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Some Improved Laboratory Devices and Apparatus

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SOME IMPROVED LABORATORY DEVICES AND APPARATUS.

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A MODEL TO SHOW THE TRANSMISSION OF A WAVE BY TRANSVERSE VIBRATIONS.

The base of the model is a plain board 26 by 9 inches. At the rear edge of this is another board 5 inches wide, set on edge, A, Fig. 1. To the upper edge of the latter are hinged 27 metal rods A D, 8 inches long. The front ends of the rods are free to move up and down in vertical slots C, and each carries a white disc D half an inch in diameter, which is soldered at its center to the end of the rod, and at right angles with it. Approximately simple harmonic motion is imparted to these discs, so that they represent the vibrations of the particles of an elastic medium transmitting a simple transverse wave motion. The mechanism for producing the motions of the discs is the following: A round half-inch steel shaft is mounted in bearings at the ends. Upon this shaft are 27 eccentrics,one of which is shown in Fig. 2. These are loose upon the shaft, except the first one, which is fastened to it. On one side of each eccentric are two short pins, or brads P P, 40 degrees apart, reckoning the angle about the axis of the shaft as a center. On the opposite face of the eccentric is a single stop T, bisecting the 40 degree angle between the brads, and consisting of a small wire staple driven in so as to protrude the same distance as the brads just mentioned. The eccentrics were made by sawing a two-inch curtain pole into three quarter-inch lengths, and boring half-inch holes for the shaft, S, Fig. 2. Besides the eccentrics the shaft also has upon it a loose wheel with a groove in its periphery, Fig. 3. Fig. 4 gives a side view. Over the wheel and in the groove, passes a string, one end of which is fastened to a

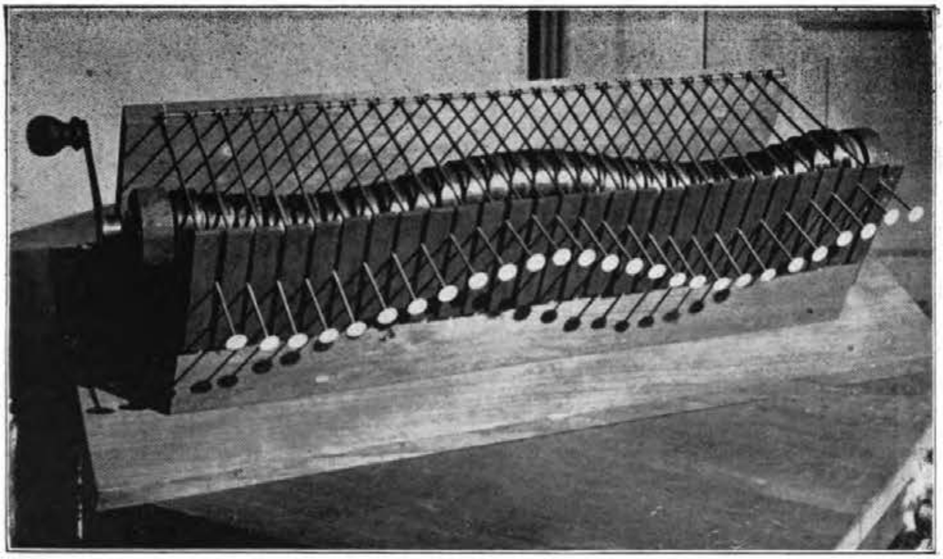


Figure 1. Model to show the transmission of a wave by transverse vibrations.

