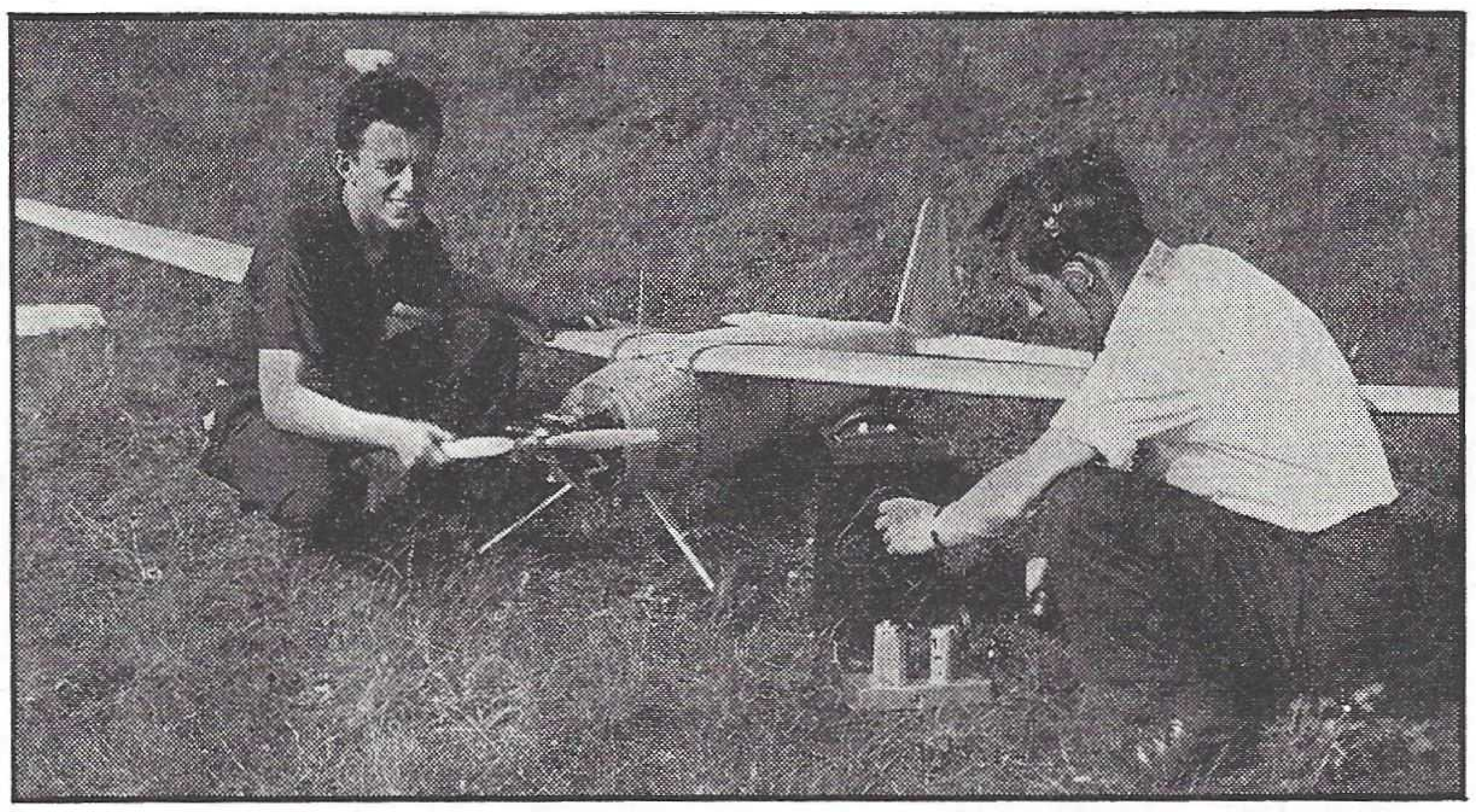
Radio Control

How Radio Control for Model Airplanes is Being Developed and a Description of One System That Gives Promise of Fine Results

By LEO A. WEISS



Weiss and Lopus tuning up their radio-controlled model

PICTURE this scene if you can. The place is Wayne County Airport, site of the 1937 National Contests, sponsored by the N.A.A. The time is Sunday, July 11, which is the last day of the outdoor competitions. Situated on a far corner of the field, slightly set apart from the Texaco and other gas model competitions are six rather large gasoline-propelled models. About each are clustered five or six model builders, some working on the models, some working on the motors, and the remainder devoting their attention to some queer-looking apparatus heretofore never seen at a national contest.

