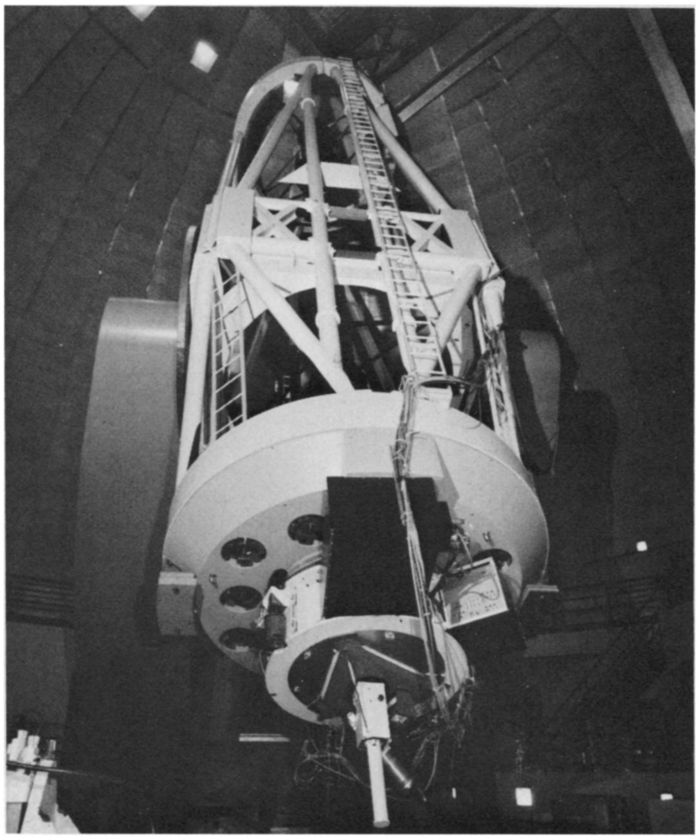
IMAGE TUBES



Astronomers now amplify the light from faint objects to obtain more of the information it brings

by Dietrick E. Thomsen

When a household radio picks up the signal from a station, it puts the signal through an amplifier. The signal as received is nowhere near strong enough to agitate the speakers and produce much sound. Nowadays when astronomers receive light from a faint object, they are more and more putting that through an amplifier. In both instances electronics makes the amplification possible. In the astronomical case the amplifier is an optoelectronic device called an image tube.

An image tube receives light from a telescope at one end. The incoming light ejects an electron from the photoelectric material of which the end of the tube is made. The electron then falls down the tube under the influence of a strong electric field. At the other end of the tube the electron strikes a phosphor in a phosphorescent screen, and makes the phosphor glow. Since the electric field has supplied energy to the electron during its fall, the phosphor glow is brighter than the original light that ejected the electron at the other end.

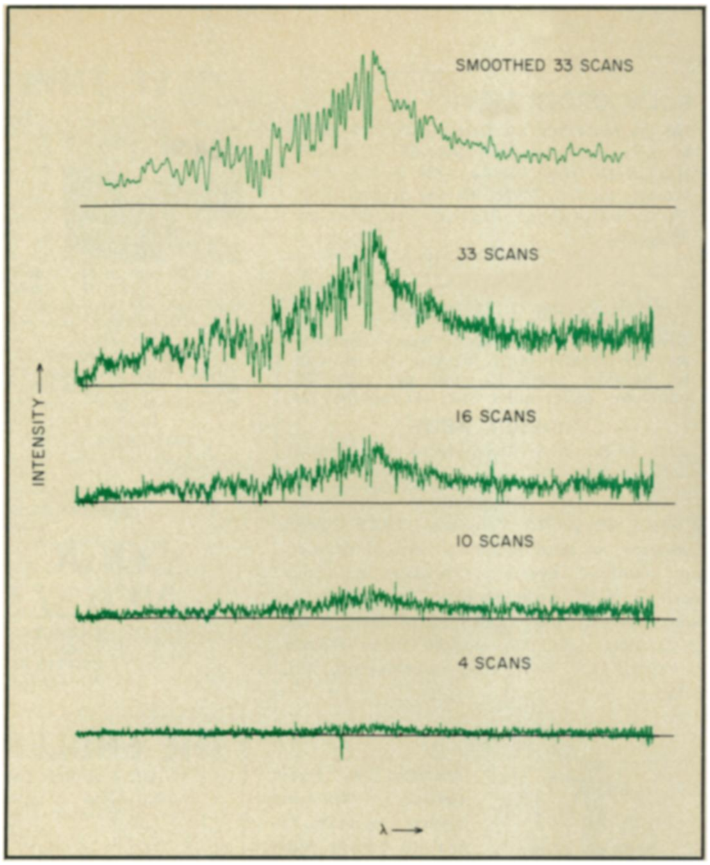
Basically, says Kent Ford of the Kitt Peak National Observatory, it is "easier to make a photoelectron with a good photocathode than it is to make a dark grain on a photographic plate." For a century photographic plates have been the universal method of recording astronomical data, but they just do not respond well to the fainter and fainter objects that are the center of astrophysicists' current interests. "We're achieving a gain of 10 to 20 times over photo plates alone," Ford observes. At the Lick Observatory in Mt. Hamilton, Calif., astronomers are using an arrangement that puts three image tubes in line, each one behind the first receiving the light output of the previous one. With this arrangement, says J. S. Miller, "the final light amplification is tremendous."

