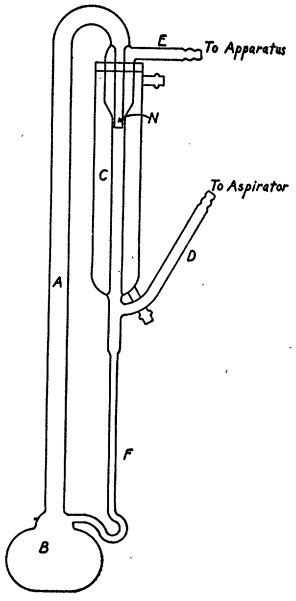
Cenco Hyvac type. Vapors from organic distilling apparatus frequently and soon ruin their efficiency either by corroding the insides of the pump or by dissolving in the pump oil and making the limiting pressure of the pump equal to the vapor pressure of the oil. In the case of corrosion, the pump is ruined, and in the case of vapors dissolved in the oil, the pump must be taken apart, cleaned and have new oil put in—a very messy job. Moreover, pumps of this kind will not pump condensable vapors, because they operate as piston pumps. Another disadvantage is that they are rather expensive.

A Pyrex glass mercury vapor pump of the type shown in the diagram, designed to work against an



aspirator as a force pump has none of these disadvantages, although it has a few drawbacks of its own. It is made of glass and so is not subject to corrosion except for the mercury that it contains. It contains no oil to absorb vapors and spoil its efficiency. When it becomes dirty, it is much easier and less messy to clean, for this can be quickly done with nitric acid. Since it works by diffusion, it will pump condensable vapors. In addition, it is a much less expensive piece of apparatus than an oil pump and occupies a smaller table space.

A type of pump suitable for doing vacuum distillations is shown in the figure. The boiler B should be a flattened bulb about 6.5 cm in diameter and 4.5 cm in thickness. It is not absolutely necessary to use a flattened bulb, but this shape gives rise to less bumping of the mercury during operation of the pump than a spherical boiler. Tube A, which leads from the boiler to the nozzle N, can be made from 1.5 cm tubing. The nozzle should be 7 mm in outside diameter and project a distance of one centimeter into the narrow part of the condenser. The condenser should be 8 mm inside diameter. A 15 cm condenser will be found long enough to condense all the mercury. The return tube F should be 14 cm long. Although most of these dimensions may vary, the dimensions of the nozzle and the length of the return tube should not be changed, since they are vital to the operation of the pump.

The operation of a pump of this type is quite simple. The main requirements for its satisfactory operation are that the apparatus to be evacuated be as free as possible from leaks and that the aspirator to be used as a force pump be one capable of producing a vacuum of 30 mm of mercury or better. In use, the pump is clamped to a ringstand by means of asbestos padded clamps at a height such that a good burner can be used to heat the boiler which has about one centimeter of mercury in it. The outlet tube D is connected by means of suction tubing through a safety trap to the aspirator which is to serve as a fore pump. The inlet tube E is connected to the vacuum distilling apparatus and the condenser is connected to the water supply and to the sink. After the apparatus is connected, the aspirator is turned on. When the pressure in the apparatus gets down to 30 mm of mercury, the mercury vapor pump is started. This is done by starting the water through the condenser and lighting the burner under the boiler. The burner should be regulated so that the mercury stands about 7 cm high in the return tube F. If the condenser used with the distilling apparatus is not efficient enough to condense all the vapors of the substance being distilled, it is a good idea to insert a trap cooled with ice between the distilling apparatus and the pump.

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SPECIAL ARTICLES

THE VALIDITY OF MEASURING EYE MOVEMENTS BY DIRECT OBSERVATION

IN clinical and experimental studies of eye movements during reading one method of measurement has been to count the number of fixations through direct observation. (A mirror is sometimes used to obtain a better view of the eyes.) However, during a recent experiment this method gave results which were inconsistent with those obtained from photographing eye movements with the Iowa Eye Movement

Camera,[1] so the following experiments were carried out to determine the validity of the former technique.

Two clinicians, *M* and *R*, both of whom were experienced in counting eye movements, photographed the eye movements of 31 and 38 poor readers in college, respectively, and at the same time counted these movements through direct observation. Paragraphs about two hundred words in length taken from the Van Wagenen Reading Scales were used as reading materials. From the records thus obtained three scores were computed for each reader: (1) the number of eye movements actually made (photographed), (2) the number counted by direct observation, and (3) the time of reading the selection (from the time marker on the film). The intercorrelations of these variables for each clinician are as follows:

Tests	*M*	*R*
r of photographed and counted	.758 ± .051	.895 ± .013
r of photographed and time	.933 ± .011	.931 ± .010
r of counted and time	.811 ± .036	.928 ± .010

On the basis of the standard error of estimate[2] the above figures indicate that *M* can predict the photographed value 28 per cent. better by using time as a measure than he can by using the number counted. If *R* uses time his prediction is 7 per cent. better than if he uses the number of fixations counted through direct observation. Therefore, time, or rate of reading, is a better measure of the number of eye movements actually made than is the number counted by direct observation.

The question then arises as to whether or not the two variables, number counted and time, will give a better prediction of the number of eye movements actually made, *i.e.*, photographed number, than either variable alone. The multiple correlation of the photographed number with the number counted and time is .933 for *M* and .935 for *R*. For *M* to use both variables for prediction is no better than to use time alone and it is only 3 per cent. better for *R*. The reason for this is found in the fact that the true correlation between the number counted and the photographed number when time is held constant is .01 for *M* and .23 for *R*. This means that if all subjects had read for the same length of time, say one minute, the empirical correlation between the number counted and the photographed number would have approximated the above noted partial correlations. Just as Holzinger has pointed out that the correlation between ossification ratio and mental age is due to variation in chronological age,[3] so the zero order correlation between the number of eye movements counted by direct observation and the photographed number of eye movements is a function of variability in the time of reading the selection.

Counting eye movements is affected by many things. In this experiment, which continued through several months, each clinician found periods in which he tended to more nearly approximate the number actually made than at other times. At one period a tendency to count more than actually occurred was noted; on the average, however, the number counted represented for *M* 77 per cent. of the number photographed and for *R* 85 per cent. In other words, the clinicians in counting did not usually approximate the number of eye movements actually made. Also, the zero order correlations indicate that the number counted is more highly related to time than to the number of fixations made.

While it is to be noted that there is some variation in the correlations of the two clinicians, the significance of their predictions is comparable, so that the conclusions of this study have a general application. If good readers had been used, more accurate results would probably have been obtained because the larger excursions would have been easier to note. However, it is with the type of student used here who fixates almost every word that clinical diagnosis from eye movements is carried out.

The zero order correlations noted above indicate the validity of these measuring instruments in the actual reading situation. They show that both time and number counted are fair measures of the number of eye movements actually made. Of the two, however, time rather than the number counted gives a better prediction. Even this technique should be used only for preliminary diagnosis, though, since it gives at best a prediction of the photographed number only 64 per cent. better than chance. For an accurate picture of the nature of an individual's eye movements, photography must be used.

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[1] H. H. Jasper and R. Y. Walker, "The Iowa Eye-Movement Camera," SCIENCE, 74, 1931, 291–94.

[2] K. J. Holzinger, "Statistical Methods for Students in Education." New York: Ginn and Company, page 166.

[3] *Ibid.*, page 284.

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