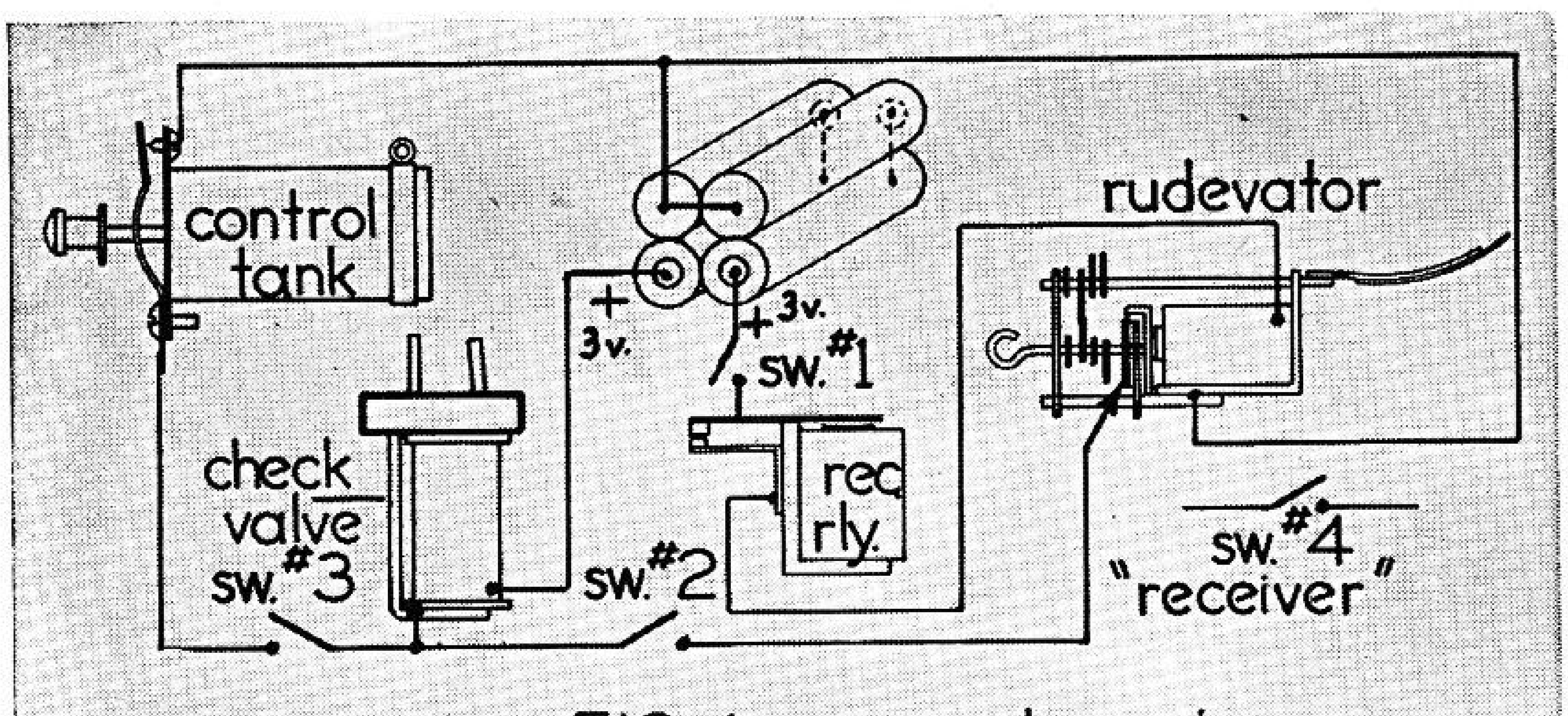

FIG. 1 - wiring diagram

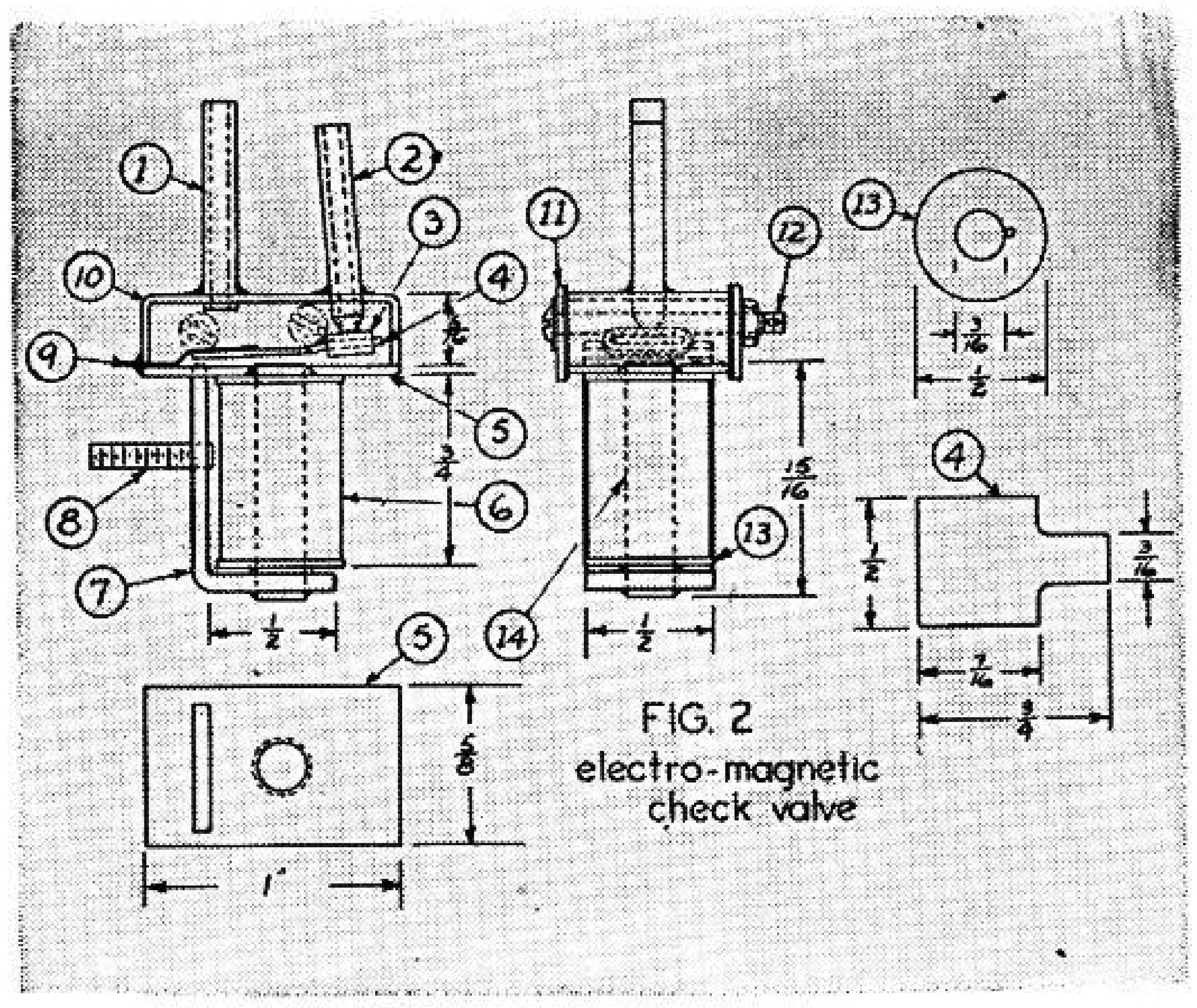
FIG. 2 electro-magnetic check valve

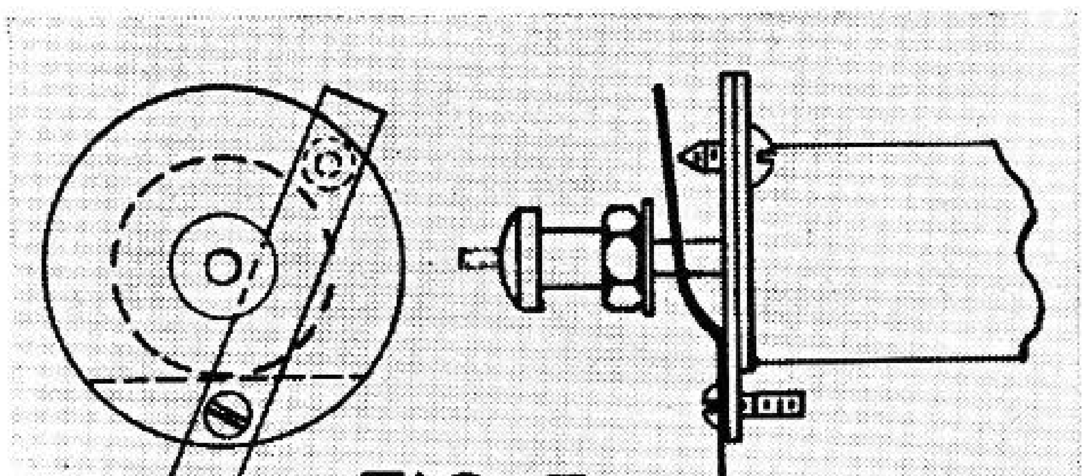
FIG. 3 control tank low level switch

# power control

By H. H. OWBRIDGE

## PART TWO

THE first half of this article summarized the reasons why a satisfactory method of glow plug engine control was desirable and how it could increase the enjoyment to be gained from both U-Control and radio control flying. A brief history was given of the experiments that gradually led to the present "control tank" fuel system and the operation of this fuel system was described. In this half of the article the methods of fitting the fuel system to the actual conditions of flight will be discussed and directions for fabrication and operation will be given.

For review, study the diagrammatic sketch of the fuel system on page 23 of the December, 1949, issue. Fuel follows the arrows from the filler tube to the main tank, then through the electromagnetic check valve to the control tank and then to the engine needle valve. When battery current opens the check valve, fuel under pressure in the main tank moves the piston of the control tank. This motion opens the engine throttle valve and at the same time, by means of a light spring in the control tank, increases the flow of fuel to the engine so that a satisfactory mixture is maintained. The flow control clamp between the check valve and the control tank is used to regulate the rate at which the engine goes from idle to full power. The time it takes for the engine to go from full power back down to idle is regulated