ON THE USE OF A REFRACTING ALTAZIMUTH TELESCOPE FOR BIRD OBSERVATION.

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Plate XXVII.

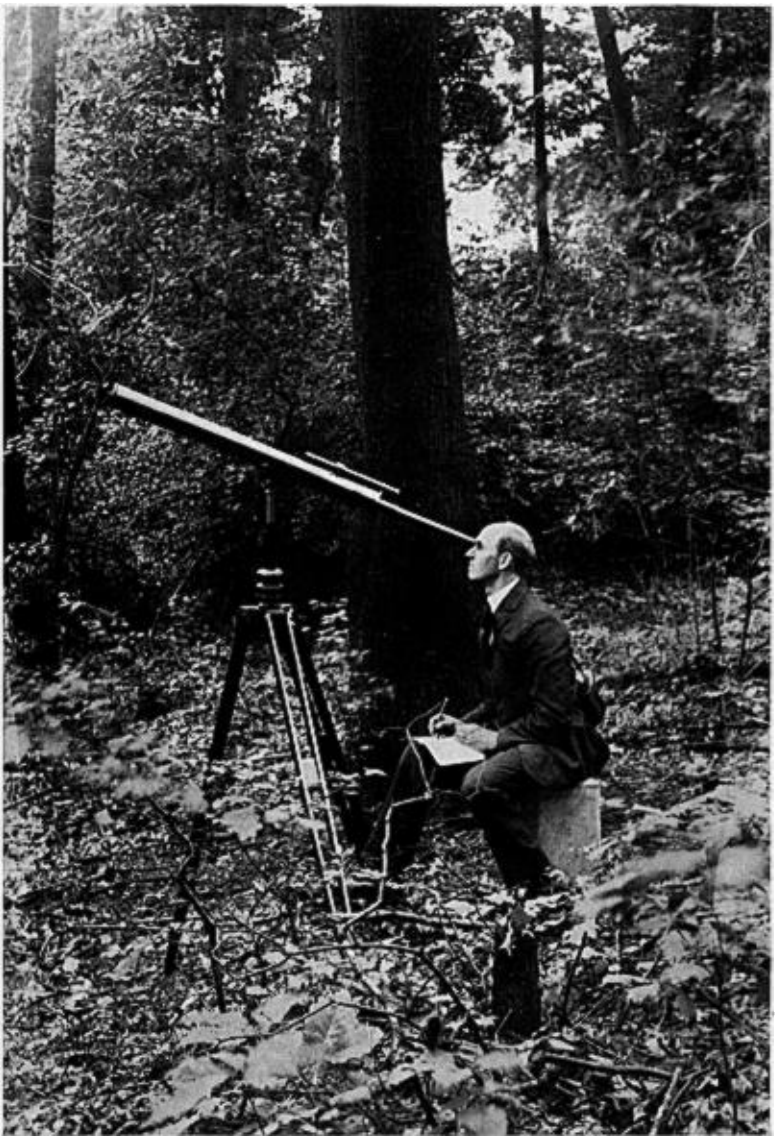
During the spring of 1926 the writer, in experimenting with the terrestrial ocular of a three and one-half inch altazimuth refracting telescope, directed the tube of the instrument toward the top of a tall Shagbark Hickory about sixty rods away across an open field, in order to test the sharpness of focus of the lenses, as well as to determine whether the ocular would resolve clearly a flock of *Icteridae* with which the topmost boughs of the tree were laden. What was his gratification to see that not only could the birds be sharply focused, but their motions in detail watched, and diagnostic characters of different species unquestionably made out. Redwings, Rusties, and Grackles could be clearly seen and indubitably identified. The telescope was then moved nearer—about thirty rods from the tree—and set up in concealment behind a row of bushes bordering a wood and behind a rail fence, and from this point a complete specific census of the flock was made. Observations of the same kind were made, of other flocks of birds during the next few weeks, and it was soon apparent that this method of observation had several very real advantages. In the first place the clear images of the birds and their relatively large size in the field of the telescope made specific identifications easy and certain, even at a distance. In the second place, it was possible to watch a flock for long periods of time, almost uninterruptedly, without fatigue, and in a comfortable sitting posture. At first a box was used as a seat but later a folding camp stool, with a cloth seat and a back was found much more comfortable. In the third place, the hands were left entirely free for note-taking and sketching, for when the focus of the instrument was once adjusted for a particular tree-top it did not need further attention. And in the last place, it was possible to make observations at some distance away from the birds under scrutiny—at a greater distance than could be ocularly over-leapt by even eight-power binoculars, and to remain concealed and quiet, the while.

