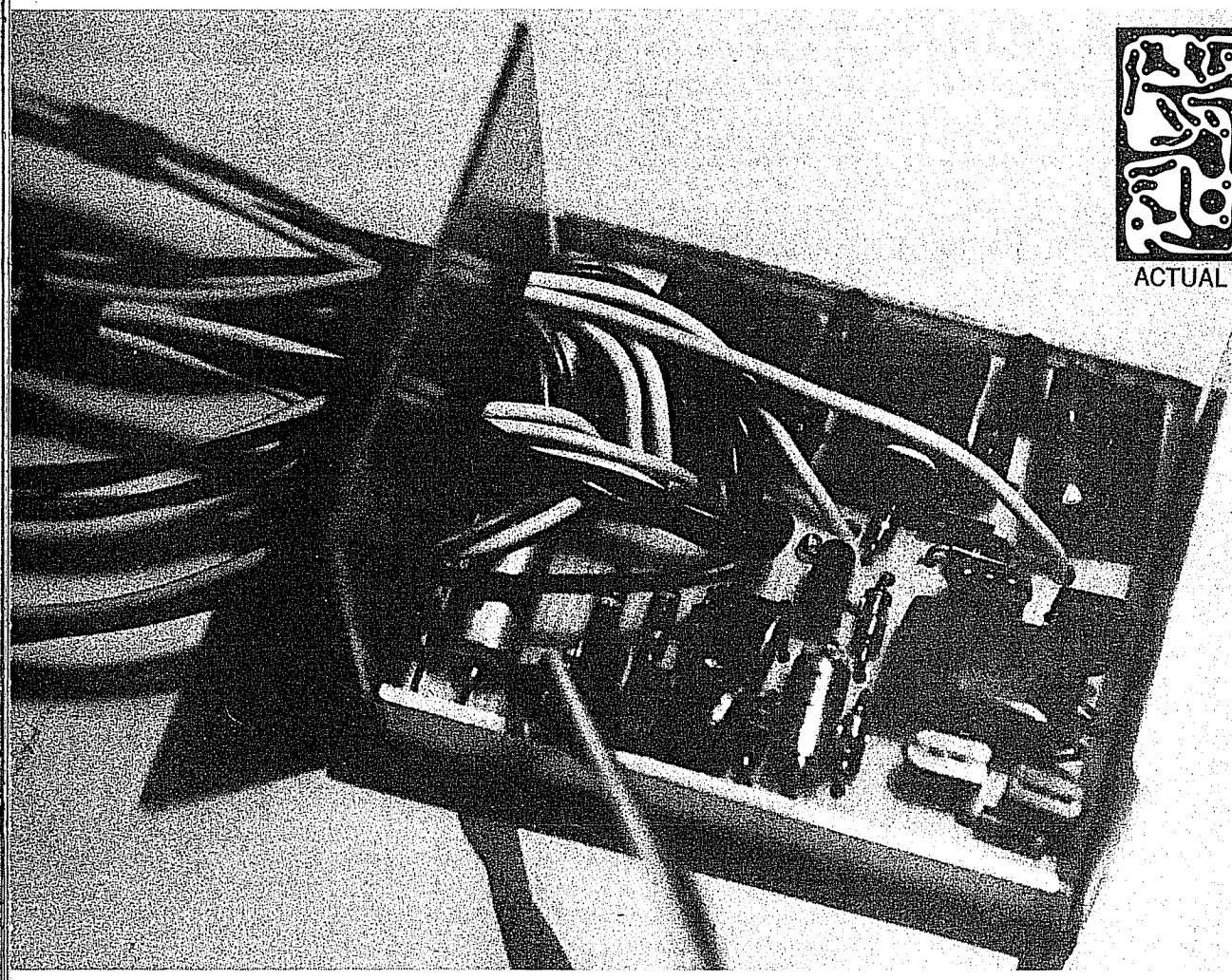
M.A.N. 2-3-4 DIGITAL SYSTEM

Part Three . . . The Decoder



ACTUAL SIZE

Looks like a bristly porcupine with all the servo and battery leads projecting through the end of receiver/decoder case, color code simplifies it.

Decoder almost lost between the fingers. Suggest use of spring clothes pin holding device while installing and soldering components.

By DON BAISDEN

The race to the smallest system has led to many claims but when you assemble the decoder for the M.A.N. 2-3-4 you will see miniaturization at its tiniest.

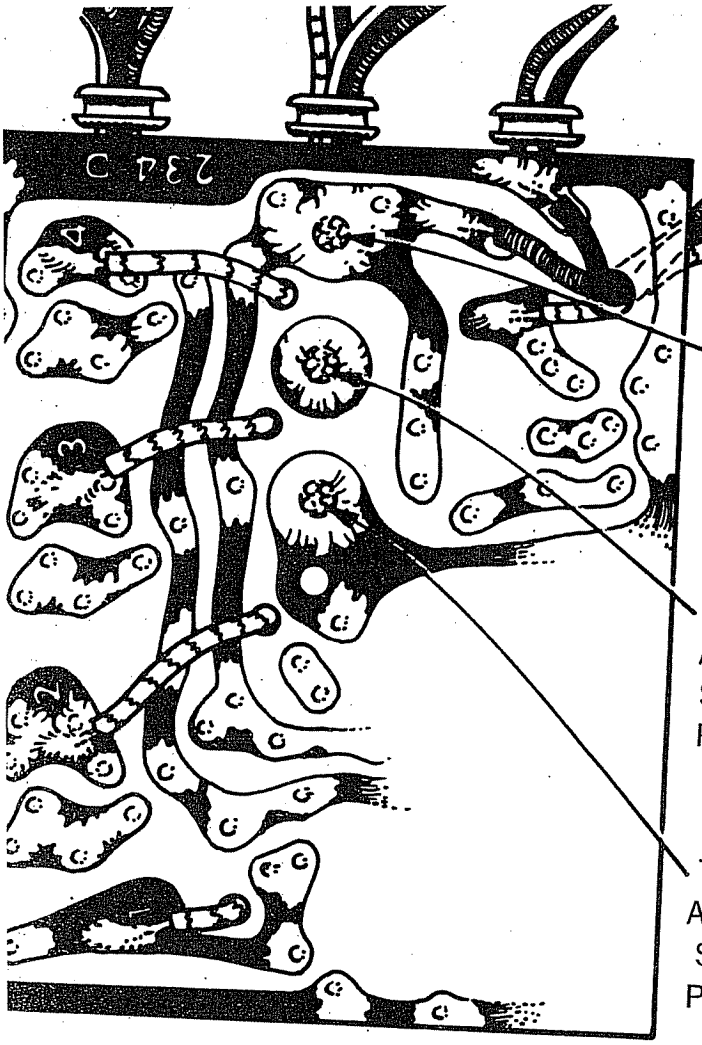
EDITOR'S NOTE

Although we at M.A.N. have been pleased with the prospect of presenting our readers with a fine economical digital system we are now also proud. When the first decoder kit reached our hands, we knew we had a really "small" system on our hands . . . see the decoder-receiver case next to the matchbook in the accompanying photo. When the first of the mini-servo cases came in, we knew we were dealing in something special. We, with obvious pride, and some degree of self consciousness are now sure we have helped advance the "state of the art." Showing of the decoder and the mini-servos to R-Cers at various club meetings and gatherings brings forth with consistency, comments about full house Minnie Mambos, Jr. Falcons, etc. With the growing paucity of flying space the M.A.N. 2-3-4 may have just given R-C a rebirth. Schoolyard multis with schoolyard power are now a snap!

