Miami, Florida, Dec. 30th: Dave Holmes of Virginia takes 1st place in Class II Novice and 2nd place Open Pylon at King Orange Internats using RCM Digitrio. Modified C.G. Falcon used in Class II, Midwest Hustler Delta in Pylon Event.

RCM DIGITRIO: FINAL SYSTEM ALIGNMENT

PART VII BY ED THOMPSON

PREFACE

ANY radio system is only as good as the care taken to adjust and check it out. If you have not bothered to read the previous articles thoroughly, followed instructions, or substituted parts without complete understanding of their use in the circuits, now is the time to read the articles thoroughly, go over your equipment and install the proper parts. The staff at RCM has spent many, many hours trying to insure successful duplication of the Digitrio, but we cannot make up for mistakes or sloppy craftsmanship by individual readers. Your system will only work as good as the efforts you put into it! Since there are only a few completed Digitrios flying at the present time I am not able to pass on the experience of many modelers at this time. For the benefit of all the readers RCM welcomes your letters pertaining to your experiences with the Digitrio. We will compile this information and publish it for all to benefit. If you make any changes or improvements please state why you did so and the results.

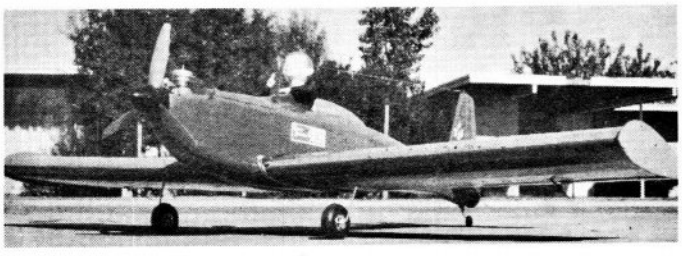
The letters for a four-channel system have been increasing and I will start packaging the "Digiquad" as soon as possible. I have several circuits built and tested and all that remains is to log one hundred flights or so to prove their reliability. I have circuits using SCR's, trigistors and plain old transistors. The one I select will be based on reliability, reasonable cost and ease of duplication. At the present time the transistor circuit looks like the best bet because most of the parts in the decoder could be used over again. It consists of two flip-flops and a one shot. It also has provisions for adding a fifth channel. The biggest problem is the mechanical changes to the transmitter. The only change in the airborne part of the system will be exchanging the decoder board with the new one and adding a servo.

I have been flying the present system as three-plus-one for the last month and will present this modification in next month's issue. Fearless Leader has designed a trainer, and Dick Smith and I have designed a contest type airplane to take advantage of the Digitrio's small size, low weight and continuity of control. Both will be presented in a forthcoming issue of RCM.

I will cover each component part of the system giving alignment instructions, preventive maintenance and pass on to you some of my experiences with the different circuits.

TRANSMITTER

The transmitter should be tuned up according to instructions in the November issue. These instructions pertain to RF tuning. The coder was adjusted when the pots were placed in the center



Upper right: Dave Holmes with 'Super Falcon' and Digitrio — winning combination at recent King Orange Internat's. Left: Dick Smith's 'Digifli', small multi designed for the Digitrio.

of their travel. Here are some things I have found necessary to insure best results from the transmitter:

1. **Problem** – Unstable operation of the 200us one shot (Q10 & Q11). This can be caused by two things. If Q10 has an above normal base emitter resistance, D4, D5 and D6 in combination may divide the base current to ground. Also RF radiation from the antenna may cause spurious triggering of this one shot.
   Solution – Insert another diode in series with the bottom of D4, D5 and D6 and base of Q10. Install a .01 MFD capacitor from collector to emitter of Q10. See figure 1.
2. **Problem** – Oscillator tuning not pronounced enough. This can be caused by operating Q1 too high on its collector current curve. This will occur especially if Q1 is replaced by a "hotter" transistor than specified, like a 2N708.
   Solution – Increase the value of R3 until the peak is well pronounced – 330 ohms is about optimum for 2N708's or "hot" 2N706's. Also replace C3 (.1) with a .01 to retain proper pulse shaping.
3. **Problem** – Excessive collector current of Q2 and Q3. This can be caused by excessive drive, "hot" transistors in the final or combination of both.
   Solution – Lower the value of C4 and C5 and in extreme cases remove them entirely to obtain collector current of approximately 100 MA. Collector current can be measured by lifting the cold end of L6 and inserting an MA meter.
4. **Problem** – RF feedback, especially with antenna collapsed or removed. This is caused by direct RF radiation of L5. This situation is exaggerated by the use of "hot" transistors which increase power.
   Solution – Install the shield as described previously.
5. **Problem** – Z1 burning out. This is probably caused by incorrect installation or "shorting" wires together while checking the transmitter.
   Solution – Install Z1 as shown on the overlay (with the bar toward Q9). Tape the ends of the pot leads to prevent shorting. Make sure there are no metal objects under the transmitter board during checkout – such as clipped resistor leads, nuts and bolts, etc.
6. **Problem** – Meter pegs when antenna is inserted or removed. This is caused by accidental "shorting" of antenna and ground.
   Solution – Turn off the transmitter before installing or removing antenna.

