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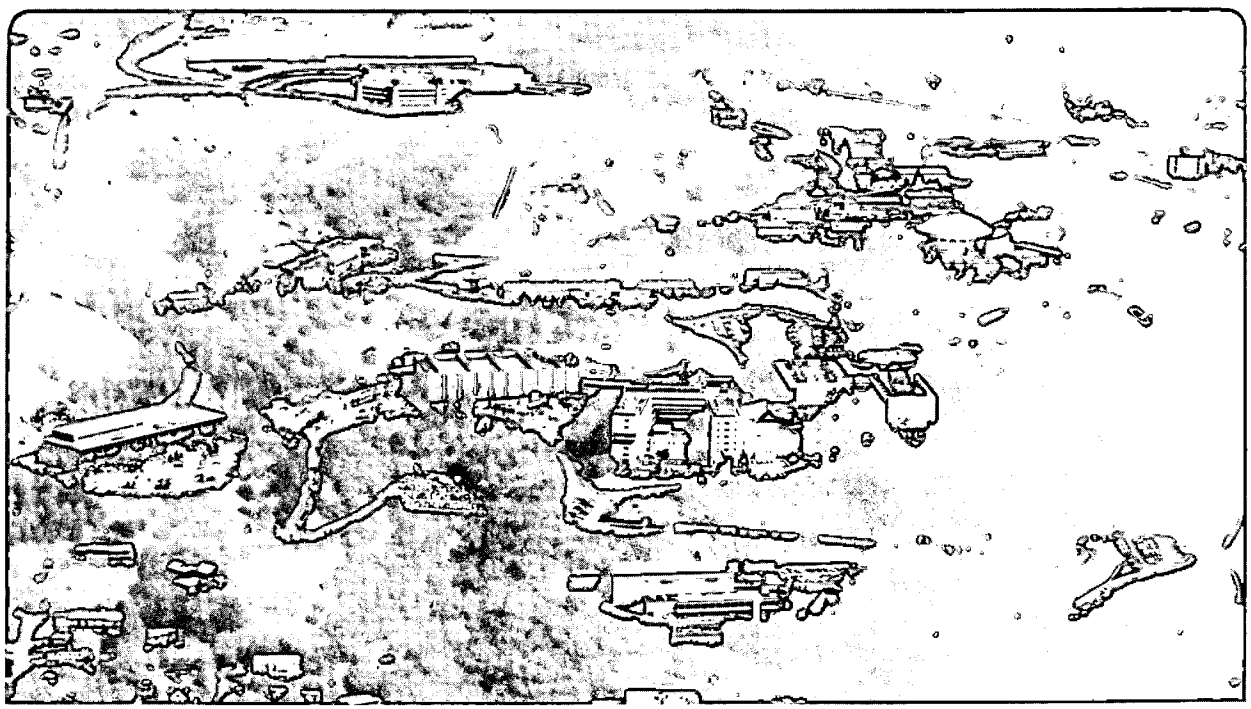

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DISCLAIMER

LAWRENCE BERKELEY LABORATORY – UNIVERSITY OF CALIFORNIA **ENGINEERING NOTE**	CODE SL0835	SERIAL M5983	PAGE 1 OF 9
AUTHOR TED LAURITZEN	DEPARTMENT MECHANICAL ENG.	LOCATION BERKELEY	DATE SEPT. 22, 1982

PROGRAM – PROJECT – JOB
SFL - VUV MONOCHROMATOR
GRATING POSITION ACTUATION

TITLE
FLEXURAL PIVOT CENTER SHIFT EVALUATION

THE VUV PLANE GRATING MONOCHROMATOR HAS DESIGN PARAMETERS THAT INCLUDE VERY PRECISE MECHANICAL MOTIONS. ROTATION OF THE GRATINGS IS ONE SUCH MOTION THAT THIS ENGINEERING NOTE WILL ADDRESS.

