TECHNICAL NOTES

VISORY COMMITTEE FOR AERONAUTICS.

No. 172

THE NICHOLS WING CUTTING EQUIPMENT.

By James B. Ford,
Massachusetts Institute of Technology.

December, 1923.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL NOTE NO. 172.

THE NICHOLS WING CUTTING EQUIPMENT.

By James B. Ford.

The wing cutting equipment about to be described was designed and built by Mr. W. H. Nichols in his shops at Waltham, Massachusetts. Its construction was undertaken in order to meet the long-felt necessity for a means of producing metal wings for wind tunnel tests which would be accurate and fair, and yet within a price commensurate with the value of a model wing test. The design and construction was commenced late in 1921, and after overcoming the difficulties which the problem presented, wings were being cut in August, 1922. The wing cutting machine will make any size of constant-section wing or strut up to six-inch chord by thirty-six inch span and up to a thickness of 1 1/4". It cuts a smooth, true model that is accurate to within two-thousandths of an inch on any ordinate. The holding jaws are so designed as to leave the model free of chip marks, and the only hand finishing necessary after the cutting is a rub with amunite paper to remove burrs. The actual change in ordinate in this finishing rub is less than .0002".

It has hitherto been the practice to use wooden models for wind tunnel tests because of the almost prohibitive cost of those cut from metal. Wood, however, has the very serious disadvantage of non-permanence in that, however well the stock be seasoned, ages and rocking shafts. The rocking shaft of the finishing cutter linkage is shown at "D", while the three movable links of the linkage can be identified at "E", "F", and "G". The roughing cutter linkage is not so evident, being on the side of the machine not shown in the plates.

The wing blank is fed continuously through the holding jaws in the rotating head and between the two cutters by means of a nut and splined lead screw. Both the speed of feed and the revolutions of the blank are adjustable and can be changed to suit the material, being controlled through a simple friction disk drive shown at "H", (Fig. 1). The cutters are driven directly from the belted countershafts through double universals. The coolant pump is belt driven from the high speed countershaft. The coolant is piped to the cutters and returns from the guards through strainers to the sump in the base of the machine. A two lobe cam is provided at "J", (Fig. 1) on the rotating head which increases the angular velocity of the templet and blank at the leading and trailing edges, where, because of the extreme elongation of the form to be cut, the ratio of linear velocity of cut to angular velocity is low. The machine operates perfectly and equally well in cutting wings of various material such as wood, steel, duralumin, etc., and of any size up to its capacity.

The Laying-out Machine.

Reference has been made above to the operating cam shown at "A", (Fig. 2), which is in effect a true templet of the wing secthe wing will change its shape due to the fact that unequal amounts are cut from the two sides of the blank in order to form the wing. Then, too, a thin wing which is supported by the tip, as is the case on balances of the N.P.L. type, will often deflect sufficiently to permit bad vibration at large angles. In the case of a complete model with thin wings in which the forces to be taken through one wing tip are perhaps twice as great as on a single airfoil, the use of metal wings becomes almost imperative. Since it is highly desirable to have wings which will retain their true contour during and after test and not be deflected by the forces they have to stand, the value and importance of this equipment to aeronautics and particularly to wind tunnel experimentation may be appreciated.

