An Apparatus for Mechanical Micro-Analysis of Sand.

By

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Some apparatus for mechanical analyses are based on the fact that grains that drop from the top of a tube through a liquid reach the bottom at times varying after the settling velocity of the grains. The first tube to be constructed on this principle is CLAUSEN's tube (1899). The material that is to be analysed is in suspension in a bulb that may be fitted into the top of the tube and the volume of the sedimented quantities is read after certain settling times. The analysis is undertaken on the same principle in three more recent apparatus where the bulb is omitted; the sand is introduced direct into the tube that is open at the top, and the volume is read at various times. Such tubes are described by VAN VEEN (1936), CAILLEUX (1937), and EMERY (1938).

It is, however, obvious that the analysis obtained by a determination of volume cannot directly be compared with analyses in which the relationship between the grainsize and the weight is measured as the volume of the fractions of various grainsizes cannot be exactly proportional to the weight; the shape of the grain and differences in grainsizes within the fraction will have a certain influence and yield different cubic weights. Further the settling way will vary from the coarsest grains, that settle on the bottom of the graduated tube, to the finest that settle on top of the already sedimented material and thus falls a shorter distance. In the case of CLAUSEN's apparatus the grains moreover start at various distances as the material from the very beginning of the analysis is distributed in the flask. The same inexactitude also occurs in a modification of CLAUSEN's tube proposed by LÖBER (1932). LÖBER leaves CLAUSEN's tube open at the bottom. Under the sedimentation it is closed with a finger, and at various times it is opened under the water in small glass dishes into which the sediment falls so that the fractions may be weighed.

Two apparatus yielding a more exact separation after size and by means of which the sedimented quantities are weighed are described by KÜHL (1926 and 1927). A description of the latter apparatus—that are constructed for the purpose of analysing the grain distributions of cement—is found in a treatise by GESSNER (1931). In the use of KÜHL's earlier apparatus—that was fitted with nine decantation cocks at various heights—it appeared that the suspension at times behaved like a liquid of a greater density and therefore dropped as a whole down through the settling tube. To avoid this in his new apparatus—where the sediment was collected from the bottom only—KÜHL used a heating device that gave the highest temperature at the top and caused sedimentation to take place undisturbed. Owing to the differences in temperature a close calculation of the settling velocities for the grainsizes is impossible, and the determination of the sizes must therefore in this case be made by microscopic measurements.

In this article a simple apparatus is described that may be used for analysing small quantities of sand. Like other apparatus, working on similar principles, it is remarkable by the fact that the analyses are quickly made, and as is the case in KÜHL's apparatus the measurements are made by weighing. The drawback KÜHL mentions from his first apparatus that the suspension falls down as a whole through the apparatus does not occur when sufficiently small quantities of sand are used for the analyses. The apparatus has further the following advantages, in the first line it is excellently suited for analyses of quite small quantities of material and secondly the various fractions are separated which is of importance for a subsequent mineralogical analysis of the material.

The apparatus consists of a 1 m long glass tube the interior diameter of which is 30 mm. At the bottom the tube is conic the inside diameter being reduced over a distance of 12 cm to 5 mm. At the bottom end a rubber tube closed with a pinch cock is fitted while distilled water is poured in till sedimentation is to take place.

At the top the tube may be closed with a rubber stopper in which is fitted a funnel with a glass cock as well as a container for the material that is to be analysed. This container (fig. 1C) consists of a closed glass tube with an interior diameter of 7 mm and is abt. 20 mm long. It turns downward when the stopper is fitted in.

The analysis takes place in the following way:

The sand that is to be analysed is introduced into the sediment container—for instance by means of a device consisting of a funnel (fig. 1F) which by means of a rubber ring is placed in the sediment container. The funnel, that at top is about 10 mm in inside diameter, and at bottom ends in an opening of scarcely 2 mm is half filled with water, the material is introduced and the grains settle down into the container. Grains, if any, that have settled on the walls of the funnel are brought down by stirring the liquid with a wire. When the sedimentation is finished the funnel is removed. It is closed at the top by means of a rubber stopper that is pierced and fitted with a rubber tube which after the fitting is again closed by means of a pinch cock. The funnel being thus closed can be removed without agitating the material in the container. When the sediment is to be introduced into the settling tube the container must be quite filled with water and the glass cock in the stopper must be left open. The stopper with the container is now rapidly turned upside down so that the edge of the container is immerged under the surface of the water in the filled tube whereafter sedimentation begins. Simultaneously a stop clock is started by an assistant who records the settling times.

