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Navy Department - Office of Research and Inventions

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NAVAL RESEARCH LABORATORY  
Washington, D. C.

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CHEMISTRY DIVISION - PROTECTIVE COATINGS SECTION

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6 November 1945

VOLATILE COMPOUNDS AS FUNGICIDES  
FOR ELECTRONIC EQUIPMENT  
PART I

by

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- Report P-2653 -

FR-2653

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Preliminary Pages . . . .	a-d
Numbered Pages . . . . .	12
Plates . . . . .	6
Distribution List . . . .	e

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TABLE OF CONTENTS

	<u>Page No.</u>
ABSTRACT	
INTRODUCTION	
A. Authorization . . . . .	1
B. References . . . . .	1
C. Background . . . . .	1
(1) General . . . . .	1
(2) Specific . . . . .	3
EXPERIMENTAL	
A. Method . . . . .	4
B. Fungicides . . . . .	6
C. Observations . . . . .	6
DISCUSSION . . . . .	6
SUMMARY AND CONCLUSIONS . . . . .	7
RECOMMENDATIONS . . . . .	7
ACKNOWLEDGMENT . . . . .	8
Table I . . . . .	9&10
Table II . . . . .	11&12
APPENDIX A	

#### ABSTRACT

In a continuing study, fifty-four chemical agents have been evaluated as volatile fungicides by techniques designed to examine fungicidity, corrosiveness, volatility, and their effects on insulation resistance and other properties of plastics. Though a number of compounds show excellent toxicity, they have other shortcomings that preclude their application to electronic equipment. A survey of fungicidal treatments for electronic equipment is included.

## INTRODUCTION

### A. Authorization

1. The study of tropical deterioration of electronic equipment is authorized under Bureau of Ships Project Order No. 212/45.

### B. References

2. (a) NRL Report No. P-2475 dated 20 February 1945.
- (b) JEIA Report No. 10560 dated July 1945.
- (c) CCRD (British) Report on Tropic Proofing dated February 1945.
- (d) NRL Report No. P-2518 dated 15 May 1945.
- (e) NRL Report No. P-2611 dated 1 August 1945.
- (f) NRL Report No. P-2626 dated 23 August 1945.
- (g) NRL Report No. P-2628 dated 28 August 1945.
- (h) OSRD Report No. 4118.
- (i) OSRD Report No. 3803.
- (j) British Report No. R-537, OSRD Ref. No. 3627-2B.
- (k) Eastern Regional Research Laboratory Report, File No. G-223.
- (l) Div. of Forrest Pathology, U.S.D.A., Office Report by T. C. Scheffer and C. G. Duncan dated 5 June 1945.

### C. Background

#### (1) General

3. The extremely rapid, deleterious, and demoralizing attacks of fungi upon all types of equipment in tropical areas received considerable publicity at the beginning of the war. Governmental and private agencies have continued to prosecute research on tropicalization and will continue to do so as long as there appears to be a need for it. At this point confusion arises. Has tropical deterioration been overcome to the extent that research is no longer urgently needed? Those who answer this question in the affirmative have been misled by many enthusiastic research papers and by the sophistic advertising of manufacturers. This Laboratory holds the opinion that tropical deterioration is still a problem of major importance, a problem largely unsolved and underrated. The feeling of confidence and accomplishment which we meet commercially is dangerous and at variance with the conditions actually existing. The introduction to this report purposes to reassert the seriousness of tropical deterioration of electronic equipment.

4. Fungus growth will occur at temperatures 0° to 45° C., with an optimum at 25° to 35° C., the latter temperatures being found in jungles. The requisite humidity is 70% RH and above, rate of growth increasing with RH. Liquid water is usually necessary in small amounts, and a number of inorganic trace-elements. Presence of nutrient material is obviously necessary in at least small amounts. The ease with which these conditions are met is the chief reason for the ubiquity of the fungi. There seem to be many factors, some apparently unknown, which contribute to luxuriance

of growth. Elements of the situation are the presence of mites, insects, growing plants, growth-promoting substances, diffuse sunlight, soil, and an enormous number of spores, as well as cycling of temperature and humidity. Fungus spores are everywhere, and being usually 1 to 10 microns in greatest dimension, are easily airborne.

5. Molds grew abundantly on the electrical equipment used in the early stages of the war. Any type of cellulosic material is easily attacked and destroyed, including cotton cloth, cotton-braided wire, plain and treated paper, cellulose plastics, and wood. Aside from these materials which may actually be destroyed by fungi, almost any organic substance will support slight growth upon its surface. Some of these materials which support fungi are: vinylite, rubber, vaseline, baked varnish, bakelite, and rosin. Fungus will grow anywhere, even on glass. It is not necessary for the surface itself to provide nutriment for the fungi, as there is always present in the air enough organic dust to settle on the surface and provide food. In addition it is not feasible to construct electronic equipment commercially without getting it seriously contaminated by oil, dirt, and salts from the hands of the workers. Only materials containing inhibiting substances will not permit fungus growth. The use of inert materials in radio construction is important, but it has been unduly emphasized as the complete solution.

6. It has been pointed out that molds actually destroy items constructed of cellulose and its derivatives, while most other substances are not completely destroyed. However, growth upon these latter materials is attended by serious effects upon the electrical circuits. One of the most serious conditions arises from the fact that fungal hyphae in the moist, living state will conduct electricity, and their presence may thus be very deleterious by shorting radio-frequency signals, shorting high-voltage circuits and altering the impedance of any of the circuits. As a result, the sets may be permanently damaged, lose their alignment, and as in radar gear, lose such important characteristics as timing and sensitivity. Further to aggravate the situation, fungi certainly have a marked "blanketing" effect in maintaining a wet surface. In addition to providing leakage-paths, fungi may damage electrical equipment by increasing contact resistances. This occurs mainly in connection with contacts of dissimilar metals. It is also possible that capacitance effects may be introduced in portions of the circuits by the presence of fungi encircling leads.

7. The corrosion of metals is a major source of difficulty in tropical climates. Fungi can accelerate this in three ways: first, by secreting organic acids, such as acetic acid; second, by producing compounds like glycine and citric acid which can coordinate with heavy metals; third, by possessing enzyme systems which may accelerate oxidation. Water, by leaching soluble products out of the molds, enhances the effect; instances have been observed (reference (b)) where stranded copper leads have been severed by fungal corrosion in four months.

