# TERRAPIN® TURTLE

## INSTRUCTION AND ASSEMBLY MANUAL

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# Introduction to the Terrapin Turtle Assembly Manual

The Terrapin Turtle can be assembled and debugged (if necessary) in a few hours by anyone with experience in electronic kit assembly. This manual covers all the steps necessary to assemble a fully-working Turtle and also includes a section of useful hints on getting rid of glitches that may have cropped up.

All Turtle parts are included in the kit. The tools you will need are a follows:

(1.) a soldering iron with a fine-point tip
(2.) longnose pliers
(3.) a pair of wirecutters, diagonal cutters or shears
(4.) a flat-bladed screwdriver
(5.) a volt-ohm meter (helpful in debugging)
(6.) a 1/16" or 3/16" Allen wrench (included with your kit)

Two helpful hints before you start assembling your Turtle:

(1.) READ ALL OF THESE INSTRUCTIONS THROUGH BEFORE YOU BEGIN ANY ASSEMBLY WORK.
(2.) CHECK TO SEE THAT YOU HAVE ALL YOUR PARTS! (You don't want any nasty surprises later on!)

Also, any warnings or helpful hints will be written in CAPITAL LETTERS so be on the lookout for those. Be patient, take your time, and have fun in the process!

## MECHANICAL PARTS LIST

| NAME | QUANTITY |
|---|---|
| Motors | two |
| Wheels | two |
| Tires | two |
| Pen solenoid | one |
| Pen plunger (nested in the solenoid) | one |
| Pen spring | one |
| Plastic threaded balls (Turtle Toes) | two |
| Touch sensor disc (yellow plastic) | one |
| Touch sensor ball joint | one |
| Allen wrench | one |
| Motor brackets | four |
| 3" motor spacers | three |
| Speaker mount (black rubber strip) | one |
| Solenoid mounting brackets | two |
| Ball-point pen refill | one |
| Speaker | one |
| 6-32 x 1/4" screws | twelve |
| #6 lockwashers | sixteen |
| 6-32 x 1" screws | eight |
| 6-32 nuts | two |
| Bottom plate | one |
| 10-32 dome screw | one |
| 10-32 white nylon dome washer | one |
| 6-32 white nylon washers | four |
| 1/4-20 x 1/2" screws | two |
| 1/4 lockwashers | two |
| 10-32 nut | one |
| #10 star washer | one |
| 6-32 black Allen screw | one |
| 4-40 x 1/4" screws | two |
| #4 flat brass washer | one |

## ELECTRONIC PARTS LIST

| NAME | QUANTITY |
|---|---|
| Printed circuit board | one |
| 1K ohm resistors | ten |
| 510 ohm resistors | six |
| 100 ohm resistors | two |
| 3.3K ohm resistors | four |
| 15K ohm resistors | two |
| 51K ohm resistors | two |
| 6.9K ohm resistors | four |
| 1N4001 diodes | nine |
| 1N478 zener diode (3.6volts) | one |
| LED's | two |
| 500 ohm potentiometers (trimmers) | four |
| 1/10th uf capacitor | one |
| #555 integrated circuit (timer) | one |
| D40C4 Darlington transistors | nine |
| 2n2222 transistors (tin cans) | seven |
| Microswitches | four |
| Solderless spade connectors | six |
| 50" 22-gauge hookup wire | one |
| Male Amphenol connector | one |
| Heat-shrink tubing | one |
| Ten-foot signal and control cable | one |

AND: one 3" diameter plastic dome

The main steps in assembly of the Turtle are 1) the soldering of components to the precut, pre-drilled printed circuit board which functions as the electronic control for all of the Turtle's activities, and 2) mechanical assembly of the motor unit which doubles as the Turtle's body. The Turtle is put together following this general outline:

(1.) PRINTED CIRCUIT BOARD

(A) Resistors
(B) Diodes
(C) Transistors
(D) Potentiometers
(E) Integrated circuit
(F) Microswitches
(G) Light emitting diodes (LED's)
(H) Capacitor
(I) Darlington transistors
(J) Jumper
(K) Attachment of cable to board
(L) Leads

(2.) Attach the ball joint and touch-sensor disk
(3.) Assemble the solenoid and pen unit
(4.) Mount the solenoid to the bottom plate
(5.) Attach one motor electrically
(6.) Screw the spacers, motor brackets and PC board onto the aforementioned motor
(7.) Wind the cable around the spacers
(8.) Connect the other motor electrically, and attach with the motor brackets
(9.) Fully attach the PC board to the assembly
(10) Attach the toes and the speaker mount to the bottom plate
(11) Attach the speaker electrically
(12) Attach the solenoid electrically and mount the bottom plate to the PC board-motor assembly
(13) Mount the speaker to the bottom plate
(14) Put the tires onto the wheels and mount these onto their axles
(15) Screw on the dome

Most of the working components of the Turtle are also structural. The gearplates of the drivemotors also serve as the main body of the device. They are held by rigid spacers and brackets. Together with the metal bottom plate and glass-epoxy PC board, a rigid framework is formed.

While you're heating up your soldering iron, read ahead a few pages to familiarize yourself with the upcoming procedures.

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XXXXXXXXXXXXXXXXXXXXXXXX
X                      X
X  ELECTRONIC ASSEMBLY  X
X                      X
XXXXXXXXXXXXXXXXXXXXXXXX
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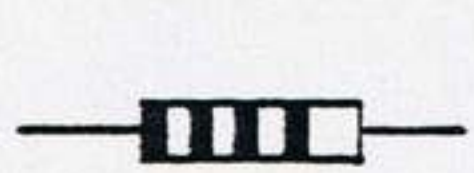
1.) THE PRINTED CIRCUIT BOARD (Illustration, please)

First, remove the PC board and electronics bag from your Terrapin Turtle kit. The PC board is a pre-cut five-inch diameter glass epoxy disc with drilled holes to accommodate all the components.

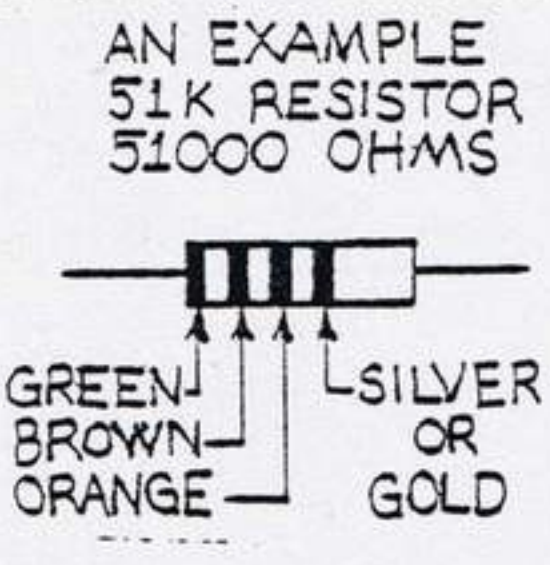
As a general overview, the object of this phase of assembly is to insert components through the top of the board (the side with all the diagrams and printed resistor values) and solder the component leads to the tinned copper conductive foil on the opposite side of the board.

A) RESISTORS- Assure yourself that all electronic components from the parts list are contained in the ziplock baggie that you took from your kit. Take out the colorful little cylinders with the long metal leads and separate these from the rest of the electronics bag. Identify these resistors by their various color codes.

COLOR CODE KEY: RESISTORS ARE PRINTED WITH STANDARD COLOR-CODE BANDS. THERE ARE THREE BANDS IDENTIFYING THE VALUE OF THE RESISTOR, AND ONE BAND INDICATING THE PRECISION OF THE INDICATED VALUE (THIS LAST CAN BE IGNORED). THE RESISTOR VALUE IS INDICATED BY: FIRST COLOR (FIRST DIGIT), SECOND COLOR (SECOND DIGIT) AND THIRD COLOR (A X10 MULTIPLIER WHICH INDICATES THE NUMBER OF ZEROES THAT YOU HAVE TO TACK ON TO THE FIRST TWO INTEGERS. THE DIGITS AND THEIR CORRESPONDING COLORS ARE:



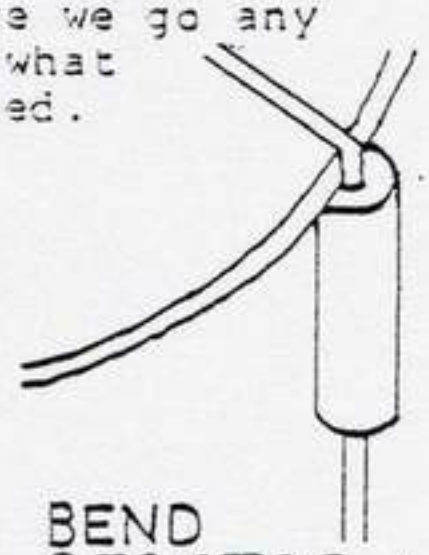
RESISTOR




| | |
|---|---|
| 0 - BLACK | 5 - GREEN |
| 1 - BROWN | 6 - BLUE |
| 2 - RED | 7 - VIOLET |
| 3 - ORANGE | 8 - GREY |
| 4 - YELLOW | 9 - WHITE |

(THE LETTER "K" IN REFERENCE TO RESISTORS, REFERS TO KILO-OHMS OR ONE THOUSAND OHMS)

Bend the leads of the resistors so that they are properly spaced for insertion into the board. * A GOOD TRICK FOR ACHIEVING PROPER SPACING IS TO BEND THE LEADS OVER THE EDGE OF THE PC BOARD AS ILLUSTRATED. THE BOARD HAPPENS TO BE THE RIGHT THICKNESS REQUIRED BETWEEN THE RESISTOR BODY AND THE RIGHT ANGLE BEND NEEDED IN THE LEAD * Each resistor location is marked on the board for proper placement and resistance value. Unmarked locations require a 1k resistor. Resistors can be inserted into their board locations in either direction; it does not matter how the bands are oriented for the resistor to do its job. After bending the leads, insert the resistors into the board and solder them in. BUT, before we go any further, a little more needs to be said about soldering and what constitutes a good technique as far as our Turtle is concerned.




## SOLDERING

Good soldering is a key factor in proper assembly of any electronic device, but is especially essential in the case of your Turtle. To solder correctly, use a small 25 to 40 watt pencil soldering iron. The soldering iron tip must be kept clean during operation, and this can usually be done by wiping the tip occasionally with a damp sponge or cloth. (We at Terrapin have found that a sponge is pretty handy.) After making sure the tip is clean, "tin" the soldering iron by coating the tip with solder. If the solder won't adhere to the iron or "cakes", then clean and tin again. (A good solder type to use has a size of approximately 22-gauge with a 60:40 tin-to-lead ratio)

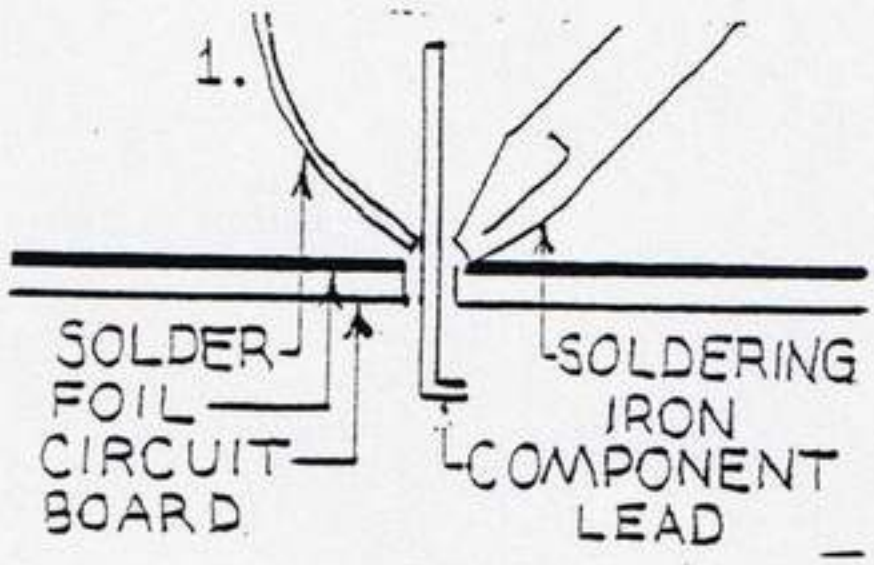
Exercise extreme care when soldering underneath the PC board. A solder "bridge" between two of the foil areas of the board must be avoided at all costs for your Turtle to function properly. A bridge is formed when two different foil lines are joined by solder. This may be the result of too much solder being melted into the target area, of an accidental dragging of the iron across several foils, or of carelessly touching a prior joint with the tip. * INSPECT THE SOLDERING AREA BEFORE AND AFTER A SOLDERING JOINT IS MADE *

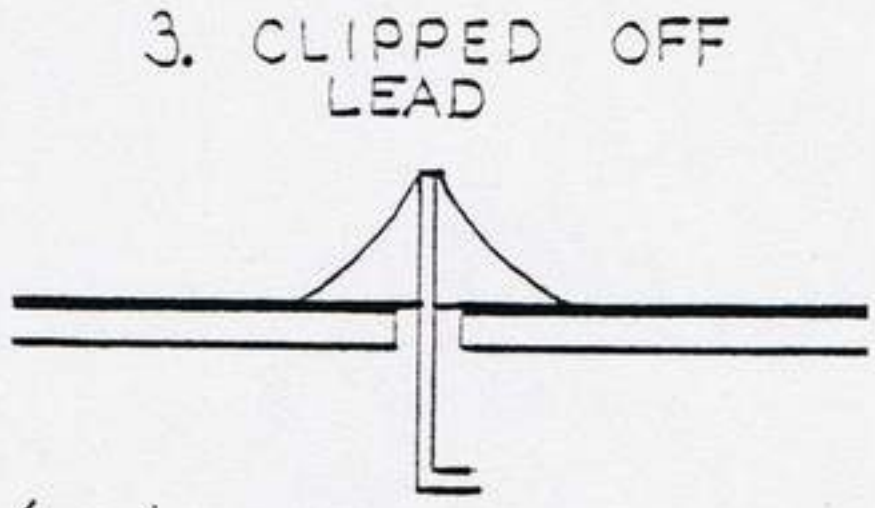
Use the minimum amount of solder necessary for a good connection. Should a bridge develop, turn the PC board upside-down and touch the iron to the bridge. This should melt the solder down onto the tip, and thus destroy the bridge.

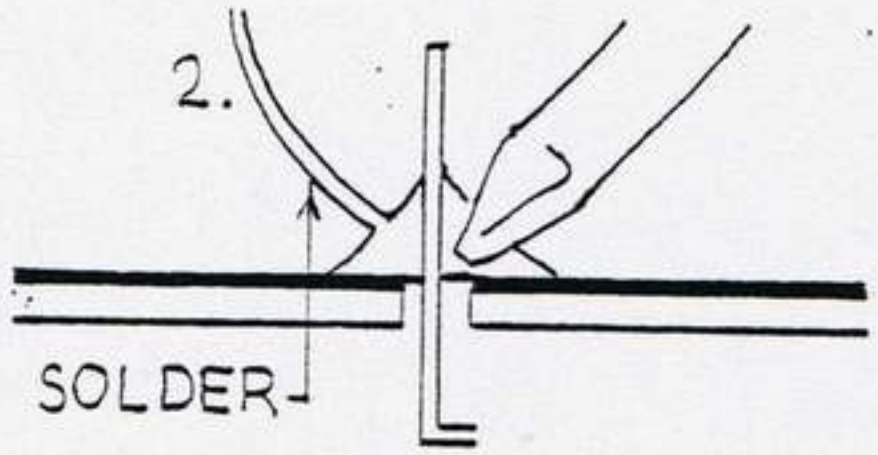
Once the electrical component is properly placed in the PC board, turn the whole board upside-down so that the lead is presented towards you. * FOR EFFICIENCY'S SAKE, PLACE ALL THE COMPONENTS THAT YOU PRESENTLY SOLDERING INTO THE BOARD ALL AT ONCE AND THEN COMMENCE SOLDERING. FOR EXAMPLE, IF YOU'RE SOLDERING RESISTORS, WHICH ALL HAVE RELATIVELY THE SAME HEIGHT, PLACE THEM ALL IN THE BOARD, TAKE A FLAT OBJECT WHICH WILL COMPLETELY COVER THE BOARD, PLACE THE FLAT ON TOP OF THE RESISTORS AND FLIP THE WHOLE BOARD OVER. THUS YOU ARE PRESENTED WITH NOTHING BUT SOLDERING AREAS * Place the soldering iron tip at a 45- degree angle to

both the component lead and the PC board foil. Heat for approximately three seconds. Apply solder to the connection on THE OTHER SIDE from the soldering iron. The foil and the component lead should melt the solder, not the iron directly. Let the solder flow around the joint and then simultaneously lift the iron and the solder straight up to avoid forming any bridge.

