at 10 minute and 24 minute intervals after introduction of the virus as shown in Table 2. The first group of mice was simply placed in the room and allowed to remain there for 20 minutes. At the 24-minute period a desiccator jar containing a second group of mice was filled with air from the room and then sealed for 20 minutes. At the end of 30 minutes triethylene glycol was introduced. A period of ten minutes was then allowed for thorough mixing of virus and vapor following which normal mice were introduced in the room. It was found that as small a concentration of triethylene glycol as 1 gram in 200 million cc of air protected mice completely against an amount of airborne virus which a short time before had caused death of all the exposed (control) mice. Control tests on the persistence of influenza virus in the air showed that for 40 to 60 minutes after its introduction sufficient virus remains in the air to kill over 90 per cent. of the mice so exposed.

The above experiments on pathogenic bacteria and influenza virus were repeated many times with essentially identical results. While different pathogens as well as certain non-pathogens exhibited slight differences in sensitivity to triethylene glycol vapor, marked bactericidal action was obtained with dilutions of 1 gram of glycol in 100 million to 200 million cc of air. Tests on the oral toxicity of triethylene glycol for monkeys and rats and exposure for prolonged periods of time to vapors of this compound are being carried out.

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PREVENTING THE BACTERIAL OXIDATION OF RUBBER[1,2]

THE recent article by ZoBell and Grant[3] notes the attack of rubber by bacteria under conditions of high moisture. It is suggested that "the life of rubber products which come in contact with moisture may be prolonged if ways can be found to retard or prevent the activity of rubber oxidizing microorganisms."

In the compounding of rubber commercially, native rubber is mixed with a number of chemicals, each of which serves a specific purpose in the properties of the finished product. Among these are the accelerators[4] which lower the temperature and shorten the time for vulcanization and lengthen the life of rubber.

Two well-known accelerators are mercaptobenzothiazole and tetramethylthiuram disulfide. These compounds[5] have been tested for their ability to inhibit germination of fungi, and gross observations have been made on their ability to inhibit bacterial growth. Mercaptobenzothiazole, known to the rubber industry as Captax, is a moderately good fungicide, and tetramethylthiuram disulfide, known as Tuads, is excellent. The latter compound is now being marketed under still another trade name as a seed protectant and for the prevention of turf diseases. Both of these materials have been tested under the field conditions prevailing in Connecticut by the authors for their efficacy in controlling plant diseases. Mercaptobenzothiazole, while inferior to tetramethylthiuram disulfide, has given partial plant disease control.

These materials, when employed in the compounding of rubber, are intimately mixed with zinc oxide, which is itself a useful fungicide and seed protectant. From a knowledge of the formulae of these accelerators, it occurred to the authors that zinc oxide might react with mercaptobenzothiazole and with tetramethylthiuram disulfide and that the reaction products might differ in their anti-microbial potency.

Spore germination tests were set up, using the method of Horsfall, *et al.*[6] Glass slides were sprayed with aqueous suspensions of mercaptobenzothiazole and tetramethylthiuram disulfide, with and without zinc oxide, and with suspensions of zinc oxide alone. Each type of suspension was sprayed in a dosage series. The glass slides were allowed to dry, after which drops of a suspension of spores of the fungus, *Macrosporium sarcinaeforme,* were placed on the

TABLE 1

EFFECT OF ADDING ZINC OXIDE TO MERCAPTOBENZOTHIAZOLE ON THEIR ABILITY TO INHIBIT THE GERMINATION OF FUNGOUS SPORES

Dosage of toxicant (γ per sq. cm)		Percentage inhibition
Mercaptobenzothiazole		
864		100
432		96
216		4
108		1
Mercaptobenzothiazole + zinc oxide		
520	345	4
260	173	2
130	86	0
65	43	0
Zinc-oxide		
864		100
432		100
216		98
108		94

[1] Contributions from the Department of Botany, University of Nebraska, N. S. No. 138, and published with the approval of the director of the Connecticut Agricultural Experiment Station.

[2] Part of the data reported were obtained in the Department of Plant Pathology and Botany of the Connecticut Agricultural Experiment Station. The remainder were obtained at the University of Nebraska.

[3] Claude E. ZoBell and Carroll W. Grant, SCIENCE, 96: 379, 1942.

[4] Paul I. Murrill, *Chem. and Eng. News*, 20: 1361, 1942.

[5] We are indebted to Mr. F. E. Hutchins of R. T. Vanderbilt Company, 230 Park Ave., New York City, for supplying us with these compounds as well as the specially purified grade of zinc oxide used in the rubber industry.