8. The research, designing, and building which are necessary to produce a piece of modern electronic equipment are expensive and time-consuming. Newly constructed gear is designed to operate perfectly under ideal conditions, but is unpredictable under the severe operating and storage conditions of the jungles. The truism that equipment worth building is worth protecting has led to considerable research, private and governmental. A general discussion will be given of the treatments recommended and their efficacy.

9. It was originally conceived that by properly designing radio gear the tropicalization problems could be eliminated. Broadly speaking there are two ways of achieving this. The first consists in selecting materials resistant to fungi and moisture. The drawbacks to this contention are listed in paragraph 5. The second suggested remedy is designing hermetically sealed cabinets for radios and placing a desiccant in the cabinets to ensure a low humidity. The advantage of hermetic sealing is that, provided it is not broken, it affords a complete answer to both fungus and moisture damage. Its disadvantages are (reference (b)) that (1) it usually adds considerably to the weight of the equipment; (2) it imposes the necessity of resealing wherever the set has been serviced; and (3) it is very difficult to achieve in a permanent fashion.

10. Measures originally intended as stop-gaps, but now considered as fundamental weapons, are those directed at killing or inhibiting fungi by means of toxic agents. Two practicable steps instituted are either spraying with a toxic coating material or exposing the interior of the set to a fungicidal vapor. The former method has received much attention and standard practice currently recommends the use of a moisture-resistant lacquer or varnish containing 1% phenylmercuric salicylate, 10% pentachlorophenol, or 10% salicylanilide. This Laboratory has shown (references (d) and (e)) that these coatings have not sufficient toxicity to merit their acceptance for the protection of electronic equipment from fungal attack. Further work by this Laboratory is reported in references (f) and (g); they conclude that it is much more difficult than is ordinarily conceded to confer persistent toxicity upon a coating material. Of the many chemical entities investigated a number showed up well in preliminary runs. These substances are being further evaluated.

#### (2) Specific

11. The second method of protection involves a fungicide which is toxic in the vaporous state. The problem has been under scrutiny by a number of laboratories. Several are indicated in references (h), (i), (j), (k), and (l). According to reference (b) it was reported "the method has the advantages that it is effective equally on all components, that it does not affect the equipment electrically, and that the effects of extreme conditions on the substance used, provided they do not induce chemical change, are unimportant". These statements need to be qualified.

If there is any "breathing" of the set at all, the concentration of vapor may not be sufficient in all parts of the set to be effective unless the fungicide is very volatile, very toxic, or placed at close intervals in the cabinet. The volatile agent may easily affect the electrical characteristics by condensing on cool components and lowering surface resistance or inducing corrosion. Changes of weather can affect the fungicide: decreases in temperature can lower the vapor pressure of the fungicide below its toxic threshold; hot weather or high operating temperatures can distill all the fungicide out of the set in a short time.

12. Thus, the characteristics which a good volatile fungicide must possess are:

- (a) It must be non-volatile enough to have a practicable service life, even at the operating temperatures of the equipment.
- (b) It must be toxic enough to prevent mold growth at the vapor concentration obtained with low temperatures.
- (c) It must not induce corrosion of metallic surfaces.
- (d) It must not dissolve or react with rubber or commonly used plastics.
- (e) It must not, in the vapor state or by condensation, markedly reduce the surface resistance of insulating materials.
- (f) It must not sublime upon the equipment and form possible short-circuits or mechanical hazard.
- (g) It must be non-toxic to the persons handling the apparatus and must not have an unbearable odor.
- (h) It must be available or potentially available in significant quantity.

13. Previous reports (references (a) and (b)) have indicated that the following substances have considerable fungicidity as volatile agents: biphenyl, camphor, thymol, chlorothymol, and trichlorophenol. It is interesting to compare these findings with the results contained in this report.

14. A volatile fungicide that is solid at the operating temperature of a radio could be easily applied to the set by enclosing pellets in tiny canisters attached to the chassis. Liquid or low-melting fungicides present a much more difficult problem, but in certain instances they have been applied by absorption in a porous block of charcoal or ethocel. Solution in a plastic gel is another feasible procedure. If the substance is entirely innocuous electrically, it could be sprayed upon the set like an insecticide spray. There is little doubt, however, that a satisfactory method of applying a good fungicide can be found.

#### EXPERIMENTAL

##### A. Method

15. The technique used at this Laboratory for the preliminary evaluation of volatile fungicides is rather simple and rapid, the essential point

being to provide a good growing medium for fungi in the presence of the toxic vapors. This was accomplished by placing cylindrical 0.25 ml. cups (1 cm. ID) in the center of 100 mm. Petri dishes, and pouring 15 ml. melted agar into the dishes and around the cups. Solid fungicides were placed in the cups before placing them in the Petri dishes, but liquid fungicides were added by pipette after the agar had cooled, and after inoculation.

16. The agar used was a modified Czapek's medium of the following composition:

Magnesium sulfate	0.5	grams
Ammonium nitrate	1.4	"
Potassium chloride	0.5	"
Potassium monohydrogen phosphate	1.0	"
Ferrous sulfate	0.01	"
Malt	20	"
Glucose	20	"
Agar	20	"
Tap water, to make	1000	ml.

The pH of the medium was adjusted to  $4.0 \pm 0.1$ , using a glass electrode.

17. Inoculation of the dishes was made with 1 ml. of a spore suspension consisting of:

Aspergillus niger	$10^5$	spores/ml.
Penicillium luteum	$10^5$	" "
Rhizopus nigricans	$10^4$	" "
Monilia geophila	$10^4$	" "

This spore suspension, as discussed in reference (d), had been found to give optimum growth of the four organisms on 0.1% glucose. With the medium used in the work reported here, the Aspergillus inoculum seems too heavy, and further work will be done on a new ratio of organisms for this agar.

