active

Proposal for Modification to Rear Projector + Screen

Introduction

Ground glass surfaces have long been used as screens upon which optical images are displayed, particularly for back-projection devices. The choice of grain size for the ground glass surface has always been the result of a judicious compromise. The grain of the glass limits the resolution of the image approximately to the dimensions of the grain. As the grain of the screen is reduced in an attempt to improve image resolution, the apparent brightness of the image decreases rapidly as the viewing angle departs from the axis.

It has recently been demonstrated that the effect of grain size on limits of resolution can be reduced by a substantial degree by imparting a vibratory motion to the glass in the plane normal to the projection axis. This, in effect, randomizes the grain, and yields resolution presumably determined by the statistics of screen brightness at any given element of area over a period related to retinal image persistance. Grain effect can be minimized further by using a double-layer screen, with the ground surfaces in juxtaposition, and with the interface filled with a suitable liquid of index of refraction similar to that of the glass.

Technical Requirements

A device designed to exploit the phenomena discussed above must provide: (1) a flexible mount that permits the screen to move freely in the "X,Y" plane, but restricts motion along the "Z" axis, (2) a drive of adequate power to transmit the desired pattern of oscillation to the flexibly mounted screen, and, (3) a method of retaining the mounting liquid in place between the screens. The latter requirement may become a serious problem for large, vertically mounted screens. Capillarity can support a film only a few centimeters in height, and the small enclosed volume in the thin film will result in a substantial change in film height for small amounts of leakage or bulge of gasketing. Furthermore, the hydrostatic forces on a large, flat screen will result in a bowing of the screen surface that may readily become significant if the clearance between the stationary and oscillating surfaces is a matter for close tolerances.

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Proposed Design

1. Mounts

It is proposed to mount the vibrating screen upon "hairpin" springs that, with the screen, are mechanically resonant at the desired oscillator frequencies. The spring mounts will be designed with two preferred modes of oscillation and with the resonant frequencies related to each other by a substantially incommensurate ratio that is approximately 3:4. This will result in a trace, for any point on the screen, represented by a Lissajous figure of long period. The preferred modes will be oriented at substantially right angles to each other, and parallel to the vibratory motions of the drives described below. The mounting hardware is schematically represented in Figure I.

2. Drive

The drives will be solenoid motors actuated by variable-frequency audio oscillators of power adequate to secure the desired amplitude. Figure II illustrates the principles of the motor drive and linkages. The oscillators will be tuned to the resonant frequencies of the mechanical system to which they are coupled. The frequencies will be adjusted to be well above the flicker fusion frequency of the retina but below those at which auditory acuity is high. It is believed that frequencies between 30 and 60 cycles per second will be appropriate.

The power required to drive the screen may be considerable. Despite the low amplitude and low frequency of the oscillatory motion, the thinness of the fluid film results in high sheer gradients and substantial viscous drag. For a filling liquid comparable to a very light lubricating oil, viscous losses in the oil will be about 40 watts initially, although the resultant heating of the oil will lead to lowered viscosity and reduced drag during long-term operation.

The filling liquid may be chosen with lower viscosity, but the lack of lubricity of the low-viscosity liquid may well result in glass-to-glass friction losses as large as, or larger than, the fluid friction losses in a light lubricating oil.

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3. Seal

It is proposed to seal the stationary screen to the projector frame with a thick joint of room-temperature vulcanizing silicone rubber. This will permit expansion and contraction of the screen or frame without breaking the seal or crushing the glass. Such rubber is highly resistant to many types of oils and to atmospheric checking and cracking.

The oscillating screen will be sealed along the two sides and the bottom by a pneumatic gasket inflated to a pressure somewhat in excess of the maximum hydrostatic pressure of the liquid between the screens. Pressure will be maintained in the gasket by connection to a suitable reservoir. A small liquid carbon dioxide cylinder, connected through a diaphragm reducing valve set for the desired pressure, would provide a reservoir with greatly reduced service demands. The gasket is made from a length of laboratory tubing, and can be replaced readily when necessary. As shown in Figure III (inset), a small reservoir is provided in a trough at the upper margin of the screen. This provides for small amounts of leakage, thermal expansion, or screen sag without the liquid level dropping to leave a meniscus in the field of view.

On a screen 30 inches square, with a liquid fill having a specific gravity of 0.8, the total hydrostatic force on each screen is over 300 pounds. This will result in some bowing of the screen, with an increase in the front-to-back screen separation. This bowing may be controlled to any required degree by a suitable combination of increased screen thickness and pre-shaping the screen surfaces so that, in their stressed condition, they are closely enough planar. In the absence of data on the permitted tolerance on screen separation, present design and cost estimates are based on a maximum separation of the two ground glass surfaces of not over 0.3 mm.