These first, somewhat casual observations, led, later in the same season, and again during recurring years, to a series of more systematic ones with the view of determining whether a telescope of the type used might not be employed with advantage in the close scrutiny of birds at greater distances than binoculars would be able to bridge successfully. Accordingly several pairs of optically good prism binoculars were secured and their relative usefulness in the field compared with that of the telescope. The binoculars used were:—(1) an eight-power, 27 mm. objective, (2) an eight-power, 30 mm. objective, (3) a ten-power, 27 mm. objective, (4) a sixteen-power, 40 mm. objective—this was the "Telsexor" by Zeiss, a superb glass! and (5) a twenty-power, 45 mm. objective. The telescope was a three and one-half inch refractor, by Bardou and Son, Paris, rack and pinion focus, with finder-telescope mounted on the main tube, altazimuth mounting on heavy oak tripod with double legs, fitted with adjustable central pillar and a device (added later) for the direct reading of the inclination of the telescope tube from the horizontal, in degrees. Three terrestrial oculars were used, giving magnifications of thirty, forty, and fifty diameters. The thirty and fifty times oculars were assembled by the writer from Leitz compound microscope eyepieces, and the forty times ocular was furnished with the telescope.

It was found almost at once that the fifty times ocular was not satisfactory for this sort of terrestrial work; the image formed was too tremulous, to allow it to be carefully examined, and the high magnification demanded the sacrifice of too much light. The forty times ocular proved very useful in good light, and the thirty times was useful in all the conditions under which the telescope could be employed at all.

One of the earliest uses made of this telescope was in studying the nest-building activities of a pair of Red Shouldered Hawks (*Buteo lineatus lineatus*).[1] The instrument was concealed in a patch of bushy woodland (Pl. XXVII) about a fifth of a mile from another wooded area from the center of which arose a tall White Oak in which the hawks had commenced operations about forty feet from the ground. In the field of the telescope the pair of birds could be

[1] Hausman, L. A., The Hawks of New Jersey, Bull. 439, N. J. Ex. Station Rutgers University, New Brunswick, N. J., 1927, p. 48.



WATCHING THE NESTING OF A PAIR OF RED-SHOULDERED HAWKS THROUGH A THREE-AND-ONE-HALF INCH REFRACTOR.

closely watched as they brought their collection of sticks, weeds, bark, leaves, and the like, and their activities in the fabrication of these heterogeneous materials into a firmly aggregated nest, studied. Unfortunately the birds deserted the nest before the eggs were laid (perhaps before the completion of the structure). It is thought that one of the pair was killed. The advantages in thus studying these birds through the telescope were that they were seemingly unconstrained and natural in their actions, apparently unaware that they were the objects of close scrutiny; and that long-continued watching was possible without fatigue to the observer. Note taking and sketching at the eyepiece were easy and pleasant, since the arms were free and not tired out holding up a pair of glasses to the eyes. The image in the telescopic field was free from vibration, for the telescope, as has been said, was buried in a wooded glade, within which even moderate winds did not make much of a stir.

