The AMA History Project Presents:
Biography of EDWARD L. ROCKWOOD

Transcribed by NR (03/2001); Edited & Formatted by SS (10/2002);
Updated by JS (10/2008), Reformatted by JS (01/2010)

Career:

- Developed the first multi-channel resonant reed decoder Radio Control system

Honors:

- 1982: Model Aviation Hall of Fame

The following is taken from Model Airplane News *magazine's August 1949 issue. Jack Albrecht, a friend of E.L. Rockwood, submitted this article to be a part of Rockwood's biography. Unfortunately, little information on E.L. Rockwood was available.*

Audio Tone Radio Control:

Adaptable to single or multi-surface control, the system described is a real advance

By E.L. Rockwood

In all the years that have passed since Radio Control was first introduced to the field of model airplanes, despite all the material published under the heading of "Radio Control," there has been actually little, if any, progress in the design of the factor that, in the first place, makes remote operation possible – the radio system itself. Certainly little has been published in the popular magazines that show more than slight modifications of the one-tube idea during the past 10 years or so; at least, nothing that could be squeezed into a model plane. A search of the Patent Office discloses a similar condition.

Desiring a very reliable set of "radio ears" that would catch the slightest whisper of impulse from the controller's hand, yet would not let him down when most needed, the author has spent a number of years investigating various angles of the problem. The answer arrived at has crystallized, for the present at least, in the form to be described here.

Early in the investigation, it became desirable to use the principle of a carrier wave from the ground, using tone modulation; the major drawback to such equipment seemed in the direction of excessive weight. The army uses tone modulation in their 12-foot ships employed as aircraft targets, but the equipment weighs much more than the total flying weight of a model plane. Tone selection is made by heavy tuned circuits requiring in addition an extra tube per ton to operate the relay putting into action the particular function selected. That means more battery to be carried; thus still more weight.

At first, it seemed that reducing the weight of the tone-selecting "filters," and working along the Army lines would be the tack to take. This line of action afforded some relief. To those

technically inclined, it may be pointed out that the higher in frequency the tones used, the lighter in weight can be the tuned circuits for their selection. There is, however, a limit to the modulation frequencies, which may be used with super-regenerative receivers.

It was desirable to stick to use of the latter for several reasons: the sensitivity that may be packed into small lightweight equipment with low battery drain, the simplicity of the circuit and the ability of such receivers to ignore interference from the spark ignition circuits of the gas engine. The technical limitation of these receivers is that detection of tones is limited to frequencies less than one tenth of the “interruption-frequency” of the super-regenerative circuit. Since the latter is, in receivers suitable for this use, around 20,000 cycles per second, the highest tone to be satisfactorily used is 2,000 cycles. A “filter,” or tone-selecting circuit, for that frequency is still too heavy, and too many tubes, moreover, must be used for the filter method of tone selection. While the tubes themselves add little weight, they must have batteries in order to function; there is the rub – the more tubes, the more weight that must be carried in the form of batteries.

The radio part of the set was finally boiled down to an arrangement using a maximum of three miniature tubes, operating from a 4-1/2 ounce B battery, with three or four pen-cells to light the filaments. The set was so sensitive to tones that when used for voice communication, it would fill a room with sound from a portable transmitter using considerably less than one Watt of power, at a distance of several miles.

In fact, at one time, loudspeaker volume was obtained from signals originating on the East Coast of the United States, with the receiver located here in California; the antenna used was short enough to be fitted from cabin to tail of a 6-foot span model plane.

This was all very encouraging but it did not constitute radio remote control. Actually, during development of the receiver itself, work was carried on to evolve a method of putting to use the excellent response of the receiver to operate relays from the tones that were so well received. Operation of relays from tones, by having the tones operate tuned reeds, which would close low-current relay circuits, was the method finally selected. It is fundamentally not an entirely new idea, certainly, but one that has never been thoroughly exploited for the purpose.

