THE KLYSTRON BOYS

Radio's Miracle Makers

By
Frank J. Taylor

PHOTOS BY DAN C. BAKER

WHEN the eager, earnest Varian brothers turned up at the Stanford school of physics one morning about four years back, they were bursting with a great idea. Down at Halcyon, California, they'd been tinkering on a scheme for generating an invisible beam down which planes might glide through soupy weather to safe landings, and up which antiaircraft gunners might sight through fog or clouds or night to pepper unseen enemy bombers harassing defenseless cities.

Though it seemed fantastic that these two country inventors might achieve what had stumped the best radio brains of the world, kindly Dean Webster said sure, go ahead and use the physics lab and shop. That was all the Varians asked, a place to work the bugs out of the idea.

By last December, when the Varian brothers, Sigurd and Russell, packed up their kit of ideas and hopped the continent to Garden City, Long Island, where the Sperry Gyroscope Company had built the last word in research laboratories for their further experiments, they were being feted as famous scientists. They had worked the bugs out of their idea, and they had delivered the klystron, a revolutionary little ultra-high-frequency resonator, inexpensive to build and light to transport, that hurled an astonishing new radio beam which promised to answer the prayers of communications engineers.

The klystron beam is even more amazing than the inventors' dreams. A Jack-of-all-trades in the communications realm, it handles jobs that never occurred to them originally. Telephone engineers think that with it they can shoot 600,000 conversations simultaneously through a six-inch cross-country pipe line and unscramble the talk at the other end as easily as you tune in your favorite radio program. Television engineers can do the same with pictures. Shot downward from an airliner, the klystron beam tells the pilot how far above the ground he is flying. Shot ahead, it warns him of hidden mountains in time to change his flight course. At many airports, U. S. Army and Civil Aeronautics Authority planes have made more than one thousand perfect blind landings, in every kind of bad weather, using the klystron beam.

"You've seen history made!" exclaimed Col. Hugh Mitchell, of the U. S. Signal Corps aircraft radio laboratory, when the first plane rode down the beam at Boston Airport. After exhaustive tests, the M. I. T. Technological Review acclaimed the klystron as "the most important advance in radio since the invention of the audion tube in 1906 by Lee De Forest." The antiaircraft use of the klystron beam is a military secret; that in itself reveals the importance which the Army and Navy attach to this new defense weapon.

There is hot Celtic blood in the tall, dark, bushy-browed Varian brothers, Sigurd Fergus and Russell Harrison. There is an inventive strain, too, in the Varians. It didn't crop out much in their father, John Osborne Varian, a masseur, born in Dublin, who migrated to California and married Agnes Dixon, who was half Celt, half British. Uncle John Osborne, who migrated from Ireland to Australia to Washington, D. C., worked out some of the basic ideas of photolithographic printing and blueprinting.

Wanted—a Surer Guide Than Luck

THE Irish in the Varians kept their chins up while they discarded theories month after month, with the specter of hunger staring them in the face, until they hit on the right idea. Russ Varian says Sig's ideas turned the trick. Sigurd thinks it was Russell's probing mind that made the ideas click. Both of them give a lot of credit to their pal, big Bill Hansen, associate professor of physics at Stanford, who first made electrons dance the rhumba inside a copper apple, which is the nubbin of the klystron. It's a bit hard to pin the ribbons just where they belong, as between The Klystron Boys.