by means of the stroke of the control tank piston. As the control tank empties, the return spring closes the throttle valve. The hose clamp shut-off between the control tank and the needle valve is added so that it is not necessary to disturb the needle valve adjustment in order to shut off the fuel system.

The fuel system is exceptionally easy to handle and most of its components are designed from readily available parts. The other parts are easily fabricated with the exception of the check valve which might take a little more patience. A wide variety of adjustment is available to suit individual requirements. Although primarily developed for radio control, this fuel system lends itself well to U-Control and should introduce the maneuver of "land, taxi and take-off" into the U-Control scale event.

In U-Control, the control tank fuel system can be operated two ways. A couple of pen cells can be made to energize the electric check valve by means of a spring contact on the bellcrank so that contact is made somewhere between neutral and full up elevator. Thus, to increase power, the control handle is hauled back or eased back depending on the flight speed at the time. Low power is achieved by flying level for a few seconds while the control tank piston moves in. Proper adjustment, of course, is all up to the individual and his particular airplane. A second and fancier method would be to rework one of the relays that were intended for two-speed control on the old spark ignition engine. These relays are of high resistance and suitable for use with high-voltage batteries through insulated controlines. The relay can be reworked into an electromagnetic check valve by following the plan of Fig. 2. This should prove easier than using the dimensions of Fig. 2 since it would eliminate the necessity of winding a 1,500-ohm coil. The insulated controline method, although more expensive, has the advantage of separating the power control from the flight control.

This fuel system is well adapted to a large fuel supply because cut-off is assured and if failure occurs, it fails safe. For instance, if batteries run down, the electric check valve cannot be opened so the engine runs out of fuel in 30 to 60 secs. or less depending on the control tank stroke adjustment. If a large size Austin flight timer is used for the main tank, experience shows this to be a 4- to 5-minute fuel supply for an *Ohlsson 19* engine. All engines will differ a little so individual experiment is necessary. If 4 min. is not enough for U-Control, then two Austin timers may be connected in parallel. An even better main tank can be found in the several types of rubber bulbs available at drug stores or photographic shops. These will be discussed later. Let's analyze the fuel system from the radio control viewpoint.

As mentioned before, the control tank fuel system has many features that are ideal for radio control flying. Engine cut-off is a natural as is safety cut-off in case of a runaway airplane. The available rpm range on glow plug is well beyond what was possible with the spark ignition engine. This is largely due to the inherent retarding of the point of ignition as the glow plug cools down at low speed. Low rpm sounds something like "ke-puckity puckity queep" and is quite amusing.

