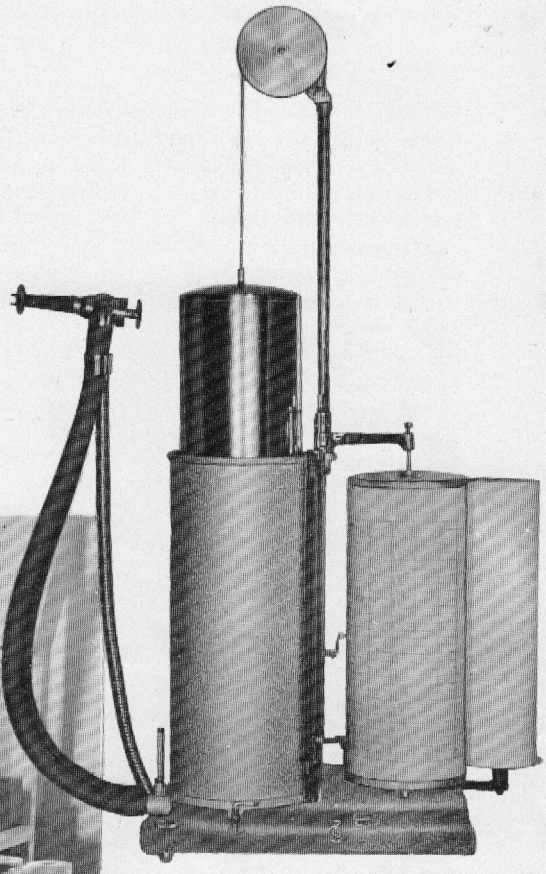
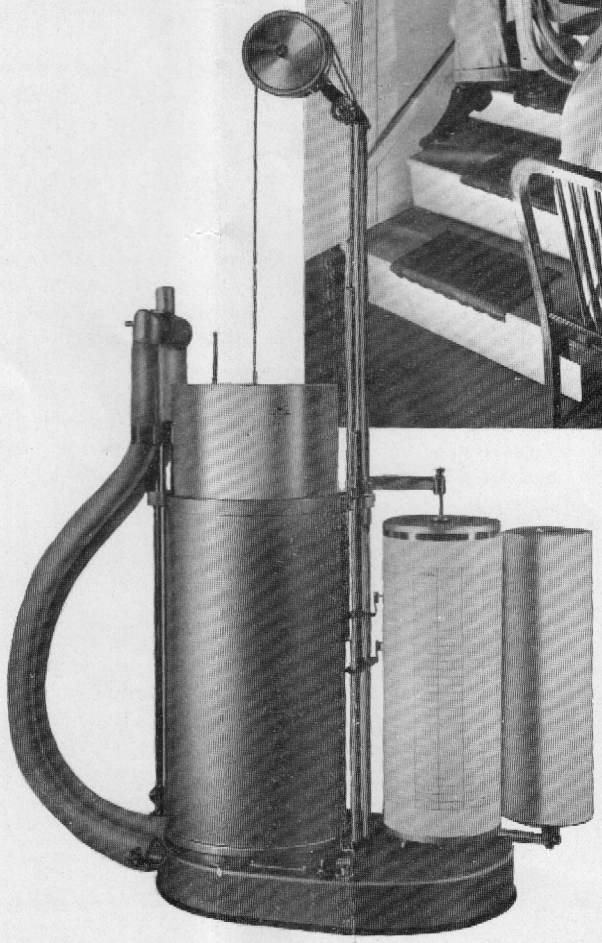
COLLINS RESPIROMETER

An apparatus for the study of Cardiorespiratory Function





Manufactured and Sold by

WARREN E. COLLINS, INC.

Specialists in Respiration Apparatus

555 HUNTINGTON AVENUE

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What it is. The Collins Respirometer embodies the same principles of construction as the Benedict-Roth metabolism apparatus plus special accessories for the estimation of cardiorespiratory function. It can be used for B.M.R. determinations, although it was designed primarily for recording the respiratory excursions and lung volumnia in pulmonary disease.