18. After inoculation the dishes were incubated at 30° C.

19. The compounds which exhibited considerable fungistatic activity were further examined for their effects upon equipment as regards corrosion, insulation resistance, and reaction with insulating materials. This was accomplished with 6" desiccators, heated by 15-watt bulbs under the plates, and with fungicides, small panels of cleaned bare metal, and Jones terminal blocks, all above the plates. The apparatus is shown on photographic plate 5-A. It was thus possible to make observations on corrosiveness and effects on insulation resistance and plastics in the presence and absence of water. The plastics observed were the rubber stopper and the vinylite covered leads to the terminal blocks. The temperature was 35-40° C.

## B. Fungicides

20. Selection of chemicals for evaluation as volatile fungicides was purposely random, for the work is of an exploratory nature. There were, of course, the guiding principles outlined in paragraph 12 to aid the choice, and in general substances boiling below about 130° C., were rejected as too volatile to be persistent. Solids were included only when there was reason to suspect them of having considerable vapor pressure at room temperature.

## C. Observations

21. Data from the Petri dish evaluations are given in Table I; the observations, made at 40 and 120 hours represent the majority reading of three dishes. The numbers in the table refer to an arbitrary scale of extent of growth, given as a footnote of Table I. The four photographs of Plate 1 illustrate the method of rating. Table II, giving the data on corrosion and effects on plastics, is supplemented by Plate 6. Table III presents the data obtained from the electrical examinations.

## DISCUSSION

22. Of the fifty-four chemical substances examined, eight exhibited considerable fungistatic activity, while the rest were almost totally inactive. Among the 46 compounds which this laboratory found to be inactive, camphor, 8-hydroxyquinoline, isobornyl thiocyanacetate, and biphenyl (Plates 3 and 4) have previously been suggested by other organizations as volatile fungicides.

23. Butyl thiocyanate (Plate 1) was fungicidal and indicates that aliphatic thiocyanates of intermediate molecular weights should be investigated, since butyl thiocyanate was too volatile and lauryl thiocyanate (Plate 1) was of too low volatility. Benzyl thiocyanate (Plate 1) was sufficiently persistent, but it lacked sufficient toxicity at the concentration achieved. The aromatic thiocyanates and the thiocyanacetates were obviously not sufficiently volatile to reach their threshold of toxicity. If butyl thiocyanate is representative, the thiocyanates are too corrosive and soluble in plastics to be useful in electronic equipment.

24. Nitrobenzene (Plate 3) exhibited fair fungidity, and showed up well in its other properties. There is not enough data to predict the future of nitro compounds as volatile fungicides.

25. 2,4,5-Trichlorophenol (Plate 2) gave excellent results as a fungicide in repeated tests, and has the further recommendations that it was non-corrosive, allowed fair insulation resistance, was inert to plastics, and is solid. One very strong disadvantage is the tendency of trichlorophenol to sublime and to condense in long, bridging crystals at the coolest parts of the container. (Plate 5-B) For this reason it is not considered suitable for use in electronic equipment, since the needle-like crystals would form leakage paths. Phenol (Plate 1) itself showed some

activity as a fungicide, but it was hygroscopic. None of the other phenols exhibited a worthwhile degree of fungicidity.

26. Salicylaldehyde (Plate 2) was a powerful fungicide in the vapor state and was not particularly deleterious to insulation resistance. Its great corrosiveness upon metals and solvent action upon plastics, however, preclude its use in electronic equipment. It is surprising to note that cinnamaldehyde and anisaldehyde displayed no activity.

27. Cyclohexylamine (Plate 2) was very fungicidal, did not lower insulation-resistance and was corrosive only to brass. It is, however, too volatile for practical use. Future investigation of less volatile aliphatic amines appears promising. Gamma-picoline (Plate 2) was a good fungicide also, but was very poor as regards insulation resistance, corrosion, action on plastics, and volatility. It should be noted that the volatile amines usually have offensive odors.

28. Orientated by this preliminary study, a large program for the examination of volatile chemicals as fungicides is being prosecuted, with the hope that a substance can be found to satisfy the requisites previously listed. There are many possibilities in this field and there is every reason to believe that such a substance can be uncovered.

#### SUMMARY AND CONCLUSIONS

29. Fifty-four different organic compounds were examined for their toxicity in the vapor state to fungi. The volatile compounds were also examined for their persistence, effect on insulation resistance, corrosiveness, and effect on plastics. Eight compounds were found to be quite fungicidal: trichlorophenol, phenol, butyl thiocyanate, benzyl thiocyanate, salicylaldehyde, cyclohexylamine, gamma-picoline, and nitrobenzene. Each of the substances, however, exhibited one or more serious drawbacks in the other examinations.

30. On the basis of the experimental findings attained to date, the following conclusions are drawn.

a. None of the volatile agents examined possesses the requisites of a volatile fungicide applicable to electronic equipment.

b. The work indicates that amines, thiocyanates, phenols, aldehydes, and nitro compounds are worthy of further investigation.

c. Current recommendations for the use of camphor, isobornyl thiocyanacetate, 8-hydroxyquinoline, and biphenyl as volatile fungicides cannot be supported by the findings of this Laboratory.

#### RECOMMENDATIONS

31. In the light of the foregoing the following recommendations are made:

a. That efforts to discover persistent, effective, non-deleterious volatile fungicides continue.

b. That the requisite properties which have been listed for a volatile fungicide be carefully considered before using any substance in that capacity.

c. That facilities for the controlled simulation of tropical conditions be established at the Laboratory.