The fuel system blends in very well with a cyclic type of control such as the Rudevator, in which all controls must be passed through whether wanted or not. The inherent and adjustable time delay action of the control tank allows the power control position (we use neutral after down) to be passed through with negligible effect on engine speed. The amount of thought necessary to regulate power in flight is much less than might be expected. For the most part, one can forget about power control until it becomes a main issue in the flight pattern. It calls for a simple habit to be formed whereby the operator goes through the neutral after down position at a normal rate. This automatically transfers a quantity of fuel from the main tank to the control tank and keeps the engine floating within a narrow rpm range. It is not necessary to hear the engine. If the ship appears to be steadily losing altitude then it is obvious that the neutral after down position is not being dwelled on long enough in passing through. It is a simple matter to return to this position and boost the rpm a little. On the other hand, if the ship appears to continually gain altitude, neutral after down is being passed too slowly and the operator should get through it faster on the next few turns of the control handle.

What about when it is desired to hold minimum rpm for a long time while making a long descent? Since the control tank will be almost empty at minimum speed, must we worry about it running out and leaving us with a dead engine?

The answer is no, because a simple switch similar but lighter than the one that came on the Austin timer is installed on the control tank. Just before the tank runs dry this switch closes and pops the check valve open. The control tank gets a pip of fuel which moves the piston out a fraction of an inch and immediately opens the switch again. This process goes on automatically so that at minimum power we can forget about the engine. It will run at minimum power until the main tank runs dry.

But now we have no cut-off. After all the discussion about cut-off that has gone before, it seems a shame to inform the reader that there is no such thing if the minimum level switch is used on the control tank. But who cares. If that engine is going "ke-puckity puckity queep," that airplane is coming *down!* The same goes for runaway safety cut-off.

Here is another good question. Suppose we were to lose contact with the airplane while the Rudevator was in the neutral after down position. The check valve would be energized open and the engine would go to full power and stay there. This could only happen on one neutral out of four but it could happen. The solution to this problem requires no extra gadgets. We simply apply a little more than the required pressure to the main tank so that when the control tank is out against the stop with the check valve stuck open, full main tank pressure is being forced fed to the engine. This will give a blubbering rich mixture and the engine will either die or it will gulp the whole fuel supply so fast that the ship won't be able to run very far.

This extra pressure on the main tank serves another useful purpose. With the ship at a distance and the engine difficult to hear, the operator could have the control tank filled to the stop and not realize it. At one time, another control tank switch was thought to be necessary to prevent this. Not so in practice. If the control tank is against the stop and you try to get more power by dwelling on neutral after down, the trail of blue smoke from the rich mixture will soon indicate the condition. However, this case has little reason to occur unless the operator is just plain throttle happy. As mentioned in the previous article, the fuel system can be juggled to suit.

Fig. 1 shows a typical wiring diagram. It too can be juggled. Switch No. 3 is thrown in just in case you might want to try a flight with the control tank minimum level switch inoperative and thus have complete cut-off available. Four pen cells are shown as a minimum battery supply. Notice that half of the pen cells go to the Rudevator and half to the power control. This is in case you get caught in the air with low batteries sometime. It's all right if the check valve can't be opened but we wouldn't want the Rudevator to quit. For U-Control of course, the wiring diagram is much simpler and since the engine can always be heard, even the control tank minimum level switch can be omitted if desired. Switches 1 to 4 of the diagram are best made from dress snaps as mentioned in a previous article (Oct. '49, MODEL AIRPLANE NEWS).

Fig. 2 shows how an electric check valve is made. Brief comments on parts and construction follow. Numbers refer to the circled part numbers of Fig. 2. (1.) Inlet tube — 1/8" brass or copper soldered in cover as shown. (2.) Outlet tube—same as 1 except lower end is

(*Turn to page* 42)

