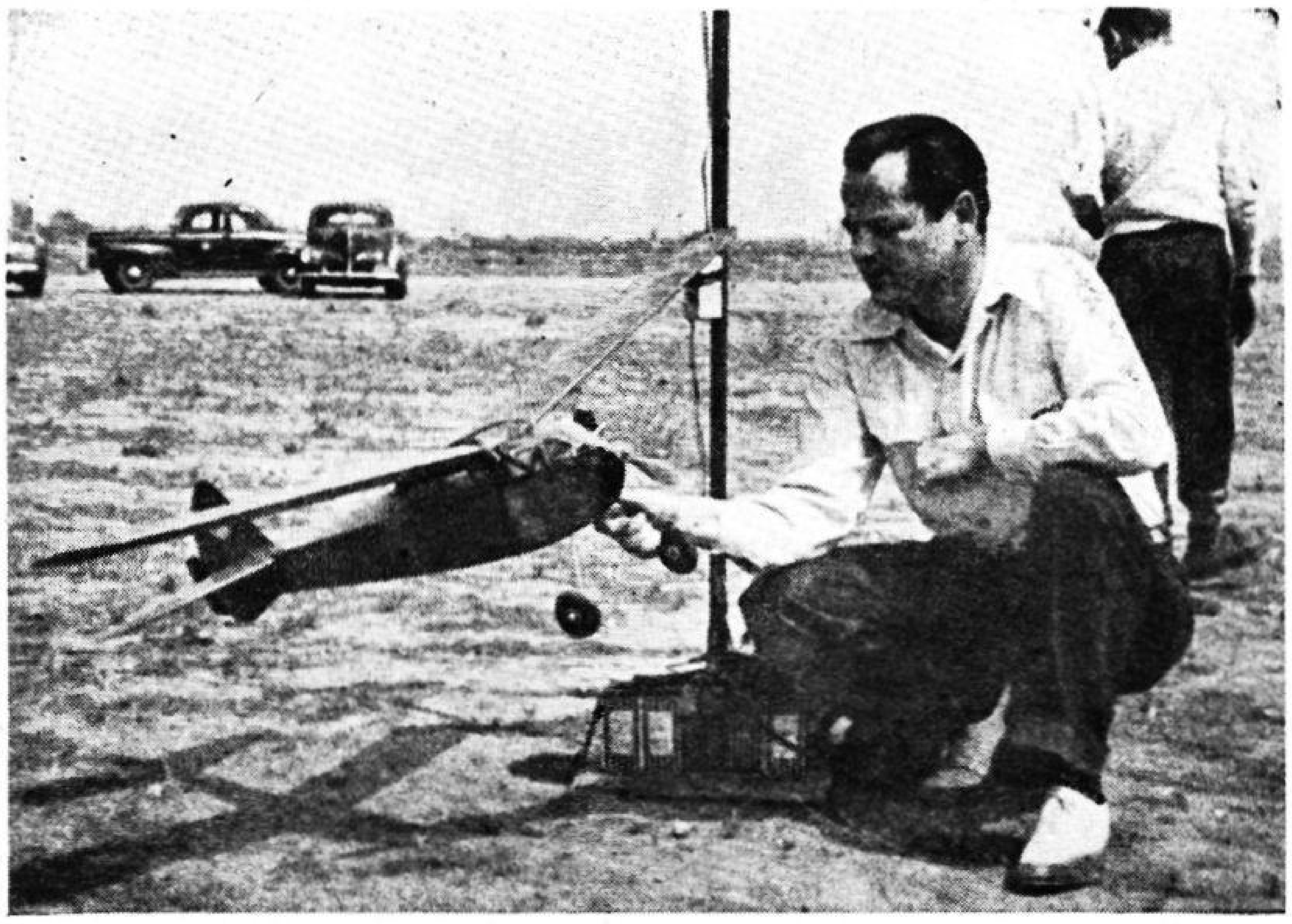

Fig. 1 The author holds the small R. C. model described in this article

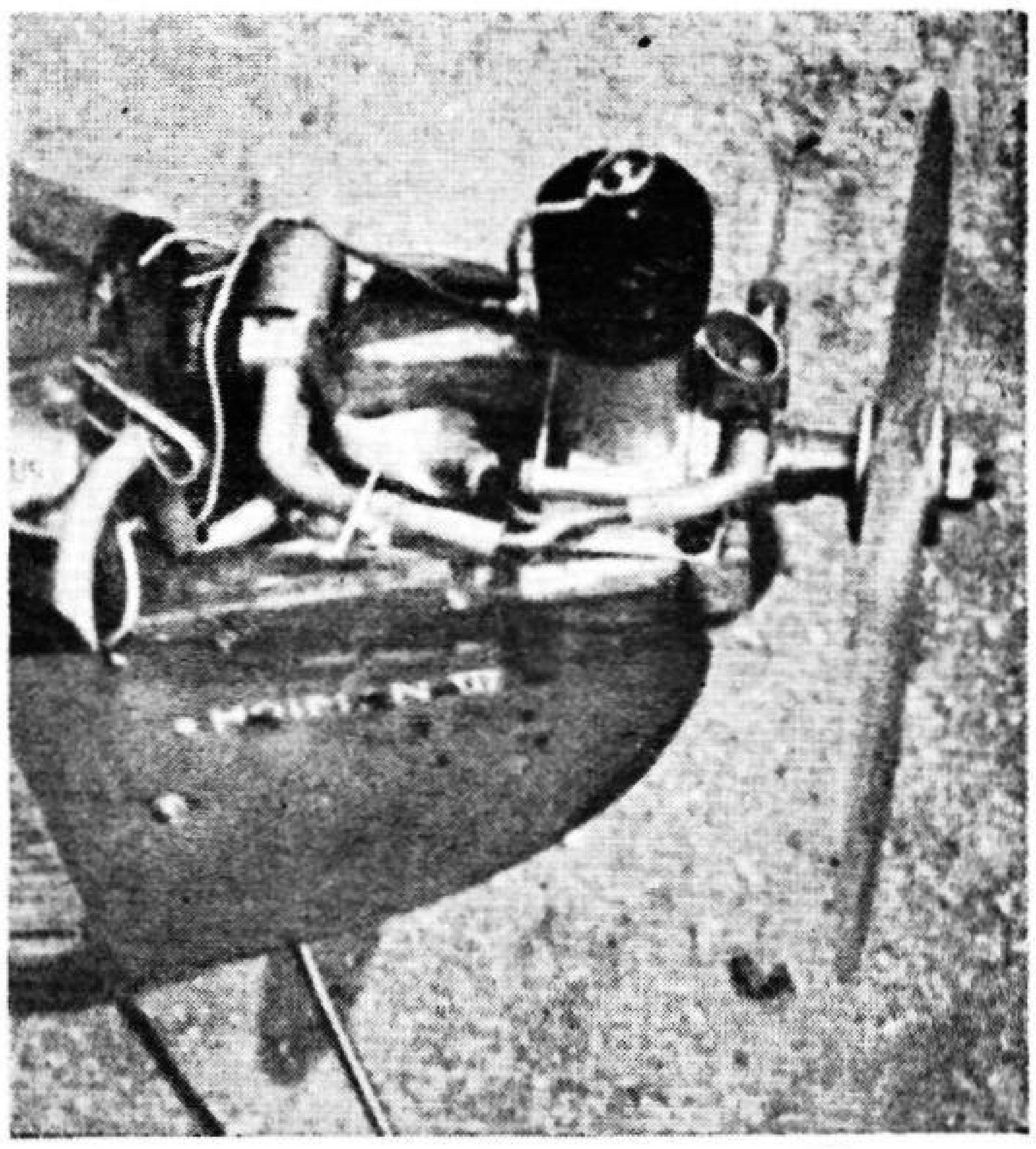

Fig. 2 Motor compartment. Glow ignition is used

Radio Control Reliability

by H. H. OWBRIDGE

RELIABILITY is far more important to radio control than to any other phase of model flying. Chasing a free flight model over hill and dale is an indication of success. With a radio controlled model it would indicate that something slipped!

Reliability is made up of several factors. Naturally we cannot expect 100 per cent reliability in model flying. What we are interested in here are some factors that will increase the over-all reliability of the model so as to obtain more flying time between repairs. "Utility factor" is what the airlines call it.

The beginner usually finds it difficult to obtain a high degree of reliability when starting out in R.C. Radio control is more complex and requires more attention to detail in order to keep things operating properly. It takes time to get used to the idea that radio control must be treated as a higher class of hobby in order to make things work at all. Unreliability can get very tiresome. It's not that the ship is completely washed out in a crash; this seldom, if ever, happens. We have one airplane in particular that has moved a lot of dirt on this earth and it's still flying, but what gets tiresome is the continual repairing it takes to keep the model airworthy. After some 400 flights with four airplanes, we are just beginning to realize that a lot of this minor damage can be avoided.

