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INTERLOCK OPERATED SAFETY SHUTTER FOR LASERS

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DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

INTERLOCK OPERATED SAFETY SHUTTER FOR LASERS

By
Patrick O. Prendergast

PROPULSION AND AUXILIARY SYSTEMS DEPARTMENT
ANNAPOLIS
RESEARCH AND DEVELOPMENT REPORT

November 1976 Report PAS-76-38

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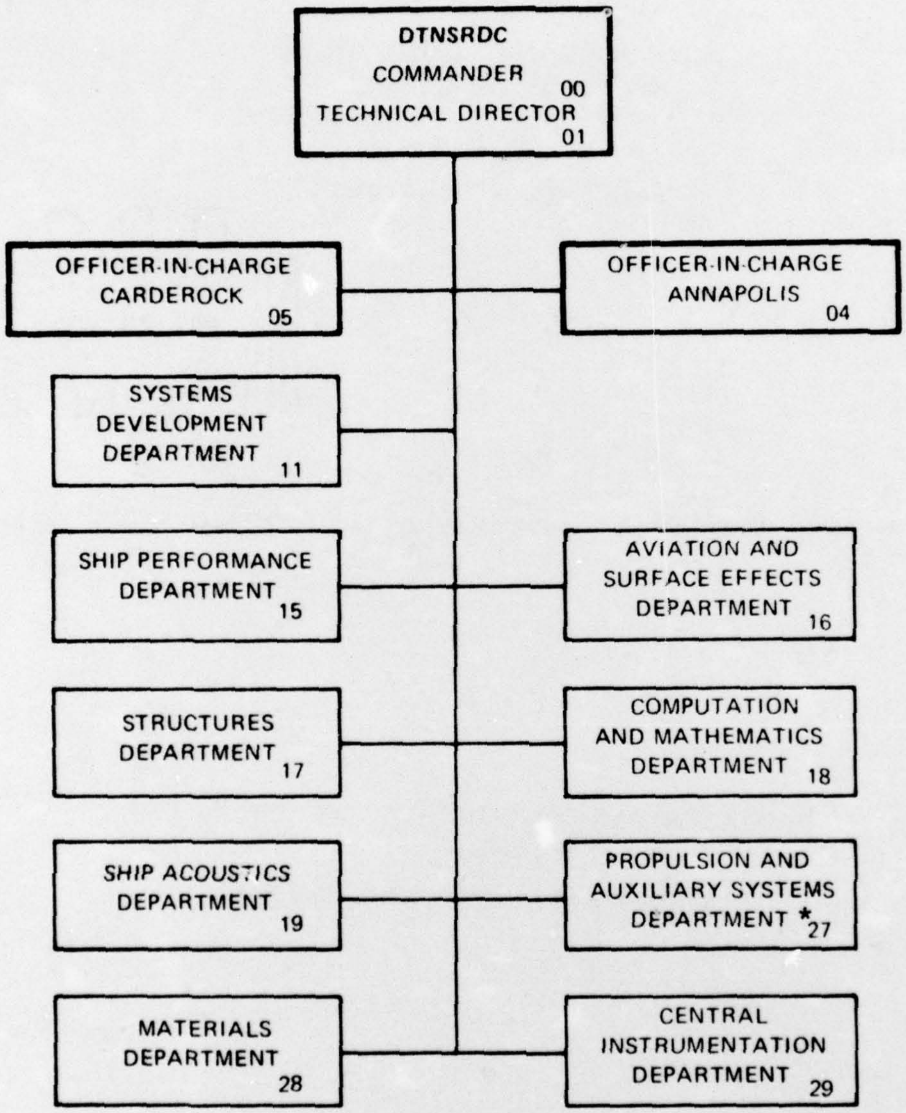

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ABSTRACT

The design and construction of a simple, low-cost safety shutter is described. Adaptation of the device to various types of lasers is discussed.

