SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE IOWA PIANO CAMERA

THE apparatus here described was developed for the purpose of studying piano playing. It gives an objective photographic record of the duration, time of incidence and time of ending as well as a relative measure of intensity of each note struck for a piano selection under normal conditions of performance.

The record is made on a 4-inch Eastman sensitized paper, passing at the rate of 12.5 centimeters per second. The record consists of a path for each of the keys on the piano keyboard and shows for each key the exact moment at which the hammer strikes the string and the moment of the beginning of the release of the key. It also shows for each note the velocity of the hammer in terms of the time for traversing the last 12 millimeters in the stroke of the hammer. On the same principle, a separate line on the film indicates the movements of the damper pedal. The time is indicated by 25 parallel lines to the second across the width of the entire film.

The record is made of the movement of the hammer by having a very light paper strip, approximately 7 centimeters long and 7 millimeters wide, glued to the tail of each piano hammer. This strip has a narrow slit, 3 millimeters by 7 millimeters, at a distance of 12 millimeters from the end of the strip. The camera is set 4 feet above the piano, directly above the hammers, and an anastigmatic 1: 6.1 lens is used. The height of the camera with this lens is so adjusted that the 4-inch film will cover the entire bank of hammers. Beneath the hammers is placed a bank of 18 60-watt Mazda lamps. A layer of glazed glass over the lamps diffuses the light and forms a support for the paper strips. A slit 2 millimeters wide and equal in length to the width of the film is placed in the camera between the film and the lens. This slit permits only a small portion of each paper tail—a section between the slit and the hammer—to be focused on the film. When the key is struck, the hammer moves toward the piano string and the slit in the paper tail allows the light to pass through to the camera. The passing of this slit leaves a dot photographed on the film.

When the hammer reaches the piano string and produces the sound, the entire tail has passed the region focused on the film and the light again falls upon the film, making a distinctive mark on the film. As soon as the hammer has struck the string, it immediately drops back to the position where the slit in the paper tail is within the region focused on the film. The hammer remains in this position, photographing as a narrow band on the film until the key is released. The movements of the damper pedal are recorded on a similar principle. The duration of each tone, whether due to holding down the key or holding down the damper pedal, is indicated with precision on the film.

The velocity of the stroke as indicated by the time of the hammer in passing 12 millimeters is taken as a qualitative and relative measure of stress or intensity of tone and is read in terms of millimeters.

The time line employed is somewhat of an innovation and will be described because of its possibilities for use in other types of apparatus. A neon lamp, built in the shape of an inverted U, is placed in the camera with the base of the U extending across the width of the film and separated from it by a strip of thin sheet brass containing a very narrow slit (about .5 millimeters wide) and as long as the width of the film. The neon lamp contains a small amount of mercury, giving a pale blue light to which the film is exceedingly sensitive. The lamp is operated by placing it in series with the secondary of a small induction coil. In series with the primary of the coil are placed one dry cell and a 25 dv. electrically driven tuning-fork. The latter makes and breaks the current in the primary of the coil 25 times per second, the neon lamp flashing only on the break. This arrangement gives 25 parallel lines to the second, each extending across the width of the film. At present, we are running the film at approximately 12.5 centimeters per second, which separates the parallel time lines by 5 millimeters. At this speed, measurements to .02 of a second can be made with accuracy, and measurements to .01 of a second with only a very slight error. Finer measurements can easily be made, if desired, by using a tuning-fork of higher frequency.

The value of parallel time lines, each of which entirely crosses the film, was realized some time ago by Dodge.[1] Time lines of this kind are especially convenient in this apparatus when it is desired to measure such factors as the beginning, ending and duration of the notes within a single chord.

In addition to its use as a means of analyzing artistic piano performance, the apparatus may also be used to secure an objective measure of motor rhythm under an actual situation where this ability must be used. In short, it records quantitatively, with adequate precision, the temporal aspects of tone production on the piano and furnishes a serviceable indication of relative stress, so that all the elements of rhythm in any degree of complex musical movement may be analyzed for interpretation. The other two factors, pitch and timbre, are controlled by the

[1] Raymond Dodge, "A Pendulum-Photochronograph," *J. Exp. Psych.*, 9: 155–161, 1926.

