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A TYNDALLMETER FOR THE EXAMINATION OF DISPERSE SYSTEMS.

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The following article describes a convenient form of Tyndallmeter which has been developed by the Dispersoid Section, Research Division, Chemical Warfare Service, U. S. A.[1] The instrument is made from stock apparatus and materials and can be conveniently used in determining the strength of the Tyndall beam in suspensions, colloidal solutions, smokes and mists.

Apparatus.—The apparatus is shown in Fig. 1. It consists essentially of an electric light bulb B, a condensing lens L giving a beam of parallel light which passes through the diaphragm D, and a Macbeth illuminometer I for measuring the strength of the Tyndall beam T. In case the material to be examined is a liquid suspension or solution it is introduced at T in a cylindrical glass tube, while smokes and mists are pumped directly through the apparatus. The long closed tubes A_1 and A_2 are provided, respectively, for absorbing the beam after it has passed through the disperse system, and for giving a dark background for observing the Tyndall beam.

The main consideration which was kept in view in the design was to obtain a serviceable apparatus made out of *stock* materials. A descrip-

[1] The article has been approved for publication by Major-General William L. Sibert, Director Chemical Warfare Service, U. S. A.

tion of the separate parts of the apparatus follows, quotation marks indicating that the item in question is listed by its trade name.

The "Macbeth Illuminometer" is manufactured by the Leeds and Northrup Company and most of the rest of the apparatus is made from standard pipe fittings. The *central examining chamber* is a "$1^1/_2''$ railing cross with side outlet," with a $1''$ hole bored opposite to the side outlet. This hole takes a rubber stopper which in turn is bored to fit the end of the examining telescope of the illuminometer. Glass windows are pro-

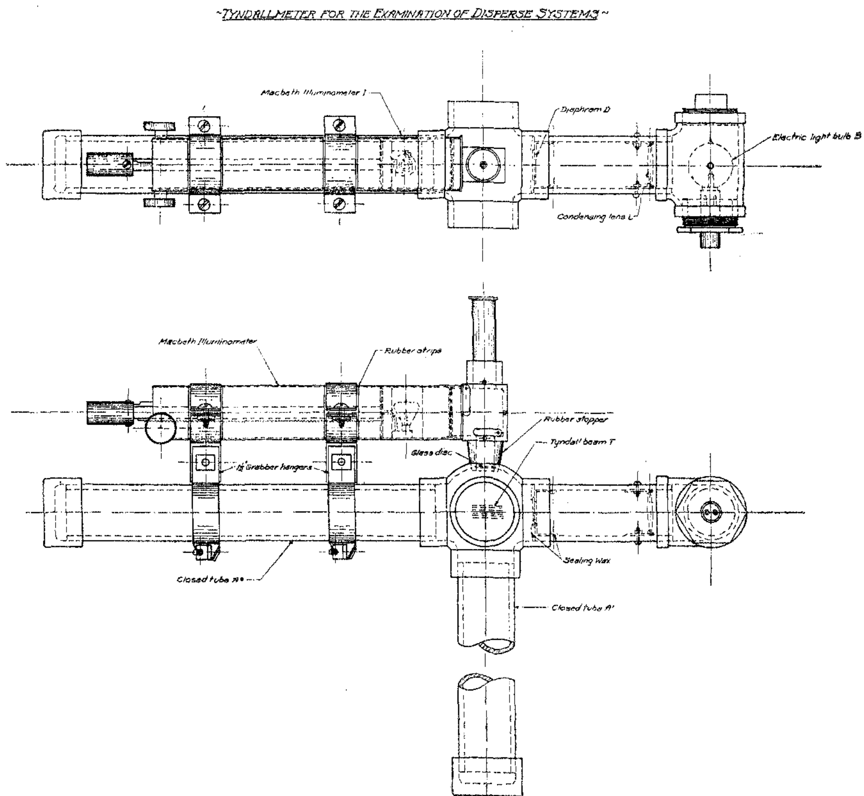

Fig. 1.