INTRODUCTION

Recent laser safety standards[1,2] require interlocks on doors to rooms in which lasers classed as "high power" (class IV) are operated. The interlock must prevent the emission of dangerous levels of laser radiation in the event that the door is opened while the laser is operating. This can be accomplished by making the interlock shut-down the electrical power to the laser by turning off the supply and discharging the firing capacitors, if they are used. In some metrological applications, however, such as holographic interferometry, it is undesirable to shut-down the laser power supply because of the time required for start-up and thermal stabilization of the system. It is also undesirable, in some cases, because of the increased possibility of failure in power supply transistors due to starting transients while the transistors are still warm. In such cases it is preferable to have the beam interrupted by a shutter instead. The shutter described herein provides interlocked beam interruption without incurring these problems while at the same time avoiding the problems associated with other types of shutters.

BACKGROUND

The elimination of job-related health and safety hazards has always been important to the Navy, but is of prime importance today because of pressure from unions and consumer groups and the recent proliferation of successful legal claims against employers for job-related injuries and disabilities. As an employer of a large number of people, the Navy is vulnerable to safety-related legal claims. For this reason it will probably adopt the provisions of the recently published standard for laser safety[1] which requires laser safety interlocks on doors to areas where high-power lasers are operated.

In some applications, as mentioned earlier, a shutter, controlled by the safety interlocks, is preferred over shutting down the laser power supply. However, commercially available shutter devices are not well suited for this job.

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[1] Superscripts refer to similarly numbered entries in the Technical References at the end of the text.

The ordinary photographic optical shutter is often used with lasers. In this type of shutter an opaque blade is placed in the path of the light to stop it. The blade must therefore absorb most of the energy of the laser beam. Such absorption heats up the mechanism and may be intense enough to damage it. Hence, this type of shutter is only practical for relatively low-power lasers. In addition, such shutters can usually be set to stay open and are thus not "fail-safe".

Another type of shutter which can be used is the optical modulator. There are several types of these devices such as Kerr cells, Pockel's cells, and acousto-optic devices, but all are quite expensive for this application and usually require external electronics to operate them. The added complexity could result in less reliability.

APPROACH

While the shutter described herein is intended for a particular Argon-ion laser, it is also to serve as a prototype for similar shutters in other laser systems. For this reason adaptability was an important consideration in its design. It was desired that it be easily constructable of available materials to keep the cost low. At the same time it was necessary to obtain reliability and fail-safe operation. To satisfy these requirements, the function of absorbing the energy of the light beam was eliminated from the shutter mechanism, itself, so that the absorber could be separately designed for the power level of any particular laser. At the same time, this approach allowed the mechanism to be designed according to the mechanical requirements of the laser application without the constraints which would be imposed by having to dissipate the heat generated by the laser beam. The only parameter which still had to be considered for both parts of the shutter system was the wavelength of the light. However, as will be seen later, wavelength considerations usually pose no particular problem.

DESCRIPTION

The shutter, diagrammed in figure 1, interrupts the laser beam by placing a mirror of appropriate reflective material for the laser wavelength in the beam. The angle of the mirror to the axis of the beam is such that the beam will be specularly reflected toward an absorber which can be constructed to have the necessary absorption and heat dissipating characteristics for the wavelength and power of the laser. If a straight path cannot be obtained, secondary fixed mirrors may also be used to steer the beam to the absorber. A manual lever and a solenoid are provided to move and hold the mirror out of the laser beam under control of safety interlock devices such as door switches, treadle switches, photoelectric cells, etc. The restoring force for the mirror is provided by the spring and/or gravity as required by the particular laser application. Figures 2 and 3 are photographs of the prototype. Note that the prototype utilizes a telephone-type relay coil and armature for the solenoid.

Item (a), figure 1, shows the shutter in its normal, "tripped", position. In this position the mirror intercepts the beam and reflects it to the absorber. This is the position the mirror will assume with no power applied to the solenoid. Dangerous levels of laser radiation are confined to the shutter and absorber which must be suitably shielded or enclosed.

Item (b), figure 1, shows the shutter in its "set" position. To reach this position, the mirror must be manually moved out of the laser beam by the reset lever. With power applied and the interlock devices closed, the direct-current power supply will energize the solenoid to hold the mirror in the "set" position. In this position, the laser beam is not interrupted by the mirror and is allowed to pass through the aperture. This condition will be maintained until either the power is removed or one of the interlock devices is opened. At that time, the solenoid will be de-energized and the mirror will move to the "tripped" position under the influence of the spring and/or gravity. The spring is needed to overcome the residual magnetism in the solenoid and ensure rapid operation.