Optimization

No funding is provided in this estimate for "human engineering" studies to determine the optimum design characteristics of the liquid-filled, double-ground glass, viewing screen system. Neither is time included for adjustments or modifications of the instrument in connection with human engineering studies of the sponsor. Should the sponsor desire such services a proposal to conduct them will be submitted on request.

Time Schedules

The proposed design and modifications are estimated to required sixty to seventy-five days for completion following authorization to proceed. The power requirements for the solenoid motors (not less than twenty-five watt each) will probably require custom design and manufacture of the motors. This will involve a delivery estimated to be from four to six weeks, and the time estimate given is contingent upon our ability to secure such delivery.

No difficulty is anticipated in obtaining promptly the other components involved. Machine and assembly time are estimated to require an additional week per unit as compared to the stationary screen model, but this will overlap the delivery time on the solenoids.

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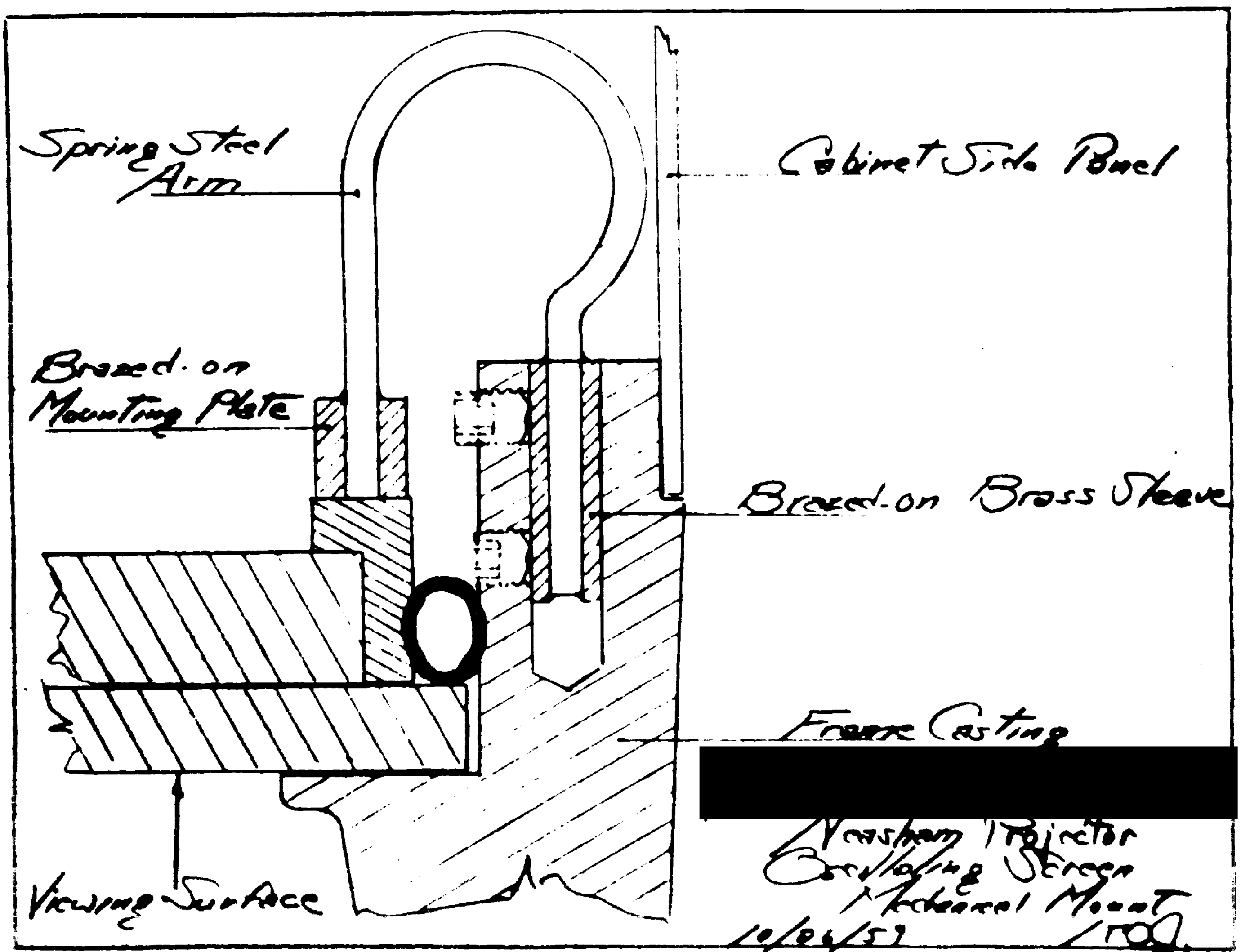
Spring Steel Arm
Cabinet Side Panel
Brazed-on Mounting Plate
Brazed-on Brass Sleeve
Frame Casting
[redacted]
Oscillating Screen
Mechanical Mount
Viewing Surface

