K was inactivated in the presence of 100 mg. of kidney tissue aerobically. Smaller but appreciable amounts of penicillin G apparently disappeared from the buffered solution in the presence of surviving kidney slices. Further studies revealed that the inactivation of penicillin K by liver and kidney slices occurs in an atmosphere of nitrogen as well as aerobically. The oxygen uptake by the tissue slices suspended in penicillin K-containing buffer was exactly the same as that observed in the case of the slices in penicillin G buffer.

TABLE 2

DISAPPEARANCE* OF PENICILLINS G AND K FROM MEDIUM IN THE PRESENCE OF SURVIVING LIVER AND KIDNEY SLICES

Tissue	Liver			Kidney		
Gas	O_2		N_2	O_2		N_2
Penicillin	K	G	K	K	G	K
	0.60	0.27	0.60	1.05	0.60	0.75
	0.75	0.27	0.60	1.05	0.60	0.75
	0.75	0.27	0.60	1.05	0.60	0.75
	0.60	0.27	0.93	1.05	0.27	0.51
	0.60	0.0	0.93	1.05	0.27	0.51
	0.60	0.0	0.93	1.05	0.27	0.75
	1.02		0.75			
	0.75		0.75			
	0.75		0.90			
Mean	0.713	0.18	0.77	1.05	0.433	0.67

* Disappearance is calculated as O.U./100 mg. of wet weight of tissue. Triplicate analyses on individual rabbits are grouped.

Additional studies are now in progress to determine whether penicillin K is inactivated by other tissues, and whether intact liver and kidney cellular structure is essential for the effect noted above.

Summary. The inactivation of penicillin K is more rapid in the renal-ligated rabbit than in the renal-ligated, eviscerate preparation. Inactivation of penicillin K occurs in the presence of surviving liver and kidney slices. Small amounts of penicillin G were inactivated by liver slices; larger amounts disappeared in the presence of kidney slices. The inactivation of penicillin K in the presence of rabbit liver and kidney slices is demonstrable anaerobically as well as aerobically.

References

1. COGHILL, R. D., OSTERBERG, A. E., and HAZEL, G. R. *Science*, 1946, **103**, 709.
2. EAGLE, H., and MUSSELMAN, A. *Science*, 1946, **103**, 618.
3. KREBS, H. A., and HENSELEIT, K. *Z. physiol. Chem.*, 1932, **210**, 33.
4. PETERSON, J. M. *Physiol. Rev.*, 1934, **14**, 586.
5. RAMMELKAMP, C. H. *Proc. Soc. exp. Biol. Med.*, 1942, **51**, 95.

IN THE LABORATORY

Measurements of Underwater Noise Produced by Marine Life[1]

M. B. DOBRIN

Naval Ordnance Laboratory, Washington, D. C.

That certain fish species make noise under water has been common knowledge among fishermen since ancient times. For at least a century, observations on this phenomenon have been published by naturalists and zoologists. Until recently, however, all observations upon noise produced in this way were incidental and qualitative. No physical measurements of its frequency distribution or intensity are reported anywhere in the biological literature. It was not until the recent war that a need was felt for exact quantitative data on biological water noise. The introduction during the war of underwater acoustic equipment, such as listening devices, submarine detecting gear, acoustic mine mechanisms, and homing torpedoes, raised questions as to the interference that might be expected from natural background noises in the water. For this reason, information was required on the nature and magnitude of the water noise to be expected at various localities and under various conditions. Since no data of the type needed were available in the general literature, it was necessary for war research agencies working in underwater sound to make their own measurements. A large body of data was accumulated in this way which should considerably augment previously available knowledge of natural water noise and its production.

Although waves, wind, and tidal currents give rise to a measurable amount of water noise, this is seldom of a higher order of magnitude than 1 dyne/cm. 2 in an octave band and is usually much lower. Biological sources, on the other hand, can be responsible for sustained noises with an octave pressure of several hundred dynes per square centimeter.