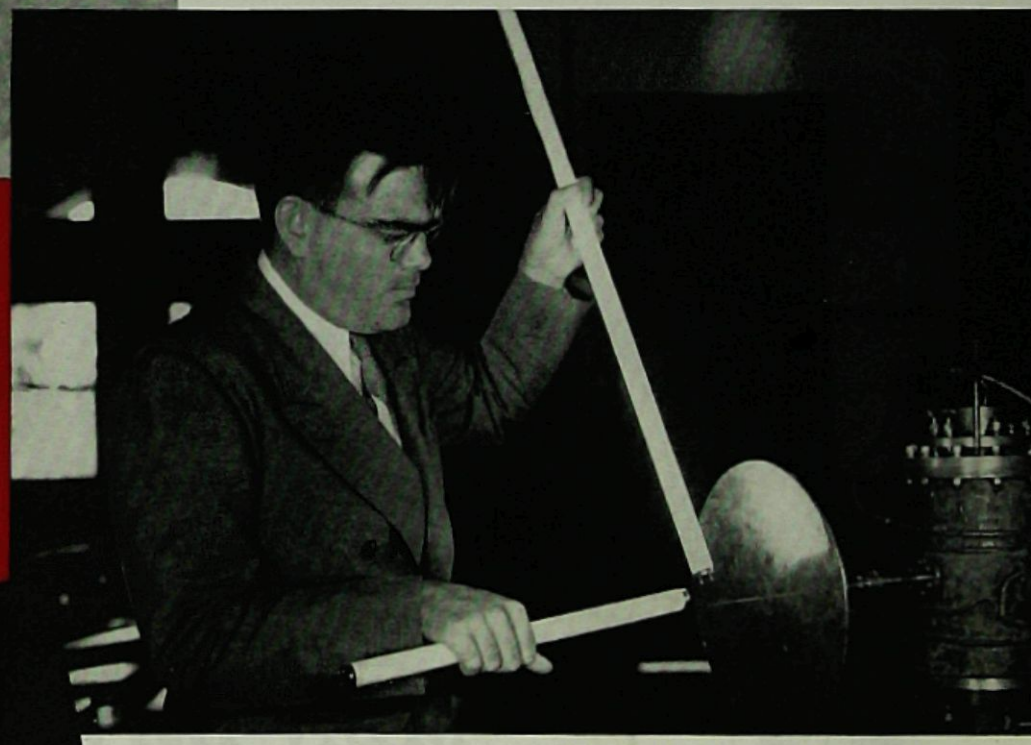
Sigurd Varian was flight captain for Pan American Airways on Mexican and Central American routes when the big idea began to take shape some five years ago. During his years of flying through tropical storms, his plane hidden by clouds from the cities and villages below, Sig Varian often brooded over the next war, conjuring mental pictures of bombers hiding above the weather, with antiaircraft defense next to useless. There were peacetime problems too. More than once, counting the minutes from the last fleeting glimpse of 18,000-foot Popocatepetl, guardian peak of Mexico City, Sig flew by compass through lashing rains to race a norther into Tampico, clipping the roof of the jungle with ceiling zero-zero to catch the Pánuco River flashing underneath and slide into Tampico airport. Once, when such a storm caught Captain Varian on the West Coast, he pancaked down to a forced landing on the beach. His plane nosed over, but nobody was seriously injured.

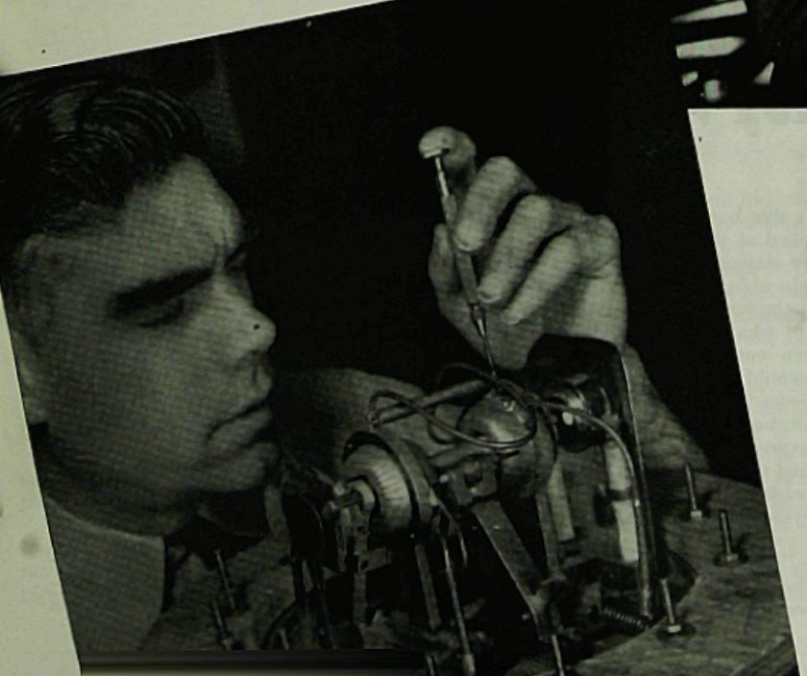
"Luck," Varian told his copilot. "Someday we won't be so lucky. What we need is a reliable beam to bring planes down through weather like this."