The principle is that a small length of steel has a certain speed at which it will naturally vibrate when secured at one end with the rest of it free. If acted upon by an electromagnet near the free end, with the current through the coils of the magnet varying in strength at a speed corresponding to the “natural period” of the piece of steel or “reed,” the latter will vibrate vigorously. If the current through the coils were varied at any other speed, the reed will hardly vibrate at all. The natural period of the reed is determined by its length, width and thickness, as well as the material of which it is made. Steel was chosen for its stiffness and its ability to be affected by a magnetic force.

Figure 1 shows *[see attached photo sheets at the end of this biography]* the arrangement whereby a pair of coils connected to the receiver, like a loudspeaker, cause the reeds to vibrate from the receiver's output. The three reeds shown have different free lengths, being secured at one end to a

“bridge.” One certain tone – and only one – will cause one of the reeds to vibrate sufficiently to touch the contactor located above it. Each of the reeds may be caused to vibrate selectively at will, by sending into the receiver the tone, which corresponds to its natural period. Vibration of the reed sufficient to cause it to touch its individual contactor will rapidly open and close a circuit through the reed and contactor, and may be made to hold a sensitive relay closed as long as the vibration continues. The vibrating contact, however, will cause a chatter of the relay, and its contacts will not close tightly. The arrangement of condenser and resistor shown in Figure 2 *[see attached photo sheets at the end of this biography]*, called the “reed filter,” smoothes out the chatter, and the relay closes firmly whenever the reed hits its contactor during vibration.

Only such a reed and contactor simple enough to be compact and light in weight for our purposes may control a small current. It is necessary to use the current passed by this arrangement to open and close a sensitive relay such as is used in all radio controls, to actually work the motor or escapement circuits, which will move the rudder or other control surface of the airplane.

One relay is connected to each reed-contactor circuit, and each relay may therefore be individually selected at will by the tone, which is sent out from the ground transmitter. Each tone will have the effect of controlling a separate control function of the plane.

Figure 2 shows the servo circuit used for rudder. When the “left relay” is pulled up by operation of the reed connected to it, a circuit is closed through the “left servo battery,” causing the servomotor to rotate in a direction to move the rudder to the left. The motor speed is reduced through a gear-train with a ratio of about 300-tone and an arm fastened to the shaft of the lowest-speed gear is connected to the rudder, as the operating rod is connected in U-Control, from the bell crank to the elevator.

A satisfactorily lightweight motor for this purpose is the Rev motor, which is very lightweight and small and uses about the amount of current consumed by a flashlight bulb. A convenient gear train, light in weight and inexpensive may be adapted from the works of a small spring-driven toy of which there are many to be found in toy and novelty stores. The spring is removed, and an operating arm attached to the end of that shaft. The wheels of the toy (an automobile, usually) are removed, and the Rev motor connected to that shaft. This may be done by a pulley and small rubber band drive or by substituting the shaft of the Rev motor for the wheel axle. The resulting actuator may be held down to a total weight of around 1-1/2 to 2 ounces including the motor.

When the motor has driven the control arm to the desired distance to the left, the limit switch stops the motor. As long as the relay is held closed its signal contact will hold left rudder. When the tone is removed at the ground control the reed stops vibrating, the relay drops to its back-contact, the opposite polarity battery is connected to the motor, which then runs back, moving the control arm to neutralize the rudder.

When neutral is reached, the neutral limit switch opens the motor circuit and the rudder stops in neutral. Sounds complicated, but its operation is much simpler than the explanation. Of course, if another tone is sent from the ground, another relay operates and the rudder operates in the

opposite direction in the same manner but let's not go over that again!

The operation of this system is as follows: the transmitter or ground control is equipped to send out a modulated wave, which is similar to the signal sent out from broadcasting stations, but instead of containing voice or music, the wave contains only one particular pitch of tone at a time.

The control equipment at the transmitter can select what pitch is desired, by means of' switches in the operator's hand. Each tone will control a function of the airplane, and only that particular tone will do it. Thus, many forms of interference to the radio wave will have no bad effect on the plane's controls.

