

[54] PARTICLE SIZE DISTRIBUTION
ANALYSER

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[58] Field of Search 209/208, 209, 453; 210/83,
210/521; 73/61.4, 28, 432 PS

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[57] ABSTRACT

A device for analysing the particle size distribution of very small particles such as sand, etc., from a given quantity of water of river or sea by precipitation onto a receiving plate rotating at a very low speed in a body of water, larger particles descending earlier than smaller ones, whereby the particles of different sizes are separately precipitated onto the receiving plate and collected according to size distribution.

3 Claims, 3 Drawing Figures

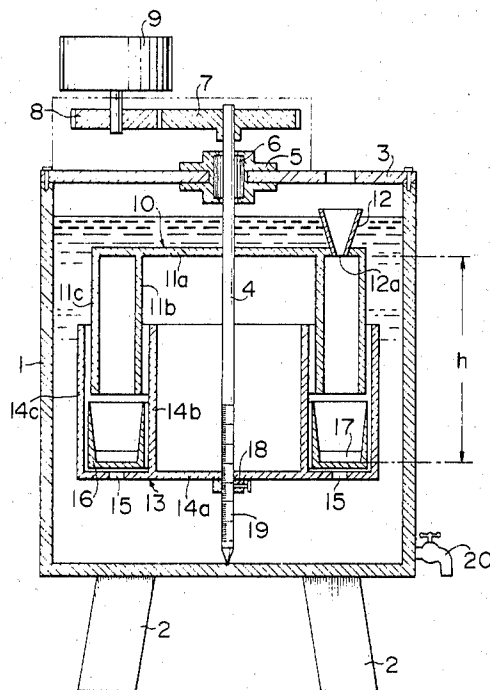


FIG. 1

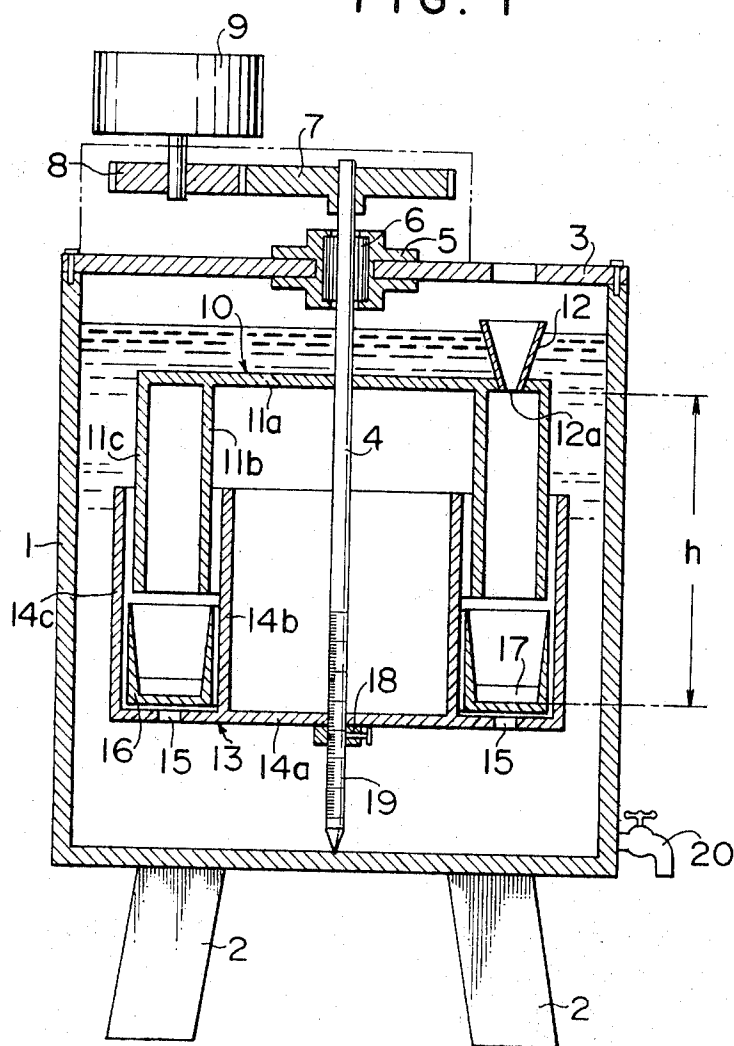


FIG. 2

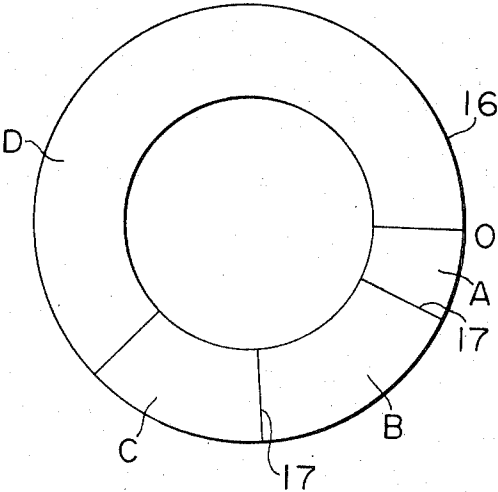
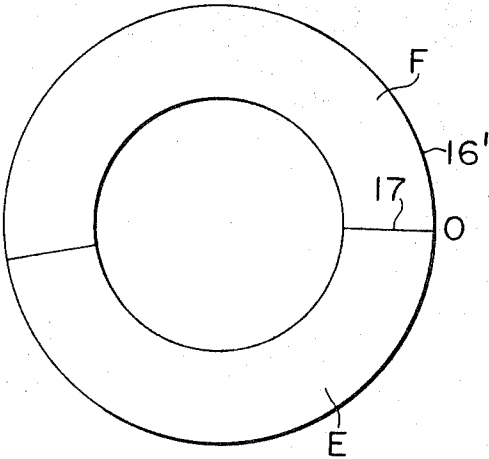


FIG. 3



PARTICLE SIZE DISTRIBUTION ANALYSER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a device for sorting and classifying very small particles.

2. Description of the Prior Arts

When the water of river or sea is treated for use as industrial water and drink water, it is required to chemically analyze the quality of water as well as to remove minerals such as sand particles. In this connection, it is necessary to know what sizes of particles of sand are contained in a determined amount of water of the river or sea. Conventionally, there is used a standard sorting device having a sieve of 0.044mm mesh, which is the minimum size of the sieve available in accordance with JIS (Japanese Industrial Standards).

A known automatic particle size measuring device includes a water vessel in which a balance is provided to measure particles stirred up and descended onto a receiving dish, thereby measuring the distribution of the particle size, based upon the amount of particles precipitated in a determined time.