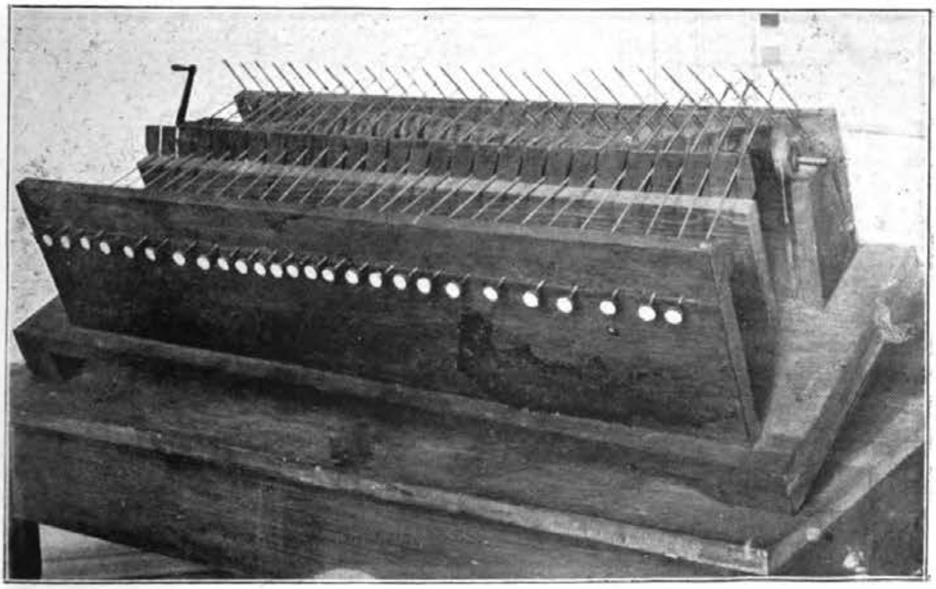
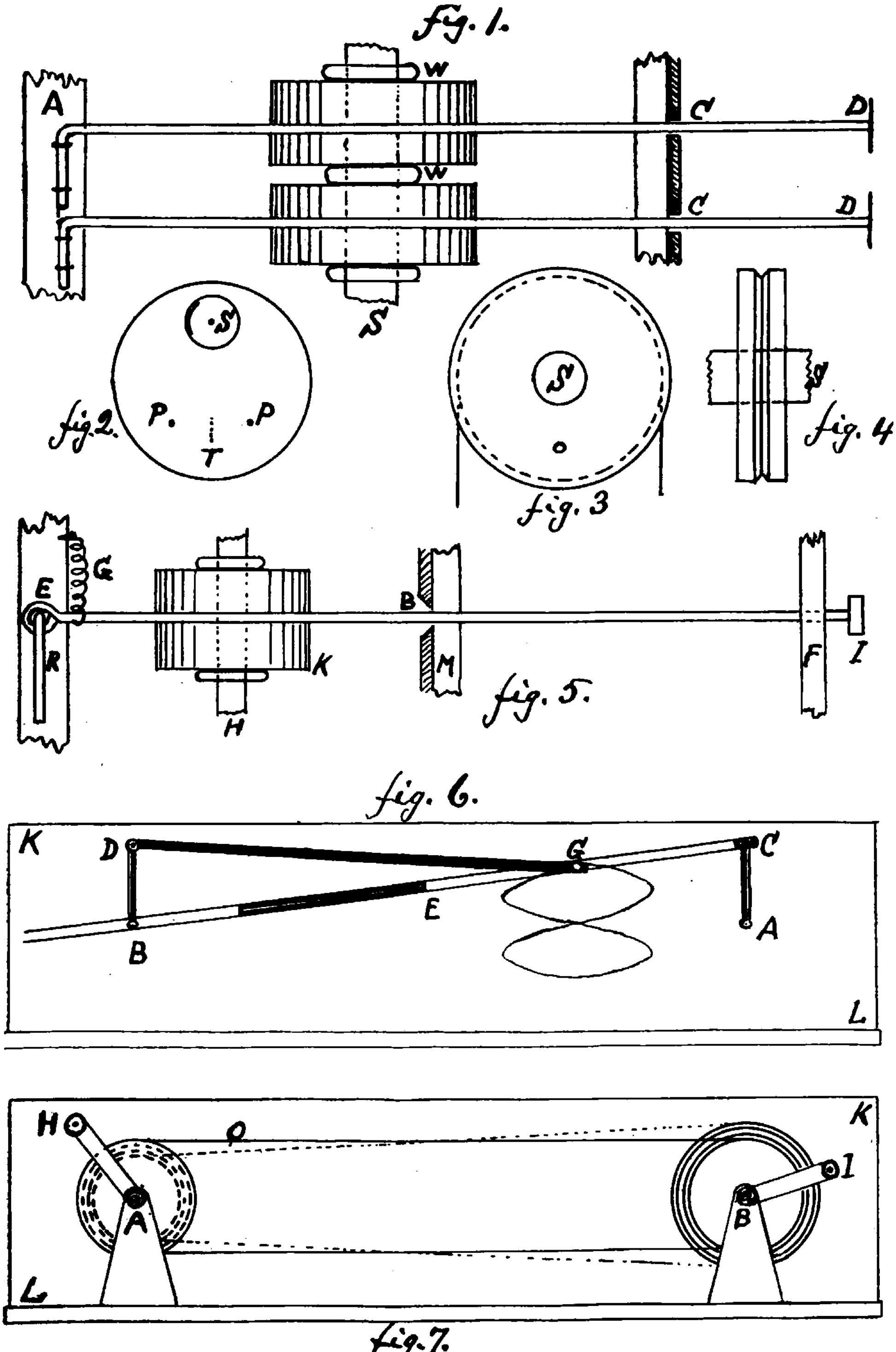


