THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION'S GILMORE LOAD CELL MACHINE

LOAD CELL CALIBRATIONS TO 2.22 x 10^7 NEWTONS

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INTRODUCTION

Designed in 1964 and erected in 1966, the mission of the Gilmore Load Cell Machine was to provide highly accurate calibrations for large capacity load cells in support of NASA's Apollo Program. Still in use today, the Gilmore Machine is a national treasure with no equal.

SAFETY CONSIDERATIONS

The four major areas of consideration of NASA's Safety Program are safety of the public, safety of the astronauts and pilots, safety of the workforce, and preservation of high-value equipment and property.

Proper operation of the Gilmore Machine is imperative for employee safety and to prevent damage to collateral equipment and customer property. The load cells calibrated by the Gilmore Machine are used in a wide range of applications that include:

1. Structural testing of flight hardware and ground support equipment
2. Thrust measurement of both solid and liquid fueled rocket engines
3. Weighing of flight hardware components and systems
4. Research and development
5. Testing when large forces are involved

The Gilmore Machine fills the need for accurate, reliable load cell calibrations that ensure product safety and reliability.

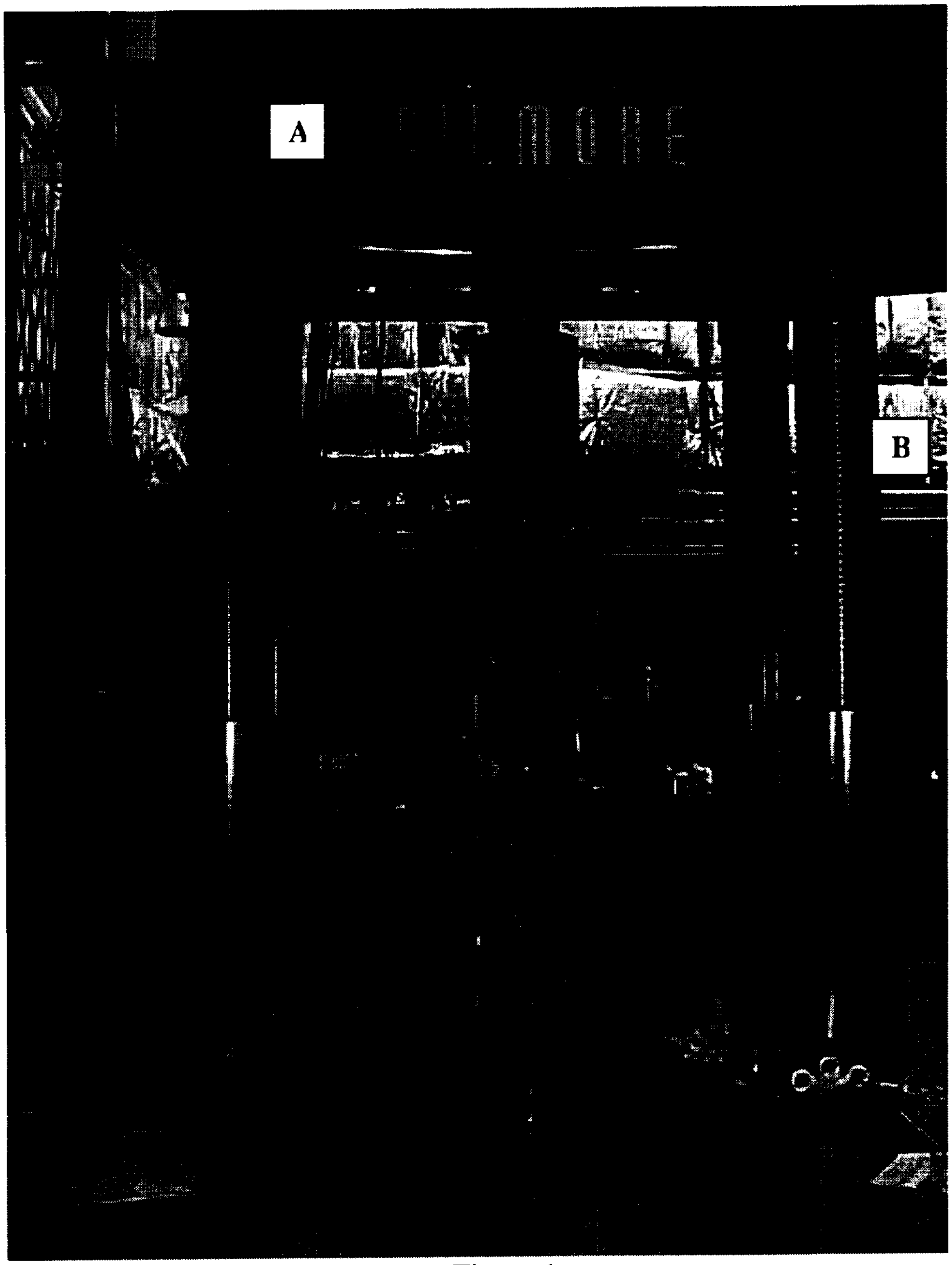