MEASUREMENT OF NATURAL WATER NOISE

The Naval Ordnance Laboratory carried on background measurements at several field locations where biological noises were particularly intense, and it has recorded the highest natural water-noise levels that have been observed anywhere. At the same time, a systematic effort was made to identify the species giving rise to the different kinds of fish noises recorded. This involved elaborate tests on segregated fish species, both in aquaria and in experimental ponds.

[1] The field measurements and data reductions upon which this report is based were carried on by the following staff members of the Naval Ordnance Laboratory: L. G. Swart, G. E. Brown, L. C. Bell, D. L. Bobroff, R. F. Grunwald, G. R. Irish, W. E. Loomis, and the author. The consulting biologist for much of the work was Cdr. Charles J. Fish, USNR, of the Mine Warfare Operational Research Group. Walter H. Chute, director of the John G. Shedd Aquarium, gave the Laboratory substantial cooperation in its measurements there, and H. F. Prytherch, director of the U. S. Fishery Biological Laboratory, Beaufort, North Carolina, generously granted use of facilities for the field measurements and segregation tests reported from that area.

Procedure. Underwater background noises were picked up at all locations by underwater hydrophones and recorded on discs which were later played through an octave analyzer into a series of Esterline-Angus tape recorders, each octave over the range 50–3,200 c.p.s. being recorded on a separate tape. Calibration was by 1-kc. signal corresponding to a known sound pressure injected into the hydrophone circuit. Spectra were calculated and plotted from the octave tapes. At the same time, the disc recordings were available for listening and identification.

The hydrophones were of the Brush C-21 rubber-covered crystal type or the RCA 2A condenser type with a Monel diaphragm. Each kind had preamplifier inside the case. Discs were made with RCA cutting heads operated through standard Brush or RCA recording amplifiers. Filters in the analyzing system were of the ERPI octave type. The recording system is designed to give mean rectified sound pressure instead of root mean square or peak pressure. For the case of impulsive noises, such as the drumming and grinding produced by fish, the peak noise would be some 40 per cent higher than the mean rectified signal.

Direct Field Data

Disc recordings of underwater background noise in open water have been made by the Naval Ordnance Laboratory at various points along the East Coast of the United States from Florida to Cape May. During the course of these surveys, biological noise of many kinds has been heard and recorded. The measurements have been under a wide variety of circumstances as regards oceanographic conditions, season, time of day, etc.

Frequency Spectra. The large variation that can be expected in the background at a single location is illustrated in Fig. 1 by spectra obtained at typical locations along the East Coast. The ordinates represent the sound pressure observed within an octave band. These are plotted at the mid-band frequency of the octaves extending from 50 to 3,200 c.p.s., the points being connected by smooth curves. The two highest curves were recorded at Wolf Trap, in the middle of Chesapeake Bay, where the water depth is 40 feet. The spectra were both recorded in early July, but in successive years. The frequency characteristics are almost identical, although the 1942 level is about 60 per cent higher than the 1943. The frequency at which the peak noise level occurs is here observed at about 350 c.p.s. This is more than an octave lower than the peak recorded at Cape Henry in 1942, about five weeks earlier, which is the third highest curve in Fig. 1. The difference is probably attributable to the time interval between the two measurements rather than to their geographical separation. Since the source of noise in all cases was almost certainly croakers or other members of the Sciaenidae family, the fish would have grown longer during the intervening period and thus would produce resonant vibrations having lower pitch.

Of the other two curves, one was recorded in June 1943 at Fort Macon, North Carolina. The peak occurs at about 600 c.p.s., and the source is very likely to be croakers. The other was recorded from a boat in the open Atlantic, approximately 20 miles off shore, south of Cape Lookout, North Carolina. The noise here, although of the same character as that of croakers, is of much higher pitch than any Sciaenidae noise recorded elsewhere, the peak occurring at about 2,400 c.p.s. A search of the literature revealed that the bastard trout (*Cynoscion nothus*) is common off shore in this area but has not been observed near shore. This species, attaining a minimum length of 3 inches, is smaller than other drumfish along the United States east coast, and would thus be expected to produce a noise of higher pitch.