The wing cutting machine proper is illustrated by Figures 1 and 2. It is essentially an automatic horizontal cam profiler. As may be seen from the illustrations, the machine is amply heavy to absorb the cutting vibrations and eliminate tool chatter. The operating cam consists of a true templet of the desired wing section, six times the size of model to be made. The templet is shown at "A," (Fig. 2), and may be made of hard wood or steel. The templet rotates with the wing blank and the two cam rolls follow the templet at 180° to each other, "B" operating the roughing cutter while "C" operates the finishing cutter. The cam rolls of course are six times the cutter diameter and their movement is reduced in the ratio of six to one by two simple four-bar linktion to be cut. The need was soon felt for an accurate means of laying out these templets with facility. Accordingly, the instrument illustrated in Figures 3 and 4 was built up, using a lathe bed and carriage. The blank from which the templet is to be cut is rigidly attached to the cross slide of the carriage and travels with it. The bridge shown at "K" carries a decimally divided scale and is traversed by a vernier carried on the carriage, which permits a reading of .001" in spacing the stations along the chord of the section. A second decimally divided scale shown at "L" is attached to the carriage normal to the scale on the bridge and is traversed by a vernier attached to the cross slide of the carriage, which also permits a reading of .001" in laying out the ordinates of the upper and lower surfaces at the different stations. Thus if the wing ordinates are given from any datum line, which may or may not be the chord line, the points on the contour may be laid in to .001", and this on a templet six times the size of the model wing to be cut, making the final possible error of layout less than .0002". A centering device attached to the bridge and set to be at zero in relation to the scales is fitted to take either a prick punch or a small drilling head. If a wooden templet is being laid out the points on the contour are pricked in with the punch and the contour drawn with a spline. The templet is subsequently cut out on a band saw and finished down to the line on a wood grinding machine. If a steel templet is being made the ordinates are recalculated to be inside of the true contour by .050" (measured normal to the boundary) and a hole is drilled in the steel at each point by means of the drilling head which fits the centering device. The templet is now roughed out and then a steel spline is clamped on, resting against pins passed through all the drilled holes, and the templet is ready for grinding down to the final true contours in the templet grinding machine described below. The sum of the thickness of the spline and the radius of the drilled holes is of course .050", the amount by which the centers of the holes lie inside the true contour.

The Templet Grinding Machine.

The templet grinding machine is illustrated in Figure 5, and is of the vertical spindle type. There are two carborundum wheels on concentric spindles. The lower wheel, shown at "N", (Fig. 5), is driven by the motor and grinds the edge of the templet, while the other runs free, but is not driven by the motor unless it is to be dressed with the diamond down to the same diameter as the working wheel. After both wheels have been accurately dressed square and true with the diamond shown at "N", their vertical position is set with a hand wheel so that the free wheel bears against the spline on the templet while the driven wheel "M", which does the cutting, is exposed only enough to grind the templet flush and fair with the batten. Thus the templet is ground absolutely to the ordinates required and its curvature is fair because of the stiff steel spline which is used as a guide in the grinding. It may be noted in passing that the grinder table is grooved so as to prevent the accumulation of grindings under the templet while it is being ground.

To date a great number of wings and struts have been cut in the machine and there can be no question of their superiority over hand-fashioned models. The cost of a duralumin, steel, or brass model is considerably less than by the older method and the accuracy of the work is beyond question. Wherever possible, machine-cut models are now used for the tests in the M.I.T. tunnels. Mr. Nichols has made an important contribution to aeronautical research in making it possible to attain a greater accuracy than has ever before been possible, and yet at a lower cost.