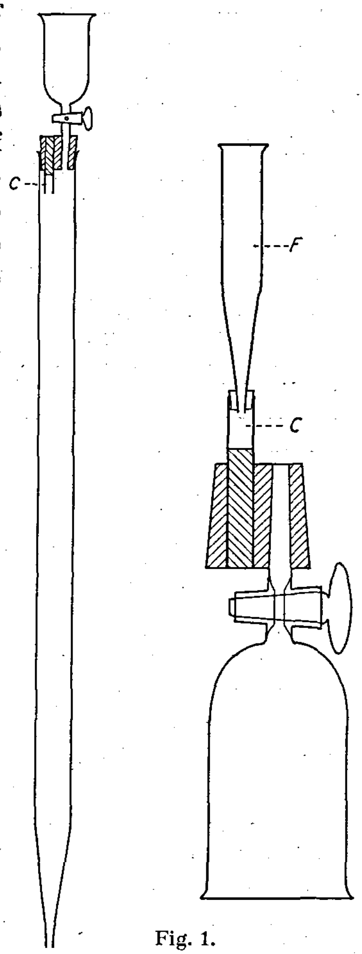

Fig. 1.

The stopper at the upper end of the tube is quickly pressed down and the glass cock closed; the rubber tube is then removed from the lower end of the settling tube. As the device is now quite closed at the top the water with the sedimenting material remains in the tube.

The material is collected in carefully weighed watch glasses into which a little distilled water has been poured. If the liquid in the watch glass is held quite close to the bottom of the tube all the material that has reached the bottom will settle into the watch glass. At suitable intervals a watch glass is removed with a quick movement, the settling time is recorded by the assistant, and a fresh watch glass is used for the collection of the next fraction. The watch glasses with their contents are dried in a drying oven and weighed by means of analysing scales.

If the sediment analysed contains fine material this may be collected on filter paper the filter device being then placed under the tube and the glass cock at the top of the apparatus is slightly opened. The filtration may take place by means of the device that is described by the author in 1941 (GRY 1941).

For determination of the grain size I have traced curves showing the relationship between the settling velocity in sec. for 100 cm settling and the diameter in mm. Such curves are traced on double logarithmic paper for temperatures of 5, 10, 15, and 18°, and by interpolation the grainsize is found at the various settling times in the different experiments. The settling times are calculated after RUBEY's formula, which according to the author's investigations (1940), yield more correct results than those of Oseen.

The results of the analyses are most simply traced as cumulative curves as the grainsize intervals of the fractions are of unequal sizes. The analyses are also suited for the graphic computation of mean grainsize, mean deviation, etc. on probability net.

Measurements under the microscope have shown that the fractions obtained in the apparatus described are well assorted, and the diameters of the grains lie within the limits determined by the settling velocities. Still, there are a few grains that are too fine and a few that are too coarse—as is also the case when other elutriation methods are applied—but not so many that the result of the analysis is influenced. A change in the results appears, however, if more than abt. 300 mg are used for the analysis as the sediment then apparently becomes coarser because fine grains are carried down through the tube together with the coarsest.

The apparatus has by the author been used for mechanical analyses of the sand that is brought into suspension owing to the tidal currents in the Danish shallows (GRY 1941). The samples that are analysed have contained from a few mg up to 100 mg sand.

The author is convinced that the apparatus will be of importance where a mechanical analysis of quite small sand quantities is desired, for instance for the study of fine stratification in sanded sediments, for analysis of small boring samples, of samples of suspended material from rivers, streams, etc.

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Resumé.

Der gives en Beskrivelse af et Apparat, der kan anvendes til Kornstørrelsesanalyse af ganske smaa Sandmængder. Analysen grundes paa det Faktum, at forskelligt store Korn, der falder gennem en stillestaaende Vædskesøjle fra dennes Overflade, naar Bunden til forskellig Tid alt efter Kornenes Faldhastighed. Med passende Mellemrum kan det sedimenterede Materiale opsamles fra Bunden, tørres og vejes. Apparatet, der har været anvendt til Analyser af opslemmet Materiale fra Vadehavet, vil især kunne faa Betydning ved Undersøgelser, til hvilke der kun kan tilvejebringes et lille Materiale, f. Eks. ved Studiet af Finlagdeling i sandede Sedimenter, ved Analyse af smaa Boreprøver, af Prøver af opslemmet Materiale fra Floder og andre Strømme o. s. v.

Færdig fra Trykkeriet 6. Januar 1942.