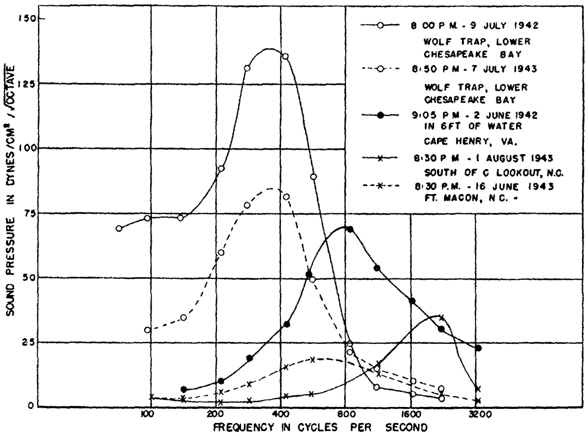

FIG. 1. Spectra of water noise caused by marine life at various points along the East Coast of the United States.

Seasonal variation. Distinct seasonal effects were observed in the water noise recorded in Chesapeake Bay. This variation was associated with seasonal movement of the croakers in the Bay. The daily maximum nocturnal noise levels at Cape Henry are plotted in Fig. 2 over the period from the middle of

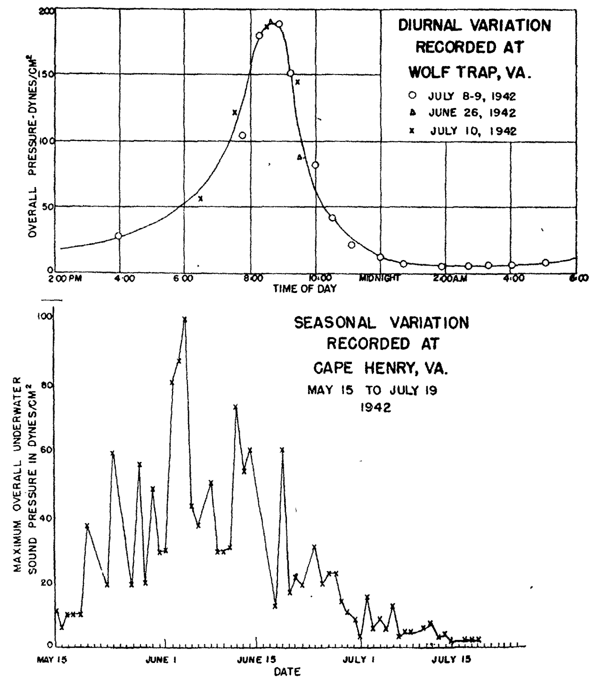

FIG. 2. Diurnal variation of water noise produced by marine life at Wolf Trap, Virginia, and seasonal variation of maximum daily water noise at Cape Henry, Virginia.

May to the middle of July. The peak of activity was during the early part of June, and by July 15 the activity was virtually over.

Diurnal effects. Diurnal variation in background noise level at Wolf Trap is also plotted in Fig. 2. The plot represents the composite of observations taken on three different days during the summer of 1942. Here the peak was reached at about 8:30 P.M., the curve being almost symmetrical around that time. At Beaufort and Fort Macon, North Carolina, the following year, the peak during June was reached at approximately 12:30 A.M. each night. The reason for this well-defined recurrent nocturnal appearance of the noise is not known definitely, although it is suspected that the peak coincides with feeding activity on the bottom.

