SAMPLING OF AIRBORNE DUST IN HEAVILY LADEN ATMOSPHERE

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A B S T R A C T

The U. S. Bureau of Mines Sugar Tube Type B for determining rock dust in air has been modified to give higher filtering efficiency in a heavily laden atmosphere.

I N T R O D U C T I O N

A RUGGED and compact apparatus which can be assembled with easily procurable components and simply operated is required for field assessment of air-borne dust. The apparatus should be capable of not only giving information regarding the coarser dust particles, but also of the dust particles less than 1 μ which are pathogenic in nature.

The US Bureau of Mines and Union of South Africa Sugar Tube Type B designed by Fieldner, Katz and Longfellow[1] though designed with this end in view, is not good enough in that it requires a powerfull pumping set to obtain the required rate of airflow and it does not filter particles less than 1μ. Various equipments based on Cottrel electric precipitators[2], Tyndall effect[3] etc. have been recommended from time to time. But these are complicated in nature and highly specialised in the technique required to operate. The Cascade Impactor designed by CDES Portion[4] is compact, rugged and easy to operate. But it has the disadvantages that :—

(*i*) The dust particles are distorted by heavy impact,

(*ii*) The apparatus cannot arrest any particle less than 1μ.

The Sugar Tube Type B of Fieldner *et al.* a sketch of which is reproduced in Fig. 1 appears to be the best compromise but requires further improvement in the directions stated above. Technical data of the tube are given in Table 4.

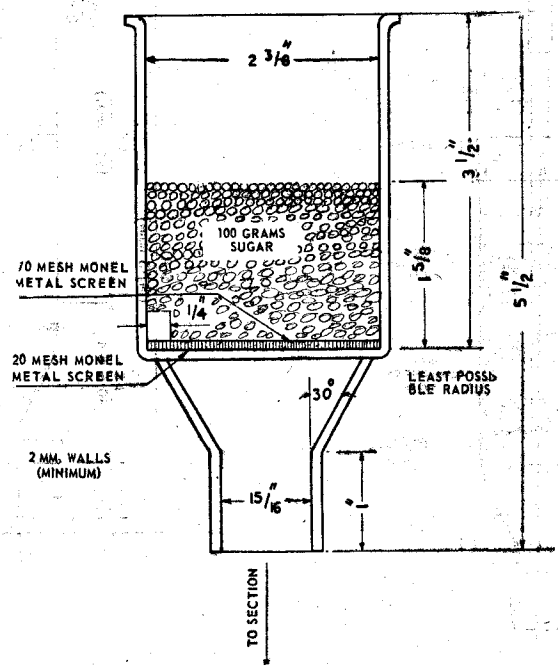

Fig. 1

Fieldner *et al*(1'5) report that the filtering efficiency of the tube could be increased to 90—100% against tobacco smoke by using 75 gms. 48—150 BS pulverised sugar (30-10 IS) in a 1 inch layer having a resistance of about 3 inches of mercury. But this is not suitable for adoption in the field on account of the powerful section required.

EXPERIMENTAL

Grist size of sugar—After a series of trials it was found that the following grist size spectrum within 170 IS and 20 IS give the maximum filtering efficiency with minimum resistance when assembled as below:—

TABLE I

Grist size Spectrum of Sucrose

IS Sieve No. Passing through	Retained on	% by weight
170	120	3
120	85	15
85	40	60
40	25	15
25	20	7

Formation of bed—A total quantity of 50 gms. of sugar of the above grist size spectrum was divided into 3 beds of 16, 16 and 18 gms. as shown in Fig. 2. Each bed was supported on a wire-mesh shown in Fig. 3. The lowest bed was supported on 5 gms. of coarse sugar