The fundamental idea employed for actuating the receiver, may be applied to any of the various control systems, which have been advanced in the form of “gadgets,” and due to its ability to handle more than one control signal from the ground, will make possible the expansion of the utility of such arrangements. The improvement in the art offered by the equipment under discussion is in sensitivity and reliability. The receiver is so sensitive that it may be reliably operated by a transmitter only 5-1/2-inches by 6-inches by 6-1/2-inches in size, containing its own batteries, and to a distance of several miles if there are no intervening objects.

This is fortunately the condition under which we operate when controlling model planes. Having more than one channel or selectable circuit makes possible the selection at will of the circuit desired without going through a sequence of signals, and without having to operate controls one after the other in a certain order. For instance, right rudder may be repeated over and over with instant reaction without proceeding through “right, neutral, left, neutral” every time it is desired to repeat a control. No matter what the last control was, any control may be executed at any time. All of these features have been brought out in a Patent Application now pending.

Fundamentally, a multi-channel system like this differs from the same number of channels of separate transmitters and receivers in that it is not practical to cause all of the various controls to operate simultaneously, unless a special arrangement is used. Sending a composite tone from the transmitter will operate the various reeds all right, but sending more than one tone at a time from the transmitter will reduce the loudness of each tone as it affects the receiver; the effective range of the equipment is thus reduced; more complicated modulating and mixing equipment is needed in the transmitter. Figure 4 *[see attached photo sheets at the end of this biography]* shows the simple transmitter and tone-generating circuit, which is used. The key switch sets up conditions that determine what tone will be generated.

A more satisfactory way to accomplish simultaneous operation of controls, if desired, is to equip the transmitter with what is called a Synchronator, which interrupts the tone controls from the control box and applies each tone to the transmitter in regular sequence, and in rapid succession, as they may be selected at the control box keys by the operator. This requires introduction of an all time delay on each relay in the receiver to make it hold up solidly with the rapid interrupted signal, and any or all of the relays may be operated at once, with full tone volume; thus full

receiver sensitivity is had on each channel. The time delay introduced need not be enough to make it noticeable in controlling.

A single-channel version of the receiver has been developed for the purpose of keeping weight down, as for use with such controls as the Owbridge-Rhodes Rudevator weighing about 6 ounces, this receiver is less than 4-inches long and 2-inches wide and operates with 4-1/2 ounces of B battery, with three to four pen cells for lighting the filaments. The tubes are good for about 1,000 hours; antenna adjustment of the receivers is not critical as to length and there is no adjustment for sensitivity. All the receivers discussed will operate without attention or adjustment while the batteries hold out. As long as the signal received is above the minimum necessary to operate the receiver at all, the relays receive full current to operate them, no matter what the signal strength. The actual value of current available to operate the relays does not depend on the signal strength, and may be preadjusted to any value desired up to about four ma., by changing the value of the resistor in the reed filter shown in Figure 2 *[see attached photo sheets at the end of this biography]*.

Considerable field experience has been rolled up, using both the single-channel and multi-channel systems; results have exceeded all expectations. Equipment given a slight touch-up of tuning adjustment at the beginning of a day has operated all day without further attention, and has at times been used for several days without readjustment. Control of a model has never been lost for even a moment due to any failure of a signal from the ground to reach the plane in the air, or even after landing again on the ground. At times, a plane flying low over the brow of a hill has been controlled so as to make it reappear in sight. No more than three Watts of power has ever been used in any transmitter, and less than one Watt is normally used.

This equipment, the result of over 10 years [of] development on the part of the author, is now available commercially and it is hoped will give an impetus to more widespread activity in the Radio Control field, which holds a great deal of enjoyment in store for all model plane flyers whether interested merely in keeping a cherished model from getting away out of sight or in doing aerobatics and pylon racing.

The following is the letter Jack R. Albrecht sent to John Worth requesting information on nominating E.L. Rockwood for the Model Aviation Hall of Fame.

Jack R. Albrecht
1809 Portofino Drive
Oceanside, California 92054

March 31, 1976

John Worth
Executive Director
Academy of Model Aeronautics
815 Fifteenth Street, N.W.