Before using the transmitter make sure that the RF signal is perfectly clean. Listen to a monitor and a clean buzzing sound should be heard with no "fuzzyness." Place your hand near the loading coil deliberately detuning the antenna and note if the signal is still clean. Retract or remove the antenna and note if the signal is still clean. Run through the tuneup procedures once more, noting if the meter peaks cleanly. If it does not have a smooth peak you probably have a little feedback. If you have an oscilloscope the signal can be observed by placing a diode between the vertical input connectors and running a 36" piece of hookup wire from the "hot" input connector. This will give you a visual display of the output signal and any trouble can be easily observed. I would suggest the scope treatment before using the transmitter (there is bound to be someone in town who has one – try your ham friend, TV technician, etc.) In any case your transmitter must be checked by an FCC licensee prior to operation. Take the RCM articles with you to assist him in this certification check.

Here are two acid tests for the output of the Digitrio. These tests will not detect regeneration but will visually indicate the radiated power.

1. With the antenna removed place a G.E. #47 pilot lamp **with a .01 MFD capacitor,** in series, across the antenna connector to ground and observe its brilliance. This is RF voltage lighting the lamp. The lamp should glow at approximately one half brilliance.
2. With a full charge on the batteries it may be possible to light an NE-2 neon lamp with RF voltage on the antenna. To do so hold the lamp by one lead and touch the other lead above the loading coil. With your other hand tune the antenna by placing it near the loading coil. The NE-2 lamp should light. This again is RF voltage doing the work.

The front panel template shows the P.C. mounting posts too close together – increase the distance between them horizontally by ¼". The only preventive maintenance necessary for the transmitter is occasional adjustment of the stick springs and a drop of oil on the pot shafts.

RECEIVER

Tune the receiver as described in the September issue. If you have any problems the voltage checkpoints should reveal where they are located. Here are some problems and solutions I have encountered.

1. **Problem** – Meter reads negative instead of positive while tuning. This is caused by improper installation of diode D1.
   Solution – Install D1 properly (with the bar up). The picture of the receiver on page 18 of the December issue shows D1 apparently installed backwards. This is due to a shadow and the bar is not visible at the top of the diode.
2. **Problem** – Lack of sensitivity. This can be caused by many things. In one case I had reversed the black and white IF transformer. In another case I used a 10K for R3 and a 1K for R7.
   Solution – Double check installation of all components as per the overlay. Again I would recommend the scope treatment prior to using the receiver. Place the scope leads where the meter is used for tuneup. Check your signal for smoothness with a weak signal. If the receiver is carefully peaked with the meter as described it should correspond to the smoothest signal on the scope. Therefore once you have ascertained that the signal looks good a scope is of no further use for receiver tuning. I would recommend that the IF's be