Be sure that the components are inserted all the way down into the holes , so that the bodies of the components are as close as possible to the PC board. When the solder is cool, clip the leads cleanly off the bottom of the board, nearly flush with the surface itself. This will prevent accidental grounding of the electrical circuit to the mechanical assembly. * DO NOT USE ACID-CORE SOLDER OR PASTE FLUX *

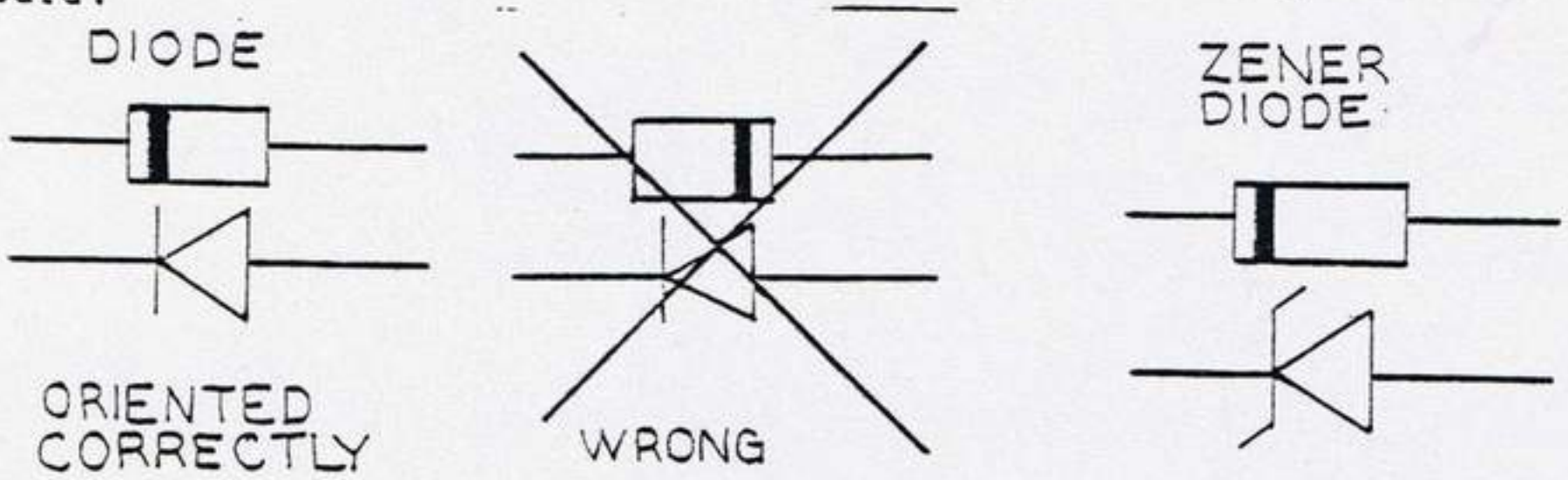



B) DIODES - There are nine power diodes and one zener diode included in your kit. * BE SURE NOT TO CONFUSE THE POWER DIODES FROM THE ZENER DIODES * In many Turtle kits, the power diodes can be distinguished from the zener diode rather easily because they are packaged in a black epoxy case with a silver band at on end to indicate their orientation in the circuit. However, some kits will contain glass-package diodes. The main difference between these and the zener device is that the power diodes are visibly fatter in appearance. The zener diode is in a glass package,is smaller than the rest of the diodes and has the designation 1N748 printed around the middle of the case.

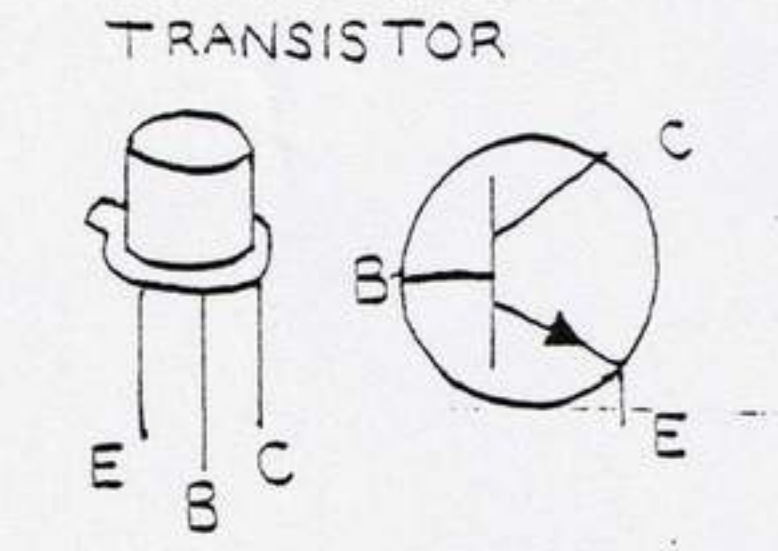
Diode cases have a single black or silver band printed at one end. This corresponds to the straight line in the symbolic representation of a diode in circuit diagrams (and on the Turtle's PC board). Diodes must be oriented with the band on the case matching the straight line on the PC board.



Bend the diode leads for insertion into the board. Proper spacing may be achieved by gripping the diode lead next to the body with a pair of long-nosed pliers and bending the lead over the pliers' jaws. Insert the diodes as illustrated.

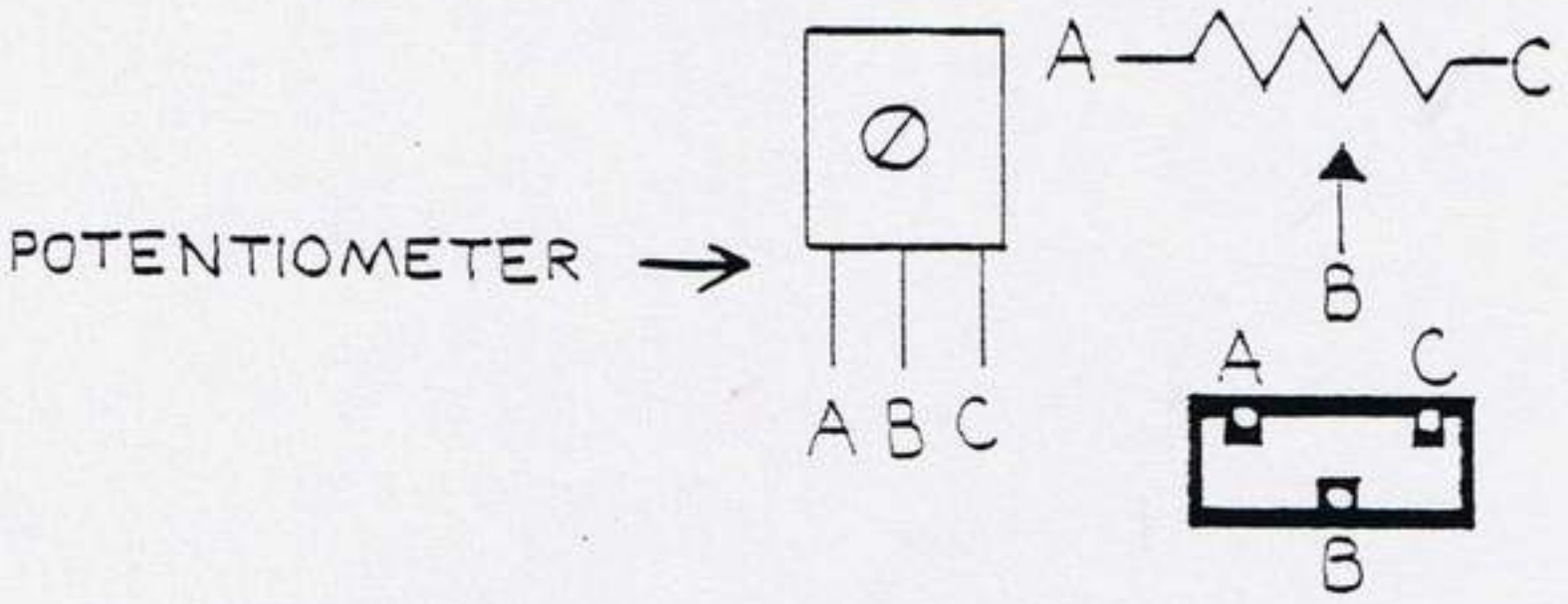
* BE VERY CAREFUL WITH THIS STEP AS THE DIODES MUST BE INSERTED IN THE PROPER ORIENTATION AND THE ZENER DIODE MUST OCCUPY ITS CORRECT SPOT ON THE PC BOARD * Solder in the diodes and clip the leads flusn with the board.

C) TRANSISTORS - Find the seven transistors in your electronics bag. They are packaged in what appear to be tiny tin cans with three very fine electrical leads coming out of the bottom. Insert the transistors into the PC board with the small metal tabs on the base of the packages aligned with the tabs on the board pattern.




The three leads on the bottom of the transistor are referred to as the emitter, the collector and the base. The tab referred to is always located near the emitter. The base is in the center. * BE CAREFUL! TRANSISTORS MUST BE ORIENTED CORRECTLY * Solder the transistors to the board and clip their leads.

D) POTENTIOMETERS- Potentiometers can also be thought of as variable resistors. The potentiometers that are part of your turtle look like small blue blocks with white notched discs in the center of one side. These are trimmer pots and are mounted on the PC board to enable you to adjust the motor circuit and synchronize the Turtle's movements. Solder the pots to the board and clip the leads. Make sure that the adjustment slots on the pots (the white discs referred to previously) face towards the front of the board.

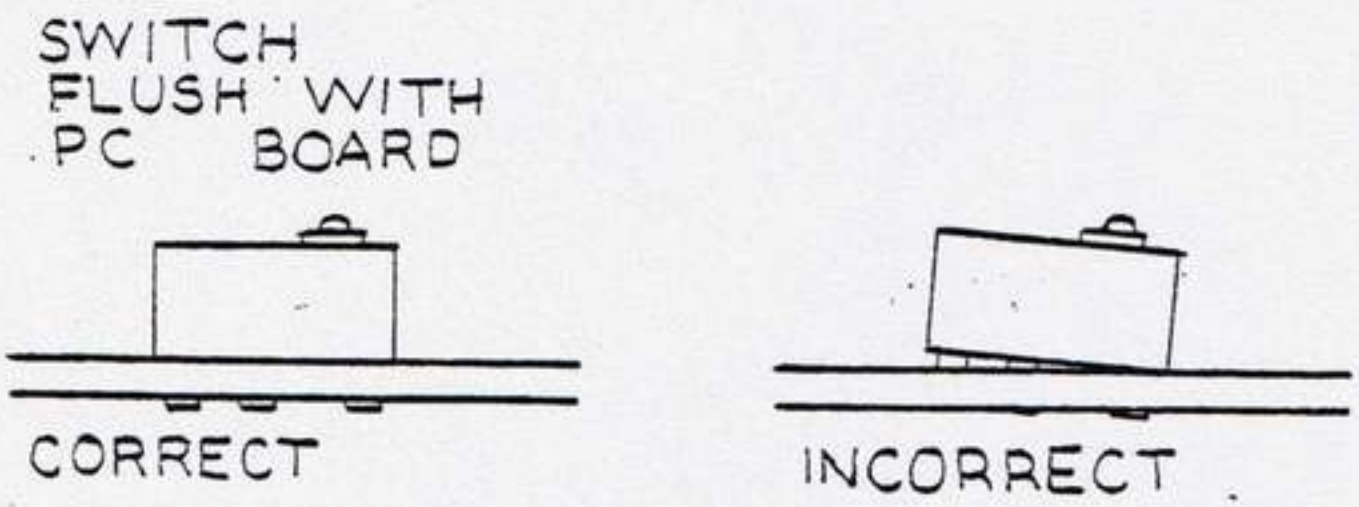


E) INTEGRATED CIRCUIT- The integrated circuit used on the Turtle is a fairly common 555 IC timing device. Insert this into the PC board. * IT IS ABSOLUTELY NECESSARY FOR THE IC TO HAVE PROPER ORIENTATION IN THE BOARD TO ACHIEVE GOOD PERFORMANCE * Attempting to operate the Turtle with the timer put in backwards will most likely result in damage to the 555 and an inoperative Turtle. The pins are numbered (by convention) as shown in the drawing below, with the 555 seen in a top view. The notch or dot visible on the case denotes the " pin #1 " end. The 555 must be inserted in the board so that this notch or dot is located at the same end as the drawing on the PC board.

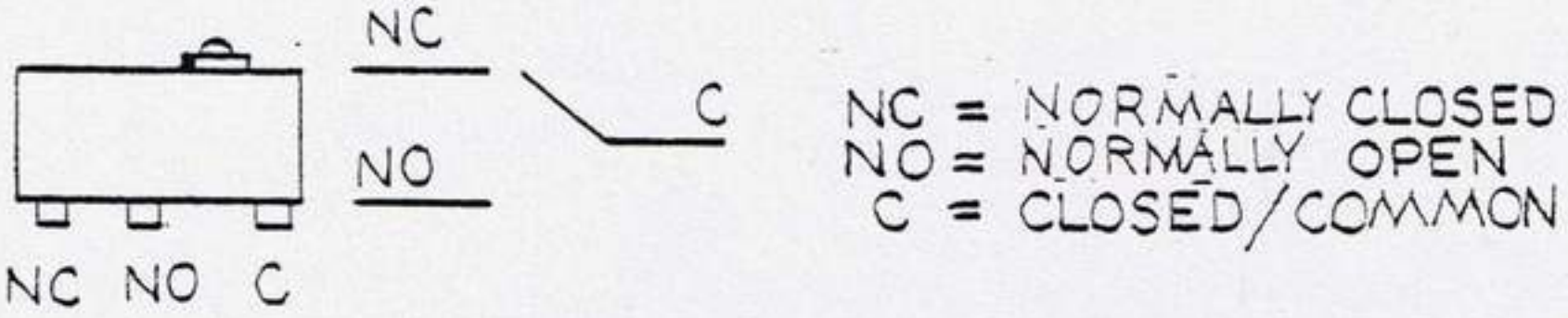

F) SWITCHES- There are four microswitches mounted in the Turtle which, when activated by the touch sensor disc, indicate to your microcomputer that the Turtle's shell, or dome has come into contact with an object. The switches are the dark brown rectangular objects that have three thick leads protruding from the base and a small red pushbutton on the top.

Insert the switches in a star pattern in the center of the board. Since the switch leads are short and rather wide, the holes drilled for them are rather large. You shouldn't expect a correct fit for all the leads; the switches will not hold themselves in position while being soldered. After placing the switches to correspond to the white rectangles printed on the board, place a book or some other suitable flat object on top them so that they won't fall out when you turn the board to the copper-clad side for soldering.

MAKE SURE THAT THE BODIES OF THE SWITCHES ARE MOUNTED FLUSH TO THE PC BOARD.

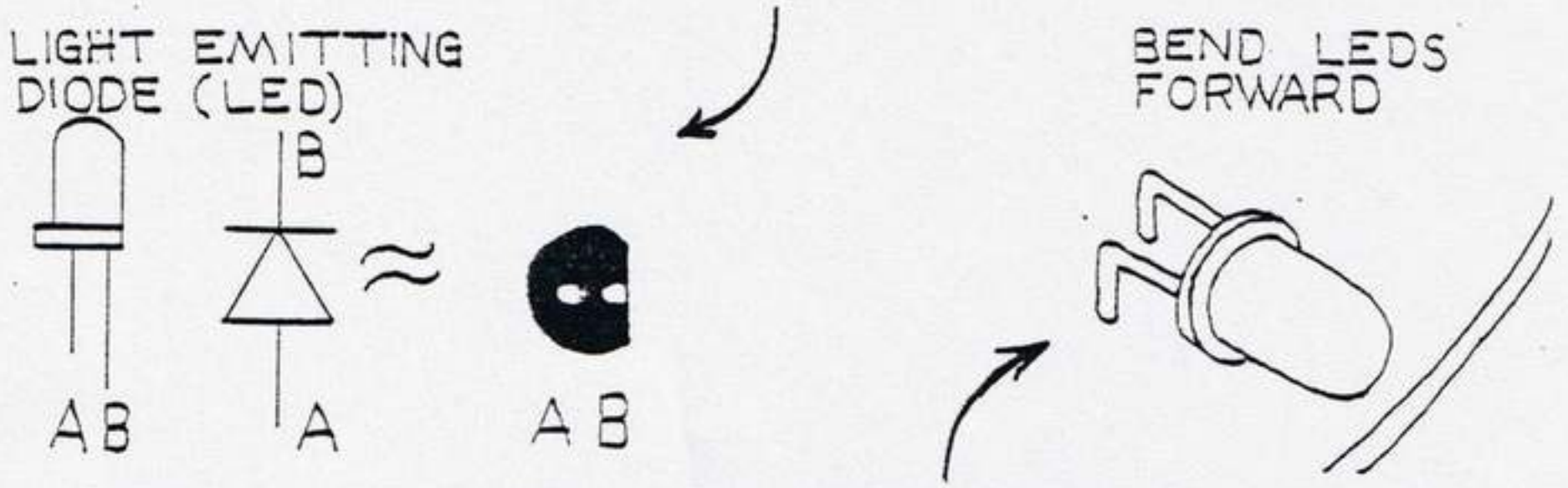



Since the leads of these switches are substantially thicker than those of the components we have been dealing with previously, they may rewire more heating than the leads of the other components in order to get the solder to flow. Make sure that your solder joints make good contact with the foil to ensure proper operation.



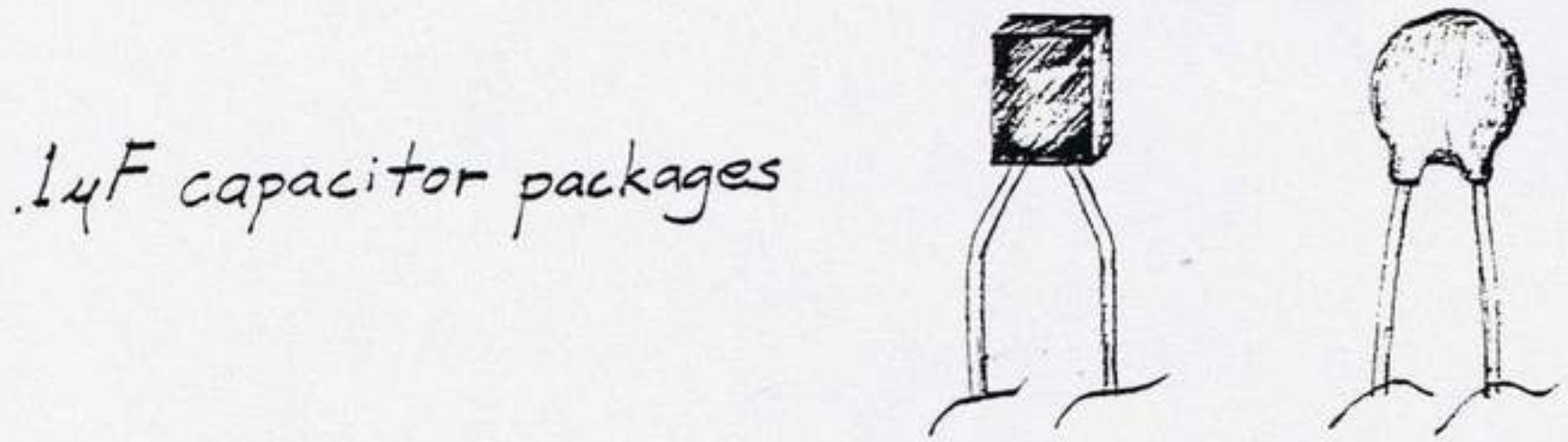
G) LIGHT EMITTING DIODES- Your Turtle has two light emitting diodes which serve as its "eyes". They are easily recognizable as small red cylinders with very long leads.