When the Italians and Germans launched their wholesale bombings of civilians in Spain, Varian's nightmare came true. One day he poured his wrath into a letter to Russell. The Varians were always writing long letters to each other, swapping ideas. Sig was the slender, nervous, dynamic Varian—a sort of terrier. Russell, the younger, was huge, slow and patient—the bloodhound. Give him a scent and he never lost it. Sig wound up his letter with, "Something's got to be done to find a short-wave radio beam that will detect bombers in the clouds, and that will guide planes into airports in soupy weather."

At that time, Russell Varian was back on the Stanford campus, where he had worked his way through the school of physics, gardening for professors, doing odd jobs in the laboratories. With his master's degree won, Russ had landed a job with Humble Oil Company, in Texas, doing geophysical surveys, then joined Farnsworth Television Corporation, to pioneer in television. In his late thirties, he returned to the Stanford physics laboratory to chase down some ideas.

Sig Varian had skipped college. Finishing a polytechnic school in San Luis Obispo, he headed south,





Above—Russell Varian and Professor William W. Hansen with the Klystron, which plays the tune for electrons traveling 25,000 miles per second. Right—Professor Hansen with neon tubes lighted by radiation from the Klystron's four-inch antenna. Below—Sig Varian, who built the Klystron. Shown are the "buncher" and the "catcher" rhumbatrons, which created radio's newest miracle.

learned to fly, bought a wartime jenny, barnstormed the country, flew the mail, became a Pan American pilot, married the daughter of the British consul in Vera Cruz, had two children. That made it tough going for an understanding the brothers reached when they were just out of high school. Sig was to make some money, Russell was to get the scientific background, after which they'd set up an invention factory and polish out some of the ideas the world was waiting for.

Sig's letter about the bombers set Russ Varian on the scent of an idea. His one-time roommate at Stanford was a lad from Fresno, six-foot William Webster Hansen, associate professor of physics. Big Bill Hansen was a rare combination, a theorist who could work with his hands. Hansen wanted higher voltages than were available in the laboratory to smash atoms for some of his advanced-physics experiments. Russell Varian once suggested a cheap way to get them, a resonator into which he could bombard electrons and multiply their velocity manifold.

Professor Hansen took the idea down to the physics-department shop and came out, after considerable experimenting, with a gadget that looked like a copper apple. Somewhat larger than a Jonathan, it had both ends indented like an apple. The bud end was sealed, but in the stem end there was a grid through which Bill Hansen fired electrons from a cathode, with 5000 volts behind them. The electrons bounced back and forth at a terrific clip, doubling their voltage every time they bounced until Hansen had frequencies approximating those of lightning. The electrons danced back and forth with a surging movement that tickled the fancy of Leonard Pockman, a research student, now at Cornell.

"They're doing the rhumba, Bill," he said. "You ought to call that thing a rhumbatron."

Swapping Eight Years' Work for an Idea

BUT scholarly Doctor Webster, uninterested in the Cuban rhumba then sweeping the dance floors of the country, insisted on a classic Greek name for the invention, and consulted Prof. Ernest Whitney Martin, of the classics department.