THE MAN 234 DECODER

Of the Receiver-Decoder Combo, we shall attack the Decoder portion first for a couple of reasons; first of all the Receiver is pretty much duck soup and it's check out is much easier with the Decoder and battery pack completed and secondly, the Decoder represents a decision point on your part as to how far you may wish to expand the system in the future.

The "Ring Counter" method is used in the decoding scheme with a separate "synch" stage to recognize the long synchronizing carrier pulse between the groups of shorter information pulses of the transmitted signal. The various control stages of the Decoder are connected in a chain following the synch stage. A more or less standard circuit is used in the counter portion with



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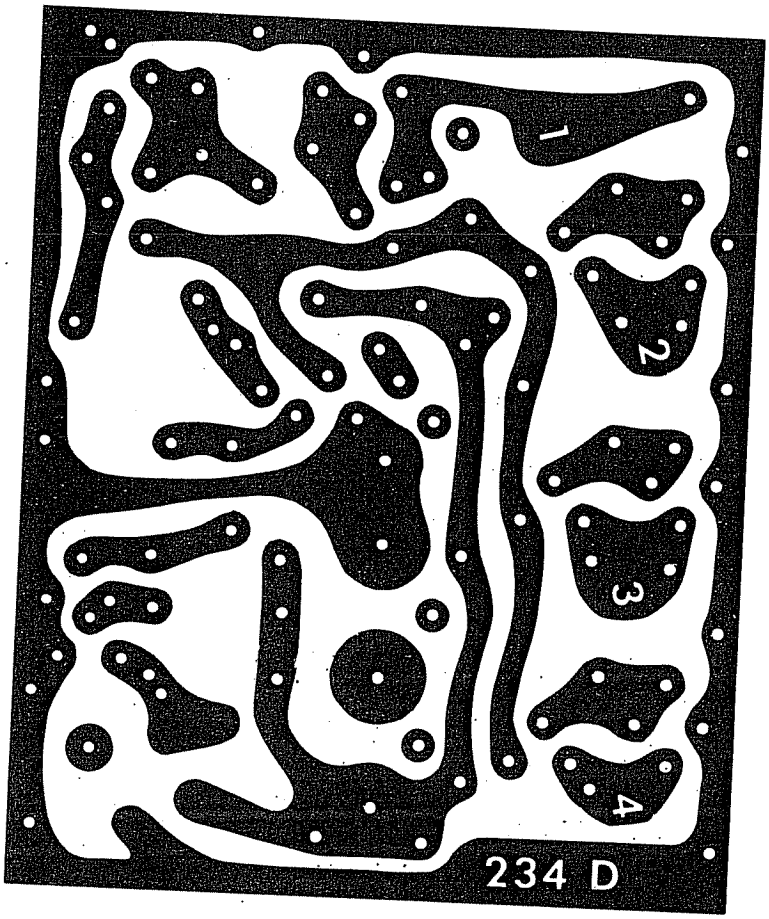


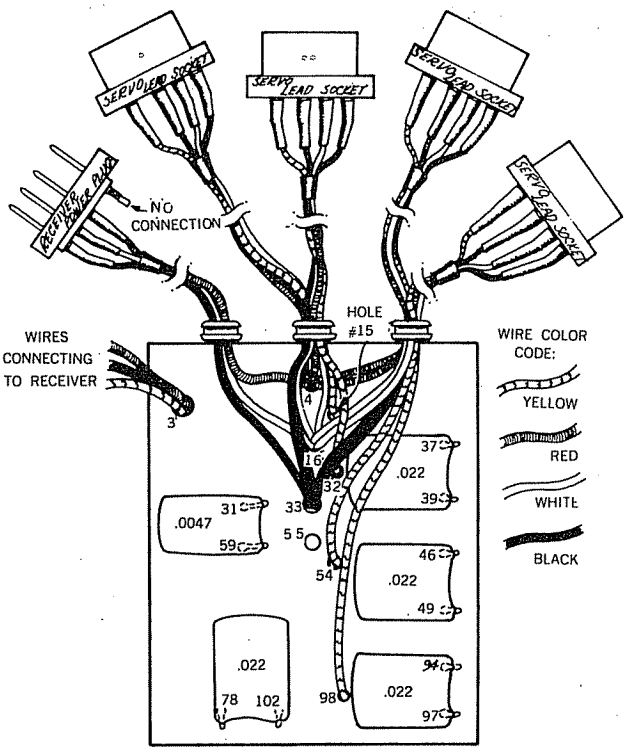
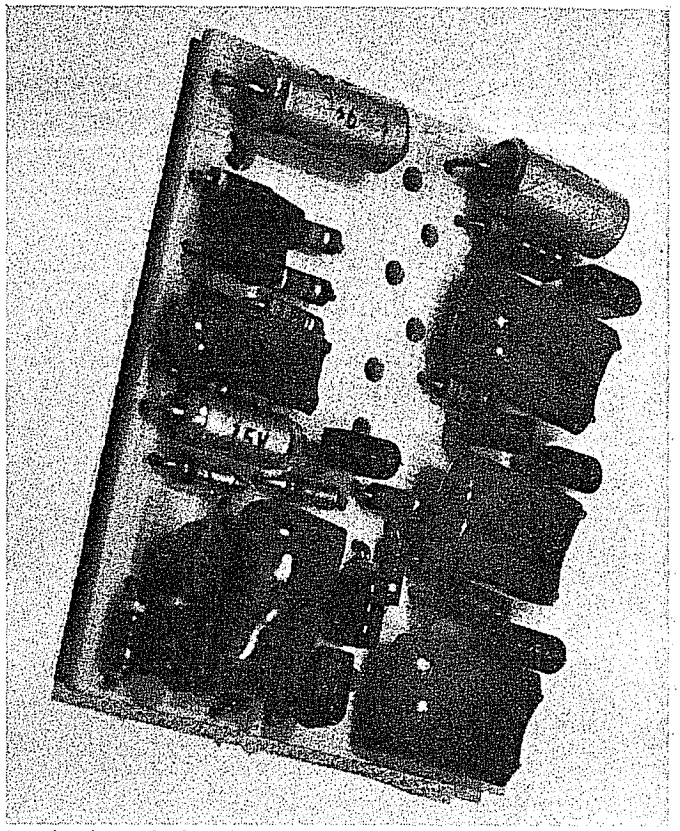


FIG. 2
COMPONENT SIDE OF BOARD SHOWING CAPACITORS ONLY & WIRE ROUTING.



Completed Decoder board with all components in place but less the servo and battery lead wires. Note mylars folded down over other components.

