

An Automatic Dewpoint Meter for the Determination of Condensable Vapors

Cite as: Review of Scientific Instruments **19**, 16 (1948); <https://doi.org/10.1063/1.1741048>
Submitted: 04 August 1947 . Published Online: 20 December 2004

Theodore T. Puck



View Online



Export Citation

Lock-in Amplifiers
up to 600 MHz



An Automatic Dewpoint Meter for the Determination of Condensable Vapors*

THEODORE T. PUCK**

Departments of Biochemistry and Medicine, University of Chicago, Chicago, Illinois

(Received August 4, 1947)

A method for determination of very small concentrations of condensable vapors by measurement of the decrease in reflectivity of a cooled surface on which the vapor has been deposited is described. The method is applicable to mixtures of 2 components, one of which may be water. Use is made of the fact that a vapor will condense at a concentration below its vapor pressure in the presence of a second vapor whose liquid is soluble in that of the first. The most volatile component of the mixture is used in the pure state as a refrigerating agent whose evaporation cools the light-reflecting surface to an accurately regulated temperature which produces condensation of the two components.

An instrument embodying these principles is described

which quantitatively measures triethylene glycol vapor in concentrations as low as 10^{-4} mm Hg. The construction is simple and the operation continuous and automatic. The calibration of the instrument is presented. By proper adjustment, automatic compensation for changing atmospheric relative humidity can be secured so as to obtain response only to the degree of saturation of the glycol vapor in air.

This device has been used to investigate condensation of vapors on atmospheric nuclei, and as a control instrument to regulate the concentration of triethylene glycol vapor employed as an aerial germicide for prevention of airborne disease transmission.

THE need for an apparatus to detect minute quantities of condensible vapors in the atmosphere, arose as a result of investigations which demonstrated that airborne, disease-producing agents could be rapidly killed by certain vapors in extremely small concentrations. Thus, propylene glycol, in a concentration of 0.20 mg per liter of air was shown to sterilize within less than a minute, atmospheres into which large numbers of pathogenic bacteria and viruses had been sprayed.^{1,2} Triethylene glycol was found to be even more potent, exercising lethal action in concentrations as little as 0.002 mg per liter of air.³ The mechanism of this effect was shown to involve condensation of these vapors on to the nuclei on which the microorganisms are suspended, so that a bactericidal concentration of the compound accumulates about the infectious agent.⁴ Both propylene and triethylene glycols are odorless and tasteless in the amounts required for air sterilization, and extensive toxicity tests

have shown them to have no harmful effect on animals or human subjects.⁵ Hence, the use of these vapors would seem to offer considerable promise in the prevention of spread of airborne diseases, provided that a method could be devised for controlling their concentrations.

A consideration of the physical properties of triethylene glycol reveals the nature of the problem involved. This compound is a highly non-volatile liquid, with a vapor pressure of only 0.0013-mm Hg at room temperature.⁶ Thus, dry air at 25°C can contain only 11 micrograms of this material per liter. For practical application it is essential that its saturation concentration is not exceeded because of the fogging of the atmosphere, a result undesirable in places of human habitation. It is equally necessary to prevent the concentration of this vapor from falling to too low a value as the bactericidal action is sharply diminished when the vapor becomes too dilute.^{2,4} Moreover, since triethylene glycol is completely miscible with water, its saturation concentration in the atmosphere is a function of the relative humidity, because glycol and water form a 2-component system with a single liquid phase. By the phase rule, then, a limiting relationship exists between the maximum concentrations of the two

* This work has received support from the United States Public Health Service and the Bartlett Memorial Fund of the University of Chicago.

** Present address: California Institute of Technology, Pasadena, California.

¹ O. H. Robertson, E. Bigg, T. T. Puck, and B. F. Miller, *J. Exper. Med.* **75**, 593 (1942).

² T. T. Puck, O. H. Robertson, and H. M. Lemon, *J. Exper. Med.* **78**, 387 (1943).

³ O. H. Robertson, T. T. Puck, H. M. Lemon, and C. G. Loosli, *Science* **97**, 51 (1943).

⁴ T. T. Puck, *J. Exper. Med.* **85**, 729 (1947); T. T. Puck, *J. Exper. Med.* **85**, 741 (1947).