The cathode of these diodes is marked by the flat side on the case. This flat side must correspond to the flat side symbolically represented on the circuit board:



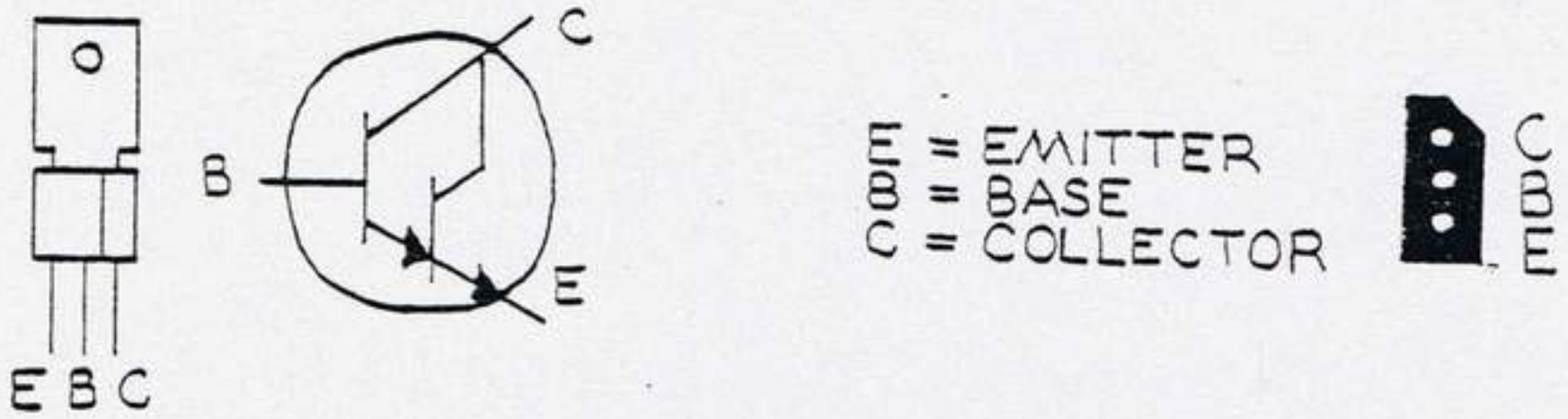

Insert the LEDs, leaving 1/4 inch of lead on the top of the board. Solder them into the board and then bend the diodes down so that they lie almost flush with the surface of the board, facing forwards. Clip their leads close to the bottom of the board.

H) CAPACITOR- The capacitor provided with your kit appears as one of two types of packages; a rectangular black block or a blue or yellow disc, both with long leads. Insert it in its proper place in the board, gently adjusting the leads of the capacitor to fit the holes in the board. Orientation is unimportant in this case. Solder the capacitor in and clip the leads.



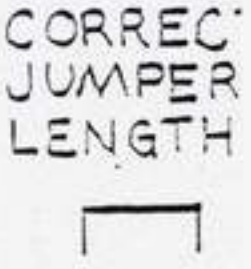

I) DARLINGTONS- The darlingtons are power transistors for the Turtle's motor circuit. They are packaged in a brown epoxy case with three short leads coming from the bottom and a large metal plate protruding from the top, much like a flag.

Insert the nine darlingtons in the in the spots indicated on the PC board, AND IN THE CORRECT ORIENTATION. The notched edges on the cases must be aligned with the notches on the symbols printed on the PC board.



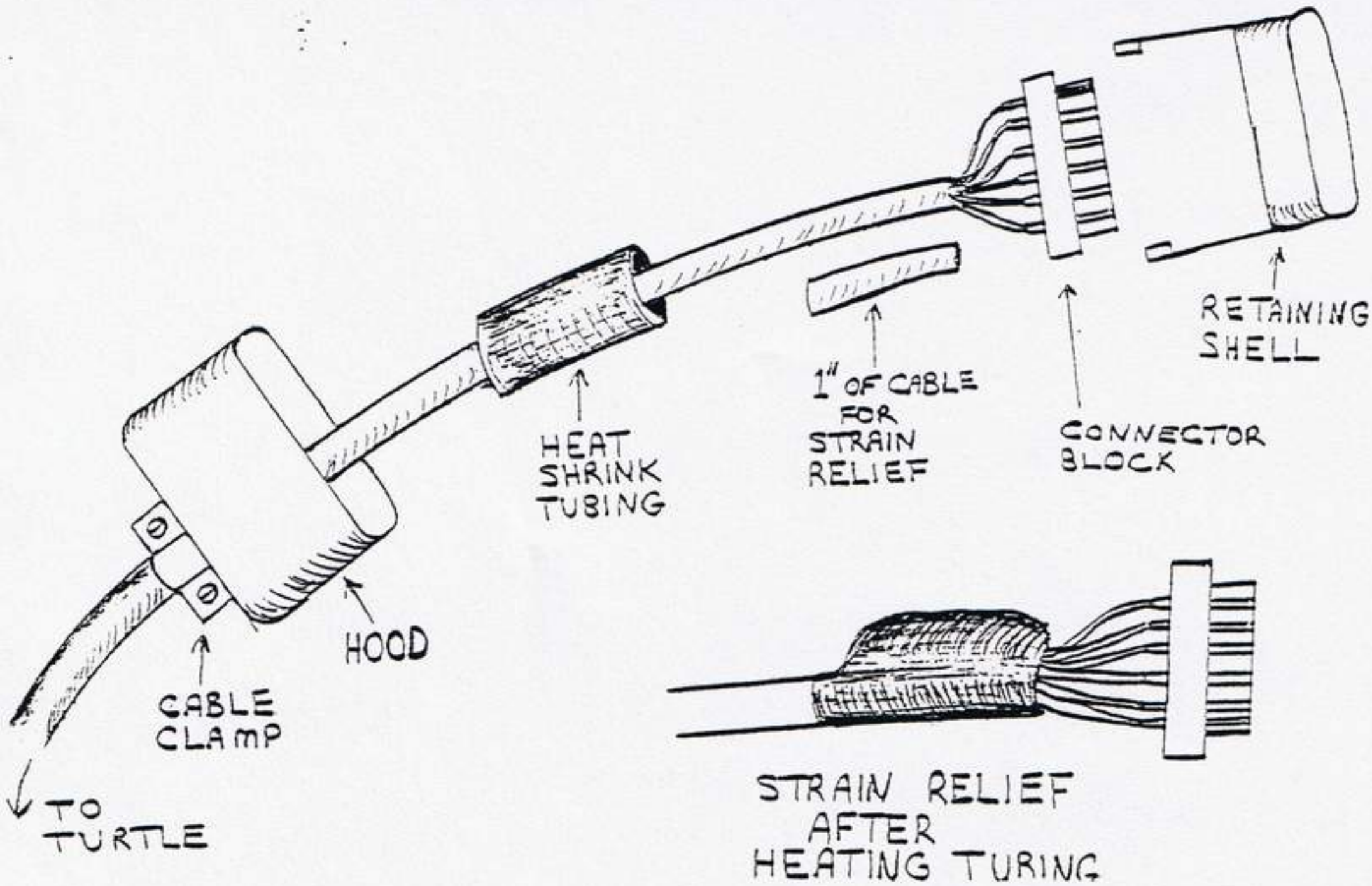
The darlingtons have three relatively short leads. Be sure that the leads contact the foil on the board. Solder the transistors to the board and clip leads. The tabs at the tops of the darlingtons should not touch while the Turtle is in operation.

J)JUMPER- A "jumper" is a piece of wire that connects one line of foil on the PC board to another. There is one jumper wire on the Turtle PC board to facilitate the efficiency of the design. It also functions as a test point for the supply voltage. This jumper can be made from an excess lead clipped from a resistor. The location of the jumper is indicated on the PC board by a line connecting two holes. Use a pair of pliers to bend the resistor lead to the dimensions shown here and solder it to the board.




K) CABLE AND CONNECTOR- WHEN READING THE INSTRUCTIONS FOR THIS SECTION PAY CLOSE ATTENTION TO THE CORRESPONDING DIAGRAM. The male Amphenol connector consists of several parts: the blue plastic connector block, a hood and cable clamp combination that slips onto the cable side of the connector block, the retaining shell that holds the connector block in the hood and two very tiny screws (BE EXTREMELY CAREFUL WHEN OPENING THE BAG CONTAINING THE AMPHENOL CONNECTOR) that hold the hood and retaining shell together. We have included a short length of heat shrink tubing to fasten a small length of cable to the connection to act as a strain relief. To prepare the cable for soldering, cut off approximately one inch of cable and save for use as mentioned above as a strain relief. Strip back the outer (gray) insulating jacket about one inch. Strip the individual conductors inside of approximately 1/4 inch of their insulation. THE INDIVIDUAL CONDUCTORS ARE COMPOSED OF STRANDED WIRE. BE CAREFUL WHEN STRIPPING OR RUN THE RISK OF BREAKING THE FINE STRANDS. The white-gray wire is unused and can be used to replace another wire if necessary. Tin each wire by heating the end and allowing the wire to "wick" a certain amount of solder to itself to avoid fraying of the end. If the end becomes frayed before you get a chance to tin it, put a point on the wire by twisting it, much as you would do with a thread. BE SURE TO SLIP FIRST THE HOOD (WITH THE CABLE CLAMP TOWARDS THE TURTLE) AND THEN THE PIECE OF HEAT SHRINK TUBING ONTO THE CABLE BEFORE STARTING TO SOLDER THE CABLE TO ITS CONNECTOR BLOCK. The terminals on the connector block should also be tinned before a solder connection is made. It is best to heat the terminal by touching the soldering iron to the side of the terminal facing the inside area of the two rows and applying a small amount of solder to the groove. To connect the wire to the terminals , heat the terminal again in the same manner. When the solder melts, slip the tinned wire into the groove, remove the soldering iron and hold the wire in place until the solder cools. Follow the connection outline below for both soldering the cable to the Turtle directly and making the connections necessary forthe Amphenol plug.

(next page for diagrams and outline.)



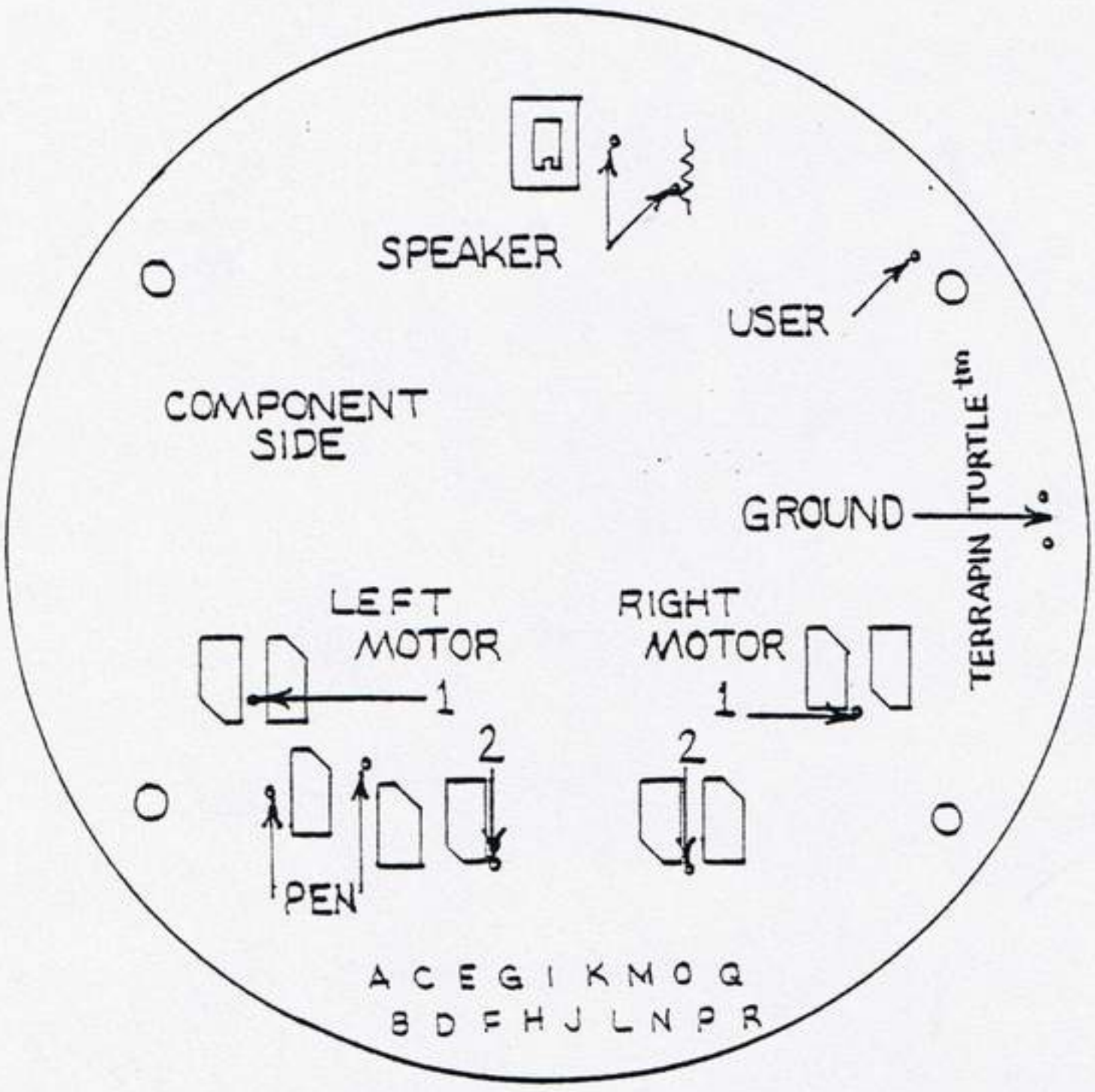



STRAIN RELIEF AFTER HEATING TURING

| Amphenol pin number | Wire Color | Turtle hole | FUNCTION |
|---|---|---|---|
| 1 | black | A | lights (L) |
| 2 | brown | B | horn high/low (T) |
| 3 | red | C | left touch (LT) |
| 4 | orange | D | left motor 1 (LM1) |
| 5 | yellow | E | power |
| 6 | green | F | pen (P) |
| 7 | blue | G | left motor 2 (LM2) |
| 8 | purple | H | ground |
| 9 | grey | I | ground |
| 10 | white | J | back touch (BT) |
| 11 | white-black | K | right motor 2 (RM2) |
| 12 | white-brown | L | power |
| 13 | white-red | M | ground |
| 14 | white-orange | N | right motor 1 (RM1) |
| 15 | white-yellow | O | right touch (RT) |
| 16 | white green | P | front touch (FT) |
| 17 | white-blue | Q | horn on/off (H) |
| 18 | white-purple | R | for user |

The cable utilised for the Turtle is too small for the clamp on the connector hood to work. Therefore a strain relief must be formed. Put the one inch section of cable which you cut previously alongside the main cable even with the cut end where you intend to put your Amphenol connector. Slip the heat shrink tubing over the double section of cable and shrink it using the heat from a match or your soldering iron. Take care that you don't heat the cable excessively, as the insulation could easily melt and allow some of the small conductors to short out. The hood and retaining shell can now be slipped onto the connector block and the position of the strain relief adjusted. The cable clamp is then tightened over the double thickness of cable and the shell and hood are screwed together.

L) LEADS FOR THE MOTOR, SPEAKER AND PEN SOLENOID HOOKUP- For this part of the procedure, you will need the 22-gauge hookup wire and the solderless spade terminals. Cut the hookup wire into eight pieces, making two of the pieces approximately an inch longer than the others. Strip the insulation from both ends of your wire pieces so that about a 1/4 in ch of bare wire is exposed. Using your pliers, crimp the spade terminals to one end of each of the six shorter pieces of wire. Use the two longer pieces for hooking up the speaker. YOU WILL BE SOLDERING THESE WIRES TO THE FOIL SIDE OF THE BOARD, NOT THE PRINTED-SYMBOL SIDE! Place and solder the wires according to the diagram:



Clip the excess wire from the top of the PC board. Connect the speaker to the speaker hookup wires by soldering one wire to each tab on the speaker. Do not use an excess amount of heat, as you run great risk of damaging the speaker.

Ignore the "user" hole in the diagram. However, the ground clip holes are rather important in the debugging process. To form a ground clip, make a loop about a 1/4 inch high out of the excess from a component lead (another clipped resistor lead will do nicely). solder, as indicated, in to the two holes in the ground foil on the PC board, inserting the ground loop from the component side. This loop provides an easyway to access ground when using a VOM's or oscilloscope's probe clips for testing purposes.

