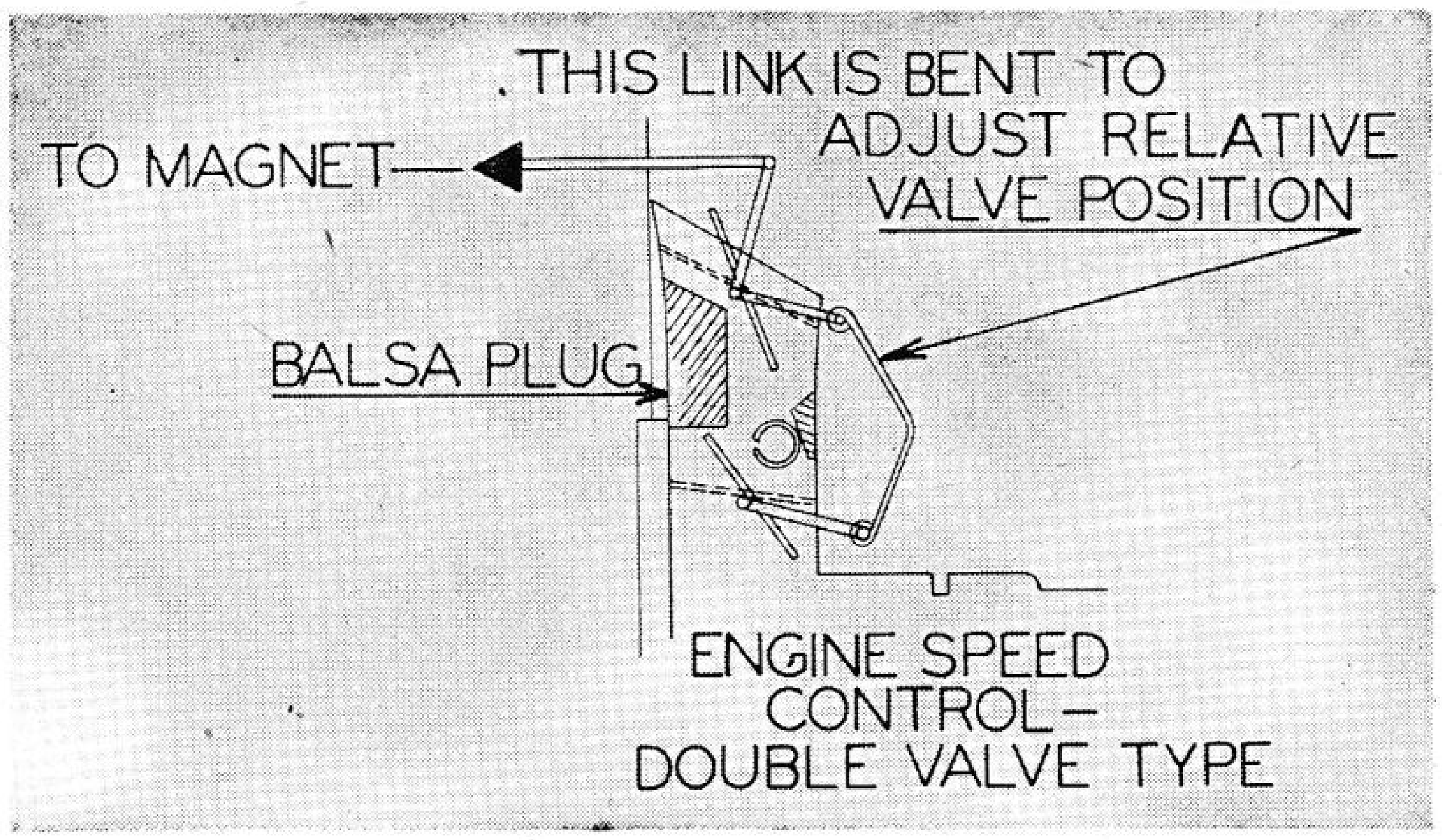


Fig. 1 The "double butterfly" system of speed control as applied to an *Ohlsson* engine