⁵ O. H. Robertson, C. G. Loosli, T. T. Puck, H. Wise, H. M. Lemon, and W. Lester, *J. Pharmacology and Exper. Therapeutics* **91**, 52, 1947.

⁶ T. T. Puck and H. Wise, *J. Phys. Chem.* **50**, 329 (1946).

vapors which can co-exist in the atmosphere at any temperature. Air at 100 percent relative humidity is in equilibrium with a solution of pure water, so no glycol vapor whatever can exist in such an atmosphere. Similarly, an amount of glycol vapor equivalent to its pure vapor pressure can exist only at zero relative humidity. At intermediate relative humidities, the maximum amount of glycol vapor which the air can support can be readily calculated (see Eq. (4) below).

In view of this relationship, the control of these vapors for purposes of air sterilization must also include provision for compensation due to changes in room temperature and relative humidity, if maximum bactericidal action without fogging of the atmosphere is to be secured.

Search for a specific chemical reaction by which triethylene glycol vapor could be detected did not prove fruitful because of the relative inertness of this compound and the difficulty of separating it from water, which is always present in the atmosphere.*** An instrument was devised which proved to be suitable for the determination of this vapor and also lent itself readily to automatic control of its concentration.**** Its operation depends upon condensation of the vapor onto a cooled, highly polished surface. A beam of light reflected from this surface into a photo-cell, suffers diminution in intensity because of interference and scattering by the film of condensate. The change in the photoelectric output is a direct function of the amount of material deposited on the reflecting surface, and hence furnishes a measure of the concentration of the vapor in the air.

When analyzing a vapor by its condensability

*** A method of estimation of this vapor based on its collection from the air and oxidation by $K_2Cr_2O_7$ was devised [H. Wise, T. T. Puck, and H. Stral, *J. Biol. Chem.* **150**, 61 (1943)]. However, the procedure is tedious and the reaction non-specific so that dust and other impurities in the atmosphere interfere. Other methods which were tested but found to be not sufficiently sensitive, included refractive index measurement with an interferometer, ultraviolet absorption, infra-red absorption and measurement of the heat of combustion by noting the increase in temperature of a glowing Pt wire when atmospheres containing the vapor are passed over it [E. R. Weaver and E. E. Weibel, *Sci. Pap. Bur. Stand.* **15**, No. 334, 47 (1919-1920)].

**** A preliminary note describing the principle of operation has been presented. The instrument has been named a "glycostat" [T. T. Puck, H. Wise, and O. H. Robertson, *J. Exper. Med.* **80**, 377 (1944)] when used to control glycol vapors for aerial disinfection.

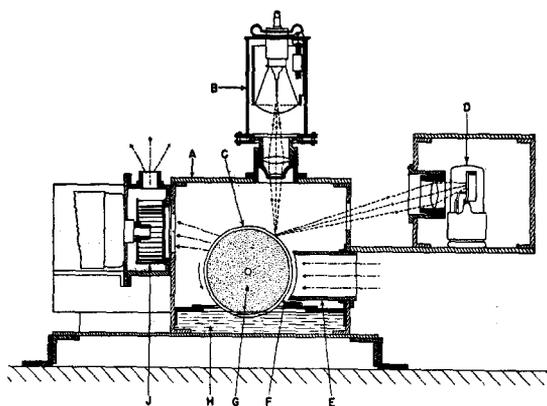


FIG. 1. Schematic diagram of the instrument for determination of condensable vapors. *A*—brass case enclosing the optical disk. *B*—light source. *C*—cooled disk whose rim is an optically polished surface on which the vapors are condensed. *D*—photo-cell. *E*—slot which directs incoming air against the condensation surface. *F*—Neoprene wiper which removes excess liquid from condensation surface. *G*—cloth wick, sewed to each face of the disk. *H*—water bath. *J*—blower. - - - - - direction of light rays. - · - · - direction of air flow.

it is necessary to prevent interference by the water vapor which almost universally co-exists in the atmosphere. This can be accomplished by regulating the degree of cooling of the condensation surface so that its temperature lies below the dew point of the vapor mixture being determined, but above that at which the water vapor in the air would condense by itself. This condition is achieved by utilizing the evaporation of water as the cooling medium. The lowest temperature which may be attained by this means is that of the wet-bulb thermometer. Since this always lies above the dewpoint for water vapor, it is impossible for pure water to condense by itself for any relative humidity less than 100 percent.