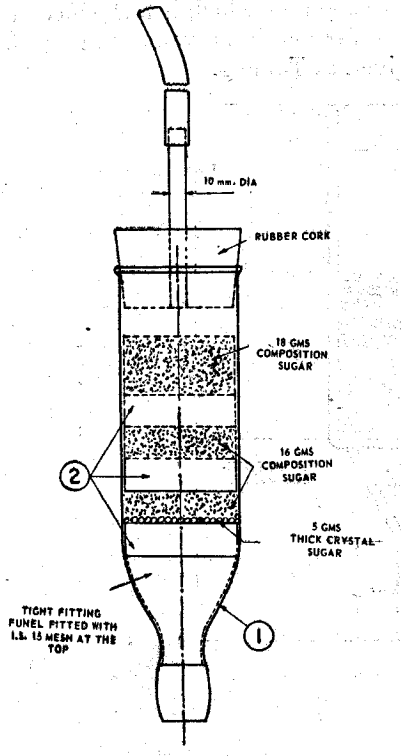

Fig. 2(a)

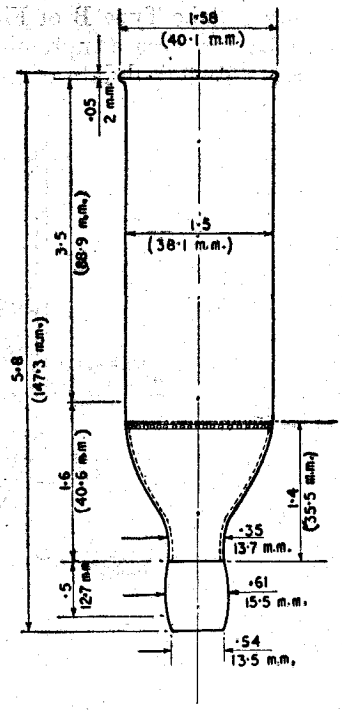

Fig. 2(b)

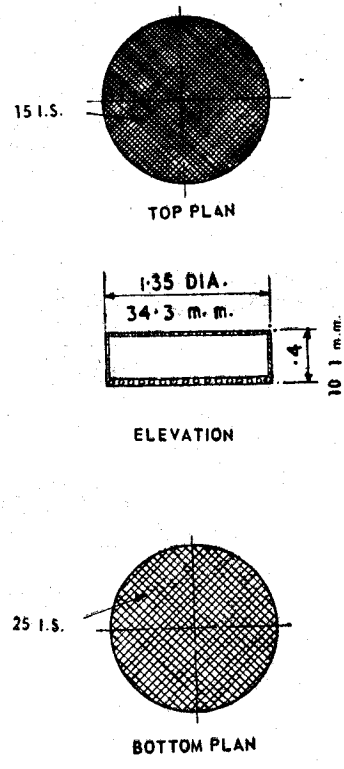

Fig. 3

passing through ISS 240 and retained on ISS 140. After the sugar had been placed in the tube, it was dampened with alcohol (35% W/V) sprayed from a continuous atomiser till both top and middle layer were wet.

Apparatus for Creating a dust cloud—The apparatus described by Fieldner *et al.* was not suitable for the present work as a very heavily dust cloud could not be created with it. A dust cloud generator as shown in Fig. 4 was used in lieu. The aluminium spiral gives a whirling current of air and ensures a uniform heavily laden air-dust mixture in the out going air stream. The buzzar is used to give a vibration in the system to prevent settling of dust. About 5 gms. of siliceous dust (passing through I.S. 8 mesh) is placed inside the generator after drying at 250°—300°C. The assembled apparatus weighs approximately 25 gms. The air to be used has to be predried as even traces of moisture prevents formation of a good cloud.

Apparatus for determining the efficiency of the sugar tube:—Lay out of the apparatus used for checking the efficiency of the sugar tube is given in Fig. 5. Air was passed through the apparatus at the rate of 10—11 litres/min for 2 mins. The loss in weight of the cloud-generator gave the quantity of dust carried in the air stream. The amount of dust arrested by the sugar tube was determined as below :—

The sugar was dissolved in 600 ml. of hot water, boiled with 10 ml conc. HCl. for 10—15 mins. and filtered through Whatman paper No. 42. The insoluble dust powder was then ignited to a constant weight at dull red heat. Blank experiment was carried out and necessary corrections applied.