Figure 4 shows the prototype installed on an Argon-ion laser in combination with other system components.

DISCUSSION

ADVANTAGES

The shutter described in the previous section uses reflective means to move the energy absorption function of the shutter away from the mechanism. This allows great flexibility in the shape, size, and method of heat dissipation of the energy absorber for a particular laser application. At the same time it eliminates the thermal problems which would have to be considered in designing the mechanism itself, thus reducing its cost, increasing its reliability, and making it adaptable to lasers of various wave-lengths and power outputs.

An additional advantage is provided by the use of a "fail-safe" design which requires power to hold the shutter "open" so that in the event of a power interruption, or a failure in the shutter supply, the shutter will automatically close rather than remain open. This is unlike photographic-type shutters which can be mechanically set to stay open without power.

Additional safety is provided by the fact that in all situations, once the shutter closes, it must be manually opened. This means that in interlock-controlled spaces the beam will not go back on again immediately after someone enters the controlled room and closes the door.

From an operating standpoint this type of shutter is better than the optical modulator types because the mirror is completely removed from the beam when it is open and therefore has no effect on the optical properties of the system. There are also savings because the mirror in the shutter does not have to have high optical quality.

ALTERNATIVES

As mentioned earlier, the prototype shutter is intended for a particular laser and uses a solenoid to hold the mirror out of the beam so that it can be operated from the 110 vac line through electrical interlock switches. However, in some applications, mechanical, hydraulic, pneumatic or vacuum devices to hold the mirror in the "set" or "open" position might be employed to advantage.

In the prototype, gravity was used to restore the mirror to the "tripped" or "closed" position, but springs or other means appropriate to the application may be substituted instead. It is only necessary that the restoring force provide "fail-safe" operation.

If it is desired to use the shutter with a laser which emits infrared or ultraviolet light, it is only necessary to substitute suitable materials for these wavelengths in the mirror and absorber components. An inexpensive front-surface mirror is suitable for all visible wavelengths.

SUMMARY

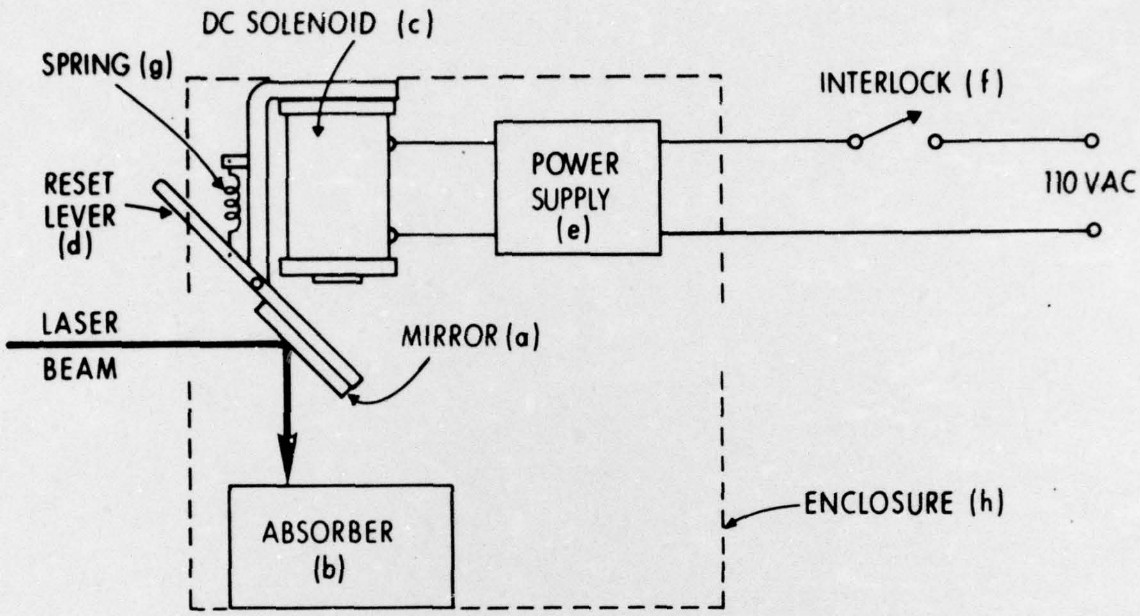
The shutter device described herein provides interlock controlled laser beam interruption without shutting down the laser itself. This permits meeting the requirements of the American National Standard on Laser Safety (ANSI Z-136.1) which calls for interlock protection on class IV ("High Power Lasers"), while avoiding the delays associated with restarting and thermal stabilization of the laser. In addition, because of its remote heat absorption feature, the shutter can be adapted to lasers covering a wide power range. Because of its adaptability, and because it answers a need by providing protection with minimum system disturbance, it could be widely applied in government and industry where lasers are used for sensitive measurements.