The principle of operation is illustrated in the schematic diagram of the instrument shown in Fig. 1. A stainless-steel disk three inches in diameter and $\frac{5}{32}$ inch thick is rotated by a synchronous motor at a rate of 1/15th of a revolution per minute. Cloth wicks sewed on to the disk by means of several holes drilled through its thickness, press tightly against each face. This disk is mounted so that its lower third dips into a water bath, which is maintained at a constant level by a float valve in a larger water reservoir, not shown in the diagram. Water, drawn up into the wicks by capillary attraction, evaporates into a swiftly flowing air stream sucked in by the

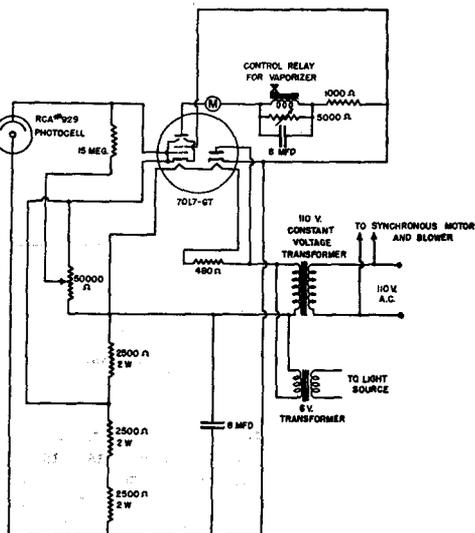


FIG. 2. Wiring diagram of the instrument.

small blower at the left. The heat absorbed by this evaporation cools the entire wheel so that any glycol vapor contained in the incoming air condenses on the rim of the cold disk which is a highly polished optical surface. A light source of constant intensity, is focused by a lens onto the rim of the disk and is then reflected from this surface into a photo-cell. Deposition of a film of condensate on this polished rim produces interference and scattering of the reflected light beam, diminishing its intensity. The extinction of the light signal reaching the photo-cell has been found to be a direct function of the degree of deposition of condensate on the rim of the wheel, which, in turn, depends upon the concentration of condensable vapor molecules in the incoming air stream.

As the wheel revolves, the portion of the rim emerging from the water encounters a wiper made of Neoprene, which, pressing tightly against it, uniformly removes the water from its polished surface in the same way that a windshield wiper cleans a pane of glass. Thus, a clean surface is continuously offered to the incoming air stream, for deposition of any condensable vapor which it may contain. The disk is contained within an airtight brass case with one transparent plastic face to permit observation of the wheel's rotation, and two smaller windows to allow entrance and exit of the light beam.

A vacuum-type photo-cell with a single stage

70L7 amplifier tube (circuit diagram in Fig. 2) provides a rugged and sensitive photometric system. A d.c. milliammeter indicates the degree to which the light reflected into the photo-cell is extinguished by the layer of condensate on the polished rim of the wheel. A relay, connected as indicated in Fig. 2, can be set to control a glycol vaporizer so as to maintain any desired degree of saturation of the air by the vapor.

DETAILS OF CONSTRUCTION AND OPERATION

An automobile headlight bulb (Westinghouse No. 1133) is used as a light source and is operated on 5 volts, a.c., so as to prolong its lifetime indefinitely and reduce radiant heating of the disk. A sola constant-voltage transformer satisfactorily stabilizes the a.c. 115-volt line for use as a source of e.m.f. for the photo-cell and the lamp. By the use of a combination of adjustable resistances in series and in parallel with the relay (Fig. 2) it becomes possible to vary its operating point so as to control the operation of a glycol vaporizer for the maintenance of any desired concentration of glycol vapor in the atmosphere. The meter employed has a full-scale deflection of 10 milliamperes. Complete extinction of the light signal entering the photo-cell produces a deflection of 8.5 milliamperes.