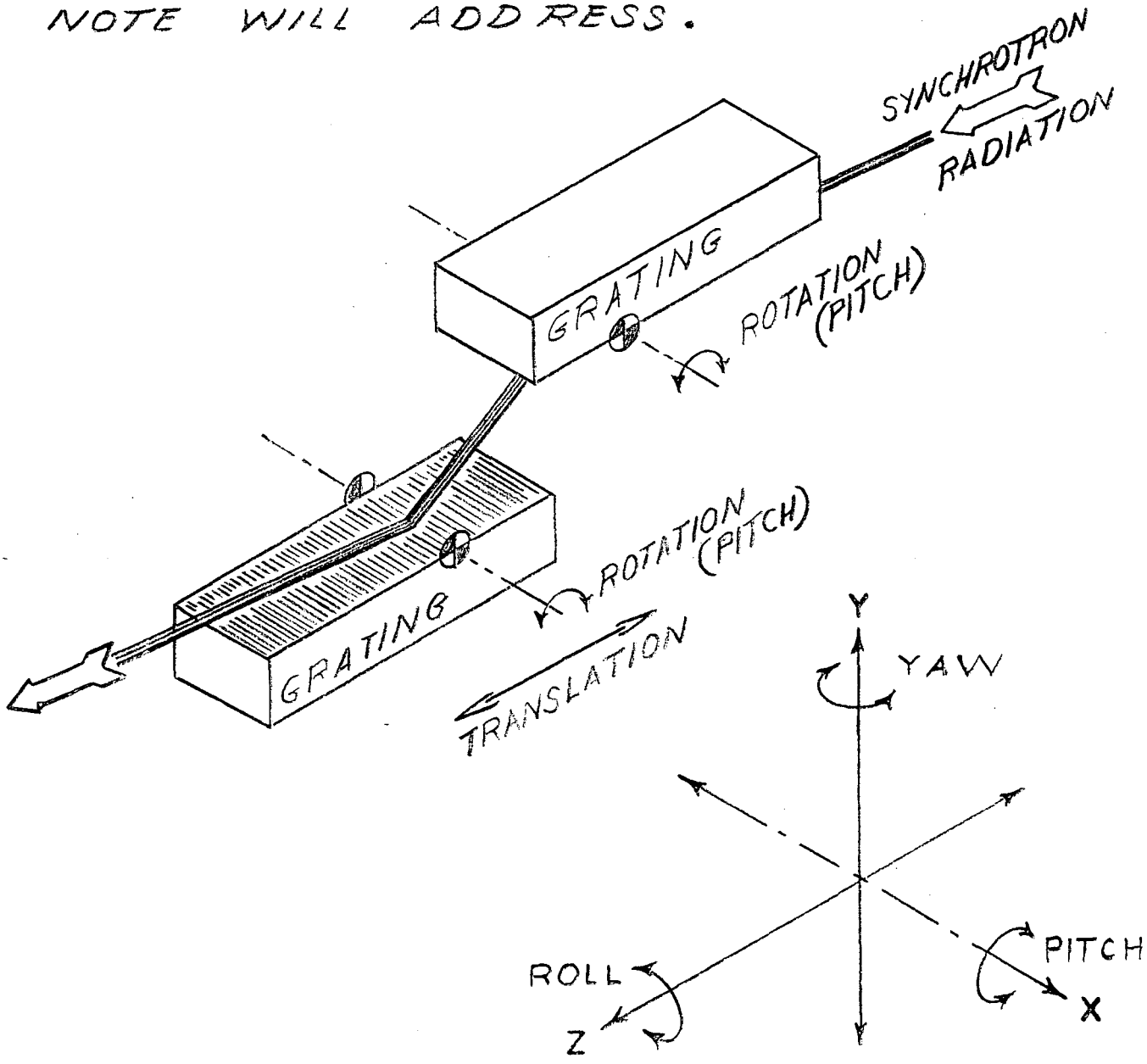

FIGURE 1

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FIGURE 1 SHOWS THE PATH OF SYNCHROTRON RADIATION WITH RESPECT TO THE GRATINGS AND THEIR AXIS OF ROTATION. THE GRATINGS ARE REQUIRED TO ROTATE A TOTAL OF 40° AND TRACK, OR FOLLOW EACH OTHER TO A TOLERANCE OF ± 1 μr (± 0.2 ARC SEC.). THIS IS FURTHER COMPLICATED BY A YAW AND ROLL TOLERANCE OF ± .05 mr (± 10 ARC SEC.). SEE FIGURE 1 FOR YAW AND ROLL. THE GRATINGS, MOUNTING STRUCTURE, AND ROTATIONAL PIVOTS ARE REQUIRED TO OPERATE IN AN ULTRA HIGH VACUUM OF 1×10^{-11} TORR AND BE ABLE TO WITHSTAND A BAKE-OUT OF 200 °C. DURING OPERATION OF THE MONOCHROMATOR IT IS EXPECTED THE GRATINGS WILL BE REQUIRED TO INDEX, ROTATE, IN DISTINCT STEPS OF 1 μr TO 5 μr (0.2 ARC SEC. TO 1 ARC SEC.).