Figure 1

THE TRAVERSE SYSTEM

In order to accommodate the various size load cells, the Gilmore Machine was designed with a movable crosshead (see Figure 1, Item A). The crosshead serves as an abutment for the forces applied by either the Dead Weight System or by the Hydraulic System.

The crosshead is supported by four stationary traverse screws (see Figure 1, Item B). The traverse screws are approximately 28 cm in diameter and are approximately 11 meters tall.

The crosshead is positioned by a gear-motor with an output of 37 revolutions per minute. The gear-motor drives a sprocket, which through a link chain, drives four traverse nuts. The traverse nuts serve as the bearing surfaces for the crosshead. The gear-motor is reversible to facilitate travel in both the up and down direction.

It is important to note the gear-motor is not used by the Gilmore Machine to apply force to a load cell undergoing calibration.

THE DEAD WEIGHT SYSTEM

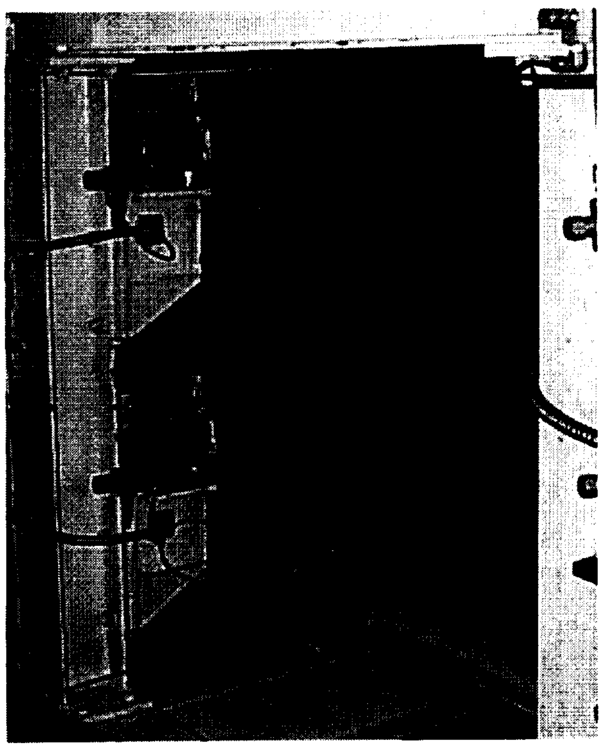

Figure 2

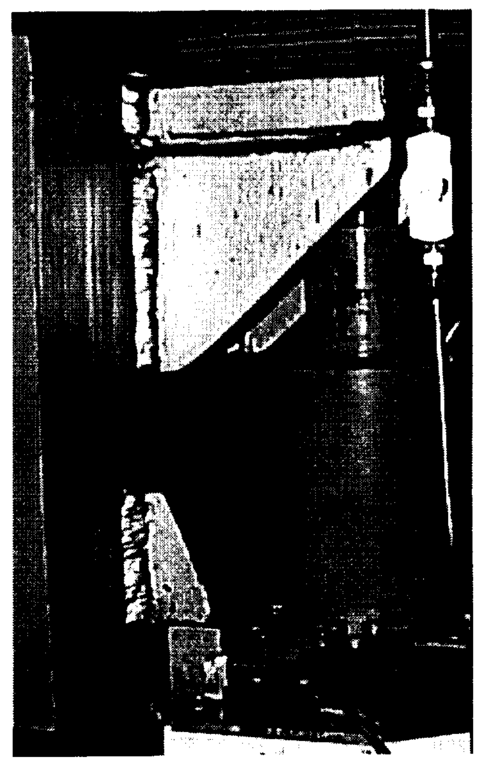

Figure 3

The Gilmore Machine is equipped with seventeen precision masses. Each mass was manufactured to a specified fabrication weight. Subsequent to fabrication, each mass was shipped to the National Institute for Standards and Technology for calibration. Each mass was calibrated to 0.006 percent of the specified value.

