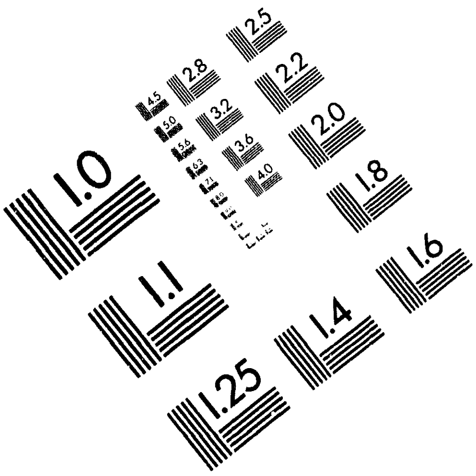
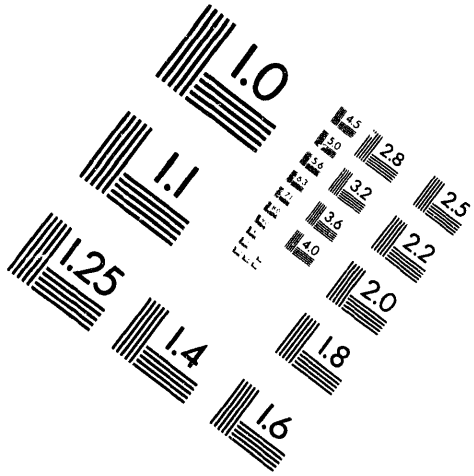

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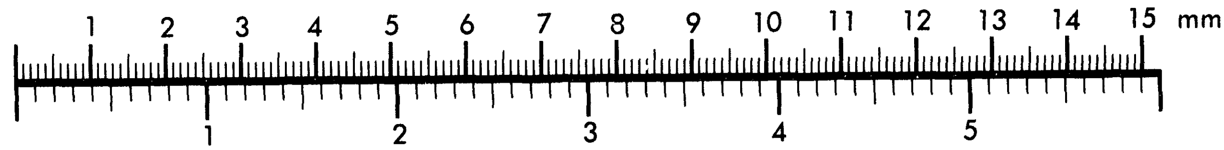

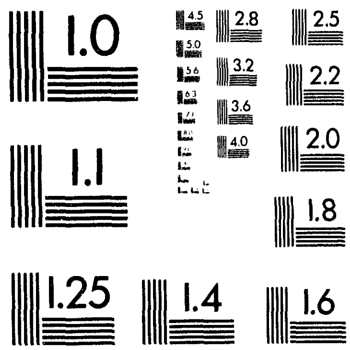

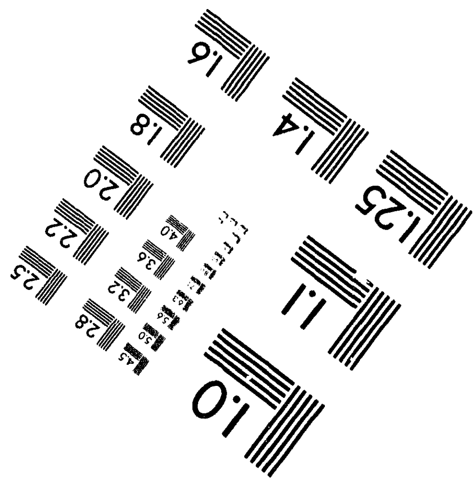
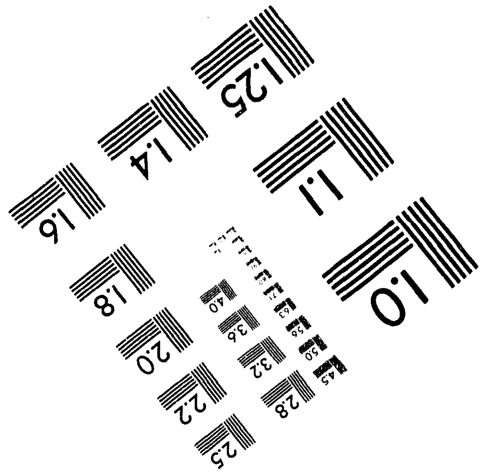

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Support Systems for Optics in the Experiment Stations at the Advanced Photon Source*

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Support systems have been designed for optics in the experiment stations of the Advanced Photon Source at Argonne National Laboratory. These systems utilize modular precision positioning slides and stages arranged in 3-point kinematic mount fashion for optimum mechanical stability. Through the use of novel configurations, these systems can achieve large linear motions, six degree-of-freedom motion, and large load capacities without sacrificing valuable experimental station space. This paper will discuss the designs and specifications of the positioning systems developed.

