998265

June 22, 1965

LINEAR PHASOLVER MEASURING ENGINE

STAT

Measuring the measuring engine is a difficult proposition
and linear measuring is tougher than rotary measuring
because of scale factor variations.

So far, the test data seems to indicate that the Linear
Phasolver electronics and patterns can measure to a
fraction of 1/10 micron. [   ] is trying to prove it   STAT
by measuring gage block lengths.   The variables they must
contend with are:

a)   Manual dexterity of the physical arrangement.
     The principal precaution is to not tilt the
     gage block and thus not measure a false length.

b)   Variations in null position of [   ]   STAT
     microinch meter. Over short periods, this
     appears to be accurate to a few micro inches.

c)   Thermal variations in gage block lengths. They
     have obtained additional gage blocks to make a
     complete set for measuring 1/8 mm increments
     within the 1 mm pole pair length in addition to
     the five lengths of 23 mm, 30 mm, 60 mm, 125 mm,
     and 250 mm. Thus handling and thermal problems
     are decreased.

d)   Temperature and humidity effects on other com-
     ponents. Room temperature is continuously
     recorded and is within 1°F. Humidity is con-
     tinuously recorded and is within about 3%.

In a meeting at [   ] on June 27, 1965, representatives   STAT
of [   ] re-   STAT
viewed the [   ] Phasolver technique of measuring and   STAT
inspected the linear phasolver feasibility model.   The
[   ] representatives were: [   ]   STAT
                                                                 STAT

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He began the day highly skeptical of the practicability of
the phasolver approach, particularly the electronics.
[ ]was able to demonstrate better than 1/10 micron   STAT
resolution and better than 1/2 micron peak to peak re-
peatability. By the end of the day, [ ]still had   STAT
the following reservations:

    a) A laser interferometer by its geometry appeared
        to be easier to incorporate into a measuring
        machine than the phasolver.

    b) The phasolver cost of [   ] for a   STAT
        2-axis system was high.

    c) In principle, a laser interferometer is much
        simpler and should be : more accurate than the
        phasolver.

    d) The scale error in the present phasolver feasi-
        bility model would not meet his requirements.

On the other hand [   ]and the others seemed to be   STAT
convinced that:

    a) The linear phasolver did produce a unique, un-
        ambiguous measurement of position.

    b) There was no limitation on slewing rate from one
        measuring point to another.

    c) The velocity error was probably satisfactory for
        servo drive of a slaved platen to retain stereo
        registration while moving.

    d) Repeatability accuracy was 1/2 micron peak to
        peak or better.

One additional point that came out of the meeting had to
do with skew and tilt of the phasolver plates. Part of the
[   ]test program calls for measurement of the   STAT
sensitivity of phasolver accuracy to relative skew of the
driver and coupler plates and variations of the gap between
the plates, including tilt. [   ]indicated that the   STAT
guiding ways and air bearings on his machine would hold
skew to only a few seconds of arc and variations in the
gap to 100 microinches (2½ microns), peak to peak. These
variations are so small that measuring their effect on
the phasolver is of second order of importance.

[   ]has now turned their attention to scale factor.   STAT
Scale factor error has two parts: a) error within a sine
wave cycle pole pair (a pole pair is one millimeter long)
and b) the incremental error from pole pair to pole pair

over the 20 inch length. It should be noted that both
these errors are systematic and can be corrected by
computer computation.

Non-Linear scale error within a pole pair can be corrected
by balancing the amplitude and quadrature of the driver
pattern exciting voltages. The uncorrected non-linear
error was 60 microns p-p. By balancing, this has been
brought down to about 1.8 micron p-p including repeata-
bility error. (Note this is later data than the previously
reported 0.8 micron p-p scale error.) Further reduction
is probably possible.

The scale error over 250 mm is about 18 microns with about
a 3 micron curvature (i.e. non linearity). In [   ]   STAT
discussion with [   ] their consultant from UCLA,   STAT
they decided that the resistance of the coupler pattern
(which is about 2,000 ohms) was probably introducing a
phase shift as it varied from near zero when measuring at
one end to its maximum value when measuring at the other
end. Tests this week and last tend to confirm that the
coupler pattern resistance is causing the 3 micron non-
linearity in the overall scale factor.

The cause of the linear error in the scale factor has not
been determined. [   ] measurement of the patterns   STAT
indicates the scale factor error should only be about 3
microns whereas the test data indicate it is about 18
microns. Thermal expansion or contraction of the glass
bar on which the coupler pattern is placed may be a factor.
If the temperature of the glass bar at the time of making
the pattern at [   ] and measuring the pattern at   STAT
[   ] is different by about 6.7°C from the tempera-   STAT
ture of the glass bar during the present test program,
a scale factor error of the right magnitude could occur.
Temperature difference is, however, probably only one
contributor.

The [   ] accounting procedure has adjusted their man   STAT
hour rates upward for the year due to increased overhead.
This adjustment makes the contract over expended and they
have officially stopped work. There is no estimate as
to when they might resume work, if at all.

The next phase of the phasolver program should, it seems
to me, be a check of the effect of temperature and
humidity and probably should be run under the direction
of [   ] to permit their thorough evaluation of the device.   STAT
With [   ] concurrance I discussed the possibility   STAT
of running such a test in the [   ] clean room with [   ] STAT
                                                                 STAT

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General Manager of [   ]   STAT

[   ] Both were in favor of such a test   STAT

and will discuss it with John on his next trip.

Unfortunately, the [ ] clean room is not too well adapted   STAT

to such a test. The rooms are not separately controlled.
The present instrumentation will only produce 45% ±5 rela-
tive humidity. It would probably be more suitable, but
more expensive, to run the test in a commercial environmental
chamber. [   ] is planning to investigate the   STAT

possibility of running a simultaneous test of a laser
interferometer measuring device. He has nothing immediately
at hand for such a test.

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