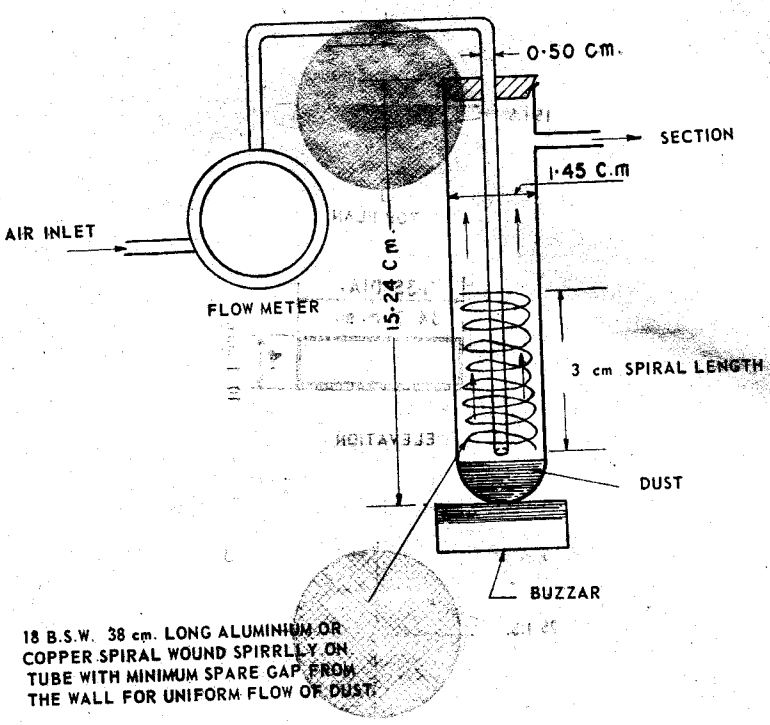
0·50 cm.
SECTION
1·45 C.m
AIR INLET
FLOW METER
15·24 C.m
3 cm SPIRAL LENGTH
DUST
BUZZAR
18 B.S.W. 38 cm. LONG ALUMINIUM OR COPPER SPIRAL WOUND SPIRRLLY ON TUBE WITH MINIMUM SPARE GAP FROM THE WALL FOR UNIFORM FLOW OF DUST.

Fig. 4

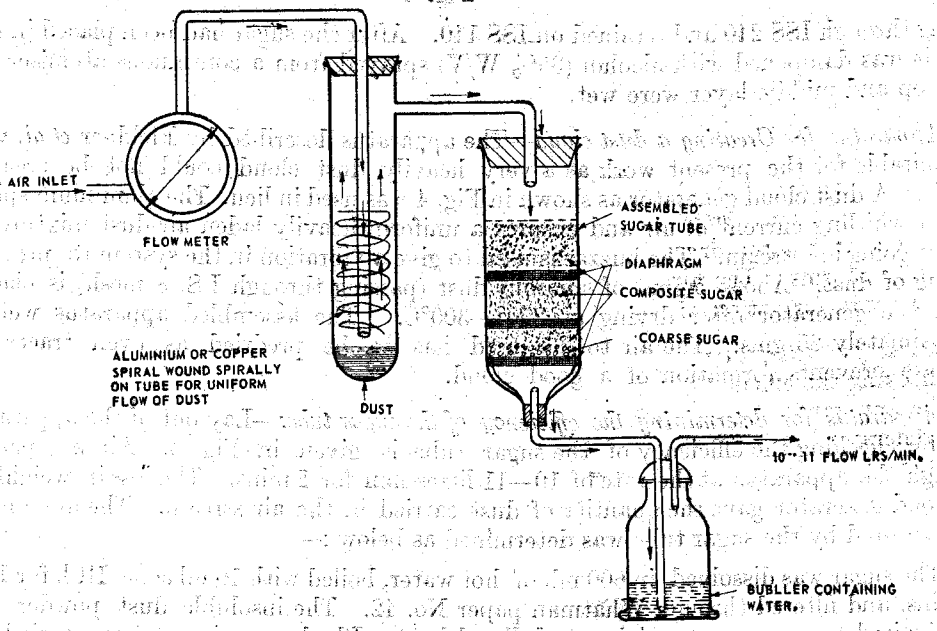
AIR INLET
FLOW METER
ALUMINIUM OR COPPER SPIRAL WOUND SPIRALLY ON TUBE FOR UNIFORM FLOW OF DUST
DUST
ASSEMBLED SUGAR TUBE
DIAPHRAGM
COMPOSITE SUGAR
COARSE SUGAR
10 - 11 FLOW LRS/MIN.
BUBBLER CONTAINING WATER.