Such a device requires a relatively large amount of samples to operate satisfactorily.

However, it is generally difficult to obtain such a large amount of samples of the water of river or sea.

Furthermore, such a device can analyze distribution of particles sizes but since the particles precipitated on the balance dish are not sorted according to the sizes thereof, it is not known what sized particles are contained in the samples in what percentage.

SUMMARY OF THE INVENTION

It is the object of this invention is to provide a device having an easy-operable and simple structure to accurately analyze, sort and measure particles even with a small amount of samples.

The device comprises a transparent water vessel, a top sealing cover, a shaft perpendicularly passing through said cover and rotatably carried by said cover, an horological mechanism to drive said shaft, a first inserted cup member having two concentric side walls and fixed to said shaft to be co-rotatable therewith, a second cup member having two concentric side walls adapted to receive said two concentric side walls of said first cup member, said second cup member being carried by said shaft to be adjustable of its position along said shaft, and an annular dish mounted in said in said second cup member in an annular space defined the two concentric side walls thereof, said first cup member having a sample inlet port opening to said annular space.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal section of an embodiment of the device according to this invention; and

FIGS. 2 and 3 are plan views of two examples of the annular dishes to be incorporated in the device as shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, this invention will be described of a preferred embodiment with reference to the accompanied drawings.

