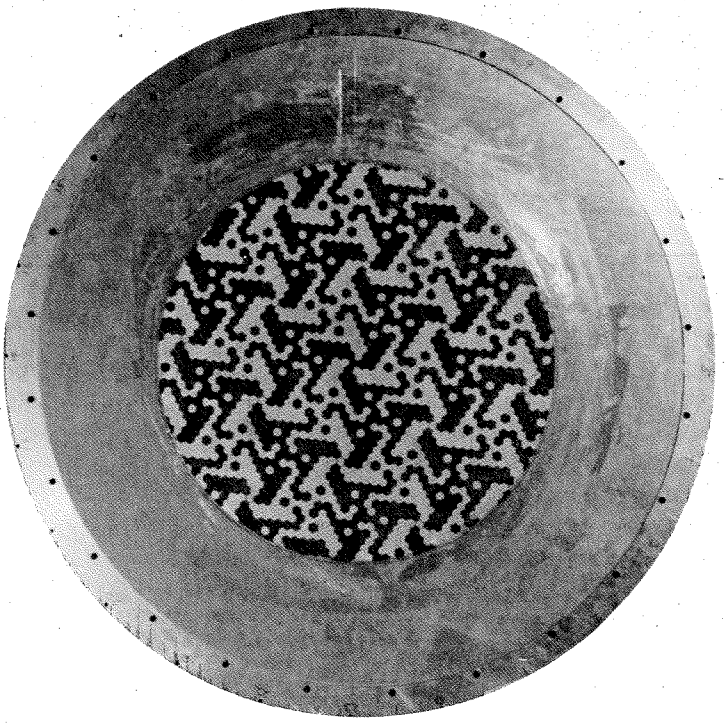
Hex Sign



THE REPEATED hexagonal design above would make a nice patchwork quilt. In fact, Tom Prince's wife, Charlene Reichert, *is* making a quilt out of it. But its primary function is as a mask for a coded aperture gamma ray camera. The hexagonal pattern forms the "code," which can be mathematically unfolded to derive an image of a source of gamma rays.

Prince, assistant professor of physics, designed the array for what he describes as a "very fancy pinhole camera." Normal telescope lenses and mirrors will not do for gamma ray astronomy, which operates in the very energetic region of the electromagnetic spectrum beyond x rays, between 30,000 and 10 million electron volts (photons of visible light have energies between 1.5 and 3.5 electron volts).

If scientists in this relatively new field can devise clever enough techniques to detect gamma rays, these high-energy photons will undoubtedly provide important information about a number of astrophysical phenomena such as supernovas, particle acceleration, neutron stars, dust grains, and processes at the galactic center, where electrons and positrons are annihilating each other and producing gamma rays. For example, gamma ray astronomers are interested in what gamma rays may reveal about nucleosynthesis — how heavier elements, whose newly formed nuclei would be radioactive and emit gamma rays, are generated from a supernova explosion.

Even a supernova explosion, however, does not dispatch gamma rays to the earth in sufficient numbers for them to be captured by a simple pinhole camera with a single hole. So Prince's "fancier" version has many holes. Because the numerous holes cast many overlapping images, they have to be arranged in a particular pattern, which allows the image to be unscrambled. Prince and co-workers have developed a whole family of geometric patterns for the mask, called "rotating hexagonal uniformly redundant arrays," based on mathematically complex arrangements of cells. These patterns are designed to cast maximally different shadow patterns from sources in different directions. In addition, while an image is being made, the entire mask is rotating to provide an additional time-dependent coding of the image besides the spatial coding of the mask pattern.

The shadow pattern from the mask is cast onto a detector — an Anger camera, which is widely used in medicine for detecting the presence of radioactive isotopes. When gamma rays pass through the holes in the mask, they strike the sodium iodide crystal of the Anger camera, producing light, which is then amplified by 19 photomultiplier tubes. A computer, which knows the code of the apertures, then unscrambles, analyzes, and produces the image.

Caltech's involvement in gamma ray astronomy has been fostered by Prince, together with cosmic ray scientists Rochus Vogt, provost of the Institute, and Edward Stone, chairman of the Division of Physics, Mathematics and Astronomy. The gamma ray astronomy group, which also includes grad students Mark Finger and Chris Starr, staff scientists Alan Cummings and Rick Cook, and technical manager Bill Althouse, has recently tested a somewhat smaller prototype of their instrument in the laboratory with low-energy (122 kev) gamma rays. In about a year they hope to launch a full-scale gamma ray telescope in a balloon to carry it to an altitude favorable for intercepting gamma rays. The telescope, weighing well over a ton, must be accurately pointed while suspended on a long tether from a spinning balloon. This requires a special pointing platform which uses computer-controlled motors to counteract the balloon rotation. In addition, the telescope must be shielded from the earth, because our own atmosphere is itself very bright in gamma rays caused by interacting cosmic rays.

The coded aperture camera has great promise for gamma ray astronomy because it promises particularly high angular resolution, more than ten times better than past instruments and better, in fact, than the instrument already scheduled to be launched in NASA's Gamma Ray Observatory satellite later in the decade. The Caltech group also hopes to have an opportunity to send its instrument into space eventually, since balloon flights provide only limited observation time. A telescope of this type carried on board the space shuttle or mounted on a future space platform would be a powerful instrument for detecting and locating weak cosmic gamma ray sources.□ — *JD*

Budget Politics

SQUABBLING over the federal budget is an annual rite in Congress and between Congress and the president. Conflicts over who gets what have been particularly noticeable lately because of strong partisan divisions in Washington. Rod Kiewiet, associate professor of political science, doesn't really care who gets what but is interested in discovering the factors that influence the federal budget appropriations process and in being able to predict for any given year how much a government agency will get to spend.

