufficient for finding the personal equation.

Nevertheless, in case of need, it might be useful to modify these appliances to some extent so as to be able to obtain apparent paths of stars fairly close to the meridian, thus permitting of a more thorough analysis of the observer's reactions.

The two visual appliances examined differ chiefly in their dimensions. That of Lt.-Colonel HURAULT, manufactured by M. CHASSELON, is much the larger, but an ingenious device avoids the necessity of using a chronograph. That of MM. CLAUDE and DRIENCOURT, made by the firm of S. O. M., is much less bulky and is easily transportable.

Hurault-Chasselon apparatus.

This comprises a frame about 2 metres long, fixed vertically against the wall. The

(1) *Lower and upper denote the two contacts of the diasporameter ; one corresponds to the reflected rising image, the other to the direct rising image.*

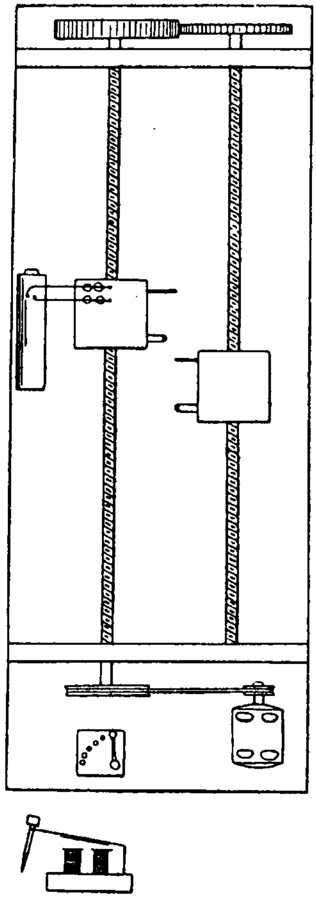

FIG 3. — *Hurault-Chasselon apparatus*

frame serves to support two vertical screws with rather fine threads which an electric motor turns in opposite directions from one another.

Along each one of them moves a guided nut, carrying a small illuminated hole. The two points of light move in opposite directions like the images of a star in the astrolabe.

The observer takes up a position some 10 metres away, and observes these two points through a very low-powered glass. The speed of rotation of the screw and the distance of the observer have been calculated so as to give him the impression of seeing a time star in a × 80 astrolabe.

The brightness and distance apart of the lighted holes are adjustable. When they are at the same height, the ends of two little flexible steel blades, each solid with one of the nuts, make contact, thus automatically closing the circuit which marks the coincidences. The blades forming the contact pieces are adjustable; their position is fixed for one direction of motion of the images; for the other direction of motion a coorection must be applied to the automatic tick, equal to the time taken by the points of light to travel the thickness of one of the blades.

One of the nuts also carries two electro-magnets, one in the automatic marking circuit, the other in the observer's marking circuit, each of which actuates a dotter.

At each tick these dotters mark points on a sheet of white paper fixed to the frame and covered by carbon paper. The distance between the points marked by the two dotters, divided by the speed of displacement of the nut, gives a value of the personal equation.

The speed of the nut is obtained by making the current from a contact pendulum pass through one of the electro-magnets for a few seconds. The corresponding dotter inscribes on the paper a series of points whose interval is the distance covered by the nut in one second.

As the electro-magnets and the dotters have appreciable time lags, they are changed during the course of the series, so as to eliminate the errors that these constant lags would otherwise introduce.

The paper is mounted on a copper cylinder which can be moved by hand, so as to separate the records of the various sights.

Owing to backlash and friction, the method of driving the paper produced variations of speed sufficiently marked for it to appear necessary, after a few experiments, to make a note of the corresponding speed at each travel of the images.

The figures obtained under these operating conditions are given in the Table below.

The letter *R* indicates that the left-hand image was rising, *D* that it was descending. The personal equation is the mean of the equations obtained in these two cases.

TABLE II.

DATES.	E. CHANDON.			R. DE VOLONTAT.			A. GOUGENHEIM.		
	R.	*D.*	*Mean.*	*R.*	*D.*	*Mean.*	*R.*	*D.*	*Mean.*
	s.	s.	s.	s.	s.	s.	s.	s.	s.
25th March				+ 0.10	+ 0.12	+ 0.11			
27th »				+ 0.14	+ 0.13	+ 0.13			
27th »	+ 0.05	+ 0.01	+ 0.03				+ 0.08	+ 0.07	+ 0.08
30th »	— 0.01	+ 0.02	+ 0.01	+ 0.12	+ 0.12	+ 0.12			
31st »				+ 0.15	+ 0.11	+ 0.13	+ 0.05	+ 0.11	+ 0.08
3rd April	0.00	+ 0.08	+ 0.04	+ 0.14	+ 0.15	+ 0.14	+ 0.10	+ 0.05	+ 0.08
5th »	— 0.01	— 0.01	— 0.01				+ 0.08	+ 0.08	+ 0.08
7th »	0.00	+ 0.03	+ 0.02	+ 0.18	+ 0.16	+ 0.17	+ 0.13	+ 0.11	+ 0.12
MEAN	+ 0.01	+ 0.03	+ 0.02	+ 0.14	+ 0.13	+ 0.13	+ 0.09	+ 0.08	+ 0.09

This Table shows that the apparatus described incontestably gives the personal equation. The figures are very homogeneous, even in columns *R* and *D* where they are the results of merely *ten sights*.