THIS CONCLUDES THE ELECTRONIC ASSEMBLY OF YOUR TURTLE. CONGRATULATIONS!!!! PAT YOURSELF ON THE BACK AND PUT AWAY YOUR SOLDERING IRON.

```
XXXXXXXXXXXXXXXXXXXXXXXXX
X                         X
X  MECHANICAL ASSEMBLY    X
X                         X
XXXXXXXXXXXXXXXXXXXXXXXXX
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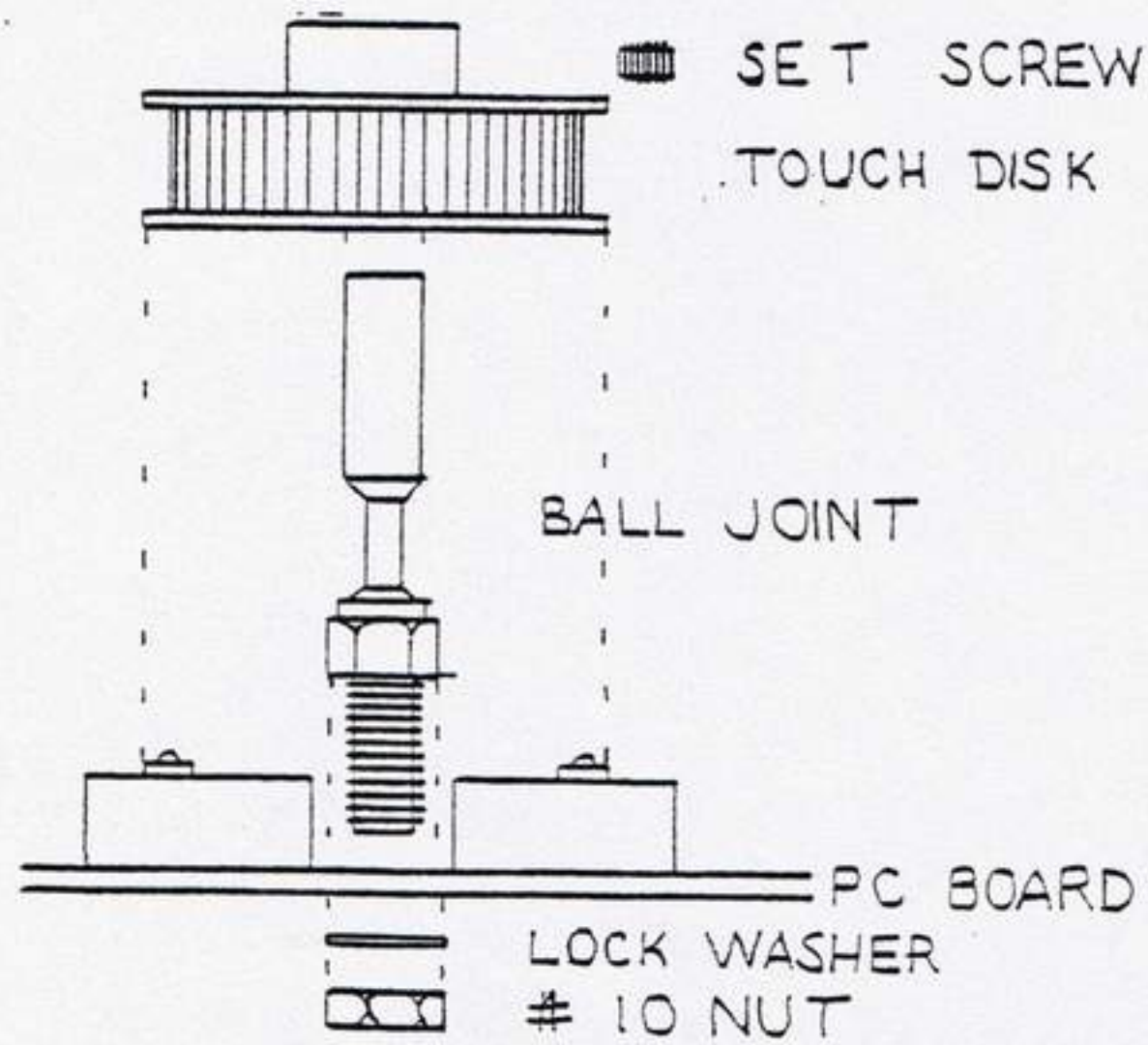
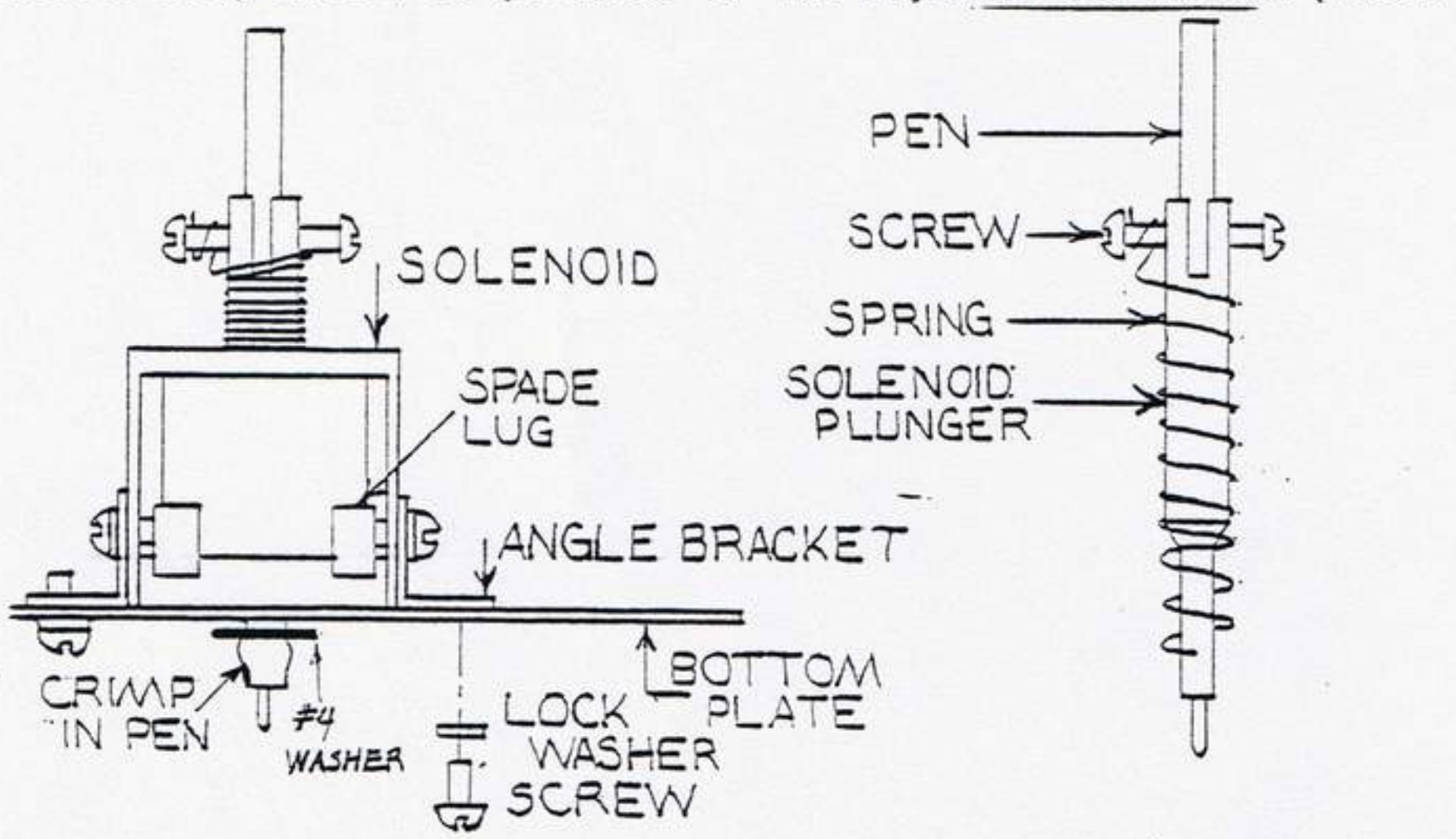
As a general introduction to this section, your main objective will be to assemble the Turtle's motors, pen/solenoid, and speaker into a coherent framework to rest the PC board and keep your Turtle together. Be careful with this section, as some of the operations described are deceptively tricky and can cost you a lot of time and effort if not properly executed. Again, always read a few lines or pages ahead in order to familiarize yourself with what's coming up. This has been found to prevent rude awakenings and gray hairs among kit assemblers. Just remember: you're halfway there!

1) BALL JOINT AND TOUCH SENSOR DISK - Find the ball joint, yellow plastic pulley (touch-sensor disc), the set screw (a small black-anodized Allen screw), and the #10 hex nut and lock washer. Insert the ball joint, threaded end down, through the center of the PC board. (Insert from the component side of the board.) Fasten the balljoint to the PC board using the lockwasher and the #10 hex nut. Then place the touch-sensor disc on the shaft of the ball joint extending upwards from the component side of the PC board. The projecting hub on the pulley should beon top of this whole assembly with the flat side of the pulley facing the PC board. With the flat surface of the pulley resting on the red buttons of the microswitches, use the enclosed Allen wrench to screw the set screw into the threaded hole in the pulley's hub. DO NOT TIGHTEN JUST YET. Allow for adjustment of the pulley so thast there is a minimum of "play" between the disc and the microswitches. Tighten down the set screw to keep the disc in place. Pressure on the ball joint in any direction should cause the corresponding microswitch to make an audible click.

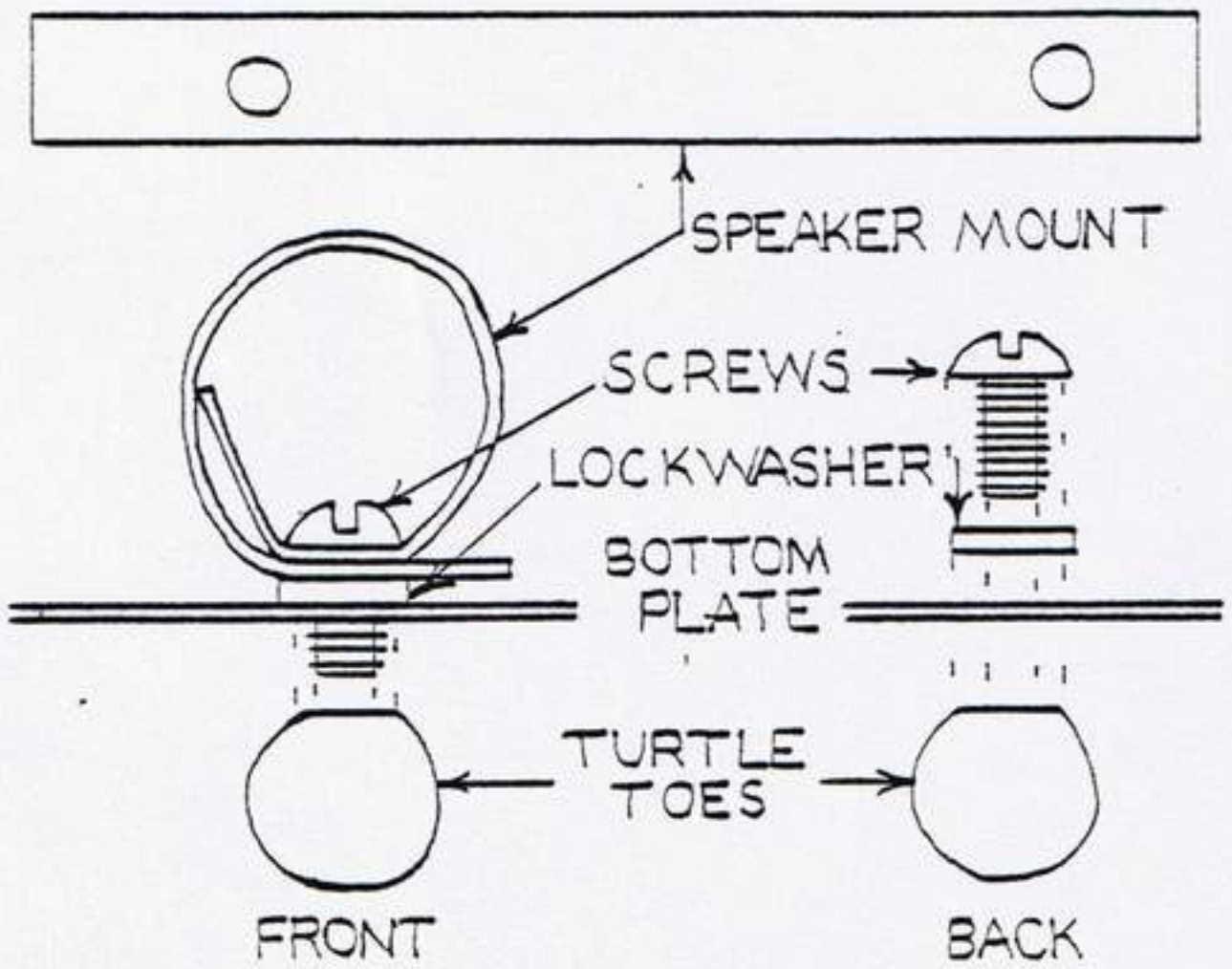


2) PEN SOLENOID ASSEMBLY- the pen assembly consists of the solenoid, solenoid plunger, ball point pen refill cartridge, four 6-32 x 1/4" screws, two small angle brackets, two 4-40 x 3/8" screws, four #6 lockwashers , the bottom plate and a spring. Screw the angle brackets (using the non-threaded hole) onto the solenoid body with the 6-32 x 1/4" screws and #6 lockwashers. Then attach the angle brackets to the bottom plate using the same size screws and lockwashers. The sides of the solenoid body should be parallel to the edges of the bottom plate.




Remove the standard ball point pen refill from its paper packet. (If your Turtle's pen runs dry, these refills are available at almost any stationery store) Following the instructions on the packet, break the refill off at the bottom line. Note that there is a crimp in the pen nearest the point end. Using your pliers, squeeze this area to get rid of the crimp so that you can insert the pen into its holder, the plunger. Insert the pen through the center of the plunger, with the ball end of the pen coming out of the pointed end of the plunger. Secure the pen in this position by inserting 4-40 x 3/8" screws into the threaded holes at the top of the plunger. Adjust the pen so that it protrudes approximately 7/8" from the pointed end of the plunger. Adjust the 4-40 screws, using them as you would a normal set screw, to grip the pen and hold it in position. DO NOT CRUSH THE PEN WITH THE SET SCREWS. Slip the music-wire spring over the pointed end of the plunger, and using the pair of pliers, wrap the end of the spring around one set screw. Insert this whole assembly into its respective spot in the solenoid. The ball end of the pen can be seen now to extend through the bottom plate. Take the #4 flat brass washer, place it over the ballpoint end of the pen and crimp the pen beneath the bottom plate to prevent the assembly from falling out of the solenoid. IN ORDER TO INSURE THAT YOU DO NOT INTERRUPT INK FLOW WHEN CRIMPING, PLACE A SCREW OR OTHER PIECE OF HARDWARE BETWEEN THE HANDLES OF YOUR PLIERS SO THAT THE JAWS CANNOT COMPLETELY CLOSE.

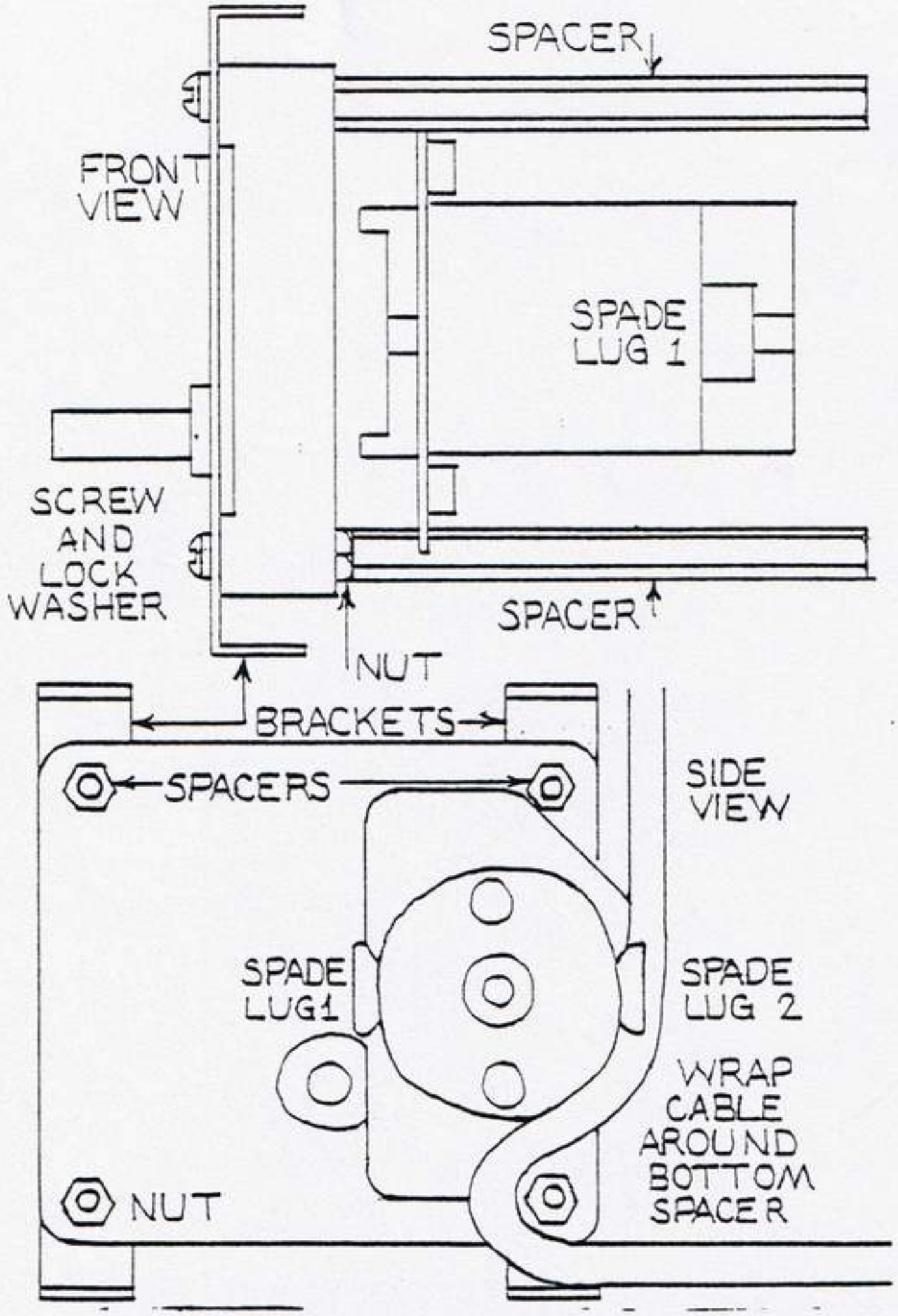
3) TURTLE TOES AND SPEAKER MOUNT: You will need the black threaded balls (Turtle toes), two 1/4" split ring lock washers, two 1/4-20x1/2" screws, speaker mount (belting with pre-punched holes), and the bottom plate. Screw one Turtle toe onto the bottom (non-solenoid) side of the bottom plate using one screw and lockwasher. Mount the other toe including the speaker mount. The speaker mount should be placed on the side opposite the solenoid spade terminals. Form the speaker mount into a ring, matching the holes. Insert the screw through the holes, holding the loop together, with the head of the screw inside the ring. The speaker mount now defines the front of the Turtle.




(next page, please.)

4) RIGHT MOTOR ASSEMBLY: You will need one of the motors, the three aluminum hex cross section spacers, two motor brackets, four 6-32x1" screws, four #6 lock washers, one 6-32 nut, the pc board, two 6-32x1/4" screws, and two #6 nylon washers. Attach three spacers and two brackets to the motor with long screws and lock washers. In the unused space insert a long screw, lock washer and nut. Attach the pc board to the top of the motor brackets with short screws and nylon washers. The top is the side with two spaces. The motor shaft should be near the bottom. The front is the side with the nut. The front of the pc board is the side containing the Turtle eyes (LEDs). It is important to use the nylon washers between the bottom of the PC board and the brackets. If the nylon washers are neglected, electrical shorts may develop. Keep all electrical leads inside the Turtle, between the front and back spacers. To provide strain relief for the Terrapin interface cable, wind it around the back spacers.

MOTOR ASSEMBLY




NOTE: For right motor assembly, spade lug 2 is on the inside, spade lug 1 is on the outside.

MOTOR ELECTRICAL LEADS: Attach the right motor leads RM1 to right spade lug 1 and RM2 to right spade lug 2 by sliding the spade terminals onto the spade lugs, with spade lug 1 on the outside and spade lug 2 on the inside. attach the left motor leads to the left motor: with LM1 on the inside, LM2 on the outside. Tape the spade terminals with common electrical tape (if available) to insulate them. BEND THE SPADE TERMINALS SO THAT THEY AVOID CONTACTING THE MOTOR CASINGS AND CAUSING SHORTS.

LEFT MOTOR ASSEMBLY: The left motor is oriented symmetrically opposite the right motor. The motor shaft goes near the bottom. Attach it to the spacers and the remaining two brackets using 6-32x1" screws and lock washers. Use a 6-32 nut where there isn't a spacer. Screw the pc board onto the brackets with 6-32x1/4" screws and nylon washers between the pc board and the brackets. You may have to bend the brackets to make things fit.

ATTACH PEN SOLENOID LEADS: Be sure that the pen solenoid leads comes through the center of the Turtle, between the two motors. Attach the spade terminals to the spade lugs on the solenoid.

ATTACH BOTTOM PLATE: Screw the bottom plates onto the motor brackets with 6-32x1/4" screws and lock washers. The solenoid inserts straight up into the center of the Turtle, between the two motors. Be careful not to break the speaker leads.

TIRES AND WHEELS: Stretch the tires onto the wheels. This may be somewhat difficult, as the tires must stretch substantially. Loosen set screws with the Allen wrench (Turtle tuner). Put wheels on the motor shafts (sticking out of the sides of the Turtle). Make sure that the set screw is on the outside of the wheel. Rotate each wheel until the set screw is over the flat portion of the shaft. Tighten set screw onto shaft to secure wheel.

DOME: Screw the dome onto the shaft of the ball joint using the 10-32x1" screw, with the nylon shoulder washer under the dome, curved side down.

Behold your finished Terrapin Turtle!

## OPERATING INSTRUCTIONS; TALKING TO THE TURTLE

Communication between the Turtle and your computer takes place over the Turtle cable. The 15 connections on the connector provide:

eight wires for Turtle control
four wires for the touch sensors
one spare for user expansion
one power
one ground

POWER SUPPLY: The Turtle will operate with a supply voltage anywhere between 12-18v. It requires one amp while moving, a maximum of two-three amps while pushing an object and less while idling. There is no need for a separate logic supply.

logic 0 = 0v. - 0.6v.
logic 1 = 2v. - supply.
This is TTL compatible.

TURTLE CONTROL REGISTER: (inputs to the Turtle): The eight wires that control the Turtle should be connected to a parallel output port serving as a Turtle control register. The Turtle itself contains no memory. A change in state in any of these eight lines is immediately reflected in the Turtle. The bit assignments and functions are as follows:

| T | H | P | L | LM2 | LM1 | RM2 | RM1 |
|---|---|---|---|---|---|---|---|

RM1, RM2 - Right motor
LM1, LM2 - Left motor
L - Lights
P - Pen
H - Horn
T - Tone control

RT - right
LT - left
FD - forward
BK - back

MOTORS: Each motor is controlled by two bits in the control register. If the bits are the same (i.e. both 0 or 1), the motor will be off. One being "1" and the other being "0" will turn the motor on with the direction being controlled by the bit that is a "1". Slower speeds can be had by feeding a square wave of different duty cycles to the motors. This will have the effect of trying to turn the motors on and off very rapidly, but due to mechanical inertia, they will just spin more slowly.