Figure 2. Model illustrating the longitudinal or sound wave.

hook in the base of the model. The other end is tied to an elastic band, and this in turn is fastened to another hook in the base. The string being short enough to be under considerable tension from the stretching of the elastic, acts as a brake upon the grooved wheel and allows it to turn only against more or less friction. The eccentrics are separated by washers or rings W, of sufficient thickness to prevent the brads and staples from touching the faces of the eccentrics opposite. On turning the shaft by the crank at one end, the first eccentric, being fast on the shaft, will after turning 20 degrees, or until one of its pins P, engages the stop T, on the second eccentric, cause this to turn with it until it in its turn carries with it the third. Finally the last eccentric will be set revolving, and will carry with it the grooved wheel, against the friction of the string. This brake prevents irregularity in the motion of the last eccentrics on the shaft. The eccentrics now revolve together, but each one is 20 degrees earlier in phase than the one just ahead. As there are 27 of them they assume an arrangement like a screw of long pitch whose thread makes a turn and a half from one end to the other. The rods which carry the 27 discs D, are so spaced that each rests on a corresponding eccentric, and transversely to the shaft. As these revolve, the free ends of the rods, with the discs, describe vertical simple harmonic motions differing in phase by successive intervals of 20 degrees. The effect of these motions is to produce a sinusoidal wave motion of the discs, which may be taken to represent individual, equidistant particles of a medium transmitting a wave by transverse oscillations. The motion may be stopped and started at any instant or made as rapid or as slow as may be wished. The particles may be brought into a straight line, representing the medium at rest, by reversing the motion a turn and a half. The model is especially useful in elementary instruction, and represents in a plain way the mechanism of this class of wave motion, without departing seriously from theoretical exactness. Its novelty consists chiefly in the application of the loose eccentrics on a shaft. Any phase difference, and any amplitude, may be provided for by varying the proportions of the parts. It is desirable in practice to include somewhat more than one wave length. This model includes one and a half. The front of the model is painted black so as to set off, with sufficient contrast, the discs, which are white.

A MODEL ILLUSTRATING THE LONGITUDINAL OR SOUND WAVE

This model is about 13 inches wide by 36 inches long. At its back is a five inch board E, Fig. 5, set on edge and extending nearly the whole length of the model. Driven into the upper edge of this board at intervals of one inch are 27 straight, smooth wires, or small rods, R, two inches long, inclined to the left, say, at about 45 degrees from the vertical. Another 5 inch board M stands on edge about the middle line of the model. To the edge of this board are fastened thin strips, inclined, so as to form 27 slots leaning to the right about 45 degrees. In a third board F standing on edge at the front of the model is a horizontal slot 30 inches long, 5 inches from the base. A small rod or stout wire E I, Fig. 5, bent so as to have an eye or loop E at one end and carrying a half inch disc at the other end I, passes through the horizontal slot in F, and through an inclined slot B, while the loop E encircles an inclined rod R. A light spiral spring G fastened to the side of the board so as to have the same angle of inclination as R, produces gentle tension on the rod against or toward the upper edge of the board. There are 27 rods like EI. It will be seen that if a rod be grasped between E and B and raised, the loop E will swing toward the left as it rises along R while its middle point will move to the right in moving up in the slot B, which leans to the right. I will therefore move toward the right, as viewed from the front. On letting the rod drop, motions in the opposite direction will take place at E and B; and I will move back toward the left. If now a point on the rod between E and B describe simple harmonic motion up and down, I will describe the same kind of motion horizontally. The up and down motion of the 27 rods is produced by a shaft H with 27 eccentrics K under the rods and between the upright boards E and M. The



Harmonic motion model.

shaft, eccentrics, washers, brake, etc. are exactly like the driving mechanism detailed in the description of the model for the transvers wave motion. The length of the eccentrics K upon the shaft H is greater in this model than in the other, chiefly because it is desirable to separate the discs I farther than the discs in the former model described.

