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FREE-OSCILLATION VARIABLE-DEFLECTION DYNAMIC RIG

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by

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and

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NOVEMBER 1959

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AERODYNAMICS

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Free-Oscillation Variable-Deflection Dynamic Rig

Presented by: R. C. Maydew
Prepared by: J. C. Weydert

Sandia Corporation Dynamic Rig No. 11 was designed to facilitate the dynamic stability testing of store models in the Sandia Corporation 12" x 12" blow down wind-tunnel facility. The rig was designed to provide a convenient and rapid method for shifting model center of rotation with respect to the rig oscillating head, and to make it possible to easily adjust the deflection mechanism to deflect and release the model at any angle desired within limits of the model and mechanism. Also, the rig has a locking unit which allows a model to be suddenly released from a zero angle orientation, and permits an oscillating model to be brought to rest.

The rig can accommodate models as small as 1.187" O.D. We normally use models of about 1.375" O.D. With this diameter, the rig will provide deflection angles up to a maximum of approximately 10 1/2° for certain configurations. The rig is of the free oscillation type and utilizes two miniature ball bearings for support. Fig 1 illustrates the rig attached to a display stand. In actual use, it is secured to the standard pitching strut boom in the tunnel by means of a taper-fit joint and locking screws.

Fig 2 is an enlarged photo of the oscillating head, the actuating and locking mechanisms, and the angular transducer. The two dovetail slots can be seen in the head. These engage mating keys which are attached to the inside surface of the model by screws through the model skin. These keys are sufficiently longer than the head slots so that the model can be axially shifted about 5/8" total travel. This represents a center of rotation shift of from 9-15% of total length for the models we have been testing. This is accomplished by loosening the six key screws, shifting the model, and re-tightening the screws. The desired location of the model on the rig is achieved by making a measurement from the aft end of the model to the reference surface of a removable gage block which fits on the tapered portion of the rig sting. This surface provides a 5.000" reference plane from the center of rotation. This method of model attachment, dependent on friction only, permits accurate and quick model shift.

The zero locking device, as can be seen, consists of two locking plungers with conical points which engage mating detents in a plate attached to the head. The plungers are operated by a single compressed air line at 50-100 psi. The fit between plungers and cylinder is lapped in, and no seals are used. The plungers are disengaged by the two tension springs when the cylinders are exhausted. The off-center design of the plungers permits the model to be restored to zero while oscillating.

The angular transducer can be seen mounted underneath the rig and head. It consists of a .012" thick beryllium copper beam fixed to the rig body at one end, and attached by means of a connecting rod to the centerline of the oscillating head. It attaches to the rig body by means of a dovetail joint and set screw. It is instrumented with 4 bakelite type strain gages hooked-up as a 4 active arm bridge circuit. Our normal recording device is a Minneapolis-Honeywell Visicorder. The beam was placed beneath the assembly for space saving reasons, and this necessitated the use of the connecting rod. The restoring moment introduced into the system by the beam is approximately 0.002 lb.-in. per degree of model deflection.

Fig 2 also illustrates the deflection linkage in a partially actuated position. In operation, the linkage receives a thrust from the pneumatic cartridge housed in the large aft end of the rig. The deflect bar tip contacts the inner periphery of the model as the bar is forced to rotate due to the thrust rod motion transferred to it through the deflect links. The model then is forced to deflect about the rig oscillation axis. The toggle action of the deflect linkage results in an increasing mechanical advantage as the model is deflected. This permits high aerodynamic model moments to be overcome with low air pressure to the pneumatic cartridge. Although this cylinder will withstand considerably higher pressure, it has been found that 50 psi air will satisfactorily operate the deflection mechanism against a dynamic pressure of 16.5 psi.

Fig 3 is a partial cutaway view showing the pneumatic cartridge unit and deflection angle adjustment system. The pneumatic cartridge unit is housed inside the aft end of the rig body and incorporates an air cylinder and piston plus a quick release mechanism. This unit permits the selection of a desired degree of deflection followed automatically by a quick release which is sufficiently rapid in return, so as not to dampen out model oscillations which follow the release. The Visicorder trace of Fig 4 indicates a typical deflection and release cycle.

