THE BUCKY DIAPHRAGM PRINCIPLE APPLIED TO ROENTGENOGRAPHY

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IN the columns of this Journal it was mentioned by the author that in fluoroscopy of the gastrointestinal tract much more clearness and contrast could be obtained by absorption of the scattered rays emerging from the body before they reached the fluoroscopic screen. A disk composed of interlaced strips of metal was rotated between the body and the screen, the design of the grid and the speed of rotation being adjusted so as to give little visibility to the metallic strips while performing the full function of a Bucky diaphragm at rest.

Believing that the constant presence of these scattered body rays presents the greatest direct limitation to the diagnostic value of our results in deep roentgenography, even more so than in fluoroscopy, we present the following arguments and results with a hope that roentgenologists and manufacturers may become convinced of the serious rôle played by object-secondary rays, to the end that it will soon be practicable for every roentgenologist to rid himself of their nuisance in his every-day work.

The accompanying diagram shows the source and direction of these scattered rays. They flood in from every side, striking a given point on the plate from every angle. Their action negatives in part the shadow-producing function of the primary focal rays, the combined result being a fog. This fog cannot be suppressed at its source by improvement in apparatus or technic, because it is a function of the action of rays on matter. It cannot be absorbed by filtration material without equally absorbing the primary rays. It remains, therefore, to bring about the absorption of the fog-producing rays between the time of their departure from the body and their arrival at the plate. The Bucky grid described in 1913 performs this function in an admirable manner, but leaves on the plate such an unpardonable shadow of the grid that no one would think of using it in practical work.

In our previous communication we mentioned the question of moving a grid as described by Bucky in such manner as to do away with the objectionable grid shadows while still performing the function of diaphragming off the scattered rays. It was brought out that to result in invisibility each and every portion of the plate should be covered by the components of the grid for exactly equal lengths of time. Failure to do this results in partial visibility of the grid, and shows in the form of various patterns on the plate. It is obvious that no linear, circular or irregular motion can be applied to the grid of square-shaped tubules such as was described by Bucky so as to result in the equal distribution of the shadows over each portion of the silvered surface. After failing to obtain complete invisibility with this construction and with others of a complex type, it was determined to find what amount of beneficial effect could be obtained by the use of parallel plates set on edge without the aid of cross members. The "clean-up" effect for the same spacing intervals was found to be less than with the cross-membered grid; but the opportunity of placing the strips much closer together by the parallel plan was much greater. It was obvious from the beginning that with parallel strips and a single uniform motion, there would result no shadows from the strips. After numerous experiments it was found that with 5/8 inch strips of type-metal spaced five to the inch, there was produced all the absorption of scattered rays that could be desired for practical work.

Working models were made and tested, the latest one of which is herewith described. Strips of type metal 5/8 inch wide, 1/50 inch thick and 2 feet long are mounted on a

form which is shaped so as to resemble a section of the shell of a cylinder. All metal strips are parallel and spaced by gutted wooden strips about 1/6 inch thick. This

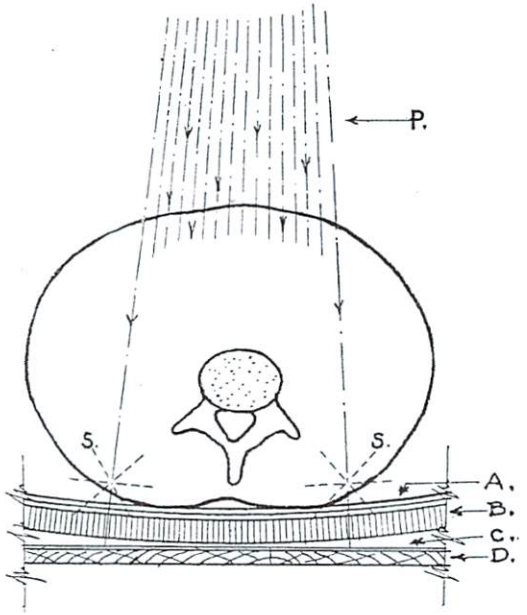

FIG. 1. Schematic representation of primary rays (P) and scattered rays (S) which are cut off by the faces of grid (B) before arriving at plate (C).

makes the strips with the spacers run about five to the inch. The curve put into the complex is such that the rays from a tube target 25 inches above, pass through the spaces without impinging on the sides of the strips, just the edges. (Fig. 1.)