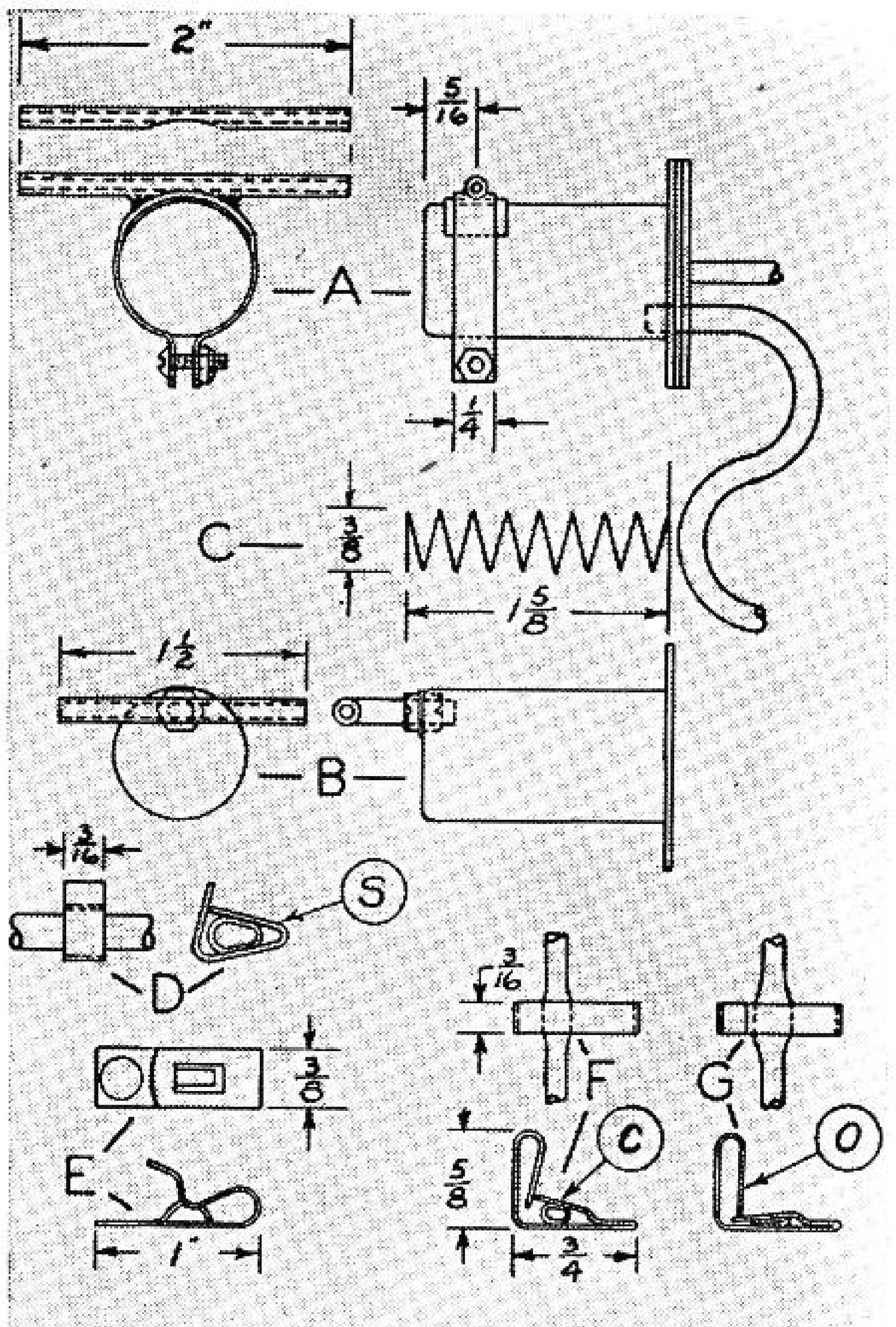


FIG. 4
some all-important details

**Further details on constructing and operating a flexible fuel system