M.A.N. 2-3-4 DIGITAL—THE Decoder...continued

future expansion is due to the fact that the servo leads & plugs are installed at this point. The common battery leads to the servos are bundled together, inserted into their respective holes in the Decoder board and soldered. It is almost impossible to add a wire to each bundle later without removing it and rebundling the wires and in essence doing the whole job over. If you're planning on expanding the system later, you may wish to plan ahead a bit and add the extra servo leads while you're doing the original assembly; on the other hand you may choose to rework or replace the servo leads as a maintenance item when you expand. At any rate, enough wire is included in all the kits to install four servo leads, so the choice is yours.

For you electronic types and scratch builders, a detailed circuit description follows the construction portion of this article, as do some trouble shooting pointers.

KIT CIRCUIT BOARD

The only difference between the decoder kit and semi-kit is apparent in the accompanying photo: The various components must be soldered into the circuit board. After that is accomplished, the construction of the kit and the semi are identical, and hence, we shall cover the circuit board construction first and proceed together through the rest of the decoder construction.

All the soldering tips and advice with regard to the transmitter construction still applies only more so. The decoder board is small and extra care must be taken to avoid solder bridges. The components are mounted as in the transmitter by referring to the pictorial diagrams and the parts placement list. Actually, the diagram here should suffice—but make doubly sure. I would advise mounting the components from the top of the board down. This will avoid confusion and misplacement of parts. Note holes must be skipped in order to leave room for placement of the MYLAR capacitors which should be mounted last, after all other components have been soldered.

The construction is straight-forward but the following tips and checks should be duly noted:

1. Polarity must be observed in mounting the three tantalytic capacitors, and the three diodes. The red ends of the tantalytics are the plus + ends, and the banded ends of the diodes correspond to the ends bearing the black bands on the pictorial.

2. Check the color of the dots on the transistors before placing them on the board, refer to the transistor identification diagram. The 2N 3794's have yellow dots, the 2N 4289's have blue dots.

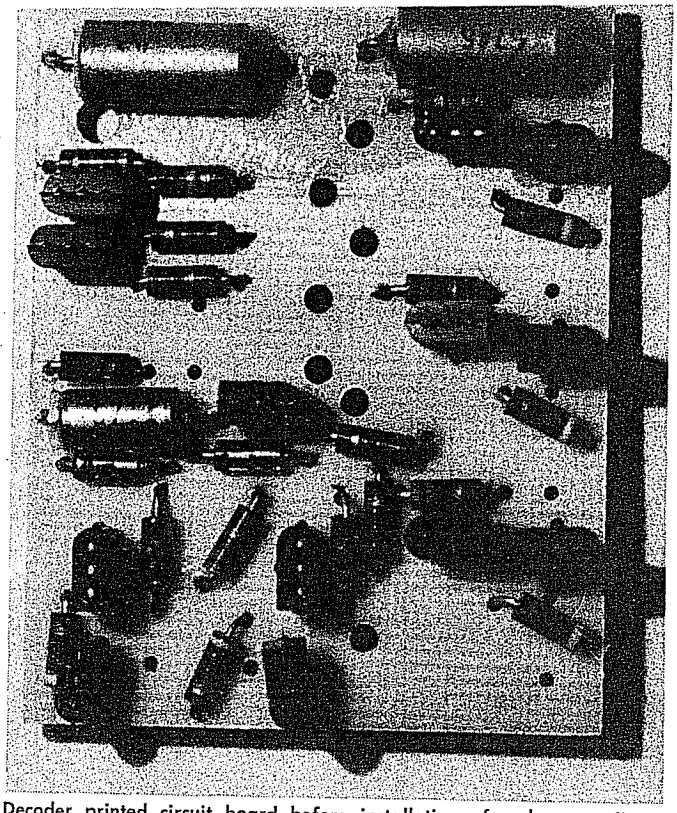
3. Mount your components close t the board. The tops of the transistors should be no higher than the height of a mylar capacitor laid flat on a 1/8th watt resistor. No transistor should be higher than 5/32"!

4. In mounting the mylars leave some slack (see photo) so the mylars may be bent back and down to lay flat over the various resistors they cover—once again, see the photos. Make sure none of the mylar leads touch resistor leads, or protrude beyond the limits of the board where they can come in contact with the case.

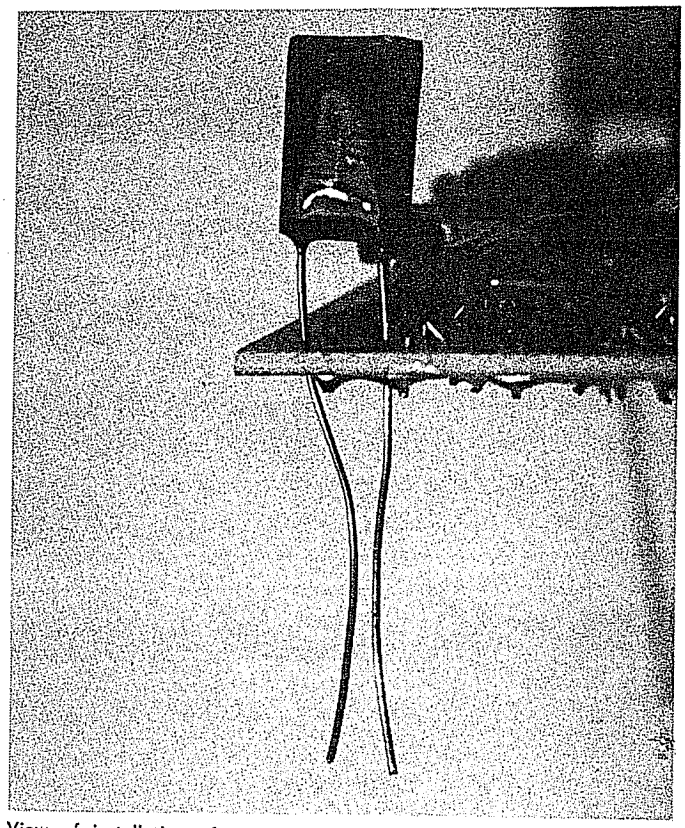
SEMI-KIT

Now that "kit" builders have converted their "kits" to "semi-kits", we can all proceed together.