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1. Introduction

One initiative in the Advanced Photon Source (APS) experiment stations is the use modular and highly flexible tables in support of optics and instrumentation for scientific research. This requirement, which includes the minimal use of floor space, has driven the development of compact optical table designs with stable large axis course and precision motion. These tables incorporate large axis manual motion necessitated by large X-ray beam deflections and flexible experiment setups. In conjunction with the manual motion, the tables also provide high precision motion using high-load-capacity positioning stages arranged in 3-point kinematic fashion. This paper describes two multi-purpose optical tables and a 6-circle goniometer support system that were designed with standard and modular stages developed at the APS [1].

2. Specifications

Table 1 summarizes the optical tables designed for use in the APS experiment stations. The basic precision motion design uses the 3-point kinematic mount concept obtained through the use of rolling vertical and horizontal stages. Figure 1 illustrates how the "cone-flat-V" 3-point kinematic mounts obtain six degrees-of-freedom motion using the stages and slides arrangement. This concept has the advantages of 3-point stability, reduced space use, minimum motor drives, free and unconstrained thermal expansion, and position repeatability after disassembly. The specifications listed satisfy the support requirements set out by the instrumentation.

3. Mechanical Designs

Figure 2 shows a typical optical table assembly combining course manual motion with high precision stages. The base assembly provides large vertical motion using three worm-gear actuators to lift a rigid inner frame (1). Once the table is positioned at the desired height, stability is maintained by locking the inner frame to the outer frame (2)

using thrust screws (3). These thrust screws are located such that the screw separation is at least equal to the vertical travel range. Using this technique, the thrust screws counteract any lateral moments that may occur at any position. Accidental motion is prevented by securing the flexible shaft clamp (4) at the hand wheel (5). Next, precision 6 degree-of-freedom kinematic motion is performed by the precision stages mounted to the base assembly. Three horizontal slides (6) provide horizontal motion and are composed of a mounting plate attached to low-profile X-Y rails. Modular leads screw assemblies (7) are attached to the horizontal slides where an axis motion is required (as illustrated in Figure 1). The three low profile vertical stages (8) [2], provide stable, precise vertical motion. As shown in Figure 3, the vertical stage design uses a preloaded, frictionless rolling structure to achieve both high stiffness and trajectory control. A worm gear actuator (1) supports the full load and is decoupled from the lifting body by a torsionally stiff spherical coupling (2). This coupling reduces the majority of the backlash in the worm gear actuator, thereby increasing the stage's accuracy and repeatability. The final element, the optical breadboard (9) (Figure 2), is attached to the vertical stages with spherical couplings (10).

Figure 4 shows a second optical table style employing the same precision stages mounted on three large telescoping legs for increased vertical travel. A detailed view of a fully extended telescoping leg, Figure 5, shows the overlapping inner bearing rail and tubing structure for optimizing lateral support. The outer tube housing (1) provides trajectory control and stiffness for the middle tube (2) by means of commercial linear slides. The middle tube, in turn, supports the inner tube (3) in the same fashion. A worm-gear actuator (4) supports and lifts the inner tube. The supporting distance between the bearing blocks (5) is related to the travel range of each telescoping section. The outer-most bearing blocks should be separated at least by the distance traveled by both tubes when the leg is fully extended. In this fashion, optimum stability is achieved by equalizing the travel range through the bearing blocks. The use of preloaded commercial

bearing rails eliminates locking schemes, and such rails are available with good trajectory specifications.

Finally, the system shown in Figure 6 supports a 6-circle goniometer instrument. The goniometer's tall profile and the large travel range requirements led to a lower profile design comprised of a rigid 3-post frame (1), secured to the floor, which guides and locks a primary frame (2) holding the precision stages and slides. Three worm-gear actuators (3) lift and support the primary frame to any height, relative to the post frame, and are locked into position with a set of thrust screws. The thrust screw spacing stabilizes against lateral moments in the same fashion as for the first optical table (described above). The precision motions are performed using three horizontal slides (4) and lead screws (5), and three high capacity vertical stages (6) designed with a similar preloaded housing structure as described above.

4. Summary

We have presented a general overview of the support systems for optics in the APS experiment stations, which include standard optical tables and standard 6-circle goniometer support systems. These support systems employ the 3-point kinematic mounting method for optimum stability, among other advantages, and are designed with large vertical motion for added flexibility. The small footprint of these tables satisfy requirements for minimal floor use in the APS experiment stations. Additionally, the tables were designed from APS standard and modular stages, permitting variations from the designs presented to suit user-specific needs.