Later in the year the telescope was taken to an undulating marsh and meadow territory, and Marsh Hawks (*Circus hudsonius*) watched in flight, and found not at all difficult to follow after practice, first with the thirty-times, and then with the forty-times ocular. The wide field of view of the telescope, and the ease with which the tube could be swung vertically and horizontally, and focussed, made it possible—not to say simple—even during periods of unusually erratic flight, to keep the bird in the center of the ocular field, provided it was at least 500 feet or more away. The farther away the bird was, the less its apparent motion, and the simpler the problem of keeping it always centered and in focus. Slight movements of the head could be observed as the bird inspected the ground over which it flew, and motions of the tail and legs which the writer had never seen before through binoculars were apparent and interesting as indicating the complexity of the muscular adaptations which were continuously going on during flight. During the observation of one individual it was seen to turn the head toward the tail, close the eye, and then to scratch the region just below it vigorously with one foot, dangling the other one meanwhile to the full extent of the leg. This observation was made through the forty-times ocular when the bird was at least a quarter of a mile away, and about 300 or 400 feet in the air. The eight-times binoculars could not give such an intimate view of this bird as did the telescope, and the sixteen-times and twenty-times were too unsteady for use.

In following bird flights—at a distance always—the tube of the telescope could be swept along steadily and evenly and depressed and elevated smoothly on its well-oiled bearings with the left hand, while the fingers of the right hand manipulated the screw of the rack and pinion focal adjustment. After practice this was found to be no more difficult than to follow a swimming protozoan under the compound microscope, the left hand moving the slide (or the mechanical stage screws) and the right hand altering the fine adjustment of the focus. After some slight dexterity in this matter had been acquired it was not difficult to keep a flying bird such as a hawk, a vulture, or a crow, in the center of the field of view with a steadiness of image sufficient to enable accurate observations to be made of the movements of head, tail, legs, and wings, or to determine, in some cases, what the bird was carrying. Thus in one instance the writer followed a Turkey Vulture (*Cathartes aura septentrionalis*) as it arose from a woodlot nearly a half a mile away, until it was lost in the distance, and could clearly make out a snake of some small species, either grasped (!) in the bird's weak talons, or tangled about the leg. The telescope showed, moreover, motions of the snake which seemed to be of its own making—upward writhings, and the like—which first led the observer to postulate it *as* a snake, and to conclude that it was still alive.

For the identification of hawks at great distances—too great for the use of binoculars—the telescope proved most useful. Thus at different times it was possible to identify the Red-Tailed Hawk (*Buteo borealis borealis*), the Marsh Hawk, and Red Shouldered species already referred to, when the birds were too far off and too high to be resolved beyond doubt by binoculars. In these instances the eight and ten powers did not magnify sufficiently, and the sixteen and twenty powers were too unsteady. Even when rested upon a support it was found that the sixteen powers did not enlarge the image enough for an undoubted identification, and the twenty powers admitted too little light. In this connection of the observation of hawks at considerable altitudes, it was new to the writer that the Marsh Hawk so often resorts to elevated soarings, *at almost any time of the year.* Again and again the telescopic image of a hawk so high in the air as to be a mere bifurcated outline, even in the ten-times binoculars, showed the diagnostic white rump-patch, or revealed the characteristic contour of the wings and tail of the species. In some instances these field marks could not be made out at all with the eight-times binoculars, and with nothing like certainty through the sixteen-times. The twenty-times were always uncertain in attempted identifications of this long-range sort because of the tremulous character of the image.

The diameter of the field of view of the telescope, with the forty-times ocular, at a distance of twelve inches from the eye, was six and a half inches. It was estimated that a flying Marsh Hawk at a distance of one-half mile, and 400 to 500 feet in the air, was seen in this field about two inches in length. With a sharply focussed image, and with the bird in good light it will be apparent that diagnostic color and contour characters could not be difficult to note.