These models were the representation of the newest and most spectacular forward step taken by the model builders of America. No doubt each of us who has flown model airplanes, be they small or large, has at some time or other harbored the desire to control their flights by other means than inherent stability. Such control was of course out of the question until the gas model reached its present advanced stage of development.

During the past three years, developmental work advanced very slowly, the main retarding factor being the lack of a national contest which would give recognition to the first person to operate a radio-controlled model successfully.

The N.A.A. officials, quick to appreciate this fact, announced last year that they would establish a radio-controlled contest and this year, MODEL AIRPLANE NEWS was generous enough to donate a perpetual trophy for this event. With such concerted action on the part of the "higher-ups," there was a period of feverish activity on the part of those model builders who could afford the expense necessarily entailed in the experimentation with radio control.

The results of this hurried work were the six models which appeared at Wayne County Airport on July 11. Not apparent at all to one looking at these models was the months of back-breaking labor and endless disappointments that had to be undergone by each of the builders.

As the meet progressed, it seemed probable that at least one of the models would fly successfully However, only Chester Lanzo, the winner, was able to fly his model, and it was apparent that his control system worked very erratically. Pat Sweeney cracked his large white model up on an attempted flight, and R. Wasman, of Jacksonville, Fla., demonstrated that he did have some control of the model on the ground, but to many observers, it seemed that his model (called the "White Mystery"—it was!!) had so many gadgets on it, including a wind-driven generator, that true control was virtually impossible.

The author brought out his attempt at a radio-controlled model, although no attempt was made at either controlled or uncontrolled flight. Mr. John Lopus, who worked on the radio apparatus, and the author, were very disappointed to be able to do no better than exhibit our model and radio. We felt, as did many others, that we should be foolish to risk a crash with a half-completed model and radio.