References

[1] D. Shu, J. Barraza, C. Brite, T. Sanchez, V. Tcheskidov, "Design of the Beamline Standard Components at the Advanced Photon Source," these Proceedings.

[2] Patent Applied for APS/ANL, May 1991

Figure Captions

1. 3-Point Kinematic Mounting

2. Standard APS Optical Table Assembly. (1) Inner Frame, (2) Outer Frame, (3) Thrust Screws, (4) Flexible Shaft Clamp, (5) Hand Wheel, (6) Horizontal X-Y Slides, (7) Lead Screw Assemblies, (8) Vertical Stages, (9) Optical Breadboard, (10) Spherical Couplings.

3. Low Profile Vertical Stage Assembly. (1) Worm-Gear Actuator, (2) Torsionally Stiff Spherical Coupling, (3) Outer Housing, (4) Inner Tube, (5) Preloading Screws.

4. Standard APS Optical Table Assembly, Alternate Style.

5. Telescoping Leg Details. (1) Outer Support Tube, (2) Middle Tube, (3) Inner Tube, (4) Worm-Gear Actuator, (5) Bearing Blocks.

6. 6-Circle Goniometer Support System. (1) 3-Post Frame, (2) Primary Frame, (3) Worm-Gear Actuators, (4) Horizontal Slides, (5) Lead Screw Assemblies, (6) High Capacity Vertical Stages.

Table 1

Specifications of the Support Systems Designed for use in APS Experimental Stations

Characteristic	Standard Optical Table	Standard Optical Table, Alternate Style	Standard 6-Circle Goniometer Table
Maximum Load, Kg	454	454	1000
Slide Type (Vertical)	Linear Rolling	Linear Rolling	Linear Rolling
Slide Type (Horizontal)	Linear Rolling	Linear Rolling	Linear Rolling
Travel Range, mm (Vertical Precision)	50	50	100
Travel Range, mm (Horizontal Precision)	150 x 75	150 x 75	150 x 75
Motion Resolution, μm (Vertical & Horizontal)	10	10	10
Motion Repeatability, μm (Vertical & Horizontal)	50	50	50
Straightness of Trajectory, rad/25mm, (Vertical)	2 E-4	2 E-4	2 E-4
Straightness of Trajectory, rad/25mm, (Horizontal)	1 E-4	1 E-4	1 E-4
Basic Operating Mode	Stepper Motor	Stepper Motor	Stepper Motor
Optional Operating Mode	Manual	Manual	Manual