The operation of this unit will be described in detail. Air is admitted through the air fitting from a 50 psi regulated pressure source through a Skinner 3-way solenoid valve normally open to exhaust. The valve is energized by a programming system which deflects the model three times during a standard dynamic stability test of 15-30 seconds duration. This causes the piston to move forward, compressing the piston spring. The piston rod has 8 radial holes which carry steel balls. When the piston rod and balls move forward, the balls shoulder on the thrust bar and cause it to move forward while compressing the linkage return spring. Notice that the balls cannot pop out of engagement because of the position of the release sleeve. The sleeve is held in this position by the release sleeve spring which forces the release sleeve against a retaining ring. In this position, the release sleeve shoulder on the I.D. is .005" past center of the balls. The piston thrust passes through the 8 balls into the thrust bar and on into the aluminum thrust rod, The thrust rod is equipped with a hardened steel button fitting on the aft end and receives thrust through a floating type connection attached to the forward end of the thrust bar. The forward end of the thrust rod is fitted with a steel clevis which pins to the deflect links. Near the aft end of the thrust rod is a cam surface which actuates the microswitch shown. Trip adjusting sleeve has a thread engagement with the trip. Turning this graduated sleeve gives axial movement to the trip. The left end of the trip moves along a graduated scale attached to the rig. Markings are from 0 to 10. Each mark represents a full turn of the sleeve and corresponds to .0625" movement. The sleeve is inscribed with marks from 0-10, and each mark represents one tenth of a turn or .00625" trip movement. The trip can be adjusted to within .0015" of a desired position quite easily. Charts such as that shown in Fig 5 have been prepared which give the proper turns setting required to result in a desired deflection and release angle for models of many inside diameters and center of rotation locations. When the release sleeve strikes the tang of the trip, forward motion of the trip ceases and continued thrust of the piston compresses the release sleeve spring. An additional .025" of motion after the release sleeve has contacted the trip tang causes the 8 balls to pop out of engagement with the thrust bar into the recess in the release sleeve. The thrust bar, thrust rod, deflect links, and deflect bar are then quickly returned to their normal position by the expansion of the linkage return spring. The energy of the returning system is absorbed by the rubber bumper. During this operation, the piston rod and release sleeve are still in the forward actuated position. Shortly thereafter, the 3-way valve is de-energized by a delayed signal from the microswitch, and the piston returns to its normal position by expansion of the piston spring. The 8 balls are forced back into the groove of the thrust bar by action of the release sleeve spring upon the release sleeve. The unit is now cocked and ready for another deflect and release cycle.

The air cylinder is retained in the rig body by the threaded positioning sleeve which is fixed in location in the rig body by means of a retaining ring. When the positioning sleeve is rotated with the special tool provided, the entire pneumatic cartridge is moved axially. This adjustment is provided for the initial positioning of the deflect bar such that the bar is retracted for maximum model clearance.

Actually, three deflect bars are provided, and the choice of which one to install depends upon the model configuration and deflect angle desired. Each bar has its own calibration chart.

Several additional components are provided with the rig for ease of calibration and testing. A calibration device clamps onto the rig and head, and permits rapid calibration of the strain beam transducer. A dummy rig allows static balancing of a model and oscillating head at the desired center of rotation before the model is placed onto the actual rig. An insertion tool and dummy inertia head permit the moment of inertia of model and head to be determined on an inertia pendulum which is available.