There was a time when we thought that all we needed for reliable radio control was a reliable receiver. That was before Bill Nuckolls showed us how to operate an RK61. After several flights with an RK61 that never missed a signal, we realized mishaps were still happening. The usual frequency was about one minor accident in every 8 or 10 flights. To describe and analyze every accident would fill a small book. Suffice it to say that between the engine, the receiver, the transmitter, the batteries, the fuel system, the wiring, the installation details, the airframe and, last but not least, the pilot—there are plenty of combinations for single and multiple failure unless things are watched pretty closely. This may sound like the whole idea of radio control is impractical, which of course is not the impression intended. One thing it takes though is the experience to detect a point of possible failure and the patience to stop and fix it before flight. This alone will go a long way to reduce the number and severity of accidents. But the number will still be considerable per hundred flights. If we could either reduce this figure to one minor accident in 20 or 30 flights or build the airplane to absorb, without damage, more of the rough treatment that every radio controlled job gets, the "fun factor" would certainly benefit. Depending on many things, sooner or later some kind of failure will occur. A typical and very common example is when a landing is forced to be made down wind. The reason might have been pilot error, engine malfunction or one of any number of things. One way to decrease accidents is to cut the amount of control equipment to the very minimum and then simplify the type of flying by super-cautiousness. This is *not* a good solution. Simple maneuvers soon become tiresome to both pilot and spectator. The fact is that we can't completely eliminate accidents, but we can do a lot to counteract for them.

Since radio control is a hobby and is governed by all that the word "hobby" implies, the only practical road to reliability is simplicity. Any other approach will most surely demand too much of the things that a hobby cannot supply such as weight, size, money, and complexity. Compare, for instance, the reliability we would like to have with that of a full size airplane and the method in which it is obtained. A classic example in the big ship field is twin ignition; two sparks are put where one will do, just to make doubly sure that the cylinder fires and fires well. The larger the airplane, the more this doubling up process is carried on as a substitute for reliability. All major systems in the airplane have stand-by systems ready to take over if the primary one fails. We cannot use these tactics in model work. With the extra weight aboard, the first instance of pilot error in flying would leave very little worth picking up off the ground. However, in model work, we have one very useful substitute for reliability and it should be used for all it's worth in radio control—this substitute is *ruggedness.*

The more correct term for ruggedness is strength/weight ratio. The more the strength and the less the weight, the more the ruggedness. Of course ruggedness is not increased merely by removing weight. More often a model needs some weight added, but this weight must be added in the form of important structure, not more control equipment. Assume that we can remove five ounces of control equipment weight from the model without sacrificing too much radio control. The model immediately becomes stronger, so to speak, because it has less weight to support not only in flight but (of even more importance) on landing. Non-structural weight never held a model together, it simply tends to break it apart.

Further improvement could be gained if part of the five ounces were put back to increase the strength of important structure. Theoretically, we can even do better than this. Compactness is closely related to ruggedness. As models are built, a 5′ ship is stronger than one of 6′ span. So, in the above example, if we were to build a smaller model at the new gross weight, it would be even more rugged. Anyone who has flown very large and very small models has noticed this scale effect. It is largely due to the fact that the smaller model has the simpler structure. Its strength is built into fewer, but relatively larger, pieces of wood. Also some material sizes are not scaled down to the smaller model. Wing and fuselage covering are often the same thickness as on the larger model. Then too, the general laws of stress