The Respirometer is made in two models — a nine liter and a thirteen and one-half liter size. Both models come equipped with extra large soda lime containers, extra easy breathing valves and large bore tubing. Each has a two-speed kymograph (32 mm. per minute paper travel at the slow speed and 160 mm. per minute at high speed), continuous roll paper and a Reichert ventilograph which integrates graphically the inspiratory excursions of the spirometer bell.

The nine liter size is usually adequate, particularly if one wants a combination instrument; that is, one for metabolism testing as well as analysis of respiratory patterns. However, for large chest clinics the thirteen and one-half liter size is often preferable.

Value of Pulmonary Function Tests. The importance and value attached to cardiorespiratory function tests have increased rapidly within the last decade. The opening of new, and the expanding, of already existing units for experimental and clinical investigation of cardiorespiratory physiology are proof of the growing interest in detailed analysis of any abnormalities of this system.

The early diagnosis of pulmonary disability and the evaluation of borderline pulmonary function are of paramount importance, particularly in patients undergoing thoracic surgery. These tests are also useful in evaluating suspected pulmonary disease in dyspnea of nonorganic origin associated with hysteria, neurocirculatory asthenia in malingering, and in industrial and compensation cases. With the Respirometer clinicians may follow the course of the disease and may evaluate medical therapy or surgical results. The apparatus has been used for differentiating dyspnea of cardiac origin from that due to pulmonary disease, and primary from secondary types of polycythemia. It is not uncommon to reveal early pulmonary abnormalities not found on physical examination or the chest X-ray.

Industrial firms, whose employees are subject to exposure to harmful dust, may screen workers with pulmonary function tests and detect early lung changes; and steps can be taken to prevent progression of the disease, and to eliminate permanent disability with its great financial cost.

The Respirometer is used in the measurement of the following static and dynamic pulmonary volumes.

Tidal Volume. This measurement shows the amount of air exchanged with each breath at any level of activity. Poor coordination of respiratory movements or shifting of the pulmonary mid-position is clearly indicated. It will show any shift of this resting position in the inspiratory direction, i.e., towards hyperinflation, or increase of functional residual capacity. This information has been found useful in the diagnosis of emphysema, in chest deformities with restricted breathing, poliomyelitis, in respiratory neurosis and malingering.

Minute Volume. This is the tidal volume multiplied by the inspiratory rate per minute. It indicates the amount of air required at rest or during controlled exercise as with the step test, treadmill or bicycle ergometer.

Vital Capacity. The importance of a lowered vital capacity in pulmonary and cardiac disorders has long been recognized. The vital capacity is always reduced in restrictive pulmonary insufficiency, such as fibrosis, bronchogenic tumor, pneumothorax, atelectasis, pleural adhesions and empyema. It is often impaired in obstructive pulmonary disorders as in asthma and emphysema. An estimate of the volume exhaled per unit of time may be obtained by using the kymograph at the 160 mm. speed and using the Segal-Herschfus Timed Interval Ruler. The level of quiet respiration may also be estimated from the magnitude of the inspiratory capacity and the expiratory reserve volume, and much significance is attached to the disproportionate decrease of one or the other. "Trapping" of air may occasionally be diagnosed by a stepladder appearance of the expiratory slope.

Congestion of the pulmonary vascular bed in heart failure results in a decreased vital and breathing capacity. Expansion of the lung is decreased in proportion to the degree of congestion, but retraction is affected only to a smaller degree. Lung expansion is limited, but it returns to its original position on expiration. Besides a decrease in vital capacity, there is a greater reduction of expiratory reserve volume. The progressive retardation found in emphysema will not be present in congestive heart failure.