(next page, please.)

| LM2 | LM1 | RM2 | RM1 | LM | RM | TURTLE ACTIONS |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | off | off | off |
| 0 | 0 | 0 | 1 | off | FD | turn LT about left side |
| 0 | 0 | 1 | 0 | off | BK | turn RT about left side |
| 0 | 0 | 1 | 1 | off | off | off |
| 0 | 1 | 0 | 0 | FD | off | turn LT about right side |
| 0 | 1 | 0 | 1 | FD | FD | move forward |
| 0 | 1 | 1 | 0 | FD | BK | turn right about center |
| 0 | 1 | 1 | 1 | FD | off | turn LT about right side |
| 1 | 0 | 0 | 0 | BK | off | turn RT about right side |
| 1 | 0 | 0 | 1 | BK | FD | turn LT about center |
| 1 | 0 | 1 | 0 | BK | BK | move backward |
| 1 | 0 | 1 | 1 | BK | off | turn LT about right side |
| 1 | 1 | 0 | 0 | off | | |
| 1 | 1 | 0 | 1 | off | FD | turn LT about left side |
| 1 | 1 | 1 | 0 | off | BK | turn RT about left side |
| 1 | 1 | 1 | 1 | off | off | off |

Note: the polarity of forward vs. back on each motor depends on how the pc board is connected to the motors. If your Turtle's motors go back when the table says forward, you can correct this by simply exchanging the two spade lugs and leads, one for the other.

LIGHTS "0" turns them off
"1" turns them on

PEN "0" is up
"1" is down

HORN "0" is quiet
"1" is noisy

TONE "0" is the low tone on the horn
CONTROL"1" is the high tone on the horn.

TOUCH SENSOR REGISTER: (outputs from the Turtle): There are four wires that reflect the state of the touch disk. These should be wired to a parallel input port. They are always valid, and need not be enabled.

BT - back touch/FT - front touch
RT - right touch/ LT- left touch

| BT | FT | RT | LT |
|---|---|---|---|

Each bit corresponds to one of the four touch sensors. If the Turtle bumps into something, the dome will cause the touch disk to press on one of the four microswitches.

"0" means something is touching.
"1" means no touch.

## ADJUSTMENTS

PEN: For best drawing ability the pen should be adjusted in the following manner: Connect the Turtle to a 12-18 volt power supply and to the parallel interface on your computer. Remove the Turtle bottom plate and turn the pen solenoid on by writing a logic "1" to the parallel interface bit connected to the pen. The soft iron solenoid core should be pulled all the way down into the solenoid body by the magnetic

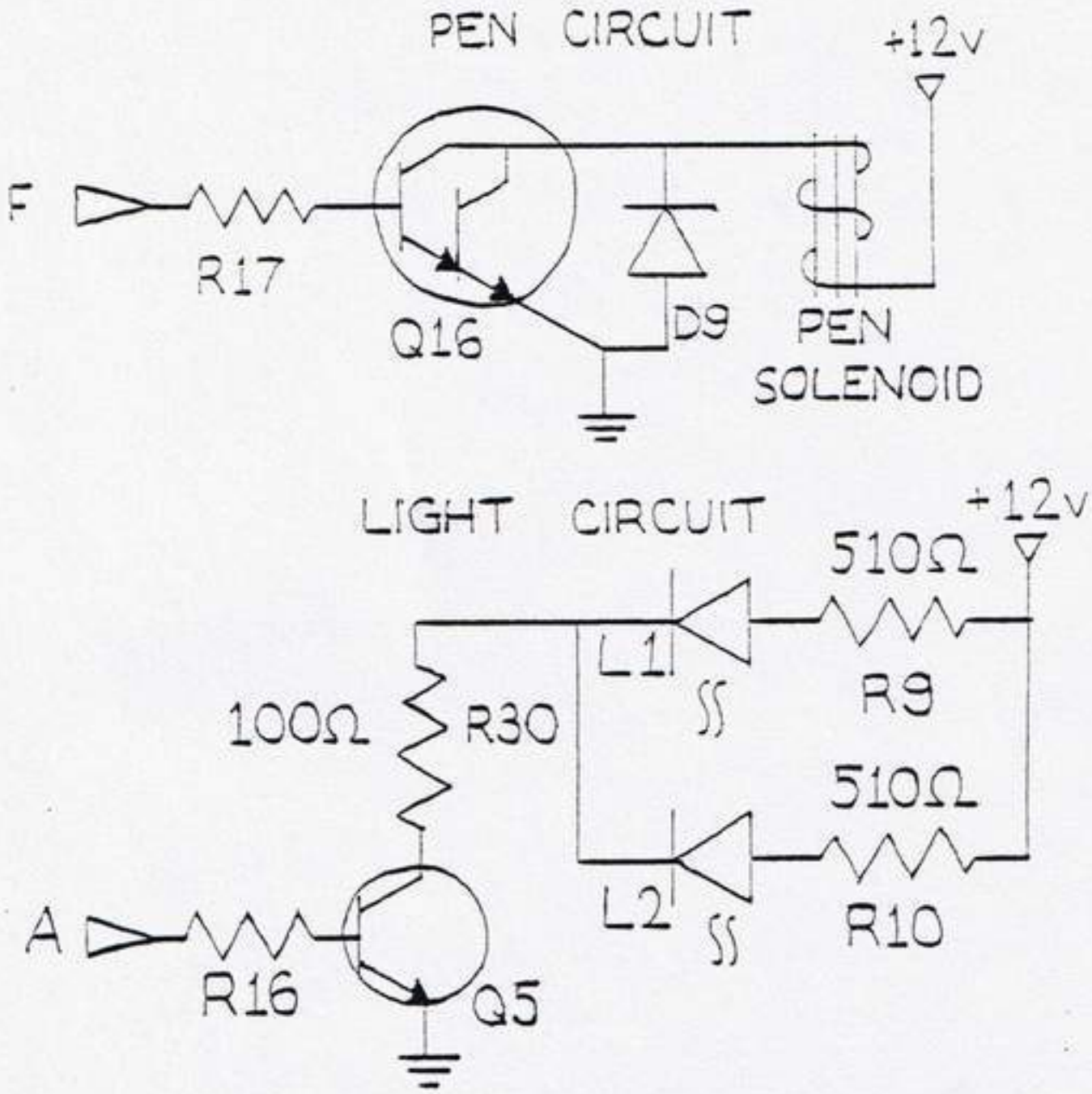
field. Loosen the two screws holding the pen refill and adjust the pen refill so that when the solenoid is down the pen refill projects about 1/4" below the bottom of the two plastic balls (Turtle toes.) Now use a software program to write a logic "0" to the pen bit on the parallel interface. The pen solenoid core should move up out of the solenoid body. Adjust the crimp point on the solenoid refill so that the upper position of the pen refill is about 1/8" above the bottom of the two plastic balls. If problems are experienced with the pen refill sticking in the hole in the bottom of the pen solenoid, try inserting a 6/32 foothead lockwasher on the pen refill and the bottom plate. Now verify that the pen moves up and down freely by alternately writing logic 1's and 0's to the pen control bit and observing that the pen extends and retracts. If the pen assembly sticks at any point try bending the refill so it travels freely. Now put the bottom plate back on the Turtle, place the Turtle on a sheet of paper, and send it forward with the pen down by writing logic 1's to the pen bit and to RM1 and LM1. If the Turtle does not draw properly, repeat the adjustment proceeding with the pen down in refill position slightly lower or higher than 1/4" below the Turtle toes. When properly adjusted the pen solenoid core should not "bottom out" in the pen down position; rather, it should push the pen against the paper with a constant force from the magnetic field inside the solenoid. This allows the pen refill and core to move up and down slightly in response to irregularities in paper height and wheel diameter.

MOTORS: In order to make your Turtle run straight when going forward or backward and turn at the same speed when going right or left, you must adjust the four motor speed adjustment pots. First, use a small screwdriver to turn the adjustment slot on each pot clockwise until it stops. Then place your Turtle on the floor (preferably one with straight floorboards or tile lines) and set it going forward by writing logic 1's to the parallel interface bits connected to RM1 and LM1 and logic 0's to RM2 and LM2. After this is done the Turtle should start going forward (if it travels backwards or turns the motors are hooked up incorrectly and should be reconnected as shown earlier in the manual). If, as the Turtle moves forward, it curves to either the right or left, turn the motor speed control pot marked FD on the side opposite the direction of turn counter clockwise until the Turtle travels straight. Once the Turtle travels forward properly use your computer to write logic 0's to the parallel interface bits connected to RM1 and LM1 and logic 1's to the bits connected to RM2 and LM2, sending the Turtle backwards. If the Turtle does not travel straight back, adjust the BK pot on the side opposite the direction of the turn in the same way the FD pots adjusted until proper backward travel is obtained.

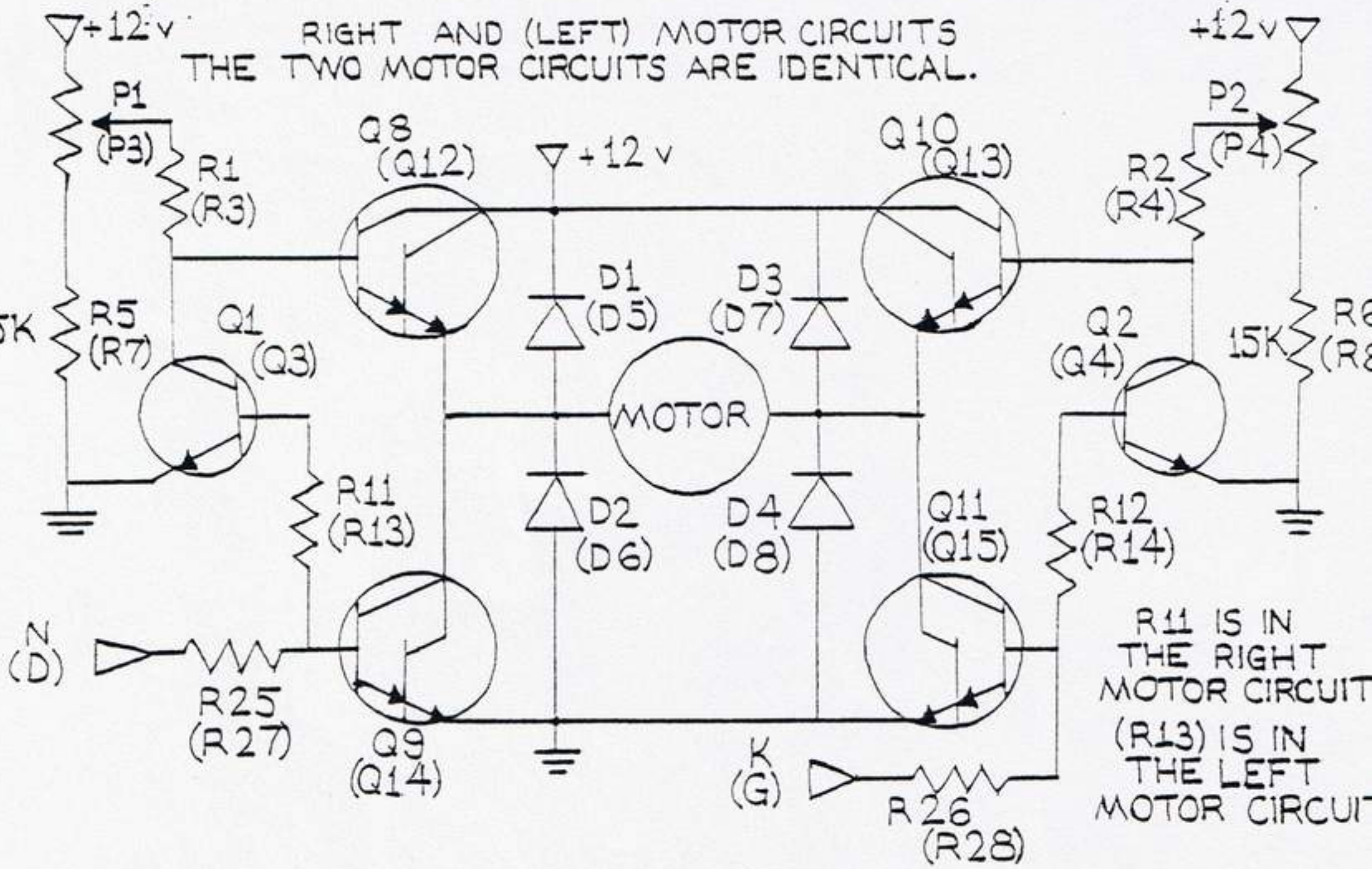
## THEORY OF OPERATION

PEN AND LIGHT CIRCUITS: The pen and light circuits on your Turtle both work in the same way. For the light circuit, if the voltage at pin A on the Turtle connector (refer to the schematic diagram, next page) is less than .6 volts (a TTL low level) then no current flows in the 1K resistor R16 or in the base of transistor Q5. Since Q5 has no base current, its connector current is zero and the LEDs do not light. If collector pin A is at a TTL high level (three volts or so) current flows through the base of R16 into the base of transistor Q5, saturating it. Current can then flow through current limiting resistors R9, R10, and R11 and also through the two LEDs into the collector of Q5. This lights the LEDs brightly. In the pen circuit if connector pin F is at less than 1.2 volts, darlington transistor Q16 is turned off and no current flows into the pen solenoid. With a TTL high level on pin F, Q16 saturates,

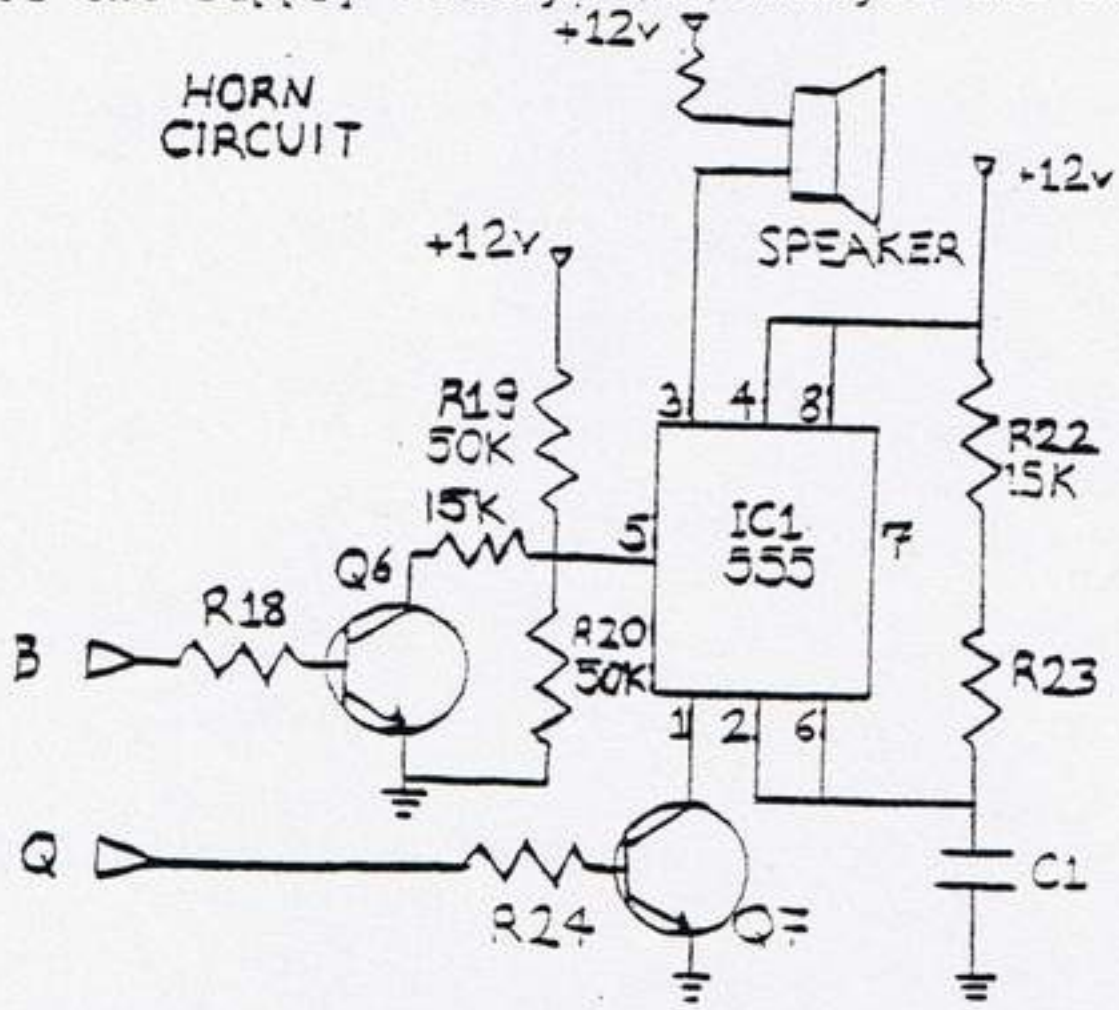
causing current to flow through the solenoid and lowering the pen. Diode D9 absorbs the inductive transient produced when current in the pen solenoid is abruptly cut off.



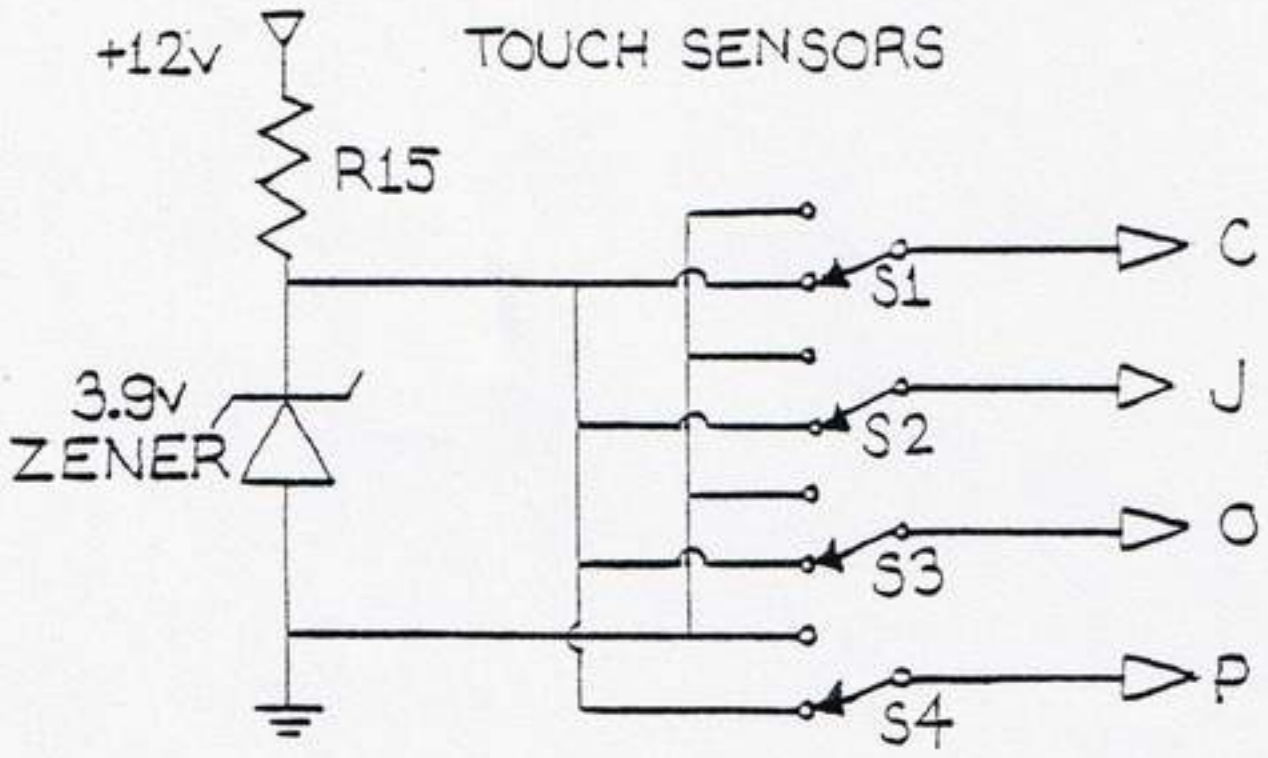

MOTOR CIRCUIT: The motor circuit on your Turtle has a more complex job to do than the pen or light circuits. Not only must the motors be turned on and off, they must also be able to rotate in either direction. To do this the motor circuit must be able to switch the polarity of the motor voltage. The way the circuit functions is modeled using switches (see figure below). If switch 1 is in the lower position, and switch 2 is in the upper position, the motor will rotate in one direction. If switch 1 is in the upper position and switch 2 is in the lower position, the motor will rotate in the other direction. If the switches are either both up or both down, the motor will not rotate. The switches on your Turtle are made of two sets of three transistors so they can be easily controlled by your computer. If pin N on the Turtle connector is at TTL low level, transistors Q9 and Q1 are turned off. Resistor R1 pulls the base of Q8 and the collector of Q1 up to nearly the supply voltage. (The actual value is set by potentiometer P1.) Since darlington Q8 is connected in an emitter- follower configuration, its emitter voltage is approximately 1.2 volts lower than its base voltage. (This corresponds to switch 1 being in the upper position.) If, on the other hand, pin N is at a TTL high voltage, both Q1 and Q9 are turned on by the current flowing through resistors R25 and R11. Since transistor Q1 is is turned on, its collector is pulled down to nearly ground level, effectively turning Q8 off and allowing Q9 to ground the motor lead. (This corresponds to switch 1 being in the lower position.) Since the other side of the circuit works in exactly the same way, the Turtle motor can be controlled in both directions using the two control lines N and K.




HORN CIRCUIT: The horn circuit on your Turtle uses a 555 integrated circuit precision timer hooked up in an astable configuration that continuously oscillates when power is applied. When pin R on the Turtle connector is at a TTL low level, transistor Q7 is cut off, depriving the IC of power and silencing the horn. When pin R is at a high level, Q7 is saturated, the IC is supplied with a ground connection, and the horn sounds. The tone of the horn is controlled by transistor Q6. If pin B is low, Q6 is cut off and the voltage at the modulation input to the 555 is 1/2 the supply voltage. When pin B is high, Q6 is turned on, thereby placing R29 in parallel with R20. This lowers the voltage at pin 5 of the IC to about 1/4 of the supply voltage and changes the frequency of the horn.



TOUCH SENSORS: Your Turtle sends information about its contacts with objects back to your computer with the touch sensor circuitry. When the Turtle's "shell" strikes an obstruction, it activates one or two of the touch sensor switches mounted on the circuit board. The touch sensor output lines are normally connected to a 3.6 volt supply by zener diode D13. This supply puts out a constant TTL high level in the electrically noisy Turtle environment. When a touch sensor switch is depressed, the appropriate output line is switched from the 3.6 volt supply to ground, giving a TTL low output.