#### ACKNOWLEDGMENT

32. The assistance of Lt.(jg) Dorothy Molnar as analyst is gratefully acknowledged by the authors.

TABLE I

## FUNGISTATIC ACTIVITY OF CHEMICAL VAPORS

N. R. L. Number	Chemical Name	Extent of Growth		Remarks
		40 hours	120 hours	
2-4	2,2'-Dichlorodiethyl ether	3		
6-1	Ethyl acetate	3		evaporated
6-2	Amyl acetate	3		evaporated
7-1	Carbon disulfide	3		evaporated
7-3	Butyl thiocyanate	0	0	evaporated
7-4	Lauryl thiocyanate	3		
20-1	Decalin	3		
20-2	Pinene	3		evaporated
21-1	Nitrobenzene	1	1	
21-11	Biphenyl	3		
21-12	Naphthalene	3		
21-13	Acenaphthene	3		
21-15	Dimethylnaphthalenes	3		
21-18	p-Terphenyl	3		
21-19	Tetralin	2	3	evaporated
21-20	Benzene	3		evaporated
22-1	Isobornyl thiocynoacetate	3		
22-2	Cyclohexyl thiocynoacetate	3		
22-4	Menthol	3		
22-5	Terpin hydrate	3		
23-1	2,4,5-Trichlorophenol	0	0	
23-5	Phenol	1	1	hygroscopic
23-6	p-t-Butylphenol	3		
23-7	p-Chlorothymol	3		
23-9	o-Cyclohexylphenol	3		
23-11	4-Chloro-6-phenylphenol	3		
23-12	o-Hydroxybiphenyl	3		
23-13	2-Chloro-6-phenylphenol	3		
23-14	beta-Naphthol	3		
23-15	alpha-Naphthol	3		
23-22	2,4-Dinitrophenol	3		
23-24	p-Chlorophenoxyacetic acid	3		
23-28	Benzyl thiocyanate	1	2	
23-29	o-Xenyl thiocyanate	3		
25-1	Hexachlorophenol	2	3	
25-7	Camphor	3		
25-8	Fenchone	3		
26-6	Cinnamaldehyde	3		
26-7	alpha-n-Amylcinnamaldehyde	3		
28-1	Salicylaldehyde	0	0	turned pink
28-3	Anisaldehyde	3		
29-1	Phenylacetic acid	3		
34-7	Cyclohexylamine	0	0	evaporated

TABLE I (continued)

<u>N.R.L.</u> <u>Number</u>	<u>Chemical Name</u>	<u>Extent of Growth</u>		<u>Remarks</u>
		<u>40 hours</u>	<u>120 hours</u>	
35-1	p-Aminophenyl thiocyanate	3		
35-2	p-Benzylaminophenol	3		
51-1	Phenothioxine	3		
51-3	Paraldehyde	3		evaporated
52-4	8-Hydroxyquinoline	3		
52-6	2-Hexylpyridine	3		
52-9	gamma-Picoline	0	0	evaporated
53-1	Hexamethylenetetramine	3		
54-8	Morpholine	3		evaporated
61-9	Sodium sulfide	3		hygroscopic
61-10	Sulfur	3		

0 = no growth

1 = narrow annular growth

2 = wide annular growth

3 = complete overgrowth

TABLE II

## EFFECT OF ACTIVE FUNGICIDES ON METALS AND PLASTICS

NRL No.	Chemical Name	Condi- tions	Extent of Deleterious Effect Upon:					
			Aluminum	Copper	Iron	Brass	Rubber	Polyvinyl Chloride
7-3	Butyl thiocyanate	wet	0	+	+++	+++	++++	++++
		dry	0	++++	+	+	++	+++
21-1	Nitrobenzene	wet	+	+	++	+	+	++
		dry	0	+	0	+	+	++
23-1	Trichlorophenol	wet	0	+	+	++	0	0
		dry	0	+	+	0	0	0
28-1	Salicylaldehyde	wet	++	++++	++++	++++	+	++++
		dry	0	++++	++++	++++	+	+++
34-7	Cyclohexylamine	wet	+	++	0	+++	+	+
		dry	0	0	0	+++	+	++
52-9	gamma- Picoline	wet	+	+++	+	+++	+	+
		dry	0	++	0	+++	++	++++
0 - no effect		+ - slight effect		+++ - extreme effect				

TABLE III

EFFECT OF ACTIVE FUNGICIDES ON INSULATION RESISTANCE OF MOLDED BAKELITE

NRL No.	Condi- tions	Initial	Insulation Resistance in Megohms ( $\times 10^{-2}$ )								
			1	2	3	4	7	8	9	10 days	
7-3	wet	28	40	60	2.0	1.5	1.5				
	dry	85	30	200	34	100	50				
21-1	wet	1000	4.0	4.4	2.0	1.9	0.12	0.3	0.18	0.2	
	dry	10000	230	180	160	160	300	300	300	300	
23-1	wet	80	70	55	5.4	4.2	6.0				
	dry	100	100	65	40	36	50				
28-1	wet	1000	5.3	4.0	2.3	2.3	2.0	1.6	2.0	1.7	
	dry	500	37	45	40	50	100	200	120	120	
34-7	wet	38	34	38	2.6	1.5	2.2				
	dry	300	2000	10000	60	100	300				
52-9	wet	1000	1.7	0.14	0.25	0.07	6.0	0.01	0.001	0.003	
	dry	500	44	20	24	24	0.08	0.05	0.06	0.1	

## APPENDIX A

Data on the Volatile Chemicals Examined

<u>N. R. L. Number</u>	<u>Name</u>	<u>MP °C.</u>	<u>BP °C.</u>	<u>Source</u>
2-4	2,2'-Dichlorodiethyl ether		179	Eastman Kodak Co.
6-1	Ethyl acetate		77	J.T.Baker Co.
6-2	Amyl acetate		149	J.T.Baker Co.
7-1	Carbon Disulfide		46	J.T.Baker Co.
7-3	Butyl thiocyanate		184	NRL synthesis
7-4	Lauryl thiocyanate		(a)	NRL synthesis
20-1	Decalin		192	Eastman Kodak Co.
20-2	Pinene		160	Eastman Kodak Co.
21-1	Nitrobenzene	5	211	J.T.Baker Co.
21-11	Biphenyl	69	255	Eastman Kodak Co.
21-12	Naphthalene	80	218	Eastman Kodak Co.
21-13	Acenaphthene	95	278	Eastman Kodak Co.
21-15	Dimethylnaphthalenes		260	Reilly Tar & Chem.Co.
21-18	p-Terphenyl	212	405	Eastman Kodak Co.
21-19	Tetralin		206	Eastman Kodak Co.
21-20	Benzene		80	J.T.Baker Co.
22-1	Isobornyl thiocynoacetate		--	Hercules Powder Co.
22-2	Cyclohexyl thiocynoacetate		(b)	NRL synthesis
22-4	Menthol	34	212	Fallek Products Co.
22-5	Terpin Hydrate	117		Eastman Kodak Co.
23-1	2,4,5-Trichlorophenol	62	252	Dow Chemical Co.
25-5	Phenol	42	181	G.A.Erkenbrach Co.
23-6	p-t-Butylphenol	99	237	Eastman Kodak Co.
23-7	p-Chlorothymol	58		Eastman Kodak Co.
23-9	o-Cyclohexylphenol	52	(c)	Eastman Kodak Co.
23-11	4-Chloro-6-phenylphenol	78	323	Eastman Kodak Co.
23-12	o-Hydroxybiphenyl	56	275	Eastman Kodak Co.
23-13	2-Chloro-6-phenylphenol	6	317	Eastman Kodak Co.
23-14	beta-Naphthol	122	285	Eastman Kodak Co.
23-15	alpha-Naphthol	96	278	Eastman Kodak Co.
23-22	2,4-Dinitrophenol	114		Eastman Kodak Co.
23-24	p-Chlorophenoxyacetic acid	157		Eastman Kodak Co.
23-28	Benzyl thiocyanate	36		NRL synthesis
23-29	o-Xenyl thiocyanate		(d)	NRL synthesis
25-1	Hexachlorophenol	105	210	Eastman Kodak Co.
25-7	Camphor	174	210	duPont
25-8	Fenchone		195	Eastman Kodak Co.
26-6	Cinnamaldehyde		252	Eastman Kodak Co.
26-7	alpha-n-Amylcinnamaldehyde		(e)	Eastman Kodak Co.
28-1	Salicylaldehyde		196	Eastman Kodak Co.