Maximum Breathing Capacity. The Respirometer may be modified for performance of this test by removal of the soda lime container and flutter valves. The Reichert ventilograph automatically integrates and records the total maximal breathing capacity. For normal or nearly normal subjects, the larger spirometer is much more suitable for this particular study. The M.B.C. is the amount of air exchanged by breathing in and out as rapidly and deeply as possible during a 15 to 30 second interval.

Expressed in liters per minute, this test indicates either restrictive or obstructive ventilatory insufficiency. An increase in the M.B.C., after the use of bronchodilator aerosol, points to bronchial asthma. The tendency to small amplitude and elevation of pulmonary mid-position is characteristic of pulmonary emphysema. By addition of carbon dioxide it is occasionally possible to detect malingering.

Oxygen Deficit. The presence of oxygen want in the blood and bodily tissues has been estimated with the Respirometer. Normal subjects will not show an increase in oxygen consumption when breathing is changed from room air to high concentrations of oxygen. Patients with oxygen deficit show an immediate and temporary increase in consumption of oxygen when this change is made. This information may be of importance in evaluating various pathological states, particularly right ventricular failure and cor pulmonale.

Minute Oxygen Uptake. This is determined from the slope of the respiratory curve at any level of activity as is usually done for the B.M.R. test. By comparing the minute oxygen uptake and the minute ventilation, it can be ascertained how much air needs to be exchanged for a given oxygen uptake (ventilatory equivalent, coefficient of oxygen utilization). Any increase of the amount of air required suggests hyperventilation, either voluntary or due to difficulties in intra-pulmonary mixing of alveolar capillary gas transfer.

The Functional Residual Capacity and Residual Volume. This volume cannot of course be read directly from the tracing. However, a number of techniques have been devised involving the use of the Respirometer, the use of a foreign gas such as helium or hydrogen and a continuous gas analyzer. By these techniques the gas of known volume and concentration in the spirometer is thoroughly mixed with the gas in the lungs and by measuring the final volume and concentration in the spirometer, the residual volume, functional residual capacity and total lung capacity can be calculated.

Constant Gas and Room Air Breathing. Use of the closed circuit technique with the Respirometer entails a constantly changing concentration of the inspired gas. The open circuit techniques have the disadvantage that no record is obtained to combine the advantages of graphic recording with those of constancy of inspired gas composition. However, the Respirometer has recently been used in conjunction with box-balloon systems making possible both recording and constant gas mixtures.

Bronchospirometry. The Respirometer has been used for recording ventilation, oxygen uptake and vital capacity and its subdivisions for both lungs — separately or simultaneously. For simultaneous recording two Respirometers may be used or a double Respirometer (bronchospirometer) is available which can be equipped with two air-tight boxes fitted with balloons. This allows the breathing of ambient air with simultaneous graphic recordings, particularly useful during differential residual volume determinations. The spirometer here is used only to reflect volume changes within the bells. The use of this method, as well as that of high oxygen breathing, gives much evidence that a greatly diseased lung will absorb relatively more oxygen at inspiratory oxygen tensions higher than those of ambient air.

The Collins Respirometer is an apparatus that provides permanent, accurate records which aid in the diagnosis and treatment of cardio-respiratory disease. Therapeutic results can be closely followed and by comparison with previous graphic records, progress can be evaluated. It has proved of value in industrial medicine compensation cases and the evaluation of validity of disability claims. The Collins Respirometer is the scientific development of the leaders in the field of cardiorespiratory function, and by its use, graphic records are obtained which aid immeasurably in the interpretation of disorders in this field.