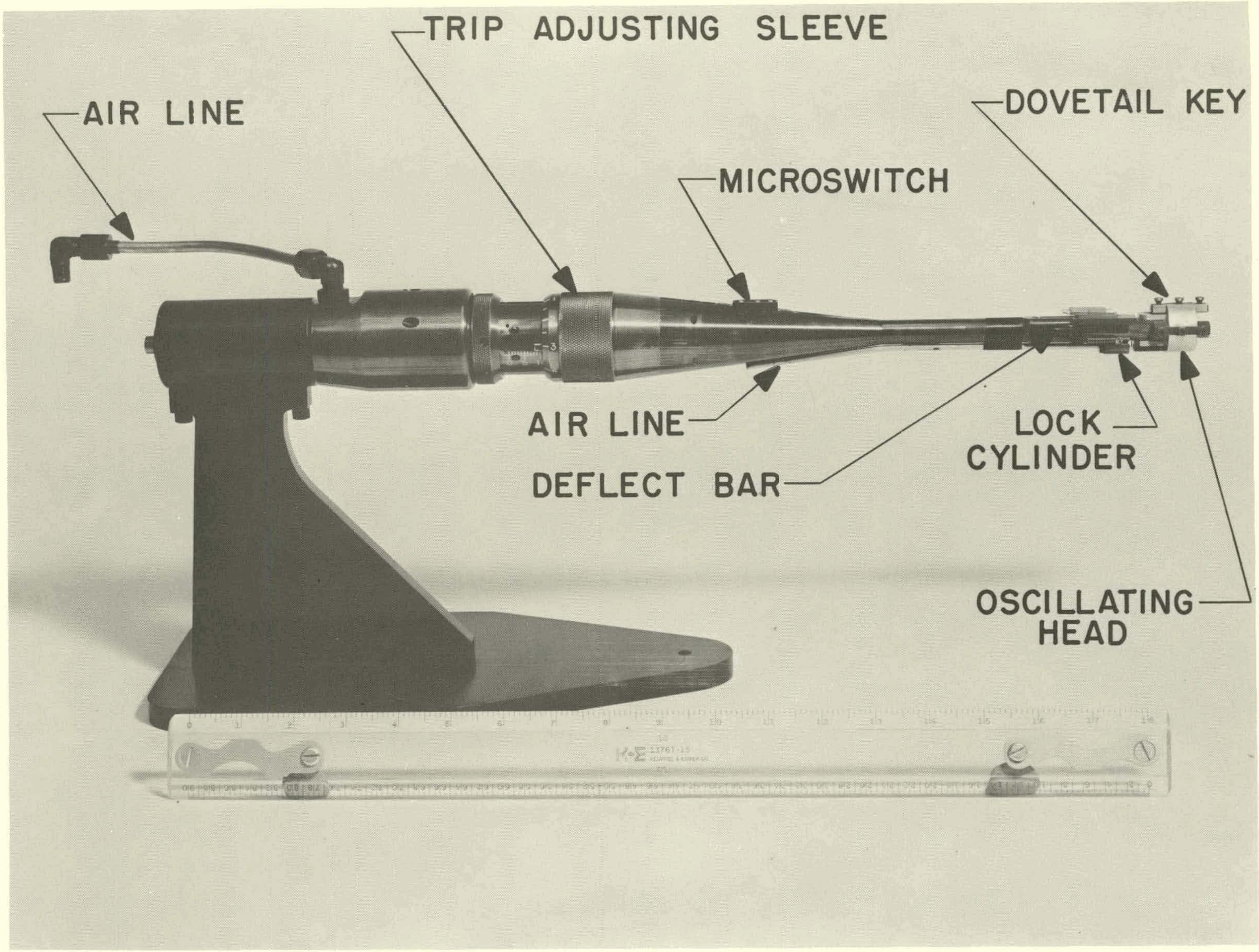