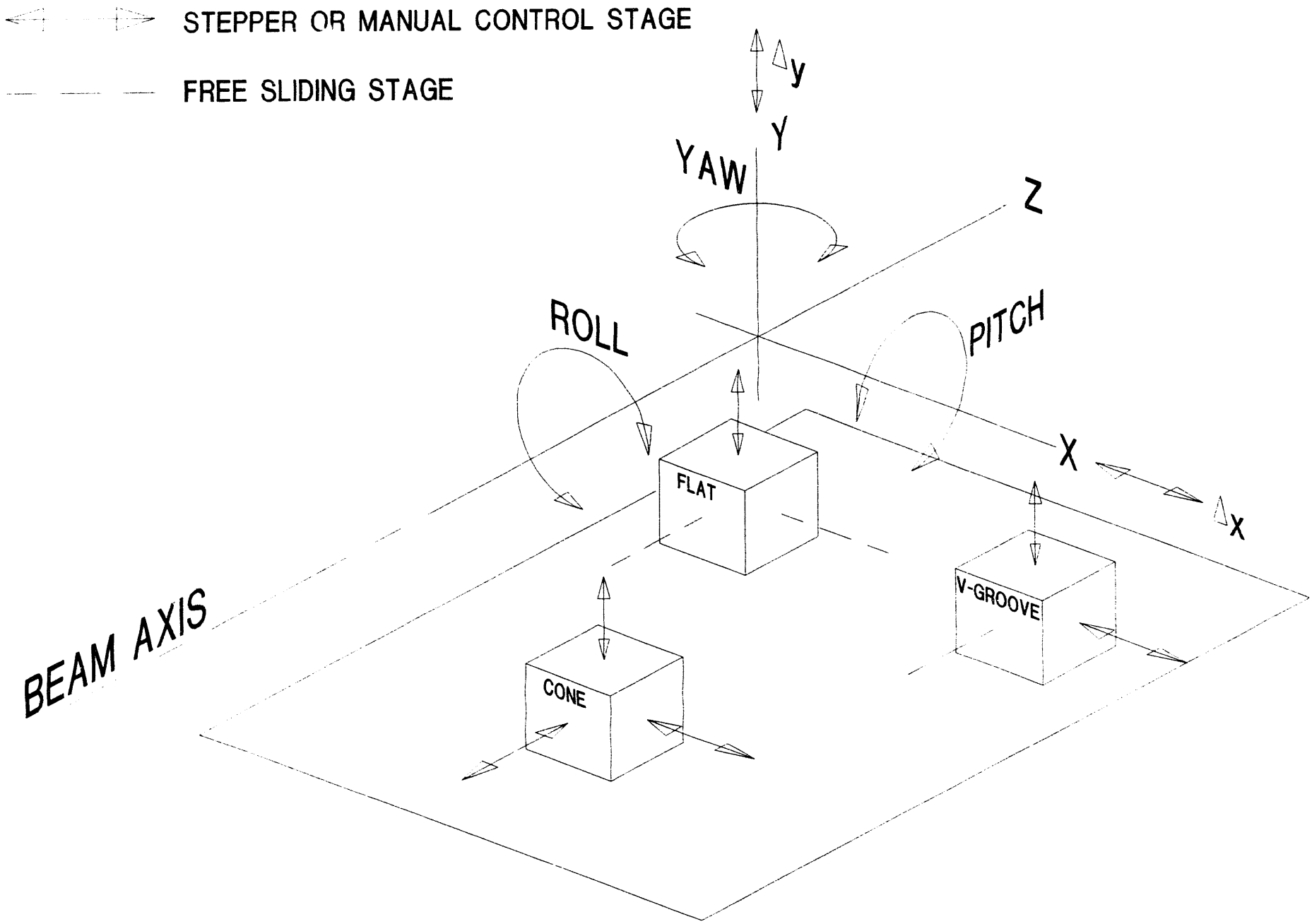

STEPPER OR MANUAL CONTROL STAGE
FREE SLIDING STAGE
y
Y
YAW
Z
ROLL
PITCH
X
x
FLAT