Making possible the study of very faint objects is not the only virtue of image amplifiers. They also make the study of brighter objects quicker. "We can use the gain to reduce exposure time and use less telescope time," says Ford. Miller points out that the Lick device can separate the spectrum of a star from noisy background in a few minutes rather than the half a night required by other methods. Doing a star every two minutes, he calculates, 20 or 30 can be covered in an hour, or 200 a night. After a few nights one could have surveys of 5,000 stars. With this kind of advantage the use of image intensifiers is not merely the coming but the current thing in optical astronomy. More than 40 percent of the observing time of Kitt Peak's 84-inch telescope is allotted to work with image intensifiers.

Right now, says Ford, an image tube is most useful where its limited size is not a handicap, in low-dispersion spectroscopy, for instance. A spectrogram of a single star is essentially a one-dimensional image, and this simplifies the application of the image tube. Tubes can be designed to give two-dimensional images for use perhaps by an astronomer who wanted an enhanced picture of a star field, but there are technical difficulties in the way. The four-meter telescope at Kitt Peak has a field with a diameter of 50 minutes of arc across the sky. This would be difficult to use with an image tube, says Ford.

But spectra of stars and other objects are one of the most important things astronomers want to know about them. The Lick device, for example, is set up particularly for spectroscopy by being fitted with an image dissector. This is a fourth tube after the three already mentioned. It takes the light from the last phosphors, converts it into photoelectrons and magnetically focuses these electrons so that all of those from one place go into one spectral band.

The image dissector is used in connection with an artificial memory. The phosphors at the end of the line already provide a kind of intermediate memory storage themselves since they glow for a few thousandths of a second when they are struck and thus hold the record of an event long enough to get



The image dissector (long white cylinder) mounted on the end of Lick Observatory's 120-inch telescope (left). The spectrum of quasar OQ 172 with the largest redshift yet measured shows how successive scans build up information (right).

Lick Observatory

a look at it. The sweeping of the image dissector is controlled by a computer that records whether it sees a phosphor glowing or not at each point on the image of the spectrum. The dissector sweeps over the spectrum again and again, building up in the memory of the computer the contrast between light and dark places on the spectrum. The sum of the sweeps can be displayed on an oscilloscope screen and dumped onto magnetic tape for future reference. This form of spectroscopy has another plus, says Miller, in being able to examine spectra beyond the limits of photographic plates, which become inefficient in the red. The blue end of the spectrum begins at about 3,000 angstroms; the atmosphere cuts off passage of shorter wavelengths than that. In the red it could go to 9,000 angstroms and may soon go to about 11,000, a wavelength where photographic plates do not work.

The next step in the development of the Lick device, says Miller, is to mount it at the Coudé focus of the telescope and try for higher dispersion (that is, greater separation of wavelengths in the spectral image). Then, he says, one could look for weak interstellar spectral lines produced by interstellar matter. One could also see what proportion of supposed new quasars really turn out to be stars.

The system would also be a boon to astronomers' comfort since it can be remotely controlled. Television can be set up to integrate the output of the computer and can be viewed from far away. "You can see fainter stars on TV," says Miller, "than you could see looking through the telescope." For astronomers it means "a warm room with easy chairs rather than a cold dome."

Miller is more hopeful about using image tubes for two-dimensional pictures than Ford. What would have to be done is to separate the action of the magnetic coils that sweep the image dissector so that they act as a two-dimensional raster as in a television tube. The picture would be somewhat fuzzy since only 4,000 picture elements are possible, arranged in a 63 by 63 array. Two thousand of these could be used to look at a star. The other 2,000 would have to be another channel to look at empty sky, since to measure the star's light the contribution of sky background has to be subtracted. A bigger computer would also be necessary. One could get a digital picture of an area about one minute of arc by one minute of arc. In contrast the field of the Kitt Peak four-meter telescope is 700 square minutes. Still one square minute is adequate to serve as a photometer measuring the brightness of individual stars, and some day the thing might be done. Some day there may be bigger image tubes, too. □