

# *A Scientist and his* **HOBBY**

W. A. Good

It was well after dark on a late summer evening when an unexpected knock sounded at the door. There stood a tall blond lad with a small bag in his hand. It was clear that he was Scandinavian from the moment he asked, "Are you Dr. Good who builds radio-controlled models?" He continued, "I am certain you don't know me but I am Arne Nielsen from Sweden. I build radio-controlled model planes and I was told if I ever

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visited America to stop and see you."

After inviting Arnie into the living room and assuring him there was a spare bed, there followed a long discussion of our mutual hobby of RC models. I discovered that he was a student in aeronautical engineering and was completing a summer in the U. S. on a student exchange program.

When I saw him last summer, five years after his visit, he was in the flight-test department of Saab Aviation in Sweden.

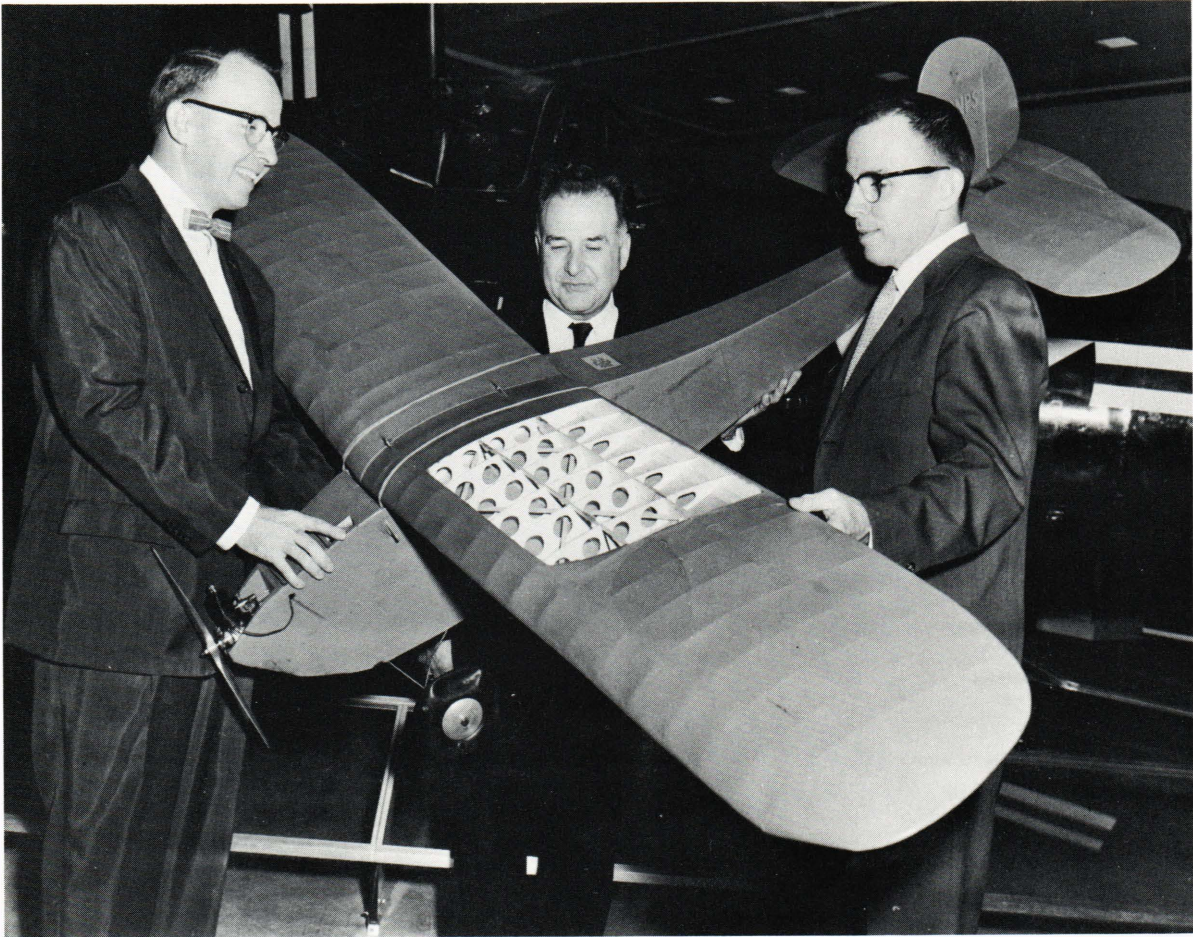
On another occasion, while in Brussels attending the annual business meeting of the International Aeromodeling Committee, I ventured into a hobby shop and identified myself to

the clerk. "Ah yes," he exclaimed, "I too build RC models." Whereupon he closed the shop and off we went to a nearby restaurant for a quiet chat for the next two hours! His name was Henri Stouffs and, fortunately for me, he spoke excellent English. A check on Henri several years later revealed that he had to give up his model shop and find a different business. He found it much too tempting to take long lunch hours with the visiting modelers.