## APPENDIX A (continued)

Data on the Volatile Chemicals Examined

<u>N.R.L.</u> <u>Number</u>	<u>Name</u>	<u>MP</u> <u>°C.</u>	<u>BP</u> <u>°C.</u>	<u>Source</u>
28-3	Anisaldehyde	2.5	247	Eastman Kodak Co.
29-1	Phenylacetic acid	76	265	Eastman Kodak Co.
34-7	Cyclohexylamine		134	Eastman Kodak Co.
35-1	p-Aminophenyl thiocyanate	57		NRL synthesis
35-2	p-Benzylaminophenol	89		Eastman Kodak Co.
51-1	Phenothioxine	58	(f)	Eastman Kodak Co.
51-3	Paraldehyde	12	125	Eastman Kodak Co.
52-4	8-Hydroxyquinoline	76	267	Eastman Kodak Co.
52-6	2-Hexylpyridine		227	Reilly Tar & Chem. Co.
52-9	gamma-Picoline		143	Eastman Kodak Co.
53-1	Hexamethylenetetramine		250	Eastman Kodak Co.
54-8	Morpholine		128	Carbide & Carbon Chem
61-9	Sodium sulfide		---	J.T.Baker Co.
61-10	Sulfur		---	J.T.Baker Co.

(a) 135° at 0.25 mm.

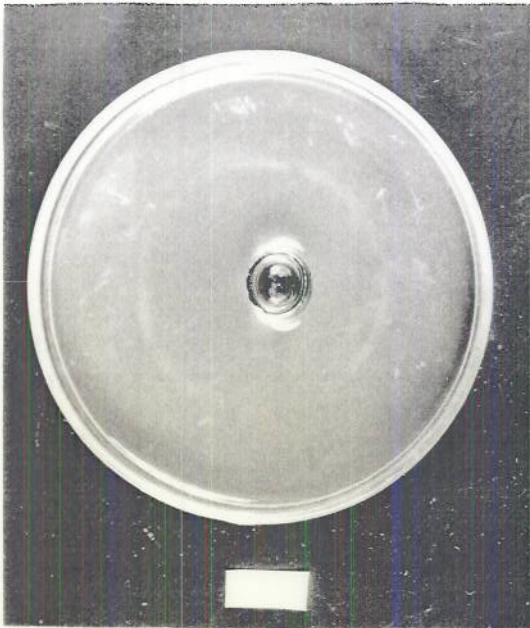
(b) 115° at 0.3 mm.

(c) 148° at 10 mm.

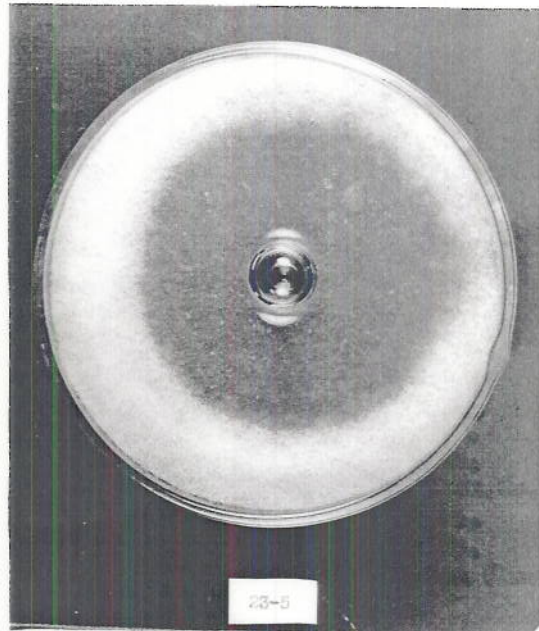
(d) 124° at 0.3 mm.

(e) 163° at 15 mm.

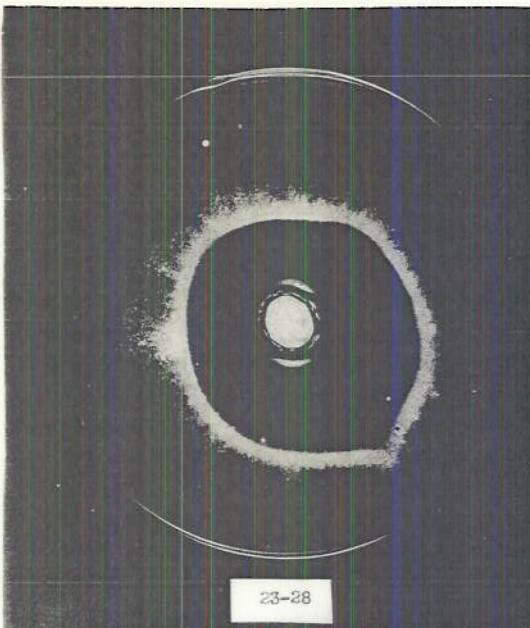
(f) 185° at 23 mm.



