CR 86307

PRECISION SENSOR ALIGNMENT

Harold H. Seward

December 1969

Prepared under Contract No. NAS 12-2056 by

HH Controls Co., Inc.
16 Frost Street
Arlington, Massachusetts 02174





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## SUMMARY

This final report describes the results of work done by HH Controls Co., Inc. in applying their Model 300-50 Wideband Autocollimator System to a Carco three-axis test-table to determine suitability of an arrangement for the testing of a precision ultraviolet (UV) horizon sensor. The UV-horizon sensor was mounted onto the Carco test platform along with two mirror flats which were used for the autocollimator systems.

The autocollimators and a horizon-simulator, also manufactured under the contract, were mounted to the laboratory floor adjacent to the Carco table and the test system was dynamically and statically observed to evaluate its performance for sensor testing.

# INTRODUCTION

The objectives of the work done may be divided into two major tasks. One task was to determine the suitability of using the NASA/ERC Carco test-table, in conjunction with the HH Controls Model 300-50 Autocollimator Systems, to follow motions of sensors under test to accuracies of under one arcsecond of motion.

The second objective was to develop a UV-horizon simulator to generate typical signals in a UV-horizon sensor which relate directly to the signals obtained by the sensor in space when directed toward the earth horizon profile.

The former task was completed in September 1969 after delivery of the Autocollimator Systems on September 19, 1969. The latter task was completed in December 1969 after delivery of the UV-horizon simulator on December 4, 1969.

Angular Precision of Carco Table.-Initial testing of the Carco table was accomplished with the two mirrors mounted on flat surfaces at the side of the inner platform. The height of the mirrors was about 4.5 feet from the laboratory floor and it was therefor necessary to mount the observing autocollimators on a husky photographic camera mount borrowed from the ERC Electro-Optical Sensors Laboratory.

With this particular arrangement, it was found that excursions of 15 to 30 arcseconds were present in the output of the autocollimators, the output being monitored on a scope.

The frequency of the excursion was determined to be about 1 Hertz and forces were applied to various parts of the system to determine if a singular source was responsible for the motion. Forces applied to the gimbals did not produce motions correlating with the oscillation, nor did forces applied between the laboratory floor and the pier supporting the Carco table (up to 100 pounds in the latter case).

It was noted that a small tap, applied at virtually any point on the camera mount, would then induce vibrations of the characteristic frequency being sought. Although of a stiff design, the mount was deemed inadequate, even after some stiffenning experiments had produced marginal results.

An alternative mount was then secured form the Electro-Optical Sensors Lab. This mount consisted of a granite slab mounted on a heavy steel-frame table with casters, used for rolling the table about. The height was not adjustable, but heavy blocks were used on top of the table to raise the effective surface of the table and support the autocollimators at the desired height.

Operation with this mount subsequently demonstrated that low-frequency vibrations were also present. This also was isolated to the mount and was most puzzling since the granite table seemed to be so much more rigid. Jacks built into the table were then used to raise the casters from the floor and remove them as a possible source of instability, but no improvement was noted from this action.
Subsequent point-by-point inspection of the table finally revealed four hidden pads of hard rubber were mounted under the granite table top.

To eliminate these pads as a possible source of the oscillation, metal wedges were introduced in parallel with the pads. Removal was considered, but the slab was far too heavy to accomplish this, and table imbalance might occur. Subsequent testing then showed that the oscillation had disappeared and noise levels of the system were under a one arcsecond level.

With the source of excessive noise eliminated, forces were once again applied to various points in the system to determine if troublesome responses would result. None were noted.

In particular, forces in excessive amounts (over 100 pounds) were applied to the pier relative to the laboratory floor, with no measureable effects in the one arcsecond range of sensitivity.

Next, the effects of air turbulence were evaluated. The mirror distance from the autocollimators was about 3 feet in all tests and the equivalent angular noise was found to be easily under one arcsecond in the general laboratory environment present in the test area. This is in accordance with the data found in the Operation Manual supplied with the Model 300-50 Wideband Electronic Autocollimator System.

As discussed in the manual, shielding of the light path might be necessary to reduce the noise level due to turbulence at ranges such as 10 feet, but at three feet the noise is under 1 arcsecond in relatively quiet air.

If reconfiguration of the system requires, a 6-inch diameter tubing of light material such as Aluminum may be used to shield the light path from stray air turbulence.

*UV-Horizon Simulator*.-The operation of the UV-horizon simulator is illustrated in Figure 1. The source consists of a General Electric Ribbon Filament Microscope Lamp. One edge of the ribbon filament corresponds to the illuminated edge of the earth as seen from outer space. Inasmuch as the filament temperature and the intensity are not the same as that of the horizon, filters are necessary to modify the source spectrally and in magnitude in order that the UV-horizon sensor will produce proper signals.

One filter is of the neutral density type to reduce the light essentially by the same percentage to be more in line with the true horizon at the wavelengths of interest. The second filter or filters is used to achieve the proper balance between the two wavelengths used in the UV-horizon sensor (e.g., 4200 Angstroms and 3600 Angstroms).

