From Brainstorm to Bread Board

There are a lot of twists in the road between a good idea and a properly working circuit. In this article we'll show you how good paperwork, like a good map, can keep you from getting lost!

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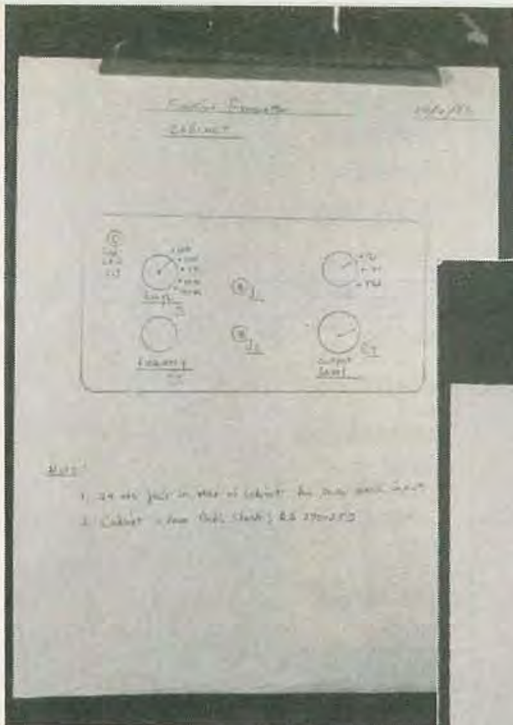