vided to prevent the entrance of smoke into the telescope tube of the illuminometer and into the Tyndall beam tube. The *Tyndall beam tube* consists of a "$1^1/_2''$ nipple" $4''$ long containing the diaphragm and lens, and a "$1^1/_2''$ tee" fitted with a "plug" at one end and a "reducing bushing" at the other to take the connector for the electric bulb. The *electric bulb* is a "30 candle power, Type C, gas filled, 6–8 volt lamp" such as may be purchased for automobile head-lights. It fits into a "standard anchor double-end socket," and connection is made at the other end with a "standard anchor bayonet connector." The *lens* is a $1^1/_2''$, 20 diopter, double-convex, such as can be purchased from an optician. The *diaphragm* is made of sheet metal and has a $^5/_8''$ square hole arranged so that the observing telescope is perpendicular to a side of the square. The *absorbing tubes* are "$1^1/_2''$ nipples" $12''$ long with "caps" painted black on the inside. The straps for fastening the illuminator to the apparatus are made from "$1^1/_2''$ grabber hangers." The arrangement of the parts of the apparatus is such as to obtain a nearly parallel beam, the light focussing as a matter of fact about twelve feet away. Both lamps were supplied with current from storage cells, that for the illuminometer being adjusted with the stock rheostat provided, and that for the Tyndall beam by an ordinary carbon compression rheostat.

Standardization of the Apparatus.—The standardization of the apparatus consists of two parts, (*a*) the standardization of the illuminometer, and (*b*) the standardization of the Tyndall beam.

(*a*) The illuminometer is standardized with the help of the regular outfit, provided by the Leeds & Northrup Co., consisting of a reference standard and a standard plate. The reference standard contains a calibrated light which illuminates the standard plate so that it has a known brightness in apparent foot candles. The standard plate is then viewed by the illuminometer and the current in the illuminometer lamp adjusted until the reading of the illuminometer corresponds to the known brightness of the plate. In the actual use of this apparatus we have found it convenient to adjust the lamp so that the readings are only *one-fifth as many apparent foot candles as marked on the scale.* This increases the life of the illuminometer lamp. The number of milliamperes determined in the standardization is maintained throughout the work.

(*b*) The Tyndall beam is most easily standardized with the help of a known suspension, or piece of turbid glass which can be inserted in the examining chamber. The standard first employed was a silica suspension, made just before use from a carefully preserved sample of ground silica which had passed a 200-mesh sieve, and was adjusted with water to contain 0.5 g. silica per liter of suspension. It was poured into a cylindrical tube about $2''$ in diameter and inserted in the examining chamber. The current was then adjusted to give a Tyndall beam having a brightness of 22.50 apparent foot candles.

The inconvenience of making a new suspension for each standardization was later obviated by the use of some opaque tubes of glass (Corning Opal Bulbs made by the Corning Glass Works) which were compared with the silica suspension and the correct adjustment found so as to give the same result as the silica suspension. It will be noticed of course that, although the above method of standardizing the Tyndall beam gives reproducible results, it depends on the preservation of a particular sample of silica or a particular piece of turbid glass. For this reason, in concluding our work, we have standardized four of our apparatus by the method described above and have then actually measured the strength of light in the beam opposite the end of the illuminometer telescope. These measurements were made by Sergeant 1st Class, V. D. Charleston, by placing at right angles to the beam of light and just opposite the end of the telescope, a piece of translucent glass which transmits a known fraction of the incident light, and then measuring the brightness of the rear side of this glass. In this way it was found that the intensity of illumination in the Tyndall beam for the four different instruments selected as typical was 638, 628, 621 and 689 foot candles. This makes possible a fairly close reproduction of the instruments even if the standard Corning Opal Bulbs should all be destroyed.

It should be pointed out that standardization with the help of a given turbid suspension or a given turbid glass is not only much simpler than the absolute standardization just described above, but leads to more accurate and reproducible results. This arises partly from the fact that this relative method involves an immediate comparison of the Tyndall beam light with the actual illuminometer lamp which is to be used. If the illuminometer lamp is low, the Tyndall beam will be set correspondingly low. A further advantage for the relative method, arises from the fact that the given tube of suspension or turbid glass is inserted in just the same way as the sample tubes which will later be measured, while the disk of opaque glass must be inserted *exactly* at the right point opposite the telescope in order to give correct results.

RELATION BETWEEN THE INTENSITY OF TYNDALL BEAM AND CONCENTRATION OF SUSPENSIONS AND SMOKES.

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The Tyndallmeter described in a previous article[1] was used for determining the way in which the concentration of a suspension or smoke affects the strength of the Tyndall beam from a given source. The work was performed by the Dispersoid Section, Research Division, Chemical Warfare Service, U. S. A.[2]

Silica Suspension.—Using a special sample of silica which had been ground to pass a 200-mesh sieve, suspensions of various concentrations were made up, poured into a cylindrical glass tube about 2″ in diameter and inserted into the examining chamber of the Tyndallmeter and the intensity of the Tyndall beam measured. The results obtained are shown graphically in

[1] Tolman and Vliet, This Journal, **41**, 297 (1919).

[2] This article has been approved for publication by Major-General William L. Sibert, Director of Chemical Warfare Service, U. S. A.