Filters offered by Corning Glass Works of Corning, N.Y. are generally suitable for these units. The color-correcting glasses are generally of a blue or violet hue for this transformation. For use of the simulator in deeper (shorter wavelength) ultraviolet, Schott Glass of West Germany has a wide selection of UV filters down to the ozone-absorbing region of the atmosphere (3400 Angstroms) where the UV-sensor would produce unreliable results.

After filtering to obtain the proper balance of the two wavelengths used, the source light is then collimated by refraction through two spherical surfaces centered on the axis of the simulator as shown in Figure 1. Upon entering the second and larger of the two lenses, the light becomes collimated and next impinges on the plane exit surface of the large lens.

Depending upon the angle of the plane surface, the light leaving will undergo dispersion as in exiting from a spectrograph prism, with the shorter wavelengths being refracted to a greater angle than the longer wavelengths. Thus, the edge of the ribbon filament is spectrally spread out with a violet edge on top of a blue edge an top of a white edge when viewed in the visible spectrum.

By varying the angle of the final lens, the dispersion may be made to increase in order to simulate viewing the horizon at a closer range.

Upon delivery of the UV-horizon simulator on December 4, The unit was aligned to the UV-horizon sensor developed by the Electro-Optical Sensors Lab and tests were run to measure the sensor using the simulator source.

Generation of the profile curves in this experiment showed that adequete margin exists in the simulator for any forseeable testing above the 3400 Angstrom range where ozone absorption uncertainties exist.

## CONCLUSION

The results of the forgoing tests utilizing the NASA-ERC Carco test-table and the ERC Breadboard UV-horizon sensor in conjunction with the HH Controls 300-50 autocollimators and UV-horizon simulator show that the system used is suitable for use as a test base in evaluating UV-horizon sensors as presently envisioned. This testing may be done in the existing laboratory with the pier-mounted Carco table and without extensive precautions to eliminate the effects of air turbulence In addition, ample design margin appears to be available for testing beyond the 1 arcsecond level, if and when desired.

