TECHNICAL METHODS

A Protective Cabinet for Handling Infective Material in the Laboratory

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A number of recent papers have drawn attention to the risks of inhaling infected material during various ordinary laboratory manipulations (see, for example, Reitman and Wedum, 1956), and Reid (1957) has produced suggestive evidence from United Kingdom laboratories that, so far as tuberculosis is concerned, the risk of contracting disease in this way may be a real one. Tomlinson's (1957) demonstration of the production of infected clouds during the opening of screw-capped bottles, which are widely used for cultures of tubercle bacilli, indicates that not all the risks can be avoided even by the most careful bench technique.

Realization of the risks has led many laboratories to install cabinets, usually ventilated in some way, to protect the worker; there does not, however, appear to be much published experimental work on the effectiveness of various designs of cabinet. This paper reports some bacteriological tests on a cabinet designed for use in the Public Health Laboratory Service.

Design of Cabinet

It was considered that, for the purpose of the Public Health Laboratory Service, the best cabinet would be of semi-portable form and suitable for one worker. Preliminary tests showed that a cabinet ventilated by the heat of a gas burner in the exhaust chimney did not provide sufficient draught to retain air-borne material when the user moved his hands in the way that he might during working. On the basis of these and other tests it was decided to test fan ventilation at a rate giving about 100 ft. per min. linear flow through the inlet. This draught is just perceptible on the bare hand but is not disturbing. If the suction fan is to be reasonably small and quiet, a linear velocity of 100 ft. per min. cannot easily be attained with a cabinet opening of more than about 2 sq. ft.

The design of the cabinet finally adopted is shown in the figure; this is referred to in the Table as No. 3. It was constructed by A.R.E. Ltd., Stafford. It is made of sheet steel finished in stove enamel; its floor is 18 in. $\times$ 30 in. and the height to the roof is 21½ in., which is sufficient to accommodate an M.S.E. homogenizer. The air is sucked from the cabinet through two ports each about 2 in. $\times$ 3 in. in the back corners (A), and through two ports each about 4 in. $\times$ 6 in. in

the roof (B in inset section). The air from the four ports is collected in the space (C) above the roof from which a single central opening leads into the filter chamber (D). The filter is a Vokes "multivee" No. A40 and the effluent air is discharged through a suitable fan (i.e., one capable of delivering at least 200 cu. ft. per min. against 1 in. water gauge) to the outside. The filter not only greatly reduces the contamination of the air but also protects the user against a back draught should the fan fail. A strip light is fitted in the angle between the roof and the sloping glass front; the space here is sufficient to accommodate an 18 in. ultra-violet lamp as well, if required.

Most of the tests reported in this paper were carried out on one or other of two prototypes (Nos. 1 and 2); both were slightly smaller in overall dimensions and the first lacked the air exits in the back corners of the cabinet. An 18 in. low-pressure, ultra-violet lamp was fitted just below the roof in cabinets 1 and 2.

Methods of Testing

Two methods were used for dispersal of bacteria. For the first a heavy suspension of spores of *Bacillus subtilis* was prepared by growing the organism in nutrient broth for 24 hours and then transferring the growth to the same volume of 0.1% peptone with 0.05% sodium chloride for seven days at room temperature. The spores were spun down and thoroughly mixed with powdered talc. The resulting paste was dried in a desiccator and then ground to a fine powder. This was placed in a conical flask fitted with a rubber bung and two glass tubes. A puff of the dust was generated by the use of a rubber bulb on one of the tubes.

In the second method the rims of a number of 5 ml. screw-capped bottles were dipped into a heavy suspension of *Chromobacterium prodigiosum* and the caps were then screwed on. For a test, 25 bottles were placed in the cabinet and their caps were removed and replaced; this took one and a half to two minutes.

The experiments were carried out in a 320 cu. ft. chamber which could be ventilated at 20 air changes per hour to remove residual contamination at the end of an experiment. The air was sampled at the rate of 22.5 cu. ft. per min. with a large slit-sampler (Bourdillon, Lidwell, and Thomas, 1948) arranged with its inlet at bench level 12 in. outside the front of the cabinet.

Results

The table shows the number of colonies of the test organism collected on the plates exposed in the slit-sampler during and after dispersal. In the case of *B. subtilis* the counts are from a single two-min. sample; for *Chr. prodigiosum* they are the total of

FIG.—Sketch of protective cabinet (isometric projection). Inset top left corner, at reduced scale, longitudinal section showing position of exit ports (B) in roof. A=One of corner exit ports. C=Collecting space for air from all 4 ports. D=Filter chamber.

three successive two-min. samples. Two-min. control samples were collected before dispersal in all experiments. With all the tests of cabinets 1 and 2 the control counts were of the order of one to three colonies and have been ignored. In the tests with cabinet 3, which were carried out at a different time, they were in the region of 10 to 20. For these tests,

the control counts have been subtracted from the "test" counts; when the control counts exceeded the test count the latter was entered as zero.