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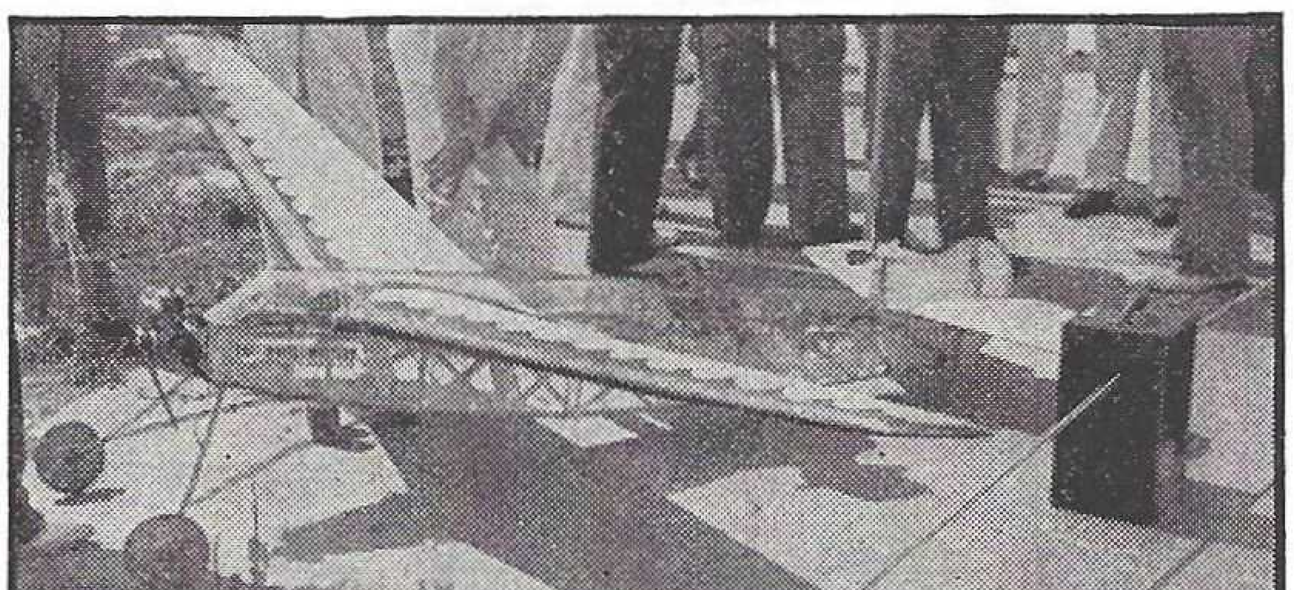