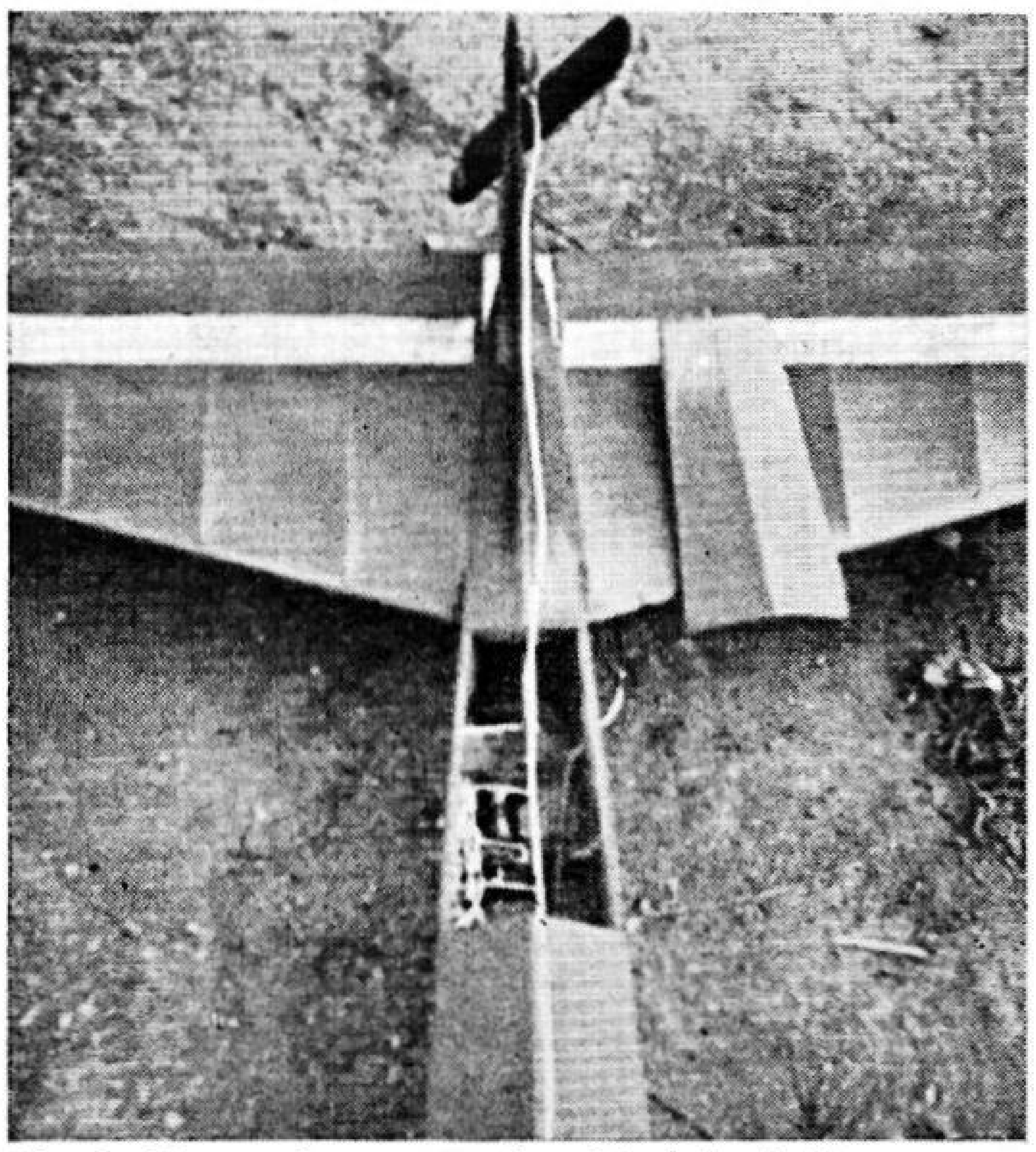

Fig. 3 The receiver compartment includes battery space

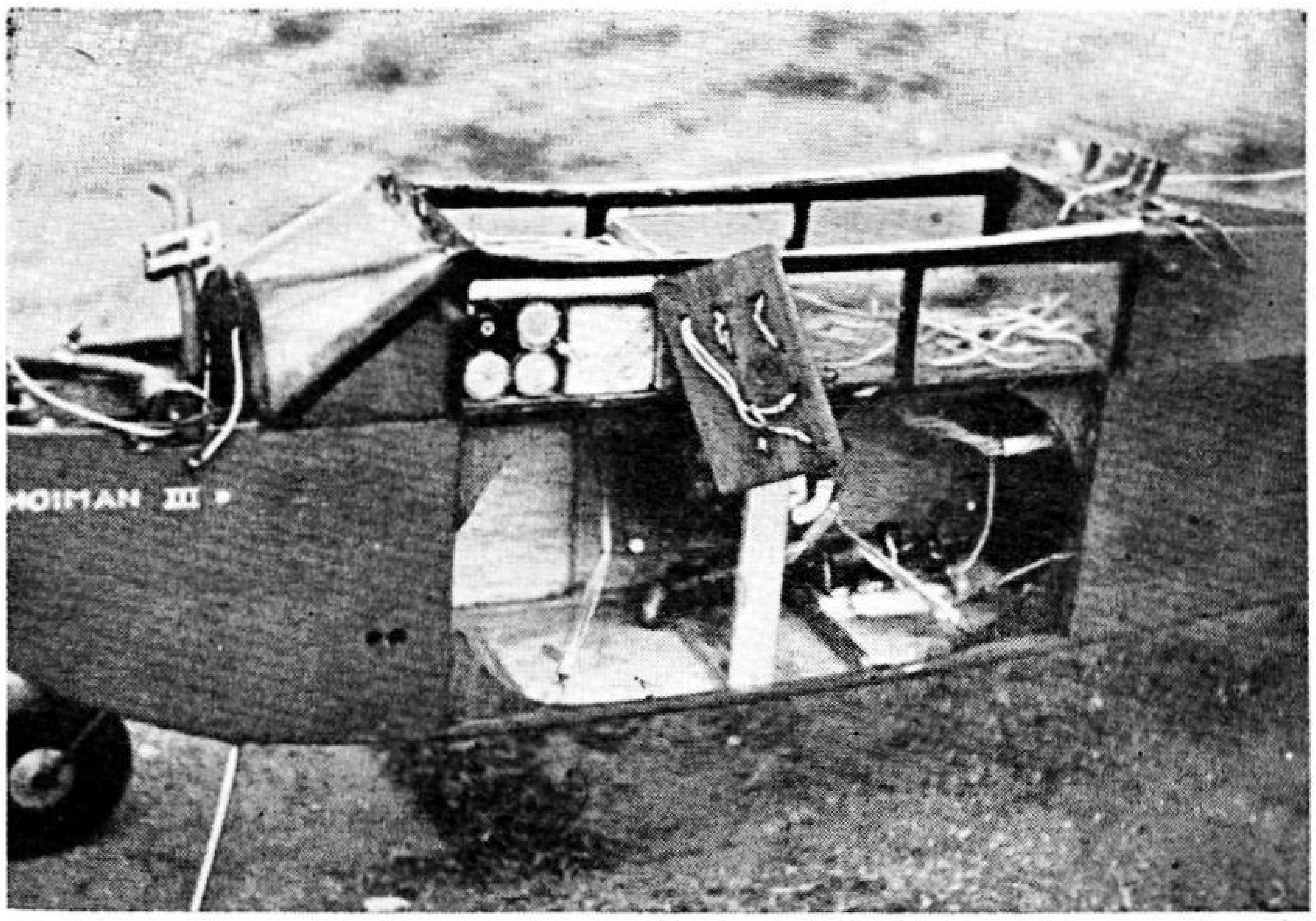

Fig. 4 Control panel uses simple homemade switches that have proven to be very reliable

and strain are in favor of the smaller, more compact structure. Consequently, if we want reliability but can't keep those rough landings from occurring now and then, the design policy for radio control should be—build 'em rugged.

Let's discuss some facts and figures. The model shown in Fig. 1 is not what we consider a final design but it approaches the theme of this discussion closely enough to serve as an example for criticism. Span is 4-1/3' and gross weight is 2-1/4 lb. Wing loading is 12.86 oz. per square foot. Span and loading are about right, but the fuselage is too narrow for good accessibility, which in turn is related to reliability. The model is quite fast because of its M6 wing section and flat trim. The speed is handy for penetrating winds, but in the future we may forsake this in favor of lower landing speeds. The landing gear is fixed rigged which is wrong. A very hard landing would either bend it or wipe out structure. The next design will have a rubber band shock absorbing gear that will allow fold back under extreme loads without breakage. The advantage of a tricycle gear still remains doubtful as we view it.

Fig. 2 shows the engine compartment. The *Ohlsson 19* glow plug engine gives plenty of power. (That's not a high tension lead to the plug but a dress snap and wire to the old booster battery plug-in.) Needless to say, the change from spark ignition to glow plug has been a large factor in increasing reliability. The object on the left side is an electro-magnetic check valve and is part of the experimental fuel system. This valve (and a few other non-electrical items) provides two speed engine, normal cut-off and safety cut-off on glow plug. This fuel system is a long story and may be covered in a later article.

The engine compartment structure is not what it could be for ruggedness. For nose-in landings (that break the propeller) it might be better if the whole volume under the engine were filled in with a balsa bumper block that would transfer the loads to a wider area of the fire wall and aft structure.