V-GROOVE
CONE
BEAM AXIS

Figure 1

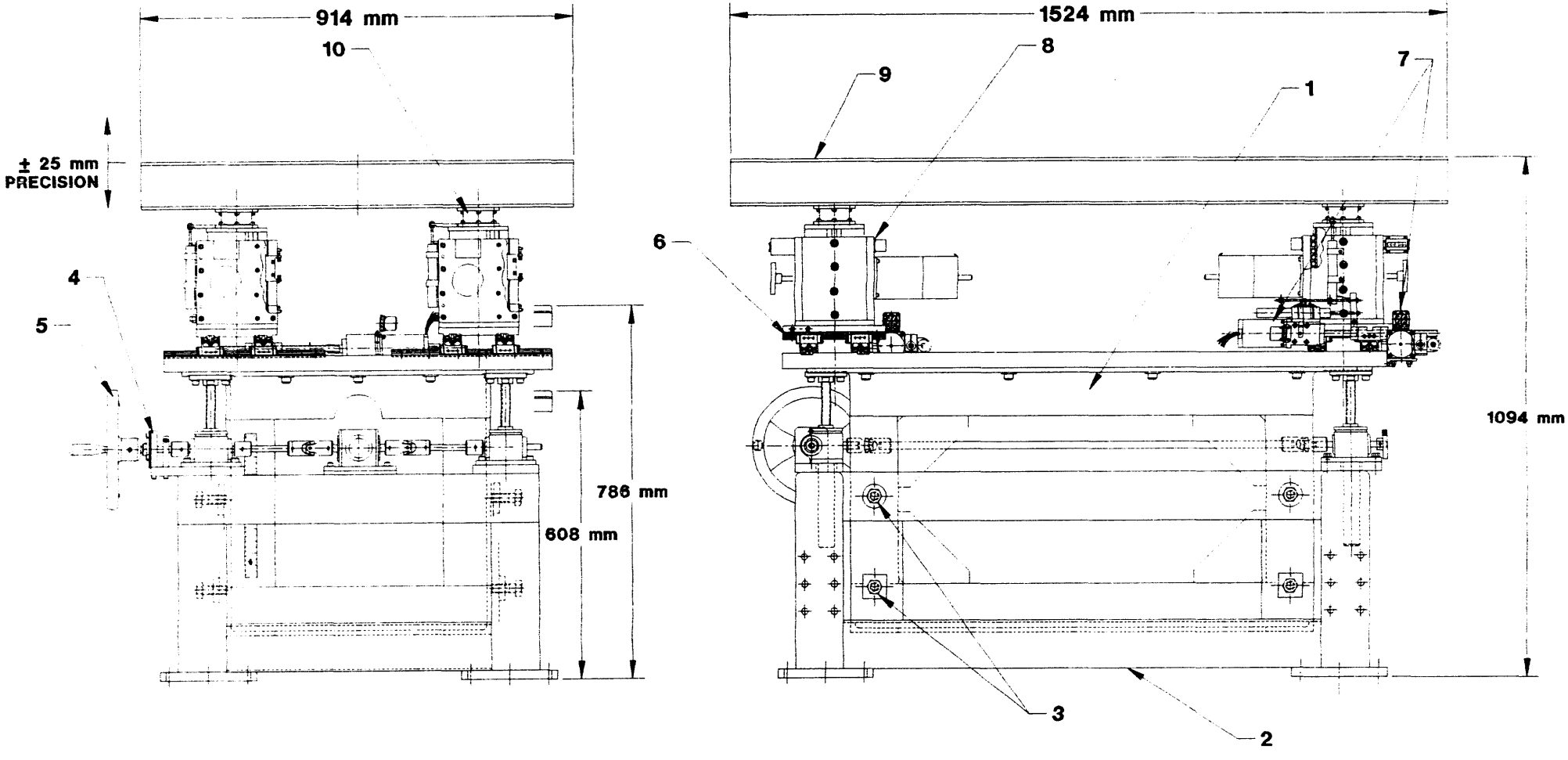

914 mm
10
± 25 mm
PRECISION
4
5
786 mm
608 mm
