GATING MECHANISM FOR MOTION-FREE LIVER AND LUNG SCINTIGRAPHY

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Radionuclide images of organs subject to physiologic motion contain distortions which are overt in rectilinear scanning (*1,2*) but obscure in camera studies. Improvement of liver images by collecting data from the gamma camera during periods of suspended breathing has been reported (*1,3,4*) but this is not feasible in many patients. Mechanisms capable of restricting data collection to limited periods of diaphragmatic motion would yield images relatively free of motion distortions (*5*). We have developed an inexpensive gating instrument that permits collection of data during any limited portion of the diaphragmatic excursion.

GATING MECHANISM

The transducer portion of the instrument consists of a 10,000 Ω potentiometer, constant tension spring, and a Teflon tape (Fig. 1). The axis of the potentiometer is fitted with a pulley on which a Teflon tape is wound and a coiled spring attached to the axis provides a constant tension for any length of extension of the Teflon tape.

The potentiometer is mounted on one side of the examining table, the Teflon tape extended across the costal margin region of the chest and attached to the opposite side of the table. Inspiration extends the Teflon band, rotates the potentiometer, and increases the voltage while expiration causes the reverse. With the patient breathing quietly the potentiometer is rotated manually, centering the midpoint of the voltage change from the respiratory movement at the approximate midpoint of the meter relay (Fig. 2). The extremes of the voltage changes are brought within the limits of the meter relay by sensitivity adjustment (50,000-Ω potentiometer). The meter relay allows adjustment of two indicators which enable two relays to be actuated when the meter needle crosses either one of the two-set indicator points. The indicator points may be independently adjusted for any position during the respiratory cycle.

The potentiometer is part of the resistance bridge that consists of two 4,700-Ω resistors (Fig. 3). The two ends of the bridge formed by the junction of a

Received May 31, 1972; revision accepted July 20, 1972.
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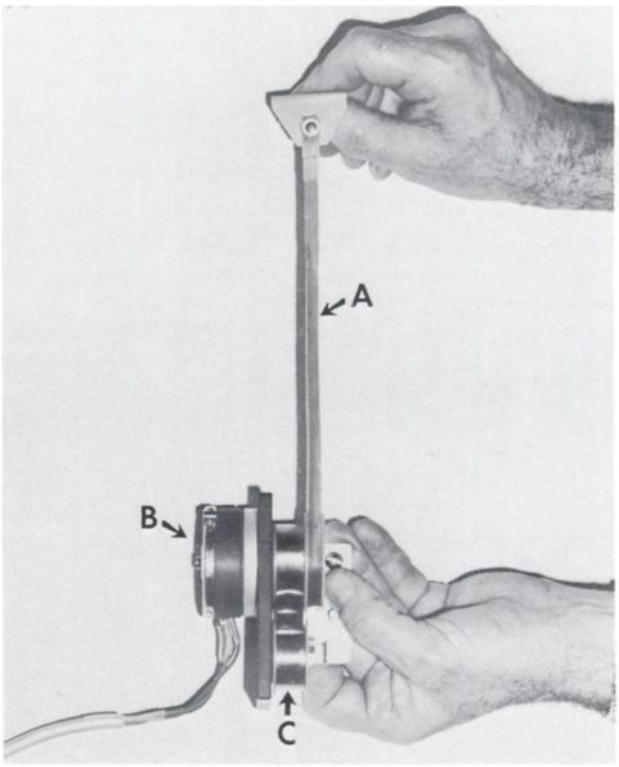

FIG. 1. Transducer portion of gating mechanism. Movement of band (A) twists potentiometer (B) which varies voltage. Tension is maintained on band by means of coiled spring (C).

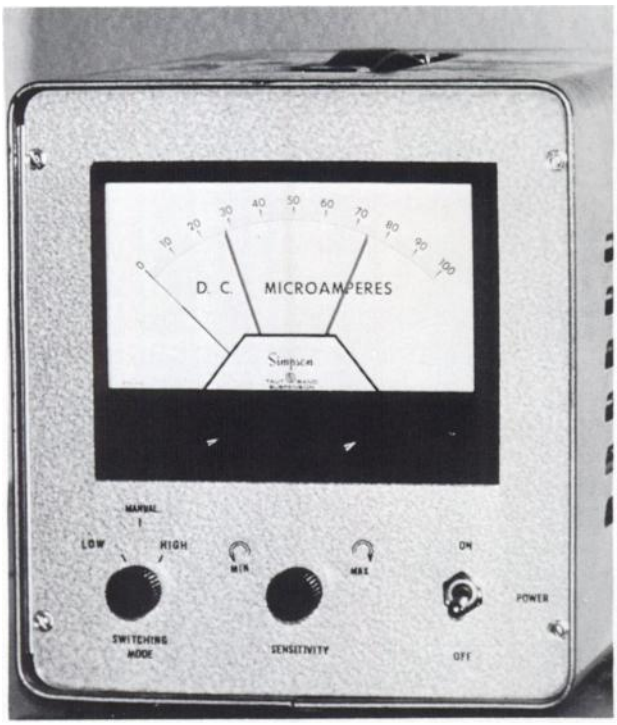

FIG. 2. Dual limit meter relay. Pointers at 28 and 74 are low and high indicators for their respective limits. Narrow pointer at 0 μA reflects instant voltage during respiration.

potentiometer end and a 4,700-Ω resistor are excited by a dc power supply. The remaining two sides of the bridge are formed by the potentiometer slider and the center between the two points. Two diodes in parallel protect the meter movement. By means of a 50,000-Ω potentiometer, sensitivity of the output from the circuit can be adjusted.