Fig. 3 shows the receiver compartment. Access doors are all right but since this receiver needs so little attention after the pre-flight check-out, we may delete this large door in future designs and resort to wing removal. This goes for the receiver only. Other items like batteries should be much more accessible. The receiver is the *Aerotrol* form, using the RK61. The rubber band mount is an accepted standard and very near perfect, but a slack cable (of wire or heavy cord) should tie from the receiver to some strong point aft to prevent violent forward motion and subsequent recoil of the receiver in a very hard landing. This idea seems better than sponge rubber bumpers because it requires less room.

Opinions of this receiver are probably pro and con. It is much like an engine. You have to live with it and learn its symptoms before you can really operate it reliably. We like it because it allows the lightest installation weight which is so important to model ruggedness. What the future will bring in this all important item—the receiver—is not known. But, let us hope the free band will not impose too great a weight penalty as far as airborne radio weight is concerned.

There is more than one version of the RK61 receiver now available. Bill Nuckolls, of Santa Monica, Calif., makes a very good arrangement of it, and we are grateful to him not only for straightening us out on its proper use but also for helping with the supplementary instructions for it that appear later in this article. The total control installation weight on this airplane is 9 oz. This includes our basic minimum of rudder, elevator, two-speed engine, and cut-off. Battery life is generous; B batteries are the smallest hearing aid type and are kept above 50 volts with a charger. Four pen cells serve all low voltage requirements. The balsa block at the rear of the pen cell compartment is the result of a bad guess. When changing over from the medium flashlight cells which were required for ignition, we didn't know that pen cells could be so hot and thought we would need eight of them. The gadget behind the receiver is what we call a dive booster (for doing screaming dives) but since it is only experimental we won't report on it here.