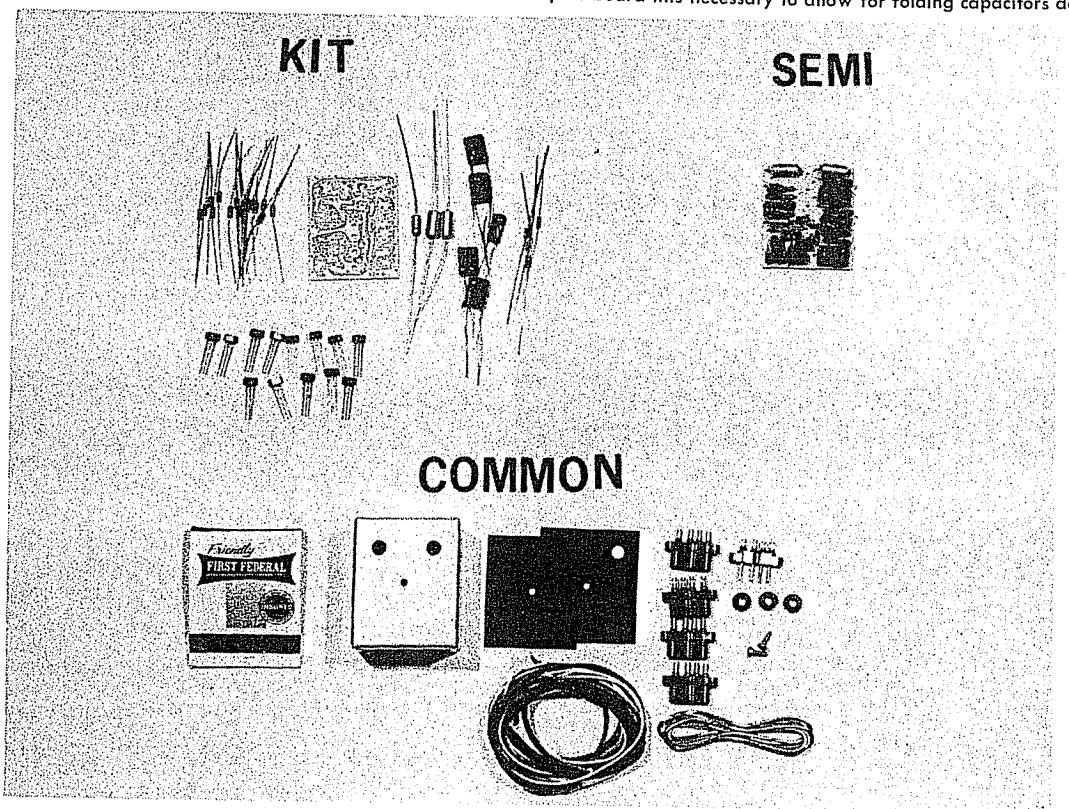
Begin completion of the Decoder by referring to the sketches and photos to get an idea of the end result you're trying to achieve. In the semi-kit you'll be attaching the servo leads, Receiver power and signal leads; routing these wires and installing the plugs. Cut a seven inch length of red wire for the positive battery lead plus another red wire of the same length for each of the servo leads you intend to install. Cut an equal number of seven inch lengths of white and black wires. Strip about 1/4 inch of insulation from one end of each wire but do not pre-tin these leads. Group the wires of the same colors together and twist the bared wires together to form a bundle. Insert each bundle into its respective hole in accordance with the illustration and solder as a group to the circuit land surround-



Decoder printed circuit board before installation of mylar capacitors have been installed—tiny board but still lots of working room for fingers.



View of installation of a mylar capacitor—note length of lead above top of board this necessary to allow for folding capacitors down in place.



No kit article is complete without photo of all of the bits and pieces—matches not part of kit.

ng the hole. When you have installed ıll three bundles, clip the excess lead naterial from these joints and check he top of the boards for stray wire trands which didn't make it thru the ıoles: clip these off to preclude shorting. Cut a seven inch length of yellow wire for each servo lead to be installed; strip about 1/16 of an inch of insulation from one end of each wire and pre-tin it. Refer to the illustration showing the circuit (land) side of the board and attach the yellow wires to the lands used on the particular model you're building. Route these leads to their exit holes, avoiding any solder or lead spikes which might puncture the insulation upon addition case.

Cut one four inch length each of red, black and yellow wire. Strip 1/16 of an (*continued on next page*)