for glow motors**

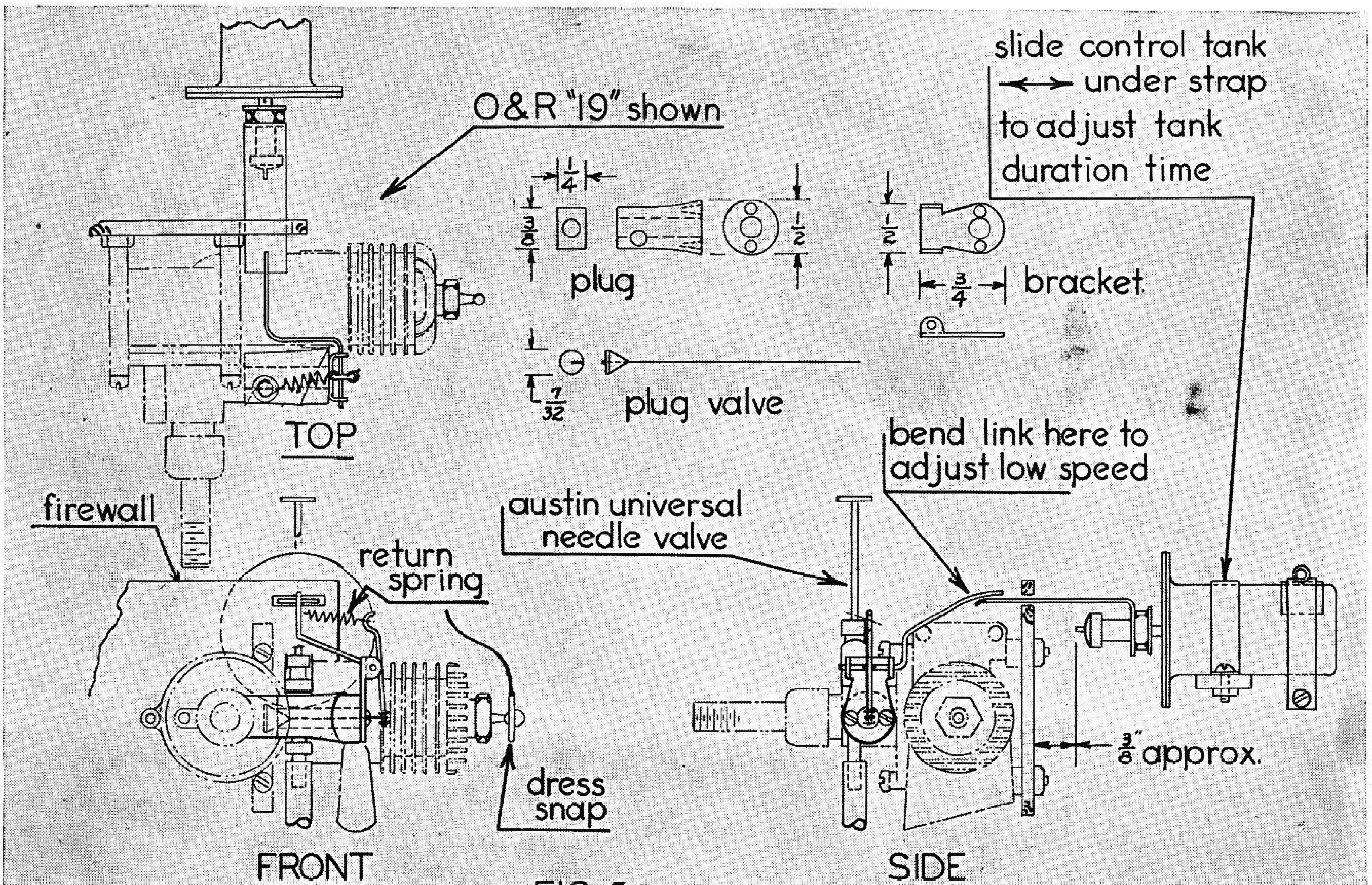


FIG. 5
plug type throttle valve and linkage

## Power Control

(*Continued from page* 27)