TO PROVIDE ROTATION FOR THE GRATINGS A PIVOT OR BEARING MUST BE PROVIDED. THE FIRST SUCH DEVICE THAT COMES TO MIND IS A BALL BEARING SYSTEM. BALL BEARINGS HAVE BEEN SUCCESSFULLY USED IN UHV SYSTEMS, BUT REQUIRE SPECIAL CARE. STAINLESS STEEL MUST BE USED WITH SPECIAL TREATMENT OF THE SURFACES TO PROVIDE SMOOTH ROLLING. TO ACCOMMODATE THE REQUIREMENTS OUTLINED EARLIER, THE BALL BEARINGS WOULD HAVE TO BE HIGH TOLERANCE, PRELOADED AND POSSIBLY RE-BUILT WITH SAPPHIRE BALLS.

THE VERY SMALL ROTATIONAL MOVEMENT REQUIRED NECESSITATES THE ELIMINATION OF STICK-SLIP. STICK-SLIP IS A PHENOMENON THAT OCCURS WHEN MOTION IS INITIATED BETWEEN TWO OBJECTS WITH FRICTION PRESENT. IT'S LIKE PUSHING ON THE SIDE OF YOUR FILE CABINET TO MOVE IT .001". NO MORE, NO LESS. YOU OVER-SHOOT BECAUSE OF STICK-SLIP. STICK-SLIP, ALTHOUGH NOT MUCH, IS PRESENT IN BALL BEARINGS.

ONE DEVICE THAT ELIMINATES SOME OF THE BALL BEARING PROBLEMS IS THE FLEXURAL PIVOT. BUT NOT SURPRISINGLY, THIS DEVICE COMES WITH PROBLEMS OF ITS OWN. FIGURE #2 SHOWS A BENDIX CORP. FLEXURAL PIVOT.

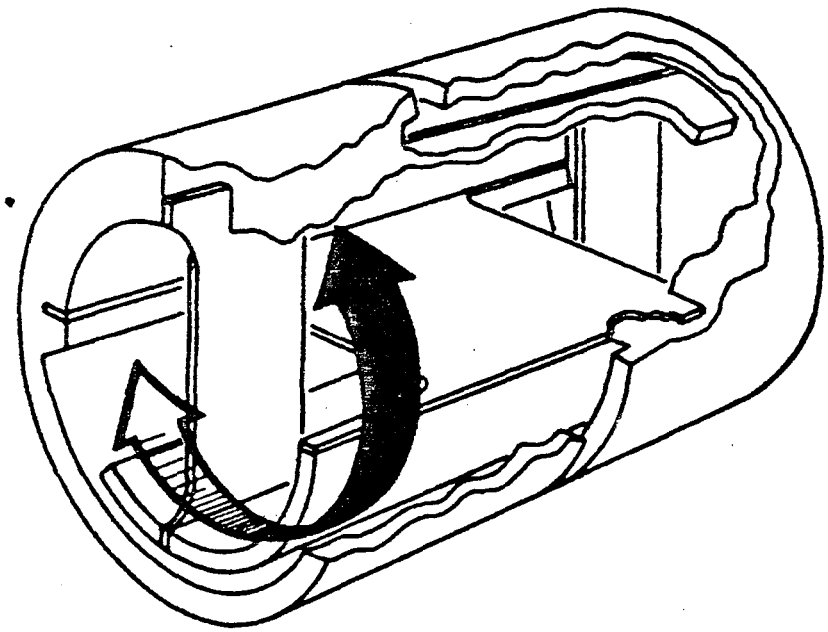


FIGURE 2

FIGURE #2 IS DIFFICULT TO UNDERSTAND WITHOUT ONE OF THE PIVOTS IN YOUR HAND, BUT FIGURE #3 SHOWS THE CONCEPT.

