tek talk

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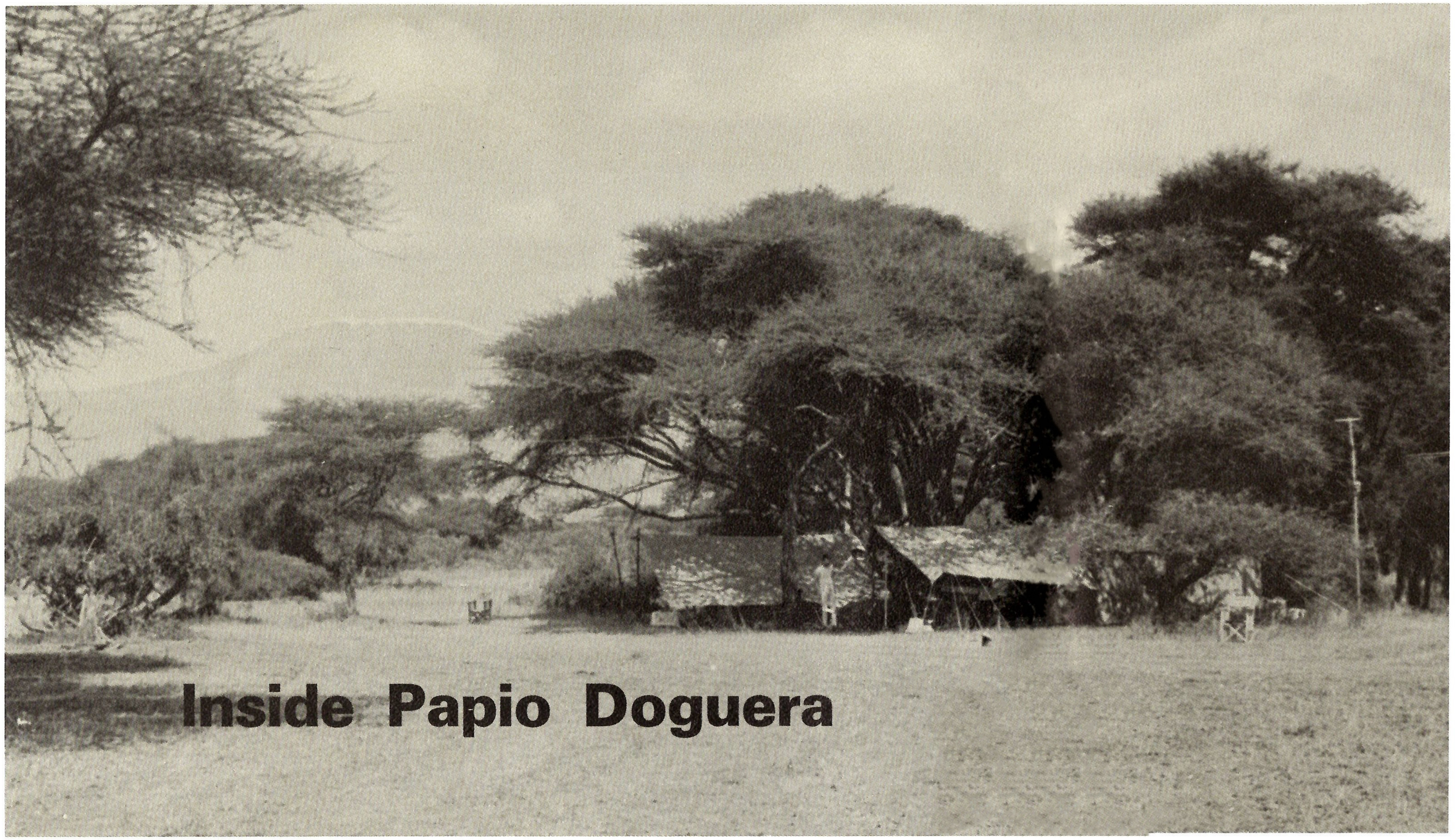
COVER—Generations of progress separate the civilization of the Masai warrior in the African bush country, from the sophistication of the Tektronix model 422 oscilloscope that has attracted his curiosity. The scope, with a half-ton of other scientific equipment, was used in an expedition to Kenya, made to collect physiological and behavioral information on baboons in their natural habitat. Several Masai were visitors at the camp, obviously curious about what was going on in the 20th century. (Story is on page 10)