Theoretically, the electronic sensitivity of response of the instrument could be increased to detect extremely small numbers of molecules deposited upon the condensation surface. In practice the smallest film of condensate which can be accurately determined is that which produces a change in light reflection greater than the largest deviations produced by natural inhomogeneities of the disk's surface to light reflection. It was found possible to prepare satisfactory disks with extremely uniformly reflecting rims by grinding cylindrical pieces of stainless steel down to the correct size on a lathe, and then polishing them with a mixture of putty powder and water by use of a pitch tool.† Wheels which exhibit a maximum deviation of less than 5 percent in the intensity of light reflection from any two points on the surface of their rims, can be cheaply produced in this way. Such wheels have been in daily use for more than a year without showing any change in their reflecting surfaces. By measurement of the surface reflectivity of the rims of these disks, it is possible to detect films of condensate containing extremely small quantities of material.

The small, squirrel-cage blower,†† 8 cm in diameter, is operated by a 3400 r.p.m. motor††† and sucks air from the room at a rate of 28 liters per minute. The cross-sectional area of the slot from which the air emerges before impinging on the polished rim of the wheel is 1.25 centimeters

† We are indebted to Dr. Niel F. Beardsley of the Department of Physics of this University for guidance in the polishing of these disks.

†† No. 2 blower, L and R Manufacturing Company, Torrington, Connecticut.

††† No. 952 motor, Speedway Corporation, Chicago, Illinois.

square, producing an air velocity of 370 centimeters per second. This blower performs the double function of cooling the disk by evaporation of water from the wicks along its sides, and of bringing a constant fresh supply of glycol-containing room air to be impinged on its rim. The presence of the constriction formed by the air slot helps to stabilize the air-flow rate against small fluctuations in the delivery of the blower.

The sensitivity of the device depends upon the amount of glycol-containing air impinging upon each square centimeter of the disk's rim and on the degree of condensation of the vapor molecules contained in this air stream. These, in turn, are determined by the temperature of the wheel, its rate of rotation, and the rate of flow of the air stream directed at the condensation surface.

The temperature of the wheel depends upon the extent of cooling due to evaporation of water by the air stream, and heat conduction into the wheel through its shaft and through that portion which is submerged below the surface of the water bath. The arrangement which was finally adopted produced a wheel temperature giving the most satisfactory response to vapors of triethylene glycol. This temperature was measured approximately by means of a small iron-constantin thermocouple clamped tightly to the rim of the wheel. It was found that the condensation surface is maintained at a point corresponding to about 65 to 75 percent of the wet-bulb depression of the air being sampled.

Selection of the rate of rotation of the wheel involves a compromise between the two desirable factors of high sensitivity and rapid response. The more rapidly the wheel rotates, the smaller is the time lag before the light beam can scan the deposited film. However, by virtue of such rapid rotation each portion of the wheel's surface would be exposed to the air stream containing the condensable vapor for only a short time, so that the extent of the deposit would be small. By utilizing a rate of rotation of 1/15th r.p.m. and focusing the light beam at the point on the wheel just emerging from the position in front of the slot, a high degree of sensitivity is attained with a lag in response of not more than one and a half minutes. The sensitivity is also increased by the use of a high rate of air flow, all of which is impinged directly upon the condensation surface so that a maximum amount of condensate is deposited on each square centimeter.

Once set in operation, the instrument requires very little attention. The water reservoir is maintained at the proper level by means of a float valve attached to a large receptacle that holds enough water to last a week. The Neoprene wiper requires replacement after about 2000 hours of continuous operation. Instruments have been in use in this laboratory for periods longer than a year without requiring any major adjustment. If the instrument is operated in dusty atmospheres it may be necessary to place a dust filter over the air intake in order to prevent excessive deposition of dust within the case.†

† The small reservoir must be flushed out periodically to prevent accumulation of the condensed component. When used with triethylene glycol vapor, the instrument functions satisfactorily with a weekly rinsing of the small water bath.

CALIBRATION

The apparatus was calibrated for use with triethylene glycol vapor, by measurement of the response elicited when atmospheres containing known concentrations of triethylene glycol vapor at various temperatures and relative humidities, were sampled by the instrument.

