As early as 1900 Kahlbaum (*3*) reported that he had successfully distilled Li in a glass system. This reference, which appeared in a rather obscure Swiss journal, seems to have been largely overlooked by subsequent workers. The trick is to keep liquid Li from coming into contact with the glass; the dilute vapor apparently does not react readily. (Whether this is due to the concentration of Li (*g*, Li/cm^3) being less, or whether the rapid reaction of the liquid metal with glass is due to the ubiquitous oxide and nitride impurities, is not known.) Kahlbaum carried out the distillation at a few hundredths of a micron pressure by putting the Li in a silver crucible inside a glass system. The glass walls, on which the vapor condenses, must be kept relatively cool; and this requires a rather delicate heat balance and careful dimensioning of the system, so that the heat applied to the bottom of the tube does not cause an excessive temperature rise in the glass walls, above the metal crucible, where the distillate is collected. The ideal way to carry out this step is by induction heating (which does not raise the temperature of the nonconducting glass significantly). Using a G-E 2-kw electronic heater, operating at about 500–600 kc, and a Type 347 stainless steel cup (instead of silver), a beautiful Li mirror can be deposited on a Pyrex glass tube. In this process, care must be taken to prevent spattering of the liquid Li on the glass walls, particularly upon initial melting; and for this purpose it has been found convenient to weld a "chimney" with baffles over the metal cup. It should be noted that because of the low molecular weight of Li vapor, this and other welds must be extremely tight, and to test this, an He mass spectrometer leak detector has been most useful.

To distill larger quantities of Li, a stainless steel "cold finger" about 1.5 cm in diameter was sealed into a large ground-glass joint by the use of Fernico. This was fitted to the glass distilling tube, about 4 cm in ID and 35 cm long, and cooled with dry ice (solid CO_2). In this way the distilled product collected largely on the metal tube and could subsequently be readily scraped off in an argon atmosphere dry box without contamination by glass or Li-glass reaction products. Although the exact rate of heat input to the steel cup is difficult to estimate because the efficiency of coupling of the work coil to the system is unknown, the following conditions are quoted for the guidance of workers who may attempt to repeat this experiment: current 0.35 a, pressure 0.01 to 0.05 μ, temperature 450° to 500° C. Under these conditions, a distillation rate of about 1 g of Li/hr was achieved, and it has been found convenient to distill 1–2 g at a time in the system.

The resulting Li, on exposure to air at room temperature, does not react and darken rapidly as a freshly cut surface of commercial Li will, but retains a shiny and metallic luster for 10 hr or more. We have also observed in this laboratory that the rate of reaction of distilled sodium with air is markedly less than that of more impure material. The effect of traces of impurities on the corrosion of other metals is well known; thus, for example, it is reported (*4*) that, whereas 99.95% pure zinc dissolves completely in 10% HCl at room temperature, in the same time under identical conditions, "chemically pure" zinc (99.99%) loses 53% by weight and "spectroscopically pure" zinc (99.999% or better) loses only 0.02%. Similarly, in a study of the dissolution rate of aluminum in NaOH solutions, Streicher (*5*) found that under identical conditions (0.3N NaOH, 23° C, specimen area 40.5 cm^2, test period 240 min), a sample containing 0.0005% Fe as the principal impurity lost only 115 mg, whereas one containing 0.84% Fe lost 1075 mg. The observations noted above on the reactions of purified alkali metals with air are consistent with these large effects of impurities on corrosion rates in electrolytic systems.

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An Instrument for Dynamic Vital Capacity Measurements[1]

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The vital capacity has been used for the clinical evaluation of pulmonary function for more than 100 years without any modification (*1*). It is recognized that this test cannot give any indication of defects of distribution or diffusion of gases. Even now, however, it is widely employed in efforts to evaluate ventilatory function concerned with the exchange of air between the outside atmosphere and the lungs. The use of the vital capacity in this connection is based on the misconception that the effectiveness of ventilation is solely dependent on the stroke volume, or the amount of air that can be moved by a single maximal effort of all the muscles of respiration (*2*).

Interest in applied clinical pulmonary physiology has been greatly stimulated during the past 20 years by the rapid advances in thoracic surgery and phthisiotherapy. During this time it has been increasingly

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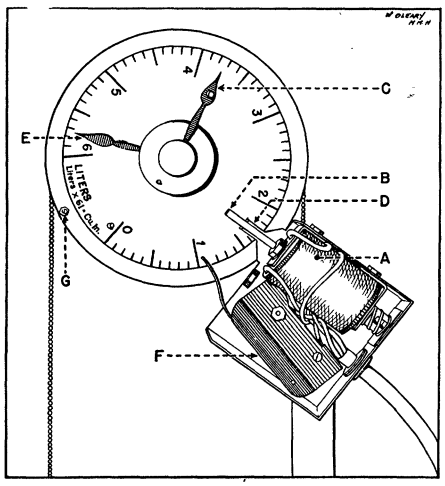

FIG. 1. Timed-capacity attachment mounted on spirometer. The cover has been removed, and changes made on the calibrated wheel are indicated.

apparent that the effectiveness of ventilation depends not so much on the single stroke volume as on the volume of air that can be moved per unit of time. A number of investigative methods, including maximum breathing capacity, high-speed recording spirometry, air-velocity studies, and alveolar pressure determinations, have been developed to evaluate this time-volume relationship. These methods, because of the complexity and expense of the apparatus and the trained personnel required, have been largely reserved for the laboratory engaged primarily in research. The vital capacity, therefore, continues to be the most widely and most frequently used test of pulmonary function, with consequent frequent misjudgment of the degree of pulmonary insufficiency.