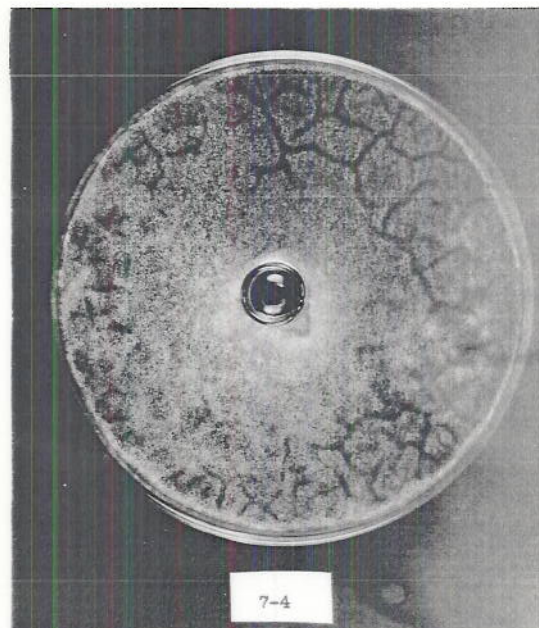
RATING 0  
BUTYL THIOCYANATE



RATING 1  
PHENOL

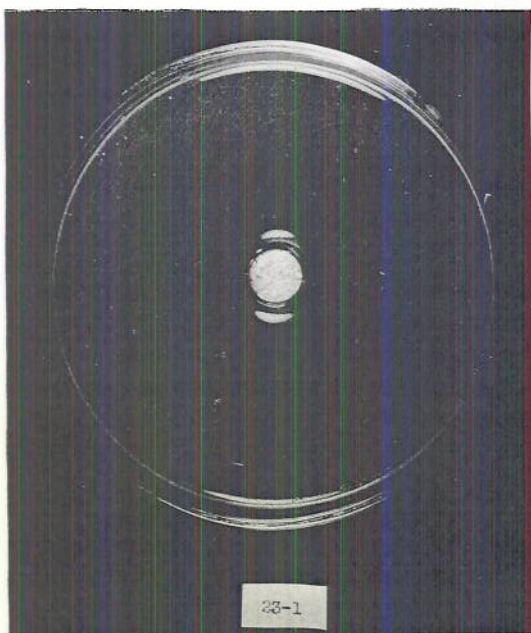


RATING 2  
BENZYL THIOCYANATE

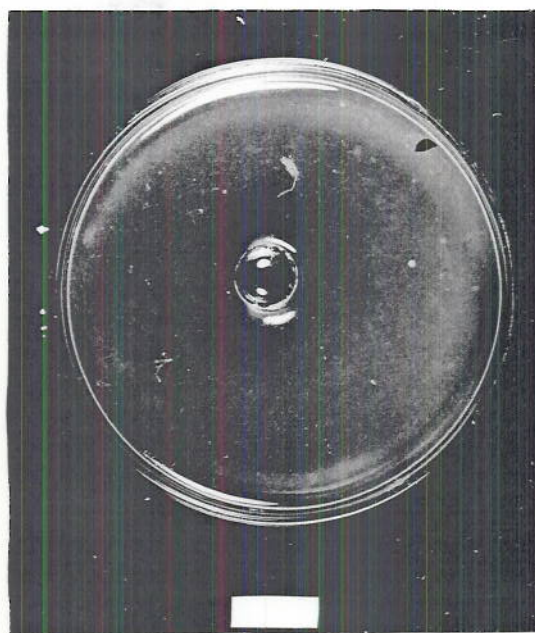


RATING 3  
LAURYL THIOCYANATE

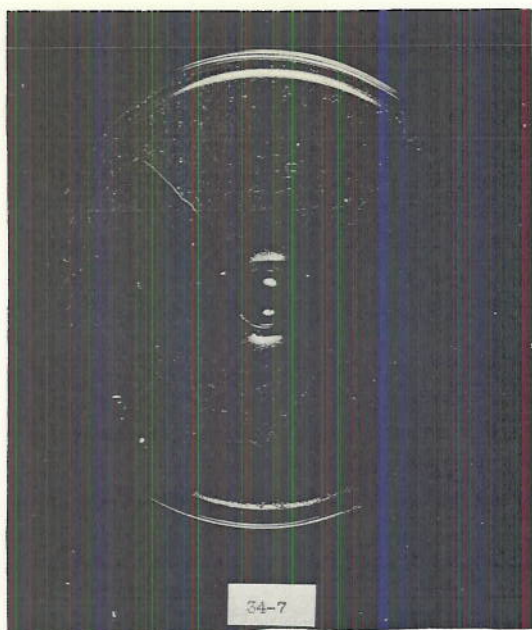
FUNGISTATIC ACTIVITY OF VOLATILE CHEMICALS