During the observation of a Red-tailed Hawk, sailing at a height of 800 to 1,000 feet it was noted that the head was moved constantly from side to side, and up and down, and obliquely inclined, as if the bird were carefully scrutinizing the terrain below. Other Red Tails have been observed, at different altitudes, to show the same head motion. The opening, and partial closing of the tail has been watched, and the delicate adjustments of tail and wings just preceding changes in the direction of flight. It is believed that studies made through the telescope of flying hawks will result in the accumulation of much data on the flight habits of these birds which we may not now possess. Some interesting, and it is thought, new observations on the flight habits of the Turkey Vulture have been made through the telescope described, and these may be presented in these pages in the near future.

The ideal location for the use of the telescope in this sort of bird study was an open hilltop, about two hundred feet above a wide-open stream valley, flanked with various types of country round about, such as; open fields, scrubby meadow-lands, marshy sloughs, patches of woodland, a high hillside covered with a dense forest of hardwoods, a farm with adjoining cultivated fields, several fence-rows with their characteristic linear conmunities of bushes and vines, and several tall dead chestnut trees in the distance. In this setting the binoculars could be used for birds close at hand, and the telescope for those more remote. Incidentally the telescope proved invaluable in the examination of the antics of a woodchuck on a far hillside nearly a mile away, who seemed to be in some difficulty respecting the renovation of the architecture of his doorway. Again the instrument afforded some respite from the more serious business of data-collecting when focussed on a farmer and a refractory colt which had gotten loose behind a barn in a little stream valley nearly two miles off in another direction. In this setting just described, and surrounded by territory of varying topography and plant associations, and inhabited by different groups of birds, the writer has spent many pleasant and profitable hours without once stirring away from the spot in which his telescope was planted. Here many notes were taken on the flight of hawks, and some observations of the Turkey Vulture made, which have been just referred to. A good deal of apparatus, it is true, had to be transported and set up, but the transportion was easily made by automobile, a roadway running to a point within a few hundred feet of the observation site. The telescope is a portable one, and fits into a box of convenient dimensions.

In the study of birds not in flight, at a distance, and undisturbed the telescope has proved of much service. Thus there have been watched among other things: the feeding of a flock of Turkey Vultures about a carcass, the courting antics of a pair of Flickers, the mutual preening of a pair of Crows (on one of the dead chestnut trees alluded to), the "nuthatching" activity of a White-breasted Nuthatch, the preening of a male Sparrow Hawk on a telegraph wire at least a half-mile away, the curious actions of a male Bluebird going in and out of a hole in a telegraph pole on the twenty-first of October (!), the feeding of a flock of American Mergansers in the mid current of a wide river, and a mixed flock of Herring and Ring-billed Gulls which the forty-times ocular resolved and identified without difficulty where the eight-times binoculars had failed, since the birds were on a tidal flat too far away to be distinguished. And the condition of such observations which makes its appeal to the observer again and again, is the ease with which one may sit at the ocular of the instrument and watch with care, and without motion or fatigue, for long periods of time, a bird or group of birds in a clear, steady, well-lighted field of view, highly magnified, clearly and sharply focussed, and unagitated by the near presence of an observer.

However, it must not be supposed that every bird focussed upon gives a satisfactory image, or that the use of the telescope is invariably attended with the successes which have been described. For the best use of such an instrument the wind must not be strong, and the subject must be seen in the best reflected light, i. e. the sun must be toward the rear of the observer. Several disadvantages, too, attend the use of the telescope. On very warm days, objects near the ground are seen to waver in the heat waves arising from the earth, and to present distorted images in the field. When a strong or even moderate wind was blowing, unless the telescope was sheltered, there was too much vibration of the field of view. This could be partly remedied, however, by steadying the tube with one hand. For days on which observations must be made in the wind a portable steadying device is desirable. In a light wind, or on calm days, the birds in the telescope showed no motions other than their own. At first, too, there was difficulty in locating a given bird, and securing its image in the center of the field. The finder did not help much here (being designed for use only in celestial observations), and after practice was ignored altogether, and the bird located and focussed through the main tube. This was found not at all difficult to do with a little practice.