Figure 3 demonstrates the arrangement employed. A 1 r.p.m. synchronous motor‡‡ is connected to a gear train which drives forward the piston of a syringe containing triethylene glycol. Thus, a metered quantity of the liquid is discharged through the needle on to a small ohmite resistor which is wound with glass cloth and serves to vaporize the glycol almost instantly. All the vapor is drawn into the air intake of the glyco-stat along with room air which enters through the two air-inlet openings shown in Fig. 3. The total air flow is measured by a flowmeter connected to the air exhaust of the instrument (not shown in the figure) so that the concentration of glycol vapor in the entering air stream can be computed. The temperature of the mixture is read on the thermometer and the moisture content of the air stream is measured before it enters the apparatus.‡‡‡ The concentration of glycol vapor in the air entering the dewpoint meter could be varied over the desired limits by changing the gear ratios in the piston-

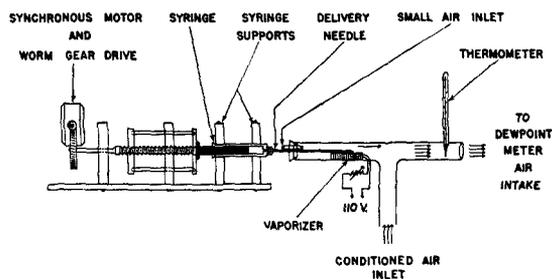


FIG. 3. Arrangement used to prepare atmospheres of known vapor composition for calibration of the instrument. The provision of a small air inlet, which conducts the vaporized glycol into the main carrier air stream, allows vaporization to be effected without excessive heat input into the system.

‡‡ Leich Electric Company, Genoa, Illinois.

‡‡‡ The entire apparatus was maintained within a chamber whose relative humidity could be accurately adjusted to any desired value [O. H. Robertson, T. T. Puck, and H. Wise, *J. Exper. Med.* **84**, 559 (1946)]. A sensitive wet- and dry-bulb psychrometric apparatus inside this chamber continuously recorded the moisture content of the room air drawn into the calibrating apparatus.

TABLE I. Summary of calibration values for triethylene glycol at various relative humidities over a range of temperature from 20°C to 28°C.

Glycol-vapor concentration: micrograms per liter	Air temperature °C	Air relative humidity in percent	Meter deflection in milliamperes
1.39	27.5	26	1.12
	27.0	40	1.71
	27.8	63	4.39
	23.3	28	1.22
	23.6	40	2.04
	23.3	67	5.30
	20.8	15	1.26
	19.7	18	1.36
	21.4	48	3.53
	20.8	58	5.34
2.16	27.2	17	3.16
	27.2	48	4.91
	26.7	61	6.53
	23.1	27	3.75
	22.9	44	4.33
	22.9	44	5.40
	23.3	50	5.99
	23.8	66	7.49
	21.2	16	2.88
	20.6	40	6.15
20.8	56	6.90	
2.78	27.2	26	3.98
	28.1	47	5.78
	27.2	62	7.18
	23.3	28	4.42
	24.4	47	5.25
	23.9	64	7.87
	23.9	64	8.43
	20.2	10	2.87
	27.4	18	6.17
	27.6	23	6.47
27.6	34	6.93	
27.2	35	6.41	
27.1	64	7.79	
4.32	24.4	13	5.97
	23.0	14	6.18
	23.4	42	7.11
	23.4	74	8.44
	20.8	11	6.40
	20.4	28	7.34
	20.4	43	7.79
	20.9	63	8.43

driving mechanism. In this way, the response of the instrument to atmospheres of varying glycol content was measured at a series of different temperatures and relative humidities. This method of calibration was carried out at temperatures between 20°C and 28°C, the limits likely to be encountered under most conditions of indoor

human habitation. The smallest glycol concentration which could be accurately delivered by the vaporization apparatus was slightly over 1 microgram per liter. It was found difficult to use this method for atmospheres whose relative humidity exceeded 65 percent because the amount of glycol vapor which the air can contain under these conditions is so small⁷ that very small fluctuations in the glycol-vapor concentration produced wide deviations in the response of the measuring instrument. Measurements of each point were repeated until satisfactory checks within 5 percent of the meter deflection were obtained at each temperature and relative humidity for each concentration of glycol vapor. A summary of the averaged results of these experimental determinations are presented in Table I. In Fig. 4 these values have been adjusted by interpolation to the three standard relative humidities, 25, 45, and 65 percent and three standard temperatures, 20.0, 23.3, and 27.5.