TECHNICAL REFERENCES

1 - American National Standard for the Safe Use of Lasers, ANSI Z136.1-1973, p. 19, Sect. 4.2.4.1

2 - Department of the Army, "Control of Hazards to Health from Laser Radiation," TB MED 279 (1973)

Item (a) - Laser Safety Shutter in Normal,
"Tripped", Position



Item (b) - Laser Safety Shutter in "Set" Position

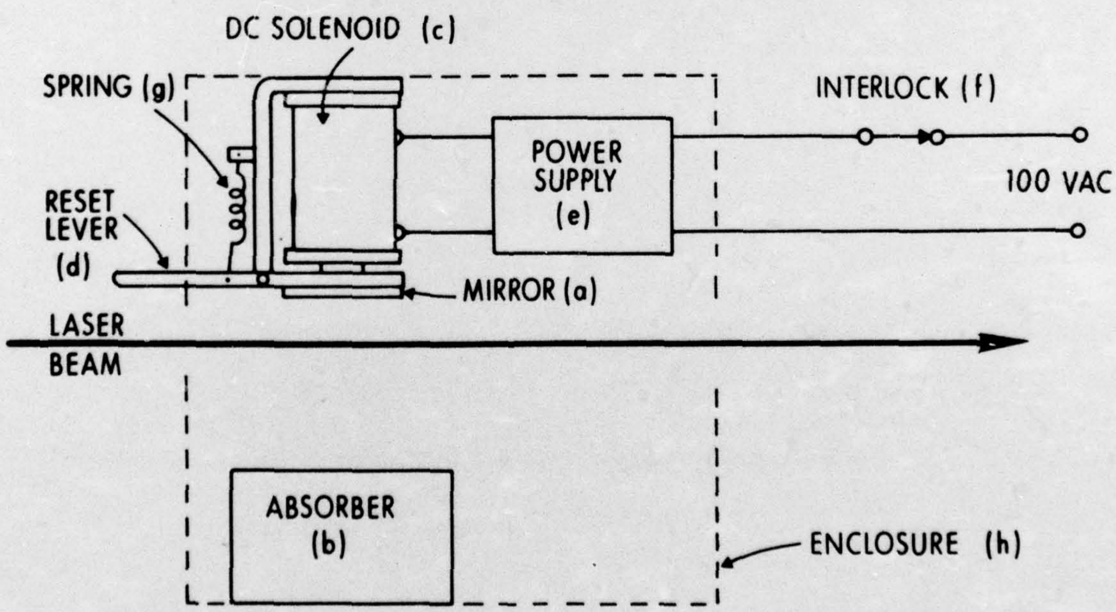


Figure 1
Laser Safety Shutter

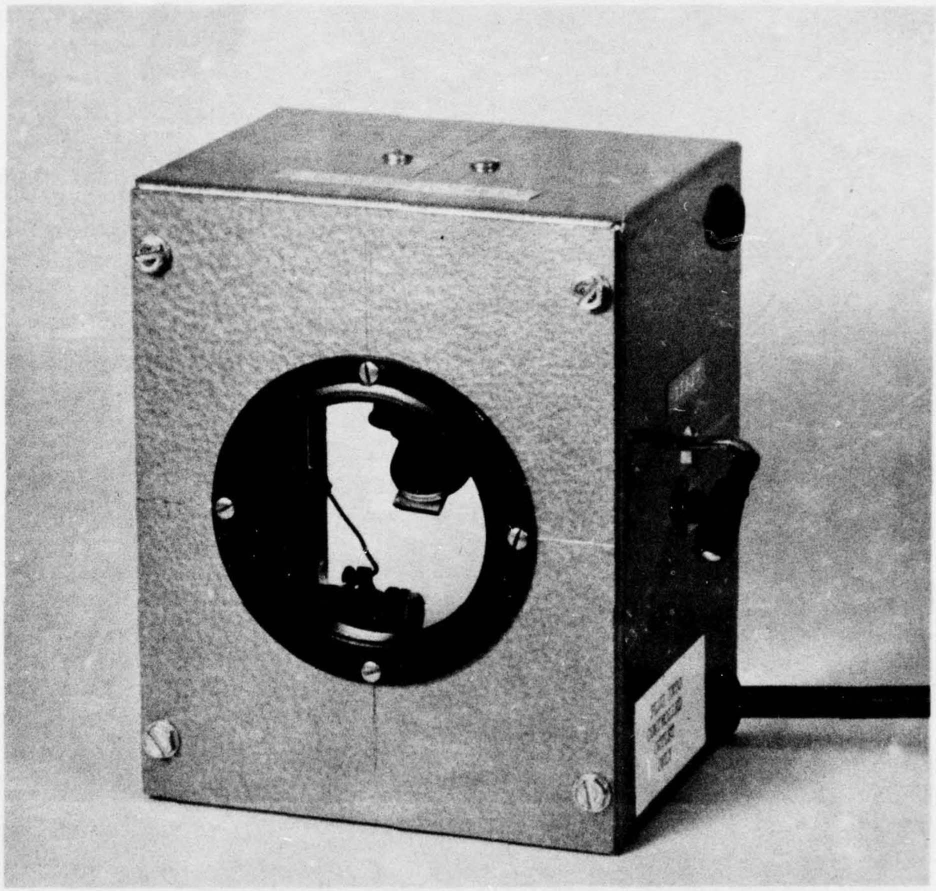


Figure 2
Laser Safety Shutter
Outside View

1. Solonoid (c)
2. Rectifier Circuit (e)
3. Spring (g)
4. Reset Lever (d)
5. Interlock Switch Cable
6. Absorber (b)
7. Enclosure (h)
8. Mirror (a)