I could tell many stories of the automatic rapport created between apparent strangers by their mutual interest in the radio-control hobby. I'm certain that other hobbies create a similar rapport but I've never witnessed one



A Walter Good-assisted takeoff of "Big Guff" in 1947, one of the more than 1000 flights by this early pioneer RC model and winner of several national championship awards.



Built in 1937, the "Big Guff" is shown here being presented by the author (left) and his brother, Dr. William E. Good (right), to Dr. Paul E. Garber, Head Curator and Historian of the Smithsonian Institution's National Air Museum.

quite as compelling. However, I'm getting ahead of my story and would like now to step back to the beginning of the hobby of the radio control of model planes.

### Early Radio Control

It all started in the mid 1930's. The amateur radio "hams" were young and growing, and the conventional model planes with rubber-band motors were being superseded by giant eight-foot models powered by infant and erratic one-cylinder gasoline engines. I had just finished building one of these eight-foot models, and having a "ham" as a twin brother, the dream of steering the plane by radio was about to be fulfilled. Immediate success was not ours. Our only early claim was that the plane landed in a different spot than it would have if it had not been under control! It is difficult to recall that miniature radio tubes had

not yet been made—we used the type-30—and that a "small" relay weighed half a pound and that small batteries had such short life that they had to be shipped by airmail and kept in the ice box. We ended up making practically every part of the system by hand. I remember the tremendous fascination I felt when the model's control would magically click away at the bidding of the transmitter push button across the room. Truly successful controlled flights were made in 1937, and our plane, the "Big Guff," with numerous modifications, flew over a thousand flights until it was retired in 1947. It now is in the Smithsonian Institution in Washington, D. C., as one of the first powered radio-controlled airplanes in the U. S. A.

It was interesting to learn later that England was just beginning to fly a military target drone called the "Queen Bee" and that American

drone efforts had not yet reached consistent success. About the same time, enthusiasts at the Amateur Radio Relay League headquarters were coasting non-powered RC gliders down the Connecticut slopes under successful control. Of course, very early successes of remote-control boats and other non-flying devices occurred as early as 1915 and are described in *Radiodynamics* by Miessner.<sup>1</sup>

Actually, these early RC models predated the guided missile, according to the Air Force *Fundamental Principles of Guided Missiles*:

"About 1935 two brothers named Good, who were amateur model airplane enthusiasts, built and successfully flew a model plane which was remotely con-

<sup>1</sup> Benjamin F. Miessner, "Radiodynamics: The Wireless Control of Torpedo and Other Mechanisms," D. Van Nostrand Co., Inc., New York, 1916.

trolled by a radio transmitter and receiver. This, insofar as can be determined, was the first radio controlled flight ever made.”<sup>2</sup>

Since the models did not carry warheads, it probably isn't fair to classify them with the early guided missile.