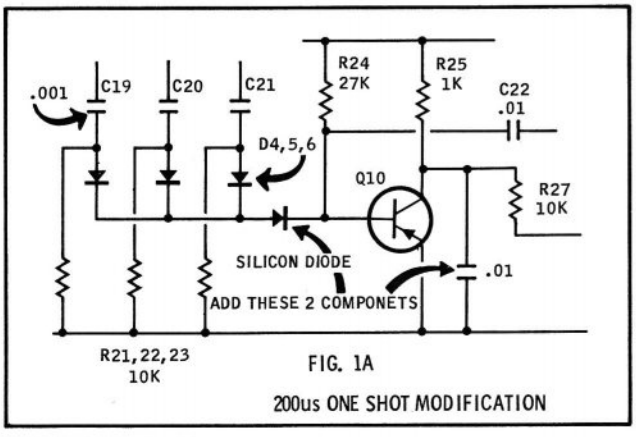


FIG. 1A

200us ONE SHOT MODIFICATION

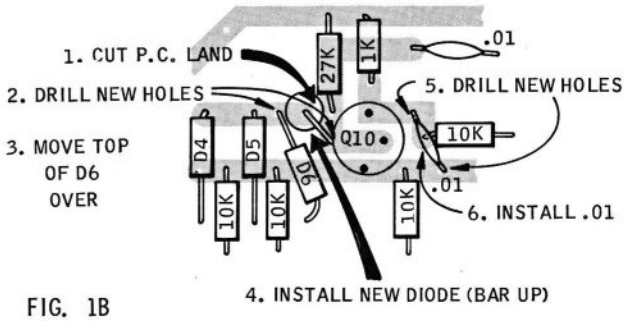


FIG. 1B

200us ONE SHOT MODIFICATION

retuned about twice a year as temperature changes go from one extreme to another.

DECODER

There is no tuning procedure for the decoder. All adjustments and circuit operating parameters are established by resistor capacitor combinations. The scope treatment here will reveal any discrepancies and is about the only way a qualitative check can be made. I have experienced no difficulty with the decoder so cannot pass on any problems or solutions at this time. I would recommend however that you double check the installation of all parts prior to using it—especially the shield installation and grounding strap. On the World Engines kit the grommet slots will have to be deeper to clear the case flange. A hole will have to be drilled for insertion of the grounding strap.

SERVOS

Close observance of the visual aids and instructions in the servo article should preclude any trouble here. I have run into a couple of problems which I'll describe.

1. **Problem** – Servo runs to one end when signal is applied. This is caused by incorrect installation of one or more diodes.
   Solution – Check the overlay carefully for improperly installed components.
2. **Problem** – Servo erratic during vibration check of aircraft. This was due to a "cold" solder joint at the collector lead of one of the motor driver transistors.
   Solution – Check all soldered joints carefully.
3. **Problem** – Motor servo chatters or buzzes with signal applied. This is due to the wide sampling period of the motor control one shot. In some cases it will not allow the extreme resolution the servo is capable of.
   Solution – Replace R14 and R15 (4.7K) with 10K's. This will broaden the resolution slightly and eliminate this condition.
4. **Problem** – Unable to secure full travel of servo output arm (adjustment will be covered later). This is caused again by the nature of the motor control one shot. Due to the demand on the one shot to recover so rapidly circuit components may make full travel impossible.
   Solution – Rather than "digging" into the decoder to replace critical parts simply replace R5 (27K) with a 33K. This will increase the reference generator one shot pulse and allow a longer recovery time for the motor control one shot in the decoder.

Although this has not been a problem, I would recommend that four small holes be drilled and resistor lead remnants soldered where the auxiliary board and main board are joined.

If other problems are encountered with the servo your best bet is to contact the local Einstein for assistance.

One source of trouble is the wearing of the wiper fingers on the output arm. This is not a new problem but it is aggravated by the coarse surface of the wirewound resistance element. My rec-