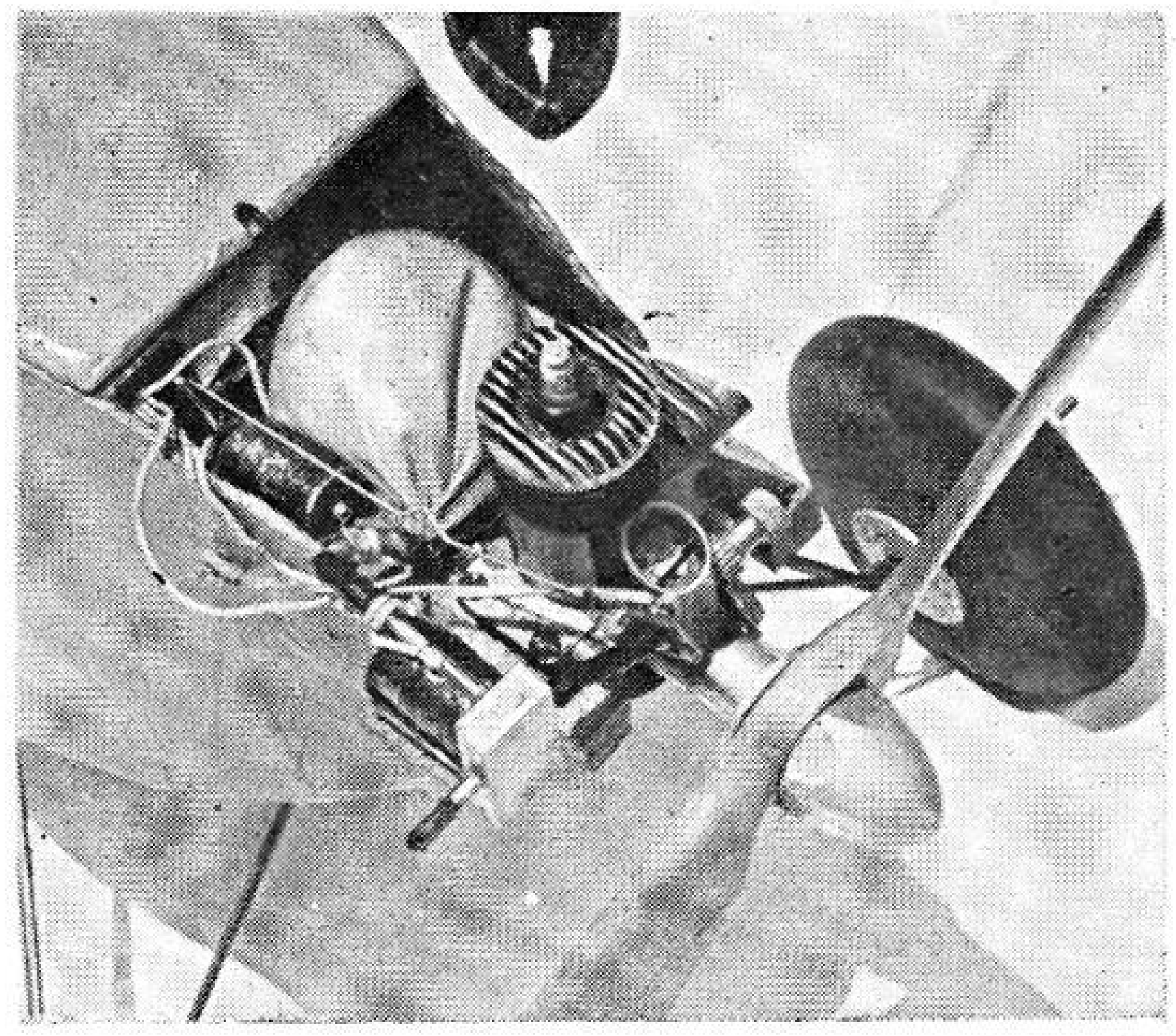


Fig. 2 An early power control system with balloon tank

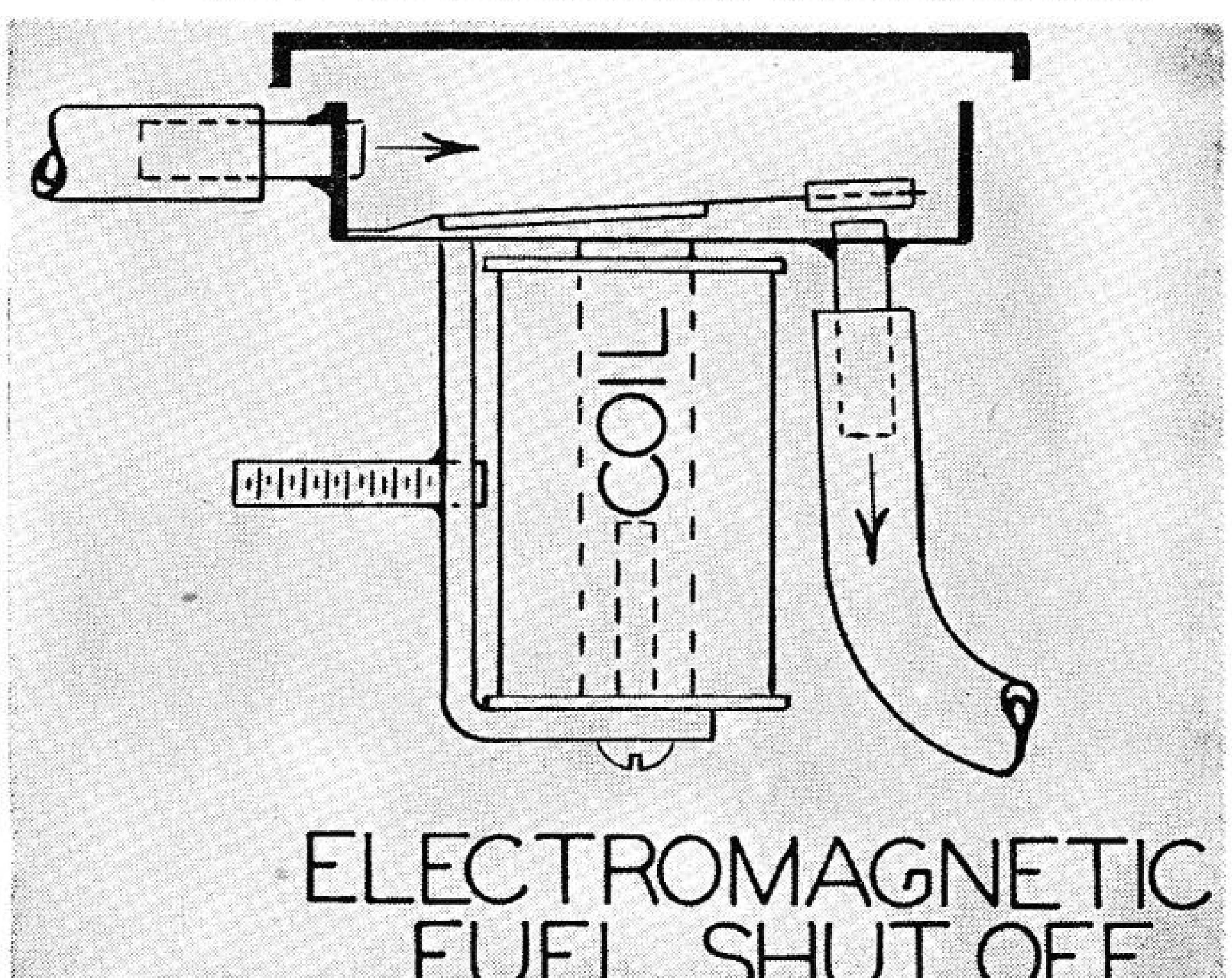
Power Control

PART ONE

DEEP in the mind of every modeler is a desire for realism—otherwise known as scale. Model aviation is primarily a hobby of miniature replicas. Unfortunately, exact replicas do not fly well so we must compromise on the scale appearance in order to gain (or surpass) scale performance. But the desire for realism lingers on. Maybe this article will offer some small measure of relief. It is addressed especially to all U-Control and radio control modelers who tire of the same old pattern in every flight and wish for some practical method of introducing a little variety. This article does not offer a new plan for a scale model but instead, a practical method for obtaining very nearly complete power control on glow plug—not just two-speed power control, like that which has been worked in the past on spark ignition engines, but proportional power control with glow plug, and several other desirable features as well. Since this fuel system required considerable time and experimental research on the part of the author, no regrets are offered for dragging the reader thru practically the whole story before revealing the final answer. Besides, the entire story may save others a lot of effort in case they choose to search for still another answer to the problem.