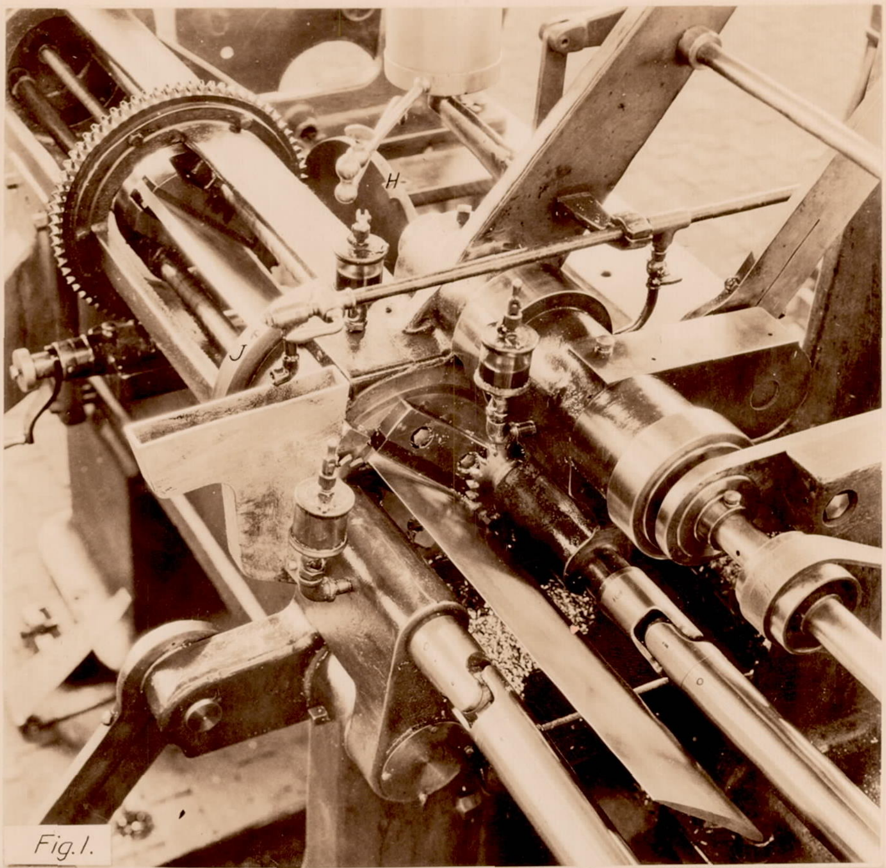

Fig. 1.

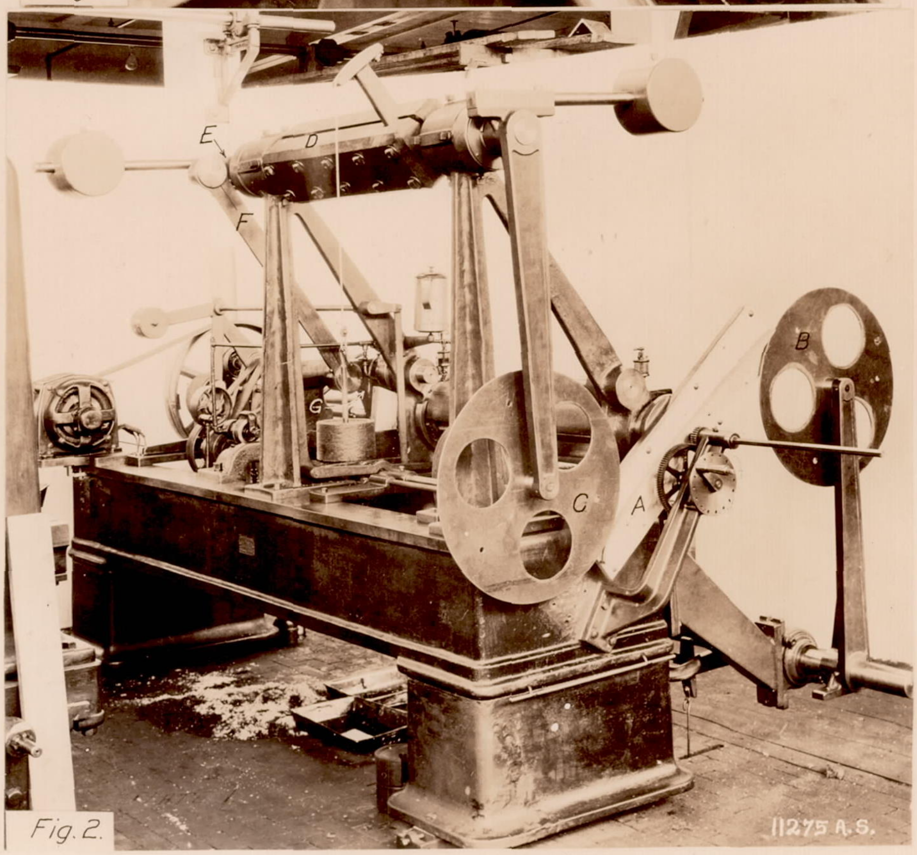

Fig. 2.