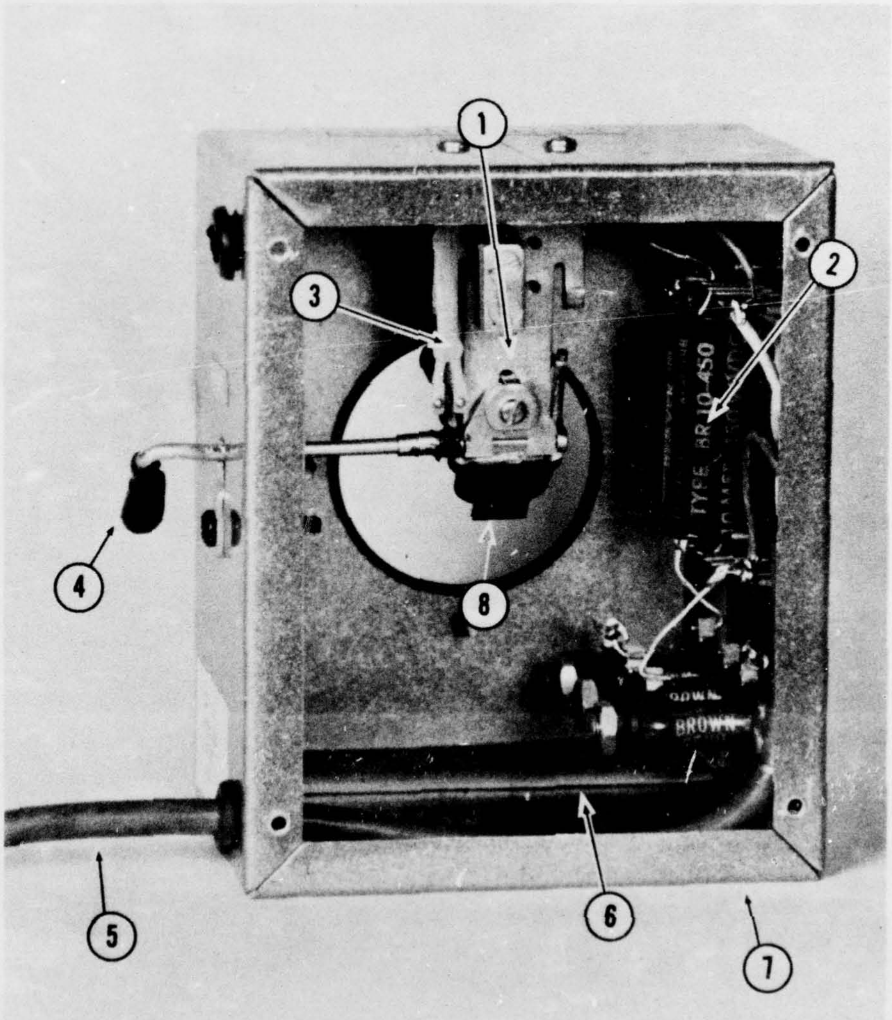


Figure 3
Laser Safety Shutter
Inside View

1. Laser
2. Safety Shutter
3. Timed Shutter
4. Timer
5. Beam Director

