The position of the electrodes determines to some extent the nature of the record. The most accurate record of wing position is obtained if the leads are placed so that the wings move either toward or away from them. Experiments were performed to determine how closely the record gives the instantaneous wing position during a cycle. For this a simple camera was constructed in which a piece of film could be pulled past two small slits opposite each other. The antihalation back was removed from the film with hypo so that, through the slits, two simultaneous records could be made. The cathode ray and the light beam from the scutellum were superimposed through the slits, and the film was pulled past when the insect began to fly. The record (Fig. 1, *C*) shows almost perfect correspondence; the solid line is traced over the wing movement record and the dotted line over the scuttellar movement record.

No methods of recording flight movements previously used could demonstrate the gradual development of a fast stop as shown in *D,* a record of scutellar movements, and *E,* a record obtained by the electrostatic method. The fast stop is reflected in changes in the thoracic potentials (*E,* middle trace). The electrostatic method, because it converts movement into electrical voltage, permits comparison with other parameters that can likewise be made to produce electrical change.

There may be some question as to whether this method records position at all movement frequencies. This can be determined directly in a specific case—at least in flies—by comparison with scutellar movements as demonstrated in this report. A simpler method of obtaining the approximate phase relation between wing position and electrical voltage is to set one input lead so that a wing just touches it when the wing is at its extreme excursion. This puts a small pip on the record at the instant the wings reverse direction. If the pip occurs at a negative or positive voltage peak, the record shows wing position. Adjustment of the polarity of the leads should be made to make a positive peak correspondence to the extreme up position and a negative peak to the extreme down position. If only wing frequency is desired these precautions are not necessary.

This method has wide application in studies of insect flight and, by comparison with the direct recording of scutellar movements, will give instantaneous position, direction of movement, and velocity during rapid flight with an accuracy sufficient for many purposes.

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Paleobotanical Investigations in Naval Petroleum Reserve No. 4, Alaska[1]

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During the summer of 1951 a party from the University of Michigan spent several weeks looking for fossil plants in Naval Petroleum Reserve No. 4 in northern Alaska. The project was sponsored by the Office of Naval Research, and the Arctic Research Laboratory at Point Barrow furnished field equipment and transportation within the reserve. The party, consisting of the writer, with Richard A. Scott and J. Stewart Lowther as assistants, arrived at Point Barrow on July 3. Most of the work was done along the Colville River at the southern edge of the reserve, but a short visit was made to the coal mine at Atkasuk, about 80 miles south of Point Barrow on the Meade River. In addition to collections made by our party, one was made by W. V. Mayer at East Oumalik, which is on the northern edge of the Arctic Plateau between Point Barrow and the Colville River.

Along the Colville River, two stretches totaling about 120 miles were explored for fossil plants, using an 18-ft canvas boat for transportation. The longest of these stretches was that between the mouths of the Etivluk and Killik rivers. The rocks along this part of the Colville River belong mostly to the Nanushuk group, and the plants were found in the Chandler formation, the nonmarine part of the group which intertongues with the marine Umiat formation. Then along a shorter stretch of the river, beginning at Umiat, which is about 50 miles downstream from the mouth of the Killik River, extensive exposures within the Colville group were examined. Formerly regarded as Upper Cretaceous, the Nanushuk group is now believed by geologists who have recently worked in the reserve to be Lower Cretaceous. The Colville group has been retained in the Upper Cretaceous, where it was originally placed (*1*).

Fossil plants were collected at 13 localities in the Chandler formation between the places where the Etivluk and Killik rivers join the Colville. The flora of the Chandler formation is a typical late middle Mesozoic one, consisting of conifers, cycadophytes, ginkgoes, ferns, and a few fragmentary dicotyledonous leaves. The latter are always a minor element, so minor, in fact, that at the best locality none were found, although they were diligently looked for. The most abundant conifers are *Sequoia*-like forms represented by cones and foliage, and foliage of ancient members of the Taxaceae. Well-preserved silicified coniferous wood was found at several places. *Podozamites* is very abundant, and the Ginkgoales are represented by the extinct genus *Baiera* and deeply dissected leaf-forms of *Ginkgo*. The most prevalent

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cycadophytes are forms resembling *Nilssonia*. A plant that is conspicuous because of the size of the leaves, but that is never present in great numbers, is a species of *Macrotaeniopteris*. Ferns are represented by *Cladophlebis* and other genera.