What may look like the console of an organ on top of the fuselage is the switch panel. We like switches for everything for separate testing. These switches (which are shown more clearly in Fig. 4) can be homemade and they avoid use of the commercial slide type which are none too reliable anyway. Each switch is made with a short strip of .005 spring brass or bronze, and a convenient size dress snap. Hollow rivets are used to fasten each brass strip down to a 1/16" micarta or plywood panel. A knife slit is made in the plywood into which each brass strip is bent to prevent turning. A little skill is required to properly solder and align the dress snaps without impairing their operation. Male parts of the dress snaps are on the brass strips while female parts are soldered to hollow rivets or small wood screws in the panel. It's not hard—try it.

Fig. 5 shows the *Rudevator* installation. This is not so good. It would be better if the *Rudevator* were mounted on the left side of the vertical fin with a removable dirt protecting cover. Up and down elevator could then be easily adjusted by simply rotating the unit on its mounting bolt. The buried installation shown, with extension shaft, does not allow this.

What about the comparative advantages and disadvantages between this small ship and the larger 6 to 8' span models? In brief, the arguments might go something like this. The large model can be seen better at a distance and they fly smoother. True, but the small model can be flown in closer, because it requires less volume of space in which to maneuver. This is easier on the transmitter range requirements. The small model is capable of smooth flight but it does take a little more trial and error to trim it out. The large model, with its larger landing gear, will ride out a rougher landing terrain. Correct, but the small model is much less subject to damage if it noses over because it is more rugged. The large model flies faster and is better suited for bucking winds at a windy contest. Quite right, but it seems only logical to expect that if the popular concept of radio control leans toward the small model in the future as it has in other phases of model flying, the good old A, B, and C classification will be resorted to—and so it goes. In the end

(*Turn to page* 51)

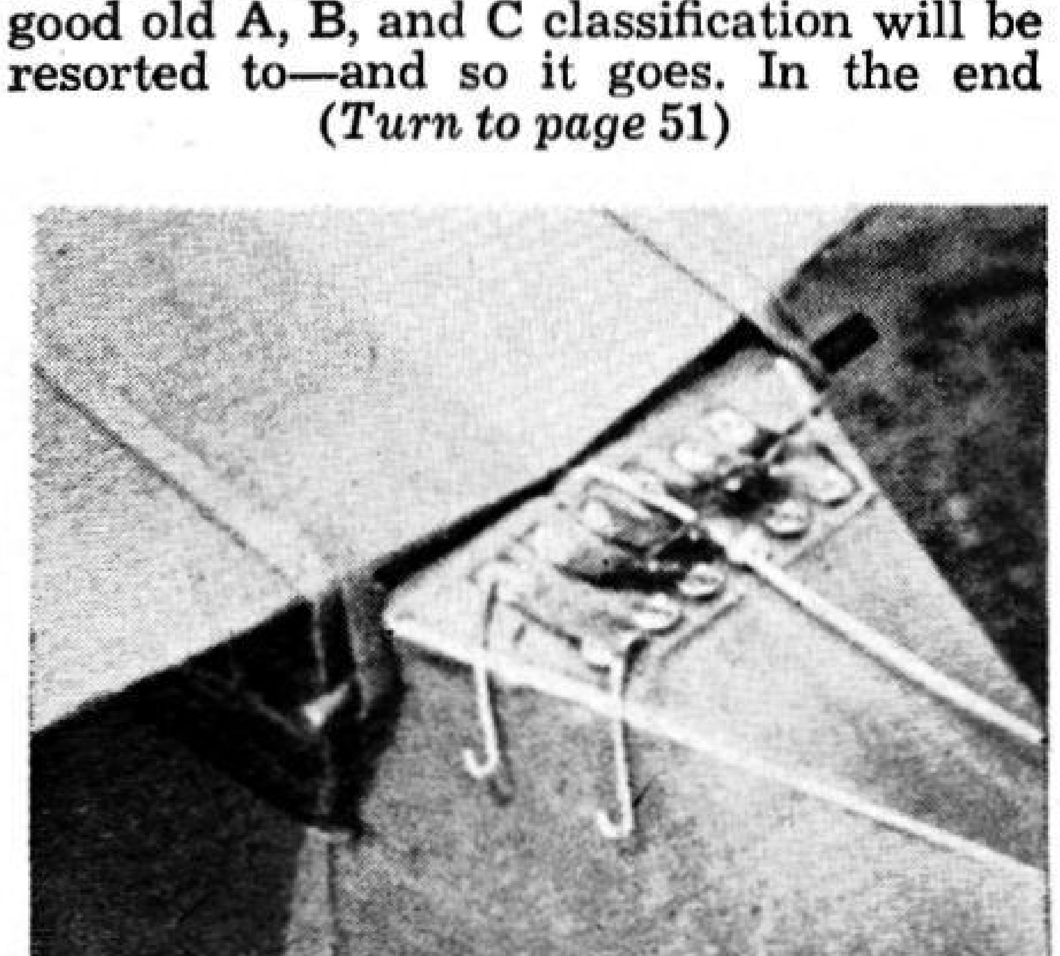

Fig. 5 Rudevator compartment near tail

Radio Control Reliability

(*Continued from page 33*)

though, we like the small airplane because you can put it in your car and still get the wife and kids in, without having to resort to prayer.