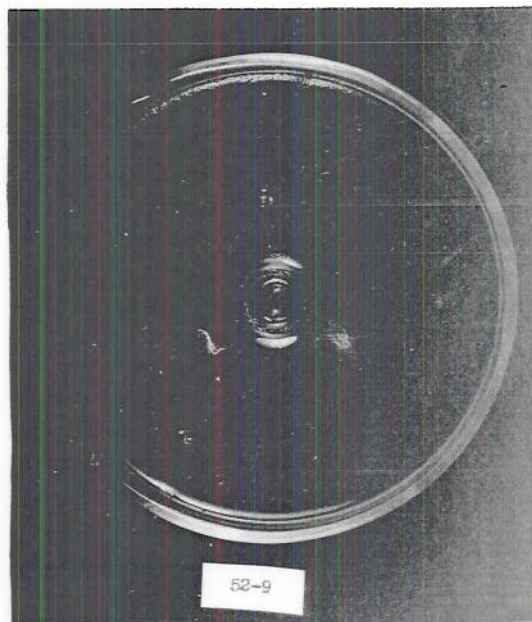
RATING 0  
TRICHLOROPHENOL



RATING 0  
SALICYLALDEHYDE



RATING 0  
CYCLOHEXYLAMINE

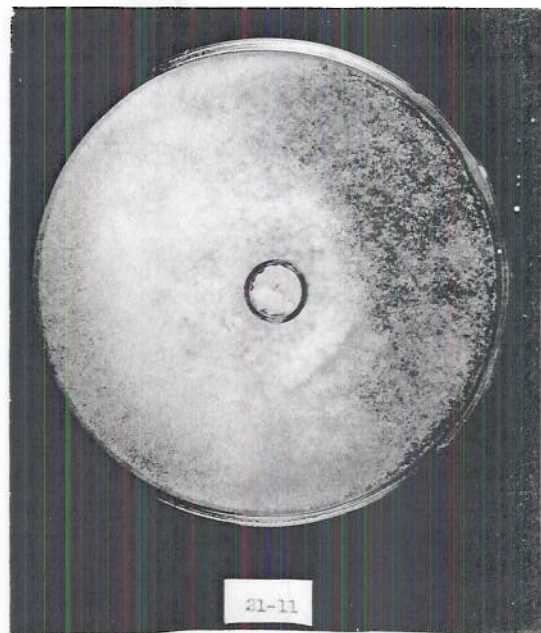


RATING 0  
GAMMA-PICOLINE

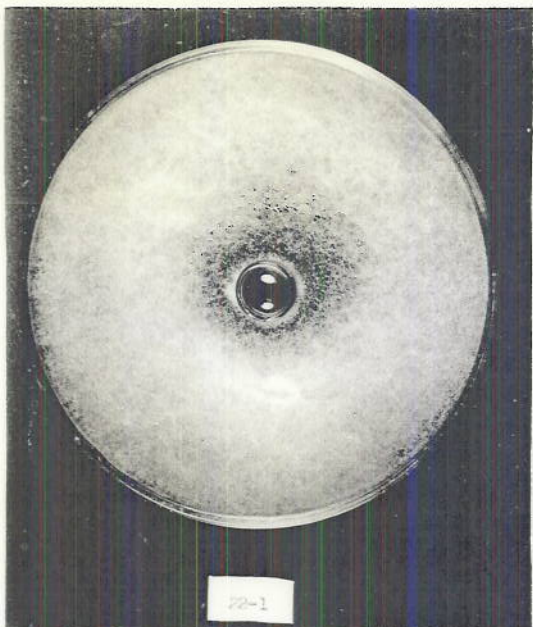
FUNGISTATIC ACTIVITY OF VOLATILE CHEMICALS



