

or blue filters must be tempered with caution, else a grossly erroneous count lying between the true light-field and dark-field counts may be obtained. The usual microscopic arrangement includes a 16-mm. objective and a 7.5x ocular containing a Whipple disk, the tube length being adjusted so that the Whipple disk exactly subtends 1 sq. mm. of the floor of the counting cell. This adjustment is made by the use of a stage micrometer.

Method of Making and Computing Counts. The recommended practice for counting is to prepare two cells from each dust sample and to count one fourth of the ruled field of the Whipple disk in five well-separated representative locations of each cell. The ten counts are averaged and from this is subtracted a similarly obtained count of a control sample of the collecting liquid through which no air has been drawn. The control count compensates for dust acquired in manipulation, as well as dust in the sampling medium or the microscopic system. This average net count per fourth of the field is then computed to million particles per cubic foot in the sampled atmosphere, taking into account air volume sampled and volume of impinger liquid.

$$\text{Particles per cu. ft.} = \frac{\text{count per fourth of field} \times 4 \times 1000 \times \text{ml. of sample liquid}}{\text{cu. ft. of air sampled}}$$

There is considerable variation in the manner of making dilutions and filling cells, the length of settling time, the choice of a counting cell, and the microscopic system employed; therefore to expect greater correlation than ± 10 per cent between two independent counts is to be overly optimistic, and variations of over 50-per-cent are not uncommon. Despite all of these objections our present system of evaluation is not to be condemned, but we should encourage research into better methods and be mindful of the folly of evaluations based upon a single dust count. We should avoid the idea that the threshold limits of dustiness now accepted are absolute figures rigidly separating safe atmospheres from dangerous ones. Rather they should be regarded as bench marks of desirable control.

Dark-Field versus Light-Field Counting. Dark-field illumination obtained by means of a Zeiss "Dissecting Condenser" and counts made with a microscopic system employing a 16-mm. achromatic objective with N.A. = 0.2 (8x), a 30x ocular, and a tube length adjusted to give a magnification of 250x have been shown to yield results from 2 times to more than 50 times as high as those obtained by standard light-field technique.⁵² The limit of visibility of this arrangement is about 0.1 μ . The ratio of DF count to LF count increases with an increasing proportion of particles less than 0.7 μ in diameter and is an indication of particle size. This does not necessarily indicate that the dark-field count is a better index or even that it would be after the establishment of sufficient correlation between lung damage and dustiness determined by such dark-field counts. Although impinger samples are more easily counted by the dark-field technique, and with much higher results, the collection efficiency of the impinger as now used, drops

⁵² T. Hatch and C. L. Pool, *J. Ind. Hyg. Toxicol.*, 16, 177 (1934).

rapidly with diminishing particle size, for particles below $3/4 \mu$, that the advantage of counting may be more than offset by decreasing efficiency of collection. Our present method of evaluation is largely limited to those particles above 0.7 μ in diameter, whether this gives rise to serious errors remains to be proved. It has been suggested that particle size may be a factor in explaining the relatively low light-field counts found in the silica brick industry in work atmospheres where silicosis is known to occur. It would seem desirable to collect samples in this and some other silica exposures and, after evaluation of all particles in the range between 0.1 and 5.0 μ , make a statistical study in an effort to illuminate the effect of the smaller particles as well as possibly to explain the incidence of silicosis in silica brick manufacture.⁵³

The Microprojector. The microprojector⁵⁴ furnishes a useful variation in counting methods for evaluating impinger samples, whereby the dust image is projected usually at a magnification of 1000 diameters, onto a ruled screen. A 16-mm. objective is used and the increased magnification is obtained by employing higher power in the ocular and by projection. Two cells are prepared and each is counted by counting all the particles in five well-separated representative fields of 0.05 cu. mm. each (10 $\times$ 50 cm. strip on the screen, at 1000x). A similar count of the control is then subtracted from the average of the counts on the two sample cells, and the final computation is as follows:

$$\text{Particles per cu. ft. of air} = \frac{\text{count in 0.25 cu. mm.} \times 4 \times 1000 \times \text{ml. of dust suspension}}{\text{cu. ft. of air sampled}}$$

The microprojector can be used for both counts and particle-size determinations, does not cause excessive eye strain, and, at least among the inexperienced, tends to promote closer agreement and reproducibility of counts. It is probably not a time saver when counts are being made by one individual. With direct counting through a microscope, the analyst can arrange all his material within arm's length and not spend time opening and closing the viewing booth door and walking from booth to microscope to adjust the light source and to fill cells and place them on the stage. The time gained with the microprojector in avoiding secondary dilution for some samples does not compensate for this loss. The microprojector is, however, very useful for counting as well as for particle size determination, yields dependable and reproducible results, and is an interesting and valuable demonstration since the gadget counterpart⁵⁵ requires less space and obviates the necessity for duplicate controls to manipulate focusing and mechanical-stage controls.

⁵³ W. B. Fulton, F. E. Butters, A. E. Dooley, F. B. Koppenhaver, J. L. Matthes, and R. M. Smith, *Study of Silicosis in the Silica Brick Industry*. Bur. of Ind. Hyg., Dept. of Health, Washington, D. C., 1941.

⁵⁴ E. C. DeBrow, L. A. Baum, W. P. Yant, and H. H. Schrenk, *U. S. Bur. Mines Rept. Invest.* No. 3373, 1935.

⁵⁵ E. C. DeBrow, *U. S. Bur. Mines Rept. Invest.* No. 3780, 1944.