Operation of the "gates" is controlled by the "switching mode" (Fig. 2). In the manual position the camera operates independently of the gating mechanism. A switch on the control panel has two positions, the low position for expiratory phase and high position for inspiratory phase. In the low position the camera is triggered when the instrument needle is below the lower limit manually set on the meter and the relay is closed, i.e., during expiration when the voltage is decreased. When the instrument needle (and the voltage) increases above the lower limit the relay opens, the circuit is broken and the camera no longer collects data. Similarly, data are collected in the inspiratory position when the meter needle (and voltage) exceed the upper limit.

DISCUSSION

It is paradoxical that the two major organs, lung and liver, commonly examined by radionuclide imaging are (A) both subject to respiratory motion, and (B) both normally visualized as a "sea" of activity. Detection of pathology in either organ depends on a focal decrease in radioactivity. It is much more difficult to detect decreased activity surrounded by normal activity than the reverse such as the case in lesions of the brain. Compounding this problem is the constant movement of both organs which decreases the differences between high and low concentrations of activity and lowers the resolution of lesions. In order to improve the resolution of organs subject to motion, it is necessary to record only during the same phase when more than one collection period is required.

Kranzler, et al (*3*) have demonstrated that respiratory motion not only displaces the entire liver but may also change its shape depending on the pathology present. Figure 4 illustrates the effect of

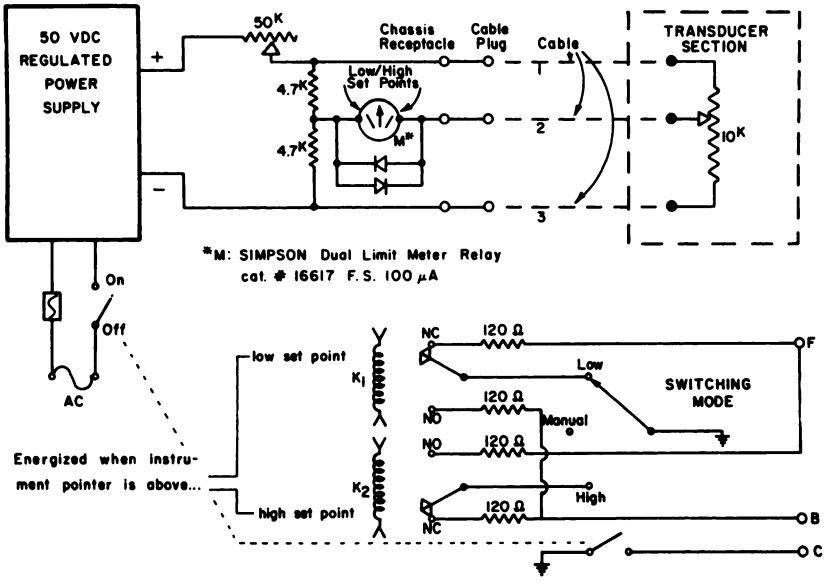

FIG. 3. Schematic diagram of gating mechanism.

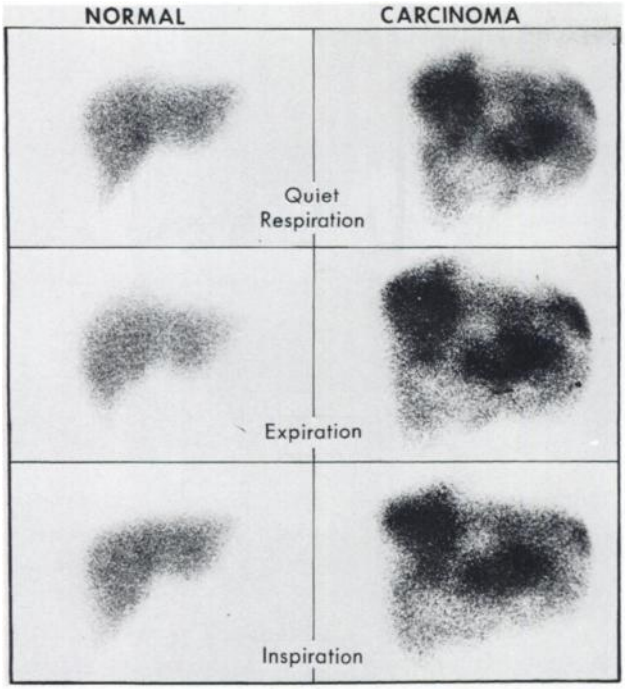

FIG. 4. Images of normal pliable liver and firm liver, largely replaced by carcinoma, were made at inspiration and expiration by means of gating mechanism. For comparison, images were also obtained during quiet respiration without gating.

respiration on the normal pliable liver, imaged during quiet respiration, at the end of inspiration, and at the end of expiration, and also illustrates the effect of respiration on a firm liver with little pliability because of metastatic carcinoma. The inspiratory and expiratory images in Fig. 4 were performed with the gating mechanism. Experience with this gating mechanism including computer analysis of data, has indicated that there is little or no enhancement of hepatic images if the respiratory rate is less than 20/min. When respiration is rapid, however, images are degraded unless relatively stationary views are made. We have also found that information obtained by means of gating respiration is helpful in evaluating pliability of the liver. Detailed data on these subjects are part of a subsequent publication.

The respiratory gating mechanism described in this paper has the advantages of (A) simplicity of coupling to the patient, (B) capability of accommodating any respiratory cycle, and (C) most important, camera data is recorded each time only during the exact same phase of the respiratory cycle.

ACKNOWLEDGMENT

We would like to thank Orhan Suleiman for obtaining the hepatic images with the gating mechanism.

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