The Colville group is less productive of fossil plants than the Nanushuk group, although a good collection was secured from the nonmarine Prince Creek formation three miles below Gubic, near the junction of the Anaktuvuk River with the Colville. *Sequoia*-like conifers are abundant, and dicotyledonous foliage is present in larger quantities than in any of the collections from the Nanushuk group.

The fossil plants of Naval Petroleum Reserve No. 4 are of special interest because of their bearing on the age of the rock formations that contain them. Originally almost the entire mantle of sandstones and shales covering the greater part of Alaska north of the 69th parallel was believed to be of Upper Cretaceous age, and was so regarded by F. H. Knowlton, who examined several fossil plant collections secured by earlier exploring parties (*2*). Knowlton formulated his conclusions from the few dicotyledonous leaves in the collections. He said that since dicotyledons did not appear until middle or late Cretaceous time, the presence of even one leaf fragment would show that the rocks are not older. If dicotyledons are present, he would reject all other plants as indicators of age (*2*).

Knowlton's elimination of all plants except dicotyledons as age indicators was done on the assumption that these plants did not appear on the earth until mid-Cretaceous time, which of course is not true. The fact that he knew of their existence in earlier rocks is shown by his list of plants making up the Lower Cretaceous Potomac flora (*3*), in which there are several dicotyledons. In his exclusive use of dicotyledons for correlative purposes, and the complete disregard of all other plants that might be present, he was ignoring the essential fact that dicotyledons are sometimes present in Lower Cretaceous rocks.

In distinguishing between Upper and Lower Cretaceous on the basis of plant remains, the criterion is mainly the relative abundance of dicotyledons and other plant types. In the Upper Cretaceous of the Yukon Valley and the Alaska Peninsula, for example, dicotyledons outnumber other plants by a proportion greater than three to one. In the Dakota group, which contains the largest of known early Upper Cretaceous plant assemblages, dicotyledons make up about 90% of the flora. Other Upper Cretaceous floras show a similar high proportion of dicotyledons, although they are not necessarily as high as in the two examples given here. However, in the Nanushuk group, where dicotyledons are scarce or absent entirely, the proportion is no greater than in the lowest member of the Potomac group (the Patuxent) where dicotyledons make up an approximate 5% of the flora. If by chance one were to happen only upon those localities in the Nanushuk group where there are no dicotyledons, evidence of Jurassic age would be as strong as Cretaceous. In view of the few dicotyledons that are present in the group, Lower Cretaceous age practically amounts to certainty.

The plants collected from the Colville group are insufficient to characterize it definitely as either Lower or early Upper Cretaceous, but the absence there of cycadophytes and *Podozamites,* and the presence of more dicotyledons, indicate a later floral development than that revealed in the Nanushuk group.

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Nomographs for Determining Seiche Periods

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Small variations of water level can be measured accurately; nevertheless the limnologist must still compute the theoretical seiche period. Seiches are found on all lakes but because of their small amplitude may escape notice. Seiches may be very significant in current analysis and to the ecologist. The nomographs (Figs. 1 and 2) express the seiche period in minutes or hours, and are based on Merian's formula, which was simplified by William Thompson (*1*). The formula is expressed as

$$t = \frac{2L}{\sqrt{gh}},$$

where t = seiche period in seconds; L = length of the center line along the seiche axis in feet; g = gravity (32.16 ft/sec/sec, 41° Lat.); and h = average depth of the basin in feet.

For an accurate computation this formula must be applied to small increments along the seiche axis (integration by approximation), but in many cases the average depth, for a small lake, will give a sufficiently accurate estimate.

A sample computation, using Fig. 1, for Lake Erie is given. The center line through the lake is 213 miles long (top line), and the average depth is 61 ft (bottom line); a line drawn between the two points shows a period of about 14.2 hr on the diagonal line, a value which agrees with computations made by Endros (*2*) and Olson (*3*).

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