1524 mm
8
9
7
1
6
1094 mm
3
2

FIGURE 2

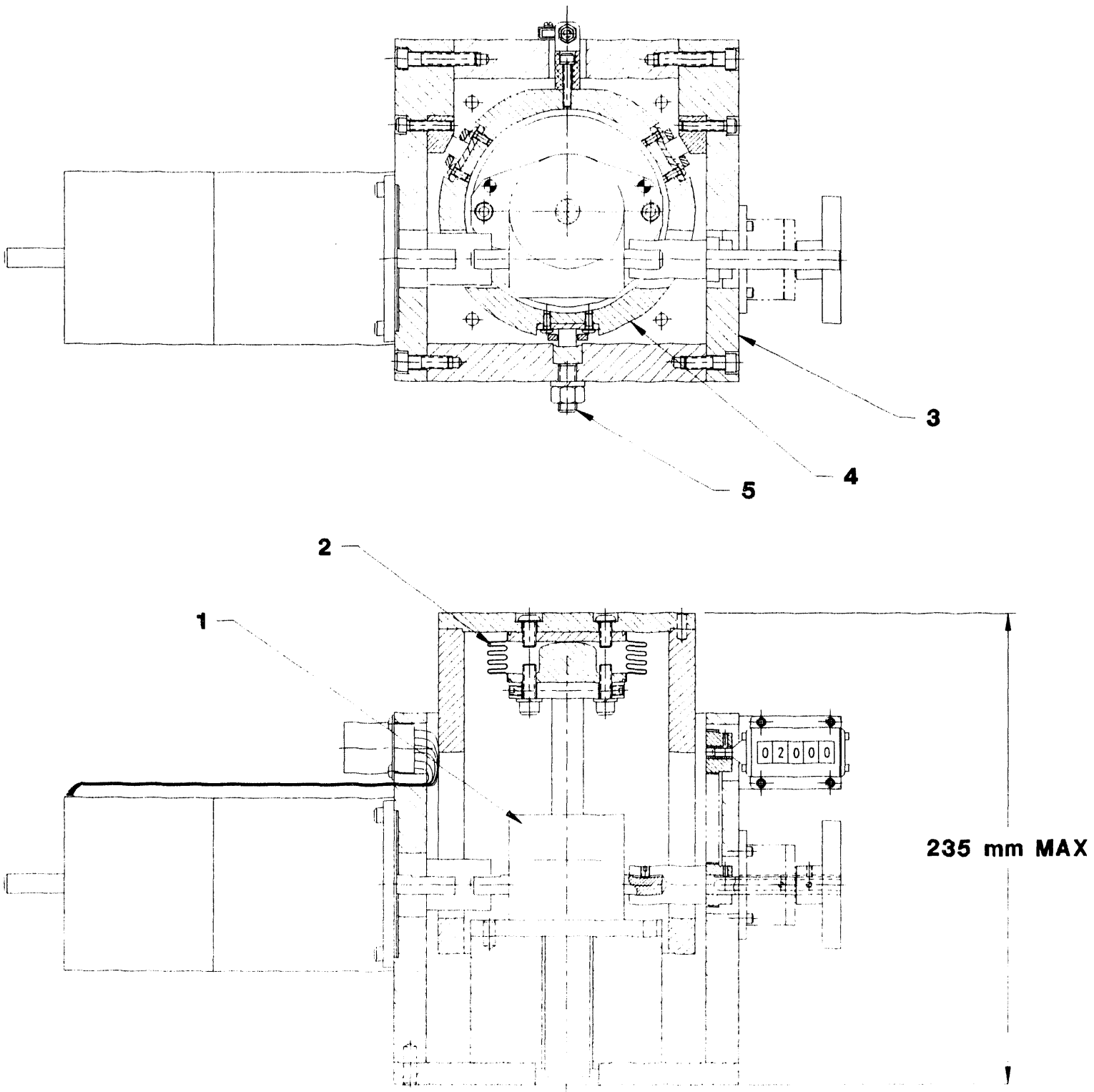
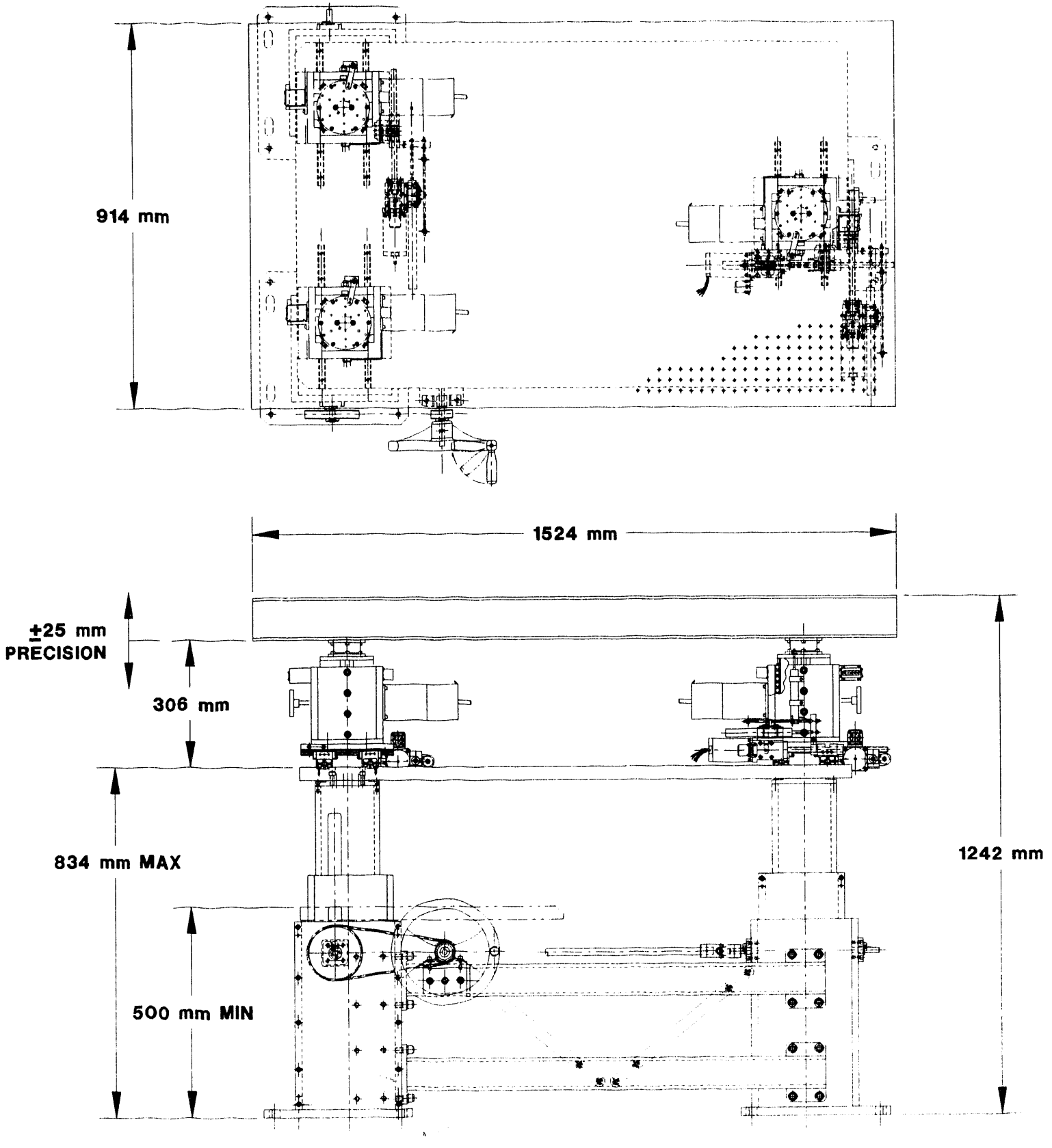