Inside Papio Doguera



In the dusty bush country of Kenya; at the toe of Kilimanjaro, Africa's mightiest peak; near the camp where Ernest Hemingway once sat and wrote, color-coded baboons with electronic backpacks romped, scratched, slept and otherwise went about their appointed rounds. Little did they know their privacy was being invaded.

Meanwhile, back at the camp, five US scientists with a half-ton of lab equipment monitored the primates' activities. It was the closest tabs man has yet been able to keep on a wild animal in its native home. As a result, he now knows quite a bit more about the baboon.

And, there in the camp, you'd have found a Tektronix type 422.

Clearly the grandest oscilloscope in the jungle, the 422 played a key role in the baboon safari, according to Nolan Watson, electronics technician with the University of Washington Regional Primate Research Center, Seattle.

"Much of our equipment was field-tested for the first time on this trip," he says. "Thus, some redesign was necessary; the 422 made it possible. I can safely say we would have been in a real bind without it, even though we had a 321 . . ."

The goal of the mission—jointly financed by the Washington State Heart Association and the National Institutes of Health—was to implant the cardiovascular systems of healthy adult **Papio doguera** baboons with miniature transducers and telemetry systems, send the animals back to their troops, study their behavior and, remotely, record signals from their heart and cardiovascular systems as the animals lived their normal lives.

Similar tests had been made on baboons at the Center, but it was felt that captivity is an artificial environment, and that a baboon ranging in the wilds of Kenya would yield results different from those of a baboon dutifully trudging on a treadmill in Seattle.

Actually, orang-utans and chimpanzees, because they're higher on the evolutionary scale, would make even better subjects for experiments, but they're hard to come by in the US, whereas baboons are a glut on the market. So, baboons it was—in the US, and thus in Africa.

Also, since a baboon has little economic worth (its main value, presumably, is to other baboons), the Kenyan government gave willing cooperation to the safari.

The expedition lasted two months, including six weeks in the bush. Of the five scientists, representing the Primate Center, and Scripps Clinic and Research Foundation, none had been to Africa before.

The exploit was made possible by miniaturization of electronic gear and refinement of telemetry techniques—and by the comforting presence of a professional hunter: Elephants were in camp about 60 per cent of the time; rhinos somewhat less frequently; leopards prowled the premises at night, while lions roared in the dark. As a precaution, each scientist learned how to climb thorn trees—not the most comfortable refuge, but the handiest.

A main function of any field study is to **observe.** This function gained a new dimension through the sophistication of electronics. The expedition used a variety of ingenious devices, including:

1. An implantable blood-pressure gauge, developed by Dr. Robert L. Van Citters of the Primate Center, working with Micro Systems, Inc. A solid-state strain-gauge bridge was bonded to a stainless-steel diaphragm welded to a stainless-steel carrier, and sealed against one atmosphere. It gave an absolute pressure measurement.
2. A flow telemetry system, designed by biomedical engineer Dean L. Franklin of Scripps. The system couples a continuous 5-mc ultrasonic wave into the blood vessel. The formed particles absorb and reradiate part of the energy; the shift in frequency indicates the particles' velocity. This "back-scattered" sound compared with the transmitted sound results in a measure of the flow velocity.
3. A system to combine pressure information from the gauge with flow information, so the two can be transmitted together. This, the first blood-flow and blood-pressure telemetry system, was developed by Bill Kemper, an electrical engineer from Scripps.
4. A remote-control feature, for data systems and power, which allowed the system to be used with wild animals. It also provided for remote stimulation of the central nervous system (to attempt to change the animals' behavior) and for anesthesia injection so they could recapture the baboons after the tests. Watson designed this system.

