oxygen uptake during step-up exercise and (6) the character and duration of dyspnea after step-up exercise.

In another study Motley[64] concludes that spirography provides a tremendous amount of information on the status of the individual's lungs. He feels that impairment of oxygen transport across the pulmonary membrane may be present in some cases with essentially normal spirographic tracings, but the percentage of this group is very low. He concludes that:

1. Spirogram tracings of the three-second timed vital capacity and the maximal breathing capacity have been found: (1) useful screening tests of pulmonary function to detect early lung function abnormalities even before subjective or roentgenologic changes are apparent and (2) suitable tests for annual or pre-employment examinations to detect susceptible or poor risk individuals who may be exposed to environmental lung irritants in their work. 2. The spirograms are cheap to run, rapid in measurement (five minutes), and easy and simple to obtain for permanent records. 3. The reliability of the spirogram data has been well correlated with complete pulmonary function studies on a large series of cases with all degrees of pulmonary function impairment, and a wide spread of values has been shown between the normal and the most abnormal. 4. If the observed measurements of either the three-second timed vital capacity or the maximal breathing capacity are reduced more than 15% from the predicted, the subject should be studied and evaluated further before being allowed further exposure to environmental breathing hazards.

Motley, Gordon, Lang and Theodos,[55] in studying the impairment of pulmonary function in anthracosilicosis, stress the importance of emphysema as the disabling mechanism in this disease. They point out that as the ratio of residual air to total capacity increases, the maximum breathing capacity and the vital capacity decrease. They note sharp decrease in the oxygen saturation of arterial blood with mild exercise and feel that this is a very significant measurement in the evaluation of disability indicating a disproportion between ventilation and perfusion ratios when the consumption of oxygen is increased by work. They emphasize that respiratory gas exchange may be normal at rest and yet show significant abnormality during exercise. In approximately 30 per cent of the cases studied, residual air percentage of total lung volume was within normal range. They felt that the dysfunction present in these cases was due to poor distribution, that is, inequality between well-ventilated alveoli and perfused alveoli. There was no apparent correlation between the roentgenographic stage of silicosis and the degree of impairment of pulmonary function in many cases. They conclude that an accurate evaluation of the degree of impairment of pulmonary function requires a battery of pulmonary function tests, and they condemn the use of a single test to appraise all cases. This opinion is shared by Comroe[54] who states "there is no single test by which all aspects of pulmonary function can be evaluated and no magic number which serves as a sharp-defined line between health and pulmonary disability."

The expression of residual capacity as a percentage of total lung capacity must be interpreted with reference to age. Greifenstein *et al.*[68] have shown that

[68] F. E. Greifenstein, R. M. King, S. S. Latch, and J. H. Comroe, *J. Appl. Physiol.*, 641 (1952).

[illegible] is not independent of age, there being a considerable rise in the percentage [illegible] apparently healthy subjects. Gilson and Oldham[59] showed normal males, age [illegible] had on the average a ratio 12 per cent greater than men age 25. They felt that [illegible] indicated changes in normal individuals that are the same as those that occur [illegible] emphysema. They also point out the difficulty of using an absolute ratio in [illegible] advanced pneumoconiosis of the massive fibrotic type where the increased ratio [illegible] principally due to a fall in the vital capacity, the absolute value of the residual [illegible] capacity being on the average smaller than in normal subjects. Motley,[50] using [illegible] absolute ratio of 35 or above as indicative of emphysema, feels that emphysema [illegible] defined as an RC to TC ratio of over 35) "does not appear to be any more a [illegible] part of the aging process than is hypertension. Many individuals have [illegible] hypertension without complaints over a period of years while actively [illegible] yet their blood pressure is not considered normal; and the same may be [illegible] of emphysema, because individuals may have residual volumes of 45 per [illegible] or more of total lung volume without complaints, but this increased residual [illegible] is abnormal and does represent emphysema in most persons."

[illegible] study of 50 men with silicosis,[69] the degree of emphysema as expressed [illegible] the ratio of residual capacity to total capacity was found to vary without any [illegible] correlation to the stage of silicosis. The maximum breathing capacity also [illegible] no significant difference between the three stages of silicosis, mean values [illegible] liters for Stage I; 50 for Stage II; and 45 for Stage III. Pelnar[70] proposed [illegible] use of ventilatory equivalents for oxygen and carbon dioxide simultaneously [illegible] during rest, exercise, and recovery as a basis for disability evaluation [illegible] silicosis. This work is predicated upon the principle that people with pulmonary [illegible] circulatory disease are unable to utilize inspired air properly even at rest. During exercise they are able to improve the utilization of air only poorly or not at [illegible] Motley,[55] using the technique of Pelnar on 100 miners, found no correlation [illegible] between ventilatory equivalents and over-all impairment of pulmonary function.

[illegible] apparent from the above review of current work that determination of [illegible] disability in silicosis through the use of function tests is not a simple matter. No [illegible] single test is adequate and the problem of the significance of minimal functional [illegible] aberrations remains unanswered. It is also apparent that the area of normal has [illegible] never been clearly defined. One must deal not with a razor's edge, but with a [illegible] band. The normal man is a nonexistent, statistical composite derived from [illegible] the study of many differing individuals.[49] For example, the normal man can be [illegible] expected to vary from his predicted normal by as much as 35 per cent. Thus a [illegible] person whose maximal breathing capacity is 35 per cent below the predicted nor-

[illegible] Broad and J. Georg, The clinical evaluation of disability in silicosis, *Acta Med. Scand.*, [illegible] 340–357 (1953).

[illegible] Pelnar, Impairment of pulmonary function in anthracosilicosis, *Arch. Ind. Hyg. and Occupational Med.*, 6, 532 (1952).

[illegible] Cochrane, C. M. Fletcher, J. C. Gilson, and P. Hugh-Jones, The role of periodic examination in the prevention of coalworkers' pneumoconiosis, *Brit. J. Ind. Med.*, 8, 53–61 (1951).