Figure 3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1524 mm
±25 mm
PRECISION
306 mm
834 mm MAX
500 mm MIN
1242 mm

Figure 4

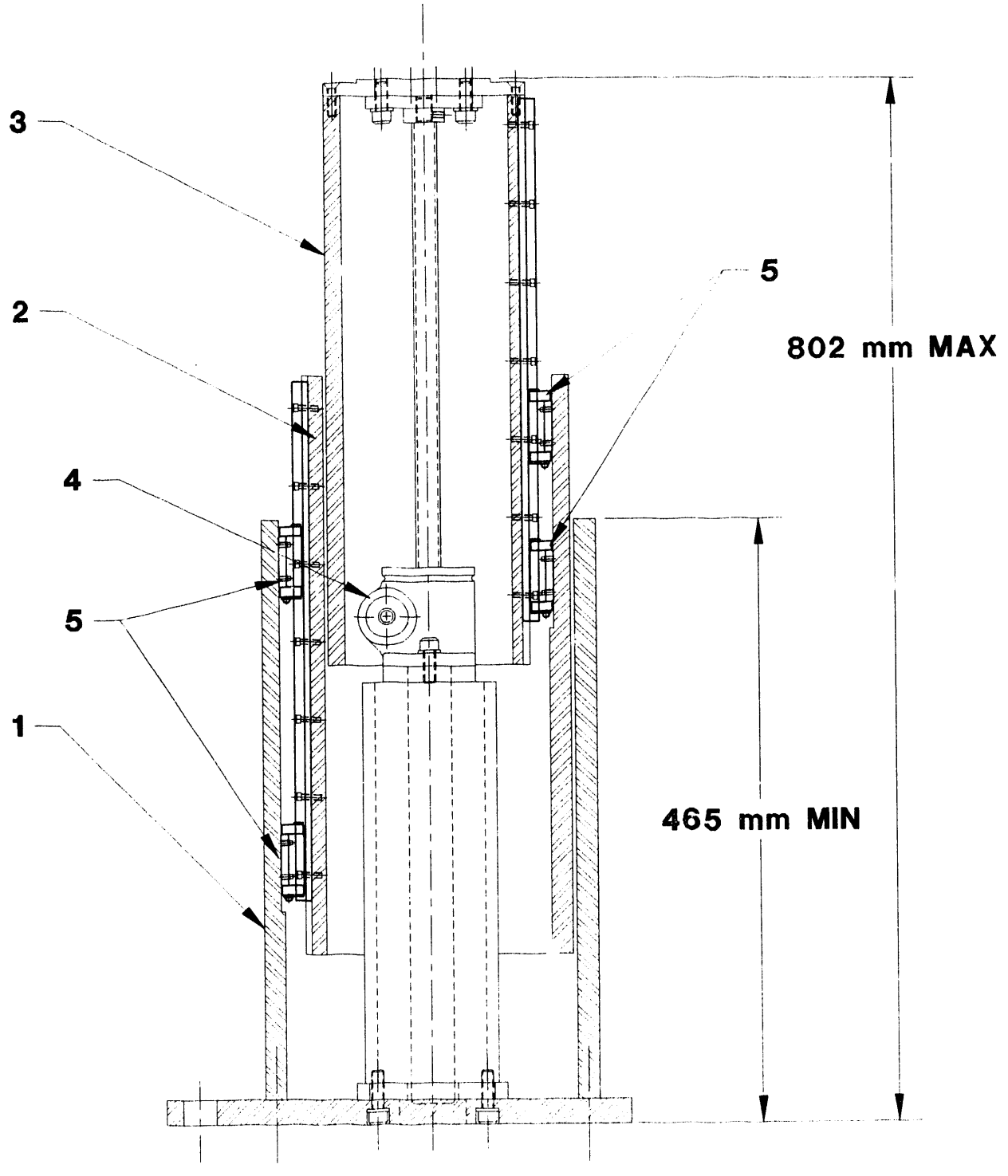

Figure 5