Unfortunately there is no such thing as a receiver that requires simply the flip of an ON-switch to be ready for operation. With such light weight requirements, this feature will probably never be realized. So don't think that your receiver is not airworthy. Knuckle down and learn how to operate it.

Here are supplementary instructions for your RK61 receiver. These instructions are the result of considerable experience. Individual experience and practice may call for slight revision here and there but on the whole, they should serve to greatly increase the reliability of the receiver for the average user.

Assuming that the receiver has been installed and connected properly, the operator should practice and become thoroughly familiar with the following ten-point check list. Once a receiver is adjusted properly and known to be in good condition, only items 3, 4 and maybe 5 will need a repeat check in the field.

1. Voltage check
2. Relay adjustment
3. Idling plate current
4. Transmitter tuning
5. Receiver antenna coupling
6. Antenna length
7. Receiver tuning
8. Meter wabble
9. Receiver response
10. Vibration

These check items are listed in the approximate order in which they can be made on a new receiver installation. Actually, they are made more or less simultaneously since they are inter-related and dependent on each other. Also, it takes much less time to do, than to read.

1. *Voltage check.* This is obvious. The RK61 receiver works best when A voltage is not less than 1.4 and B voltage is above 45. With the battery charger described in the March, 1949, issue of this magazine, it is an easy matter to keep batteries fresh. The use of a Centralab #NS13-25,000 ohm potentiometer in the B supply and either two #412E hearing aid batteries maintained well above 45 volts with a charger or two 413E batteries (a total of 60 volts) is highly recommended. The 60-volt batteries will require little or no charging.

2. *Relay adjustment.* The relay adjustment should always be checked on a new receiver. Once made, this adjustment seldom needs repeating unless a crash landing warrants it. The *Sigma* relay is easier to adjust than the *Kurman* (which is used in Aerotrol) because it is more rigid, and has screws for contact and spring adjustment. The armature of any relay should never touch the iron pole piece of the coil because sticking will result. The *Sigma* relay armature should be adjusted so that at 1.5 ma., light can just be seen between the armature and the pole. It is good practice on the *Kurman* relay to glue one or two thicknesses of tissue paper over the iron pole of the coil. This spacer is not necessary on the *Sigma* because of its extra rigidity. Detailed instructions for relay adjustment are not given here because experience shows that the operation must be understood rather than memorized for best results.

After the armature to pole gap is adjusted as above, there are two points to understand. Generally speaking these are (a) the contact spacing is used to adjust the relay sensitivity or pull-in to drop-out range on the meter scale, and (b) the spring tension is used to adjust the point of relay operation on the meter scale. The relay can be completely adjusted without use of a transmitter if the recommended 25,000 ohm potentiometer is used. Slowly swing the plate current with the potentiometer and note the pull-in to drop-out range on the meter. We want this to be about 0.1 ma. If it is much more, the contacts are spaced too far apart. Use only the "live" contact to bring them closer together since the "dead" contact (on the *Sigma* relay) has been set to control armature gap. If the pull-in to drop-out range is too small, move the contacts further apart. If the relay operation is difficult to hear, use the noise of the control escapement. Now adjust the spring tension to bring the operating range to the proper place on the meter scale. We want this to be around 0.8 to 0.9 ma. Increasing the spring tension will raise the operating point, while decreasing spring tension will lower it. Very little spring adjustment should be used; if too much is required, the contact spacing may need readjustment to maintain the 0.1 ma. operating range.

3. *Idling plate current.* This check is very common to the receiver and, of course, should be done in the field before each flight. An idling current of 1.1 to 1.3 ma. is to be recommended over higher currents because of increased tube life; 1.1 is preferred and can be used with the *Sigma* relay without fear of vibration effects. The *Kurman* relay should be operated at 1.2 ma. Care should be taken in using the potentiometer not to turn it the wrong way, as each surge of high current means that much shorter tube life.

4. *Transmitter tuning.* It is assumed that the transmitter is the commercial version that comes with the RK61 receiver. A new transmitter should be checked with the antenna on and clear of metal objects to see that the plate circuit draws at least 30 ma. If not, the antenna coupling coil should be moved in or out until it does. For flight operations, all work should be done with the transmitter antenna connected to prevent de-tuning. For bench testing, this is not necessary. The fact that the transmitter, with 135 volts and antenna connected, gives too strong a signal for accurate tuning, is taken care of under test item number 7. Tune the transmitter so that you get the lowest receiver plate current reading (0.1 to 0.3 ma.) as usual.