The limit of motion of each eccentric being 20 degrees with respect to the one next to it, the harmonic motions of the discs I will differ by intervals of 20 degrees difference of phase. The model therefore represents a longitudinal or sound wave, and includes a wave length and a half. But the phase differences could be made different by choosing different angles between the pins in the eccentrics. The degree of compression and rarefaction in the wave will depend on the "throw" of the eccentrics and other proportions of the model. The chief usefulness of this model, as of the other, consists in the simplicity of the mechanism, and the perfect control which the operator has over the motions.

The models can be made with very meager shop facilities. Anyone who sets about making them will easily apply improvements in the devices. The contrivance of the loose eccentrics on a shaft is probably susceptible of being adapted to other illustrations of wave motion.

A MODEL FOR COMPOUNDING SIMPLE HARMONIC MOTIONS.

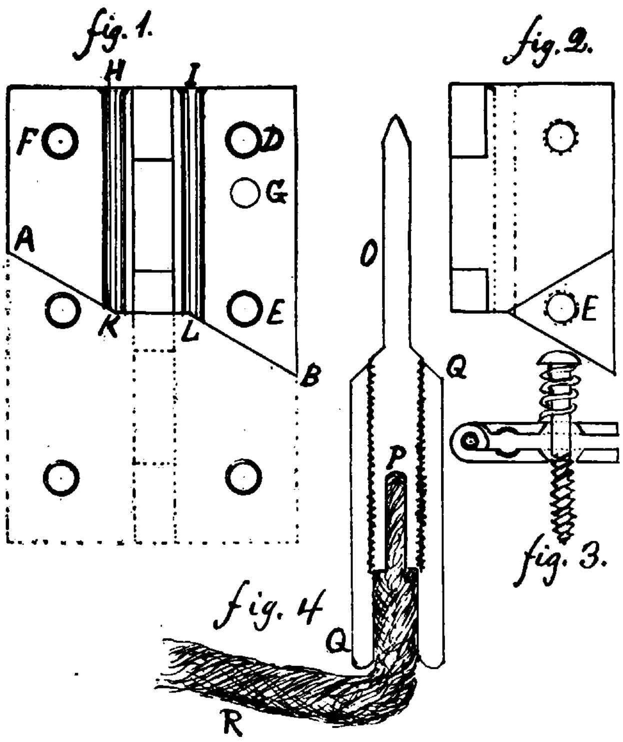
In teaching the properties of simple harmonic motion it is desirable to show in an elementary manner how two such motions, when compounded, will produce the beautiful figures shown by the method of Lissajous. But when the tuning forks are used the actual tracing of curves cannot be watched. The resultant is all that can be shown. In addition to the tuning forks of Lissajous and various contrivances, employing pendulums, the stereopticon, and the like, a contrivance is useful which will trace the figures so slowly that their production may be watched by a whole class, and which may be stopped, and started again at any point to take up the tracing where it was stopped, without spoiling the continuity or regularity of the curve.

A simple and satisfactory model of this kind is here described. On one side of a board KL, Figs. 6 and 7, about 40 by 7 inches, and standing on edge upon a second board which serves as a base, are two pulley cones with four (grooved) steps on each; and these are so proportioned that when a belt or endless cord O passes over corresponding pulleys in the two cones their relative angular velocities will be in the ratios 1:1, 3:4, 2:3, or 1:2. Upon the axes of these cones, and revolving with them, but on the other, or front, side of the board KL, are two cranks AC and BD. A connecting rod BEC actuated by one crank, AC, slides horizontally upon the shaft B of the other crank, being slotted at the end B for this purpose. Another rod DG actuated by the crank BD has at one end, G, a sleeve which slides in the long slot EG of the other rod. A pencil, at right angles to the upright board, and carried in this sleeve, G, traces the curve upon a sheet held or pinned against the front of the board. To press the pencil against the paper a rubber band may be passed around the outer end of the pencil and the end of the rod at G.