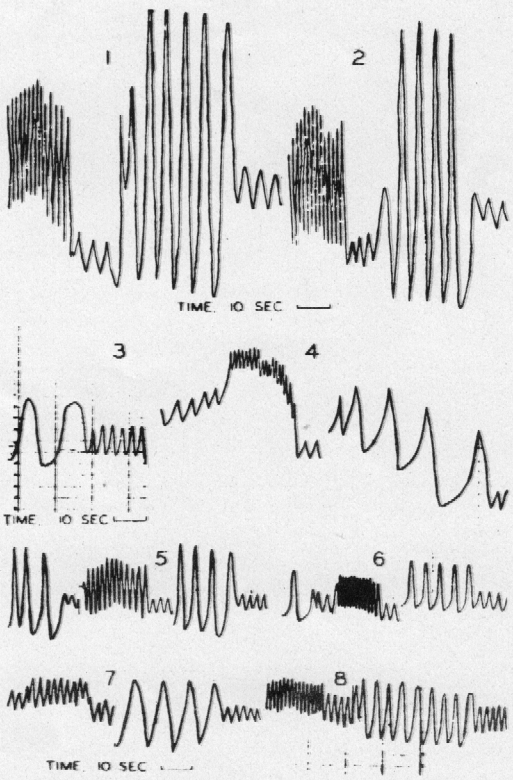


Fig. 2. Spirograms of normal and pathological subjects, in quiet breathing, vital capacity breath, maximal deep breathing, maximal rapid breathing. Tracing reads right to left, inspiration upward, expiration downward. Sections 1 and 2, normal subject; 3, cardiac patient; 4, advanced emphysema; 5, after thoracoplasty; 6, after thoracoplasty; 7, fibrosis and tracheobronchial stenosis; 8, kyphoscoliosis.

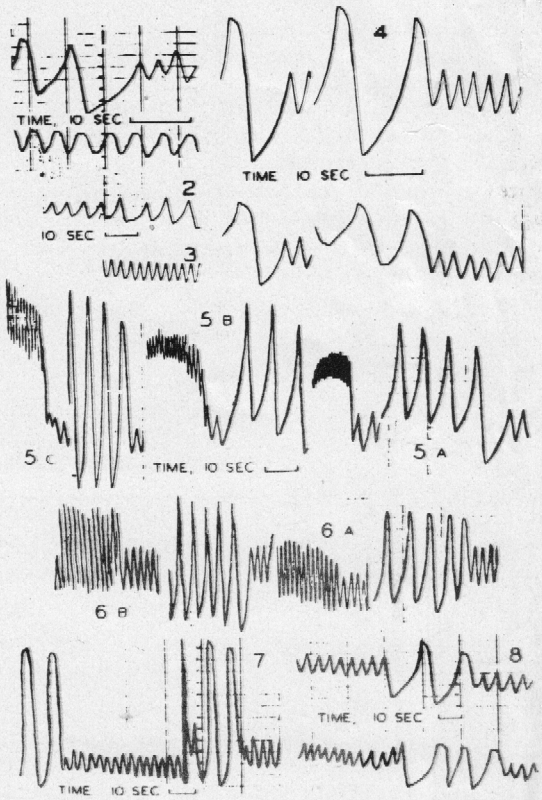


Fig. 3. Pathological spirograms. Section 1, emphysema, deep breathing; 2, emphysema, quiet breathing; 3, after thoracoplasty, quiet breathing; 4, emphysema before adrenalin (lower tracing), after adrenalin (upper tracing); 5 and 6, emphysema before and after bronchodilators; 7, cardiac patient (compensated); 8, combined cardiac and emphysema.