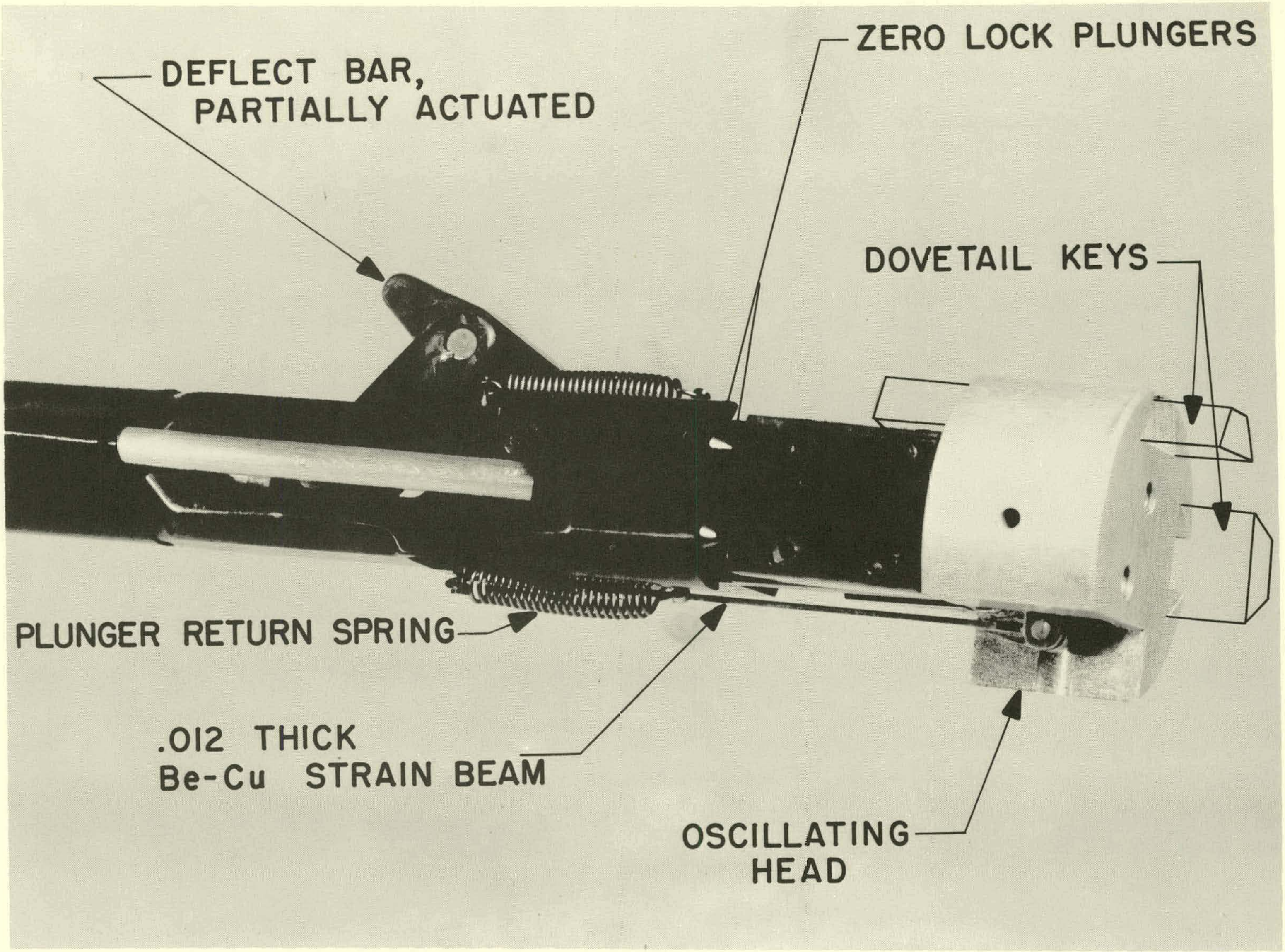