The mean difference of an individual sight, within a series, is 0.03 sec.

Claude and Driencourt apparatus. (1)

This apparatus is the only one which can be easily transported. It comprises a vertical mounting some thirty centimetres in height, acting as a guide for two racks which can be moved in opposite directions by a handle at the rate of one centimetre per turn of the handle.

On these racks, two holes 0.3 mm. in diameter, lighted by small electric lamps, form the images to be observed.

An observer at 1.30 metres has the impression of seeing a time star in an astrolabe of × 80 magnification, when the handle is turned at the rate of half a turn per second.

A cardboard tube 1.30 m. long, blackened inside and placed horizontally before the apparatus, protects the observer from interference from the outside light.

The adjustment is made by bringing the two holes to the same height. A vernier on one of the racks moves past a scale engraved on the other. It is thus possible to take several readings of the horizontality of the holes. A locking screw enables the racks to be fixed at the mean reading.

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(1) *Constructed by the Société d'Optique et de Mécanique de Haute Précision* (*S. O. M.*).

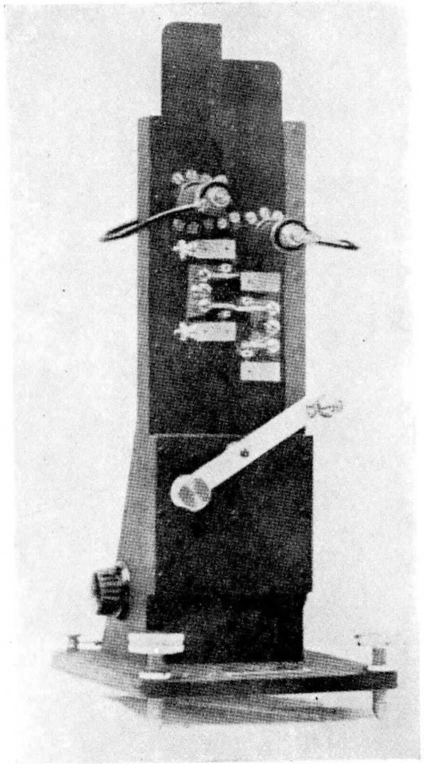

Fig. 4

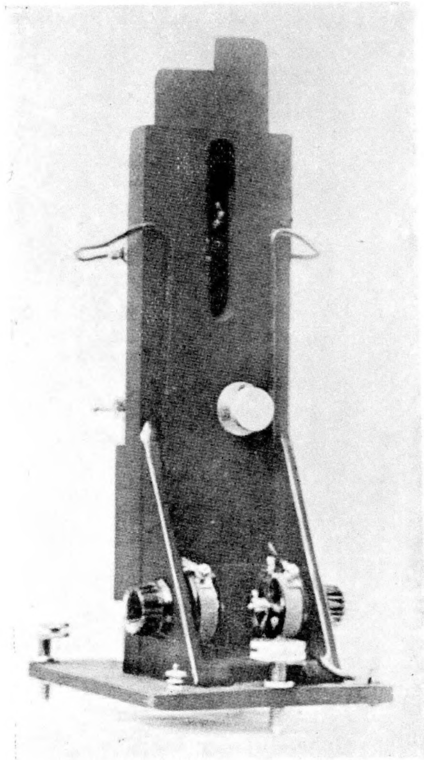

Fig. 5

*Claude and **Driencourt** apparatus. — Appareil Claude et Driencourt.*

One now adjusts the automatic coincidence contact which works by breaking. The contact is carried on one rack, the finger opening the contact is on the other. There are two of these contacts, corresponding to the two directions of movement.

An accuracy of 1/20 of a millimetre, corresponding to 5/1000 of a second, is obtained in the adjustment of these contacts — an amply sufficient degree of precision.

The following are the personal equations obtained with the CLAUDE and DRIENCOURT apparatus :

TABLE III.

(Same remarks for *R* and *D* as for the HURAULT-CHASSELON apparatus).

