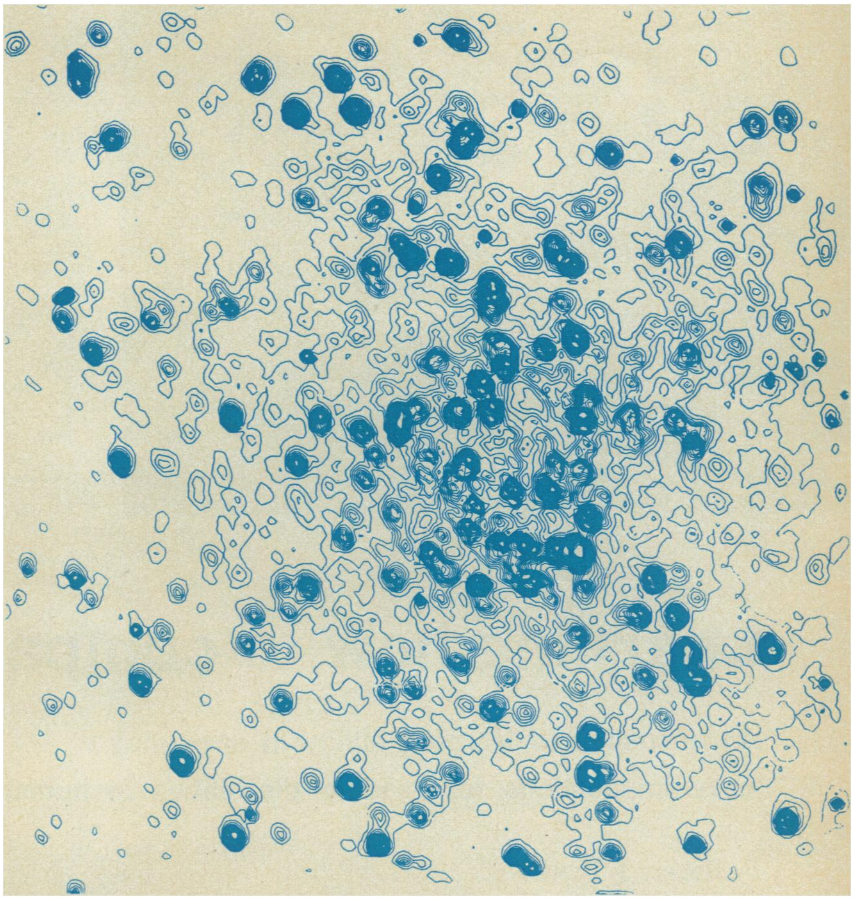
# Photographing the stars electronically



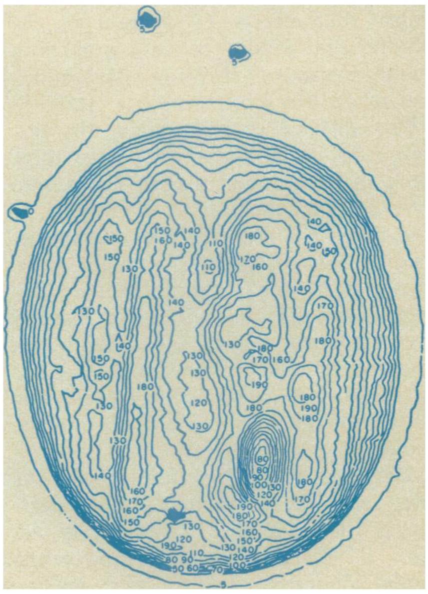
*Intensity contours of part of the globular star cluster 47 Tucanae.*

**Optical astronomy's reliance on the photographic plate is giving way to sophisticated devices that act on the principle of the television camera**

by Dietrick E. Thomsen

The invention of the photographic plate made a revolution in astronomy that was perhaps greater than the invention of the telescope. For millennia astronomers had depended on the retina of the human eye as an imaging medium. To inform colleagues, observers would make drawings or write descriptions of what they had seen. At times the drawings and descriptions varied widely from astronomer to astronomer, as the controversy over the canals of Mars illustrates.

Photography provided objective, storable images in which, presumably, everyone would see the same things. Coupled with a spectroscope, the camera could make records of spectra that would then be available for examination and measurement at leisure. Photography made modern astronomy and astrophysics possible.



*Intensity contours of planet Jupiter.*

But lately astronomy's totalitarian dependence on the photographic plate has been slipping. The science has expanded beyond the range of visible light to ranges of the electromagnetic spectrum where photography is either impossible or not very useful. Now, even in the visible range, astronomers are becoming impatient with photography. Those who want to study the faintest known objects in the sky (which are usually the most distant seen) or very faint spectral lines (whether they happen to be in the spectra of distant or nearby objects) are finding that if the camera does not give the lie direct, it can be at least highly imprecise.