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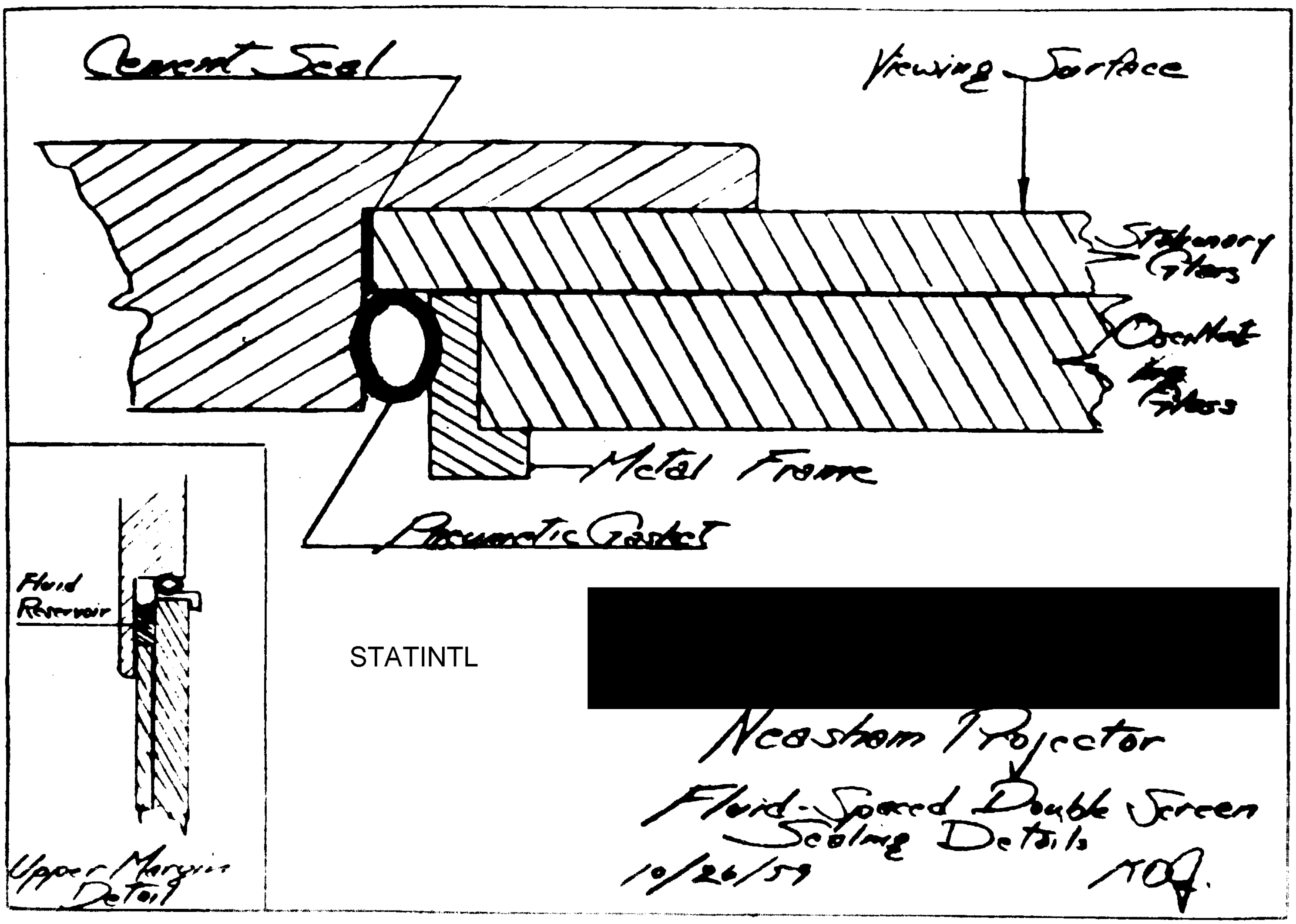

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