There are eight 20,000 kilogram (kg) masses, eight 10,000 kg masses, four 5,000 kg masses, and a single 2,500 kg mass arranged in a vertical stack (see Figure 2). Force is transmitted from the masses through a vertical spindle that passes through each mass. The spindle passes through the lower cradle. The lower cradle transmits force to the upper cradle through tension rods to facilitate calibration of load cells used in compression. The spindle may also be used to apply a tensile force directly to a load cell.

To apply force to a load cell undergoing calibration, the selected mass is lifted from its safety stops by a set of hydraulic lift cylinders (see Figure 3). The safety stops are then retracted by a set of pneumatic actuators. The lift cylinders then lower the mass to a collar attached to the spindle. Each mass can be selected individually or used in combination with any or all of the other masses. The Dead Weight System can apply a force of 2.22×10^6 Newtons.

THE HYDRAULIC SYSTEM

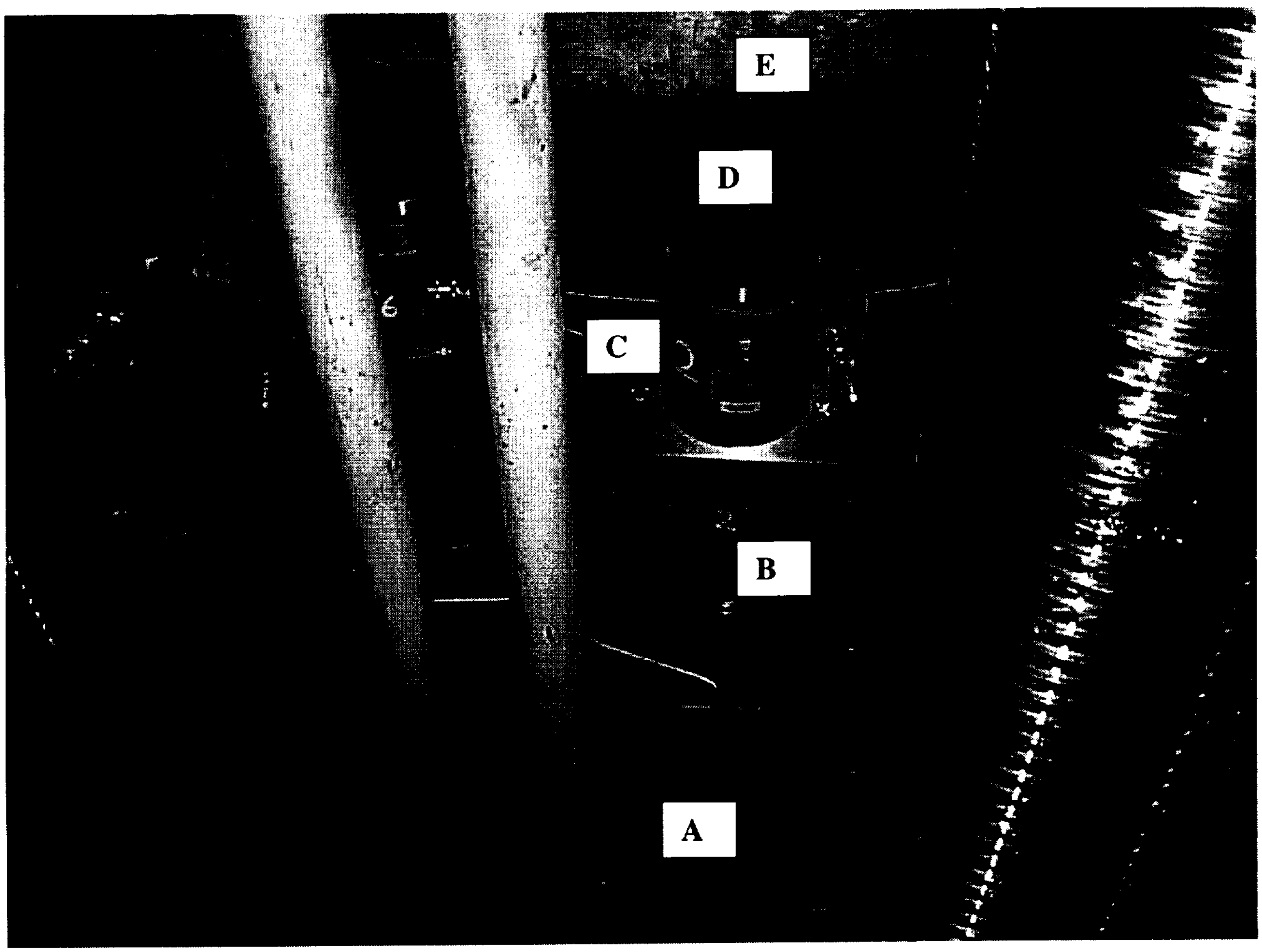

Figure 4

The Hydraulic System consists of a 6-kw electrically-driven hydraulic pump providing hydraulic fluid at pressure up to 3.45×10^7 Pascals and a set of 10 hydraulic cylinders (see Figure 4 Item A) which is arranged in a circular pattern on top of the crosshead. Pressure actually applied to the cylinders is controlled by a servovalve that is controlled by the Hydraulic Control System.

The hydraulic cylinders have a bore of 30 centimeters and have a stroke of approximately 6.4 cm. Each cylinder is capable of providing a force of 2.22×10^6 Newtons. Acting through the Load Equalizer Ring (see Figure 4, Item B), the cylinders are capable of providing a combined force of 2.22×10^7 Newtons.

Forces applied to load cells undergoing calibration are transmitted by the platen (Figure 4 Item E) through the hydraulic equalizers (Figure 4, Item D), then to the load cells of the Load Measurement System (Figure 4, Item C).

AUTOMATED HYDRAULIC CONTROL SYSTEM

Figure 5

The Gilmore Machine Hydraulic Control System was updated with an Endura-Tec Systems Corporation automated control system in July 1999. The new control system provides hydraulic system startup and controlled force application through the entire control range.