First, a general discussion: in U-Control a reliable method of power control can be a lot of fun in shooting landings, especially with a scale job. The old method of retarding the spark by switching from an advanced set of engine timer points to a retarded set never became very popular and the reasons are

Fig. 3 Cutaway view of the magnetically operated shut-off valve



understandable. The system gave only two speeds, one at screaming full power, and the other, at some power that was seldom quite right for landing. However, that's all history now. With this new system, any power from idle to full can be selected and held.

Power control is even more useful in radio control. True, it adds equipment to the airplane which requires a little more attention and disagrees with the basic rule of simplicity for radio control. But that simplicity rule is only an order of the day. It is good practice while radio control is new and it is especially useful to the beginner, but it could very easily be overdone. Some of us must stick our necks out and try something new or radio control will never get out of the rudder stage. Then too, this fuel system would not be published if it were thought to be no more reliable than power control was on the old spark ignition engine.

An important use for power control in radio flying is, of course, for touch- and go-landings. This is a realistic maneuver if there ever was one, and requires not only good power control but also some practice. It is not a perfect maneuver today but rather something to strive for in the immediate future. (We are still trying to do a good one at this writing!) A drastic power cut-back is required. These models are pretty efficient in the glide and if just a little power is remaining, that glide is stretched out to almost endless proportions. You would almost have to start the approach to the runway over the next county. Simple escapement operated flaps would help here but it is doubtful if they could be made simple and reliable enough to add more fun rather than just more trouble.

Another important use for power control is automatic altitude control. The power on a model with only single-engine speed must be set very low for a very important reason. The ship must be able to take off and climb to a safe altitude for maneuvering, but this fixed rate of climb goes on and on. In a matter of only a few minutes, even a large model can become a mere speck in the sky, unless considerable attention is paid to keeping it down. It is no wonder that large models are advocated. A small one would be out of sight when less than a mile away. Spiraling the ship down with rudder is possible but not entirely satisfactory. The spiral always builds up speed. Upon recovery, the model (unless handled very skillfully) will usually zoom back up almost to where it started. Then the spiral process must be started all over again. In the meantime the ship has no doubt drifted down wind. By the time it is flown back over head it may well be up to that high altitude again. Single-speed engine is a good idea when one is getting acquainted with radio control flying, and it is not a bad idea even for the initiated while the art is so new. However, let us hope that two years from now it will be largely a thing of the past—at least on an expert's model.

To consider the advantages of power control as an automatic altitude control, let's assume just a simple two-speed engine and then the advantages of a multi-speed engine will be obvious. With two-speed, the model can take off and climb rapidly to a safe altitude for maneuvering. Then, with power cut-back, it is a simple matter to keep the ship close in where both pilot and spectator can enjoy the fun. At reduced power, the ship