Washington, D.C. 20005

Dear John,

This note is in regard to the information contained in the May 1976 issue of Model Aviation [magazine] concerning Model Aviation Hall of Fame nominations for 1976.

I think that I have been remiss in that I have not gotten to this subject before this time. I would like to nominate Edward L. Rockwood (deceased), who designed and developed the first model reed control Radio Control system way back in 1949. He was a real pioneer in the field and his work led to others following in his footsteps to develop the multi-channel reed systems that we flew in the 1950s and early 1960s. I would appreciate it if you could mail me the necessary forms so that I can get the necessary data together.

I know that I will probably have to get input from Glen Carter and Dale Root of the East Bay Radio Control Club since they also knew him well, as did Alex Schneider.

Best Regards,
Jack R. Albrecht
Member, AMA Frequency Committee

The following is the letter that Jack Albrecht sent to John Worth with his application to have E.L. Rockwood inducted into the Model Aviation Hall of Fame. After the letter is the response that John Worth wrote on the bottom of Jack's letter and returned to him. E.L. Rockwood was inducted posthumously into the Model Aviation Hall of Fame in 1982.

Jack R. Albrecht
1809 Portofino Drive
Oceanside, California 92054

December 26, 1979

Mr. John Worth
Academy of Model Aeronautics
815 Fifteenth Street N.W.
Washington, D.C. 20005

Dear John:

Enclosed is the nomination of Ed Rockwood to the Model Aviation Hall of Fame. As you may recall, I knew Ed in the early 1950s and flew Rockwood Reed equipment as did Alex Schneider, Bob Beckman and others from the San Francisco Bay area.

I have also located some of Ed's original Radio Control equipment, the radio, and a Pacific Coaster and Schneider aircraft. The individual that has these items also has some eight-millimeter film taken in the 1950s by Rockwood of early Radio Control model Flying. I will attempt to obtain these items for the AMA Museum that you are intending to establish in the future.

Best Regards,
Jack R. Albrecht

Jack,

Thanks very much. Anything you can do to obtain the above noted items for the National Model Aviation Museum will be appreciated. At the appropriate time, we will have some paperwork to accomplish to make the property transfer official.

Best Regards,
John Worth
December 31, 1979

Jack R. Albrecht received the following letter regarding the E.L. Rockwood's induction into the Model Aviation Hall of Fame.

Academy of Model Aeronautics
National Headquarters
815 Fifteenth Street, N.W.
Washington, D.C. 20005

September 20, 1982

Mr. Jack Albrecht
1809 Portofino Drive
Oceanside, CA 92054

Dear Mr. Albrecht:

The name you submitted for 1982 Hall of Fame, Edward Rockwood, was one of the winners for 1982. I need some help in locating his wife so that she may be informed and possible come up with some date to present her the award. Any help you could give would be appreciated.

Sincerely,
Joyce Hager
Executive Secretary

The following is a sheet of information on E.L. Rockwood that Jack Albrecht submitted with the Model Aviation Hall of Fame application form in December 1979.

Supporting Data: Nomination to the Model Aviation Hall of Fame of Edward L. Rockwood

Edward L. Rockwood was a pioneer in the development of Radio Control in the early years and directly contributed to Radio Control as we know it today. During the late 1940s and early 1950s, Ed Rockwood developed the first multi-channel resonant reed decoder Radio Control system. Prior to this time, most of the Radio Control systems either used single channel rubber-powered escapements or other forms of simplistic control in aircraft that were really Free Flight types with momentary interruption of control.

All of this changed when Ed Rockwood developed the resonant reed decoder, which activated relays to cause a servomotor to run. Since there were no servos available, Ed Rockwood designed his own using small D.C. electric motors obtained from England. There were no commercially available miniature lightweight gear trains suitable for a Radio Control servo, therefore Ed improvised and used a gear train from a toy car for his servos. Limit and neutral return switches were fabricated from spring brass and were held in place on the 1/16-inch fiberglass boards by small rivets. Although the entire servo assembly is crude when compared to today's standards, the servo unit performed very well considering it was the first of its type.