FIG. 1 DYNAMIC RIG NO. 11


ZERO LOCK PLUNGERS
DEFLECT BAR, PARTIALLY ACTUATED
DOVETAIL KEYS
PLUNGER RETURN SPRING
.012 THICK Be-Cu STRAIN BEAM
OSCILLATING HEAD

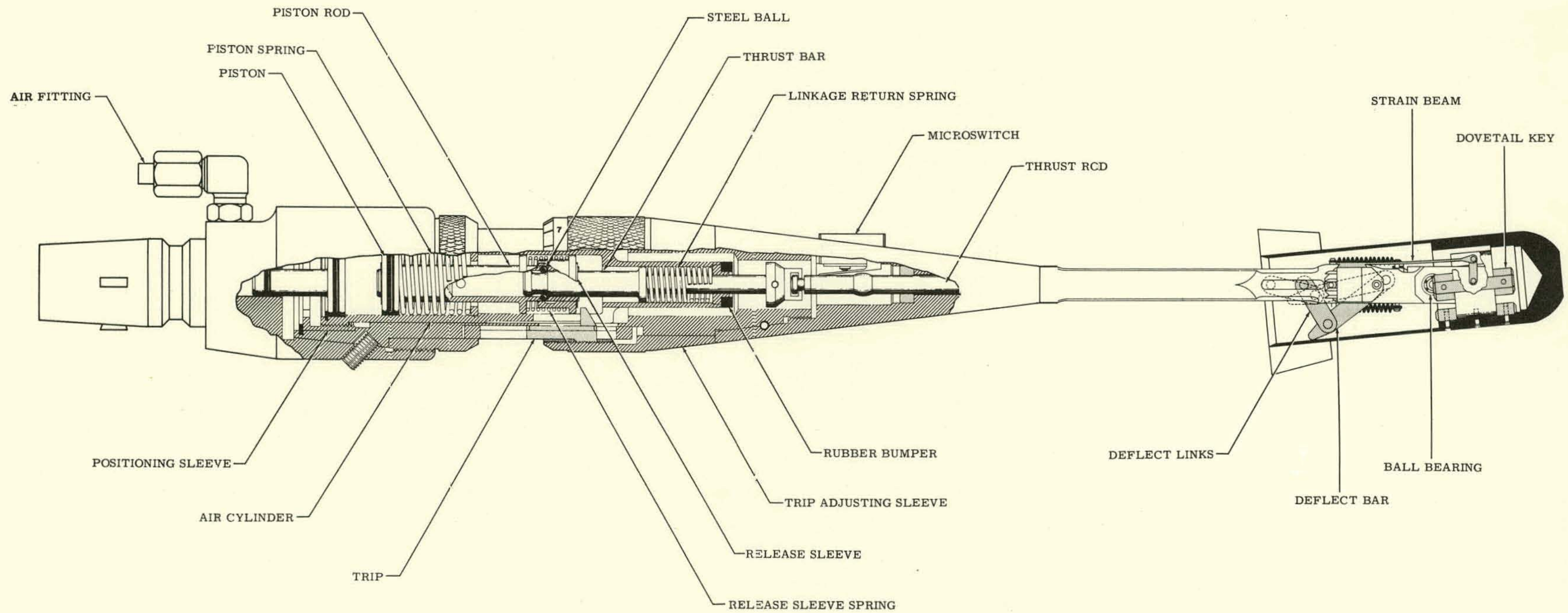