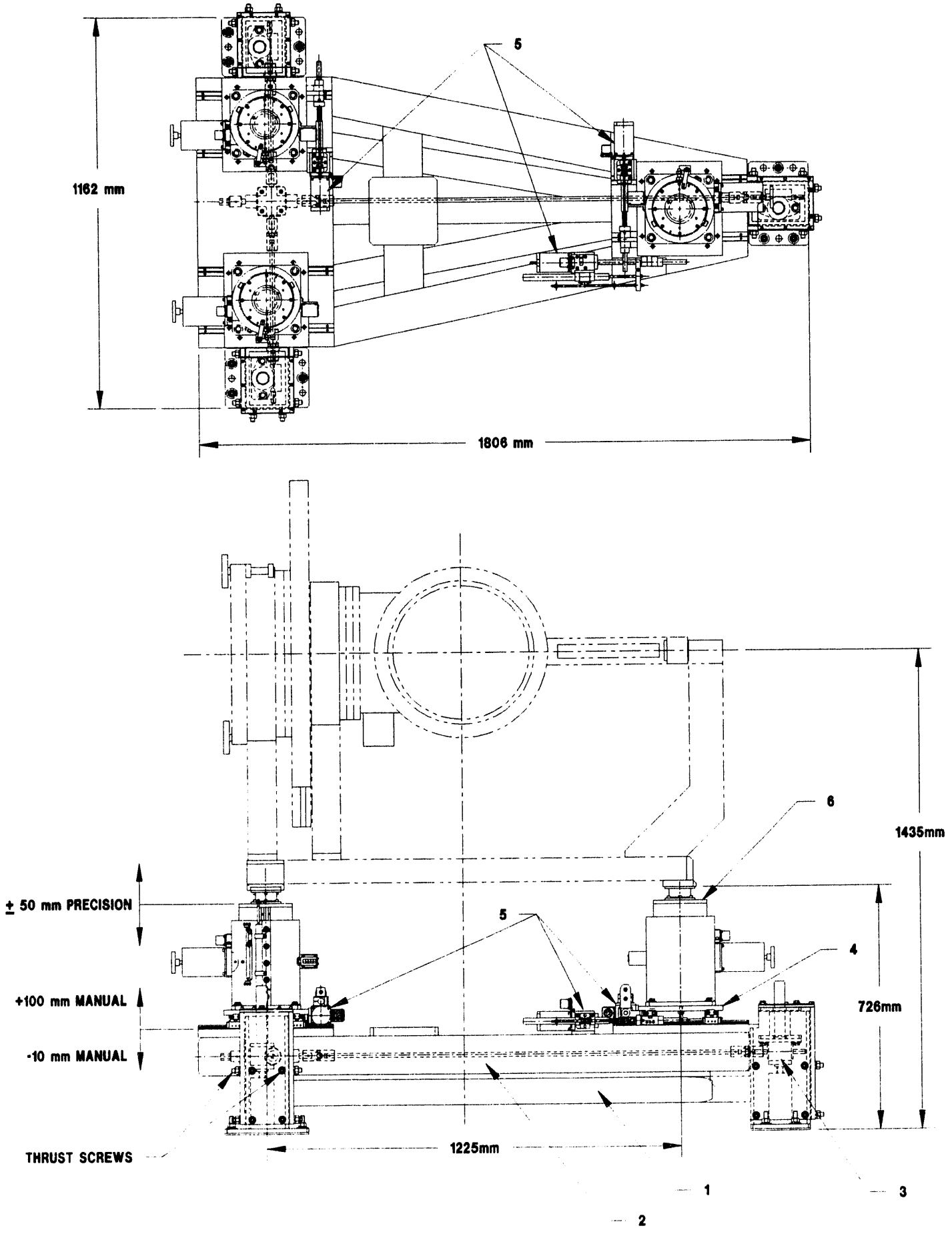
1162 mm
5
1806 mm
± 50 mm PRECISION
+100 mm MANUAL
-10 mm MANUAL
THRUST SCREWS
6
1435mm
5
4
726mm
1225mm
1
2
3

Figure 6

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