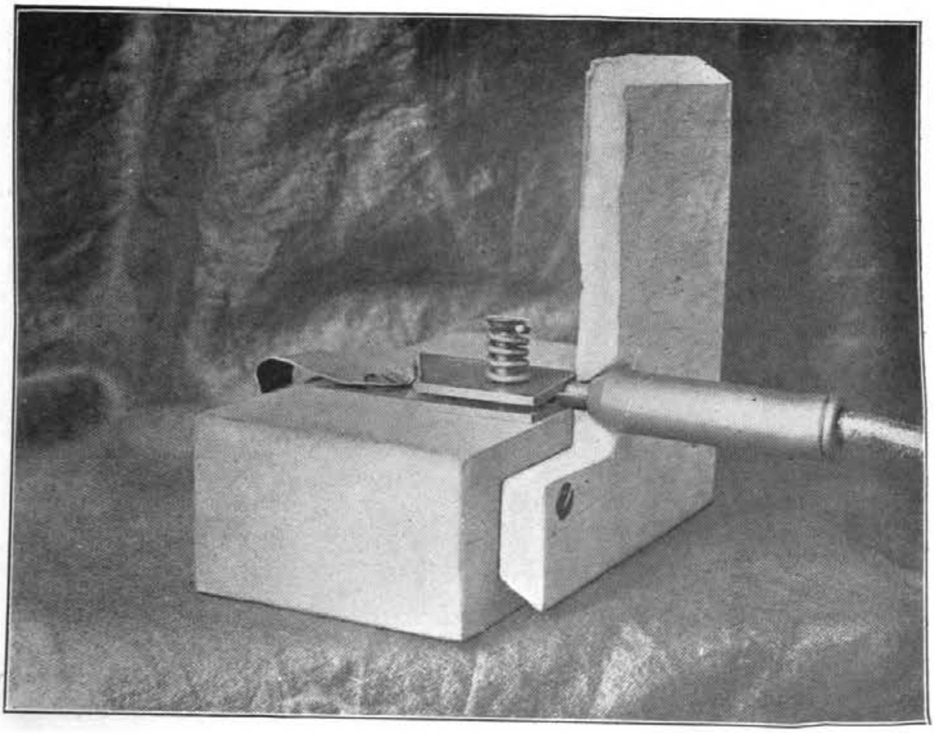
With the belt thrown off the pulleys, it may be shown that the crank AC alone produces harmonic motion in a vertical line; and that the crank DB produces horizontal harmonic motion. And it is plain that the curve traced when both cranks revolve is the resultant of both these motions.

If the radii of the pulleys are not exactly in the simple ratios 1:1, etc., the model is the more instructive as it shows the mechanism of the progressive motion or revolution of the curves produced by tuning forks in the similar case. The fact that the curves are slightly distorted because the right and left motion of G departs from a strictly horizontal direction in the upper and lower positions of C does not detract from the usefulness of the model. The longer the model is in proportion to the lengths of the cranks, the smaller will this distortion become.

In Fig. 7, the belt is on the two equal pulleys, or the two motions are in unison. If the belt be in the position shown by the dotted line the model produces the curve of the two



Cable switchboard.



Cable switchboard. View of one jack mounted in the switchboard, with a plug inserted. The front panel is partly cut away.

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motions differing in frequency by an octave. One variety of this curve is shown in Fig. 6.

A SIMPLE AND EFFICIENT CABLE SWITCH BOARD.

A serviceable, cheap, and easily constructed switch board, which has been in use for several years, has a jack of novel design. These jacks are, in the switch board in question, mounted on a wooden frame. This is proper enough where the circuits terminating in the board are subjected to pressures of only a few volts, as in connecting batteries and apparatus for the ordinary purposes of a physical laboratory. But where an indestructible board is required, the jacks in question can readily be mounted on slate or marble.

To make the jack, take a common heavy brass hinge three inches wide, and cut it in two like halves along the line AKLB, Fig. 1. Now fold the leaves of one-half together until they are parallel, clamp it in a hand-vise, with a plate of proper thickness between the edges of the leaves. With a drill three-sixteenths inch in diameter bore the hinge out near the joint, so as to make the channels HK and IL, to receive the round plug of the cable, which is to be used in connecting different jacks in the switch board. Bore the extra hole G. The jacks may be mounted upon horizontal bars forming the frame-work of the board. A screw is driven through the hole A so as to fasten the jack down to the bar, with the end I nearly flush with its front edge. A round headed screw in G will serve to keep the leaf AH from closing down too closely upon BI, but leave room for the easy insertion of the plug.

Another screw through E will also serve to fasten the jack to the bar. The terminal of the circuit coming to this jack may be clamped to the hinge by the same screw. The hinge is now closed by folding the opposite leaf over. A spiral spring of a few turns of spring brass wire is slipped on a rather long screw, which is then driven through the holes F and D, into the wood, until the spiral spring presses the upper leaf of the hinge down firmly. See Fig. 3. The jack is now complete.