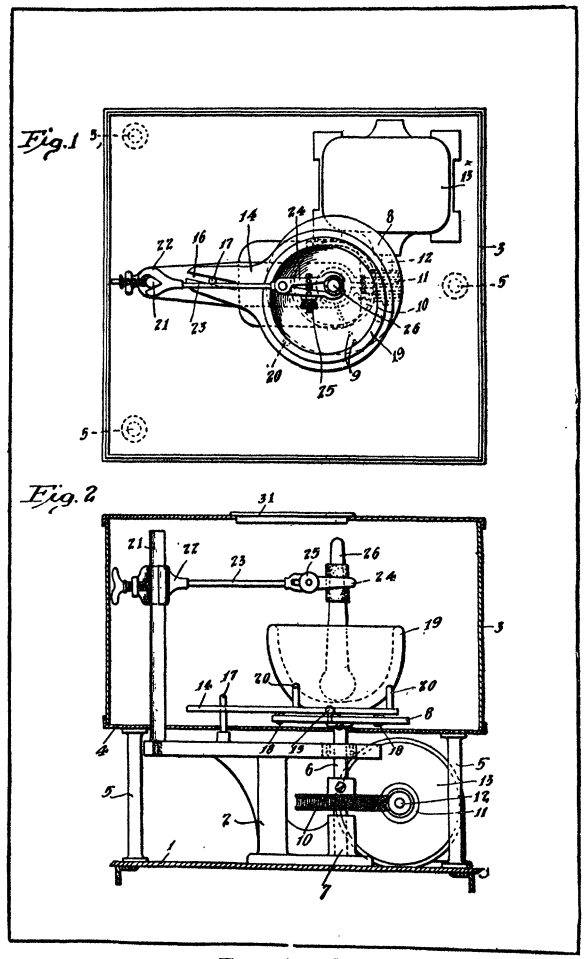
piano itself. The film, therefore, furnishes a full and adequate record of piano performance.

This preliminary notice of the camera was sent to this journal because it was felt that the method here employed has many possibilities for application in other fields of science.

JOSEPH TIFFIN
CARL E. SEASHORE
STATE UNIVERSITY OF IOWA

A NEW MECHANICAL DISINTEGRATOR

INVESTIGATORS working with filterable viruses appreciate how much time may be consumed in reducing virus tissues to a finely divided physical state, a task generally carried out by hand with the aid of a mortar and pestle. This method of grinding tissues is not only comparatively inefficient but also exceedingly monotonous and tiring. In order to overcome these objections in our own work, we designed a machine some time ago whereby the mortar and pestle could be operated mechanically. This apparatus has proved so satisfactory that we offer a brief description of it for the benefit of those who may be interested.



FIGS. 1 and 2

Fig. 1 gives a top view and Fig. 2 a lateral view of the machine. It consists of a suitable cast-iron pedestal (2), provided with a thrust bearing (7), into which is fitted a shaft (6), which passes through the floor (4) of the grinding chamber and bears at its upper end a driving disk (8) provided with several eccentrically placed apertures (9). Shaft (6) is driven by means of worm gear (10), which engages with a worm (11), attached to the horizontal shaft (12) of an electric motor (13). The machine is fastened to a metal base (1) on which rest also the legs (5) which support the floor (4) of the grinding chamber.

Within the grinding chamber a platen (14) is movably positioned above disk (8) by means of a pin (15) which fits into one of the eccentric apertures (9). The platen (14) is provided with a bifurcated end (16), which engages with a fixed pin (17) attached to the pedestal (2). The mortar may be fixed into position on the platen by means of rubber-covered metal fingers (20) extending upward from the platen (14).

The pestle (26) is held in position by means of a round flexible metal arm (23) provided with a clamp (24), operated with a thumb screw (25). The metal arm (23) is fastened by means of a special clamp (22) to a vertical triangular rod (21) fixed to the pedestal (2).

The mechanism described imparts to the platen holding the mortar an eccentric motion. By thus moving the mortar the pestle is brought into essentially the same operable relationship with the mortar as when the grinding process is carried out by hand. When desirable, grinding may be carried on under a hood (3), which may be entered by means of a hinged lid, provided with a glass window (31) to facilitate inspection of the material while the machine is in operation.

The machine described should prove useful not only in grinding virus tissues, but also in grinding most substances that are commonly disintegrated by means of a mortar and pestle.

E. W. SCHULTZ
F. D. BANHAM
STANFORD UNIVERSITY

A METHOD OF TITRATING PROTEOLYTIC ENZYMES

IN 1927[1] the author published a brief note on a method of enzyme titration, which was later somewhat modified and demonstrated at the 1928 meeting

[1] *Proc. Soc. Exp. Biol. and Med.*, 24: 936, 1927.