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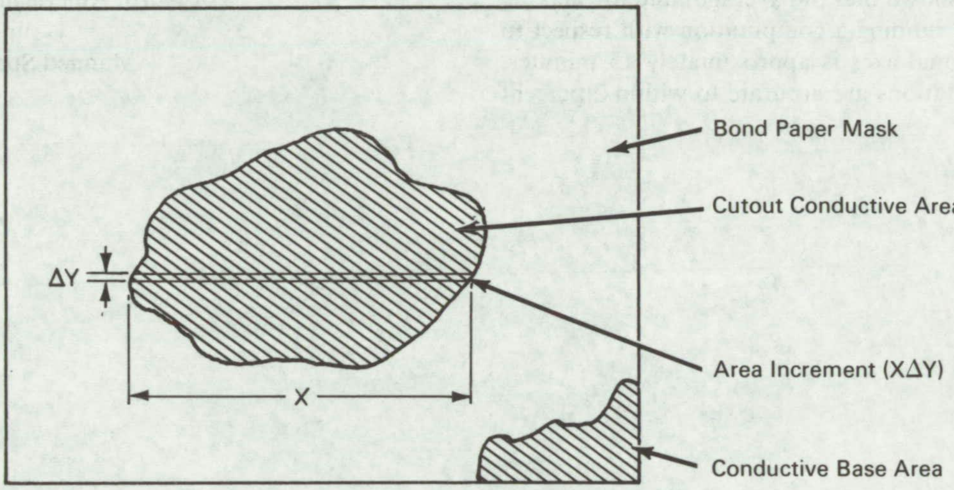
NASA TECH BRIEF

Instrument Calculates Moments of Inertia of Complex Plane Figures



The problem:

To provide an instrument that will calculate distributive-area properties, such as centroids and moments of inertia, of complex or irregular plane figures representing cross sections of structural members. For figures of this type, the required properties cannot be obtained from tables or calculated analytically, as in the case of simple geometrical figures. Manual methods, which yield approximations of the true area properties, are laborious and time consuming.

The solution:

A calculator consisting of a narrow field scanner coupled with a relatively simple preprogrammed computer.

How it's done:

The calculator uses a servoed X–Y plotter, with a linear sweep voltage applied to one input axis and a linear step voltage to the other input axis, to scan the area in small incremental steps. The output data from the scanner are fed to an analog computer, which performs a series of discrete summations, closely approximating the exact integration, to yield the value of the desired property (e.g., centroid or moment of inertia).

The area whose properties are to be computed is cut from a sheet of bond paper and the remaining outline is cemented as a mask on an electrically conductive base. The exposed conductive area is then used for incremental scanning. A linear sweep voltage causes the probe of the X–Y plotter to scan across the conductive area in the X direction, and a linear step voltage applied at the end of each sweep causes the probe to step a constant small increment (ΔY) in the Y direction. In this manner, each incremental area ($X\Delta Y$) is swept out over the entire conductive area. The stepping voltage at any given time corresponds to the distance from a selected arbitrary reference axis

(continued overleaf)

(which serves as a base for calculation of the desired property, e.g., centroid or moment of inertia) to the incremental area being swept out. As the probe makes one sweep across the surface, a sweep voltage pulse will be generated as long as the probe is in contact with the conductive surface. Since the probe sweeps at constant speed, the time of the sweep voltage pulse is proportional to each incremental area. The outputs from the plotter and the conductive surface are fed to a preprogrammed analog computer which uses an integrator to compute the desired distributed-area property represented by the conductive area. To determine the area property with respect to an orthogonal reference axis, the step and sweep voltage input axes of the plotter are interchanged

Notes:

1. Tests have shown that the average time for making a mask and running a computation with respect to two orthogonal axes is approximately 15 minutes. The computations are accurate to within 2 percent when the area is scanned in 0.01-inch steps. Greater accuracy can be obtained using shorter steps in the scanning process.
2. An electro-optical scanner or pure mechanical scanner can be used in place of an X–Y plotter.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10306

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Wilbur J. Myers
of North American Aviation, Inc.
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(MSC-628)