DEBUGGING TIPS

If your Turtle does not operate properly check the circuit board carefully for bad solder connections, incorrectly inserted components, "solder bridges" between adjacent tracks on the circuit board, and loose wires. Make sure that the metal tabs on top of the darlington transistors are not touching each other and that no component leads (particularly the leads of the 100 ohm light resistor) or motor or pen spade lugs are contacting the metal frame of the Turtle. If the Turtle electronics assembly looks OK make sure that the parallel interface is functioning and that the power supply is providing 12-18 volts at 2 amps.

If you still haven't found the problem, refer to the paragraphs below Listing common problems and their solutions:

Symptom: Nothing on the Turtle functions.
Possible Problem and Suggested Solution: Power supply not working. Test supply with meter; repair or replace if not working.
PP & SS: Parallel interface not working. Test for data at interface with logic probe; repair or replace.
PP & SS: Power or ground connections open. Test for voltage at Turtle; if not present, correct bad connection.
PP & SS: Power to ground short circuit. If Turtle draws excessive current or blows fuses or supply does not work with Turtle connected, check carefully for a power to ground short.

Symptom: Interaction between pen and motor control; i.e. when motors are turned on pen operates and vice versa.
PP & SS: Short circuit between motor or pen leads and Turtle frame or incorrectly wired pen and motor connections. Carefully check that the pen connections on the Turtle board are not wired to the motors; correct any short circuits between the motor spade lugs and the Turtle frame.

Symptom: Interaction between the "eyes" and pen or motor.
PP & SS: Almost certainly caused by the leads of the 100 ohm current limiting resistor for the LEDs being long enough to touch the motor bracket and short-circuit it. Trim the leads on the resistor.

Symptom: Pen doesn't work.
PP & SS: Shorts between the pen and solenoid leads and frame, bad connection in the cable, pen solenoid plunger up too high in the rest position, friction between pen refill and hole in the bottom of the solenoid. Check for shorts and bad connections. The rest (pen off) position of the solenoid plunger should be no more than about 1/2 inch above the pen down position or the magnetic flux in the solenoid will not be strong enough to pull the pen down.

If in the course of using your Terrapin Turtle you come up with any other bugs that we havn't listed here, please feel free to drop us a letter or call during normal business hours. We'll set our experts to the solution of the problem and get back to you. Our new address is:

TERRAPIN, INC.
380 Green Street
Cambridge, MA 02139

Using a Turtle with the SSM IO-2 Parallel Interface Board

The Solid State Music IO-2 parallel interface card is an ideal device for interfacing a turtle to S-100 bus computers. It is a well designed circuit which provides, at low cost, 8 parallel outputs for control of the turtle's horn, pen, lights, and motors. In addition, it has 8 parallel inputs, 4 of which can be used to read the turtle's four touch sensor lines. Unfortunately, the assembly and instruction manual which comes with the board requires that the builder have a lot of knowledge of digital electronics. The purpose of this document is, therefore, to provide information on how the IO-2 should be assembled and connected to the turtle.

A. Assembly (skip this part if you purchased an assembled interface)

First, check kit contents against the following parts list:

| Part | Quantity | Reference #(s) | Description |
|---|---|---|---|
| 7485 | 1 | U1 | 16 pin IC |
| 74LS04 | 1 | U2 | 14 pin IC |
| 74LS42 | 1 | U3 | 16 pin IC |
| 7486 | 1 | U4 | 14 pin IC |
| 74LS00 | 2 | U5,U6 | 14 pin IC |
| DIP switch | 1 | U7 | 16 pin package with 8 switches on top |
| 8212/74LS412 | 2 | U8,U10 | 24 pin IC |
| DIP plug | 2 | U9,U11 | black 16 pin plug |
| 2.2k resistor | 5 | - | red-red-red |
| 1k resistor | 1 | - | brown-black-red |
| 0.1 uf cap | 6 | - | flat ceramic cap |
| tantalum cap | 2 | - | tubular electrolytic |
| 7805/LM340-5 | 1 | - | voltage regulator in |

| | | | |
|---|---|---|---|
| | | | 3 lead power package |
| 14 pin sockets | 4 | - | - |
| 16 pin sockets | 4 | - | - |
| 24 pin sockets | 2 | - | - |
| heat sink | 1 | - | black aluminum heat sink for volt. reg. |
| screw | 1 | - | for volt. reg. |
| nut | 1 | - | for volt. reg. |
| lock washer | 1 | - | for volt. reg. |
| circuit board | 1 | - | double sided board |

After it is determined that all parts are present, the sockets should be inserted into the printed circuit board. Place the board component side up on the table with the words 'COMPONENT SIDE' away from you. Now examine the sockets. Each socket will have some marking to identify which pin on the socket corresponds to pin 1 on the chip to be plugged into the socket; this should be identified from the drawing below:


The sockets may now be inserted into their proper places in the printed circuit board; this should be done with pin one on the socket on the lower left for the sockets for U1-U6,U8,and U10, and with pin one on the lower right for the sockets for U9 and U11 (refer to the layout drawing for the locations of these sockets). Care shold be taken while this is being done, since the pins on some sockets are fragile and can be easily broken when inserted. No socket should be inserted in the space for U7, as the dip

switch will be soldered in directly there. Once this is done, a piece of flat cardboard should be placed over the board and sockets and the board should be turned over with the cardboard holding the sockets in place.

After making sure that all the socket pins are through the holes, two diagonally opposite corner pins in each socket should be soldered to the board, and the board turned over again. The sockets should then be inspected to make sure that they are flat against the board. If any sockets are not, they should be seated by heating the soldered pins of the offending socket while pressing the socket down to the board. When all sockets are flush with the board, the rest of the pins on each socket can be soldered. Rosin core solder and a pencil type iron with it's tip kept clean by frequent wiping on a damp cloth or sponge should be used. Enough solder should be used to form a conical 'fillet' between each pin and pad, but it is important not to heat the joint excessively long as this may result in the seperation of the copper trace from the epoxy board.

When the sockets have all been soldered, six 2.2k resistors should be soldered into the holes above the pads for U7 as shown in the layout drawing. The resistors are placed in this manner: Starting at the left of the line of nine resistor pads above the pads for U7, five resistors should be inserted. Then, three pads should be skipped and the sixth resistor placed in the pads at the far right. If there are extra 2.2k resistors do not worry. The single 1k resistor should be soldered in the place shown in the layout drawing, just to the left of U10.

Next, the two tantalum electrolytic capacitors should be soldered into the board in the places shown in the layout drawing, near the regulator at

the far left of the circuit board. It is extremely important that proper polarity is observed when inserting these components, since they will be destroyed if incorrectly inserted. Close examination of the electrolytic capacitors will reveal a '+' at one end. This end must face the lower edge of the board on both capacitors. A large '+' on the board as well as '+' signs on the layout drawing identify the proper direction also.

When this has been completed, the six ceramic .1 uf capacitors should be soldered into the board as shown in the layout drawing, and the DIP switch should be inserted and soldered in the pads for U7. The voltage regulator should then be placed on the circuit board with it's flat side down and the hole in it's tab lined up with the hole in the large square area in the upper left hand corner of the circuit board. The three regulator leads should then be marked for bending into the three holes directly below the square area. When marking the leads, be sure to allow for the lead used up in bending. Bend the regulator leads and make sure that, when the regulator's leads are inserted in the three holes, the large hole in the tab lines up with the large hole in the board. Position the heat sink over the large hole, place the voltage regulator on top, insert the #6 screw from behind, and secure the regulator with the lock washer and nut. Finally, solder the voltage regulator leads in place, being careful not to use excessive heat.

The IO-2 board must now be configured for use with the turtle. To do this some insulated hook up wire (not supplied) is needed. First, the memory read option must be disabled: Look above U5 on the component side of the board to find a small round pad labeled SM. Using a length of the hook

| IO-2 DIP Plugs | Turtle Function | DB 25 | Ribbon Cable Colors |
|---|---|---|---|
| U9-1 | TØ | 12 | Black |
| U9-2 | T1 | 25 | Brown |
| U9-3 | T2 | 11 | Red |
| U9-4 | T3 | 24 | Orange |
| | | | |
| U11-1 | RM1 | 6 | Yellow |
| U11-2 | RM2 | 19 | Green |
| U11-3 | LM1 | 5 | Blue |
| U11-4 | LM2 | 18 | Purple |
| U11-5 | E | 4 | Grey |
| U11-6 | P | 17 | White |
| U11-7 | H | 3 | Black |
| U11-8 | T | 16 | Brown |
| U11-11 | User | 15 | Red |
| U11-12 | Ground | 1 | Orange |
| U11-13 | Ground | 7 | Yellow |
| U11-14 | Ground | 13 | Green |