An attachment for the standard vital capacity spirometer has been constructed with the aim of evaluating stroke volume as well as its time relationship. It measures and records simultaneously the total vital capacity and the volume exhaled during any preset time interval from 1 to 10 sec without recourse to a kymograph and later tracing analysis. The timing cycle is initiated by the onset of the patient's maximal expiratory effort. The apparatus does not introduce added resistance in the airway, it is inexpensive, its use requires no special training on the part of physician or patient, and the test requires no more time or effort than an ordinary vital capacity determination.

The spirometer attachment.[2] The unit, with its cover removed, attached to a spirometer is shown in Fig. 1. It consists of a small, plunger-type solenoid (*A*) and a microswitch (*F*), both used in conjunction with a simple electronic timer (Fig. 2). Before the test, the graduated wheel is set at zero liters, as in the usual vital capacity test. This setting impinges the small pin (*G*) against the lever of the normally closed microswitch (*F*) and thereby opens that switch. As the patient exhales into the spirometer, the graduated wheel turns clockwise and the pin (*G*) moves away from the microswitch actuator, closing the switch, which initiates the timing cycle. For the duration of the timed interval the solenoid (*A*) is activated by the timer, and the plunger (*B*) protrudes. At the end of the previously selected time interval, the plunger retracts. The standard pointer (*E*) indicates the total vital capacity by arrest of its motion by the customary pointer rest (*D*). A second pointer (*C*) was added the motion of which is arrested by the solenoid plunger (*B*) only for the duration of the timed interval. At the completion of the test the pointer (*E*) indicates the total vital capacity irrespective of time—in the illustration, 5,740 ml. Pointer (*C*) shows the volume exhaled during the preselected time interval—here 3,750 ml. Return of the calibrated dial to the zero position automatically resets the timer and spirometer for the next test.

The timer. The circuit for the timer (Fig. 2) was adapted and modified from a welding control (*3*). Instead of a high-vacuum tube it uses a miniature thyratron tube, whose cutoff is sharp and does not depend on a slowly rising plate current. It is therefore well adapted to timing very short intervals. The interval does not fluctuate with line voltage and is not

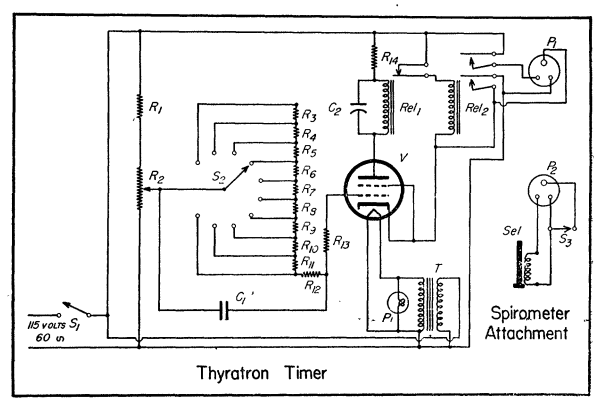

FIG. 2. Circuit diagram for thyratron interval timer and vital capacity attachment for determination of timed capacities. (Entire timer can be enclosed in a 5″ × 7″ × 2½″ chassis.)

List of components

R_1 = 100,000-ohm, ½-w resistor
R_2 = 10,000-ohm potentiometer
R_3–R_{12} = 180,000-ohm, ½-w resistor
R_{13} = 10,000-ohm, ½-w resistor
R_{14} = 100 ohm, ½-w resistor
C_1 = 2-μf, 600-v oil condenser
C_2 = 4-μf, 150-v electrolytic condenser
Rel_1 = 10,000-ohm, s–p, s–t, normally closed midget relay
Rel_2 = 115-v a-c, d–p, s–t, normally open midget relay
Pi = 6.3-v, 0.25-a pilot light
S_1 = s–p, s–t toggle switch
S_2 = 10-pole, single-gang, single-circuit nonshorting rotary switch
S_3 = Microswitch, BZ-2RW, with spring removed, wired normally closed
Sel = Miniature solenoid, 115-v a-c, 1-oz pull, intermittent duty, modified as in Fig. 1
T = Transformer, 115-v–6.3-v, 1-a
P_1,P_2 = 3-prong polarized plug, male and female
V = Tube 2 D 21 (Types 2050 and 2051 may be used, requiring slightly different value for C_1)