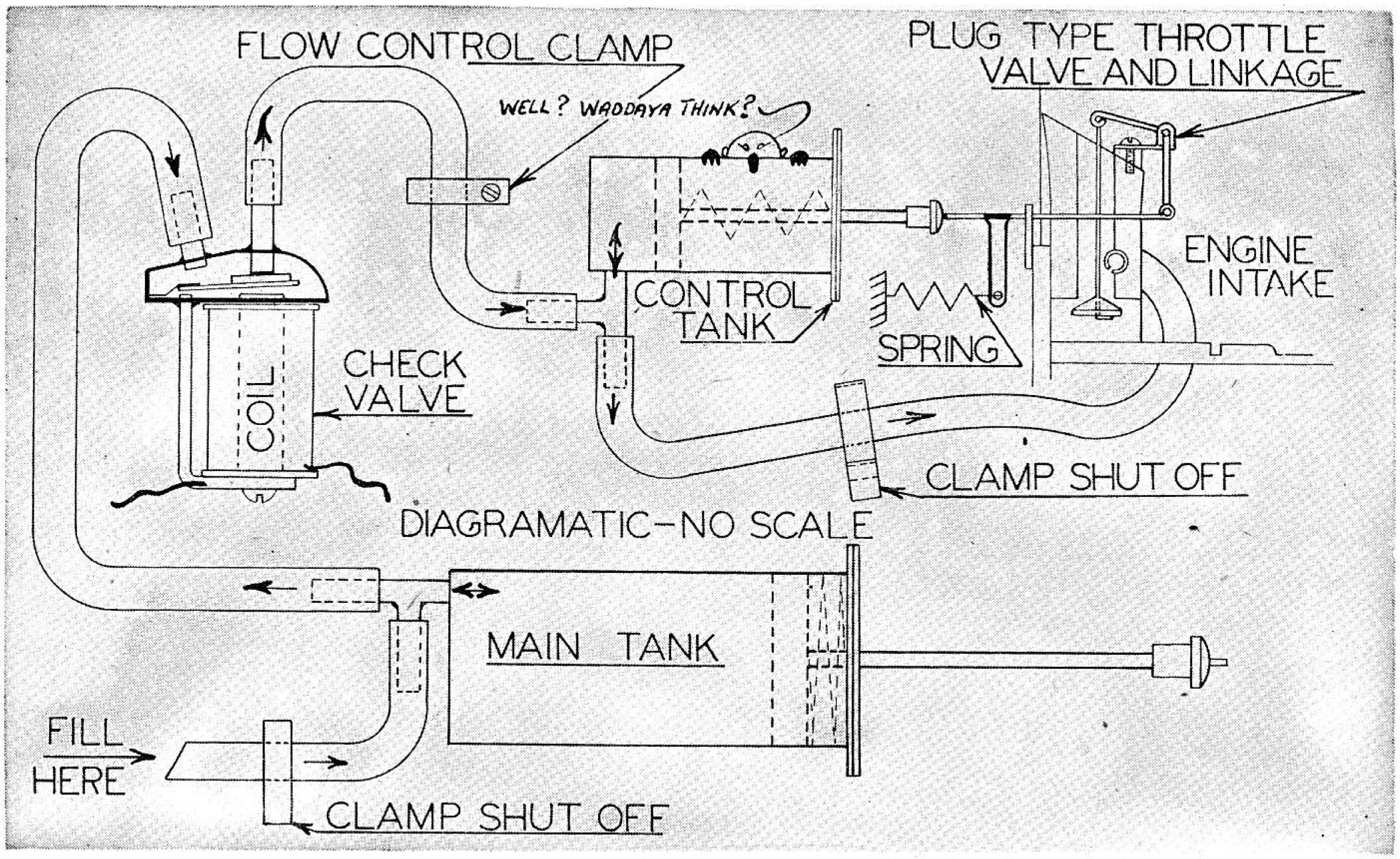


Fig. 4 The complete control system, arranged for use in a radio control plane. The various elements can be shuffled for different purposes

by H. H. OWBRIDGE

has either a very slow rate of climb or a very slow sinking speed. It is almost impossible to get that reduced rpm setting right on the button. If the ship still tends to climb away, holding a turn a little longer will cause it to lose altitude gently. If the ship tends to sink, a little full power now and then will keep it up there. While if the power setting is just right, the ship, if left alone in its large natural circle, will soon find its service ceiling and (assuming thermals are not too strong or numerous) never go any higher.

This last power setting is very difficult to find so a multi-speed power control is even a better solution. There are other ways to obtain altitude control. The Army uses only single-engine speed in their target ships but they have a trimable elevator. A short pull or push on the ground control stick moves the elevator up or down just a little and it stays there until signaled to move again. This type of control requires audio tone signals and electric motors, hence it is not so well suited to the hobby field. George Trammell has a very good proportional elevator control that installs in the ship for very little weight but it takes a separate transmitter and receiver to operate it. The least expensive method of altitude control appears to be in the field of power control.

An important part of the engine control subject is engine cut-off. If it can be had cheaply enough, it is well worth it. At present, radio control jobs are carrying a fuel supply that will run the engine from 6 to 12 min. The occasion often arises when it is desirable to terminate a flight before the fuel runs out. It is tough to be caught with a 10-minute fuel supply and not be able to stop that motor from churning away. Consequently, cut-off by remote control can come in handy.