beveled and polished to give a seat of minimum area and the tube is slanted to align with the valve. (3.) Check valve. This is a very short piece of fuel line hose and is stretched tightly over part four. (4.) Armature—.020" to .040" sheet iron or steel. Bend as shown so that part three allows the armature to come close but not touch the core of the magnet. Watch the 3/16" dimension of part four. It is a guess and depends on the size fuel line used so as to give a tight fit. (5.) Valve chamber bottom—1/32" to 1/16" brass. File slot and hole as shown in detail to fit coil core and pole piece. A good fit is not necessary since solder will fill the cracks upon assembly. (6.) Coil—wind almost full with No. 30 enameled copper wire. Scrambled turns are all right since the resistance will come out close enough anyway. The coil can be wound in many ways but the technique described here and shown in Fig. 2 assumes that a minimum of tools are available. Here's how. Obtain a two- or three-inch length of 3/16" iron or steel rod for part fourteen. It might be found in a large bolt or wood screw. Don't let anyone talk you into buying a fancy piece of special magnet iron because there just isn't enough to be gained in this case. File out two washers (part thirteen) from .040" or .062" micarta or fibre. Drill a small hole as shown near the center hole in one of them. The center hole should fit close to the iron rod. Push these two washers on the iron. Now solder a fine copper wire a little more than the thickness of part five from one end and another wire about 3/4" away from it. These wires will serve to hold the washers on the rod when the coil is wound. Spread the washers on the rod and glue a thin layer of paper on the rod between washers. Set a hand drill in a vise, chuck the iron rod in the hand drill and wind the coil. Start by threading the coil wire through the small hole that was drilled in one of the washers. This lead is now out of the way and is later soldered to the iron pole piece for ground. A good cover for the coil that is not effected by glow plug fuels has not yet been found so just take a hitch in the last turn to hold it down—fuel will not effect the enamel on the wire. Saw off the iron rod about 1/8" from the coil. (7.) Pole piece—.040" to .062" sheet iron or steel. (8.) Mount bolt—No. 3-48 or No. 4-40 machine screw tapped or jam fitted and well soldered into part seven. Use the screw head while fitting and then saw the head off. (9) Armature leaf spring —.005" spring brass or bronze—1/2" wide. (10.) Valve chamber cover—1/32" brass 5/8" wide. (11.) Valve chamber side plates —1/32" brass. (12.) Thru bolts—No. 3-48.

Start assembly by soldering coil six in the hole of part seven. Mount and solder part five and then file the coil core and pole piece almost flush with part five. Solder part nine to part four and then solder to part five. Top off with parts one, two, and ten. Test valve by sucking on tube two before closing chamber with end plates eleven, nuts, bolts, washers, and gaskets. Valve should travel about 1/16" and the armature should not touch the pole. The valve should just operate at 1-1/2 volts so as to be safe on three volts. File or sand edges of chamber flat before sealing closed. (It is hoped that this valve may be made available commercially or we may consider furnishing it on request.)

Fig. 3 shows how the control tank low level limit switch can be mounted. Switch arm is .005" spring brass and a fibre washer is added to the piston rod for insulation. Point the contact screw for good contact thru any castor oil that may be present and make the spring action as light as possible.

Fig. 4A shows one method of mounting the inlet and outlet tube on the control tank and Fig. 4B shows an alternate method. Take your choice. Either the Austin *Timerette* or the *Baby Timer* can be used. The larger one of course gives more push for a given fuel pressure. In Fig. 4A, the tube is soldered to a strap of 1/32" brass and mounted over a small hole in the tank with a 1/32" rubber gasket. The tank should be mounted in the airplane with the brass tube on top, not at the bottom as shown in Fig. 1.

If a large Austin timer is used for the main tank, the same holds true and the rework is identical to figures 4A or 4B. The rubber hose at the other end of the tank can be added along with a gasket under the tank end cover to provide a drain overboard in case the slight fuel seepage past the leather piston becomes objectionable. In the main tank, the original spring is used but in the control tank a new spring is made about as shown in Fig. 4C. Ten to fifteen turns of .020" music wire are wound close and then pulled to the size shown.

Fig. 4D shows the simple flow control clamp that goes on the hose between the check valve and the control tank. Squeeze with pliers at S to reduce the rate of flow and hence the rate at which the engine accelerates.

Fig. 4E shows the approximate size of Fashnstock clip to buy for use as a shut-off valve on the fuel system filler hose. A little bending with pliers may be required to get it working right.

Fig. 4F shows how the engine shut-off clamp is made that goes on the hose between the control tank and the engine. 1/32" brass is used as usual but all dimensions can be varied to suit. Fig. 4F shows the valve open; squeeze at C to close. Fig. 4G shows the valve closed; squeeze at O to open. This little gadget is a great help in the ground handling of the engine.

Fig. 5 shows throttle details for an O & R engine. This plug type valve eliminates the necessity of drilling holes in the engine and it requires the least accuracy of workmanship to get a satisfactory fit. The principle of this valve can be applied to almost any engine by changing the details to suit. Of the three views, some parts are omitted for clarity. The dress snap on the glow plug is just an incidental idea thrown in for the record. The wire is run to a booster battery plug and simply saves a few more of the clumsy motions necessary when starting the engine. The throttle linkage shown is about as simple as can be made. Spring brass wire (0.040") is used, and in the side view an adjustable cam action is obtained by bending the wire.