"You've got a good Greek name already," laughed the professor. "Rhumba is a good old Greek word for rhythmic motion."

To Russell Varian, this rhumbatron was more than a generator of high voltages for laboratory atom smashing. It looked like the clue to the strong, stable, short-wave radio beam that Sigurd wanted to make plane landings safe and to spot the ruthless unseen bombers of the dictators. He wrote Sig Varian that Hansen's rhumbatron might be the starting point for the hunt for the infallible beam that aviators wanted.

In Mexico City, Capt. Sigurd Varian took stock of his assets—four thousand dollars saved up the hard way, perhaps enough to support his family for a year. Then he asked his superior officer for a leave of absence.

"Why do you want to quit now?"

"My brother and I have an idea for a blind-landing beam. I'm going back home to work on it."

"Sig, you're nuts. You're slated for a Pacific clipper command in a few weeks."

"I can't help it. We've got to have a dependable beam."

"Better think it over. You'll be tossing away eight years of hard work to fool with a crazy idea."

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than crooked—who will deliberately lie about a catch. One, for example, weighed in a common shark, disposed of the carcass, and said he had caught a mako. On examination by a judge, he proved unable even to describe a mako, which is different in color, shape, teeth and eyes, from all other sharks. I've never seen tried the old gag of stuffing lead sinkers in a fish's throat, but I once found a man who attempted to increase the weight of his catch by pushing into its maw another, smaller fish. Now, anything a fish has eaten naturally is reckoned in its weight. But this man, unfortunately for him, had force-fed his quarry a fish that simply did not live in the same waters. And the tail stuck out! An embarrassing error which produced a red-faced confession. And, two or three times, a man who laid claim to a big fish was seen during the fight to change places with somebody else in order to rest. The witness of that heresy—another angler on a distant boat, or a skipper idly peering through binoculars—reported the fact to me and the fish was not entered.

It can be seen that cheating of any kind may result in humiliation. It should be repeated, however, that the fishing fraternity—and sorority—is probably the most dutifully honest bunch of people in the world.

Imitations of the Miami tournaments—there is one in the winter and one in the summer—have sprung up all over the country. Miami has gladly supplied full particulars to any community desirous of inaugurating such an event. Inquiries come from as far away as Australia, where the fishing is fine and a good catch gets a three-column picture on the front pages with a banner headline. The press and radio in Miami have learned, year by year, that angling is Florida's biggest sport and they have given it increasing attention. Men have come all the way from England to compete in our tournament. Some of those men, now, to my knowledge, are out on their fishing cruisers sweeping mines from the Channel. Others—several of them—commuted in sports fishermen for ten days between Ramsgate and Dunkirk.

This year, on the twelfth of January, the glamorously decorated fishing fleet paraded along the Causeway and out to sea, opening the 1941 tournament. There was, as always, a special prize for the first eligible fish brought to a weighing station on that starting day. Perhaps some millionaire, with a cruiser that cost forty thousand dollars, hung a sailfish the minute he dropped a bait overboard and raced back to collect that prize. Perhaps, as in 1940, that prize was taken by a young man in a rowboat with an outboard motor, who started to fish when the gun was fired and actually cut through the marine flotilla to win before the more ostentatious anglers had wet a single line!

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Two months later, with high hopes, the Varians opened their invention factory in the sleepy microscopic village of Halcyon. They settled on Halcyon because it was their old home town, and they figured Sigurd's four thousand dollars would last longer there than anywhere else. Russell was the idea man. Sig, who could make anything with his hands, was the mechanic. Their first discovery was that, though they worked hard, they were getting nowhere fast.

"We've got to have a physics lab," said Russell.

"We need a precision machine shop just as much," insisted Sig.

"We'd better go up to Stanford and see if we can make arrangements to use the university's," suggested Russell.