A water vessel 1 made of a transparent synthetic resin or glass having feet 2 is equipped with a top cover 3 sealing the upper opening of said vessel, and a rotary shaft 4 is perpendicularly passing through the cover 3 at the center of the vessel 1.

The rotary shaft 4 is abutting against the bottom of the vessel 1 at the lower-most end thereof where it is conically shaped and is carried at its upper portion by rollers 6 of a bearing 5 provided at the cover 3. The shaft 4 is in turn carrying a gear 7 at its upper end portion, which is in meshing engagement with a gear 8 of an horological mechanism 9 to be driven by the mechanism.

An upper end plate 11a of a first cup member 10 is fixed to the rotary shaft 4 and inner and outer cylindrical side walls 11b, 11c integrally connected with the end plate 11a extend downward therefrom.

The end plate 11a is provided with a funnel shaped sample inlet port 12.

A second cup member 13 includes a bottom plate 14a through which the rotary shaft 4 passes in a manner to permit axial movement therebetween. Side walls 14b, 14c of the second cup member 13 receive therebetween the side walls 11b, 11c of the first cup member 10, thereby defining an annular space closed at upper and lower ends thereof. The bottom plate 14a is provided with several draining holes 15 opening in the region of the annular space. An annular receiving dish 16 is placed at the bottom of the annular space to fit the side walls 14b, 14c.

The receiving dish 16 may, for example, be of the shapes in FIGS. 2 and 3. The receiving dish 16 shown in FIG. 2 is used to analyse and sort particles of diameter d in the range of $0.005 < d < 0.05$ mm. The annular dish is divided by partitions 17 to provide separate receiver sections A, B, C, and D on the receiving dish 16. The receiving dish 16' shown in FIG. 3 provides receiver sections E and F adapted to sort particles two parts of $d < 0.005$ mm and $d > 0.005$.

The bottom plate 14a of the second cup member 13 is provided with a stopper 18 to adjustably mount the second cup member 13 to the shaft 4 with respect to its height.

The shaft 4 is provided with centimetric measuring marks 19 at the lower end portion thereof for the convenience of adjusting the height of the second cup member. Said centimetric measuring marks 19 is conversely marked from up to down to give the height h from the inlet point of the sample introduced through the inlet port 12 to the bottom of the receiving dish 16.

The particles to be sorted in the receiver sections A, B, C, and D of the receiving dish 16 are within the range of $0.005 < d < 0.05$ mm particle size as mentioned above. The descending speed (cm/sec) of the particles varies according to water temperature and specific gravity of the particles and as a result of experiments, the inventor has obtained the data as shown in Table I. Table I. Descending speed (cm/sec) of the Particles in the water.

Thus, assuming conditions that the descending height h is 20cm and the water temperature is 15°C, a particle having diameter of 0.05 mm and specific weight 2.65 shows descending speed of 0.196 cm/sec and takes about 1 min. 40 sec to reach the receiving dish. For the same conditions, another particle of 0.005 mm diameter and 2.65 specific weight shows descending speed of 1.96×10^{-2} cm/sec and takes about 2 hours and 46 min. to reach the receiving dish.