5. *Receiver antenna coupling.* Set the transmitter up in an open area, or on the flying field, with antenna connected. Have a friend stand by to operate it. Set the ship on the ground at least 100′ away (20 normal steps) and off the end of the antenna to avoid too strong a signal. Place the meter in the receiver circuit, turn the receiver on and call for transmitter on. Swing the antenna coupling condenser for minimum plate current reading on the receiver. This may or may not be lower than that obtained in step 4. Now turn the condenser back until the plate current just barely starts to rise. This is considered the optimum setting for a new tube. An ageing tube will require more antenna coupling than this, or enough to stop meter wabble as described under test item No. 8.

6. *Antenna length.* When a new receiver is installed, the antenna length should be as recommended by the manufacturer. The best length may vary according to the arrangement of wiring in the airplane and the age of the tube. With the ship still at least 100′ off the end of the transmitter antenna, try 4″ more and 4″ less antenna and repeat item 5. The best antenna length is the one that will give the lowest plate current reading (signal on) with the least antenna coupling of step 5. The antenna coupling adjustment is far more convenient than antenna length adjustment and they accomplish almost the same thing. However, increasing the antenna coupling raises the minimum plate current reading available with signal. To avoid too much of this, the antenna length adjustment must be resorted to especially as the tube gets older. Generally speaking, the older the tube, the more antenna length required. The antenna seldom requires lengthening in the field because step 5 is usually sufficient to get by for the day.

7. *Receiver tuning.* Still with the ship away from the transmitter and with signal on, here is a simple way to check transmitter tuning. A polystyrene screw driver is needed. Polystyrene is a very good insulator for radio frequency current and should be used in preference to other plastic materials, or wood. Radio stores sell these screwdrivers, or better yet, buy a length of rod and make a long one. Place the screw driver between the two end loops of the receiver tuned circuit coil, and spread these loops apart very slightly. This raises the operating frequency of the receiver. If the transmitter was previously tuned to the receiver, the receiver meter will rise. If it does not or if it reads less, the transmitter frequency is too high. Either re-tune the transmitter, or spread the receiver coils a little more until the meter stays down. Don't do too much coil spreading as this effects the receiver in other ways and may require the re-check of items 5 and 6. To lower the receiver frequency, push the top of the end loop of the tuned circuit coil so that it bends in very slightly. Observe as before—if the meter goes down, the transmitter frequency is too low. In this test, care should be taken to keep the hands well away from the ship as body capacitance might confuse the action.

8. *Meter wabble.* Wabbling of the meter

pointer while the receiver is idling at or near 1.1 ma. indicates fluctuating plate current and since the meter cannot follow all of this plate current change, the amount of change is even greater than indicated. The condition can become bad enough in flight to trip the relay. Meter wabble is an indication of tube aging. New tubes should not show meter wabble. At the first sign of meter wabble, increase the antenna coupling capacitance enough to stop it. With further aging of the tube, a point will be reached where further antenna coupling will cause erratic and improper receiver operation. The plate current may go down on signal and never come up, or it may never go down on signal at all. At this point, we resort to increasing the antenna length several inches (by trial and error) and at the same time reduce antenna coupling as in item 5. If the above procedure completely eliminates meter wabble, it is still safe to operate at 1.1 ma. idling current. A point will be reached in tube life where this procedure will not completely stop meter wabble. At this point we resort to using an idling current that is progressively higher until the wabble stops. As high as 1 6 ma., or even more, can be used so as to prevent the plate current fluctuations from reaching the relay operating point. At this stage, the 60-volt B battery is capable of producing safe tube operation. The tube life at this point is well beyond the published 8 to 10 hours. Finally a point is reached where all the extra attention required is well worth the price of a new tube.

9. *Receiver response.* Finally, before taking the ship back to the transmitter, have the friend send rapid pulses. The receiver should follow. If it misses a few, better leave it alone since flying any escapement control like Rudevator does not require very rapid pulses. However, if response is too slow, more antenna coupling capacitance may be required. Repeat items 5 or 6 or both carefully and improvement is certain.

10. *Vibration.* This test is covered in other instructions but is added here because it is actually the last test that is done before launching the model. With the engine running, hold the ship off the ground while your friend sends signals. If the control chatters through more positions than signals are sent for, then either a wire connection is loose or the receiver is mounted too rigidly which allows the relay armature to vibrate. This latter is *very unusual.* If the control still chatters through positions with the receiver off and servo (control) power off, the engine is shaking the ship too hard. More spring tension will be required on the escapement armature. At any rate, don't launch that ship until it is right. A ship in the hand is worth two in the next county.