up are all but unchecked by the atmosphere. They strike the ground with nearly all their original speed. This ranges from about 20 kilometers per second to just over 70 k.p.s. The higher figure is the maximum which any member of the solar system can attain at the Earth's distance from the sun. The limit for a body which moves in from the galaxy with some speed to begin with is clearly much higher. A few small meteors have, in fact, been tracked by radar at over 150 k.p.s.

As the meteorite dives to the surface, there will be a formidable pressure wave. At Mach numbers 60 to 200 the sonic boom will be awesome. But it will not only be short-lived; it will be dwarfed by the blast arising from the surface impact. The relatively small Siberian shower of 1908 flattened the conifers of the Taiga to a range of 30 miles.

There are many other effects:

(a) Heat. In a large strike, the instant flare of the impact is reckoned to convert more than a quarter of the total energy into prompt heat. You should notice that in the end almost *all* the energy will degrade into heat. There is an exception, see (e) below; and for some effects, the degradation will take a considerable time.

A feature of large strikes such as Vredevoort is that the fireball must be enormous. Think of it as that from a 250,000 megaton fusion bomb. It will probably not reach the diameter of 200 miles given by a cube-root-of-power comparison with an "ordinary" Hydrogen bomb. But its measurements will *certainly* exceed the total depth of the atmosphere and stratosphere together. As a result of this, the fireball will squat upon the target area, doming up into the ionosphere, but unable to rise. It will radiate terrific energy into space. Even when the fireball has at last cooled out, the target will glow for weeks and months—again radiating a good deal of energy into space.

(b) Severe earthquakes will damage the crust.

(c) Material will be ejected beyond the crater's periphery. This will range from large crustal blocks down to microscopic powder; some of this material will travel a long way.

(d) Volatilized matter and even plasma will be thrown out to space at escape speed. Here, see Ralph Hall's fact article, "Secondary Meteorites," January and February issues, 1964.

(e) There will be some exchange of impetus between the meteorite and the spinning Earth. Substantially, this would

be confined to alteration of the Earth's axial tilt and rotation period. Even an impact by Juno would affect the orbital speed by only a few centimeters per second. The reference here is to Rene Gallant's book, "Bombarded Earth," published in London by Baker.

Not merely are staggering energies released. The explosion has high "brisance," is shatteringly intense. Tremendous temperatures combine with tremendous pressures. Ralph Hall explained that nuclear reactions will occur at the heart of the flare. These, I think, may just as well *absorb* energy as release it, but either way, there will certainly be a flood of X rays and neutrons. I suspect that these might leave faint but discernible traces in the surrounding rocks.

So far, my discussion has followed precedent. I have considered a *continental* strike—one which hits a land target area. What has so far been overlooked is that three-quarters of the Earth's surface is *ocean.*

The odds are, therefore, three to one in favor of an ocean strike. For the 40+ known land craters, there must have been 120+ strikes at sea. It is *certain* that some of these marine falls equaled or exceeded the power of the Vredevoort impact. But the count does not end here.

For a start, the large majority of explored craters are in North America, just three per cent of the World's surface. There are several reasons for this: one is the comparative failure of attention to the subject elsewhere. Another is the Canadian Shield—the widest area anywhere of bare, primeval rock, where the craters of gigayears are easy to find. In any case, we must obviously multiply the number of known falls not by a factor of three, but by thirty. Hold the total down to a probable 1,000 falls in all—750 of them were at sea. There have been a sizable number of Vredevoorts in the ocean.

Your first thought will be that an ocean strike is just a damped-off edition of a fall on land. Not on your life! It's distinctly different, *and* distinctly more lethal!

Unfortunately, craters in water have a way of filling up and leaving no evidence on the surface, whatever happens to the ocean bed. We'll just have to manufacture a model by mental experiment; see where a few calculations from known facts will take us. Gauss was too lazy to reach out his arm for his