DATES.	E. CHANDON.			R. DE VOLONTAT.			A. GOUGENHEIM.		
	R.	*D.*	*Mean.*	*R.*	*D.*	*Mean.*	*R.*	*D.*	*Mean.*
	s.	s.	s.	s.	s.	s.	s.	s.	s.
19th April......	+ 0.01	+ 0.05	+ 0.03	+ 0.15	+ 0.16	+ 0.16			
20th »				+ 0.15	+ 0.19	+ 0.17			
20th »				+ 0.14	+ 0.23	+ 0.18			
20th »				+ 0.18	+ 0.22	+ 0.20			
21st »	+ 0.01	— 0.01	0.00				+ 0.10	+ 0.10	+ 0.10
21st »	+ 0.02	— 0.03	— 0.01				+ 0.11	+ 0.09	+ 0.10
24th »	0.00	— 0.01	0.00				+ 0.19	+ 0.09	+ 0.14
24th »	— 0.06	0.00	— 0.03				+ 0.13	+ 0.11	+ 0.12
25th »	+ 0.01	— 0.02	0.00				+ 0.11	+ 0.09	+ 0.10
25th »	+ 0.08	— 0.01	+ 0.04				+ 0.13	+ 0.03	+ 0.08
1st May........	+ 0.06	+ 0.04	+ 0.05				+ 0.02	+ 0.06	+ 0.04
MEAN...........	+ 0.02	0.00	+ 0.01	+ 0.15	+ 0.20	+ 0.18	+ 0.11	+ 0.08	+ 0.10

During the course of any single series, the mean difference of a sight came to 0.07 sec. The results thus appear to be of the same order as with the other appliances.

N. B. — It should be noted that the residual personal equations, in observations of stars' meridian passages made with the aid of the driven hair-line (1), are in better agrreement from day to day than the equations in Tables I, II and III ; in fact it is found in the former case that the difference between the two extreme values does not exceed 0.04 sec. for a given observer.

The reason for this is that the personal equations in meridional observations are deduced from a *hundred* or so sights, while in our experiments we limited ourselves to *twenty* sights for each determination.

7. *Comparison of the results furnished by the various appliances, and conclusions.*

The Table below summarises the personal equations obtained with the three appliances, as well as the equations of the same observers during the longitude operations of 1926. These latter values, deduced from a comparison of the results from the transit instruments, are only given by way of a guide, as it was not possible to reduce the different registering keys used to the same key for comparison.

(1) A. LAMBERT. — L'équation personnelle absolue dans les observations méridiennes de passage. (*The absolute personal equation in observations of meridian passages*). (Bulletin astronomique, Mémoires, *Vol. VII*, *N*° IV).

TABLE IV.

Observers.	*Jobin-Yvon apparatus.*	*Hurault-Chasselon apparatus.*	*Claude and Driencourt apparatus. (S. O. M.)*	*October 1926.*	*November 1926.*
	s.	s.	s.	s.	s.
C........................	+ 0.04	+ 0.02	+ 0.01	+ 0.03	+ 0.05
V........................	+ 0.19	+ 0.13	+ 0.18	+ 0.07	+ 0.16
G........................	+ 0.12	+ 0.09	+ 0.10	+ 0.11	+ 0.11
C-V	— 0.15	— 0.11	— 0.17	— 0.04	— 0.11
C-G	— 0.08	— 0.07	— 0.09	— 0.08	— 0.06
V-G	+ 0.07	+ 0.04	+ 0.08	— 0.04	+ 0.05

From an examination of this latter table, several interesting conclusions emerge.

(*a*) The three appliances retained appear to be equally suitable for the measurement of the absolute personal equation of observers with the prismatic astrolabe.

By making use of them, the astrolabe could be used for determining the absolute time, thus checking the results given by the meridian instrument with driven hair-line micrometers.

It is to be hoped that the makers will be willing to make the few improvements in matters of detail which the experiments have shown would be useful, viz. better fixing of the *zero* in the JOBIN-YVON apparatus; more regular speed of traction and simplification of inscription in the HURAULT-CHASSELON; use of locking screws, a level and a motor in the CLAUDE and DRIENCOURT (S. O. M.).

(*b*) For the determination of the personal equation pure and simple, *visual appliances* are sufficient. Experience has confirmed the legitimate hypothesis on which they are based, viz. if the appearances are the same, the personal equation is the same, whatever eyepiece is interposed between the eye and the phenomenon to be observed.

The JOBIN-YVON apparatus presents the additional interest that it permits of a more complete study of the observer's reactions, and of establishing the law of variation of the personal equation of a given observer as a function of the velocity and the magnitude of the star.

(*c*) It will further be noticed from Table IV that the personal equations *C* and *G* are of the same order of magnitude respectively as in 1926. Thus, for several observers by astrolabe, the personal equation appears to be sensibly constant; this fact has already been mentioned by Mr. N. STOYKO. (1)

The results we have set out show that great hopes may be founded on the use of the prismatic astrolabe for determining the absolute time; the realisation of appliances for measuring the personal equation thus marks an appreciable advance in materiel and we can only express our thanks to General BELLOT, Director of the Army Geographical Service, whose fecund initiative has enabled an investigation which threatened to become protracted to be brought to a speedy conclusion.

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(1) N. STOYKO. — Sur la précision de la détermination de l'heure et sur les moyens de l'améliorer. (*On the accuracy of time determination and methods of improving it*). (*Report of Proceedings of the Congress of Learned Societies of Paris and the Provinces held at Lille in* 1928, *Science Section*).