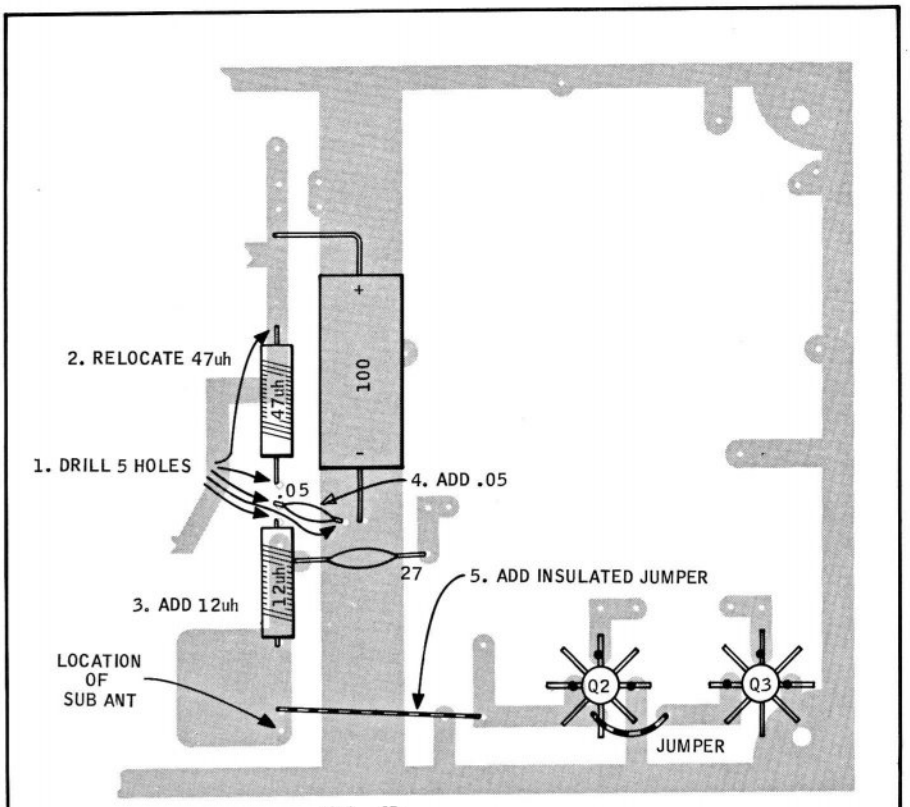


FIG. 2B

MODIFICATION OF TRANSMITTER POWER AMPLIFIER

Artwork illustrates simple modifications to transmitter power amplifier, described in article.

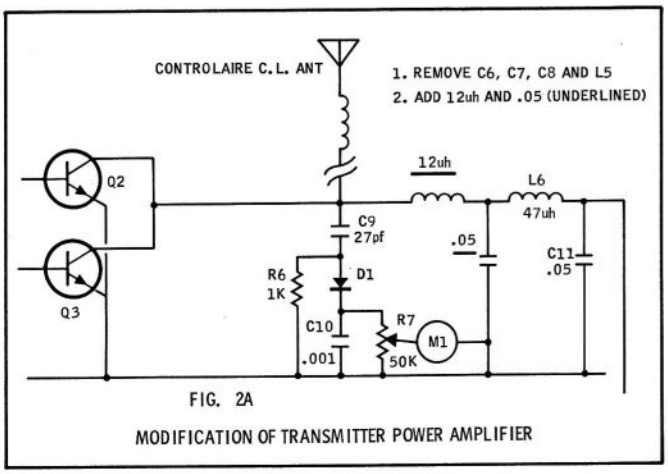


FIG. 2A

MODIFICATION OF TRANSMITTER POWER AMPLIFIER

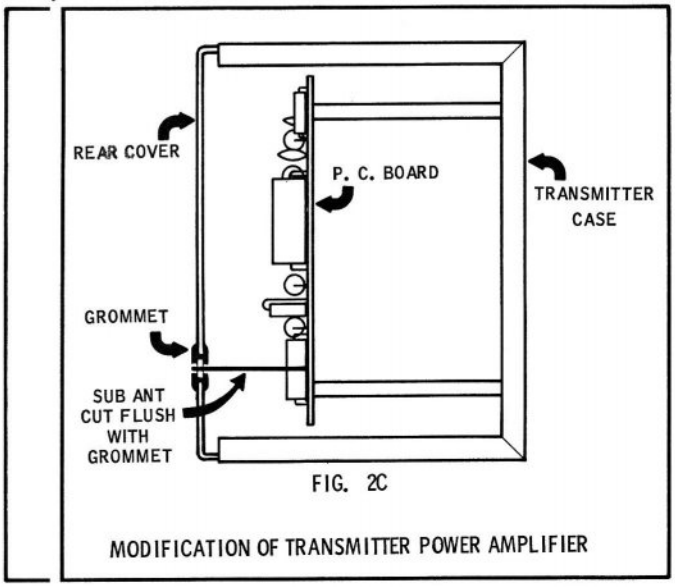


FIG. 2C

MODIFICATION OF TRANSMITTER POWER AMPLIFIER

ommendation here would be to replace the output arm when wear becomes excessive. Each servo should be thoroughly checked and cleaned, the wipers retensioned and inspected every fifty flights or so. When you consider the price of an output arm against the cost of a complete aircraft it is easy to arrive at the benefits of output arm replacement. I use "Spra Kleen" produced by G.C. Electronics Co. #8666. It both cleans and lubricates. After wiping clean the gears, etc., spray the solution into the front compartment of the servo and blow away the excess. This will also quiet down a mechanically noisy servo. Each servo can be tailored for more or less resolution by changing R14 and R15. Increasing their values will widen the resolution and vice versa. The operation of the servo as is produces optimum results.

