April 30, 1965

LINEAR PHASOLVER MEASURING ENGINE

STAT [redacted]

The linear phasolver is an adaptation of the rotary phasolver.

The rotary phasolver is a standard product of the [redacted] STAT
STAT [redacted] which measures shaft angles to a very high accuracy, 19 bits. It is used for remote measuring of radar antenna angular position, theodolite pointing direction, and the like. The linear phasolver uses the same principles as the rotary phasolver but for measuring linear dimensions to sub-micron accuracy.

STAT About two years ago, [redacted] foresaw the need for a new measuring engine, but he did not have a new machine to tie it to. The shortcomings of the then existing yardsticks were painfully apparent to him. The electronics were poorly done with low reliability and uncertain drift. Some of them were limited by the lead screw which had about reached the end of its advancement in capability and was slow. Others were limited by pulse detection and counting rate.

In looking around for a solution the best bet appeared to be the phasolver. It offered the following advantages:

(a) Determination of position was unique and unambiguous and did not depend on counting pulses.

(b) It did not use a lead screw and the traversing speed was thus not limited by the measuring speed.

(c) The electronics were well developed and had many years of production and development debugging behind them. The rotary phasolver electronics were extraordinarily stable and free of drift.

Since linear measuring has some problems different than
STAT angular measuring, [redacted] decided to get them started with a feasibility study. It is a good thing he did, too.

The phasolver works on the basis of determining the capacitive coupling between metallic patterns on two glass plates, a driver and a coupler, which slide along each other. The coupler plate would be mounted on the stationary bed of the measuring engine. The coupler pattern is merely straight bars perpendicular to the direction of motion.

The driver would be mounted to the moving head of the measuring engine and its pattern has a sinusoidal variation as shown on the attached sketch. Two pattern designs were to be tested in the feasibility demonstration.

The electronics measures the phase angle between electrical signals impressed on the driver and picked up by the coupler. The phase angle varies with position, hence, the term "phasolver." The entire problem has been the preparation of a master driver pattern by [redacted] STAT
STAT [redacted] had as much trouble with the linear patterns
STAT as [redacted] had making the original rotary patterns. The project was stalled for about 10 months waiting for good patterns. The electronics were completed almost a year ago.
STAT After [redacted] finally made a good driver master pattern of photographic emulsion on glass, [redacted] made working patterns STAT
STAT from the [redacted] master of deposited metal on glass. [redacted] also STAT
made the coupler.

The test program is now under way to determine how good the phasolver really is. Test results are encouraging but, of course, not complete and definitive. The electronics are very stable and free of drift. When a measurement is set up in the evening and left overnight, it is still registering the same measurement to 1/10 micron the next morning. (Room temperature is controlled to $\pm$ 1°F and relative humidity varies less than $\pm$ 5%.)

The pattern appears to have a scale error of about 15 microns over its 20 inch length. A scale error was expected and it can be balanced out electrically. Also, there appears to be a variation from pole pair to pole pair of from 1/4 micron to about 1-1/3 micron. They are not sure whether this occurs in the test equipment or in the phasolver, but they suspect the test equipment. They are presently trying to pin down the source of the error. Probably the most

encouraging news is that they can repeat a given measurement an hour later and get the same reading to ± 1/10 to ± 2/10 micron. There is still quite a bit of checking to do, but they expect that Test #2 "accuracy, resolution, and repeatability" will be almost complete by the end of next week, May 7, 1965.

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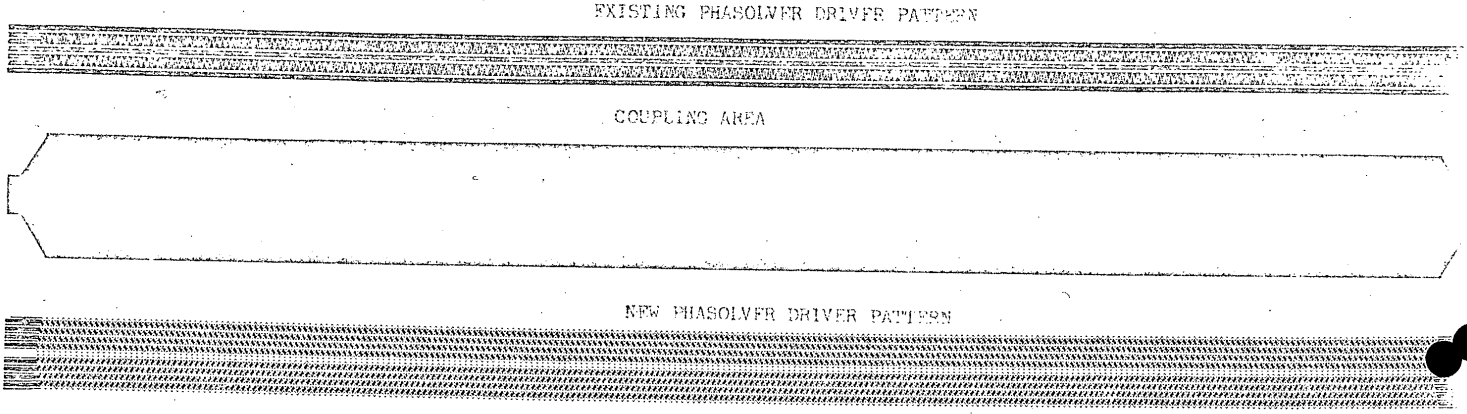
Attachment



DRIVER PATTERN

MODEL 933 PHASOLVER

(ACTUAL SIZE)