With their belongings, and Sig's family, the Varians headed for Palo Alto. When they laid their idea before Dr. David L. Webster, head of the Stanford physics department, he said: "We can stretch a point and make you research associates without pay; that will give you the use of the laboratory and the shop. We can furnish you with materials. But we haven't any money."

Sigurd Varian found a tiny cottage across the creek from the campus. Russ located a cheap room in Mayfield. The pair came to work early, quit late at night, working against time and Sig's slim bank account. Big Bill Hansen joined them before and after classes. Likewise, Doctor Webster, with his flair for higher-mathematic computations, took a lot of the guesswork out of electronics. Sig sat around drumming with his fingers, restless and impatient, rearing to reduce ideas to metal and glass and plastics. Slow and deliberate Russ was forever citing some advice about inventing that his father picked up from Uncle John Osborne.

"There are only two ways to invent," quoth Uncle John. "One is to make a model of every idea you have and try it. That's the slow way. The other is to discard all your ideas on paper but the last one. That's the fast way."

While Sigurd fretted, Russell Varian washed out twenty-six different ideas for landing beams that looked rosy when they started. He washed them out on paper with the help of Professor Hansen and Doctor Webster. As fast as the group doused cold water on one idea, imperturbable Russell Varian came up with a new one.

There was one tremendous drawback to using Bill Hansen's copper apple. The stream of electrons it built up into such terrific voltages was direct current. For their beam, the inventors needed oscillating energy. They could think of no mechanism fast enough to break up energy traveling at such terrific speed, 25,000 miles per second. It looked as though they were stumped. Then, as Russ Varian sat at his desk late one night, his twenty-seventh idea began to take shape.

"It was a kind of fancy idea, and I was skeptical at first because all ideas have bugs," recalls Russ. "Still, it looked like a darn good lead. So I told Sig and Bill the next morning and they thought it might work. It sounded better yet when we outlined it to Doctor Webster."

Offhand, the notion sounds as fantastic as a Rube Goldberg cartoon. First you join two of Bill Hansen's rhumbatrons with a short copper pipe. Then you shoot power into the first rhumbatron, known as "the buncher." The grids at both ends of this copper apple slow down some of the electrons, while the others speed ahead at their regular gait of 25,000 miles a second. Speeding through the copper pipe, the fast electrons begin overtaking the slower electrons ahead of them, very much as the cars in a fast traffic lane

overhaul those in the slower lane. This causes the electrons to spew into the second rhumbatron, "the catcher," in bunches. Between the bunches are spaces, maybe 1/25,000th of a second in length, with few electrons in them. The alternate bunches and spaces make pulsations and, presto, there's your oscillating energy in frequencies running up into the billions.

At least that's the way the notion shaped up in Russell Varian's mind. It still looked that way when Doctor Webster had covered the blackboard with equations, and Bill Hansen had reduced the theory to sketches. Sig Varian fidgeted around while they figured and drew pictures. The twenty-seventh idea was one they couldn't tear to pieces and, at last, as Russell Varian puts it, "after four months of tossing out bum ideas, we hit on the klystron." Klystron, incidentally, is from the Greek word for the breaking of waves on a beach. "That is what the electrons do in the klystron," explains Doctor Webster.

Neglecting even to eat, Sig Varian worked night after night until the others drove him home. The parts he needed were parts nobody could buy anywhere. He made them all from copper, brass and plastics. Exactly six months after the brothers hit the campus, Sig Varian invited the three others to come down and inspect the first finished klystron, a neat little machine weighing about five pounds.

"I wonder if she'll really oscillate?" Russell asked.

"Boy, she'd better oscillate!" exclaimed Sig. "We're down to our last fifty bucks."

The test of whether the klystron worked was a tiny beam focused on a plate of willemite, which is a fluorescent material that glows when radioactive energy strikes it. If the beam registered a lively little line on the willemite, it meant the current was oscillating. If it made a dot, it spelled failure.