An attempt was made to devise a means whereby the altitude of soaring hawks, or other large birds, might be computed, a method which it is thought may be useful where something more than a guess is desirable. The diagram given in Fig. 1 shows the method employed. After the soaring bird (C) has been sharply focussed, the angle of the telescope tube with the horizontal is read directly from a protractor and indicator attached to the tube, and recorded. This is angle S, Fig. 1. The telescope is now directed downward toward any prominent objects in the country around (the focus remaining unchanged) which may be located on a U. S. Geological Survey topographic map of the region, such as, e. g., a sharp hillside, a village church, a railroad track, a steep declivity in a stream bank, or a tall tree in a prominent hollow or ravine. When some such object is found to lie sharply in the focus of the telescope, it is located on a topographic map of the region, and the distance between it and the point of the observer is measured. This point is called the "focal object point," and labelled B in Fig. 1. Since the topographic maps run about one mile to the inch, it is possible to determine the distance in feet accurately enough, in an air line from the observer to the position of the "focal object." This gives us the value of the line AB (Fig. 1), and since the focus of the telescope was the same for the soaring hawk, gives us the value of line AC, as well. AB, AC, AE and ET (the latter being the vertical axis of the telescope) are now measured. Then, of the similar right

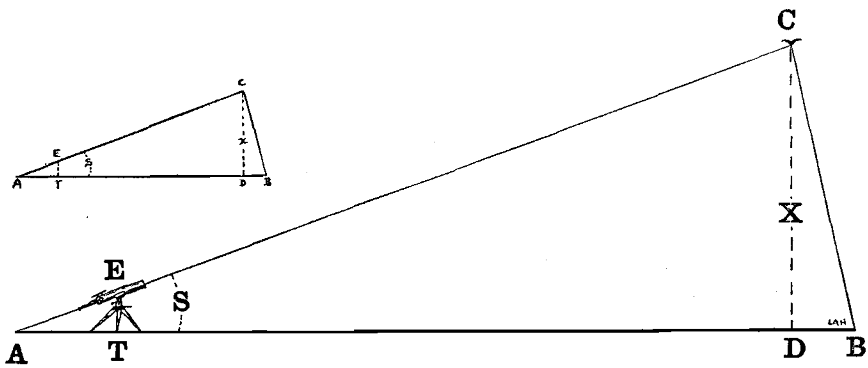


Fig. 1. Method of computing the height of soaring Hawks with an altazimuth refractor. A. Theoretical position of the observer; C. Soaring Hawk; B. Position of the "focal object;" X. Altitude; ET. Vertical axis of telescope; S. Angle of inclination of tube.

triangles, AET and ACD we know the values of AE, ET, and AC; and the altitude (X) of the larger right triangle (ACD), is easily found. Strictly speaking, the triangles should be formed with the vertex within the telescope tube, to the point where the image is formed, and the measurements of the base line of the larger triangle made from this point. But it was felt that this refinement was not at all necessary. An equally simple method of arriving at the value of the altitude, AD, is to consider that, of the isosceles triangle BAC, we know the value of the sides AB and AC, and of the vertex angle BAC. One may then construct a similar triangle, with the sides any convenient length in inches, and in this way find value of the altitude CD.

Several tests of this method indicate that it is a useful one, and while it gives us, it is true, a very rough figure, it is thought that, in conjunction with, and as a check upon a purely unaided ocular estimate it has appreciable value.

It is not here suggested that any of these uses of the telescope should supplant the more intimate stalking and close scrutiny of birds with binoculars at short range, nor are they offered as being entirely new, except in their more precise application. In a limited application, however, it is believed that the telescope of moderate powers, and accurate adjustments has a very real service to offer to those who wish to carry on the observation of birds from one place, and to those who would study intimately the flight habits of soaring birds high in the air, or at a distance undisturbed.

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