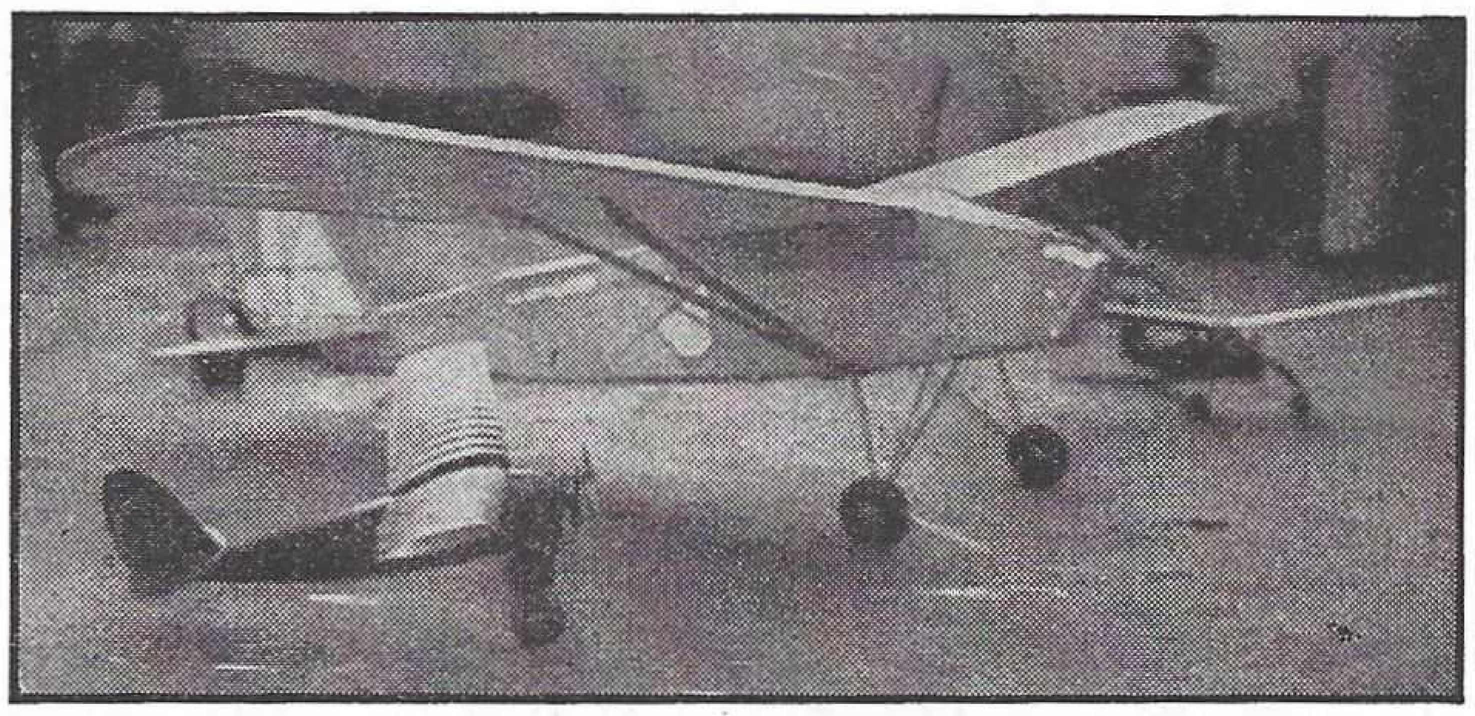
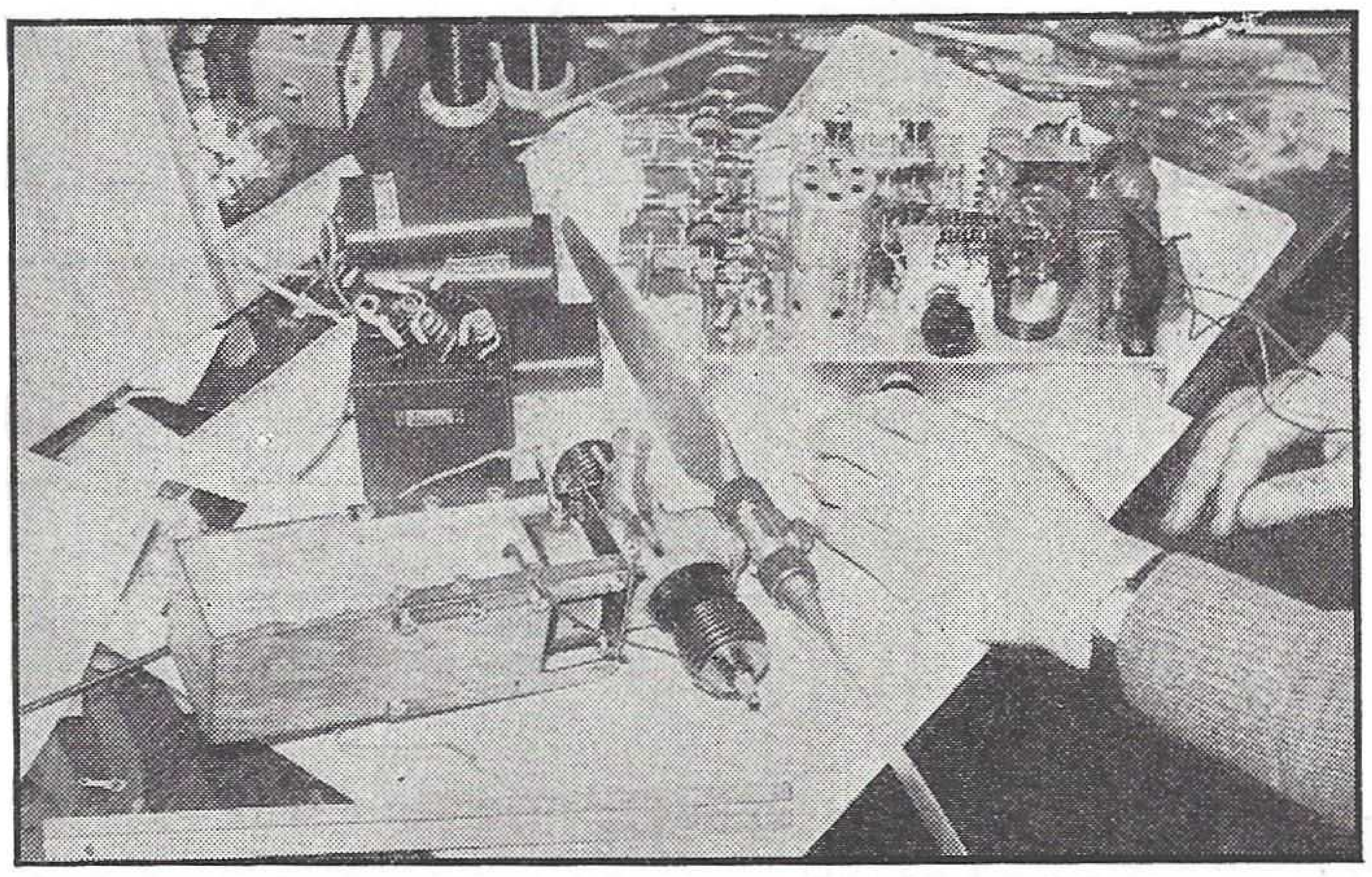