Fig. 5

The dust collecting efficiency of the tube (% by weight) as determined by the above apparatus is given in Table II below :—

TABLE II

Expt. No.	Loss of wt. of the dust cloud generator (gms).	Wt. of dust collected in the sugar tube	Efficiency % by wt.
1	1·773	1·767	99·7
2	1·665	1·665	100·0
3	1·727	1·729	100·2
4	1·455	1·450	99·4

Particle size of dust collected—The mechanical analysis of the dust collected in the Sugar Tube was carried out by the Andreasen pipette method with sodium metaphosphate solution (17·85 gms. of sodium metaphosphate and 3·97 gms. of anhydrous sodium carbonate dissolved in 500 cc water) as the dispersion fluid. Typical results of a series are given below :—

TABLE III

Particle size (microns)	Weight %
< 1	9·04
1—2	2·22
2—5	3·10
5—10	3·94
10—20	5·93
20—50	7·31
50—25	67·74
25—42	0·72
Total	100·00

It will be seen that even most of the particles (as determined by % by weight) below 1μ have been arrested by the tube.

COMPARISION WITH BUREAU OF MINES SUGAR TUBE TYPE B.

Technical data for Bureau of Mines Sugar Tube Type B and the Modified Sugar Tube under report are given in Table IV for comparison :—

TABLE IV

	Bureau of Mines	Modified
1. Diameter cm.	6·04	3·81
2. Height of sugar bed cm.	4·12	2·67 (total height with airspace 4·72)
3. Quantity of sugar gms.	100	50
4. Wetting liquid	35% (w/v) alcohol	
5. Rate of flow litres/min.	32	10
6. Resistance under above rate of flow (cm. water)	17·7	5·33
7. Filtering efficiency wt.%	75-95	99—100

REMARKS

It will be seen from Tables II and III that the filtering efficiency of the modified sugar tube is high and most of the particles below 1μ range, as judged by weight efficiency are also arrested. The high efficiency of the modified tube appears to be due to—

(*i*) Low rate of flow as compared with the sugar tube Type B,

(*ii*) Interposition of the metallic sieve partitions which combined with (*i*) above reduce the distortion of the sugar bed to a minimum. Possibility of partial contribution of these partitions to the filtering efficiency due to sudden lowering of velocity of the air stream as it emerges from the sugar bed cannot be ignored.

Further, the low resistance allows very simple field arrangements for suction. The quantity of sugar has been reduced by 50% compared to the Type B tube which makes filtration quicker and easier.

From Table II, it will be seen that the work has been carried out with heavily laden with dust. Though no experimental evidence is available, there is no reason to think, that this method will not work in an atmosphere of lower dust content. Only duration will have to be increased to obtain a weighable quantity of insoluble matter in the sugar bed.

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[1] FIELDNER, KATZ and LONGFELLOW, *U. S. Bureau of Mines, Tech., Paper No. 278*, (1921).

[2] TOLMAN, R.C., RYERSON, I. H., BROOKS, N. P. and SMITH, H. D., *J.A.C.S.*, **41**, 587 (1919).

[3] FIELDNER, OVERFALL, TEAGUE and LAWRENCE, *J. Ind. Eng. Chem.* **Vol. II**, 519 (1919).

[4] SUPPLIED by M/s. F. C. CASSELA, LONDON.

[5] *Bureau of Mines, U.S.A., Tech. Paper P 105*, p. 22—32 (1915).