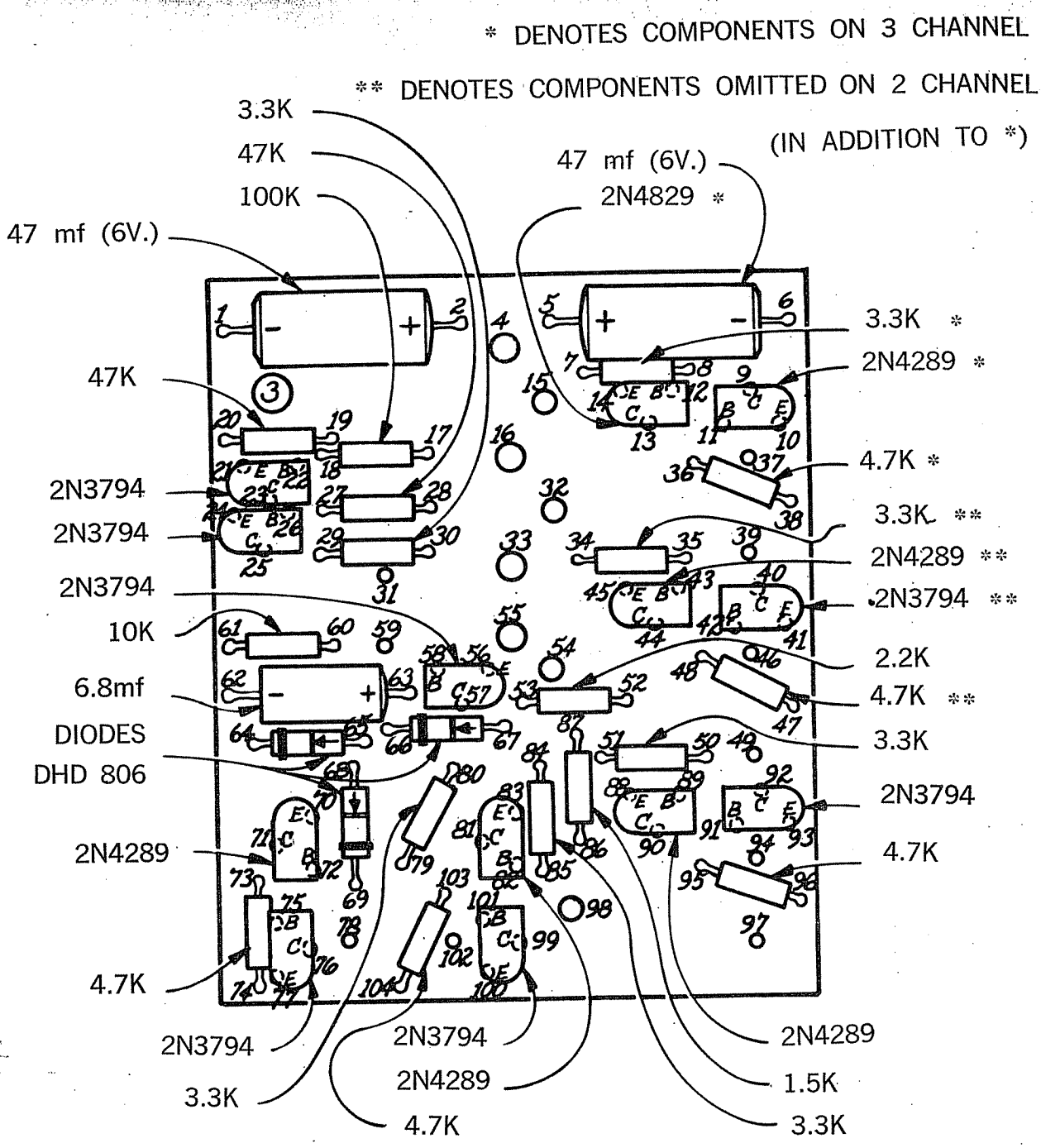


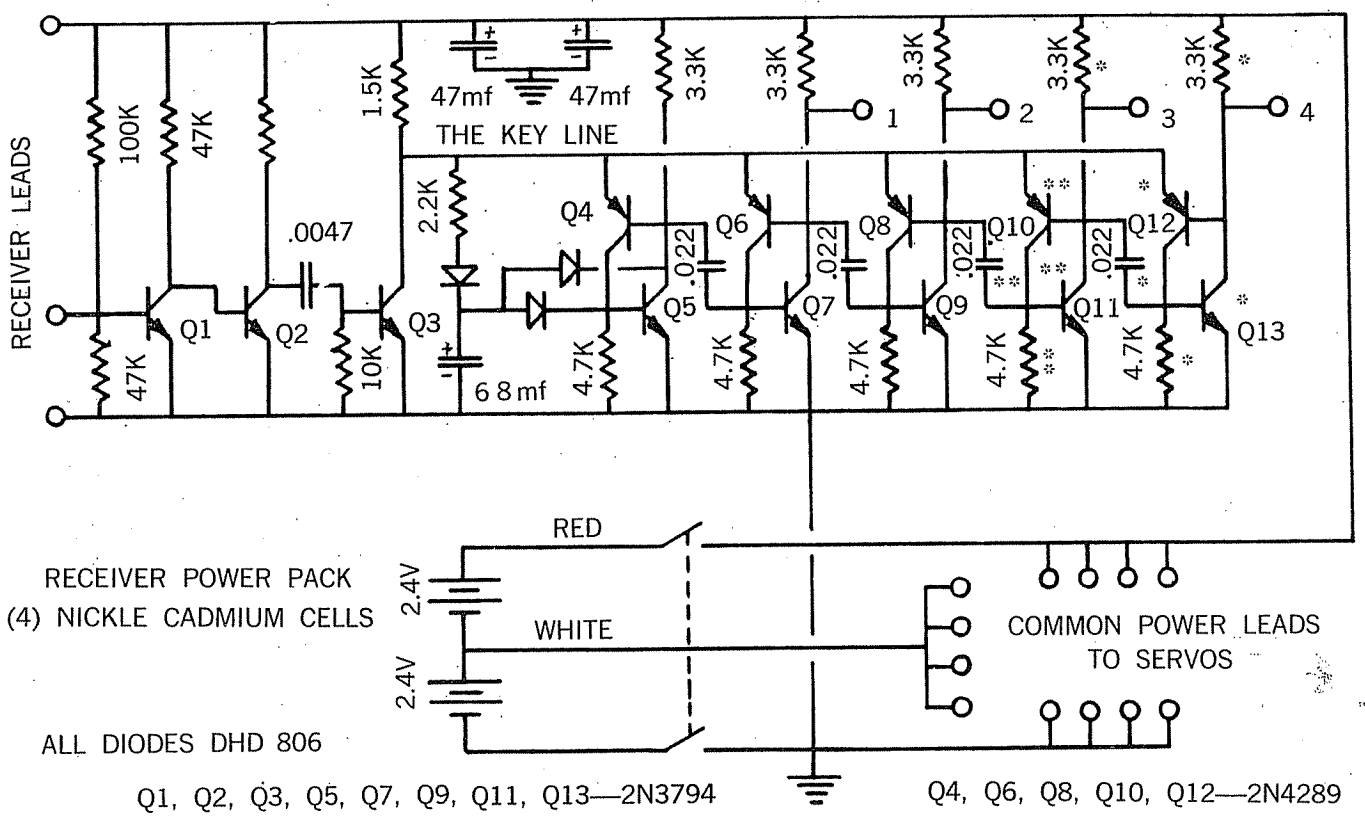
FIG. 1 COMPONENTS (LESS CAPACITORS)

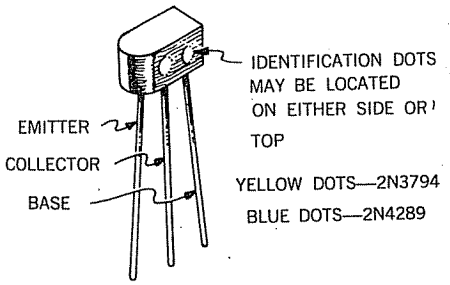
inch of insulation from one end of each of these leads and pre-tin these ends. Again, refer to the circuit-side illustration and solder these leads to their proper circuit land and route them thru hole (#3) to the top of the board. These leads will be used later to couple the Receiver to the Decoder.

At this point you're ready to install the Decoder board into the case so give the circuit side a close look to check wire placement and routing and to make sure that you haven't created any solder bridges or potential shorts. Inspect the Decoder case, remove any burrs around the grommet holes with an exacto knife and install the three (3) 3/16 rubber grommets in the end of the case. Fit the insulator board in the case, correctly orient the Decoder board and attach it to the case with a #2 x 5/16" sheet metal screw.

Orient the Decoder as shown on fig. 2 and begin routing the red, white, black and yellow wires thru the grommets. Notice that the battery leads are brought out thru the left hand grommet and two servo leads are brought out thru each of the center and right-hand grommets. If the leads are routed as shown, this will result in the aileron and elevator leads coming from the right-hand grommet and the rudder and motor from the center. The two receiver tuning leads to be installed later will pass out of the case thru the left-hand grommet. On the two and three channel versions, the choice is left up to you; in production units, the three channel has the rudder and elevator passing thru the right-hand grommet, the motor thru the center and on two channels the rudder goes thru the right and the motor (or elevator if you choose) goes thru the center grommet.