But suppose you have lost radio contact with the ship. This means that your cut-off is useless and the ship could fly away with some 10 minutes' fuel aboard. The ship can be followed and found although it would be better if we had an emergency runaway cut-off, providing it doesn't cost too much in weight and complexity. This has been accounted for in the new fuel system. A quick cut-off should be considered too. At that all-important moment when launching a new ship (we don't free flight them without radio anymore) it would be nice to have a quick cut-off in case the ship showed spiral tendencies. So there are really three kinds of cut-off that are desirable. Let's refer to them as normal cut-off, runaway cut-off and crash *cut-off*. We feel their importance is in the order listed. Normal cut-off is most useful and simply operates when signaled for Runaway cut-off is less important because we have never had it before and we have never lost a ship. But we have done some nice chasing and since runaway cut-off should at least reduce this chasing and since we get the cut-off free, we gladly accept it. Crash cut-off is least important because it is only useful when launching a new ship. Once the ship is proven airworthy, crash cut-off is seldom needed again. We have had a quick crash cut-off in the past and found that it takes unusually quick action and a lot of luck to get that engine stopped in time to save the ship.

We have found that in launching a new ship, it is better to install the radio control complete, make sure the ship is trimmed straight and has no warped surfaces and that the C.G. is about normal or a little forward and that everything is working well at a distance from the transmitter. Then we launch it. If it shows a spiral tendency (and they have), it is just a matter of keeping cool or at least cool enough to fight the spiral until the ship is safely on the ground. If you lose the battle, there is always the glue pot.

Just how much equipment it will take to get all these cut-offs and power control depends on how it is done. There is one way to get such control and still keep the amount of equipment down to reasonable weight and complexity. This way is to have one part serve at least two or more purposes. That's the way it is with this fuel system. Power control is the major issue but normal cut-off and runaway cut-off are obtained as by-products at no extra cost. It would take extra equipment to get crash cut-off, so we would rather do without it.

There are three other problems which the reader should be reminded of before we go on. One is the problem of getting all this power control on a single radio frequency channel because it seems likely that only single channel equipment can become popular in the future. The second problem is related to the first. It would be better to have our control available on the simple cyclic type of escapement control because this type will always give the most control for the least weight. But in a cyclic system in which all controls must be passed through whether they are wanted or not, we must have a time delay so that we can avoid a power change and thus keep the power control separated from the aerodynamic control. This also is inherent in the fuel system to be described. The third problem has been with us for a long time and becomes apparent almost every time we try a violent maneuver. This is the problem of momentary air pick-up in the fuel line when this line becomes uncovered in the fuel tank. There is often air in the fuel line, but if the amount becomes too great it will stop the engine. Many tank shapes have been tried to avoid this. Those who do not have trouble simply don't do violent maneuvers. The elimination of this problem is another one of the extra features that are inherent in our fuel system. (*Continued on page 46*)

Power Control

(*Continued from page* 23)

When a system inherently solves so many of our problems at once, we feel that it is worth working with.

In order to review the story of power control for the record, we should go back to the days of simple two-speed control when the possibility of multi-speed operation was only a dream. This was not very long ago. Many hours were spent on the problem in connection with the spark ignition engine. Suffice it to say that the most common method of two-speed control on spark ignition is the double-breaker point method. Cut-off was handled by means of a thermal delay switch in the battery lead to the spark coil. This is all obsolete now and good riddance—glow plug has the advantage. The effect of glow plug fuels on airplane finish is mild and not considered as serious a problem as it was rumored. The price of glow plug fuels is a little high considering the quantities that must be consumed, but these disadvantages are outweighed by the fact that glow plug fuels will run on a wider range of fuel/air ratio than the old white gasoline. Besides the more trouble-free operation, the weight saved (spark coil, ignition batteries, condensers and timer points) cannot be ignored.