This complex is mounted on roller bearings made to run on a curved track, so that motion is across the length of the strips, and the distance of movement about five inches. (Fig. 2.) The power used for movement is the weight of a mass of lead. This weight is hung from an equalizing rod, each of whose ends is attached by cable over pulley to a side of the movable grid. The movement is regulated in speed and made uniform in rate by an oil drag placed on the opposite side of the grid and attached thereto by a pair of cables and equalizers similar to that used for the weight. A valve in the piston controls the opening for the passage of oil and makes it possible for the grid to describe its arc of movement in any desired time between ½ second and 3¼ minutes. Above the grid is built a curved support for the patient. This is made of laminated wood and just allows the grid to clear underneath. Below the grid is a space for plates and screen holders. These are mounted, so that the grid members just clear them during the movement. The whole is mounted beneath a canvas-topped table with just enough slack to the canvas to allow patient to come in contact with the laminated wood over the "sieve." (Fig. 3.)

To operate, one places patient and plate in position, sets the oil drag in "down" position by trigger, and sets the valve for speed desired for the exposure. Just before starting the exposure the trigger is tripped by a pull on a string and the "sieve" set in motion. The exposure must be completed before the sieve comes to a stop, otherwise the strips cast their shadows.

It is not necessary that the strips be made to pass over the plate at any great speed, nor is it advisable. With the grid built as above it is found by experiment that one does not obtain uniform invisibility of the grid unless the movement is an inch or more during the exposure. In using the grid we usually aim to have a moment of from 2

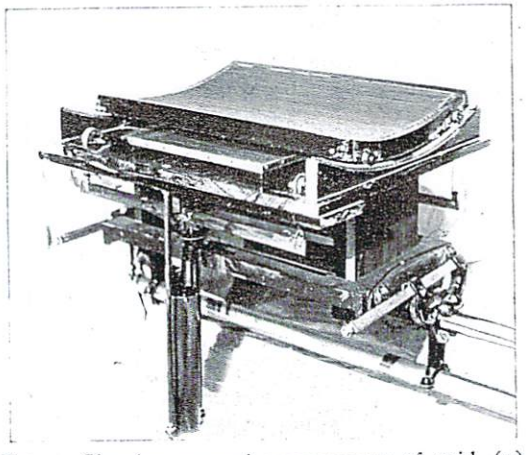

FIG. 2. Showing general arrangement of grid (a) moving on roller bearings in an arc (b) over plate (c). The oil drag (d) connects through equalizer (e) and cables to the grid. Valve (f) controls speed of movement. Equalizer (g) carries weight not shown. The whole is mounted on the sub-frame of a Kelly-Koett fluoroscopic table.

to 4 inches, for this always produces complete invisibility.