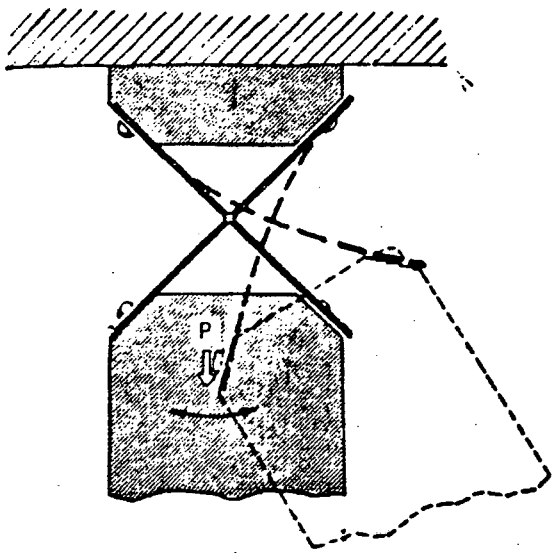


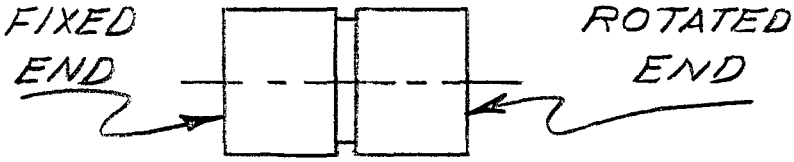
FIGURE 3

ROTATION TAKES PLACE WHEN THE METAL STRIPS FLEX. THIS TYPE OF DEVICE HAS MANY FEATURES. THE FLEXURAL PIVOT IS A FRICTIONLESS DEVICE SO IT IS FREE OF STICK-SLIP. IT REQUIRES NO LUBRICATION, IS SUITABLE FOR VACUUM USE, HAS ZERO BACKLASH AND VERY REPEATABLE. THE ONE PROBLEM IT DOES HAVE IS CENTER SHIFT VS. ANGULAR DEFLECTION. AS IT TURNS OUT, THIS WOULD BE ACCEPTABLE IF FLEXURAL PIVOTS

ARE REALLY REPEATABLE AND THEIR CENTER SHIFT VS. ANGULAR DEFLECTION IS NEAR IDENTICAL FROM ONE PIVOT TO ANOTHER.

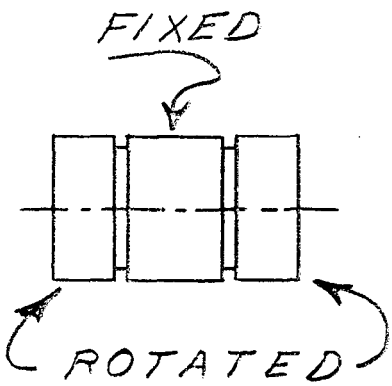
THE FOLLOWING IS A TEST PROCEEDURE THAT WAS USED TO TEST THE PIVOTS. FIRST OF ALL WE ARE LOOKING FOR REPEATABILITY, THEN IDENTICAL BEHAVIOR BETWEEN PIVOTS. TWO TYPES, OR SERIES, OF PIVOTS WERE TESTED. ONE PIVOT IS A CANTILEVER OR SINGLE SHEAR TYPE, THE OTHER IS A DOUBLE END OR DOUBLE SHEAR TYPE.

FIGURE 4



CANTILEVER

BENDIX 5024-800
.750" DIA. × 1.200" LONG
± 30° TOTAL ROTATION



DOUBLE END

BENDIX 6024-800
.750" DIA. × 1.200" LONG
± 30° TOTAL ROTATION

THE PIVOTS WERE ROTATED IN 1° INCREMENTS UP TO A TOTAL OF 20°. THE PIVOTS WERE THEN ROTATED IN THE OPPOSITE DIRECTION IN 1° INCREMENTS UP TO A TOTAL OF 20°. A TOTAL OF 40° ROTATION IS REQ. THIS WAS DONE IN A SPECIAL FIXTURE MOUNTED IN THE "TALYROND" MEASURING MACHINE. THE TALYROND IS LOCATED IN THE PRECISION SHOP, BLDG. 77. THE TALYROND WAS INTENDED TO MEASURE ROUNDNESS AND TO PLOT THE ROUNDNESS OF THE OBJECT BEING TESTED ON A CIRCULAR GRAPH. SINCE THE FLEXURAL PIVOTS ARE ROUND IT WAS POSSIBLE TO GRAPH THE ROTATING PART OF THE PIVOT AT THE DIFFERENT ANGULAR SETTINGS. WHEN MORE THAN ONE TRACE IS DONE ON AN INDIVIDUAL GRAPH YOU CAN SEE AND MEASURE THE CENTER SHIFT BY THE RELATIVE LOCATIONS OF THE TRACES. AFTER A SERIES OF TRACES WERE DONE ON A SINGLE GRAPH, THE PIVOT WAS ROTATED BACK TO ITS FIRST ANGULAR POSITION AND RE-DONE. IF THE PIVOTS DID NOT REPEAT, YOU WOULD EXPECT TO SEE A SECOND TRACE MISALIGNED WITH THE ORIGINAL TRACE BY THE AMOUNT OF NON-REPEATABILITY.