M.A.N. 2-3-4 DECODER

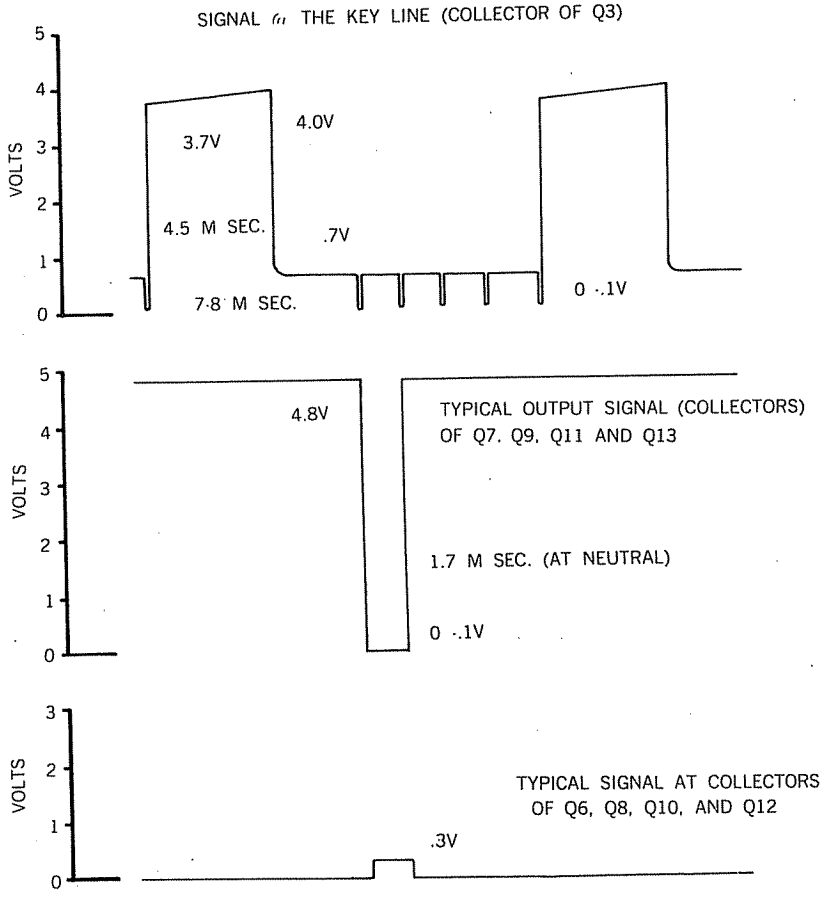




TRANSISTOR IDENTIFICATION

When running these wires thru the grommets, pull the slack out of the first few to get them out of the way, but when you get down to the last two or three at each grommet, leave a little slack to aid inserting the next wire as it will begin to get a bit crowded.

When you have all the lead wires, run thru the grommets, bunch all the servo leads together and cut them to the same lengths. There seems to be no real convenient way to differentiate between the different leads other than a color code (*continued on page* 58)



NOTE—USE 4.7K OR 10K RESISTORS IN SERIES WITH SCOPE LEADS TO PREVENT LOADING DOWN THE CIRCUIT AND CAUSING MISTRIGGERING.

VTO

(*Continued from page 56*)

still air concept than the Ha-13. The Bucher section is a modification of the section used by Thomann on his Aquila. The section has excellent glide characteristics when used with a turbulator, but has not generally proved too satisfactory under the turbulent conditions prevalent in the midwestern U.S.

The E-59 was specifically designed for model glider work by Dr. Eppler and is a semi-laminar flow low drag section. As advertised my experience with it has revealed very low drag characteristics. The rearward high point and highly flapped trailing edge help bring up the maximum lift coefficient, but dead air performance is

MOON BEAMS

Recently Carroll Moon, an old time FF'er, wrote to one of the model mags asking about the existence of plans for the Buzzard Bombshell. His query was met with much interest. Here is the story in his own words, punched out on an IBM typewriter

"Dear Dave:

Received your very interesting letter (with enclosures) just yesterday, and enjoyed it very much. Bill Winter should have remembered where I live. He's been at my house several times, even for an over-night. And I haven't moved. It's a beautiful old place, right on the edge of the Dutchess County Airport in the town of Wappingers Falls, N.Y.

So far I've received about 10 letters from all over the USA in regard to the item appearing in the American Modeller. Would you believe, I haven't seen the issue as yet. Local newsstand sold out. I used to write considerably for Air Trails and Model Airplane News, but have been sadly out of print for quite a while—since I yast wrote up FF at the Nats (M.A.N.) back several years ago when it was held at Willow Grove, Pa.

Despite the fact that I have numerous (and agile) grandsons to chase errant FF's, I haven't built one in the past few years. Seems always that I have other things scheduled. Started to build a Great Lakes FF for 1 grandson, but didn't finish it because somebody dumped a perfectly good (but rather old) Hallicraft ham receiver on my bench and said I could have it for the fixing. So I got into the guts of that and just last week it peeped its first peep. Now to clean off the table and get into a FF. Incidentally, among the first returns from that AM item was a full set of the plans from John Pond, who was mentioned in several of the letters.

So back to the stock pile and build—build—build. A couple of years ago I visited Angie Cardiello, an old Sky-Scraper who now owns and operates Eastern Woodcutting, Inc., a firm which only packages kits and cuts balsa and is located in Brooklyn. He had a whole pile of scrap ⅛th and ¼ sheet which he said was reject on account of tiny knotholes (which I couldn't even see). Filled the trunk of my Saab with balsa and went away happy. Since then have used some of the wood in making HL gliders (all of which have been lost by now).

Besides fixing up old radios (I have some BC receivers dating back to 1921) I also spend at least one night a week as piano player with a Dixieland Jazz Band, and also mucho time with the Poughkeepsie Sports Car Club for which I edit the monthly paper. And now that summer is starting, will be sojourning about twice a month to Lime Rock Park, a sports car race track about 40 miles away in Connecticut. Over there I'm chief timer and also do the Associated Press Stories after every race date. We're having races this coming Saturday, Eastern Regionals which will probably have about 120 contestants and several thousand spectators.

So you see life doesn't stand still for this old timer. Professionally, I'm a technical editor for Internatioal Business Machines Corp., in Poughkeepsie, and that job occupies my daylight hours.

Spent a month last summer on a trip to Alaska to see #1 son who is chief inspector of FAA up there. En route to Alaska, stopped off in Frisco and stayed overnight with Maurice Schoenbrun, a wonderful designer in the old Club, who did many planes for Air Trails and Model Airplane News. Did the Gladiator, Tomahawk, and many others. In fact, I have two of his FF plans right now in my shop. Neither plane was ever published. Suppose somebody would want a crack at them?

Well, this'll have to sign it from now. Nice hearing from you and hope you find time to drop another line.

Sincerely,
Carroll Moon
New Hackensack Road
Wappingers Falls, New York

P.S. Nice letter from John Pond. He wanted to know Maurice's address, which I promptly forwarded. Also sent him two FF plans because I knew Maurice wouldn't have any plans of his fine ships. He is going to contact Maurice out there."

Part Three . . . The Decoder

(*Continued from page 49*)

dot on the plugs. A good method is to use small lengths of colored tape—as used in label makers. Check the lead holes in the plugs and run a piece of wire or a small drill into them to remove any burrs or metal flakes before trying to solder them. Make sure that each group of four wires comprising a Servo lead are all the same length, slip an ⅛th inch length and a half inch length of the large heat shrink tubing over each group and a half inch length of small heat shrink tubing over each wire, in that order. Keep the shrink tubing away from the soldering till it has cooled to avoid the tubing shrinking before you are ready. Strip ⅛th inch of insulation from each wire. There are two methods of attaching the wires to the plugs; the first consists of pre-tinning the wires and plugs and then soldering the two together, the other of merely inserting the bare wire into the plug and soldering as a unit. The first method is recommended, since the plugs are sometimes stubborn about taking solder, and considerable burn-back of the wire insulation can occur. If you choose to pre-tin, twist the strands of the wires slightly to hold them tightly together while tinning. The trick of this method is to apply heat to the plug pin until the solder filling the pin hole is flowing and insert the wire quickly as a solid piece before it's solder has a chance to melt.

Shrink the tubing on the leads with the heat from your soldering iron or the flame of a match. This completes the major portion of the construction on the Decoder, the only thing remaining is to apply Silastic or some other potting compound to the Mylar capacitors after checkout to insure against vibration fatigue of the leads.