Studies of Segregated Fish

Noises made by known fish species have been recorded and measured both at the Shedd Aquarium in Chicago and at the U. S. Fishery Biological Laboratory, Beaufort, North Carolina. The purpose of the tests in the aquarium was to determine which of the species in the collection was sonic, the conditions under which the sonic species could be induced to make noise, and the general nature of their noise. Although the noises were recorded on discs, it was not possible to measure absolute sound pressures or to make accurate frequency analyses. Most of the fish that produced noise in the aquarium belonged to families previously reported to be sonic in the biological literature. There were several species, however, for which no record of sound production could be found in the literature which turned out to be prolific noisemakers. Several members of the Pomacentridae family, such as the *Hypsypops rubicundus*, or garibaldi, of Southern California and the *Eupomacentrus fuscus*, or coral-reef fish, were among these, as were certain species of catfish.

At Beaufort, conditions of segregation were much more favorable for accurate quantitative measurement of fish noise. Species were put into separate enclosures set off by chicken-wire fence in a 75 x 85 foot experimental salt-water pond about 3 feet in depth, with a mud bottom. Hydrophones were planted in each enclosure. Fish were caught by commercial fishermen, who transported them to the experimental pond in a live car. The number of specimens investigated ranged from several hundred in the case of croakers to three in the case of sea robins. Results of the tests will be discussed briefly here. Fig. 3 shows the frequency characteristics of the various sonic species.

Croaker (*Micropogon undulatus*): The most common drum-fish in the estuarine waters of the U. S. East Coast is the croaker, and this is believed to be responsible for the greatest part of the noise observed in the open-water tests previously discussed. Its noise consists of rapid drum rolls resembling the sound of an electric drill being driven into asphalt. This sound is made by the action of special "drumming muscles" against the fish's air bladder, which is set into resonant vibration at a frequency that should be inversely proportional to its length. In captivity, inside a wire-net enclosure, croakers made noise spontaneously but with noticeably less vigor and intensity than when observed under entirely natural conditions. The noise came in bursts consisting usually of only two or three drum beats of lowered pitch instead of the rapid, vibrant trill heard in open water. Noises were audible under water as much as 25 feet from the source, as was evinced by moving the hydrophone away from the croaker enclosure until the characteristic noise could no longer be distinguished.

Toadfish (*Opsanus tau*): Most remarkable of all fish studied in the current survey was the toadfish. A sluggish, ill-tempered, nest-building bottom dweller, this genus produces a much more intense noise than any other form of marine life investigated. The sound is an intermittent, low-pitched musical blast of about ½-second duration, somewhat similar to a boat whistle, and is concentrated at the low-frequency end of the spectrum, as shown in the typical curve of Fig. 3, which represents the noise emitted by a toadfish within a few inches of the hydrophone.

Unfortunately, the identification of this noise must be based on circumstantial rather than direct evidence. A direct identification was never possible, because no toadfish specimen would make noise in captivity. Hence, instead of following the usual procedure of capturing a specimen and inducing it to make noise, one first located the suspected noise in open water and tracked down its source. This was not difficult, because the characteristic musical sound was heard almost constantly, at least in the distance, wherever a hydrophone was lowered into the water. On moving the hydrophone toward the source of noise until maximum intensity was recorded, it was found that the source remained at one spot on the bottom for days at a time. This fact definitely suggested the toadfish as source, since it is the only sluggish species in this area.

To obtain direct proof, diving was tried but failed because of poor visibility. A baited crab trap was then lowered into the water at the point where the hydrophone indicated maximum noise. Shortly thereafter the blasts stopped for the first time in over a week; and when the trap was pulled up, it contained a toadfish.

Hogfish (*Orthopristis chrysopterus*): A close relative of the grunt, a common tropical offshore fish, the hogfish gets its name from the characteristic grunting noise it makes when taken from the water. This noise is produced by gnashing of the pharyngeal teeth and has a harsh, rasping quality. Under water the noise is made spontaneously in bursts of four or five rasps following each other in rapid succession.

The hogfish is common in the waters surrounding Beaufort, but its noise was heard only occasionally from the Fishery Laboratory Pier on Piver's Island or at Fort Macon. It was concluded on the basis both of tests at Beaufort and of previous aquarium studies that those fish making noise by gnashing of the pharyngeal teeth are not as important sources of underwater noise as those producing sound by action of the air bladder, viz., croakers and toadfish.