Earlier studies have already looked at this process, but they came up with what Kiewiet considers boring conclusions that really don't explain anything at all. Most of the studies have concluded that the final appropriation is merely a function of what the president asks for. They consider the federal budget a self-contained process that inches inexorably upward, immune to changes from outside factors. Kiewiet dismisses these notions as the result of inadequate statistical work and poor interpretation. Along with Matthew McCubbins, PhD '83, and now assistant professor of political science at the University of Texas at Austin, he set out to develop a statistical model of the appropriations process that would have some reasonable theoretic and predictive value.

For one thing, earlier studies didn't correct for inflation; McCubbins and Kiewiet's model deflates budgets into real dollars. Also, instead of looking at raw dollar amounts, they concerned themselves with the percentage change in an agency's budget compared to the previous year. Kiewiet sees this as the real budget battleground, since the percentage change in real terms is what determines whether an agency will be able to carry out new policies or will have to cut back. And the changes are what congressmen look at, line by line, when making their decisions.

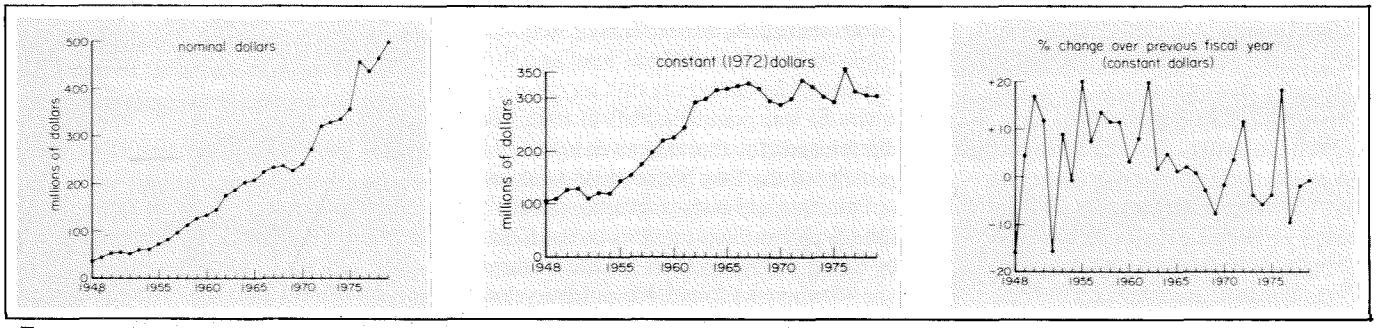
Kiewiet and McCubbins are analyzing time series data (from 1947 to 1979) on 37 government agencies — a diverse set ranging from the FBI and the Office of Education to the Geological Survey and the Soil Conservation Service. They are not dealing with defense agencies because the ups and downs of defense spending, as well as of social spending (the lion's share of which is entitlement programs) are the product of broader trends in budgetary fiscal policy.

Unlike earlier studies, the Caltech research, which was the first to examine factors external to the budgetary process in a multivariate model, shows that these factors do affect how much the government spends. For instance, the state of the economy (things like rates of inflation and unemployment) even influences different agencies in different ways. When the two political scientists divided the agencies into two groups — standard line agencies, such as the Bureau of the Mint and the National Bureau of Standards, and what they called constituency-oriented agencies, which deliver benefits to clearly identifiable groups of people — it turned out that unemployment, but not inflation, affected the two groups differently. Budgets of the constituency-oriented agencies, in particular the public works agencies — the Corps of Engineers, Bureau of Reclamation, and so on — grew at a much greater rate during periods of high unemployment. It appears, then, that Congress really does use public works to give people work.

Whether or not it's an election year also matters to agency budgets, according to the Caltech study. Congress is more generous in an election year — not much, but a little. The partisan makeup of Congress, on the other hand, matters a lot. Budgets are one area where party differences are undeniably important, according to Kiewiet. The more Democrats there are in Congress, the larger the agencies' growth rates. Democratic presidents submit bigger budgets too.

Kiewiet and McCubbins want their two-equation model, which uses the statistical technique of two-stage least squares, to predict simultaneously both what the president will ask for and what Congress will give him. And while some factors affect both, others influence only one side of the equation or the other. For example, preliminary testing indicates that the president's budget is affected by wartime. Korea and Vietnam, which occurred within the scope of the study, had similar effects of lowering presidential requests for agency funds. The effect of Vietnam can be seen most dramatically during the Johnson years, when all the factors should have favored government growth. Kiewiet's figures indicate that agencies would have grown at a 5-6 percent faster rate than they actually did, if the Vietnam war had not occurred.

Another variable they are currently testing is the internal structure of Congress, not the new budget procedures introduced in 1975, which are largely considered to be window dressing, but rather the growth in the number of subcommittees since World War II and the consequent diffusion of power. Kiewiet suspects that this institutional change could easily generate pressure to be more generous to everyone's pet agencies, with the end result that "it's a bigger log that gets rolled down the road."□ — *JD*



Federal budget appropriations over 30 years for the Soil Conservation Service look very different when viewed in nominal dollar amounts (left), corrected for inflation (center), and expressed as a percentage change in constant dollars over the previous fiscal year (right). The last graph gives the best picture of this agency's actual funding fate.