Inspection of these curves of Fig. 4 shows that at any single temperature the response of the instrument increases markedly with increasing concentration of either glycol or water vapor in the incoming air stream. Also, as the temperature rises, the response to any given concentration of glycol vapor at any constant relative humidity, shows a slight diminution.

This behavior can be understood in terms of the vapor-liquid equilibria of the 2-component system formed by glycol and water. The meter deflection depends upon the extent of condensation on the polished surface. At each relative humidity, the amount of material condensed will be determined by the degree to which the incoming air becomes supersaturated at the temperature of the cooled surface. Since glycol and water are miscible in the liquid state, an increase in the vapor concentration of either component will tend to promote more extensive condensation when the temperature is lowered. The condensate will consist of a solution of glycol in water, whose composition could be determined from a pressure-composition diagram at the temperature of the condensation surface. At higher relative humidities the condensate will be richer in H₂O, whereas at low relative humidities it will contain more glycol.

⁷H. Wise and T. T. Puck, Science 105, 556 (1947).

Similarly, at higher temperatures the capacity of the air to hold glycol vapor and water vapor increases. At a fixed relative humidity the higher the temperature of the air being sampled, the higher will be the temperature of the condensation surface, which is determined by the wet-bulb temperature. Therefore, a given concentration of glycol vapor at a constant relative humidity will produce a smaller amount of condensation at higher temperatures and so will result in a smaller deflection of the instrument.

These considerations make it clear that the apparatus here described responds to the tendency of a vapor mixture to condense on a cold surface, which depends upon its degree of saturation in the air. The quantitative relationships are as follows:

Let p_g' be the maximum concentration of any water-miscible vapor which can exist in the air at any temperature, T , and relative humidity, RH . Then from the laws of solution

$$p_g' = p_g^0 N_g \gamma_g, \quad (1)$$

where p_g^0 = vapor pressure of the pure substance g , at the prevailing temperature, N_g is the mole fraction of g in a solution in equilibrium with the given vapor mixture, and γ_g is its activity coefficient in this solution. Therefore,

$$p_g' = p_g^0 \gamma_g (1 - N_{H_2O}), \quad (2)$$

where N_{H_2O} = the mole fraction of water in this equilibrium solution. But

$$\begin{aligned} N_{H_2O} &= (p_{H_2O}) / (p_{H_2O}^0 \gamma_{H_2O}) \\ &= RH / \gamma_{H_2O}, \end{aligned} \quad (3)$$

where RH is the relative humidity of the atmosphere. Hence

$$p_g' = p_g^0 \gamma_g \left(1 - \frac{RH}{\gamma_{H_2O}} \right). \quad (4)$$

Now let S_g = degree of saturation of the water-miscible vapor in the atmosphere, defined as the ratio of its actual concentration in the air to the maximum concentration which can exist at the prevailing temperature and relative humidity. Then

$$\begin{aligned} S_g &\equiv p_g / p_g' \\ &= p_g / \left[p_g^0 \gamma_g \left(1 - \frac{RH}{\gamma_{H_2O}} \right) \right]. \end{aligned} \quad (5)$$