R. Wasman's "White Mystery" was a unique piece of work with a wind-driven generator



Pat Sweeney's radio-controlled monster as it appeared at the "Nationals," Detroit, Mich.

Weiss and Lopus in their "lab" working on the intricate details of their model plane radio equipment. Note the 2 cylinder ½ h.p. engine



A close-up of some of the parts composing the receiving apparatus to be installed in their model plane

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This brings us up to the main point of this phase of radio-controlled models; that is, that their treatment should be more as one would treat a full-sized airplane.

Briefly, it must be understood that work on these highly complicated problems must be studied and careful until we have reached a satisfactory solution. After that it will be a mere matter of improvement, but now we must experiment. Therefore, when we considered construction of a radio-controlled model there were some very definite rules that we laid down for ourselves. In the first place, everything that we did in construction was to be done thoroughly. We knew that the days of slapping on an extra piece of balsa to hold a wing down in a circle were gone, especially when there was something like one hundred dollars of airplane and radio flying around. Therefore, it was our decision to build one airplane, not with the idea of cracking it up or building another one later. This one must be built well enough to stand our experiment and stay together for later exhibitions.

We knew that it would be necessary to build a rather large model since the radio would weigh at least six pounds. As a matter of fact, our first estimate was eight pounds.

It was also obvious that we would be forced to use a rather high wing loading. Our plane weighed sixteen pounds ready to fly, and this would require sixteen square feet of wing area to get the loading down to one pound per square foot. With this in mind, we knew that it would be foolish to use anything but a high-speed wing. Had we used a low-speed wing section, giving a high lift, we still would have had quite a bit of speed, but it would not be enough to make the model really controllable. With a high-lift wing, the model would fly at about twenty miles per hour. This means that there would be virtually no advantage in having controls in any but the slightest breeze.

However, one should not come to the conclusion that it is absolutely necessary to use a high-speed wing section on a radio-controlled model. This is merely a suggestion. Results with high-lift wings will probably be just as good, and after all, this is relatively unimportant when compared to some of the other problems facing us.

It must be understood that the control system be speedy and flexible. It is extremely unsafe to fly the model when there is any appreciable time lag in getting the controls to operate. It must be possible to move controls simultaneously. This will be found to be a great advantage in taking off.

As for the number of controls, it seems that the highly necessary ones are elevators, ailerons and some shut-off or throttle on the motor. It is also advisable to include a rudder, but this is not absolutely necessary. On our first experiments, we omitted ailerons, but after more careful study of the reaction of an Aeronca to different controls, the author has decided to include ailerons before any flight is attempted. How many times have you wished that you had a pair of ailerons on your gas job as she was "winding up" into a tight vertical bank? With a full and flexible set of controls, we can reduce the hazard of crack-ups to nil.

Remember, when something is made to be put into the plane, make a good job of it. Makeshift apparatus may be used to experiment on the ground, but when that model is flying, it is best not to take chances. To fly a radio model without good control is the same as winding up the motor on an Aeronca or Taylor Cub and letting it take off by itself. The results, sad to say, are certain to be disheartening. Also, picture yourself flying around the country in an Aeronca with nothing but rudder control. It could be done, but overhead would be terrific.

Having arrived at these conclusions regarding the fundamental characteristics of our radio control, we then set to work choosing a definite system which would give us the desired results. To do this, we used a process of elimination, considering all the systems that we knew, and discarding those insufficient to our needs.

Having decided that it would be best to use a system involving four different controls, it became necessary for us to develop some sort of system to select between these different controls. That meant that we had to select between eight different operations, since each of the four controls had an opposite movement, or reversal. Thus, if we set our controls for neutral, we would have two controls for aileron, two for elevators, etc.

The selection system is a device which would act as the "brains" of the radio control, causing the correct controls to be moved when the proper signal is sent up by radio.

Thus far, there have been but two outstanding methods advanced for obtaining this desired selection. The first and most common of these is the dial selector system. In this case a radio wave is received by the plane, reception of this wave causing the operation of a very sensitive relay. This relay will cause a solenoid to pull on a ratchet wheel. At the reception of a single radio signal, the relay will operate by a change in the plate current of the audio section of the receiver, in turn operating the solenoid, which will turn the ratchet wheel one notch. As the ratchet wheel turns, one notch at a time, contacts are made which will move some sort of a controlling device.