COMPLETE SYSTEM ALIGNMENT

After you are satisfied that all components are in proper operating condition hook the system up making sure the batteries are fully charged and that they are in good shape. Preliminary to final adjustment remove all gears from the servos and reinstall the output arms. Place the output arm in the approximate center of its travel on each servo. Temporarily disconnect the motor control servo, we'll do it last. Adjust the motor control trim pot (R13) inside transmitter to its highest resistance – clockwise looking down on the transmitter with the rear facing you. Turn on the transmitter and receiver – the rudder and elevator servo motors should run. Now move the output arm manually and find the point where each servo motor stops and reverses direction. Manually place the servo output arm between motor reversals until the motor is stopped. By movement of the control stick of the transmitter you should be able to control the direction of motor rotation. If your servos do not meet this condition recheck the centering of the transmitter control pots and try again. If it still does not operate properly you have system troubles and trouble shooting will be necessary to isolate the malfunctioning unit. If only one servo works properly your best bet is a defective servo. If neither works properly swap one with the extra servo and if it does not work either start with the decoder and work your way backwards until you find your trouble. If the servos work properly or you have corrected your trouble you can now disconnect the two servos and connect the motor control servo. With the motor control pot centered adjust the motor control trim pot R13 (inside transmitter) starting from the high resistance end.

Continue adjusting slowly until the motor stops and reverses. You should now be able by movement of the motor control stick to reverse the motor like the other two servos. Turn off the equipment and reinstall the gears and output arms. Turn on the system and note the position of the output arms. Move the stick and note the direction in which the servos travel. Now move the trim levers to see if the servos respond in the same direction as stick movement. If not reverse the yellow leads on the trim pot affected.

Chances are your output arms will not be exactly centered. To center the rudder and elevator servos loosen the trim pot collars and rotate the shafts until centering is accomplished. Place the trim pot levers to the center of their cutout and retighten. To center the motor servo slightly readjust R13.

You should have approximately ½" overall servo throw with 12% trim action on the rudder and elevator. The motor control servo should have slightly more throw. The servo throws can be altered for use with different types of control sticks by changing R9 and R11 (1.2K). Larger values will increase the throw and vice versa. The motor control servo throw can be altered by changing the value of R29 in the transmitter – lowering its value will cause more throw and vice versa. Servo resolution can be checked by slowly moving the trim pot to one end of the cutout. Listening very carefully move the trim pot stick in the opposite direction until the servo starts. You should have about 1/16" to ⅛" movement before the servo starts. Servo tailoring for more or less resolution is described previously under servo comments. If satisfactory motor control operation is not obtainable modify this servo as described previously in servo comments. To peak the antenna coil place the back on the transmitter and remove the antenna. Extend the receiver antenna and with your wife "pumping" the control stick have her back off until servo action is erratic. Peak the antenna core until solid operation is obtained. With your wife backing and you peaking adjust for maximum range. You should get from six to ten feet with solid control even though the servos will become noisy at about four feet. Make any last minute checks and if your conscience bothers you about any shortcuts you may have taken during construction, now is your last chance to repent. "Button up" your servos, check all screws for tightness, etc.

INSTALLATION

Installation of the system does not require more than average care or consideration for a digital system, just pack it in. Here are a few tips that should be followed for best results.

If you are using a shoulder wing aircraft run the antenna out the leading edge of the wing, loop it over the wing dowel and run it back to the rudder. If you are using a low winger run the antenna out the top of the fuselage at the leading edge of the wing and run it back to the rudder. Possibly the best antenna you could use would be a 36" piece of music wire as a vertical antenna. A short length of brass tubing can be epoxied in the aircraft, the end of the wire crimped and forced into the tubing. The main point here is to keep the antenna away from the servos so it does not pick up servo noise. This can shorten range considerably. Do not worry if the controls bind a little. This does not mean that good craftsmanship practices should be ignored however, as a good mechanical linkage system will enhance the system's characteristics. I have used nylon tubing and flexible cable for all control surfaces including aileron and find it hard to beat for easy installation and trouble free operation. Avoid any metal to metal joints by using nylon clevices – especially on the motor control arm. Be sure your servos are shock mounted using the brass bushings supplied. If you mount the servos on a flat piece of plywood, countersink ¼" holes beneath the two servo cover screws to allow free movement. If it is desirable to reverse servo throw it can be accomplished easily at the transmitter. Reverse the outside leads on both the stick and trim pot affected.