Astronomers want photographic plates on which the darkness of the image is well enough related to the brightness of the light that printed it to enable them to deduce that brightness. With extended images and spectral lines they want to be able to make profiles of brightness over the extent of the image. It is from work of this sort that the bulk of astrophysical data are determined. But at the faint limits of current astronomy even the best photographic emulsions are proving to be incapable or imprecise.

To record fainter light astronomers are turning to electrooptic devices of one sort or another, and especially to vidicon systems, which replace the photographic emulsion with the principle of a television camera. A device of this sort, which its inventors, Thomas B. McCord of Massachusetts Institute of Technology and James A. Westphal of California Institute of Technology, say is much more versatile and sensitive than any previous effort, has recently finished a series of test observations with the 152-centimeter telescope at the Inter-American Observatory at

Cerro Tololo, Chile. McCord and Westphal call it a two-dimensional silicon vidicon astronomical photometer, and they describe it in the March APPLIED OPTICS.

The heart of the system is the receiving element in the vidicon tube. This is basically an array of solid-state silicon diode junctions fabricated on a single wafer of silicon.

The optical image from whatever telescopic system is being used is cast onto one side of the array. Each photon generates a charge-carrier pair, an electron-hole combination, on the side where it falls. The hole diffuses across the nearest junction and reduces by $1.6 \times 10^{-19}$ coulombs an electric charge previously stored on the far side of that diode.

Thus the image is stored. Each diode receives the holes corresponding to photons in a given part of the optical image, and its charge is decreased in proportion to their number.

The image is read out by sweeping an electron beam across the far side of the junctions. This recharges each one in turn. As it does, a current flows through and out the near side to form the video signal, which is recorded on magnetic tape.

Besides greater sensitivity this system has another advantage over photographic film: Its response to the light is linear. Each photon causes the transfer of the same amount of charge. The response of photographic emulsions is more complicated. McCord says their photometer has a similar advantage over other vidicon systems that use the photoelectric effect and count photoelectrons instead of current pulses. They depend on the quantum effects of photons. The silicon system is more linear.

The vidicon system also has the great advantage of providing the data in ready-made digital form. "You get the data out in an array of numbers," says McCord. These can be fed directly into computation. In fact McCord and Westphal suggest that the system will be a good laboratory instrument for digitizing the information on old photographic plates.

On the other hand, pictures can be made from the taped information. McCord and Westphal have made brightness contour maps of some of the areas they have tested the photometer on. Photographs could be made from the information too, says McCord, but "the photos would be useful pretty much only to look at."

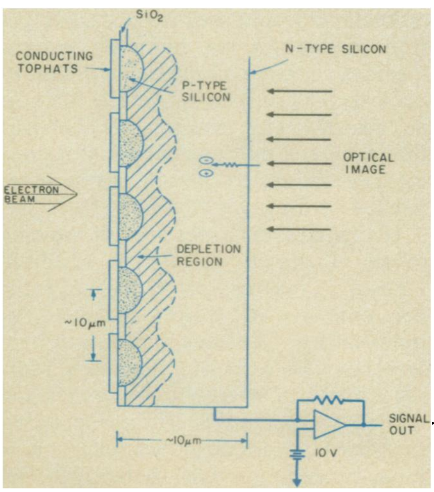
The vidicon system has a dynamic range greater than 1,000. That means it will record with relatively equal accuracy brightnesses from its lower limit to 1,000 times as bright. Its sensitivity, says McCord, "makes it possible to separate overlapping stars in dense clusters, providing for the first time, distinct measurements of the individual stars." In proof thereof they supply a contour map of the star cluster 47 Tucanae, in which stars down to 18th magnitude are contoured.

The new photometer also responds to a wider range of frequencies than photographic emulsions. It is especially useful in the near infrared where photographic possibilities are poorer than they are in visible light. This infrared sensitivity enabled McCord and Westphal to map the brightness of methane emissions in the atmosphere of Jupiter for the first time. It is also important in the investigation of the Maffei objects that they plan to start soon. The Maffei objects (SN 1/16/72, p. 42) appear on photographs as faint blobs lying in the plane of the Milky Way. They are believed to be small galaxies, satellites of our own. They lie in a direction where a great deal of visible light is obscured by cosmic dust, but infrared gets through.

The investigation of the Maffei objects will use the 84-inch telescope at Kitt Peak National Observatory near Tucson. It was supposed to start at the end of March, but McCord says, "We were bumped off the telescope."

Meanwhile Westphal is working on the application of the photometer to spectroscopy. The plan is to use it with the 100-inch Mt. Wilson telescope of the Hale Observatories to take spectra of cosmic objects, especially quasars and other faint sources.

McCord says there is already some commercial interest in the photometer, but as yet nothing like firm plans. If it continues to prove itself and be improved, it or its descendants may some day come to be standard observatory equipment like the special cameras and other photographic devices now manufactured for astronomers. □




*Vidicon detector: Better than film.*

Diagrams courtesy Applied Optics, © Optical Society of America