The problem of two-speed control on glow plug is quite different from spark ignition. There are no timer points to switch or electric circuits to open. Instead, we must work with the fuel and air alone. At first a simple choke was tried. This works in a sense but it is not very satisfactory. Although the choke reduces the amount of air that enters the engine, it also increases the rate of fuel flow drastically. You get reduced speed all right, but the engine consumes buckets of fuel and the exhaust products shower the ship with castor oil. It is necessary to maintain the fuel/air ratio within a reasonable range in order to operate with fuel economy and also to keep the exhaust reasonably dry. Next we tried a simple butterfly throttle even though it meant drilling holes in the engine. This might work if the air inlet to these miniature engines were high-class venturis, but this is not the case. All engines that we are interested in have more or less simple tubes for air inlets and rely on air velocity past the needle valve body to induce fuel flow; a throttle valve stops this air flow, so as a result, fuel flow stops. Hence the engine will not run because of too lean a mixture. Next, a double valve was tried as sketched in Fig. 1. The needle valve of our *Ohlsson 23* was straddled by two butterfly air valves linked together. The valve above the needle acted as a choke and the valve below acted as a throttle. For simplicity, it can be considered that the throttle reduces the air entering the engine, while the choke creates the necessary suction to maintain fuel flow. We still have one ship equipped with this method as shown in Fig. 2. A simple electro magnet (in the rear right corner of the engine compartment) operates the linked valves from wide open for full power to almost closed for low power. Since we use a Rudevator for control, the electromagnet is energized through a wiper contact on the Rudevator escapement wheel on the UP and neutral after UP control positions. This gives full power. All other control positions give low power since it is low power that is used the most in flight. The same idea could be worked on a simple rudder escapement in which, say, neutral after right would be high power and all other controls low power. Or, since this would make it necessary to skip neutral after right and dwell on neutral after left to avoid high power, perhaps it would be better to put high power on some half rudder control position even though more servo batteries may have to be installed in order to supply the escapement magnet for the time that the transmitter signal was held on to get full power.

When it comes to experimenting with these extra controls, Rudevator has the advantage because it has four neutrals to play with instead of just two. Another way of saying it is that for a given four-point escapement wheel, Rudevator gives four controls (right, down, left, and up) and four neutrals (one between each control) whereas the rudder escapement gives only right and left rudder and only two neutrals. The half rudder positions in between are (in actual practice) wasted. However, the double valve power control will operate with any escapement control. The reasons why we consider it obsolete are as follows: it is intricate and requires drilling holes in the engine to install. Also it does not include cut-off. For cut-off we tried a thermal delay operated fuel cut-off. This worked but again it was not satisfactory. Unless bimetal thermal delays are compensated both for air temperature and battery voltage they are guess work at best. Next, we developed a fully enclosed magnetic check valve. This valve in its experimental form is shown hanging outside the engine compartment in Fig. 2 and Fig. 3 is a sketch of it.

The valve is operated by an electromagnet and it turned out to be easier to build than expected. In fact, Dick Schumacher built it, and he has never been known to wind a coil in his life. Since the valve is enclosed in what is the equivalent of a very small fuel tank, about a three-second time delay occurs before cut-off which is just what is needed. The contact for this electromagnet cut-off was obtained from another wiper on the Rudevator escapement wheel and the neutral after down was chosen for the cut-off control position.

Much flying was done with this double magnet, double valve two speed and cut-off combination. Gradually the disadvantages became apparent. Two magnet coils for power control was not exactly intolerable but it was certainly a high enough price to pay. More important were the facts that batteries were being used too much of the time and two more pen cells had to be added to get a reasonable battery life. Then too, when we wanted full power, the sudden surge would nose the ship up and make smooth flying difficult.

We feel that two engine speeds are just not enough. If we set the low speed low enough for touch-and-go landings, then we had to be very careful on that first turn after take-off because rudder would give us the low speed and the ship would threaten to sag in the turn and hit the ground. On the other hand, if we set low speed high enough to take care of this, we could never get the ship down with the motor running for a touch-and-go landing. There was an optimum power setting for low power that would work but it was always too hard to find and maintain.

It was obvious that we needed at least three engine speeds to meet all requirements. This could be done with a lot of machinery but how could it be done *simply?* Admittedly it took a lot of time, (but then there wasn't much in the way of brain power to work with!) and Mother Nature was waiting at every turn to see that we didn't get something for nothing.

Our present method of power control may well come as somewhat of a shock to those who are used to using a simple tank and a piece of rubber hose for a fuel system, but that is a typical reaction to something new. Furthermore our new fuel system is pressure-operated. That alone will probably raise the eyebrows of many modelers until they realize how low the pressure really is and how simple a pressure fuel system is to handle.

Credit must go to Jim Walker for revealing the possibilities of a pressure fuel system to the author. Jim has been working with pressure for some time in order to lick some problems of his own. Jim also gave us the idea of the balloon fuel tank which appears in Fig. 2 and which served pretty well as an interim fix for the fuel feed problem in the violent maneuvers mentioned earlier. However, the balloon tank was messy and is now also a part of past history.