Spot (*Leiostomus xanthurus*): The spot, as a member of the Sciaenidae family, is closely related to the croaker, but its noise is of quite a different timbre. The sound might best be described as a series of raucous honks, having a volume level and frequency distribution typified in Fig. 3. Moving the hydrophone away from the enclosure containing the spot indicated that the noise was audible no more than 5 feet from its source, and hence is initially not as intense as that of the croaker.

Spot were heard occasionally around Piver's Island and in offshore waters around Cape Lookout, but the magnitude and character of the noise are such that it is not believed to be a significant contribution to the over-all background level in open water. Moreover, spot are reported to be solitary rather than gregarious, and hence sources of this noise would probably be dispersed.

Sea robin (*Prionotus carolinus*): The segregation tests on sea robins were not very satisfactory because specimens were seldom available, and the only recordings of their sounds were made in aquarium tanks rather than in the experimental enclosures. The noise of this species is so characteristic, however, that the aquarium tests made its identification in natural waters quite simple.

levels due to sea robins alone, since they were always heard simultaneously with croakers and other sonic species.

The mechanism of sound production in the sea robin is, according to Tower (*1*), the same as that of the toadfish. The considerable difference between the noises, however, both in character and intensity, casts doubt upon the correctness of this observation.

Sea catfish (*Felichthys felis*): During the course of the segregation tests it was found rather unexpectedly that the common