While Sig Varian pumped the air out of the rhumbatrons, then turned on the power to warm up the machine, the others returned to the laboratory to finish their tasks, anticipating a night of tinkering and adjusting to synchronize the activities of the two rhumbatrons. They had barely climbed the stairs when Sig came tearing after them.

"Hey, Russ, Bill, Doctor Webster. She oscillates! She oscillates!" he yelled.

They rushed pell-mell to the basement. There, on the first throw of the switch, the first klystron hummed and surged, and on the plate of willemite a lively little line less than an inch long danced like a neon sign.

Looking for a Sponsor

On the bench was a flashlight. Bill Hansen unscrewed the bulb and held it near the four-inch antenna at the outlet of the klystron. The bulb glowed like a tiny bright star from the energy released. Next he held an electric-light globe near the antenna. It glowed, too, as did a cluster of globes upon which they focused the beam fifty feet from the machine.

The next day Sig Varian spruced up and caught a train for the city to call upon the Civil Aeronautics Authority officials, Army and air-line pilots, and anyone who would listen at Oakland Airport, where both the Government and commercial air lines were experimenting with a blind-landing system. Sig asked the airport authorities to send a competent radio engineer down to Stanford to see the klystron work.

"Send somebody who understands high frequencies," he warned. "We don't want any ordinary knob turner."

"I guess we don't have anybody around here like that," he was told.

Tired and discouraged, Sig Varian returned to the Stanford campus with only forty-seven dollars in the kitty. The next morning, while the inventors were debating what to do with their new beam maker, now that they had it, the phone rang in the physics lab. Long-distance calling from Oakland Airport, Irving R. Metcalf, of the Civil Aeronautics Authority, in Washington, D. C., calling the inventor of the new radio beam.

A Research Fund

Mr. Metcalf himself was the originator of the Metcalf blind-landing system, which reduced the technique of bringing a plane down through fog or rain to an airport, so far as the pilot was concerned, to keeping three luminous dots on a plate in the plane's cockpit in a straight row. All the system needed was an infallible radio beam to deliver the dots on the plate. As he traveled about the country, Mr. Metcalf never failed to run down leads on any new beam that might do the work. Dropping unexpectedly into Oakland Airport, with John Easton, another key CAA official, he had overheard pilots discussing Sig Varian's visit of the previous day, and lost no time getting to the phone to ask the inventors if he and Easton could see their new beam maker in action.

"By the way," he told Sig Varian, when the latter had urgently invited them to the Stanford campus, "there's a fellow from Sperry here with me. Can I bring him down with me?"

The inventors were a little dubious about showing their invention to manufacturers until they had applied for patents.

"Oh, he's all right," Metcalf assured them. "Better let me bring him down."

The "fellow from Sperry" was Dr. H. Hugh Willis, chief research engineer for the Sperry Gyroscope Company. Doctor Willis' eyes lighted as he watched the glowing line on the willemite plate when the Varians tuned up their klystron.

"You've got an oscillator that really works," he told them. "You'll hear from us shortly."

When they heard, it was in the form of a $25,000 check from the Sperry Gyroscope Company to Stanford University, an outright gift to finance klystron research. The gift enabled the university to add the Varian brothers to the faculty pay roll, with payday every month, and to employ competent research assistants to make more klystrons and find out what they would do under working conditions.

At this point, things began to happen thick and fast. Sig Varian, his physical stamina diminished by long hours in the shop, collapsed one day, to spend the next six months in a nip-and-tuck battle with tuberculosis. Sperry Gyroscope Company contracted to produce the klystrons for commercial and military uses, paying royalties to be shared jointly by the Varians and Stanford University. At San Carlos, a few miles from the campus, the company established a staff in a laboratory to double-check the Stanford experiments and to turn out the first klystrons.