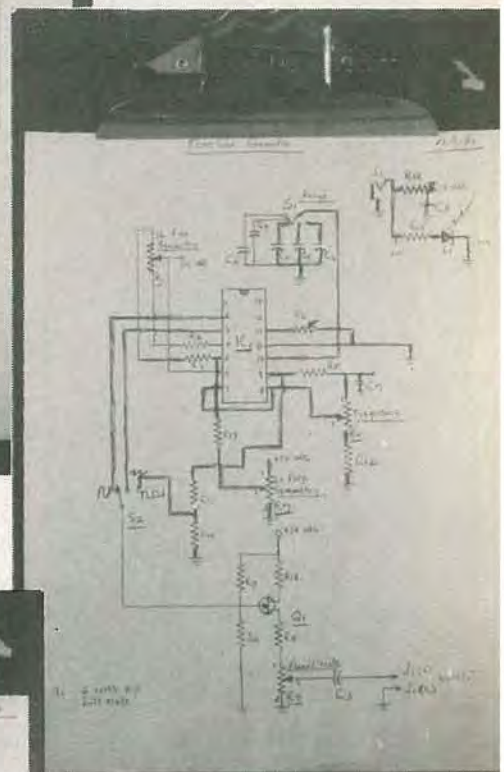

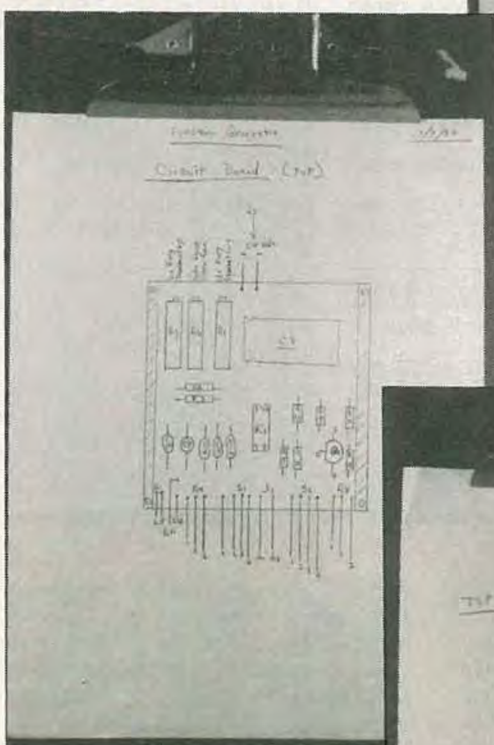

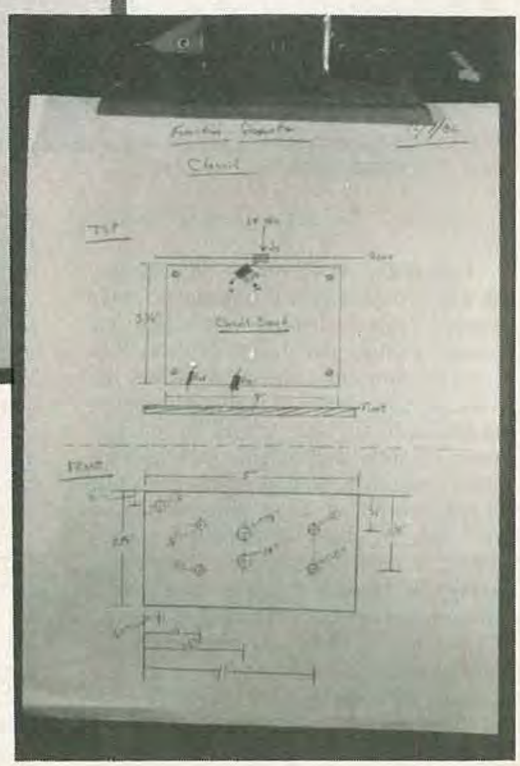

IF YOU HAVE EVER DESIGNED AN ELECTRONICS project, you probably know that the job goes faster with an organized method for documenting the device as you build it. Despite that, diagrams and notes are usually produced as an afterthought, especially by less experienced designers. But rather than being a chore, or something that slows down the process of getting a project up and running, effective documentation can greatly reduce the time it takes to design an effective circuit. That's because poor documentation, or none at all, can cause design errors and construction mistakes, and constant rechecking; that can make building of a project drag on for weeks when it really should take only days.

To focus on methods for applying paperwork to electronics construction projects, this article splits the record-keeping task into manageable pieces. We'll look at a drawing plan that can be used to completely describe any type of electronics equipment, and we'll show you how to make that plan a part of the creative process as you design your own project. We'll also show you a way to keep track of circuit wiring during the construction phase of your project. It can be applied to point-to-point, wire-wrap, or PC-board construction and automatically shows what has been connected to what, and simplifies keeping track of progress.

Starting the paper trail

The process of getting an idea, diddling with it, deciding to do it, then establishing a formal set of drawings to control the project is shown in block-diagram form in Fig. 1. If you follow the procedure shown, when you finish you'll have a document that fully describes the device, the hardware housing it, and the history of your experience with it. The documentation process does not take long. Instead, it