Development by Ed Rockwood of the first truly multi-channel Radio Control system led to its use in scale and other type of model aircraft that heretofore could not have been flown with radio control. A group of modelers in the San Francisco area banded together to form the San Francisco Mustang Club, which developed and flew aircraft from the Rockwood Radio Control equipment. Several reels of eight-millimeter film are available showing these aircraft in flight.

One of the San Francisco Mustangs, Alex Schneider, went on to develop the famous Schneider Cub. Alex used this aircraft, powered by an ignition Anderson Spitfire 61 and controlled by Rockwood Reed equipment, to win the Nationals three times, i.e., 1951, 1952 and 1954. Bob Beckman later published the plans for Alex's Cub in American Modeler magazine.

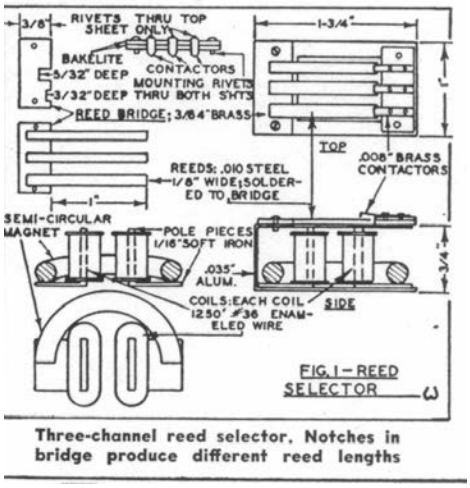
The foresight and dedication shown by Ed Rockwood in the development, manufacture and sale of the first multi-channel resonant reed decoder Radio Control system led to follow on systems by other manufacturers, namely Orbit, Kraft, Bramco, Min-X and others. All used Ed Rockwood's basic concept of resonant reed decoding of the transmitted audio tone signals. Howard Bonner later developed the Trans-mite relayless servo for use with multi-channel reed equipment. These servos were later modified for use with some of the first digital proportional Radio Control equipment, which were designed in the United States. This was indeed an evolution from the first reed equipment designed by Ed Rockwood, which gave us selective control of roll, pitch, yaw, and throttle to today's highly sophisticated multi-channel proportional equipment.

Ed Rockwood, who was the father of multi-channel Radio Control reed equipment, directly contributed to the state of the art of Radio Control, as we know it today, and deserves recognition for his work. He is, therefore, recommended for the Model Aviation Hall of Fame.

The following photographs and sketches ran with the article written by E.L. Rockwood and published in the August 1949 issue of *Model Airplane News* magazine.

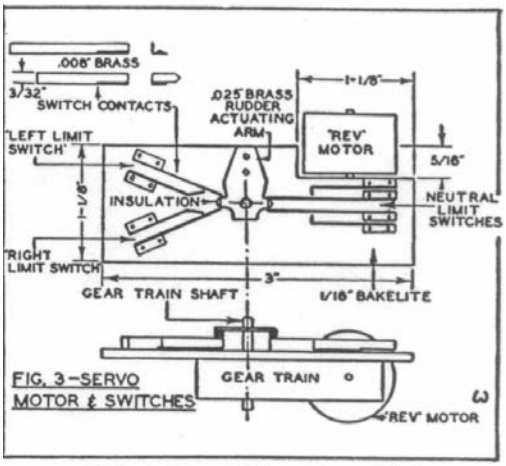
John Terry, of Oakland, at the controls

7' Piper Cruiser, built by the author, has 3-channel tone control described herewith



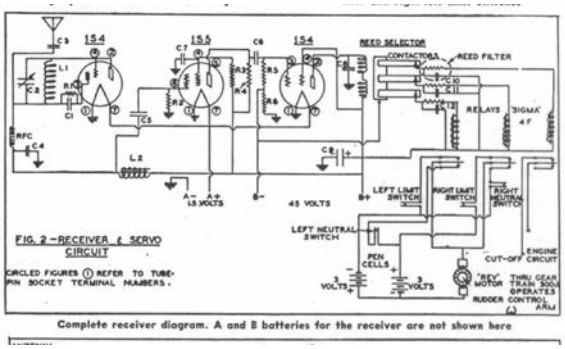
Three-channel reed selector. Notches in bridge produce different reed lengths