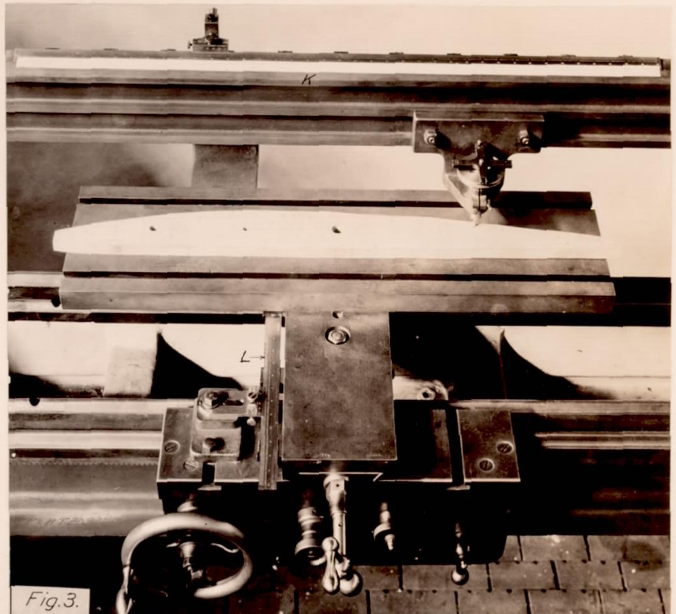

Fig.3.

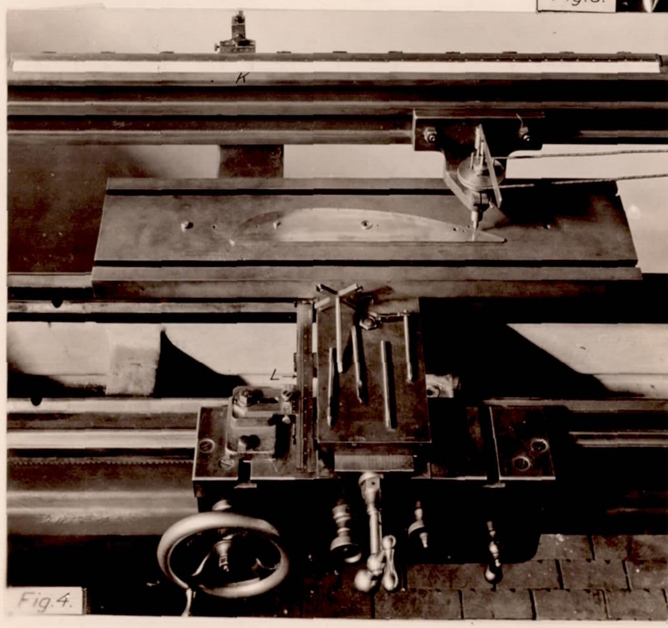

Fig.4.

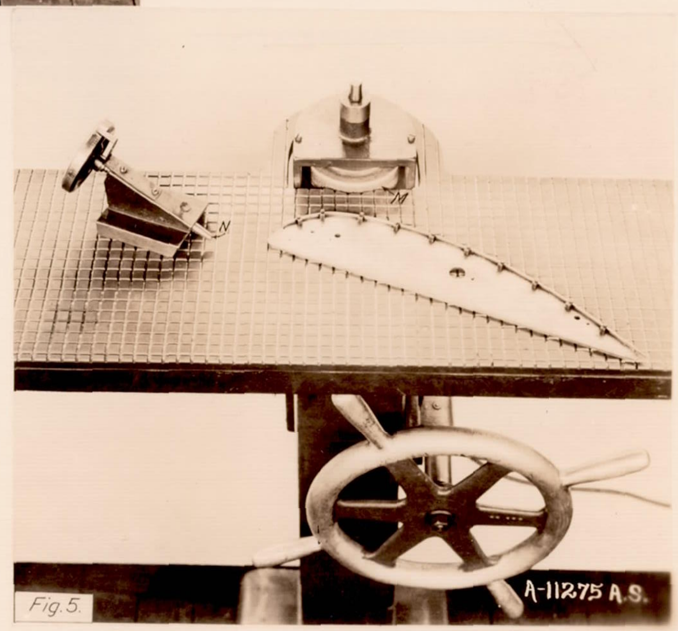

Fig.5.