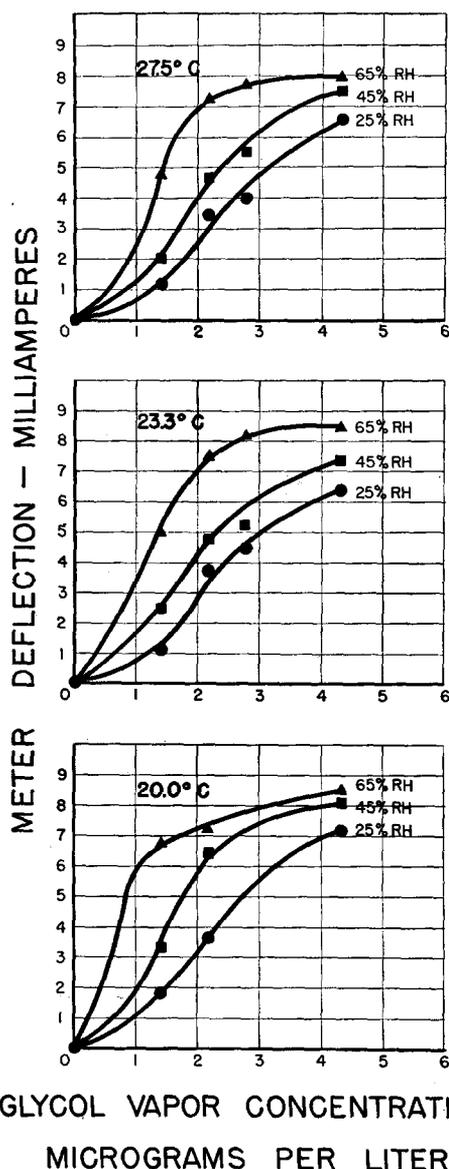


FIG. 4. Calibration curves showing response of the instrument to triethylene glycol vapor for three standard relative humidities at three different temperatures.

Values of p_g' for triethylene glycol have been obtained experimentally over a wide range of atmospheric relative humidities at a series of different temperatures.^{11,12} By means of these data it is possible to calculate S , the percent saturation of triethylene glycol, for each of the experimental determinations listed in Table I. The results of such calculation applied to each point in Table I are plotted in Fig. 5, wherein the

¹² H. Wise, T. T. Puck, and C. Failey, to be published.

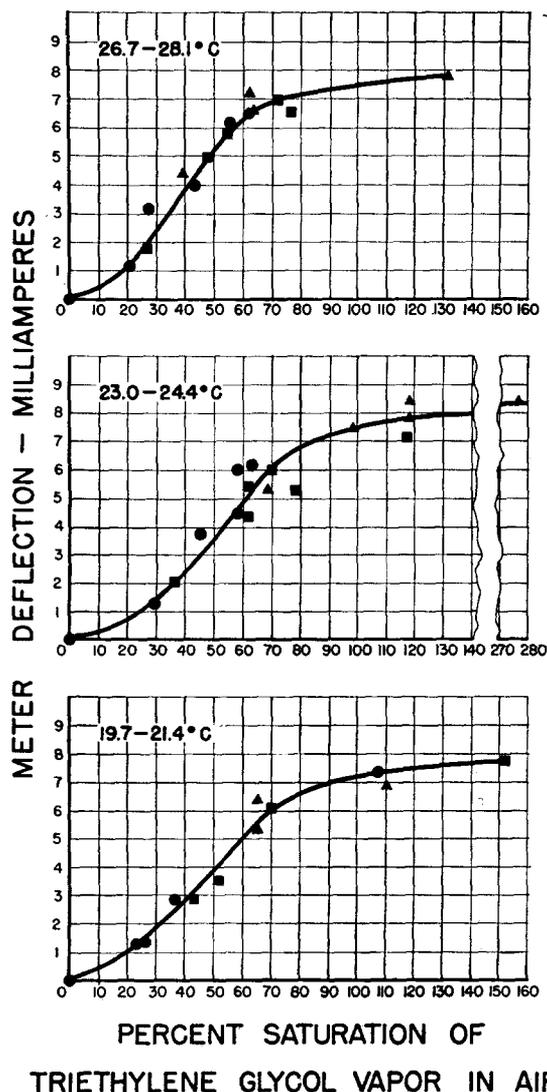


FIG. 5. Calibration values of the meter, showing its response to S , the degree of saturation of triethylene glycol vapor in the air. The value for S has been calculated for each concentration of glycol vapor at each temperature and relative humidity, by means of Eq. (5), and values of p'_0 presented in another publication.^{16,17} Each set of three curves in Fig. 4 is replaced by a single curve in Fig. 5 when the independent variable is transformed to S , the degree of saturation. The circles represent relative humidities between 11-26 percent; the squares 40-50 percent, and the triangles 56-67 percent.

response of the instrument is presented as a function of the percent saturation of triethylene glycol vapor in air over a range of relative humidities at three different temperatures. It is found that at each temperature, a single smooth curve is obtained when the meter deflections are plotted as a function of S for each calibration

point, regardless of the absolute glycol concentration or moisture content of the air sampled. These curves show that at least within the limits of the calibration region the instrument responds directly to the percent saturation of glycol vapor rather than to any other simple function of the relative humidity or glycol concentration. The temperature coefficient of the response of the instrument to the degree of saturation of glycol vapor in moist air is slightly greater than zero. Thus, although the two lower sets of data in Fig. 5 superpose on a single curve, that at the higher temperature range averages about 15 percent higher, an amount beyond experimental error.