CIRCUIT DESCRIPTION

The first two transistors in the circuit, Q_1 and Q_2 form a squaring amplifier for the Receiver signal. Since Q_1 is biased in the "Class A" region, it is turned on and it's collector voltage is quite negative

keeping Q_2 turned off. The narrow incoming negative pulses of the carrier-off portion of the signal drive Q_1 off and therefore turn Q_2 on briefly. The key line transistor, Q_3, is biased off by the 10K resistor from base to emitter but the addition of the .0047 coupling capacitor forms an integrator circuit allowing it to turn on for a given length of time when ever the collector of Q_2 goes positive. It stays on until the charge on the .0047 bleeds off thru the transistor and the 10K resistor, the result of this is that Q_3 turns on briefly at the beginning of each information pulse or Synch pulse and at this time it's collector and therefore the entire key line has almost zero voltage.

To understand the operation of the ring counter portion of the circuit we must examine the mechanics of a single stage and see what makes it tick; let's look at the first information stage formed by Q_6 and Q_7. Notice that the base of Q_6 is tied to the collector of Q_7 and vice versa under normal circumstances, both transistors are biased off. The unusual feature of this arrangement is that if a "turn-on" signal is applied to either base, both transistors will turn on and "latch" until a turn-off signal is applied to one of the bases or the power is removed from the circuit. The preceding stage is coupled to the base of the NPN (Q_7) with a .022 MF capacitor; when the signal at the other side of this capacitor goes positive quickly enough, it provides the turn-on signal for the Q_6 and Q_7 combination.

At this point think back about the action of the keying transistor, Q_3. It is biased off so it's collector, the key line, is normally at a positive voltage. The incoming signal pulses which turn Q_3 on are about 3/10ths of a millisecond long but the base coupling circuit of Q_3 limits it's turned on time to about 1/10th of a millisecond for each incoming pulse. When Q_3 turns on and pulls the key line negative, this is equivalent to removing the power from the circuit, thereby unlatching any stage that was conducting previously, For the ring counter to operate correctly, the coupling capacitor between stages (the .022 MF) must be large enough to store up the turn-on signal to the next stage long enough to out-last the brief "power failure" of the key line when Q_3 conducts. Therefore, when the voltage rises on the key line again, the turn-on signal is still waiting to latch the next stage into conduction. When any one stage is in conduction, the key-line voltage drops to around .7 volts which prevents any other stage from conducting simultaneously. When a series of pulses come into the Decoder, the stages pass the ball down the line so to speak with each stage showing the length of it's particular pulse when the collector voltage of the NPN goes negative and then returns positive. This process goes on until you either run out of incoming pulses in the sequence or stages in the counter.

The heart of the system is the "Synch Stage" formed by Q_4 and Q_5. Though identical to the stages following, it gets it's turn-on signal directly from the key line. When the last stage of the counter turns off, the voltage on the key line rises sharply to around 3.7 volts, indicating that no stage in the counter is conducting. At this point, current begins to flow thru the 2.2K resistor and Diode to charge up the 6.8 MF capacitor. If you monitered the voltage at this capacitor, you would find that while the key line voltage was low during stage conduction, the voltage stays relatively steady at about 3 or 4 tenths of a volt. When the last stage goes off, a steady rise in voltage occurs up to about 1.0 volt at which time the synch stage latches into conduction. Meanwhile the keyline voltage has steadily risen to about 4.0 volts but drops back to .7 volt as the synch stage fires. The time period required for this action is about 4½ milliseconds and normally it is taking place during the 7 to 8 millisecond duration synch pulse transmitted between each group of information pulses. Since the synch stage is in conduction during the last portion of the transmitted synch pulse, it is switched off at the beginning of the first information pulse and the first information stage of the counter is latched on as soon as Q_3 quits conducting.

If there are an excess of incoming pulses, after the last stage has unlatched, the key line voltage will rise to 3.7 volts but will fall to near zero for .1 millisecond at the end of each excess pulse. This action does not substantially change the charging operation of the 6.8 MF capacitor in the synch circuit until the total time involved with the excess pulses begins to exceed the charging time necessary to turn on the synch stage (4.5 milliseconds) This should explain why a two channel Decoder can be used with a three or four channel transmitter. As for the converse, lets see what happens; just imagine for a moment that you have a four channel Decoder and a two channel transmitter. If we start out in correct order the first time around, channel one and two of the Decoder are fine but since there are only two information pulses, channel three latches in for the duration of the transmitted synch pulse. Since channel three was conducting during the entire synch pulse, the synch stage could not charge up and fire so it sits there patiently waiting for some non-conducting charg-

ing time. When the first transmitted information pulse comes around again, channel 3 goes off and channel four presents information pulse one. At this point there is no place for information pulse number two to go since there are no more stages so it is simply lost in the process and the synch stage finally gets to fire. It's kind of obvious that the Decoder is mixed up at this point and about the best you're going to do is get the correct information to the servos every other time around.

TIPS FOR THE TROUBLE SHOOTER

If you've managed to keep up during the Circuit Description portion of the article you should have a good handle for trouble-shooting. Obviously there is no way to really check out the Decoder at this point without the receiver, transmitter and either a servo or an oscilloscope. If you are experiencing malfunction the common causes and cures are listed below: (assuming you have the correct signal input from the receiver).

1) Decoder completely inoperative
   a) short or defective component in Q_1, Q_2, Q_3 circuit.
   b) one stage or counter latched in- check bases of NPN transistors. check for correct transistor placement.
2) First information stages work correctly, latter stages dead.
   a) defective .022 capacitor.
   b) defective NPN transistor in first inoperative stage.
3) Extremely short pulse appears at one stage, it's information pulse appears at output of following stage.
   a) this stage "firing-thru"—probably defective or low gain PNP failing to latch.

A NOTE FROM WORLD ENGINES

We thank M.A.N. for this opportunity to make a personal appeal for your understanding of our position as the parts supplier for a kit. When the components for a production run of kits are gathered for packaging, they are done in groups of 20, 50 or perhaps 100 at a time, in order to cut down the time involved and therefore the labor charge which ultimately appears in the kit price to you, the builder. Many times, the packers don't know what the individual components are; their only interest is to get two of this color resistor in each box or bag, four of these things and three of those, etc. From our past experience with Digitrio kits, we get a lot of letters which read similar to the following: Dear Sirs, I have the following parts—(2) 2.2K resistors, (3) 4.7K resistors, (1) 47MF capacitor, etc., etc., (5 to 25% of the parts in a kit)—please send me the rest of the parts I need to build a SuperTwitch four channel transmitter. Thanks, signed: Joe Smith. What Joe doesn't realize is, that an order such as this takes special handling because first of all, someone who does know one component from another must either take a kit package and remove and return to stock the parts Joe has or get a parts list, mark off the parts Joe has and individually collect the rest of the parts on the list. For this reason, Joe is charged the individual component prices for the parts he receives. The next thing that happens is that Joe receives his parts—with a small C.O.D. amount due because he enclosed enough money with this order to cover the kit price minus the sum of individual component prices of the parts Joe had. Joe writes another letter asking for an explanation of the charge and also the reason why his Buddy, who ordered a standard kit package, received his a day or two earlier. Well—I think you can see how it goes; the moral of the story is that if you're in Joe's position and have a few parts which are called for in one or another of the assemblies, add up the individual component prices of the parts remaining in that kit; you may find it to your advantage to get the whole kit and retain the parts you have as spares. You probably won't run into this situation on the Decoder since most of the parts used are not "standard" yet. But it could easily come up on the transmitter and receiver.