The exposure time for plates made with this arrangement is somewhat increased by

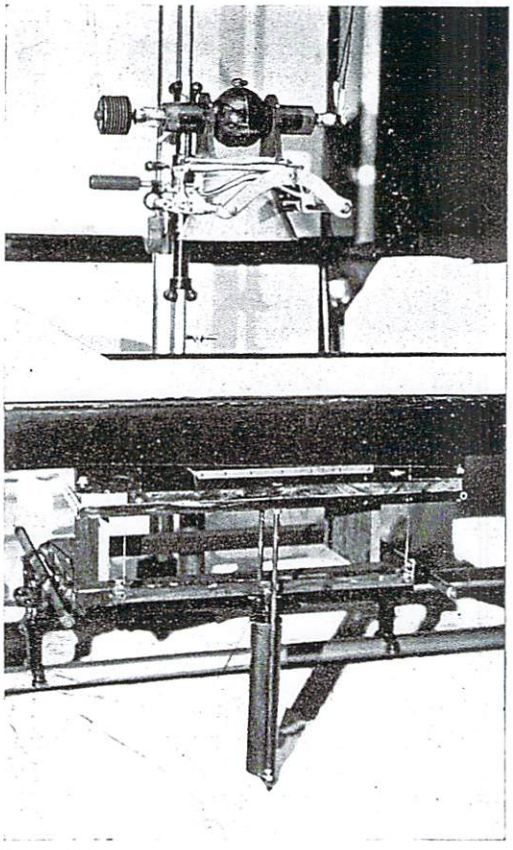

FIG. 3. DIAPHRAGM ARRANGEMENT IN POSITION FOR USE UNDER CANVAS-TOPPED TABLE. Tube 25 inches above.

the absorption of some of the direct rays by the edges of the metal strips and by the wood used above the grid and for spacers. This loss of speed is compensated for, however, by the fact that with this arrangement it is possible and advisable to use rays of a greater penetrability than by plain radiography. With ordinary *x*-ray emulsions a full five-inch spark equivalent is used without obtaining on the plates that objectionable fog so common with this gap. At the same time the detail in all osseous structures is greatly increased by this full penetration, and the markings in the softer structures so often glutted out by aberrant rays are preserved.

The field of usefulness for this diaphragming instrument is, as would be expected, in

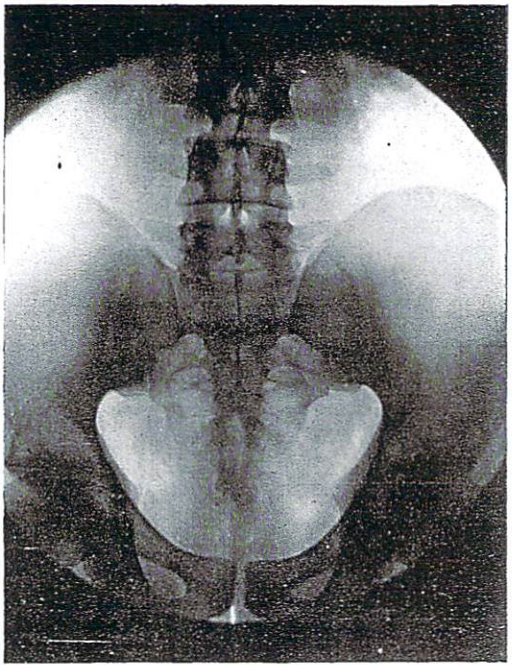

FIG. 4. PRINT OF SPINE, ETC., illustrating freedom from grid shadows obtainable by uniform motion of grid of construction described.

the roentgenography of the deeper structures mainly lying in the abdomen and pelvis. For anteroposterior and lateral spines it is especially needed, and the roentgenographic quality obtainable in the exploration of these structures would more than justify its use in every laboratory. For urinary calculi and gall-stones its use makes quite visible and distinct those calculi of semidense composition which are so often doubtful on routine plates. One of the most gratifying uses is in connection with especially corpulent individuals. Here the scattered rays reign supreme and account for most of the silver actually reduced on the average roentgen plate. Absorption of these aberrant rays gives us radiographic results of the lumbar spine that we formerly considered impossible to obtain.

Another phase of usefulness lies in the

increased size of field which can be covered without loss in diaphragming effect. The clean-up effect over every portion of a 14 x 17 plate is scarcely distinguishable from that obtained when adding a small cone and including a small area only. This allows the roentgenography of the entire urinary tract at once, the entire pelvis at once, or large sections of spine in any direction without reducing the quality at any one point.