While these projects were going on, Dr. Orville A. Smith, physiologist, psychologist and assistant director of the Center, was working to learn how the brain controls and modifies heart output, particularly under the stimulus of fear or anxiety. He wanted particularly to locate the mechanisms, and the brain areas, that controlled the change in heart output in response to "warning" stimuli.

The 422 was used to adjust the animals' backpack systems, and to monitor the telemetry information as it went on tape.

The base area—a day's drive from Nairobi, Kenya's capital—was picked partly because several baboon troops lived there, and partly because it was mostly open plain, allowing easy tracking and observation.

The climate in Kenya posed no problems ("more pleasant than Seattle" is Watson's comment—probably a compliment.) But the unrelenting wind blew fine sand into every cranny. And ants got into the electronic equipment and ate the insulation (not on the 422, however; it proved to be ant-tight.)

Recording equipment was carried on a five-ton truck with receiving antennae, telemetry receivers, a four-channel magnetic tape recorder, a direct-writing recorder, a motion-picture camera, 12-volt storage batteries for power, and miscellaneous communications equipment.

First step was to capture some baboons, using box traps baited with maize. The traps, placed near waterholes or beneath trees where the primates slept, were surrounded with dried corn and sugar cane—tempting fodder, judging by the number of baboons who let themselves be trapped over and over again.

In all, thirty-two animals were caught. Three of the females and the 16 males were implanted with gauges and transducers. All the 27 major surgeries were performed under the open sky by Dr. Van Citters and Watson, with the local Masai natives kibitzing. Somewhat incongruously in this jungle setting, aseptic procedures were used, such as pre-operative scrubbing, and use of masks, surgical gowns, gloves and pre-sterilized disposable surgical equipment.

Fifty transducers were installed to indicate blood flow and heart pressure, and electrodes were implanted in the brains of four animals, for remote stimulation to temporarily change their behavior—a procedure tested in captive animals but very new in the field. (A typical controlled change would be from docility to anger.)

The number of sensors and gauges differed from animal to animal, to study various combinations of parameters. After about five days, when the baboons had convalesced, they were fitted with fiberglas backpacks spray-

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painted with brilliant fluorescent colors, to make it easier to track and observe them.

Trapped animals not used in the tests were painted bright colors and released back into the troop, to use as controls; that is, the scientists had to make sure that the mere fact of being captured wouldn't somehow change the animal's behavior. Observations of control baboons showed that their behavior had **not** been affected.

The lightweight (under two pounds) backpacks contained the electronic gear, including combinations of flow and pressure telemetry systems and a control system for anesthesia capsules. The packs, held on bandolier-style by plastic and steel cable, didn't bother the wearers. None tried to remove theirs.

The baboons were released to their troops, and the scientists' vigil began.