234 DECODER PARTS LIST

COMPONET	NUMBER REQUIRED 2 Chan.	3 Chan.	4 Chan.
RESISTORS 1/8th Watt			
1.5K	1	1	1
2.2K	1	1	1
3.3K	4	5	6
4.7K	3	4	5
10K	1	1	1
47K	2	2	2
100K	1	1	1
TRANSISTORS & DIODES			
2N 3794 (NPN)	6	7	8
2N 4289 (PNP)	3	4	5
DHD 806 DIODE	3	3	3
(or IN 4148 DIODE)			
MYLAR CAPACITORS			
.0047	1	1	1
.022	2	3	4
TANTALYTIC CAPACITORS			
47 MF @6V	2	2	2
6.8 MF @ 15V	1	1	1
MISC.			
OS PLUG			
MALE HALF	1	1	1
Female Half	2	3	4

HARDWARE ITEM	NUMBER REQUIRED
RECEIVER-DECODER Case with insulator boards	1
3/16" Rubber Grommets	3
#2 x 1/4" sheet metal screws	2
Wire & Heat Shrink Tubing Pkg.	
40" length of red hook-up wire	
35" " " white " "	
40" " " black " "	
33" " " yellow " "	
10" " " small heat-shrinking tubing	
5" " " large " "	
P C Board	1

234 DECODER COMPONENT PLACEMENT

RESISTORS

VALUE	COLOR CODE	HOLE NUMBER
100K	Brown-Black-Yellow	18 & 17
47K	yellow-violet-orange	20 & 19
47K	" " "	27 & 28
3.3K	orange-orange-red	29 & 30
10K	brown-black-orange	61 & 60
4.7K	yellow-violet-red	73 & 74
4.7K	" " "	103 & 104
3.3K	orange-orange-red	80 & 79
3.3K	" " "	84 & 85
1.5K	brown-green-red	87 & 86
2.2K	red-red-red	53 & 52
3.3K	orange-orange-red	51 & 50
4.7K	yellow-violet-red	95 & 96
4.7K	" " "	48 & 47
4.7K	" " "	36 & 38
3.3K	orange-orange-red	34 & 35
3.3K	" " "	7 & 8

DIODES

	ANODE HOLE NO.	CATHODE (Banded End) Hole No.
DHD 806 or IN4148	65	64
DHD 806 or IN4148	67	66
DHD 806 or IN4148	68	69

Note: DHD 806 & IN4148 diodes are interchangeable in this application

TANTALYTIC CAPACITORS

VALUE	HOLE NUMBERS NEGATIVE LEAD	POSITIVE LEAD
47 MF @ 6V	1	2
47 MF @ 6V	6	5
6.8 MF @15V	62	63

NSISTORS

	EMITTER	COLLECTOR	BASE
3794	21	23	22
"	24	25	26
"	56	57	58
"	77	76	75
"	100	99	101
"	93	92	91
"	41	40	42
"	10	9	11
4289	70	71	72
"	83	81	82
"	88	90	89
"	45	44	43
"	14	13	12

. . . step up to Stunt

(*Continued from page* 19)

n stunt could be going through ims, just trying to keep his airplane on lines if he was directly behind the *d* airplane. The thing that saved us n this lurking monster was the fact we didn't have two sets of matching test lines, so we used a set of 67 foot- on the *Lead* plane, and 62's on the *ise* model, reasoning that it would be er for the following airplane to be fast- Use of the shorter lines inadvertently ed the second airplane into a relatively an" traffic lane, and we flew innocent- dvantaged this way for several months, ore matched lines showed us how rt (lucky) we had really been. Team ig became a little spooky until we red out why we were having so h trouble with turbulence.

long the line, we discovered that amers added quite a bit of color he show and also provided a spectacu- ending, if the plane pulled in and le a few snips. (Use extra long string veen plane and streamer and it's safe igh). At one show, we used three streamers on each plane—one on each wing tip and one on the tail. This really made the sky look like it was full of airplanes, and the tip streamers showed up some very interesting facts about wing turbulence in the turns.

I believe that any two accomplished stunt flyers who trust each other (this is important) can work up a pretty interesting routine. In the last two years, I have chased three different pilots—Son Jim—Son Tom—and good friend, Bart Klapinski. Bart and I rehearsed the established routine, and had it down pat in about 10 days. We were in a hurry to fly before a baseball game at Angels Stadium. (Ed's Note: You club people looking for a spectacular should latch on to this.) We were up on cue, put on a spectacular 4 minute show, and quit together just as we had planned. The crowd loved it.

Team stunt is a natural sideline for any serious flyer, as the basic requirement to keep a fresh and improved airplane "on the fire" usually provides a stable full of tired old work horses. This does not necessarily mean that your skill should be contest level before you try it, because we were not in that class when we started.

Following are some suggestions on how to get started, some of which will be a repetition of points already made:

(1) Pick a partner with whom you share a mutual respect of flying skills—One that you can count on to be available when practice is needed.

(2) Use old airplanes at first that fly well, but which you feel you can afford to *lose*.

(3) The lines on the *Lead* plane should be about 5 ft. longer than on the *Chase* plane.

(4) *Walk through* the maneuvers first before you ever attempt them with airplanes. This little step would best be taken *inside the house* with the doors locked and the shades drawn! Here's why! Imagine two fellows walking around each other with arms extended, ducking and dodging heaven knows what, reversing occasionally, and moving their arms in unexplainable gyrations. Get the picture? Bart's wife couldn't stop 'cracking up' when we were practicing for the Stadium bit, and we finally got so self-conscious, we had to blindfold her. Seriously, this has been one of the most important things we've done, as we've advanced into new maneuvers. Here's how you do it. Pretend you're the Lead pilot, hold your arm out and follow your imaginary airplane just like it was out there. As the Lead airplane starts into an inside loop, you back around behind the Chase pilot. Your plane is going over the top, so your arm is high, and the Chase plane is starting into the loop as it's pilot ducks under your lines—Now you're starting down the back half of the loop, so you must duck down and follow through. As you duck down to your left, the Chase plane goes over the top, its pilot backing behind you with arm raised. Just keep repeating for each loop.

Rotation in the center of the circle is reversed for outside loops. So far, conventional loops have required more footwork than any maneuver we've tried. Lazy Eights are accomplished with the Lead pilot standing stationary about 5 ft. behind the Chase. The Leader walks into this spot as he starts the maneuver and you can keep it up all day without moving out of your tracks. Vertical Eights are the same way, but these seem to work out best with the Lead pilot just a little bit to the left of his partner. For one thing, the line length advantage is