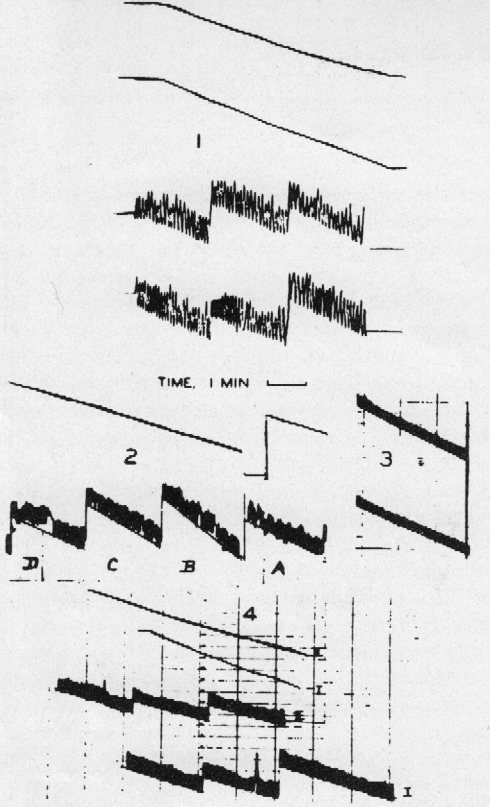


Fig. 4. Oxygen deficit tracings. 1, normal subject; 2, anoxaemic subject; 3, dyspnoeic subject, slight anoxaemia; 4, dyspnoeic subject, not anoxaemic.

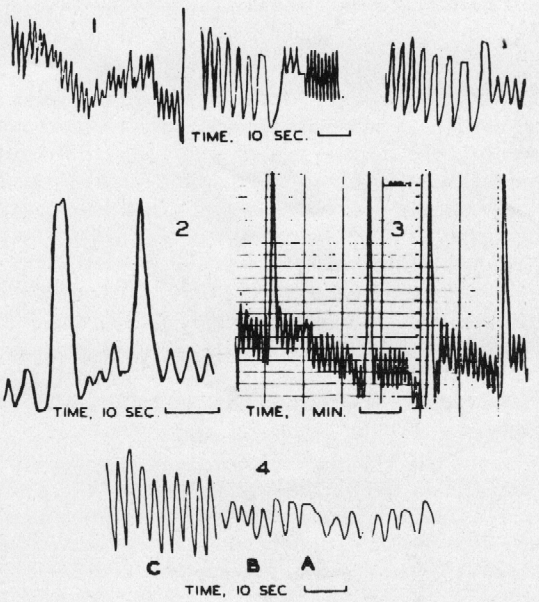


Fig. 5. Abnormal spirograms. 1, nonunion of ribs; 2 and 3, respiratory neurosis; 4, malingering: (a) vital capacity, (b) voluntary maximum breathing, (c) reflex (CO_2) maximum breathing.

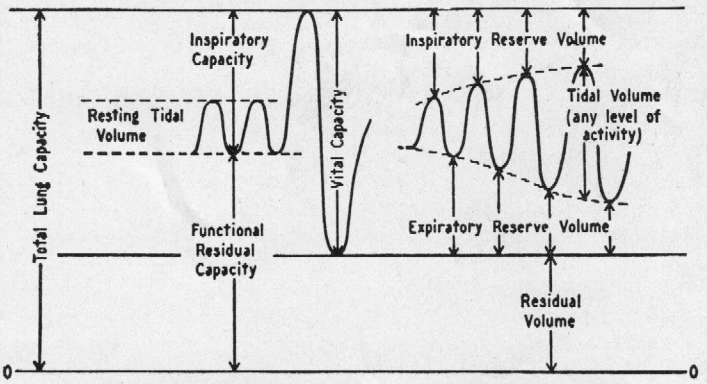
Specifications

The Collins Respirometer consists of either tne nine or thirteen and one-half liter spirometer equipped with quickly removable soda lime containers. Two low resistance, easy breathing valves direct air flow silently without a motor-blower unit; a two-speed electric kymograph provides a paper travel of 32 mm. and 160 mm. per minute. The Reichert ventilograph (automatic ventilation recorder) integrates all the inspirations and is a standard part of the apparatus. The apparatus is fabricated of copper, bronze and other rust resisting materials and finished in baked enamel hammertone with trimmings of chromium.

Complete with continuous roll of graduated kymograph paper, one gallon can Baralyme, 3 rubber mouthpieces, 1 rubber-tipped noseclip and 1-one oz. bottle of recording ink.

STANDARDIZED TERMINOLOGY

A committee of respiratory physiologists have agreed on the following terminology when referring to lung volumes and subdivisions:



(Courtesy of *Federal Proceedings* and J. R. Pappenheimer)[10]

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