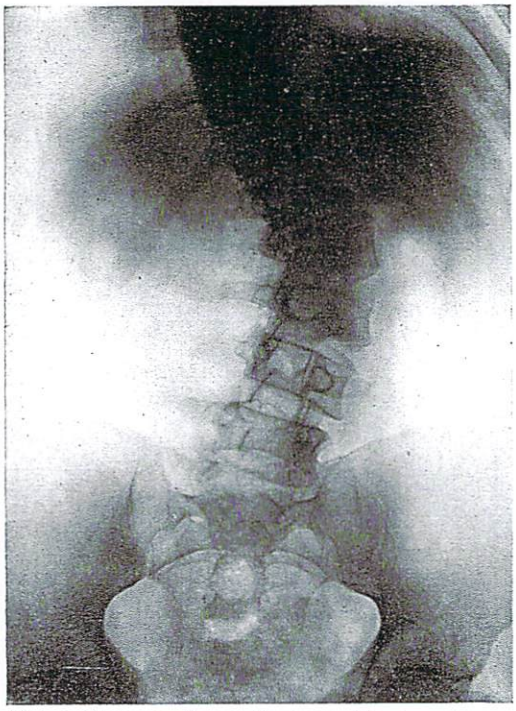

FIG. 5. PRINT OF SPINE SHOWING GENERAL QUALITY OBTAINABLE WITH THE GRID. Half-tone illustrations cannot be expected to show the intimate details of bone visible in the plates.

So far we have used it but slightly on sinuses and gastrointestinal work, although in both these regions its use is indicated. In the latter field the crudeness of our apparatus requires a very sharp coordination between exposure and grid movement. After the installation of a magnetic release for the grid we expect the apparatus to be ready for routine use in rapid exposures, and the results so far are so brilliant as to justify further experiment.

[NOTE: Before Dr. Caldwell's death he visited our laboratory and was shown this apparatus and some of the results. He told us at the time that he was informed that Bucky, who lives in Germany, had been experimenting with moving grids of some type to obtain the same invisibility with suppression of secondaries toward which we have been working. In Cincinnati, at the February, 1917, meeting, our present apparatus was described and results shown. Further mention of it has not been made until recently, when visiting roentgenologists urged that it be written up for the Journal.

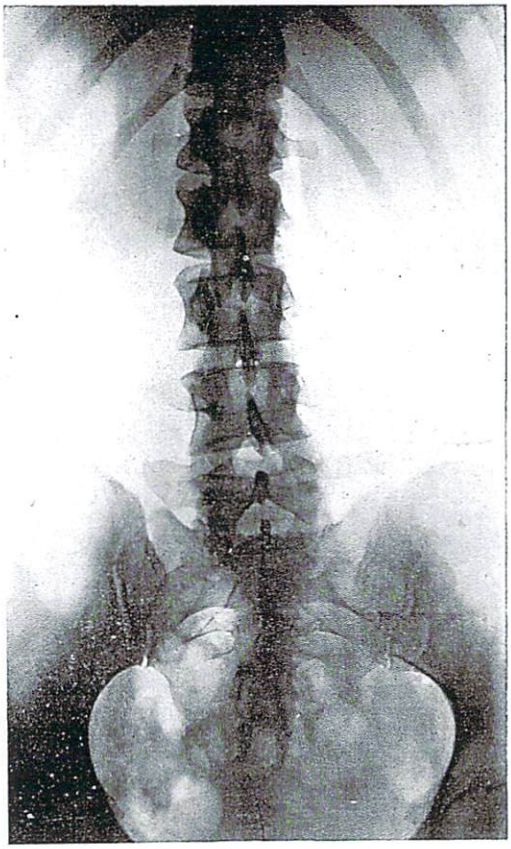

FIG. 6. PRINT OF SPINE SHOWING THE UNUSUAL CONTRAST OBTAINABLE IN PERSON OF LIGHT WEIGHT. With intensifying screens these contrasts can be made so violent as to be objectionable.

It has been difficult to learn what Bucky may have accomplished along this line, but certainly there has been no announcement that a practical working method of suppressing object-secondaries has been brought out. The method above described is fairly simple and it seems time that manufacturers should make it available for our routine work.]