[2] The entire spirometer or the attachment and timer may be obtained from Warren E. Collins, Inc., 555 Huntington Ave., Boston 15, Mass.

affected by heat and humidity if a high quality oil condenser is used for C_1. The constants given in Fig. 2 permit choice of any time interval from 1 to 10 sec in 1-sec steps. After the tube has been installed the time selector is set for 10 sec and the potentiometer R_2 is adjusted with a screwdriver until the timed interval is exactly 10 sec as checked with a stop watch. No further time adjustment is required until the tube is changed. The timer has only two external controls, S_1, which turns the instrument on and off, and S_2, which permits selection of the time interval.

The test. The timer is turned on about 1 min prior to the test to permit warming of the tube filament. The graduated dial is set at zero, the desired time interval is selected, and the patient is instructed to take as deep a breath as possible and then to exhale all the air as rapidly as possible into the mouthpiece. The dial is returned to the zero position, and the timed volume and total vital capacity are recorded. Before the test only two special precautions must be observed. The patient must be instructed to exhale *all* the air in his lungs as *rapidly* as possible. The mouthpiece used must have an internal diameter at least as large as the inlet to the spirometer; otherwise an undue resistance to the flow of air is introduced and expiration will be abnormally prolonged.

Results. A detailed clinical analysis of the timed capacity tests in normal volunteers and in patients with various types of ventilatory insufficiency will be presented elsewhere (*4*). The instrument has been used as a part of the routine pulmonary function work at our laboratories for the past 18 months.

A number of time intervals from 0.1 to 10 sec have been tried. The 1-sec, 2-sec, and 3-sec volumes were found to be the most significant for differentiation between various types of ventilatory insufficiency. Normal volunteers and "pulmonary normal" hospitalized patients were able to exhale on the average 83% of the total vital capacity during the first second of the vital capacity effort, 94% during the first 2 sec, and 97% during the first 3 sec.

When a 4-mm stenosis, approximately the smallest compatible with life, was introduced in the spirometer tubing, no effect on the volume of the total vital capacity was observed. However, the 1-sec volume was reduced by 84%, the 2-sec volume by 59%, and the 3-sec volume by 39%.

Patients with ventilatory insufficiency fell into two groups. Those with "restrictive" insufficiency (*5*) usually had pulmonary parenchymal or pleural disease or had had previous resection or collapse of pulmonary tissue. The ventilatory defect in these patients was one of reduced stroke volume, and the percentages of the total vital capacity expired during the various time intervals were essentially normal. For example, in 58 patients who had had thoracoplasty, the mean vital capacity was reduced to 61% of predicted normal, but 74% of this volume was exhaled during the first second of the effort, 89% in the first 2 sec, and 93% during the first 3 sec.

In the second group were patients with "obstructive" ventilatory insufficiency (*5*). They had bronchial disease or loss of pulmonary and thoracic elasticity, as in bronchial asthma, pulmonary emphysema, and anatomic obstruction of a major bronchus. The defect in ventilation here was due to abnormal resistance to the flow of air or abnormal resistance of the lungs and thorax to deformation. In these patients the single stroke volume was often nearly normal, but the expiratory velocity was markedly reduced, and the percentages of the total vital capacity exhaled during 1, 2, and 3 sec were extremely abnormal. In 28 patients with severe bronchial asthma, for example, the mean total vital capacity was 71% of predicted, but only 43% of the total volume was exhaled during the first second, 59% in 2 sec, and 71% in 3 sec.

Results of the timed capacity tests were correlated with a number of other tests of ventilatory function. The coefficient of correlation, r, between the conventional vital capacity and the maximum breathing capacity varied from 0.24 to 0.56, depending on the number of patients with "obstructive" insufficiency included in the series. The correlation improved with the shorter timed capacities, and r between the 1-sec volume and the maximum breathing capacity was 0.88. regardless of the type of patients included in the series. In contrast to the total vital capacity, timed capacities correlated well with the air-velocity index (*2*) and the ratio of residual volume to total lung capacity. Furthermore, in normal volunteers and in all patients except those with bronchial asthma the percentages of the total vital capacity expired at the various time intervals varied little on repeated occasions the same day and from month to month over the course of 1½ years.

A larger number of studies will be required to correlate clinical symptoms of dyspnea with the timed capacities and to determine whether the actual volumes exhaled at the various time intervals or the percentages of the total vital capacity are the more significant data.

The timed capacity is not suggested as a substitute for any of the more elaborate tests of ventilatory function available in the physiology laboratory. It is suggested for use in the clinic, hospital ward, and physician's office, for large-scale and screening studies, and for the study of the effectiveness of protection afforded by bronchodilator drugs. It offers a simple method for measurement of both stroke volume and effective ventilation and for differentiation between "obstructive" and "restrictive" ventilatory defects.

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