A meter deflection of 8.5 milliamperes corresponds to almost total extinction of the light beam entering the photo-cell. When atmospheres corresponding to complete saturation enter the dewpoint instrument, the film of condensate is so heavy as to eliminate almost completely the integrity of the reflected beam. This is the reason why the curves in Fig. 5 bend over and become almost horizontal in the neighborhood of 100 percent saturation.

The operation described, by which the instrument responds directly to the degree of saturation of the glycol vapor is determined by the temperature of the condensation surface. In the present model this operating temperature was adjusted by regulation of the velocity of the air stream, the thickness of the wheel, and the degree of the wheel's submergence in the water bath. These factors were varied by trial and error until the desired type of response was attained. A colder wheel will increase the sensitivity of the instrument but will eliminate the automatic compensation, which is highly desirable.

Calculation of the total numbers of molecules which condense on the light-reflecting surface, when various vapor mixtures are sampled by the instrument, requires knowledge of the activity coefficient of each component in the solutions which are formed. Activity coefficients for the triethylene glycol-water system are being determined and will be reported in a forthcoming publication.¹²

That the temperature control of the condensation surface is sufficiently precise for the purpose, may be judged by the fact that the calibration

values are easily reproducible within about ± 5 percent. Instruments in operation for periods of more than a year have exhibited no change in their response to glycol-water-vapor mixtures.

DISCUSSION

The response of this instrument is exactly that which is required for practical application of condensible germicidal vapors as a means of prevention of spread of airborne disease. It has been shown in a previous publication that the efficiency of any chemical agent used as an aerial germicide is a direct function of S , the degree of saturation of its vapor in the atmosphere.⁴ Hence, when triethylene glycol or propylene glycol is used for aerial disinfection, it is desirable to employ the highest possible concentration that can be maintained in the air without exceeding the saturation point. If the room temperature rises, the capacity of the air to contain glycol vapor increases, so that it is necessary to increase the vapor concentration if an equally effective bactericidal action is to be maintained.^{2,4} On the other hand, if the room relative humidity rises, the glycol concentration must be correspondingly reduced or else the saturation point may be exceeded and a fog will result. Since the glycostat responds directly to the degree of saturation of the condensable vapor in the air, its use as a control instrument results in automatic compensation for changes in temperature and relative humidity so as to maintain most effective germicidal action.

This instrument has been installed in hospital wards and has functioned continuously for long periods of time in regulating the concentration of

triethylene glycol vapor. Tests carried out in such wards revealed that the use of these vapors reduced by over 90 percent the numbers of pathogenic microorganisms present in the air.¹³

This instrument furnishes a method for maintaining constant percent saturations of one component in the vapor phase of a binary system, and has made possible investigation on the kinetics of condensation of vapors on atmospheric nuclei.^{14,15} The instrument may also find application as a simple, yet sensitive means for determination of a number of vapors. Water is a suitable refrigerant for use with propylene glycol, dipropylene glycol, triethylene glycol, or lactic acid, some of the important agents that have been suggested for use in air sterilization. By proper selection of the refrigerant liquid whose evaporation cools the wheel, the wheel temperature can be regulated so as to cause condensation of a wide variety of compounds. The simplicity of the apparatus and its adaptability to automatic control may make it a useful device for experimental investigations of vapor systems, as well as a practical field instrument for determination and regulation of a number of vapors of toxicological importance.

It is a pleasure to acknowledge the very valuable cooperation of Dr. A. L. Chaney, Consultant, Lockheed Aircraft Corporation, Burbank, California, whose design modifications considerably simplified the form of the instrument.

¹³ T. T. Puck, M. Hamburger, O. H. Robertson, and V. Hurst, *J. Infect. Dis.* **76**, 216 (1945).

¹⁴ O. H. Robertson, W. Lester, T. T. Puck, H. Wise, and H. Lemon, to be published.

¹⁵ T. T. Puck, to be published.