In order to have a name, we call the latest arrangement a "control tank" fuel system, because the whole idea revolves about a control tank which serves several func-

(*Turn to page* 48)

tions. Once the control tank idea was latched onto, many different configurations were tried starting, of course, with the most complicated and ending with what we think is the most simple. However, the system has many possibilities and users may choose to juggle the details a little. In time we probably will ourselves.

A complete discussion of the pros and cons of the system and plans for building its component parts will appear in a succeeding issue but with the space remaining we can at least get started on an introduction. Much of the development work consisted of simplifying the parts so that commercially available parts could be utilized. This is especially true of the engine. Some time was required to find a type of air valve that was simple and universal enough to be installed in any engine without too much exacting workmanship and without requiring that holes be drilled in the engine. The whole project came to a grand climax when a real universal valve was found.

Fig. 4 will help to convey the theory. The main tank is a large size *Austin* flight timer. With a little rework, this item is very satisfactory for the purpose and affords a fuel supply under slight pressure. Fuel is held in the main tank by the electromagnetic check valve, but flows through the latter when the valve is energized by a couple of pen cells. The construction of the electric check valve is similar to that shown in Fig. 3. (Full plans for it will appear in the next article.) From the check valve the fuel goes to the all important control tank. This is another *Austin* flight timer, but this time we use either the *Austin Timerette* or the still smaller *Baby Timer*. The spring in this timer is replaced with a much lighter one. From the control tank, the fuel line goes on to the engine needle valve.

All of the main tank volume is used but we need only a part of the control tank volume. When the electromagnetic check valve is opened (either by radio or by controline switch), fuel flows from the main tank into the control tank and forces the control tank piston out under very light spring pressure. This motion is the heart of the fuel system. The motion is linked to a plug type of throttle valve in the engine air inlet. We said before that a throttle valve would not work, with these small engines and their simple tube air inlets, but we were talking then about suction fuel systems; now we are talking about a *pressure* fuel system. The light spring in the control tank forces fuel into the engine and at a rate that is reasonably correct for the amount of air that the throttle valve is letting into the engine. Because of this very useful pressure, the control tank doesn't need to be near the engine. The piston rod motion can be extended from almost any convenient distance to the throttle valve.

With fuel under slight pressure at the needle valve, the fuel feed problem in violent maneuvers is taken care of. Fuel flows from the needle valve under the combined action of both pressure and engine suction. Therefore, when the engine stops, the suction stops and the fuel flow all but stops so the problem of flooding the engine is not near as great as one might expect. However, there is an ideal way of doing everything so we choose to mount the engine on its side with the intake tube horizontal. A detail in the rework of the control tank also has a solution for this problem.

It is the details that determine whether any theory will work or not. For instance in this fuel system, when the control tank fills, the piston rod moves the engine throttle open toward full power. Nevertheless, we don't want this to happen too fast or it will be tricky to control, so an adjustable clamp is added to the hose that leads from the check valve to the control tank. This is used to adjust the rate at which the control tank fills when the check valve is opened. Another detail is a very simple hose clamp between the control tank and the engine needle valve. This is used in ground handling to shut off this line so that the needle valve setting need never be disturbed from its adjusted position. When the check valve opens, our present setup is adjusted so that full power is attained in about 2 secs. from idle. The control tank stroke is adjusted to give about 50 to 60 secs. of engine run before low power idle is reached.

In practice, very little attention is needed to control power. Remember, we use Rudevator which is a cyclic control. This means that we go through the check valve operating position once in every revolution of the escapement wheel. Therefore, the control tank gets a pip of fuel every now and then whether we remember it or not. This power control position is the neutral after down. If the ship is obviously sagging for want of power (whether we can hear the engine or not), then a short dwell on neutral after down will pour the coal to it. On the other hand, if the ship is obviously climbing away because of too much power, then we have been going through neutral after down too slowly and must remember to get through quicker the next few times. How do we get cut-off. That's simple. Just stay off of neutral after down and in less than a minute the control tank will run out of fuel because it can't get any more from the main tank. Runaway cut-off is very similar. If we can't get a signal through to the ship, then we can't get fuel through to the control tank.

How do we get low enough power to do touch-and-go landings? How do we keep the control tank from running out of fuel when it is near empty? How do we cut the engine if the ship runs away while in neutral after down? Don't worry, it's all figured out for you. Come to the next meeting in Part Two which you'll find in the January issue.