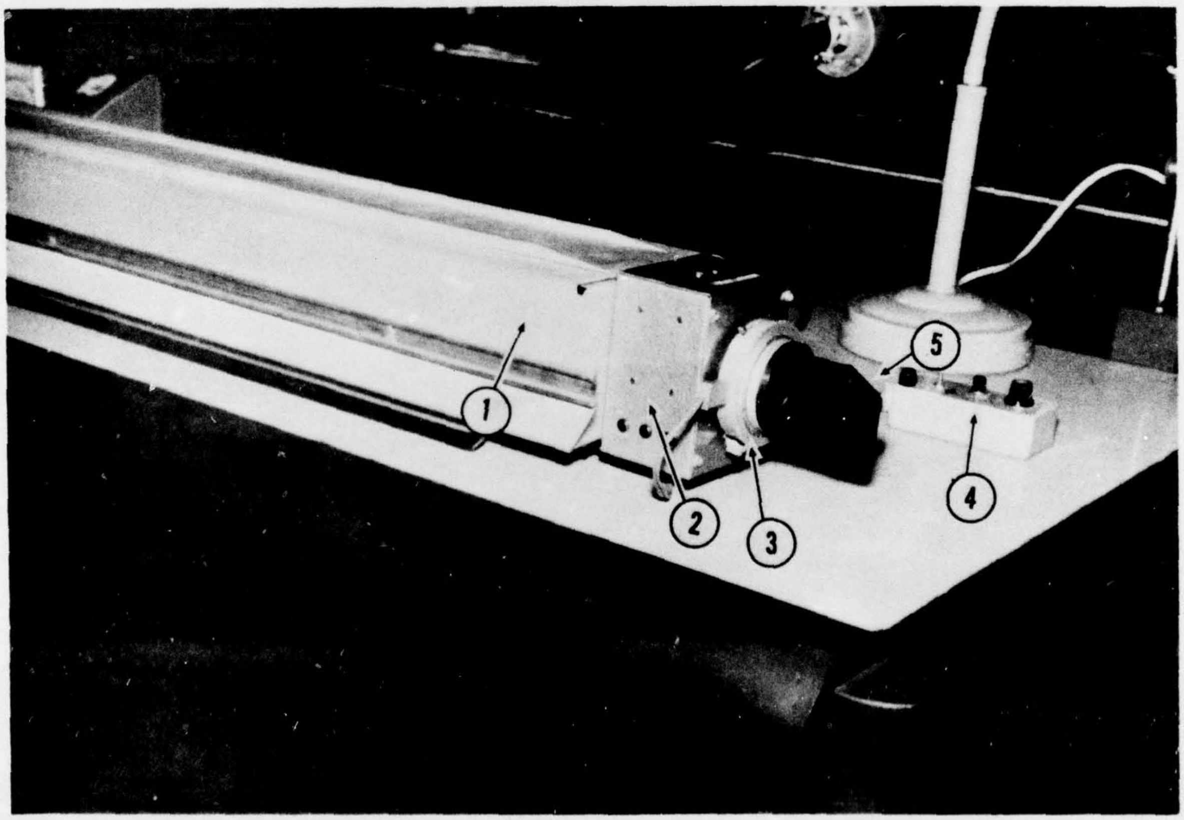


Figure 4
Laser Safety Shutter Mounted on an Argon-ion
Laser with Other System Components

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