THE GRAPH SHOWN ON PAGE 7 IS REPRESENTATIVE OF THE DATA TAKEN.

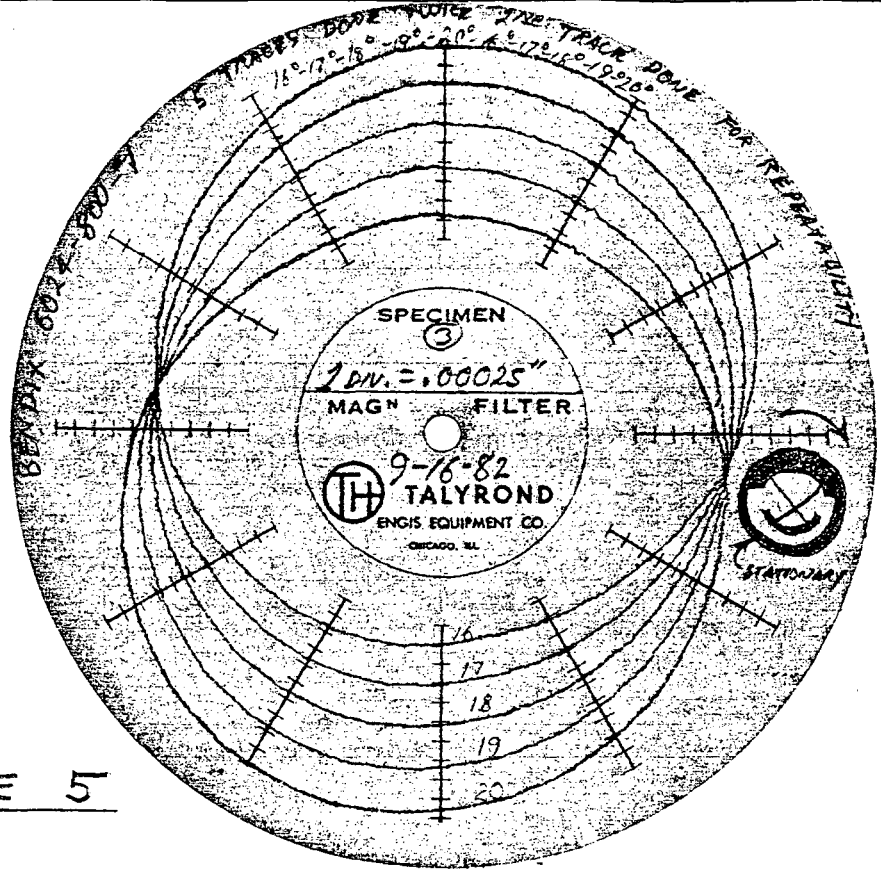


FIGURE 5

THE ABOVE GRAPH IS REPRESENTATIVE OF THE DATA TAKEN ON THE FLEXURAL PIVOTS. EACH DIVISION ON THE GRAPH EQUALS .00025". A TRACE WAS MADE AT 16°, 17°, 18°, 19° AND 20°. THE PIVOT WAS RESET TO 16° AND NEW TRACES WERE MADE ON THE SAME GRAPH. THE SECOND TRACES, 16° THRU 20°, FELL EXACTLY (SUPERIMPOSED) ON THE FIRST TRACES WITHIN THE THICKNESS OF THE TRACE LINES. THIS MEANS THIS PIVOT REPEATED TO THE THICKNESS OF A TRACE LINE, OR FOR THIS SCALE, .000 001 3". IT WAS NOT POSSIBLE TO CHART THE REPEATABILITY BECAUSE ALL 3 PIVOTS TESTED LIKE THE SAMPLE GRAPH, FIGURE 5, ABOVE. FOR THIS TEST THE PIVOTS WERE NOT CYCLED, SO AT PRESENT IT IS NOT KNOWN HOW REPEATABILITY DEGRADES WITH USE.

