3. Zusammenfassung.

Aus den obigen Resultaten fassen wir folgende Sätze zusammen.

1. Einfluss auf die Treffähigkeit haben nur die transversalen Schwingungen, die anderen bringen fast gar keine Modifikation hervor. Es ist erforderlich die transversalen Schwingungen in beiden Ebenen gleichzeitig zu fixieren, um die Stelle und die Bewegungsrichtung der Gewehrmündung genau bestimmen zu können, die für den Abgangsfehlerwinkel in Seiten- sowie Höhenrichtung und die Pendelung des Geschosses während des Flugs grosse Bedeutung haben.


3. Die Torsionsschwingung wird gleichzeitig mit dem Anfang der Geschossbewegung erregt, so ist es möglich, die Zeitdauer der Geschossbewegung im Laufe und die Entwicklungszeit der Spannung zu bestimmen.

4. Man kann die Mündungsspannung aus der Untersuchung der longitudinalen Schwingung des Gewehrlaufs bestimmen.


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On a Quasi-etalon Fabry-Perot Interferometer and its Applications.

By

Hantaro Nagaoka.

(Read January 20, 1917.)

Of different interferometers that of Fabry-Perot is characterised by the simplicity of construction and by the great resolving power which is easily available in instruments of the sliding type. In spite of the
various other advantages which it will be needless to enumerate, there is always some difficulty in adjusting the plates to parallelism. In the form first introduced by Fabry and Perot, the manipulation to parallelism is greatly facilitated by the slight pressure exerted by the india-rubber bags filled with water; in the instruments as manufactured by Hilger, one of the semi-transparent mirrors is attached to a stout arm, which allows of minute displacements in two mutually perpendicular directions by means of springs connecting the arm with the fixed block of the apparatus. These arrangements are indeed very delicate, but are often liable to changes, which gradually creep in when the observation is extended over several days. The constancy of the air plate is guaranteed in the etalon form of the instrument, but it is not at all easy to adjust the length of the etalon so that it is the same all over its end-faces to small fraction of a wave-length.

This difficulty was to a great extent overcome by a simple device due to P. P. Koch, who took advantage of the slight unevenness of the mirrors made by Hilger, near the periphery, which is ground down from the silvered face. Simple as is the device the fringes observed with such a quasi-etalon apparatus are not so well defined as those obtained with the fixed etalon or sliding interferometer well adjusted, so far as my experiences indicate.

In most laboratory experiments, the essential requirement is the swift adjustment of the mirrors to parallelism, which should not be easily deranged in course of a few days, but remain in that state without being affected by slight external disturbances to which the laboratory is constantly exposed. In actual observations, the length of the etalon can be accurately determined from the interference fringes obtained with light of different wave-lengths, provided the approximate length be known previous to experiments. In the form of the interferometer which I have lately constructed, a hollow cylinder of invar (internal diam. 2.5 cm., external diam. 4.5 cm.) is provided with three projections of brass as shown in fig. 3, on both of its end faces. The mirrors whose cross-section is as in fig. 1 rests on them; the height of the projections is about 1 mm., which compensates the expansion of glass mirrors tending to alter the thickness of the air-plate. These brass projections facilitates the adjustments of the etalon to its proper length, but owing to the difference in the thermal conductivity of brass and glass, the compensation is not complete for rapid changes of temperature. For obtaining perfectly consistent results it seems advisable to
dispense with the use of such compensating arrangements, but make
the projections out of the same piece of the invar cylinder, and use the
mirrors whose section is of the form shown in fig. 2, the edge being turned into a
cone of obtuse angle very little different from two right angles. The length of the
etalon need not be adjusted to less than a hundredth of a millimeter. By placing
the mirrors on these projections and pressing them by means of spring
(s, s, s) provided with ebonite knobs coming just opposite over the projections,
the pressure on the mirrors at these points are regulated by screws
(a, a, a) till it is nearly the same at these points of contact. When the
pressure is in excess, these springs offer a resistance to the sliding
motion of the glass mirrors, and must be avoided; when pressed too
loosely, the adjustment becomes impossible; a few experiments easily
tell how tightly the springs should be screwed down. The essential
part of the present arrangement consists of a device for giving one of