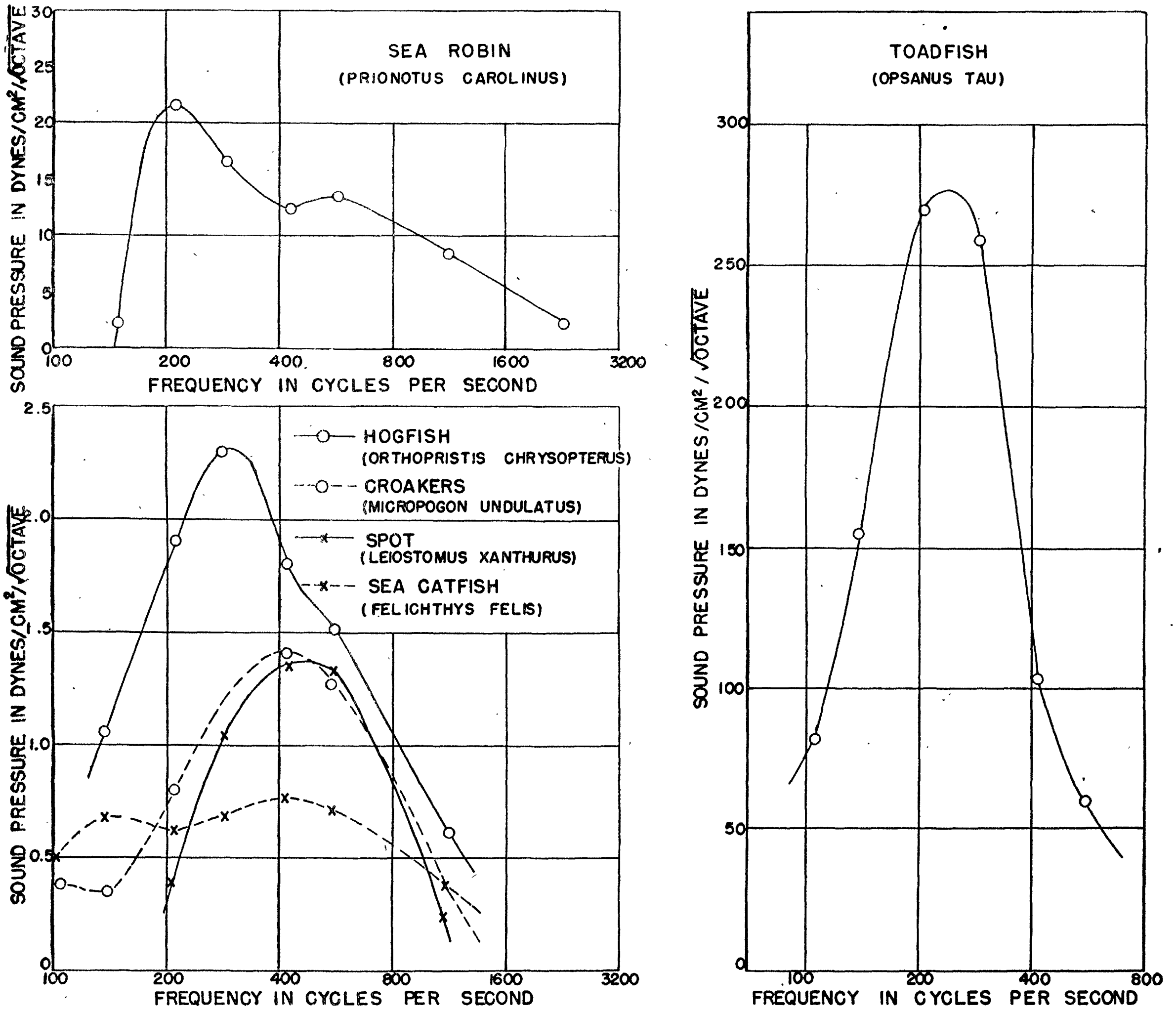

FIG. 3. Spectra of noise produced by segregated groups of sonic fish.

The sound of the sea robin might best be described as a modulated, rhythmic squawk, squeal, or cackle, resembling noises ordinarily associated with a barnyard. The curve in Fig. 3 gives the frequency characteristics and level for the case of a single specimen in a highly reflecting concrete pool.

Sea robin noises were frequently heard in the course of the open-water listening tests both at Piver's Island and Fort Macon, particularly at the latter location. They were also discernible during offshore listening tests past Cape Lookout. It was never possible in field measurements to determine sound

sea catfish is a significant noisemaker. It makes a rhythmic drumming noise like the beating of a tom-tom, differing from the drumming of the croaker in that it comes not in rolls but in rapid, evenly-spaced beats. This noise was heard under natural conditions at Fort Macon and in Bogue Sound, near Morehead City. For this study measurements were made on four catfish in an experimental enclosure.

The motivation for noise production by marine life lies outside the scope of this paper. Further light on it, however, should make possible a more substantial knowledge of behavior patterns in sonic species.

The disc recordings made in connection with water listening described above as well as in the tests on segregated fish are available in the Naval Ordnance Laboratory's files. Dubbings can be made available to any biological laboratory which can put them to use.

Reference

1. TOWER, R. W. *Ann. N. Y. Acad. Sci.*, 1908, **18**, 149–180.

Portable Glycol Vaporizers for Air Disinfection[1]

F. C. W. OLSON, EDWARD BIGG, and BURGESS H. JENNINGS

Northwestern Technological Institute and *Department of Medicine, Northwestern University Medical School*

The promising results of recent studies (*3, 5, 6*) on the use of propylene glycol and triethylene glycol vapors for air sterilization have created a need for portable and inexpensive glycol vaporizers for constant or intermittent use in small spaces such as operating rooms, two- or three-bed hospital wards, laboratories, classrooms, etc. Vaporizers in present use (*1, 4*) are suitable for large spaces, as dormitories, auditoriums, assembly halls, office and factory buildings. While they fulfill the requirements for generation of vapors at a constant rate, size and cost limit their use to relatively large installations.