To make the plug, take a brass rod about 3.5 inches long and, say, $\frac{3}{8}$ inch in diameter. Turn one-half of it down to the size of the drill used in boring out the channels in the jack; point the end neatly. See Fig. 4, O. Thread the other half with a rather coarse screw thread. Also with a drill about one-eighth inch thick bore a hole a half or three-quarters of an inch deep in this end; P, Fig. 4. The end of the cable R is stripped and soldered into the hole P. To make the handle for the cable take a piece of thick walled, hard rubber tubing about two inches long, tap it out to fit the thread upon the plug, finish it neatly, and screw it on the plug into the position Q, Q. The other end of the cable is finished in the same way. It is advantageous to slip the handle Q on the cable before the latter is soldered in to the plug. The cables must, of course, be long enough to reach between the jacks farthest apart in the board. In the board constructed, 100 jacks are arranged in ten rows, and occupy a space about 30 by 40 inches.

The front of the board is protected by thin panels, with holes corresponding to the channels in the jacks, and admitting the plugs.

When this style of jack is to be used in a fire-proof switch board, the back of the board may be a slate slab to which may be bolted small brackets or right angle pieces of brass, upon which the jacks may be fastened in almost identically the same manner as when wood is used. The bolt, or bolts, by which the brackets are fastened to the slate may serve also to connect the terminals of the circuits to the jacks. The front of such a board may be protected by panels of marble or slate, with holes properly located for the admission of the plugs to the jacks.

A CAMERA TABLE.

By a camera table is here meant a device by which an ordinary camera is conveniently mounted for photography for scientific purposes, such as enlarging or reducing cuts, charts, etc., for lantern slides or for illustrations to be used in the class room, in note books, and the like; or for photographing small objects, such as pieces of apparatus, and botanical, zoological, and geological specimens.

The table proper is 7 feet long by 24 inches wide, and 27 inches high, and is mounted on substantial two-wheeled casters. The framework consists of two pieces, S, Fig. 1, 1 by 5 inches, and 7 feet long, for the sides; four cross pieces, Q, 2 by 5 by 17 inches; and the four legs L, 2 by 3 inches, bolted on near the ends of S, and spreading somewhat so as to give greater stability. The top consists of two thin boards of such width as to leave an opening or slot, three-quarters of an inch wide, in the middle and running the whole length of the table. On the outside of the side pieces are two rails, R, one (on the left) being flat, the other having a ridge above. Upon these rails slide the movable parts to be described. The ridged rail at the right serves as a guide. The other rail, being flat, allows the sliding parts to adjust themselves without binding, from unequal expansion of the parts.

The cross pieces of the frame are partly cut away under the central slot, as shown at E, so as to allow the clamps attached to the movable parts to move freely in the slot.

The stand or pillar, on which the camera K is mounted is fastened to the base U, which can slide sidewise between guides at the front and back as a sub-base V, about 20 by 23 inches. It lies on the cleats W, which rest on the rails R, upon which the whole may slide along the table. The pillar may be firmly clamped to the table by tightening the nut C, which raises the clamping screw that passes through a transverse slot in U, a hole in V and the opening in the table top. The screw is attached, below, to the clamp which consists of a piece of wood about 6 inches long and having the cross section shown above E.

The pillar itself is adjustable in height. It consists of two parts. The inner part I, being raised or lowered by the large screw D, which passes through the nut N attached to the movable portion I, I. To promote rigidity in this structure it is made triangular in section, and when adjusted to the proper height it may be clamped firmly by the three-way clamping device shown in cross section through A. See Fig. 2. M, M are the sides of the fixed portion of the pillar. I, I are the sides of the movable parts. The bolts X, X are screwed into a hexagonal ring or collar, and pass through holes in M and vertical slots in I. The clamping screw A is attached to the same collar. Tightening the thumb-nut A clamps I, I firmly against M, M.

On the top of this triangular pillar is a device for further adjusting the camera by revolving it about the axis of the lens. This is effected by placing the camera K (see Fig. 1) on a base CB whose curved supports Y (one at each end of the camera base) slide upon a sub-base, fixed on top of the pillar and having end pieces Z curved to receive Y. Cleats on Z prevent Y from displacement forward and backward. The center of curvature of Z and Y is in the axis of the lens. When the adjustment of the camera about its axis has been made, the base CB is clamped by the screw H, which engages a slotted plate of metal of the same curvature as Y.