diameter (mm)	water tem.(c)	specific gravity				
		2.5	2.6	2.65	2.7	2.8
0.05	0	0.114	0.121	0.125	0.129	0.136
	5	0.134	0.143	0.148	0.152	0.161
	10	0.156	0.166	0.171	0.177	0.187
	15	0.178	0.190	0.196	0.203	0.214
	20	0.202	0.215	0.222	0.229	0.242
	25	0.227	0.242	0.249	0.257	0.272
	30	0.254	0.271	0.280	0.288	0.305
	35	0.279	0.298	0.307	0.317	0.335
0.03	0	4.09 $\times 10^{-2}$	4.37 $\times 10^{-2}$	44.46 $\times 10^{-2}$	4.50 $\times 10^{-2}$	4.91 $\times 10^{-2}$
	5	4.84 do.	5.16 do.	5.32 do.	5.48 do.	5.80 do.
	10	5.61 do.	5.98 do.	6.17 do.	6.36 do.	6.73 do.
	15	6.42 do.	6.84 do.	7.06 do.	7.29 do.	7.70 do.
	20	7.27 do.	7.75 do.	8.00 do.	8.24 do.	8.72 do.
	25	8.16 do.	8.70 do.	8.97 do.	9.24 do.	9.79 do.
	30	9.15 do.	9.76 do.	10.07 do.	10.37 do.	10.98 do.
	35	10.05 do.	10.72 do.	11.06 do.	11.39 do.	12.06 do.
0.01	0	4.55 $\times 10^{-3}$	4.85 $\times 10^{-3}$	5.00 $\times 10^{-3}$	5.15 $\times 10^{-3}$	5.46 $\times 10^{-3}$
	5	5.37 do.	5.73 do.	5.91 do.	6.09 do.	6.45 do.
	10	6.23 do.	6.65 do.	6.85 do.	7.06 do.	7.48 do.
	15	7.13 do.	7.60 do.	7.84 do.	8.10 do.	8.55 do.
	20	8.08 do.	8.61 do.	8.88 do.	9.15 do.	9.69 do.
	25	9.06 do.	9.67 do.	9.97 do.	10.27 do.	10.88 do.
	30	10.17 do.	10.84 do.	11.18 do.	11.52 do.	12.20 do.
	35	11.17 do.	11.92 do.	12.29 do.	12.66 do.	13.41 do.
0.008	0	2.91 $\times 10^{-3}$	3.11 $\times 10^{-3}$	3.20 $\times 10^{-3}$	3.30 $\times 10^{-3}$	3.49 $\times 10^{-3}$
	5	3.44 do.	3.67 do.	3.78 do.	3.90 do.	4.13 do.
	10	3.99 do.	4.25 do.	4.39 do.	4.52 do.	4.79 do.
	15	4.56 do.	4.87 do.	5.02 do.	5.19 do.	5.48 do.
	20	5.17 do.	5.51 do.	5.69 do.	5.86 do.	6.20 do.
	25	5.80 do.	6.19 do.	6.38 do.	6.57 do.	6.96 do.
	30	6.51 do.	6.94 do.	7.16 do.	7.37 do.	7.81 do.
	35	7.15 do.	7.63 do.	7.86 do.	8.10 do.	8.58 do.
0.005	0	1.14 $\times 10^{-3}$	1.21 $\times 10^{-3}$	1.25 $\times 10^{-3}$	1.29 $\times 10^{-3}$	1.36 $\times 10^{-3}$
	5	1.34 do.	1.43 do.	1.48 do.	1.52 do.	1.61 do.
	10	1.56 do.	1.66 do.	1.71 do.	1.77 do.	1.87 do.
	15	1.78 do.	1.90 do.	1.96 do.	2.03 do.	2.14 do.
	20	2.02 do.	2.15 do.	2.22 do.	2.29 do.	2.42 do.
	25	2.27 do.	2.42 do.	2.49 do.	2.57 do.	2.72 do.
	30	2.54 do.	2.71 do.	2.80 do.	2.88 do.	3.05 do.
	35	2.79 do.	2.98 do.	3.07 do.	3.17 do.	3.35 do.

Therefore, it will be particles of $0.005 < d < 0.05$ mm, under the conditions that the specific gravity thereof is 2.65 and the water temperature is 15°C , descend distributedly over the receiving dish 16 which rotates one turn in 3 hours.

In more detail, it will be apparent that the particles are sorted separately, according to the sizes of $d > 0.02$ mm, $0.01 < d < 0.02$ mm, $0.008 < d < 0.01$ mm and $0.005 < d < 0.008$ mm, respectively.

In the above example, the descending height (h) is set at $h = 20$ cm, under the conditions of 15°C water and 2.65 specific gravity, but the descending height is to be changed according to the changes of water temperature and the specific weight of the particles. For that purpose, Table II gives the descending height (h) varying according to variations of the water temperature and the specific gravity.