A few tests were done to compare dispersal on the open bench with dispersal in an unventilated cabinet; these did not suggest that the unventilated cabinet offers any appreciable degree of protection. Ultra-

TABLE
RESULTS OF BACTERIOLOGICAL TESTS OF PROTECTIVE CABINET

Cabinet No.	Test Organism		Dispersal					
			Outside Cabinet	In Cabinet with				
				No Ventilation No Ultra-violet	No Ventilation Ultra-violet On	Ventilation at 50-60 ft./min. No Ultra-violet	Ventilation at 100 ft./min. No Ultra-violet	Ventilation at 100 ft. min. Ultra-violet On
1	<i>B. subtilis</i> , dust 3 puffs	Mean and no. tests As % of "no ventilation "	—	2,900 (2)	459 (2)	36 (1)	8.4 (10)	11.5 (4)
2	<i>B. subtilis</i> , dust 2 puffs	Mean and no. tests As % of "outside cabinet "	1,350 (2)	440 (3)	89 (2)	—	9.7 (15)	—
		As % of "no ventilation "		32.6	6.6		0.7	
		" " " " "no ventilation "			20.2		2.2	
3	<i>B. subtilis</i> , dust 2 puffs	Mean and no. tests As % of "no ventilation "	—	5,100 (3)	—	27.6 (5)	3.5 (6)	—
						0.5	0.07	
3	<i>B. subtilis</i> , dust 1 puff	Mean and no. tests As % of "no ventilation "	—	764 (1)	—	5.5 (2)	9.7 (3)	—
						0.7	1.3	
2	<i>Chr. prodigiosus</i> , opening 25 bottles	Mean and no. tests As % of "outside cabinet "	29.5 (2)	31.5 (4)	2.5 (4)	1.5 (2)	0.7 (10)	—
		As % of "no ventilation "		107	8.5	5.1	2.4	
		" " " " "no ventilation "			7.9	4.8	2.2	
Mean of values of " % of outside cabinet "				(69.8)	7.6	(5.1)	1.6	(0.4)
" " " " " % of no ventilation "				—	14.6	1.8	1.2	—

violet irradiation of the interior of the cabinet had a definite effect in reducing the number of colonies both of *B. subtilis* and *Chr. prodigiosus* liberated, but the effect was less than that obtained with ventilation. Of the two ventilation rates, that giving a linear velocity through the mouth of the cabinet of about 100 ft. per min. seemed slightly better than that giving 50 to 60 ft. per min., and it was generally possible to reduce the count on the plates to 2% or less of the number obtained with dispersal in an unventilated cabinet.

In about half the experiments a hand was waved to and fro in the cabinet for 15 to 20 sec. after dispersal of the bacteria. With cabinet 1 this seemed to have a definite effect in increasing the number of colonies on the plates, but no such effect could be discovered with cabinets 2 and 3; it was not possible to discover the reason for this difference, which did not seem to be due to the presence of the air outlets at the back of the cabinet in the latter two types of cabinet.

Discussion

It may be concluded from these experiments that a cabinet ventilated so as to give an air velocity through the entry of 100 ft. per min. can provide substantial protection against the risk of inhaling particles dispersed in the cabinet. At an air velocity of 50 to 60 ft. per min. the protection may be slightly less, and it seems best therefore to specify 100 ft. per min., which will provide a reasonable margin of safety.

It may be that the protection is actually better than indicated. The number of colonies on the plates after dispersal in the ventilated cabinets was usually less than 10, and it was not possible to be certain that these were not, in part at least, dispersed from the experimenter's clothing.

Ultra-violet irradiation without ventilation evidently gives some protection. For most purposes, however, irradiation probably would be less satisfactory than ventilation, partly because of its lower efficiency and partly because without good ventilation of the cabinet it is not practicable to use a bunsen burner inside it.

The cabinet described here has now been in use as a number of public health laboratories for several months and has proved reasonably convenient.

Summary

Clouds of *B. subtilis* and *Chr. prodigiosus* were dispersed in a bench cabinet designed for handling infective cultures. When the air velocity through the inlet was 100 ft. per min. the number of test bacteria collected from the air in front of the cabinet was less than 2% of the number collected when the cabinet was not ventilated. Ultra-violet irradiation of the interior of the cabinet was rather less effective than ventilation.

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Those planning to attend the 7th International Cancer Congress, which will take place at the Royal Festival Hall, London, from July 6 to 12, 1958, are reminded that enrolment forms must be received at the Congress Office, (45 Lincoln's Inn Fields, London, W.C.2) by January 1, 1958, if a late fee is not to be incurred. Registration forms may be obtained from the Secretary-General at that address.