Thus, by keeping track of the sequence of the control contacts on the ratchet wheel with a similar wheel on the ground, one can get a form of selection by sending up just the exact number of impulses to make the control wheel turn just the correct number of notches. This gives the desired control. As one can immediately see, there is much chance for confusion and mechanical breakdown when using this method. We discarded it as being insufficiently flexible for what we desired. The system may be used for experimentation, however, but it seems that it has very little future.

The second method hinges on audio selection. That is to say, if we have eight different operations which have to be selected from each other, we will modulate (or superimpose) a low frequency or audio signal on the high frequency radio signal, for each of the eight operations. Thus, we will have eight different audio frequencies superimposed on the same radio frequency. These eight different audio frequencies are chosen at random except for the fact that they must not be harmonically related. Thus, values of 100, 107, 114, 121, 128, 136, 142, and 149 cycles per second might aribitrarily be chosen. If a piece of wire were made to vibrate at each of these frequencies, a musical note, rather low in pitch, would be obtained, different for each frequency, and getting higher with the increased frequency.

To make this a bit clearer, let me give this example. An opera singer is singing into a microphone on some big radio station. She is striking a certain musical note, causing a diaphragm in the microphone to vibrate with a certain definite frequency. It might be as high as 1,000 cycles per second. This causes a variation in the current flowing through a wire in an electric circuit. This is of the exact same frequency as the original note. Then, by means of what is known as a modulator, this audio frequency is superimposed on whatever radio frequency the radio is transmitting.

Then your radio receiver receives the radio wave with its audio modulation, and after it has gone through the set, it exists in the same form as before transmitting; an electric current varying with the same frequency. Then the process in the microphone is worked backward in the loud speaker, and sound comes out of the radio in the form vibration of air particles.

Now to get back to our radio control, there are two methods of modulation and selection. The modulation in transmission may be done either electrically or mechanically, as may be the selection. We chose both mechanical modulation and selection. Remember in this following discussion that selection is merely an "unscrambling" of modulation.

In mechanical modulation, a device similar to a doorbell buzzer is used. Here, when a switch is closed, a piece of iron is deflected by an electro-magnet. However, when it is deflected, it opens a switch, cutting off the current in the electro-magnet, and a steel spring causes the iron to go back to its original position. It can then be seen that the piece of iron will be set to vibrating, at a frequency depending upon the stiffness of the spring. By having eight such vibrating reeds on a common electro-magnet, and having the springs of different lengths on each of the reeds, we will obtain eight different frequencies.

To get the actual modulation, the electro-magnetic coil is hooked up directly or through a transformer to the transmitting set. This is much the same as plugging in a microphone and speaking through it.

Electrical modulation is obtained by using, in effect, eight different audio oscillators. Difference in frequencies are attained by changing certain constants in the circuit. Such a system is less compact and more expensive to construct than a mechanical modulation system.

The matter of modulation is indeed simple when compared to the blank wall confronting you when selection is attempted. It may be said that if it weren't for the problem of selection, radio control would have been perfected long before this. Electrically speaking, it is quite a job to split off some eight frequencies from each other. As yet, we have not arrived at a purely electrical method of splitting the frequencies from one another. It will be found that to select between more than two frequencies will give rise to so many "bugs" that years of experimenting will be required. However, it is possible that someone will uncover some radically new method of electrical selection that will be fool-proof. Until that time, we will have to rely on mechanical selection as the safest.

In the mechanical system, the place of a diaphragm in a loud speaker is taken by eight steel reeds. The actuating electro-magnet has a specially designed gap between which the reeds fit. The reeds we used were $\frac{3}{16}''$ wide and but a few thousandths of an inch thick. Lengths of the reeds ranged from 1" long to 1¼" long.

It is probably a well known fact that if a piece of spring steel is held rigidly on one end and tapped on the other, it will vibrate with a definite, unchanging frequency. This frequency is called the natural frequency of that particular piece of steel of that length. The frequency decreases with increases in length, but not in direct proportion.

These eight reeds are then adjusted so that their lengths will give the same frequencies as the eight modulation frequencies. Or the process might be reversed, changing the modulation frequencies to fit the natural frequency of the reeds. It was found that the frequencies must be matched to within less than half a cycle, if selection is to be obtained at all.