The object to be photographed is mounted on the rack or holder shown in Fig. 3. It consists of two uprights F standing on a base 20 by 33 inches which rests upon the rails R, and slides on them the same way as the camera stand already described. If a drawing is to be copied, it is pinned on a board 22 by 20 inches which rests in grooves in the uprights F and is held up by the support P which can be clamped at any height by the clamping device BO. The construction of this clamp is shown in cross section in Fig. 4. The rod BO, by pressure of the thumb nut B causes the hinged plates at the ends to grasp the uprights FF on the outside. The top of the support forms a shelf OJJ on which small objects may be placed while being photographed. The board P, which forms part of the adjustable support, slides up and down in the grooves J of the uprights.

This whole rack or holder may be clamped to the table by the clamp G, which slides with it in the longitudinal slot. Besides being a clamp this contrivance, when the

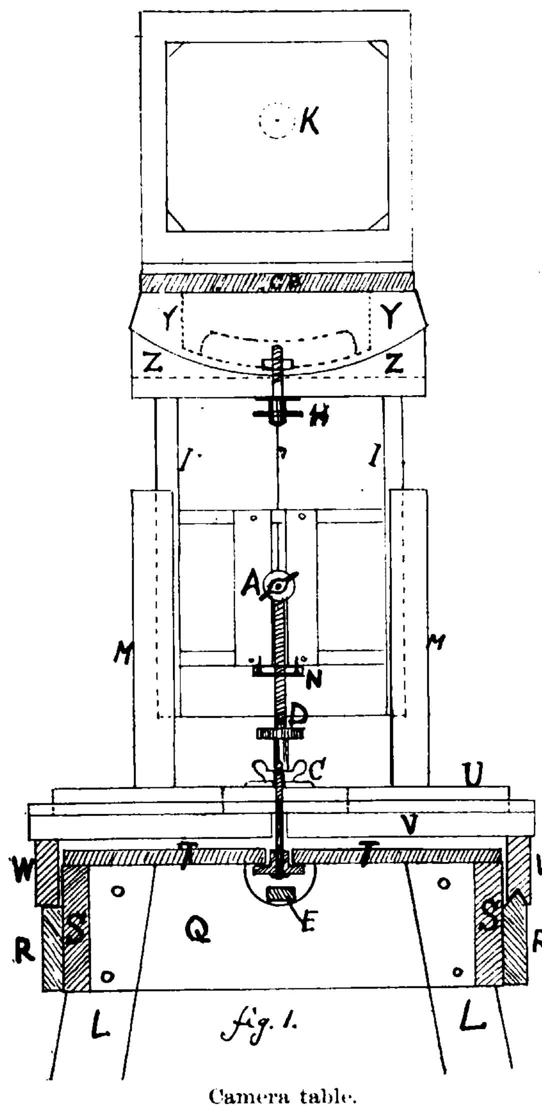
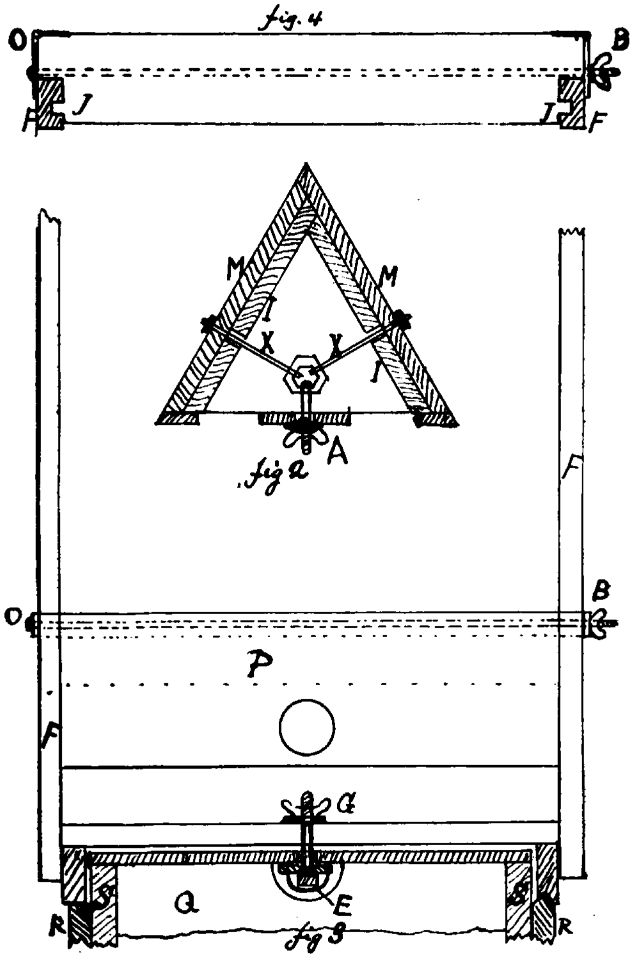
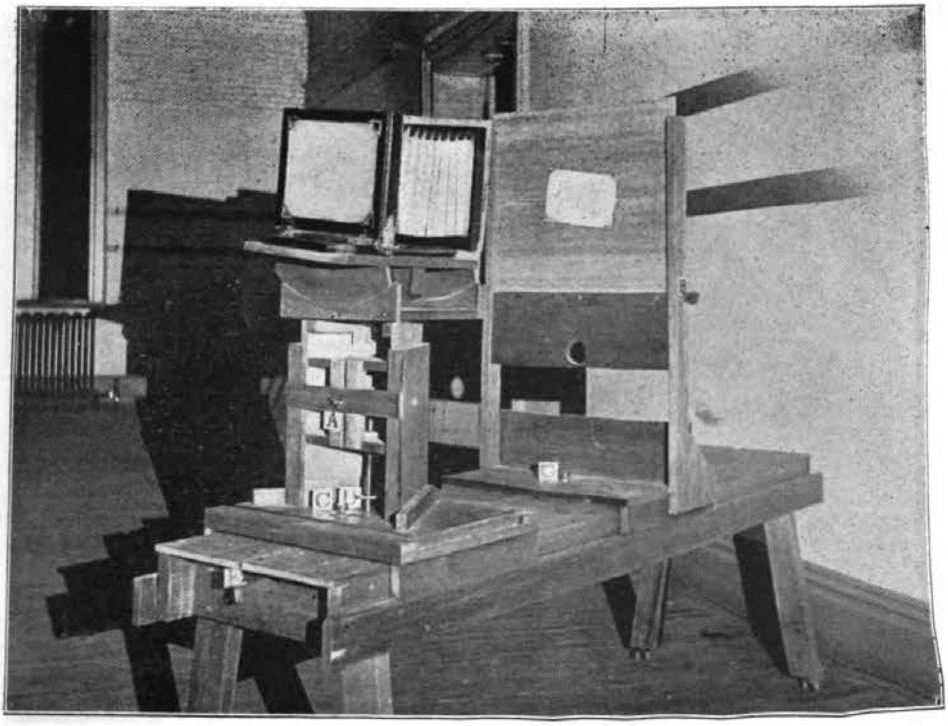