PRE-FLIGHT CHECK AND ADJUSTMENT

Make a last minute check of antenna core tuning with the transmitter antenna removed. Adjust all your flight surfaces to neutral with the trim pots centered in their cutouts. Now make a ground range cheek of the system with the antenna installed and completely collapsed. Do not settle for less than 300 feet under these conditions. Make a vibration check with the antenna removed – the range should be approximately the same as when the motor is not running. Turn the transmitter off and install and extend the antenna. You should be able to place the transmitter and receiver antennae within 12" of each other before swamping occurs. If the system appears erratic in any way whatsoever find out why and correct the problem before you fly.

FLYING

If you are not used to flying a digital system you are in for a few surprises. The first one will probably be on takeoff when you pull the stick back and the plane goes straight up into a stall due to over control. The next one will

be when you give it up or down and get right or left simultaneously because as you push the stick you will inadvertently veer off to one side or the other, especially during rolling maneuvers. And finally when you flare the plane out for a landing it stalls again due to over control. If you get past your first flight successfully by judicious control stick movement rather than cramming the stick around, your next flight will be better and about your fifth flight you will be truly amazed by our own capability and your friends will soon get tired of your bragging and tell you to "shut your mouth!" Even your wife will get tired of hearing about your new experience. As your proficiency progresses and time and money permits you will go from one plane to another trying to find one to match the system's capabilities.

CONCLUSION

After you are satisfied with the system performance some of the components can be epoxied in place to prevent vibration problems later on. Here are some recommended areas.

Receiver – FL1, Q2, D1, both 40 MFD caps, Q6 and T4.

Decoder – Q10, both tantalums (.1 and .22) and D5.

Servo – .1 tantalum, Q11, Q12, and junction of auxiliary and main board.

In general look for items that appear top heavy, have a large mass or are fragile. The more epoxy you use the harder it will be to repair the equipment later on if necessary.

I have begun simplifying the Digitrio and have just recently completed a modification to the transmitter eliminating some parts and making tuneup much simpler. These changes are shown in the drawing and tuneup requires only peaking the core in L2 with the antenna extended. This also eliminates the troublesome RF radiation of L5.

The final amplifier collector current should be 45-60 MA. Install a subantenna ala Controlaire – you should get approximately two feet of range with the antenna removed. As ways to simplify the circuits are proven they will be published and in a short time with your help, by your letters, the Digritrio should become a commonplace item in the RC modeler's inventory. I am proud of the Digitrio and I think you'll see why when you get yours completed. The entire staff of RCM deserves the lion's share of the credit because the "Digritrio" would not have been possible without them. I have been so swamped with letters that it may seem that replies are slow (which they are). Now that the bulk of the work on Digitrio is completed I will try to be more prompt. Your letters, comments and questions are always welcome.

The Editors of R/C Modeler Magazine would greatly appreciate your assistance in completing the attached questionnaire. It will assist us to determine how we may improve future technical articles similar to the Digitrio series:

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1) I built my Digitrio system from: kit ____ scratch____ both____.

2) My Digitrio: worked right off or with modifications____
My Digitrio: worked with help of a technician____
My Digitrio: doesn't work____.

3) How well does your Digitrio work compared to other proportional systems? Excellent____ Fair____ Poor or doesn't____.

4) Did you like the presentation of the Digitrio? Yes____ No____
(If no, please say why in remarks.)

5) How much experience in electronics do you have? Years____
In R/C? Years____.

6) How many Digitrios are flying or being built in your area?_____.

7) How much (approximate) did it cost you to build the Digitrio?
$_____.

8) If you had to do it over, would you still build the Digitrio?
Yes____ No____ (If no, please say why in remarks.)

9) What single thing do you like the most about the Digitrio? _____
_____.

10) What single thing do you dislike most about the Digitiro? _____
_____.

11) What other gear do you own? reeds____ single channel____
proportional____.

REMARKS: _____
_____
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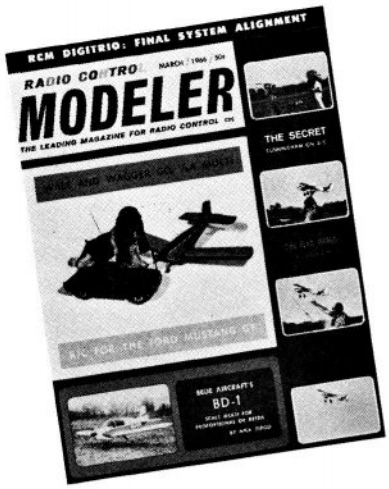

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