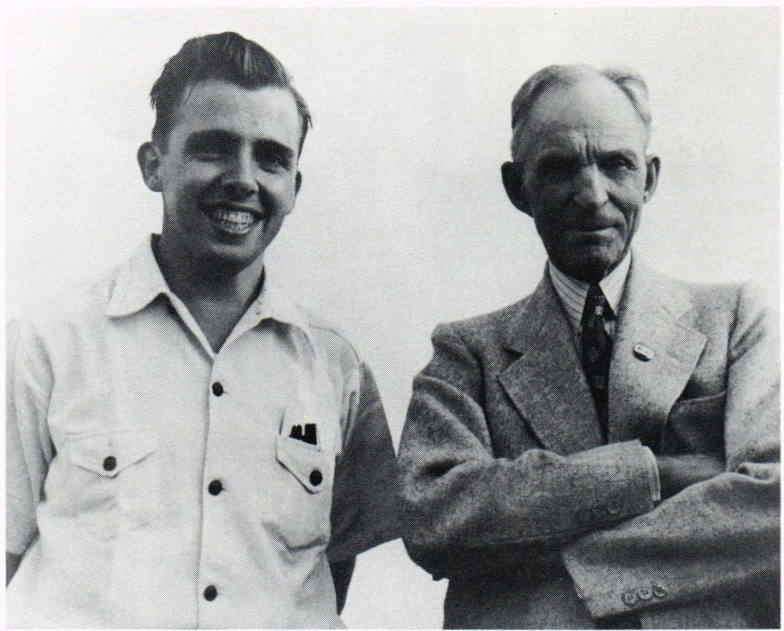
These earlier models were steered by the rudder only, primarily because no one had yet devised lightweight radio equipment which would control more than one channel. In spite of this, the rudder allowed a surprising variety of maneuvers beyond the obvious right and left circles. For example, loops were possible by holding full rudder to build up speed in a steep spiral dive, then flip to opposite rudder and quickly neutralize, bringing the ship into a “wings-level” high-speed dive from which it would zoom up from its own natural stability and then fall over into a loop. After the war, a young Navy pilot approached me at a contest and related how he had tried a “rudder-only” loop while flying in an F6F Hellcat. He said he got into the spiral dive all right but when he gave opposite rudder, the plane kept right on diving and he had to resort to pulling “up elevator” to recover. We decided that the Hellcat must be trimmed differently from our stable models.

Just before World War II, I was asked to leave graduate school for two weeks and go to the Bureau of Standards in Washington on an unspecified mission. When I arrived, I was led into the office of Dr. Hugh Dryden\* who was leafing through copies of our articles on radio-controlled models. It was then that Dr. Dryden showed me a sketch of a small aircraft, not too different from a model plane, and asked if our radio controls could be adapted to it. Although at the time I wasn't aware of the intent of this machine, it was later revealed as the forerunner of the Navy's Bat missile that saw active service in the war.

It wasn't until 1954 that a multicontrol model finally beat out the rudder ships in a national contest. The “multi” ships had made their appearance several years earlier but they

<sup>2</sup> *Fundamental Principles of Guided Missiles*, Vol. 1, “Guided Missile Structures,” USAF Extension Course Institute, Air University, Feb. 1956.

\* Dr. Dryden is now Deputy Administrator, National Aeronautics and Space Administration.



William Good and Henry Ford, Sr. at Dearborn, Mich. in 1939 following an RC-model demonstration for the famed auto manufacturer.

were plagued with the reliability problems associated with greater complexity and were consequently held back. Needless to say, the model airplane Contest Board was forced immediately to make two separate classes, one for rudder models and one for multicontrols.

### Some Personalities

Some of the early modeling activities led to strange meetings with interesting people. As a winner in a midwest contest, I found myself on a sleeper-type DC-3 on the way to Hollywood as a guest of Paramount Studios. That was 1938 and it was all part of a publicity program for an aviation picture called “Men with Wings.” Dorothy Lamour, a top Paramount star, was one of several film-land notables I was privileged to meet.

Another memorable meeting occurred as we were packing the radio plane after completing demonstration flights at the old Ford testing grounds in Dearborn, Mich. A young lad urgently persuaded us to unpack the plane and make a special demonstration for his uncle, Henry Ford, Sr. After the quickest setting-up we had ever made, brother Bill piloted a successful flight and brushed so close to Henry Ford on the landing that I was concerned for his safety. Ford never

batted an eye. He thought it normal! There followed a tour of Ford's museum with Henry Ford himself as the guide.

### Current Models

The modern RC multi model represents a substantial investment of time, energy, and money. Several months of spare time are required to construct the six-foot model from balsa wood, glue, and nylon covering, and to install the radio receiver, batteries, electric motor servos, and the engine. If one designs his own plane from scratch, considerably more time is required. The commercial radio equipment consisting of a transmitter, receiver, and servos, runs close to \$300.00 if you control rudder, elevator, ailerons, and engine. Again, building your own radio gear is cheaper but more time-consuming. I find I enjoy designing and building the plane and radio gear from scratch.

The finished plane will weigh about six pounds ready to go. It will be steerable up to a range of about two miles (our eyesight runs out before that!) and will fly about 15 minutes on a half-pint of fuel. Even after the engine stops, the controls are effective; then, of course, you're committed to land “dead-stick” and that gives you only one try.

## National and International Modeling

Since the Federal Communications Commission in 1952 granted a special Citizens Band license for radio-controlled devices, over 30,000 modelers in the U. S. A. have taken up the RC hobby. Much credit for the FCC action should go to APLer David Rabenhorst who intervened with his late stepfather, Senator Charles W. Tobey, and got the action under way. With the aerobatic RC models, over 100 contests are held each year, culminating in the annual National Championship which is held for a full week on a Navy base. The Academy of Model Aeronautics, the national model organization, has been fortunate in receiving this support from the Navy for the past 14 years.