the mirrors minute displacements nearly parallel to its plane, by means
of three screws (b, b, b) placed in the space between the springs; the
screws are of fine pitch, having four threads to the millimeter. Each
of these screws is tipped with an ebonite knob having a spherical head, so that on coming into contact with the lateral edge of the mirror, it does not cause fracture of glass by pressing it more gently than with steel, of which the screws are made. The mirrors are roughly adjusted to parallelism by observing filaments of an incandescent lamp through the mirrors; with short tubes the reflected images of the filaments are brought nearly to coincidence, with long etalons they are brought to a good perspective. It generally takes a minute to make this adjustment, and when observed with green light of mercury, somewhat distorted fringes are already visible. The next step is the fine adjustment by the extremely slow motion of the three lateral screws; during the operation, only one of them touches the mirror; when however the two screws are moved, both of them are simultaneously turned by an equal amount, so as to make the resultant displacement tend in the direction of the remaining screw. Only a few minutes are required to complete the adjustment; this being finished, the screws are turned back free from the mirror, which is then held only by the pressure of the three springs before mentioned. The interferometer so adjusted and fixed to the support can be gently transported without appreciable change in the parallelism of the mirrors.

For measuring the length of the etalon, the light consisting of a number of known spectrum lines, preferably from a mercury or a cadmium lamp, is passed through the interferometer and then analysed by a prism or a grating spectroscope, which at once gives systems of fringes from the different lines of the source. Based on the approximate length of the etalon and the known wave-length, the exact thickness of the air plate is calculated from the measurement of the fringes.

With different aims, I have constructed etalons of 2.5 mm., 5 mm., 1.0 cm., 1.5 cm., 2 cm., and 8 cm. These may be used for the analysis of the structure of spectrum lines, of which I have given a number of instances in the constitution of mercury lines and may here be left out.

The principal applications of the present form of the interferometer I have now in view are two-fold: namely, for the exact measurement of the coefficient of thermal expansion of metals and other solids, and for use as an interferential galvanometer.

Measurement of expansion coefficient:—The use of interference fringes as a natural micrometer of great delicacy by Fizeau in the determination of thermal expansion marks an epoch in the history of fine measurements of linear dimensions. Anybody who is familiar with
Fizeau's apparatus or with the modified form by Abbe and Pulfrich will not deny the difficulty of obtaining a system of fringes, which are suitable for observation, without at the same time noticing the extreme sensitiveness of the fringes to external disturbances, a slight jerk to the apparatus ending in the complete derangement of the fringes. In addition to this the measurement of the air film is another source of difficulty. Most of these objections are got rid of in the present arrangement, as the adjustment of the fringes is made so easy and tolerably free from external disturbances. Another advantage lies in the simple construction of the sample to be tested; if the material be turned to a hollow cylinder whose height is uniform to within a hundredth of a millimeter, it may be placed instead of the etalon and the displacement of the fringes observed simultaneously with the rise of temperature, the expansion coefficient can be very accurately determined with a sample of 1 cm. length, without entering into the tedious operation of determining the air film, which must at any rate be found with Fizeau's original apparatus or with Abbe's modified form. It is further to be noticed that the sample may not necessarily be a hollow cylinder, but of such a geometrical form, that the adjusting mirror can be fixed on it and the fringes formed by the mirrors observed through a telescope or photographed. Another great advantage which must not be omitted is the constancy of the fringes; if we have a number of samples to test and a corresponding number of the apparatus, we can place them in a long thermostat provided with a rail in it, and bring the apparatus one after another into the field of view for examining the fringes; in this manner a number of samples can be tested without much loss of time. This will have an important bearing on the subject of material testing.

Interferential galvanometer:—So far as I am aware, there is as yet no application of the interferometer to galvanometry. With the present apparatus there is some hope of applying the extreme delicacy of the interference fringes to changes of temperature in the intervening medium to current testing, as a new form of thermo-galvanometer. A coil of many hundred ohms wound with bare wire of a resisting metal can be easily inserted into the hollow space of the etalon, leaving the space at the centre sufficient to the formation of the fringes. When the wire is traversed by a current either direct or alternate, it will be heated and the fringe affected; with feeble current, the effect will accumulate in course of time, and we shall have to wait for a few minutes to ascertain if there is any effect or not. There is as yet no hope of making accurate
QUASI-ETALON FABRY-PEROT INTERFEROMETER.

quantitative measurement with such an arrangement, but for use in the
null method, such as the resistance measurements of electrolytes with
alternate current, it will replace the telephone whose silence is very
difficult to ascertain. With due improvements the interferential galvano-
meter may become a handy form of a thermo-galvanometer. Experi-
ments are now going on in this direction, and I hope to be able to
communicate the result to the Society in the near future.

Physical Institute, Imperial University, Tokyo.