Now let us say that an audio frequency of 100 cycles is superimposed on the radio frequency constantly being received by the radio in the airplane. This will result in an alternating curent of 100 cycles per second being fed into the vibrator coil of the reed system by the radio. This means nothing to seven of the reeds, but the eighth one has been matched to this frequency, and it will start vibrating immediately. This, of course, is the phenomenon of "sympathetic vibration."

Words can hardly describe our feelings the first time we tested our reed system, affectionately dubbed "Choe". We used a regular audio oscillator, and played around with the frequency until one of the reeds began vibrating. In this way we were able to get each of the reeds to vibrate separately. We found that in one case, the reeds were separated by only 7/10 of a cycle, yet we had selection! As a matter of fact, the lowest frequency was 112 cycles, and the highest 122, with four reeds between. This was better than we had expected.

As the reeds vibrate, they make and break a contact which is in reality a switch for a sensitive relay which will operate an electric motor. We found that placing the contacts approximately $\frac{1}{16}$" apart gave satisfactory results. One of the contacts was mounted on a light spring so that contact was obtained a larger part of the time during each cycle.

One of the pictures shows a shot of our work-bench where the entire radio apparatus was built. The complete radio apparatus is seen with a ruler and hand in the foreground for size comparison.

Also shown is one complete set of batteries. Their combined weight is approximately three pounds. Not shown in the picture is the battery mounting. This is mounted below the metal chassis on which the radio is built. The reed selector system may be seen on the upper right hand corner of the chassis. The metal-covered tube is the detector tube, and the other is the audio. The former was a type 1A6, and the latter a type 33.

On the left side of the chassis are the three (in the first case) electric motors and gears for moving the controls. Motors are reversed by reversing the direction of the current through the field. The upper knob on the radio is for the tuning condenser and the lower one for volume control.

The relays are an interesting part of the radio system. The combined weight of six of them is 2¾ oz. They make and break four contacts, this being necessary to reverse the motors.

Seen in the foreground is the two-cylinder motor used on the airplane.

Naturally, as in all new things, there is a great deal of experimenting to be done, and consequently, a large number of people should become interested and do some work on different radio systems. However, here is a bit of warning. This is decidedly not a one-man job. There should be at least two, one to work on the plane and the other on the radio. Also, it is advisable to get a little backing. Do not go into this thing on a shoe-string unless you have a set of cast iron nerves. Your estimated expenses should be around a hundred dollars for experimenting. However, the cost of building a radio-controlled unit for a model will cost a little more than a motor for the same plane, once we have departed from our present hit-and-miss policy.

There is much back-breaking effort confronting you, but go to it with plenty of gusto, for the end in this case most assuredly will justify the means, whatever they be.

A Precision Contest Gas Job

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curve very gradually, using a hardwood stick (about 1" x 1") with corners all rounded off and smooth. The stick must be long enough to reach under one arm so that sufficient leverage and pressure can be obtained with it. The lathe should be operating as fast as possible. After the metal has been completely worked around to the rear face of the wooden form, use a cut-off tool to remove the excess metal and to form the rear edge of the ring. The next step is to polish the ring to a plating finish, which is followed by the use of a narrow lathe tool in cutting through the metal on the front face to obtain the desired size opening (3¼" diameter.) The ring will then fall free from the form. Remove a section of a 1-7/16" circle as shown on cowl detail, Plate 4. This is of course the opening through which the cylinder passes. The holes required on the front face of the ring should be drilled next. The three large holes are 120 degrees apart.

The landing upon which the side panels rest, at their front edge, is riveted in place around the cowl ring as indicated on Plate 4. This discontinues at the cylinder hole. When done correctly, a ⅛" strip will remain for the side panels. Use small aluminum rivets, ⅛" long with ⅛" flat heads, in all small riveting done on the cowling. The spacing of them for fastening the strip just described is clearly shown on the front view of cowl. The center top section of the cowling is made and installed next. It is 20-gauge aluminum (soft.) First cut out the remaining section of the cylinder hole to match that in the ring. Prepare the hinge notches and holes, also the needle-valve and