The hydraulic control system operates in a "closed-loop" mode. The command value is input to the control system via keyboard. The digital input signal is converted into an analog command signal by a digital-to-analog converter. An error signal is generated by comparing the output of the load measurement system to the command signal. The error is subsequently multiplied by a proportional control factor and is then utilized to drive the hydraulic system servovalve. The proportional control factor is selected to ensure the load applied to a load cell undergoing calibration does not exceed the specified amount.

A video display unit provides the operator with real-time force measurements, displacement measurements, system command values, and operator command values. Force, displacement, and command values are also represented graphically with respect to time.

The hydraulic control system provides three keyboard shutdown commands, force and displacement limits, and an external "panic" button for safety considerations.

LOAD MEASUREMENT SYSTEM

The Load Measurement System consists of 10 TORROID Model 40C-232-1A load cells (see Figure 4, Item C). The output of the TORROID load cells is integrated by the INTERFACE GOLD DW software program and displayed at either the display station located near the controls of the Dead Weight System or at the display station located near the controls of the Hydraulic Control Station.

Each TORROID load cell is individually calibrated using the Dead Weight System. Each TORROID load cell has a capacity of 2.22×10^6 Newtons.

VERSATILITY

The practical calibration range of the Gilmore Machine is from 4.45×10^5 Newtons to 2.22×10^7 Newtons. The Gilmore Machine can perform load cell calibrations in either compression or tension mode.

When performing calibrations in the compression mode, the subject load cell is placed between the platen and the upper cradle. When performing calibrations in the tension mode, the subject load cell is suspended from the platen and connected to the spindle. A large assortment of fixtures is available to fit the large variety of load cells in use.

The location of the traverse screws and the tension rods limit the diameter of the subject load cell to approximately 200 centimeters. The crosshead is positioned by the traverse system to accommodate the vertical dimension of the subject load cell. The Gilmore Machine can accommodate a vertical dimension of approximately 7 meters.

ACCESS

Customers seeking load cell calibration services should submit their request to:

Marshall Space Flight Center
Technology Transfer Department
Manager – CD30
Marshall Space Flight Center, AL 35812

Rates have not been established at this time. Each request will be individually quoted.