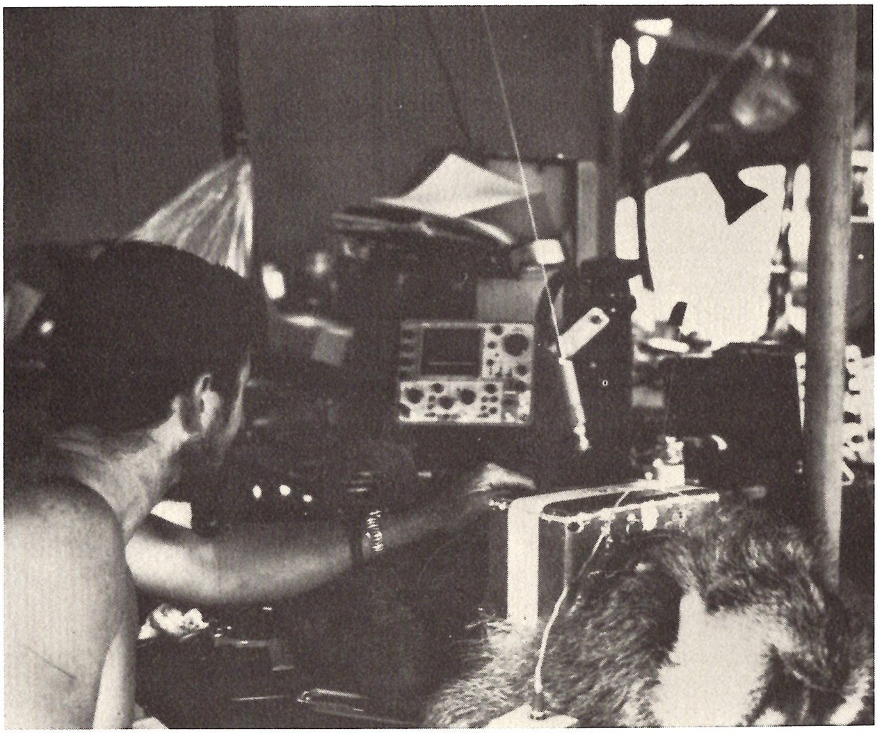
Because the need was to get simultaneous physiological and behavioral information, only one animal was generally studied at a time. Two scientists spent about five hours of the day tracking and watching an animal, and making notations on his posture, activities and relationships with other animals. This information, in three-digit letter code, was recorded onto the same tape that was electronically recording bloodflow and pressure signals.

The code was simple but comprehensive. "PR", for instance, meant "walking upright," and was defined in degrees of intensity, from 1 to 10. Thus, PR-10 would be a full run. And even finer breakdowns were made; PR-10 while running from a leopard differed (understandably) from PR-10 while chasing a girl baboon.

Recording usually began at daybreak, when the animals could be easily located sleeping in the trees. (When aloft, they transmitted as far as two miles; on the ground, often less than 500 yards.)

"We learned," says Watson, "that you can't measure physiology without seeing what the situation is; telemetry systems get us closer to the **whole** animal."

TECHNICIAN NOLAN Watson uses a Tektronix 422 to make last-minute adjustments to the backpack of a Papio doguera baboon, before releasing the animal back to its troops.



For instance, heart rate is far slower in baboons playing on their home field than in baboons in cages. And, whereas a baboon in captivity is likely to gnaw the hand that feeds him, in the bush country "you can damn near walk up and pat him on the head," according to Watson.

Baboons, as it turns out, have a very routine routine. The day begins when they come down from the trees. Then is the time for a whole gamut of activities that, if they were humans, you might classify as human relations: Social, mating, grooming, flea-removal activities and so on. Then they're off to forage in the denser bush or to mush about the local bogs—followed when possible by scientists. For four or five hours at midday, they snooze. Then, just before bedtime, comes another social hour. This goes on, pretty predictably, day in, day out.

In most cases, the troops accepted the "bugged" baboons without incident. But in the rigid structure of simian society, some of the returning males seemed to have been "demoted" from leader to subordinate status in the troop.

Data was taken for a maximum of 15 days per baboon. All in all, about 250 hours of cardiovascular activity were recorded, on 57 rolls of magnetic tape. Some records contained flow information, some simultaneous flow and pressure. Most of them had accompanying notes on the animal's behavior.

"It is expected," says Watson, "that some of the classical concepts of flow distribution under stress may well be challenged by the findings of the baboon safari."

In any case, the expedition was a "first" for science—and for the portable oscilloscope that helped make it possible. And, vicariously, for the people of Tektronix who designed and produced it.

Plans are already being talked of for a follow-up project, this one using giraffes—to find out, among other things, why they don't faint every time they stoop to get a drink of water.