Figure 1



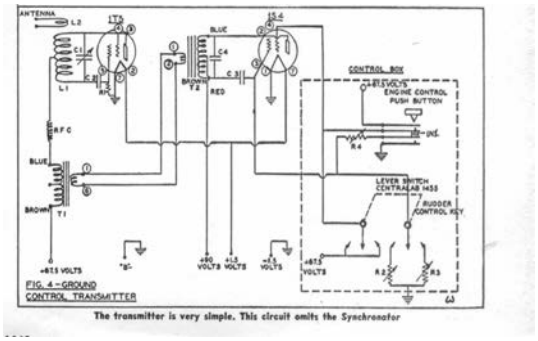
This servo unit has both neutral limit and right-left limit switches

Figure 2
For circuit values see copy of the article in Model Airplane News or in the History Project's file on E.L.



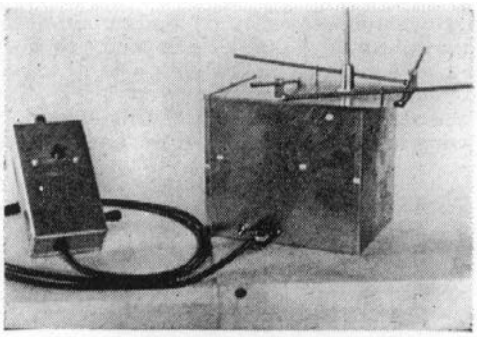
Complete receiver diagram. A and B batteries for the receiver are not shown here

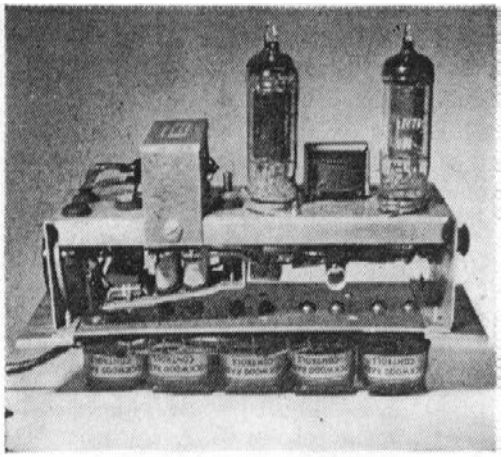
Figure 3

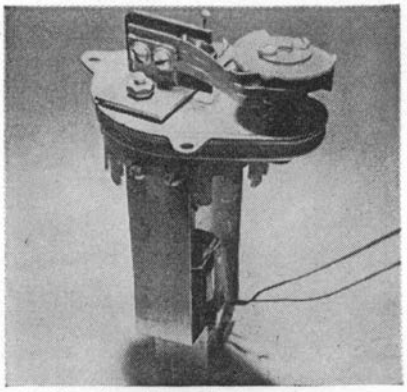


The transmitter is very simple. This circuit omits the Synchronator

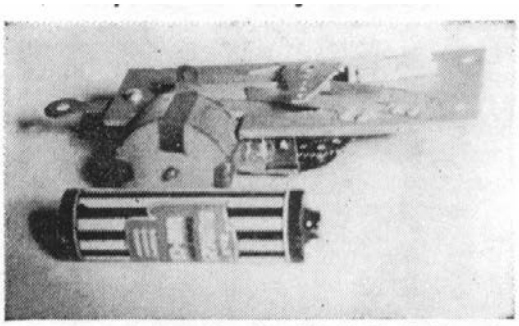
Figure 4
For circuit values see copy of the article in Model Airplane News or in the History Program's file on E.L.


5-channel transmitter and control box. Stubs on case carry "ground-plane" rods


5-channel receiver with sensitive relays in line along the bottom



Synchronator picks audio tones in sequence, enables 5 simultaneous operations, if desired



Servo motor equipped with both limit and neutral return switches; weight is 1½ oz.