September 1969 Brief 69-10405

NASA TECH BRIEF

Improved Method of Optical Design

An improved method of optical design has been developed through the combination of two separate and distinct computer program techniques to resolve several long standing optical design problems.

There is in rather wide use today a class of design programs known as ray deviation programs. In these programs rays are traced through the optical system, and the imagery is evaluated by calculating the rms radius of the spot formed by the entire bundle of rays which go through the system, and the average position of the spot in two dimensions. The spot sizes and positions relative to desired positions are weighted and added into an "error function" which the automatic features of the program minimize by changing optical system parameters.

Another class of programs in wide use employ certain traced rays to compute aberration coefficients which characterize the quality of the imagery in a completely different way. The third order (found by truncating infinite series) aberrations are called spherical, coma, astigmatism, distortion, and Petzval. There are derived aberration characteristics, such as offense against the sine condition, which are also used to characterize the quality of the imagery. Some programs in this class, called aberration programs, use higher order terms to characterize the quality, but these terms become so numerous that it is difficult to name them. These aberration programs are not as independent of each other as the third order terms.

The principle which has been discovered, and which represents the new technology, is that an optical system prepared or designed by third order aberration theory can be significantly improved by placing it into a ray deviation design program. This improvement is measured by the criteria used by the ray deviation program and also by the criteria used by aberration theory. Thus, the improvement is real and not just a theoretical improvement according to a particular set of criteria. Efforts to obtain still greater improvements by cascading the operations (alternating repeatedly between aberration design and ray deviation design) result in marginal improvement. The sequence of the two-step operation is important. The preferred order is aberration design followed by ray deviation design.

Notes:

1. The new principle has been tested on a number of systems, all with positive results. Ritchey-Chrétien and Dall-Kirkham telescope systems, which have unique solutions in terms of third order theory, have been designed. An ultraviolet relay lens, having greatly improved performance, has been designed with the new technique in a small fraction of the time used in a previous effort. A four-lens corrector system to remove residual aberrations in a Ritchey-Chrétien telescope was designed with the new technique, resulting in a 300 cm focal length f/10 diffraction-limited 1.2° flat-field system for white light.
2. Requests for further information may be directed to:
   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: TSP69-10405

Patent status:

No patent action is contemplated by NASA.

Source: Barton J. Howell of
Sperry Rand Corporation
under contract to
Goddard Space Flight Center
(GSC-10743)

Category 02