[6] James G. Horsfall, J. W. Heuberger, E. G. Sharvelle and J. M. Hamilton, *Phytopath.*, 30: 545, 1940.

dried residues of sprayed material. The slides were incubated for 18 to 20 hours and then counts were made of the percentage inhibition of spore germination.

TABLE 2

EFFECT OF ADDING ZINC OXIDE TO TETRAMETHYLTHIURAM DISULFIDE ON THEIR ABILITY TO INHIBIT THE GERMINATION OF FUNGOUS SPORES

Dosage of toxicant (γ per sq. cm)		Percentage inhibition
Tetramethylthiuram disulfide*		
34.3		53
24.4		54
17.1		75
12.3		74
8.5		23
6.1		10
Tetramethylthiuram disulfide + zinc oxide		
8.6	69	99
6.1	49	50
4.3	34	24
3.1	25	15
2.2	17	6
Zinc oxide		
137		100
98		99
68		67
49		32

* The dosage-inhibition relation shown for tetramethylthiuram disulfide is characteristic. See Albert E. Dimond, James G. Horsfall, J. W. Heuberger and E. M. Stoddard, *Conn. Agr. Exp. Sta. Bul.* 451, pp. 649–652, 1941.

These tests indicate that in compounding with zinc oxide, mercaptobenzothiazole becomes inactivated as a fungicide, whereas tetramethylthiuram disulfide does not. Since the presence of zinc oxide is absolutely essential to the successful compounding of rubber, it is evident that when mercaptobenzothiazole is used as an accelerator in rubber, it will be rendered wholly innocuous as an inhibitor of microorganisms, and that the resulting rubber will be susceptible to attack by microorganisms under the conditions noted by ZoBell and Grant.

On the other hand, it is evident that tetramethylthiuram disulfide retains a large part of its activity against microorganisms in the presence of zinc oxide.

That mercaptobenzothiazole, tetramethylthiuram disulfide and zinc oxide as such remain in vulcanized rubber is implied by the fact that their presence in rubber can be estimated quantitatively.[7] We may therefore conclude that accelerators incorporated into rubber in vulcanization at least partly remain in the manufactured product. Any anti-microbial properties possessed by an accelerator would be a decided factor in preventing bacterial oxidation of rubber.

In view of these results, it is clear that, when rubber is to be used under conditions where it is likely to be in contact with water over long periods or even intermittently (as in the tropics), tetramethylthiuram disulfide be used as an accelerator in preference to mercaptobenzothiazole, provided that other desirable properties of the resulting rubber are not sacrificed by this procedure.

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[7] K. Shimada, Jour. Soc. Rubber Ind. Japan, 10: 431, 533, 1937; *ibid.*, 11: 1, 1938. E. Slipushkina, Caoutchouc and Rubber (USSR) 1937: 48, 51, 1937.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLE METHOD FOR CONVERTING A LINE-RECORD INTO A SHADOWGRAM[1]

LINE-RECORDS are easy to obtain and entirely satisfactory for visual inspection, but they are difficult to deal with photoelectrically. Where it is desired to change the record into electrical energy, a shadowgram, *i.e.*, a record in which the signal appears as a black and white profile, has obvious advantages.

In electroencephalography, for various practical reasons,[2] records are made in ink on a moving paper tape. Such records can not be analyzed with the Grass frequency analyzer,[3] for it requires that the electroencephalogram be projected electrically through a continuously varying filter. A way out of this difficulty was discovered, and because the essential problem involved is more or less general, it was believed that the solution might interest workers in other fields.

A line-record can be converted into a shadowgram by the following procedure: A high contrast negative is made of the record and this negative is placed in an enlarger, preparatory to printing on film of the type used for sound recording. While the film is exposed, it is not held in a fixed position but moved at right angles to the axis of the line-record, and the movement continued until the image of the line no longer falls on the film. One of the many ways in which this can be accomplished is to place the film in a holder mounted on the carriage of a typewriter. The carriage can be set in motion by pressing the tabulation key and the motion can be slowed by keeping the carriage in contact with the plunger of an oil-filled hypodermic syringe, which is clamped to the body of the typewriter.

[1] From the Department of Neurology, Harvard Medical School, and the Neurological Unit, Boston City Hospital, Boston, Mass.

[2] F. A. Gibbs and E. L. Gibbs, "Atlas of Electroencephalography." Lew A. Cummings Co., Cambridge, Mass., 1941, pp. 221.

[3] A. M. Grass and F. A. Gibbs, *Jour. Neurophysiol.*, 1: 521–526, November, 1938.