Recently, the international popularity of the RC model has evolved the World Championship competition sponsored under the Fédération Aéronautique Internationale (FAI). The FAI homologates world-wide aviation records, including full-scale speed records and all sporting aviation. The first radio-controlled World Championship meet was held in Zurich in 1960, with eight countries attending; the second was held near London in 1962

with 13 countries, including Russia, among the contestants. The U. S. A. won both of these meets, with the English and Germans close behind.

The administrative portion of the international aspects of the model hobby is controlled by the International Aeromodeling Committee under the FAI. Some twenty countries send delegates to this committee which meets each fall in Paris and threshes out the regulations for the coming year. Various world championships are scheduled several years ahead. I've been fortunate to be the United States delegate for the past few years and have found it a real challenge to participate.

### Design

To me, the most fascinating aspect of the RC model hobby is technical design of the airplane and radio equipment. This whole operation is one beautiful technical and artistic compromise. Here one has the opportunity to be the preliminary planning department, the systems engineer, the engineering group, the structure engineer, the aerodynamicist, the weight and balance department, the electronics engineer, the production shop, the installation and test crew, and

finally, your own test pilot! Oh yes, if things don't go too well and a crash ensues, you may also be your own flight analysis group to decide what happened and how to fix it for the next time.

Probably the common denominator is that your only real judge is Mother Nature herself. She is fair but ruthless. If you've not used enough rubber bands to hold the wing on, she'll yank it off at the bottom of a dive and downward scream the pieces to destruction. If your servo spur-gear doesn't have a tight set-screw to hold it on the shaft, she'll slip it off at 200 feet in the air and you'll be flying minus one of your controls. Sweat it down, Mr. Test Pilot! I could list thousands of occasions where Mother Nature has intervened with her logical laws and forced a moment-of-truth. Needless to say, the designer tries not to repeat his old mistakes. But "back to the drawing board" is not just a hollow joke because "the next one is always going to be better." Fortunately, this same Mother Nature provides the designer with oceans of optimism, and time rapidly erases the disturbing memories of his recent failures.

### Models and Missiles

The parallel between an RC model and a guided missile is conceptually very striking. The sketch shows a missile with its engine, the airframe with its wings, the movable control surfaces actuated by servomechanisms, the radio receiver listening to the commands from the guidance radar, and the batteries for electrical power. Alongside is the RC model with its almost exact counterparts. Perhaps the only significant difference is the human ground-based pilot who is linked into the model's transmitter guidance loop. Or is he, after all, only a "computer" performing the error-detection and command functions?

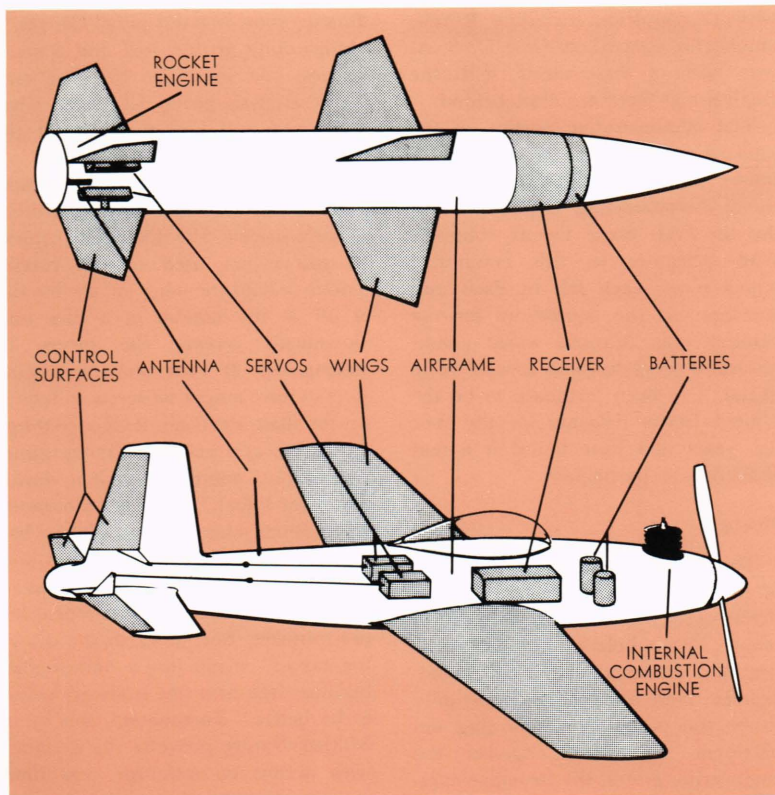
### Aerodynamics

The RC designer is concerned with many aerodynamic problems—what wing airfoil section to use, for instance. It must have good lift for inside loops and still be able to fly inverted and not stall unexpectedly. It seems that most of the good airfoils for this purpose have come from the NACA\*