Fig. 3 DYNAMIC RIG NO. 11 CUTAWAY VIEW

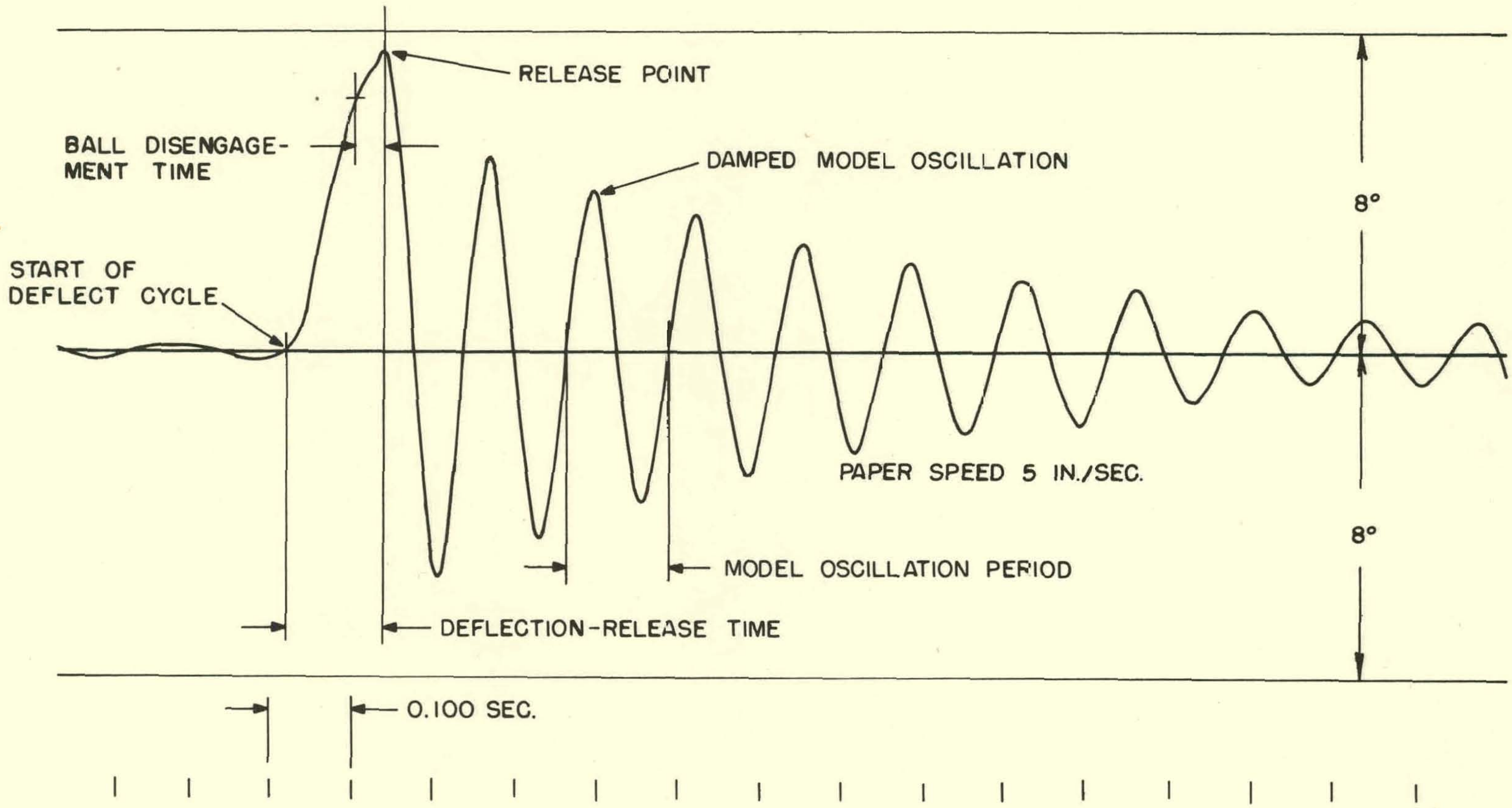


FIG. 4 - VISICORDER TRACE OF TYPICAL CYCLE

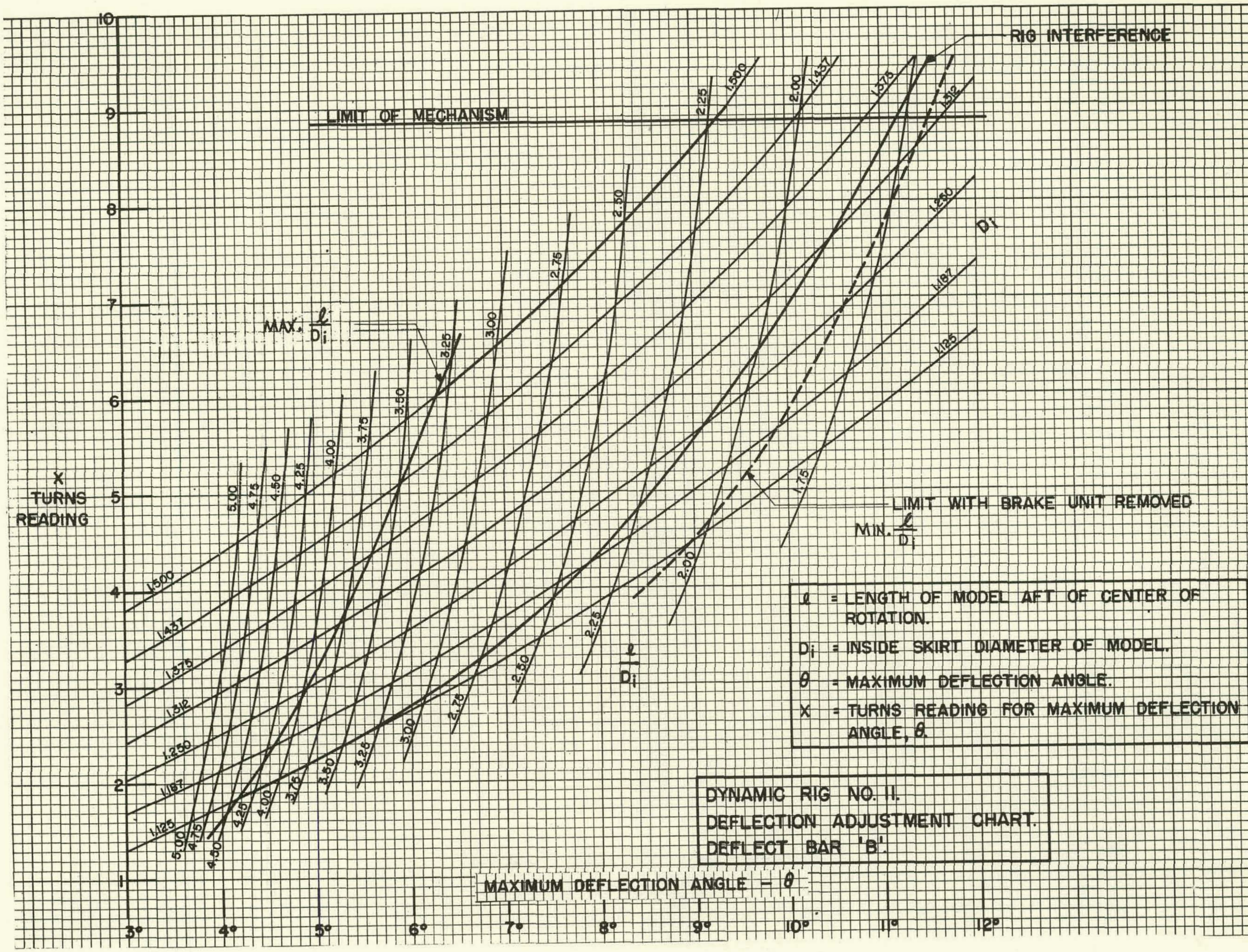


FIG. 5 - DEFLECTION ADJUSTMENT CHART