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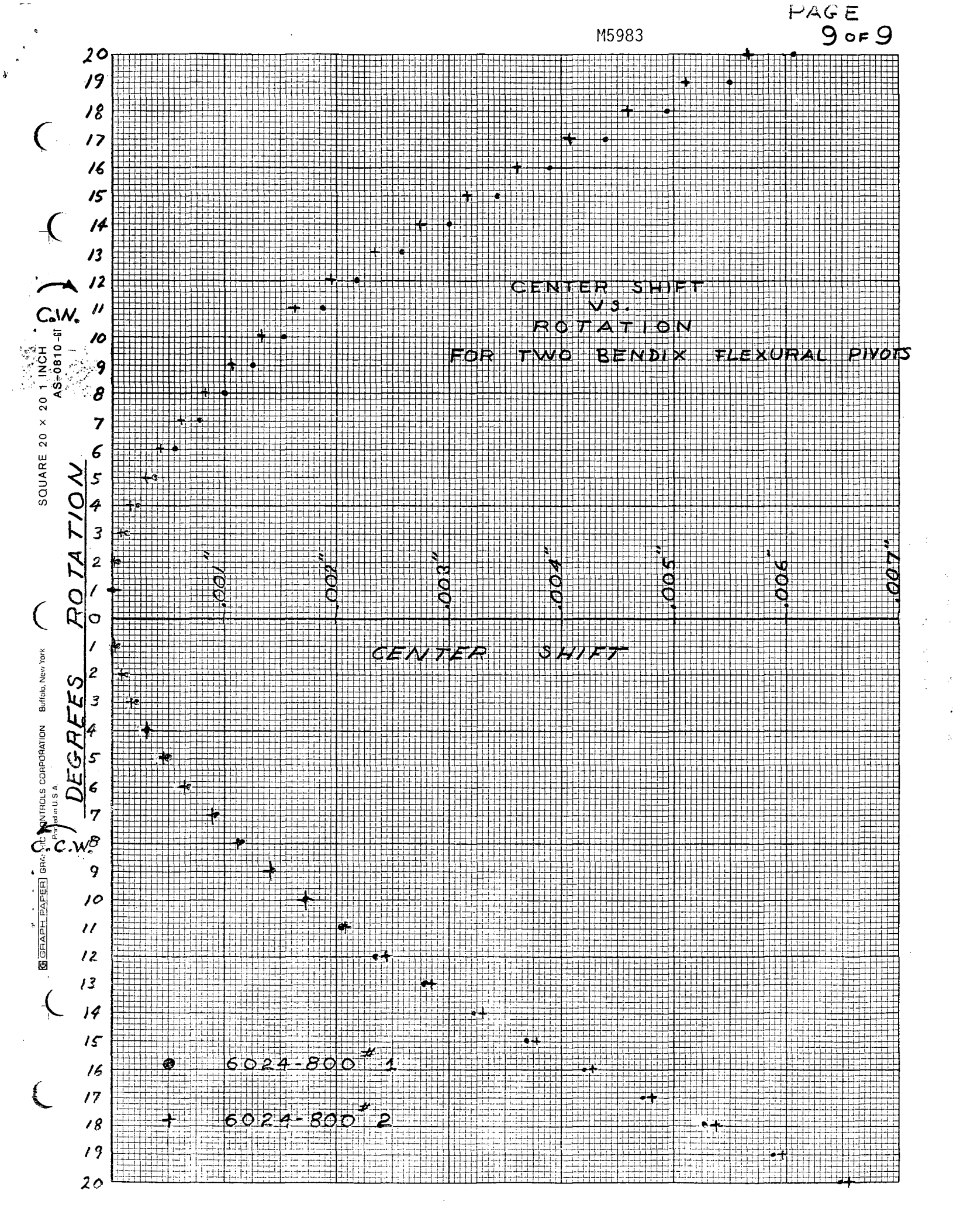
FLEXURAL PIVOT NUMBER	TOTAL CENTER SHIFT	
	↙ C.C.W.	↘ C.W.
5024-800	.0049"	—
6024-800 #1	.0065"	.0061"
6024-800 #2	.0066	.0057"

THIS TEST WAS NOT SPECIFICLY SET UP TO FIND THE DIRECTION OF THE CENTER SHIFT OR THE MAGNITUDE OF THE CENTER SHIFT IN THE PLANE 90° TO THE PLANE OF MAXIMUM SHIFT. THE CENTER SHIFT DID SEEM TO FOLLOW A SLIGHT CURVE. BOTH DOUBLE END TYPE PIVOTS APPEARED TO SHIFT IN THE SAME DIRECTION. BOTH PIVOTS ALSO MOVED APPROX. .0005" IN THE PLANE 90° TO THE MAXIMUM MOVEMENT.



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