The author is shown with a modern radio-controlled model and its supporting ground equipment. This model has radio control of its rudder, elevator, ailerons, flaps, and engine.

\* National Advisory Committee for Aeronautics.



Graphic illustration of the basic similarity of components in a modern missile and a radio-controlled model airplane.

wind-tunnel experiments of the 1930's when subsonic and low Reynolds numbers were of concern to the aircraft industry.

Then there is that all-important center-of-gravity position which must be located within  $\pm\frac{1}{4}$  inch of the right spot on a high-performance model because it determines the stability of the model and how sensitive the controls will be. Careful shifting of the batteries will usually secure the right c.g. spot without adding the extra ballast weight that is a mark of poor design.

Deflection of the control surfaces is sometimes reduced because the force of the airstream overcomes the torque from the tiny electric control actuator. In order to obtain quantitative design data on this effect, experiments were carried out with parts of a model supported outside the car window while whistling down the highway at 60 mph. The measured hinge moment due to the air impinging on the control surface was about one inch-pound, a far cry from the thousands of inch-

pounds exerted by a missile flipper.

Even aerodynamic "flutter" occurs in the RC model, especially in the ailerons. It's not too unusual to hear a loud Bronx-cheer sound emitting from the plane in a dive, see some fuzzy wing tips blurred by their rapid oscillation and then witness the departing ailerons float to the ground. If the pilot has survived all this and still has some control of the rudder and himself, he may be able to land the plane successfully. As many modelers have now learned, stiff linkages and mass-balanced surfaces eliminate this problem.

The spiral stability of the model depends on the balance between the wing dihedral angle and the area of the vertical fin. Since this balance is almost unpredictable, even in full scale, the modeler starts with an over-size fin and whittles it down as the test flights proceed, until the turn characteristics meet his desires.

Another "unpredictable" is downwash from the wing onto the horizontal stabilizer. Improper downwash affects the stabilizer action and tends

to make the longitudinal control erratic. A graphical check of this problem was found by pouring titanium-tetrachloride fluid onto the wings, then quickly flying the plane in front of the observer who visually determines the flow of the resulting smoke trail in the vicinity of the stabilizer. The method has worked well but tends to rust metal parts and discolor the finish.

These are just a few samples of the many aerodynamic problems confronting the RC model designer. Now let's take a look at the radio-control problem.

## Electronics

Somehow the transmitter part of the problem always seems the easiest to solve since it is ground-based and is required to emit less than a watt of radio frequency energy into a simple whip antenna. But the receiver which is carried in the plane is a more complex problem. First it must operate at a distance of several thousand feet as well as just a few feet from the transmitter. In addition, considering the signal reduction caused by antenna patterns, polarization, and awkward flight aspects of the model, we find that the receiver must operate properly over a range of signal strengths of 100,000:1!

This is not an insignificant problem because sometimes an overloading signal doesn't just compel more output from the receiver but inverts the signal and gives the plane a "down" control instead of "up." This could be catastrophic. Empirical work with the almost unanalyzable superregenerative receiver circuit has developed it into a very useful device. From such a one-tube detector stage several volts of output can be squeezed, with a radio-frequency input of only a few microvolts. A description of the interesting self-oscillating nature of the superregenerative action sounds almost like some of the recent self-oscillating machines labeled "self-adaptive." For example, the superregenerative receiver oscillates in repetitive bursts of 27 mc at a rate of 60 kc and accurately detects modulation in the incoming signal up to several thousand cycles per second.

Transistors are taking a natural place in the airborne equipment of

the models due to their very low power requirements and the resulting low weight. As soon as the new transistors were reaching experimental laboratories, the RCA research engineer who invented the complementary symmetry circuit was placing them in his radio-controlled model. Nowadays transistor receivers weighing less than an ounce are powered by two half-pencells and operate a tiny magnetic actuator so that a flying weight of less than two ounces is possible. This makes a plane with a 1.5-foot wing span very feasible. There are many more examples of how the RC hobby relates to the modern world, such as whether the power should be nickel-cadmium cells or silver-zinc. One modeler, an electronics instructor, placed solar cells in the wing of his model to keep the batteries charged.