The plug must fit well in the intake of the engine to be sufficiently airtight because any air leakage will make it impossible to get a really low rpm. This plug can be made by pushing a wood dowel into the main bearing of the engine and filling the intake with melted solder, but a preferred method is to carefully shape a rubber or neoprene plug that gives a cork fit in the intake. The needle valve serves to hold it in. Get an Austin *Universal* needle valve, as the *Ohlsson* valve has no seat and doesn't shut off well. Look for plug material in the rubber eraser line or tear a hunk off a truck tire while the driver isn't looking. The rubber must be soft enough to seal well but hard enough to mount the throttle valve bracket which is made of 1/32" brass. Saw the plug off about 3/16" below the center of the needle valve hole. Don't try to drill the final sized holes in the rubber but start small and finish with a rat tail file; 1/8" to 3/16" is plenty of diameter for the air intake hole. The plug valve is made from 1/4" brass rod. Hold the rod in a hand drill and put the hand drill in a vise. Drill a small hole in the rod and then taper with a file while turning the hand drill. Saw off the finished plug and solder in a length of .010 music wire. Getting a nice swivel connection between this wire and the valve rocker arm is a small but fussy job, so take your time. Use your head on the rest of the details; this article is getting too long!

A very satisfactory main fuel tank comes already made in the form of a rubber bulb. Ask a druggist for an infant size rectal syringe. Don't be surprised if he gives you a queer look. Just explain that it's for a radio controlled airplane; this will probably cause him to close the store and go home early. In fact, rub it in by buying two syringes. One is used for the main tank and the other is used as a filler bulb. The one for the tank is lashed down to a plywood floor or bulkhead with enough rubber bands to give the required pressure.

(*Turn to page* 44)

Place a piece of square balsa on top of the tank to keep the rubber bands from sliding off. Push a piece of hose line over the spout of the tank and lead this to a tee that is made from two pieces of 1/8" copper or brass tubing. Mount the tank with the spout up so that all air will escape by the time the engine is started and running well.

The syringe that is used as a filler is much better than a pump can because all air can be removed from it with a gentle squeeze before the fuel is transferred into the main tank. Here's how to fill the filler bulb rapidly from the fuel can. Solder a short length of brass tube into a hole drilled into the fuel can cap. Don't run it to the bottom of the fuel can but stop it short inside the can cap. Put a short hose on the brass tube or on the filler bulb spout. Now, pressurize the fuel can by squeezing the volume of the filler bulb into it. Then turn the fuel can upside down and rest it on the edge of something. The pressure in the fuel can will fill the bulb in a hurry. Before filling the main tank, squeeze the filler bulb until solid fuel runs out. Connect the filler bulb back to the fuel can and let it hang there for storage.

Just a few hints now on how to operate the control tank fuel system. The details are somewhat different from the usual pressureless fuel system. With the main tank full, operate the check valve. Things won't work right at first. For one thing, the fuel system is full of air which must be displaced. Open the shut-off and the needle valve and let the main tank prime the whole system until the control tank is full of fuel and not just air. If the control tank piston is dried out, it may need some pushing and pulling to get it to take hold and seal. Now to start the engine. Close the shut-off, plug in the starter battery and flip the prop over to make sure the engine is dry. When dry, open the shut-off and go on flipping while making the usual needle valve adjustments. When the engine starts, close the check valve switch (if radio control, the Rudevator should be on neutral after down) so that the control tank will fill. Adjust the needle valve for full speed. Now let the control tank run down. If the engine starts to fail, push lightly on the control tank piston rod to determine whether the engine is failing because of too rich or to lean a mixture. If too lean, the control tank spring is not strong enough. Take it out and stretch the spring a little. If too rich, the opposite is true. Clip a turn off the spring. This may be cumbersome work but once the spring is within range it is there to stay. Some adjustment can be had by turning the needle valve fuel hole down if the engine goes rich, or up if lean. Now proceed to clean up all the other details. Time the control tank from full power to idle (or cut-off) and adjust the stroke to suit. Also time it from idle to full power, and adjust the flow control clamp to suit. In fact, you can count on running a whole pint or more of fuel through the engine before things are all ironed out to satisfaction. Some details haven't been mentioned for lack of space but these are minor and will soon become obvious. When finished, you will have the cleverest darn fuel system that was ever invented. (We say this just in case nobody else will.)