One of these was flown by John Woodyard, a Stanford research associate, in February, 1939, to Boston Airport, and set up on a dismal rainy day

with a zero-zero ceiling on an Army truck, under the direction of Edward L. Bowles, professor of electrical communications at Massachusetts Institute of Technology. While CAA and U. S. Army Signal Corps authorities watched intently, Doctor Bowles shot the klystron beam into space through a directional horn originated at M. I. T. Ten miles out of the airport, Pilot Jack Jaynes, flying blind in the clouds, picked up the beam and, using the Metcalf blind-landing method, glided smoothly down to a perfect landing in the middle of the main runway.

"It worked swell," declared Jaynes. "I couldn't see a thing up there in the soup. All I did was stay on the beam."

Since then pilots have learned a lot about coming down safely through the soup. The klystron hurls a strong, stable beam in a wave length about four inches long, as compared to the forty-inch beam now used by air lines. It cuts through static and every other type of interference. It radiates on a narrow angle of six tenths of one degree, enabling pilots literally to "ride the beam" like a trolley instead of gravitating between the edges of two nearly parallel beams, as they do with existing equipment on the country's air lanes.

In the two brief years that they have been able to play with the klystron, experimenters in both university and commercial laboratories have found the amazing beam with the diminutive wave length a veritable Jack-of-all-trades in the communications realm.

Like light rays, X rays, heat rays and the other radio rays, the beam shot out by the klystron has its eccentricities. Some of these are advantages, and some are not. One of the eccentricities of the klystron beam is that, where ordinary radio waves go bounding around the globe, bouncing back and forth between the earth and a mysterious ionized ceiling, sixty miles above terra firma, known as the Heaviside layer, the new rays shoot off into space as straight as sunbeams. Another peculiarity is that when they hit something solid, they bound back at a terrific clip approximating that of light. The "boomatron" is the pet nickname of Bill Hansen for the klystron, because of this odd boomeranging habit.

Boomeranging will undoubtedly be one of the klystron beam's most important jobs. Pointed groundward from a speeding plane, a rebounding klystron beam furnishes the basis for an infallible absolute altimeter. Pointed horizontally from the plane, the beam detects mountains miles ahead and reports how far away they are. It "sees" through darkness or clouds or snowstorms as clearly as it does through daylight.

Even more startling is the "boomatron" angle when the klystron is pointed from the ground through fogs or clouds to the sky. Every time a plane crosses its path, the beam boomerangs. Though this phase of the klystron's use is shrouded in military secrecy, the klystron beam seems all that Sig Varian hoped for as a sure-fire means of locating enemy bombers hidden by clouds or darkness over defenseless cities. Faster than the most expert gunnery range finder could do it on a perfectly clear day, the klystron can "sight" invading bombers and register their range. It promises to make anti-aircraft guns more deadly at night and in cloudy weather than they are now in fair weather. It looms now as the possible secret weapon that will restore the balance in war once more to the defense.

Another gay eccentricity of the lively little klystron beam is that, though it shoots as straight as a sunbeam into space, it readily takes curves in high, if they are not too sharp, when fired into a copper or brass-lined pipe. This peculiarity intrigues telephone, telegraph and television engineers, particularly the former, who have battled snow and ice winter after winter to keep their lines up in storms.

Using klystron beams to carry messages through pipes, 600,000 telephone conversations could be fired simultaneously through a six-inch pipe laid cross-country. Furthermore, one or one hundred thousand conversations could be detoured from the pipe to Detroit, Chicago, St. Louis or any other city, just as easily. And there'd be no listening in on the line!

This fantastic concentration of talk or telegrams or television images in a six-inch pipe is easy, the klystron inventors explain, because the number of wave bands available at the ultra-short end of the radio spectrum rivals the national debt in ciphers. In the first comparatively crude klystrons, the frequencies ran up to 6,000,000,000 cycles. In the improved models they are expected to hit 30,000,000,000—ten thousand times the number now being used by the broadcasters and the air lines.