### Controls

Following the receiver in a radio-controlled model is the control mechanism. One of the most ingenious proportional-control methods is a motor that oscillates back and forth uniformly to give neutral control, and, with a variable dwell-time, to give various degrees of left or right control effect. This is not original with the modelers since it was used in the German wire-guided missiles of World War II. Another more recent use is in the Acceleration Switching Hydraulic Servo invented by John Chubbuck at APL in 1955. Here, Chubbuck asked a tiny flapper in the hydraulic valve to vibrate at 200 cps and he then used the error signal to vary its dwell-time against the hydraulic jets. The great value of creating proportional-amplitude information from on-off time signals thus appears in many places.

### Piloting

Becoming a skillful pilot requires many hours at the control stick and even more hours at the work bench repairing the consequences of pilot error. Even such a mundane matter as which is left and right as the model approaches or recedes does not become automatic until after a large number of flights have been executed. It is not uncommon for a newcomer to develop that anxiety known as

"ramp fever" in missile circles and launch his plane without turning on the switch to the control receiver.

To many RC modelers, piloting is the central attraction because every flight is different. Due to the vagaries of the wind, engine, and controls, it is literally impossible to make two flights exactly the same. To the experimentally-minded modeler, piloting is interesting only as long as some new idea is being tried out. After the idea is shaken down, the interest wanes and he's off trying another change. It goes almost without saying that the experimental modeler doesn't fare well at aerobatic competition flying because his plane and equipment never reach a finished, stable state. I must confess I belong to the experimental category.

### Modeling Friends

The RC fraternity is composed of modelers from all walks of life—engineers, ministers, pediatricians, technicians, radiologists, farmers, dentists, physicists, and many others. I've never found a common denominator other than the hobby itself except that I've never met a modeler who was a lawyer; and I don't know how to interpret that. However, the many friendships gained through this great cross-section of people are a most rewarding part of the hobby. When this extends to the many fine foreign modelers I've met in the past five years with my European trips, I find I have a new awareness of their countries' problems. When a Finnish modeler tells you that Finland is surrounded on three sides by Russia, and they've fought twenty-nine times, you begin to feel convinced that the Finns have some problems but will be around for quite a while yet. While sitting around the conference table with modelers from twenty countries and transacting the international model business in English, French, German, and Modeleze, I receive a tremendous stimulation from the fact that it is possible for countries to negotiate amicably with their strong common interest completely overwhelming the political aspects.

### The "Why" of RC Modeling

Somehow this story was triggered by a question from Dr. A. M. Stone,

who asked, "Why do you engage in this radio-control-model hobby?" I replied, "Because I like it." "I know that," he countered, "but *why* do you like it?" I've thought about the answer many times and recalled a real life experience of a friend at graduate school many years ago. My friend Bill had just finished his Ph.D. in physics and was an instructor in the Physics Department. This particular Friday afternoon he was invited by the head of the department to join in the weekly tea with the first-year graduate students. The purpose of the tea was to give these students a view of an active scientist; after they had quizzed Bill about his nuclear machine and the theories of the day, the department head delivered his profound question to Bill, expecting from him an equally profound answer, designed to impress the captive fledglings. The question: "Doctor, why did you take up the field of physics?" To which Bill replied, "I guess it's because I like to build things!" Perhaps the chairman was the only person in the room not impressed with the honest and unprofound answer. Where is honest Bill today? He is the Technical Director of the Naval Ordnance Test Station in California, and recently won the nation's highest Civil Service award of \$25,000 for his personal contribution to the Sidewinder missile program! He is Dr. William B. McLean.

I, too, must be honest in answering Dr. Stone's question and say I like to build technical things that move. I like the self-satisfaction of winning an occasional bout with Mother Nature, I like having been a participant in the development of an idea, and I especially like the many friends I've made while pursuing the pioneering paths of this hobby. Perhaps in a small measure our international person-to-person relations have been strengthened. It is my hope that the earlier paragraphs of this story have related just a few samples of the answer I've tried to summarize here. It's difficult to say how much longer the hobby will stay in my blood—probably forever—but every time I feel the end is in sight, something new comes along, like the transistors—or a meeting in Paris.