Fig. 1.

Camera table.



Camera.



Camera table.

nut G is released, serves to enable the operator to move the object holder along the table, by means of a rod E lying under the slot. This clamp, like the one at C, Fig. 1, consists of a piece of wood about six or eight inches long. It has a cross section somewhat resembling an inverted capital T, as shown just above E, Fig. 3. The tongue projecting up into the slot keeps the clamp in alignment. The screw or bolt G passes through the body of the clamp and up through a hole in the base of the object holder. And when the latter is to be clamped fast the nut is simply tightened down. During the process of adjustment the nut is kept loosened so that the clamp may slide freely in and under the slot. The rod E by which the operator moves the clamp, and with it the object holder, is oblong in cross section. It lies under the slot in the table top and reaches the whole length of the table. Screwed to the under side of the body of the clamp is a loop of plate brass; and in Fig. 3 the rod E lies, thrust loosely through this loop. If it be now twisted some 40 degrees it will bind in the brass loop and so engage the clamp. The latter, with the object holder, can then be drawn back or thrust forward at the will of the operator. The rod may be disengaged from the clamp by a turn of the hand, and may be left, pushed in under the table, out of the way, when the adjustments are finished.

By the arrangements here described all adjustments of the camera and object may be made without removing one's head from under the focusing cloth. Any one who has used a camera for the purposes mentioned here knows that all the adjustments of this apparatus are desirable. First, the object to be photographed is placed approximately in the right position on the object holder. The exact vertical and horizontal adjustments are next made; and finally any fault in the orientation of the image on the ground glass is corrected by revolving the camera about the axis of the lens. When the image is of the right magnitude and in proper position the movable parts are fastened in their positions by the clamping screws or nuts.