C	Wt	2.5	2.6	2.65	2.7	2.8
0		11.6	12.4	12.7	13.1	13.9
5		13.7	14.6	15.0	15.5	16.4
10		15.9	16.9	17.5	18.0	19.0
15		18.2	19.4	20.0	20.6	21.8
20		20.6	22.0	22.6	23.3	24.7
25		23.1	24.6	25.4	26.2	27.7
30		25.9	27.6	28.5	29.4	31.1
35		28.5	30.4	31.3	32.2	34.1

From the above Table II, the height (h) can be modified according to the variations of water temperature and specific gravity, so that, for example, a height (h) is to be selected as 22.6 cm, when the specific gravity

is 2.65 and the water temperature is 20°C . Such a height is readily available by setting the receiving dish 16 at a required level according to the centimetric measuring mark provided on the rotary shaft 4.

The embodiment of this invention is constructed based on the Tables I and II. A sample inlet opening 12a is positioned correctly above the zero (0) line of the receiving dish 16 in the water vessel 1, and a water is poured in the sample inlet 12. The samples to be measured are dropped into the water from the inlet 12 when the water is in a still condition.

Samples are obtained in a manner that water of river or sea is evaporated to educe particles contained therein. However, since very small particles other than $0.005 < d < 0.05$ mm are mixed (sieve according to JIS is available to analyze and sort particles larger than 0.05 mm), the particles are sorted into two kinds one being of $d > 0.005$ mm and the other being of $d < 0.005$ mm on the receiving dish 16 shown in FIG. 3 before hand, and thereafter, the particles precipitated as $d > 0.005$ mm on the funnel dish are collected, evaporating water, the sample obtained is sorted by the device having a receiving dish 16 shown in FIG. 2.

Since samples descend very slowly, and the cup member 10 including upper end plate 11a and side walls 11b, 11c and the cup member 13 including lower end plate 14a and side walls 14b, 14c rotate at very low speed, the water contained in the vessel is kept in a still condition.

Thus, the samples descending perpendicularly in the water are sorted and precipitated correctly into several groups of certain sizes on each funnel section as the receiving dish rotates.

The sorting device according to this invention is of descending and precipitating type wherein the samples are dropped in the still water thereby analyzing the particles regardless the quantity of the samples, and since the samples descend perpendicularly in the water, the weight of the samples themselves is clearly distinguished whereby no differently-sized particles are mixed in a group of the particles precipitated on a funnel shaped section. The device itself is operated with a simple mechanism and construction in such a manner that the receiving dish 16 is rotated with an horological gear through gears 9, 10, thereby allowing cheaper installation cost, wherein the height (h) of the receiving dish 16 is indicated on the given centimetric marks through the transparent vessel 1. By the transparent vessel, there are obtained other features of permitting to check the descending and precipitating condition of the samples. Furthermore the device is used to analyze and sort the particle sizes of medicines and other materials which are not soluble.

As discussed hereinbefore, the sorting device of this invention can be widely used in the industries for sorting and classifying particles.

Modification to the above embodiment will be made without departing from the spirit and technical scope of this invention.

What I claim is:

1. A device for sorting and classifying very small particles comprising:

- a. a transparent water vessel,
 - b. a top sealing cover,
 - c. a shaft perpendicularly passing through said cover and rotatably carried by said cover,
 - d. an horological mechanism to rotatably drive said shaft,
 - e. a first inverted cup member having two concentric side walls and fixed to said shaft to be co-rotatable therewith,
 - f. second cup member having two concentric side walls adapted to receive said two concentric side walls of said first cup member, said second cup member being carried by said shaft and including means for adjusting its position along said shaft, and
 - g. an annular dish mounted in said second cup member in an annular spaced defined by the two concentric side walls thereof, said first cup member having a sample inlet port opening to said annular space.
2. A device according to claim 1, wherein said annular dish is separated into sectoral portions by partitions.
3. A device according to claim 1, wherein said rotatable shaft is provided with means for measuring the position of said second cup member on said shaft.

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