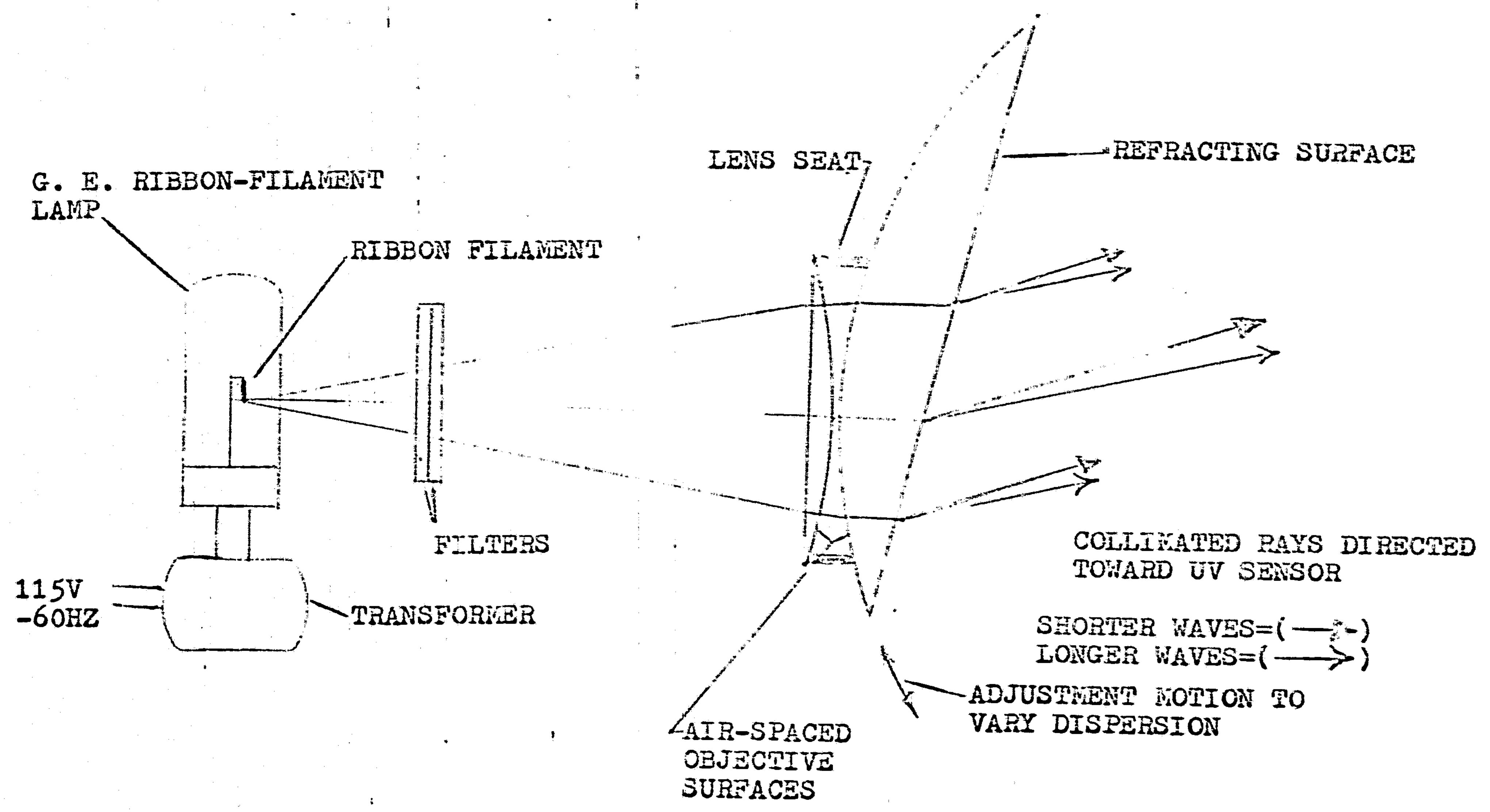


FIGURE 1. UV-HORIZON SIMULATOR

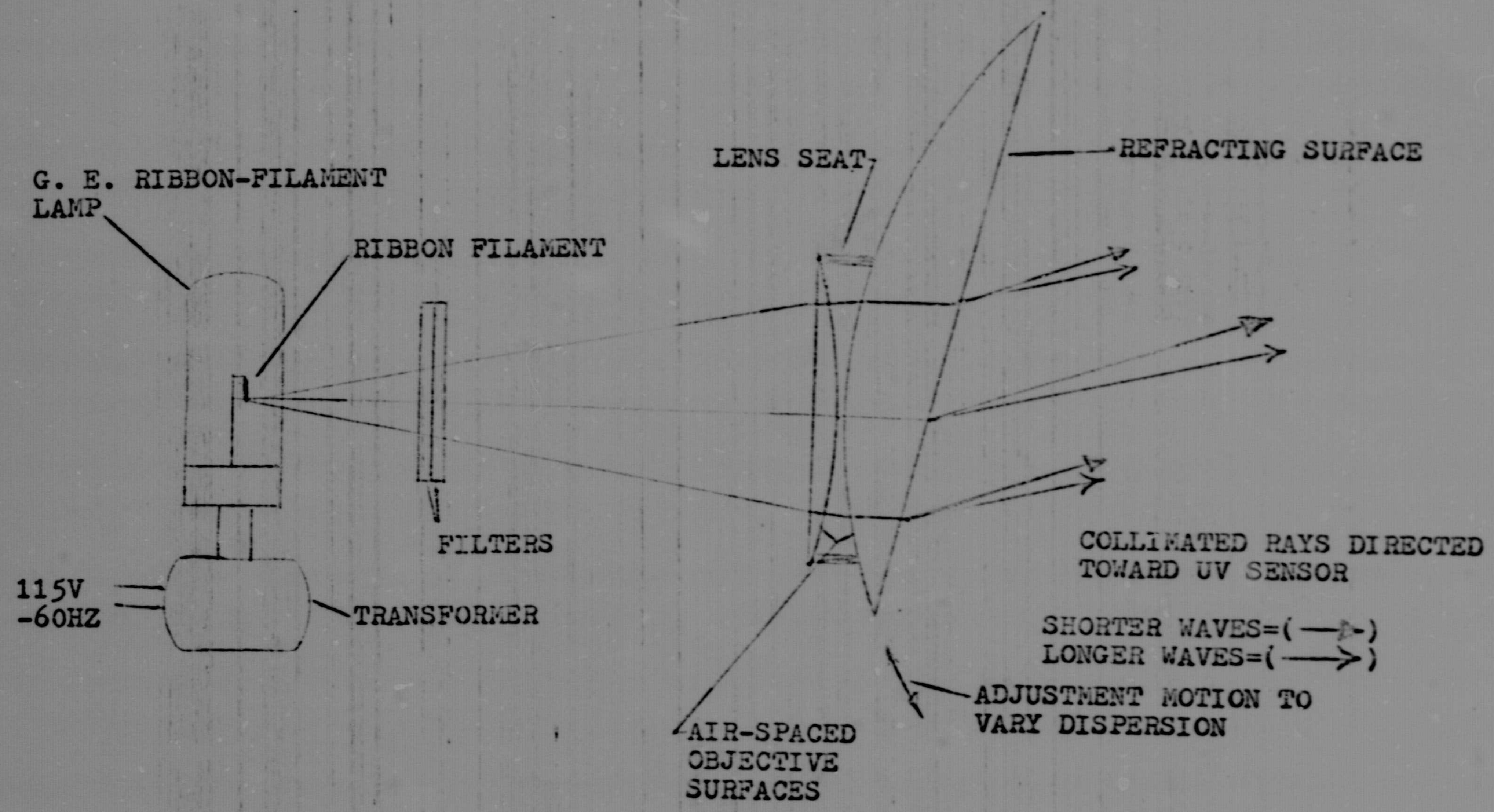


FIGURE 1. UV-HORIZON SIMULATOR

## NEW TECHNOLOGY APPENDIX

After a diligent review of the work performed under this contract, no new innovation, discovery, improvement or invention was made.