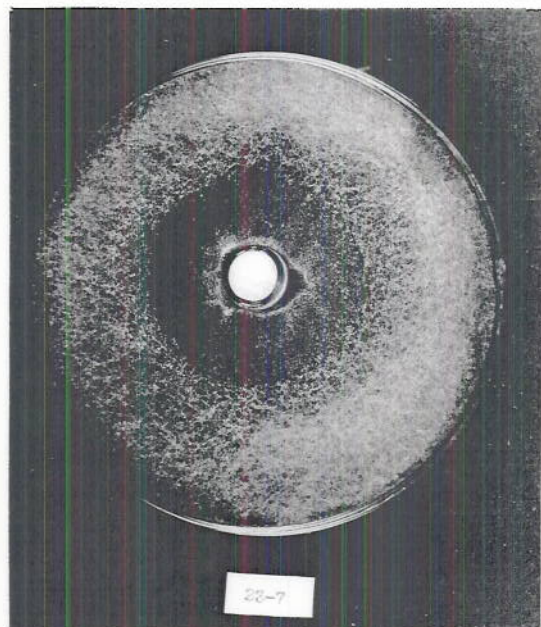
RATING 1  
NITROBENZENE



RATING 3  
BIPHENYL



RATING 3  
ISOBORNYL THIOCYANOACETATE

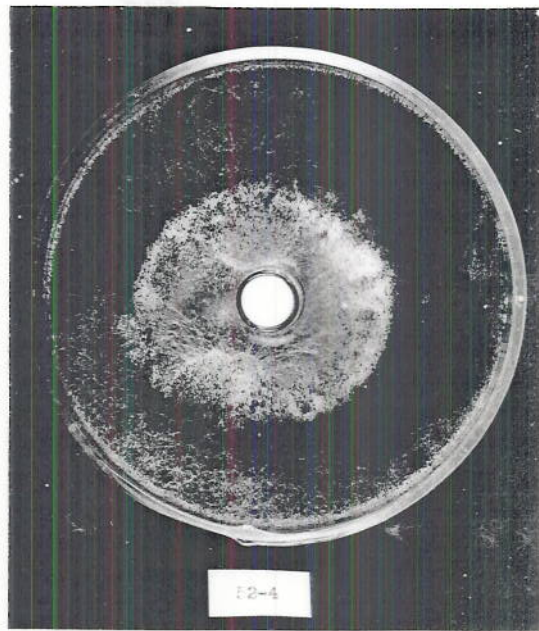


RATING 3  
PARA-CHLOROTHYMOL

FUNGISTATIC ACTIVITY OF VOLATILE CHEMICALS

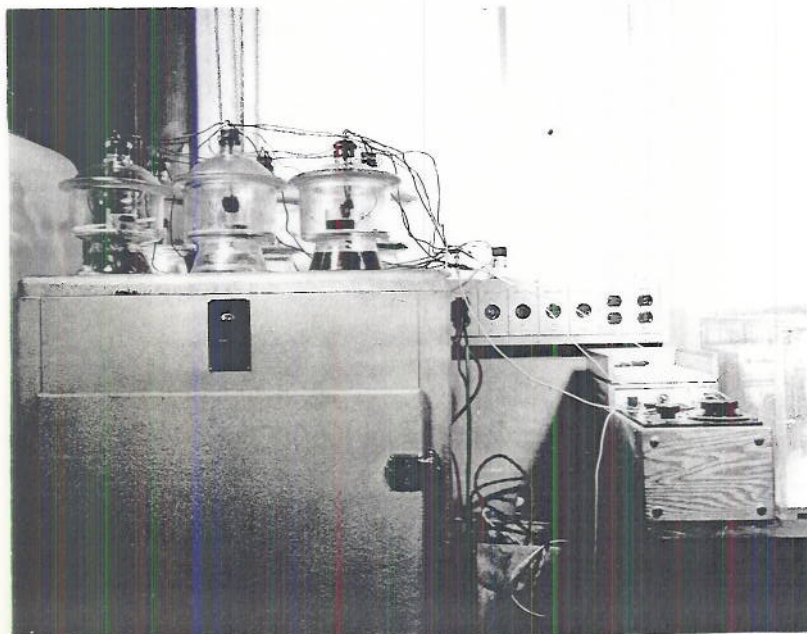


RATING 3  
CAMPHOR



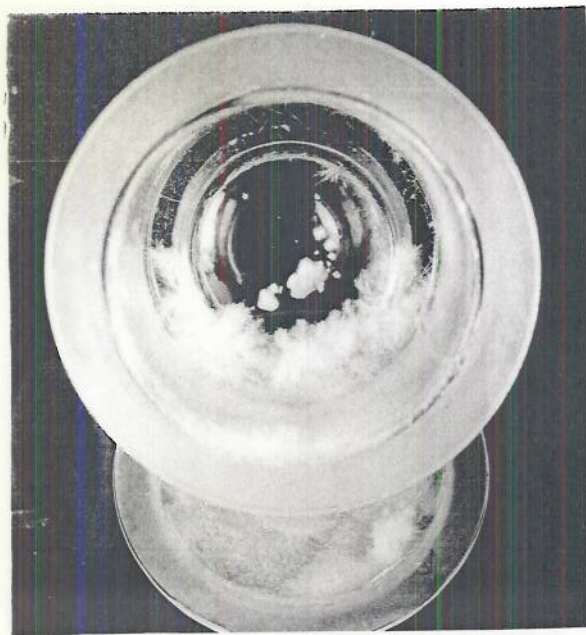
RATING 3  
8-HYDROXYQUINOLINE

FUNGISTATIC ACTIVITY OF VOLATILE CHEMICALS



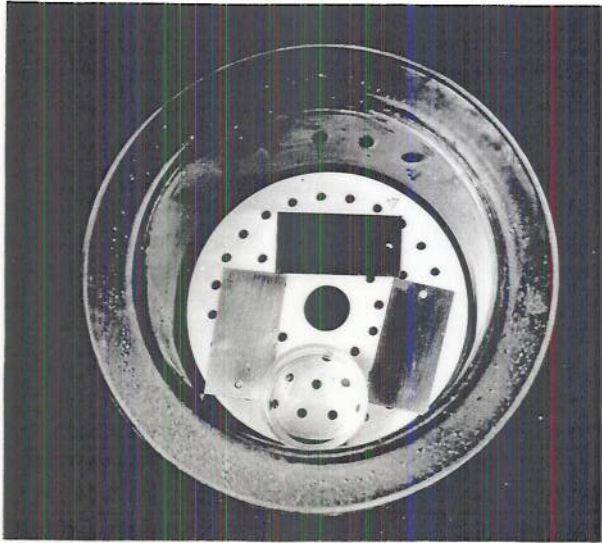
A

APPARATUS USED FOR INSULATION-RESISTANCE AND CORROSION.



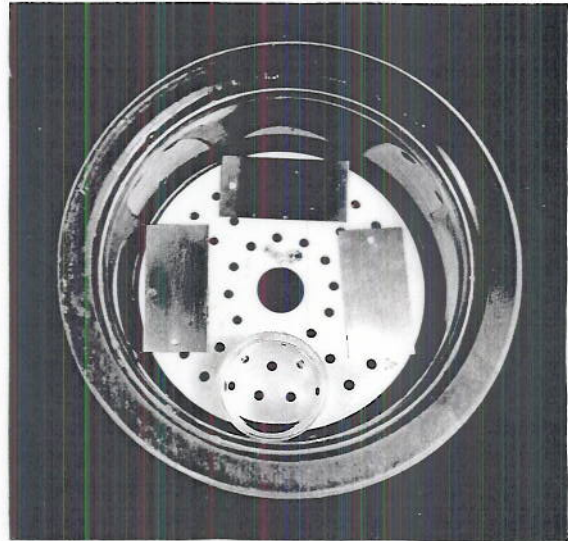
B

NEEDLES OF TRICHLOROPHENOL FORMED BY SUBLIMATION.

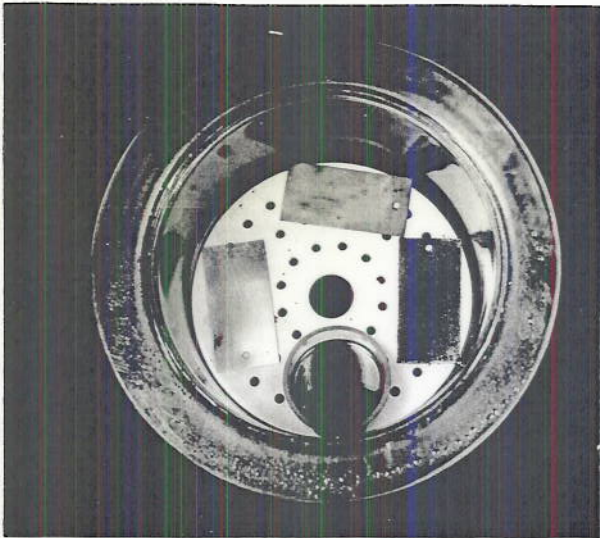


DRY

NITROBENZENE

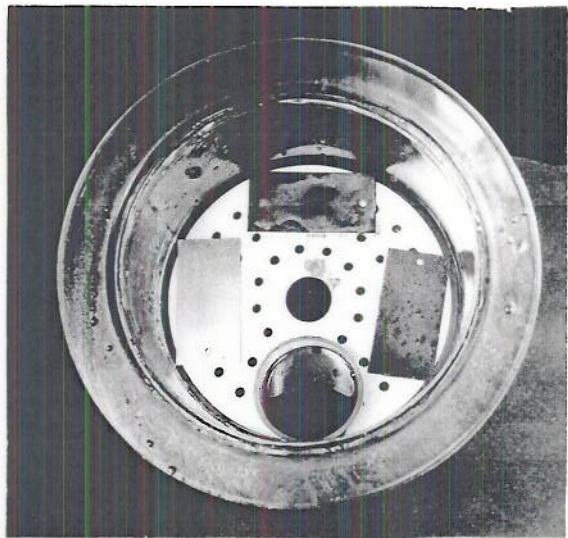


WET



DRY

SALICYLALDEHYDE



WET

CORROSIVE TENDENCIES OF VOLATILE FUNGICIDES