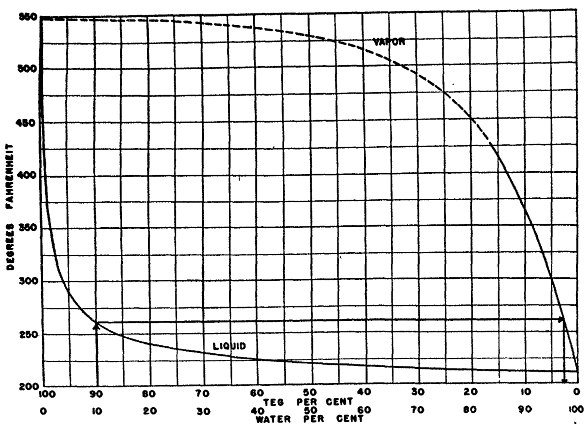

FIG. 1

From study of the temperature-composition diagram of glycol-water solutions (Fig. 1), it may be seen that the relative proportions of vapors emitted from a boiling mixture are dependent upon the concentration of the solution. The total vapor output will depend upon the heat input (rate of boiling). A method for controlling the concentration of the solution would, of necessity, determine the ratio of glycol and water vapor emitted. We have utilized two such control measures in the devices described below.[2] It should be pointed out that while only triethylene glycol (TEG) is mentioned in the description, the apparatus may also be used with propylene glycol (PG) if the different boiling temperature of PG is considered.

The portable vaporizer shown in Fig. 2 retains the essential features of the larger field model, but replaces the expensive and bulky thermoswitch-solenoid valve control system with a thermostatic bellows directly connected to a small valve. A low-pressure water line, which may be an aspirator bottle, is connected to the water inlet. The bellows is filled with a TEG-water solution in equilibrium with the desired concentration in the liquid container. For satisfactory operation, the bellows should be completely immersed and the valve must be above the surface of the liquid.

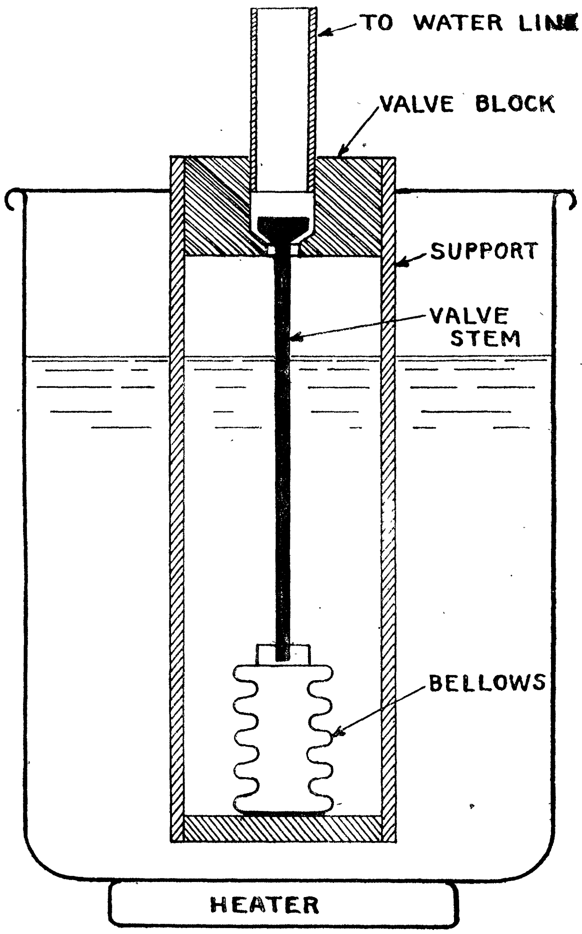

FIG. 2

The container has a capacity of approximately two quarts. It is preferably heated by a disk type three heat coil (100, 200, 400 watts) mounted beneath the vaporizer. An immersion heater may also be used, although it may not be quite as convenient.

To illustrate the mode of operation, assume we wish to vaporize TEG at 290° F. From the temperature-composition diagram, a solution of 4.7 per cent water and 95.3 per cent TEG boils at 290° F., and the corresponding water output is about 96 per cent water and 4 per cent TEG. The bellows is accordingly filled with a 95.3 per cent TEG solution and sealed.

[1] The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Northwestern University.

[2] Patent applications made and assigned to Northwestern University.