```
0005 =          BDOS    EQU     5
0000 =          BOOT    EQU     0
000D =          CR      EQU     0DH
000A =          LF      EQU     0AH
0010 =          TURTLE  EQU     10H

0100                    ORG 0100H               ;START OF CP/M TRANSIENT PROGRAM AREA
0100 0E09       START:  MVI C,9                 ;ASK FOR HEX BYTE
0102 115901             LXI D,INMSG
0105 CD0500             CALL BDOS
0108 CD1D01             CALL GETBYT             ;GET HEX BYTE FROM CONSOLE
010B D310               OUT TURTLE
010D 0E09               MVI C,9
010F 118501             LXI D,OUTMSG            ;DESCRIBE TOUCH SENSOR DATA
0112 CD0500             CALL BDOS
0115 DB10               IN TURTLE               ;GET TOUCH SENSOR DATA
0117 CD4701             CALL PUTNIB             ;PRINT IT ON THE CONSOLE
011A C30001             JMP START

011D CD3001     GETBYT: CALL GETNIB
0120 07                 RLC
0121 07                 RLC
0122 07                 RLC
0123 07                 RLC
0124 E6F0               ANI 0F0H
0126 47                 MOV B,A
0127 C5                 PUSH B
0128 CD3001             CALL GETNIB
012B C1                 POP B
012C E60F               ANI 0FH
012E B0                 ORA B
012F C9                 RET

0130 0E01       GETNIB: MVI C,1
0132 CD0500             CALL BDOS
0135 E67F               ANI 7FH
0137 DE30               SBI '0'
0139 FA0000             JM BOOT
013C FE0A               CPI 10
013E F8                 RM
013F DE07               SBI 7
0141 FE10               CPI 010H
0143 F8                 RM
0144 DE20               SBI 20H
0146 C9                 RET

0147 E60F       PUTNIB: ANI 0FH                 ;PUNT HIGH NIBBLE
0149 C630               ADI '0'                 ;CHANGE 0 TO ASCII 0
014B FE39               CPI '9'                 ;IS DATA GREATER THAN 9?
014D FA5201             JM PRNTIT               ;IF NOT, PRINT ON CONSOLE
0150 C607               ADI '@'-'9'             ;CONVERT TO A THROUGH F
0152 5F         PRNTIT: MOV E,A                 ;PUT ASCII IN ARG TO BDOS CALL
```

```
57:  0153 0E02              MVI C,2         ;CP/M CONSOLE OUTPUT CALL
58:  0155 CD0500            CALL BDOS
59:  0158 C9                RET
60:
61:  0159 0D0A456E74INMSG:  DB CR,LF,'Enter hex data for turtle output port....$'
62:  0185 0D0A546F75OUTMSG: DB CR,LF,'Touch sensor data in hex is....$'
```

```
0005 BDOS       0000 BOOT       000D CR         011D GETBYT     0130 GETNIB
0159 INMSG      000A LF         0185 OUTMSG     0152 PRNTIT     0147 PUTNIB
0100 START      0010 TURTLE
```

This is the hex listing of the control program.