"The radio industry began at the hard end of the frequency band," explains Doctor Webster. "Now that we have the klystron device, it looks as if the extreme short-wave band will be the simpler end of the radiation spectrum to work on and understand. What made modern radio broadcasting possible is De Forest's audion tube and its development into all the modern radio tubes. The klystron promises to take the same place in the ultra-short-wave range."

Among the other jobs they have found for the klystron beam is boomeranging through fogs to warn ships off rocks or from crashing into one another. Used as a communications beam, the klystron permits ships to talk with one another without eavesdroppers picking up the messages. Still another task is the one Bill Hansen first set out to handle with his original rhumbatron, that of developing inexpensive high voltage for testing metals and for therapeutic work. The klystron weighs from five to ten pounds, where the present coil and condenser high-voltage machines run into tons. A klystron costs about five hundred dollars to build, but shortly will be turned out for a tenth that sum in a metal or glass vacuum case as compact as a portable radio.

In December of last year, because of the military secrecy surrounding the klystron's use as a much-needed defense weapon, the Sperry Gyroscope Company concentrated research work in a brand-new laboratory built especially for the purpose at Garden City, Long Island. Just before Christmas, with real money jingling in their jeans, the Varians turned their experiments in the Stanford physics laboratory over to several research fellows supported by Sperry, and headed for Garden City to join the Sperry research staff. Their eyes glowed at the prospect of working in what is probably the country's newest, most modern invention factory, if not the world's. Just before he left the Stanford campus, a friend asked Russ Varian what they were going to do back there. He thought it over seriously.

"Oh, we'll just keep on eliminating bum ideas," he said. "That's all."

SUNDOWN

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"We could get Dewey to fire the huts for us," Turner suggested. "I'll arrange it with him."

From where he sat, Crawford could see Dewey just inside the guest hut, stewing fresh leaves which Ibrahim had gathered for him that morning.

"Queer bloke!" Turner said. "A little keen on Zia, I think." Crawford did not answer, and Turner went on, "How was she last night?"

"She seemed all right." Crawford looked at him. "I had to go over, Roddy. It was the decent thing to do."

"I suppose so," Turner agreed. "Only that girl's subtle!"

"I don't think she is."

"No? Then you're practically sunk." Turner was smiling oddly. "You'd better be careful, Bill."

He said no more. They worked on over the gun while isolated sounds came across the post, dulled in the heat. Crawford was wrapping the removed mechanism in a cloth when they heard Coombes shouting. His voice was loud and rousing in the quiet, and he came jumping onto the veranda.

"Bill, here's a runner from one of those tribal policemen we sent out! He says there are camels on the old Kassaba track!"

The native appeared behind him, arriving at a trot, mired to the waist from stretches of black cotton soil, sweating and panting.

"Kassaba track?" Crawford stared, and Coombes reached for the hand-drawn map of the district, which stood rolled up in a corner. He opened it on the table.

"There you are!" His finger stabbed to where a camel track came up from Kassaba on the coast. It wavered across Somaliland, across the interior below Manieka, then cut over the frontier into Shifta country and ran toward the Habash hills beyond.

"There you are!" Coombes said again. "And I bet you there's guns on 'em! That's the way they've been getting in!"

"It's what we've been talking about!" Turner pointed to the map. "Arab dhows land them at Kassaba, and that's how they smuggle them up here!"

"Well, we sent the tribal police out to watch for something like this," Crawford answered. "Whose camels are they, Herbie?"

"He doesn't know," Coombes said.

They looked at the runner. He was holding a veranda post, gripping it high up, pulling gently to keep the weight off his legs and rest them. He had run fifty miles and he knew that if he were to crouch or sit down it would be a long time before he could move again, so he was careful to remain upright.

"They found a day-old trail by the border," Coombes added. "And all he knows is that there are ten camels."

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