```
:10010000E0911590ICD0500CD1D01D3100E0911A5
:10011000850ICD0500DB10CD4701C30001CD3001C5
:10012000707070 7E6F047C5CD3001C1E60FB0C9A4
:10013000E01CD0500E67FDE30FA0000FE0AF8DE93
:1001400007FE10F8DE20C9E60FC630FE39FA52016C
:10015000C6075F0E02CD0500C90D0A456E746572B3
:1001600020686578206461746120666F7220747500
:1001700072746C65206F7574757420706F727412
:10018000E2E2E2E240D0A546F7563682073656E13
:1001900036F72206461746120696E2068657820D5
:0701A00069732E2E2E24A0
:0000000000
```

up wire, connect this pad to one of the five pads coming off the 1k ohm resistor to the left of U10. Solder at both ends. Next, the input and output control lines must be hooked up: Connect the small oval pad labeled SO on the lower right hand edge of the board to the small round pad labeled SOUT on the lower side of U6 in the same way. Similarly, the small oval pad labeled SI (which is right next to SO) should be connected to SINP on the upper side of U6.

Note, just to the right of U6, the five pads marked OUT STB. One of these pads should be connected to the device select 2 input of U10 by soldering one end of a piece of hook up wire to the OUT STB pad and the other to the small round pad directly to the right of the upper right hand corner of U10. (This pad is not marked on the board, but it can be found on the layout drawing marked with P-13 near the upper right hand corner of U10). In the same way, one of the five INP STB pads should be connected to the device select 2 input of U8, which is a small round pad directly to the right of the upper right hand corner of U8. This pad can also be found on the layout drawing near the upper right of U8 marked as P-13.

The clear inputs of U8 and U10 must then be tied to a TTL high level by wiring from two of the remaining four 1k resistor pads to the small round pads on the right sides of U8 and U10; directly below the device select pins just wired to. These pads can be found on the layout drawing, both marked as P-14 on the right sides of U8 and U10. The strobe input of U8, which is a small round pad slightly below and to the left of the lower right hand corner of U8, (marked P-11 on the layout) must then be tied to one of the remaining 1k resistor pads. Finally, the input mode control of

U8 must be grounded by wiring from the pad just below and to the right of the lower left hand corner of U8 (marked P-2 on the layout) to the small hole in the wide ground bus which can be found along the lower right hand edge of the circuit board, directly below the right edge of U8.

If you have a voltmeter the following optional test can now be performed: Plug your IO-2 board into your S-100 computer with the power off. (Boards should never be plugged or unplugged with power applied to the computer.) Then turn power on and measure the voltage between the +5 volt bus and the ground bus with your voltmeter. The voltmeter should read between 4.5 and 5.5 volts. If it reads less, check for shorts between +5 and ground and improperly inserted capacitors. If it reads more, suspect a short between pins 1 and 3 of the voltage regulator, or a defective regulator. Chips should not be inserted unless the supply reads within limits!

Now that the board is finished, spend a few minutes checking both sides for bad solder joints, solder bridges, and other imperfections. Some time spent now may prevent many wasted hours debugging later. When you are satisfied, insert the integrated circuit chips into their respective sockets (refer to layout drawing) making sure that pin one of each chip is at the lower left. At all chip positions except U3 there are small dots on the component side of the board to mark pin one. The following drawings will aid you in identifying which pins on the ICs are pin one:

Check one last time to make sure all components are properly inserted and the board is complete.

B. Addressing

Once your board is finished, you must set it up so that it will respond to the proper S-100 IO address. First, a few words about choosing an address: Since there are 256 possible addresses and most S-100 systems don't have more than a few IO devices it's pretty easy to do. If you know the addresses of all your IO devices it is quite simple; just pick one that is not in use. If you don't, there are some popular addresses which should be avoided: Addresses 0 and 1 are often used for serial interfaces, address 40hex is used for bank select memories, and FFhex is often used for front panel switches. Address 10hex is probably as good as any. If you have more than one turtle interface on your system it is important not to place two of them at the same address.

Once you have selected an address you can configure the IO card to respond to it. The first five from the left of the 8 dip switches select one of 32 blocks of 8 addresses each, and addresses within those blocks are selected by which of 8 pads the device select 1 pins on U8 and U10 are connected to. The 5 switches select the 5 most signifigant bits of the address, and the pad which the select lines are connected to determines the 3 least signifigant bits. Thus, if we want to configure the card to respond to address 10 hex, which is 00010000 binary, we would set the DIP switches from left to right to open (or off), open, open, closed (or on),

open. This can be easily seen by noting that the most signifigant 5 bits of 10hex are 00010 and that an open switch corresponds to a 0; a closed switch to a 1.

To set the 3 least signifigant bits of the address the device select 1 pins of U8 and U10 must first be connected together. Solder one end of a piece of insulated hook up wire to the small round pad directly to the left of pin 1 on U10. Next, strip the other end of the wire and insert it into the pad below and to the left of pin 1 on U8, but do not solder yet. Strip the end of another piece of wire, insert it in the same pad, and solder both wires to the pad. The other end of this wire should then be soldered to the pad near U3 determined by this table (pad numbers can be found on the layout drawing above and below U3):

| 3 least signifigant bits of address | Pad near U3 |
|---|---|
| 000 | 9 |
| 001 | 7 |
| 010 | 6 |
| 011 | 5 |
| 100 | 4 |
| 101 | 3 |
| 110 | 2 |
| 111 | 1 |

Important Note: Assembled interfaces come with these wires preset to make the three least signifigant bits 000. If this is acceptable in your application the above proceedure does not have to be followed. If you wish to have the three least signifigant bits be some other value, merely unsolder the lead from pad 9 near U3 and connect it to the pad that will give the desired value.

C. Connecting Your Turtle to the IO-2 Interface

Now that your turtle interface is complete and addressed it is time to connect it to your turtle. First, take the short piece of turtle cable with the female connector on it which came with your turtle and strip off about 3 inches of the grey outer insulation from the bare end. Next, strip about 1/8 inch of insulation off each of the 19 wires inside the cable. Find the two black DIP plugs that came with the IO-2 board and insert them into the sockets for U9 and U11 with pin 1 on the plugs at the lower right.

Solder the wires from the turtle cable onto the pins on the two plugs according to the following table:

| Plug and Pin | Wire Color(s) | Data Bit | Turtle Function |
|---|---|---|---|
| U9-1 | red | DATA IN 0 | Left touch sensor |
| U9-2 | white-yellow | DATA IN 1 | Right touch sensor |
| U9-3 | white-green | DATA IN 2 | Front touch sensor |
| U9-4 | white | DATA IN 3 | Back touch sensor |
| | | | |
| U11-1 | white-orange | DATA OUT 0 | Right motor 1 |
| U11-2 | white-black | DATA OUT 1 | Right motor 2 |
| U11-3 | orange | DATA OUT 2 | Left motor 1 |
| U11-4 | blue | DATA OUT 3 | Left motor 2 |
| U11-5 | black | DATA OUT 4 | Lights |
| U11-6 | green | DATA OUT 5 | Pen |
| U11-7 | white-blue | DATA OUT 6 | Horn |
| U11-8 | brown | DATA OUT 7 | Tone |
| U11-9 | yellow | - | Power |
| U11-10 | white-brown | - | Power |
| U11-11 | white-purple | - | User |
| U11-12 | purple | - | Ground |
| U11-13 | grey | - | Ground |
| U11-14 | white-red | - | Ground |

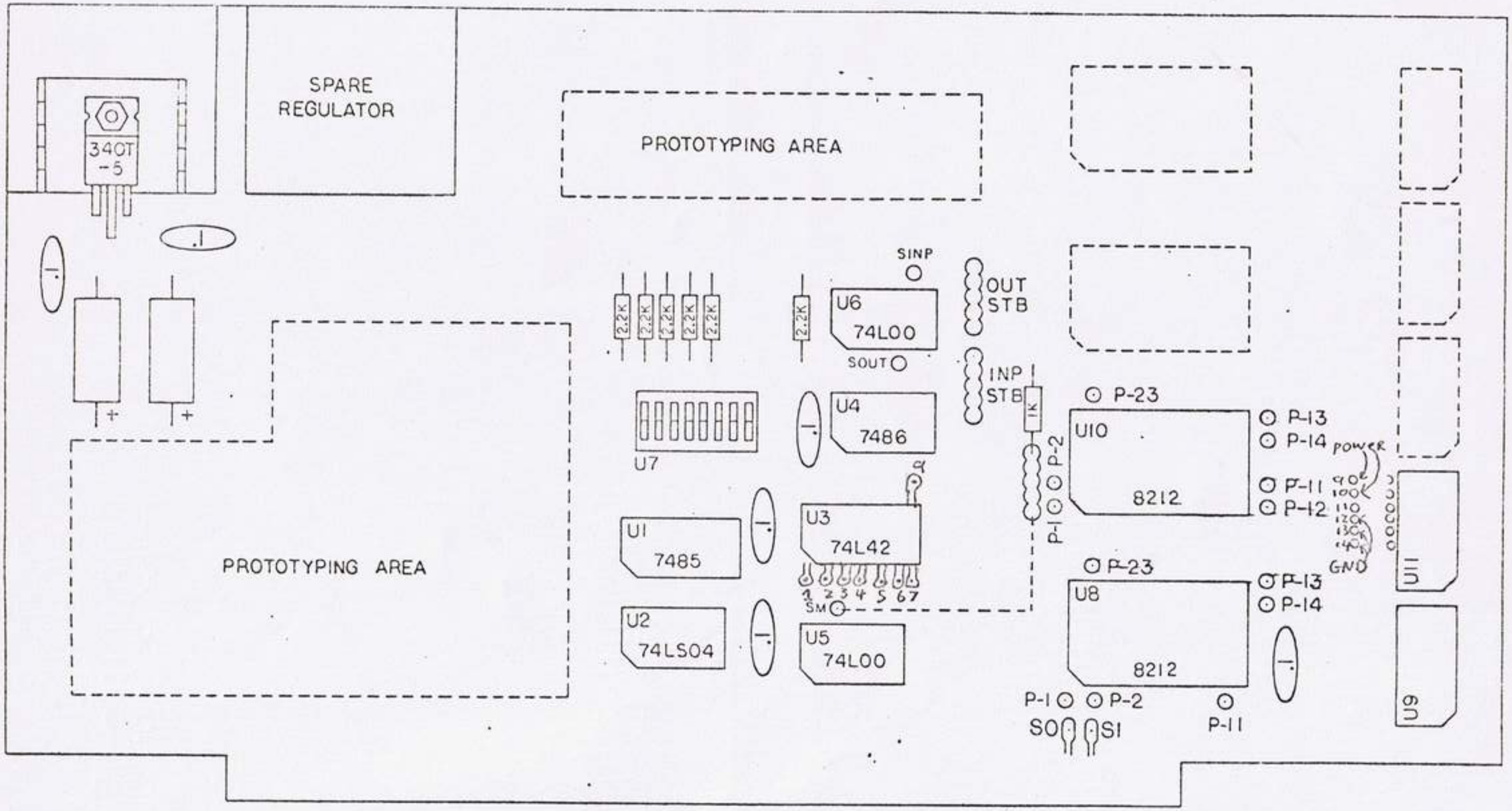
When you have finished soldering these wires you should have one white-grey wire left over in the turtle cable; this is an extra and should be clipped off. When this has been done, find on the layout drawing and printed circuit board the three pads connected to U11-12, U11-13, and U11-

14. Using pieces of insulated hook up wire, connect these three pads together and wire them to one of the holes in the thick copper ground bus directly to the right of U9 and U11. With the exception of the power supply, this completes the hook up of your turtle.

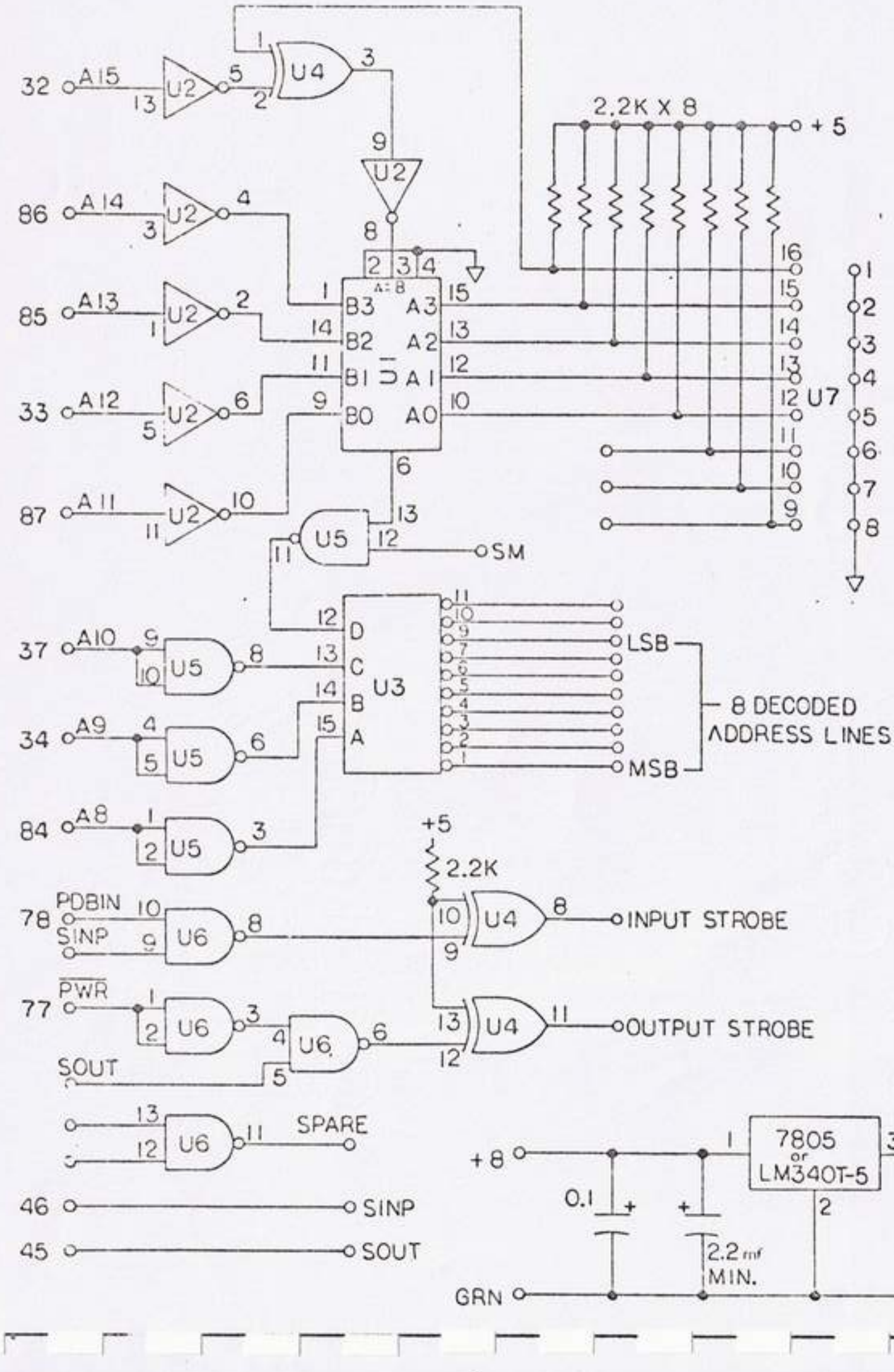
C. Power Supply

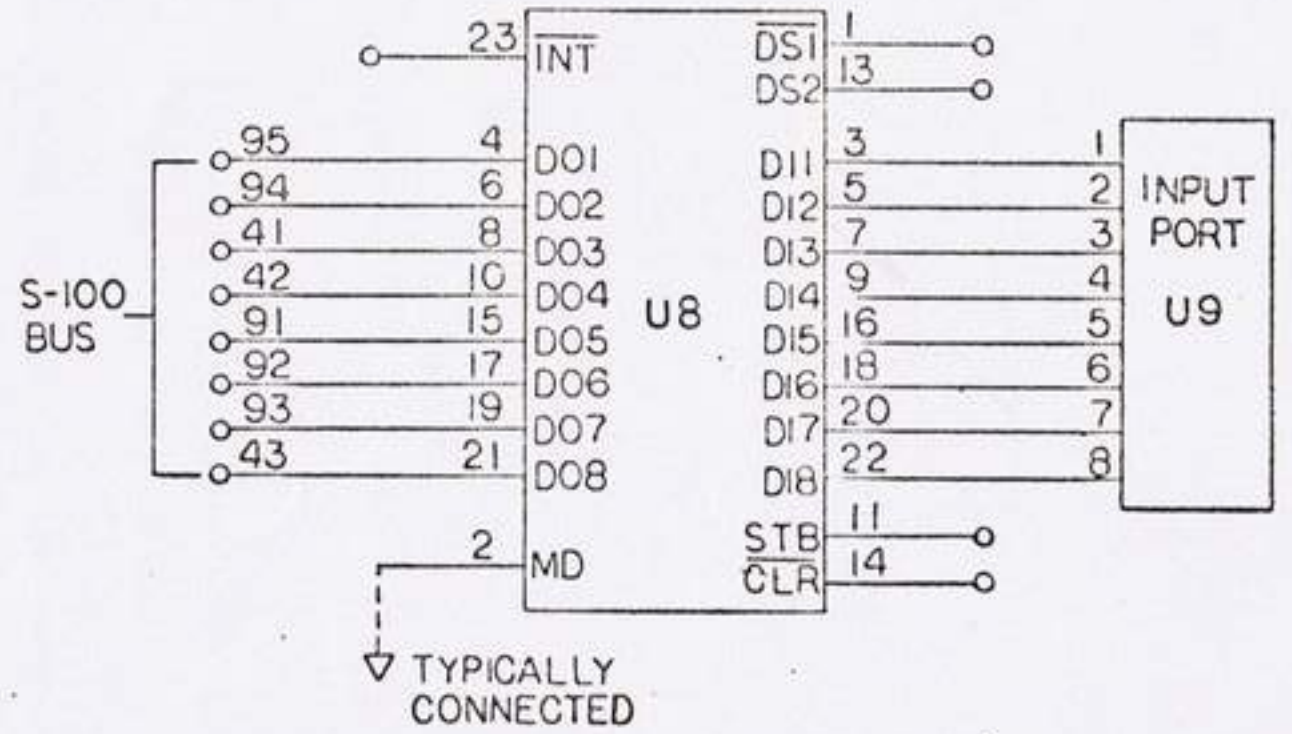
Your turtle requires a power supply which can provide 12 to 16 volts at up to 2 amps. This supply does not have to be regulated, although turtle motor speed will be more constant with changes in load and line conditions if it is. There are several ways that this can be accomplished with a S-100 computer. Perhaps the simplest is to just run the turtle off the 16 volt dc unregulated supply present in all S-100 computers. This is not reccomended, however, since the 16 volt supply in many S-100 computers is not strong enough to supply 2 amps to the turtle and also run the memory and other boards in the computer. In addition, the turtle motors make a lot of electrical noise on the supply when running, and this might cause the computer to crash or lose data. If it is decided to try this method, it is important to connect a 0.1 uf ceramic capacitor in parallel with a 50 uf or so, 35 volt electrolytic capacitor between the 16 volt power line to the turtle and ground. This can be done on the IO-2 board by mounting the components in some of the blank prototyping holes. Another possible method is to use a 12 volt regulator mounted in the spare regulator pads to provide a 12 volt regulated supply to the turtle. Again, if this is tried, bypass capacitors should be used between the turtle power line and ground to prevent noise from causing eratic computer operation.

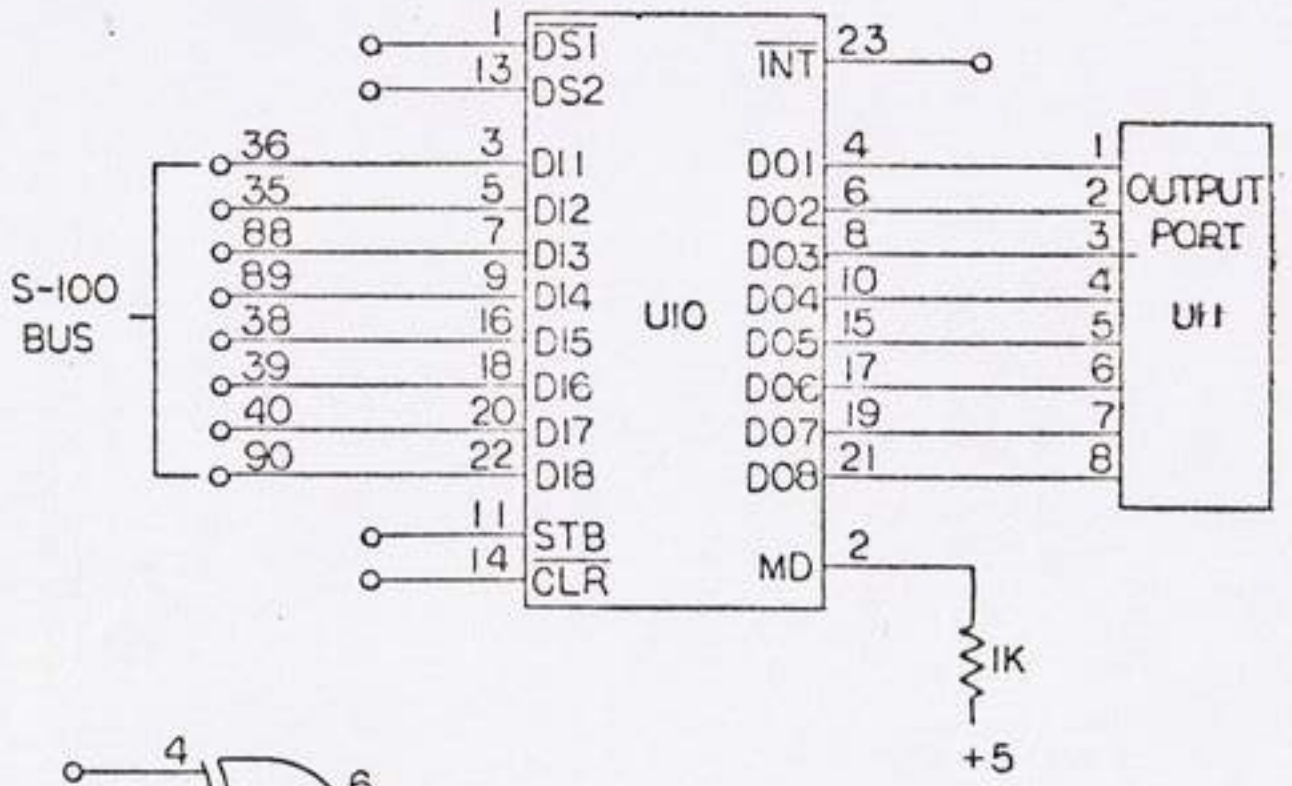
Perhaps the best solution is to use an external power supply to provide the current. One can be bought off the shelf from a number of vendors, or one can be built inexpensively. Two possible power supply designs, one regulated, and the other unregulated are included with this report. Whichever power supply scheme is used, the positive power line should connect to both U11-9 and U11-10 and the negative line to the ground bus on the IO-2 board.




| | |
|---|---|
| TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DEC ANGLES | COPYRIGHT SOLID STATE MUSIC |
| APPROVALS / DATE | SOLID STATE MUSIC IO-2 PROTOTYPING CARD |
| DRAWN MTM 11-22-77 | SCALE 2:1 · SIZE C · DRAWING NO 1 |
| CHECKED MTM 11-23-77 | DO NOT SCALE DRAWING · SHEET 1 |









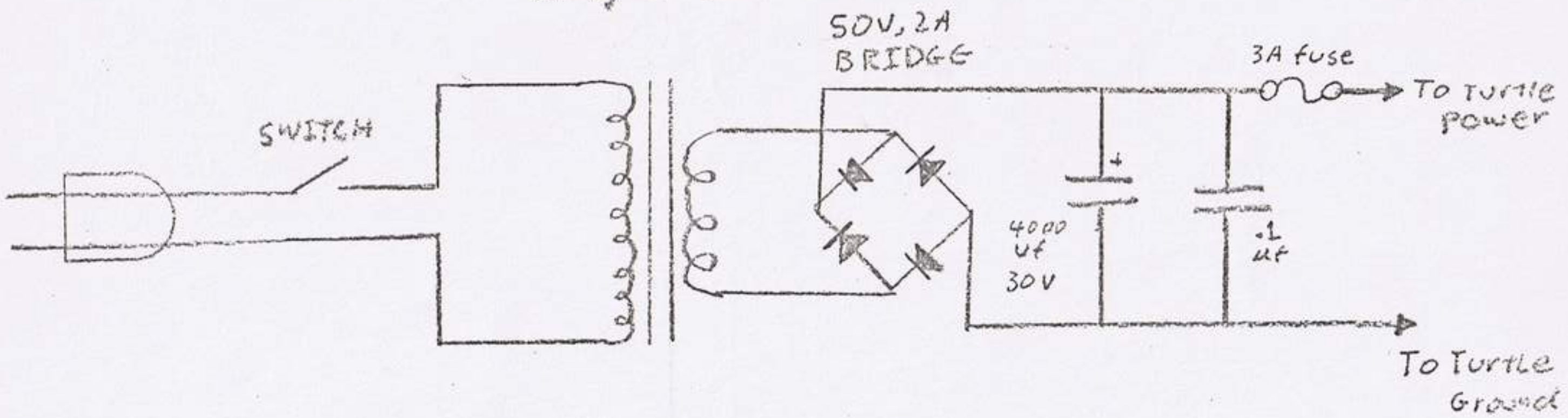
SOLID STATE MUSIC IO-2
SCHEMATIC

| APPROVALS | DATE |
|---|---|
| | 11-25-77 |
| | 11-25-77 |

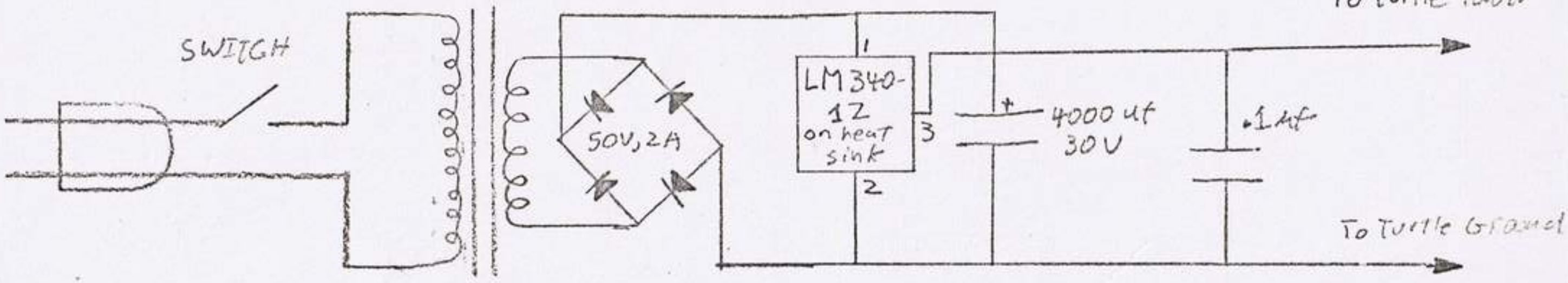
SCALE NONE | SIZE C | DRAWING NO

DO NOT SCALE DRAWING | SHEET

# UNREGULATED TURTLE SUPPLY



12 V, 2A TRANS


To Turtle Power
SWITCH
50V, 2A
LM340-12 on heat sink
1
2
3
+
4000 uf 30V
.1 uf
To Turtle Ground

Terrapin, Inc.

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# Connecting a Terrapin Power Supply to the IO-2 Interface Board

This replaces section C, pages 9-11, of "using a Turtle with the SSM IO-2 Parallel Interface Board.

To connect your Turtle to the Power Supply, you must make a connecting cable with the two DIP plugs from the SSM kit at one end and a DB-25 S connector supplied by Terrapin at the other. To make the cable, find the wider of the two 3-foot lengths of ribbon cable supplied by Terrapin. (The narrower one is for use as jumper wires. The individual wires can be separated and cut to the lengths needed.)

Next you should choose the length of the cable. If the cable will be plugged directly into the Power Supply, it should not be shortened. However, the connector can also be mounted in one of the RS232 cutouts commonly found in the rear panel of many S-100 card cages. If this is done, another cable with DB-25 male and female connectors must be made or bought to connect between the card cage box and the Power Supply. This can be ordered from Terrapin or can be found as a standard item in many computer stores or from mail order supply houses, listed as an RS232 jumper cable. If you do decide to mount the connector in the back of the card cage, cut the cable to the length needed. If you decide to use only the supplied cable, the end with the DIP plugs can be passed through an RS232 cutout so the cable will not get in the way.

Separate the wires at each end of the cable for 1-2 inches, then strip and tin a 1/8 inch length on each end of all the wires, except the blue and purple wires on one edge. These last two wires are spares. Next, tin the following DB-25 connector pins. Numbers 1,3-7,11-13,15-19,24,25

Caution- Before going further, slide the DB-25 hood onto the cable with the wider opening facing the end you will solder the DB-25 connector to.

The four wires on the edge with the black wire should be separated as a unit from the rest of the cable for several inches. Solder them to one of the DIP plugs using the connection pattern for U9 in the table below. The remaining wires, continuing from the same side, are soldered to the DIP plug, using the pattern for U11 as shown in the table. Finally, the other end of the cable is wired to the DB-25 S connector in the order shown in the table. Do not forget to slide the connector hood on before soldering. After soldering, the hood can be slipped down the cable and onto the connector and screwed in place.

Three ground jumpers must be connected to U11 on the IO-2 board. Find on the layout drawing and printed circuit board the three pads connected to U11-12, U11-13, and U11-14. Using pieces of insulated hook-up wire (from the small width of ribbon cable), connect these three pads together and wire them to one of the holes in the thick copper ground bus directly to the right of U9 and U11.

The assembled cable is connected to the SSM IO-2 board by plugging the two DIP plugs into the sockets at the lower right side of the board. The plug with only four wires is plugged into the bottom (U9) socket and the other plug goes into the socket U11 directly above. Both DIP plugs should be plugged with pin one at the bottom. The DB-25 connector at the other end of the cable is then either mounted in the RS232 cutout or connected to the Terrapin Power Supply.

The Power Supply can be plugged into a wall socket and the Turtle cable can be plugged into the Power Supply. The switch will glow red when the Power Supply is on. There is a small knob on the Power Supply to allow for fine tuning the turns of the Turtle, after the turns have been roughly calibrated by software.

The last two pages show an assembly language program for CP/M systems using 8080 or Z80 processor cards. The high half of the address must be the same as the low half of the address during I/O instructions. Most Z80 and 8080 cards have this setup and there should be no problem.

The program asks for a two digit hex number representing the bit pattern to be sent to the Turtle, which will cause a function to be turned on. The program then prints a hex number indicating the current touch sensor state and then waits for your next input.

The hex listing at the end may be directly poked into the system, or the mnemonic code can be entered and assembled.

This program is included to provide an example of how to program the Turtle.