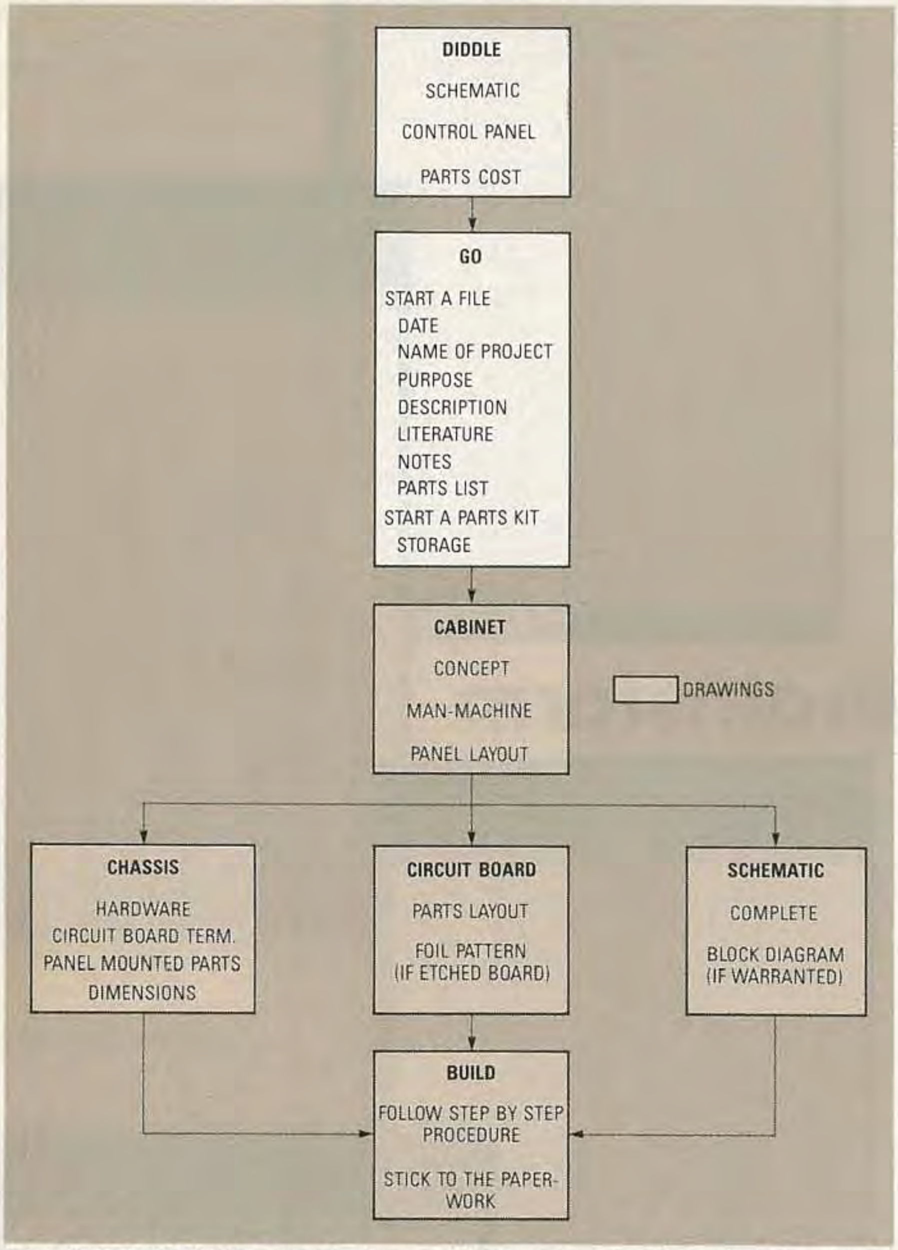

FIG. 1—THIS FLOW CHART shows the proper sequence of steps for turning your brainstorm into a properly working project.

saves time. You begin in the "diddle" stage.

During the diddle stage, the idea germinates. You sketch a schematic, make some changes, theorize about how the circuit works, and decide whether you have the time and money to build the device. The device requires controls, so you diddle with the front-panel layout, add more controls, and imagine how nice the device will look. You might also consider the possibility of using parts from your junk-box. Perhaps you can use the audio section from a portable stereo you stopped using long ago or the control board from a mothballed printer. In addition, you might search a library for books or magazines with useful information.

After diddling with the various aspects of the project, you enter the "go" stage. In the go stage, you gather the information that forms the basis for the project. First, open a document file. Enter the name of the project, the purpose of the device, any preliminary sketches, and a list of the parts you will need. Also, establish a project kit—simply a box for keeping the construction materials as you acquire them. If the idea requires a lot of complex circuitry, generate a block diagram and place it in the file. If a magazine article sparked the project, it, too, should go in the file. Finally, any other information regarding use or purpose should be included.

You're entering all of that information for a good reason: If you get sidetracked for a while, when you get back to the project you could find that you have forgotten some of the details. A lot of very good ideas get lost that way.

After you've completed the steps outlined in the go stage, it's time to make the drawings that will become the formal documentation for the project. Four separate drawings should be made. Those are cabinet layout, chassis layout, schematic, and circuit layout. All of the drawings must coordinate with each other. If done properly, those drawings will contain all the information required to completely describe any device under construction.

Cabinet

In many ways, the cabinet design is the one from which all of the other designs evolve. That's because the cabinet's design can directly affect any of the subsequent drawings. Even a simple change can affect the layout of the chassis or the circuit board. Those changes can, in turn, cause changes in the appearance of the schematic.

When designing the cabinet, thought should be given to both function and aesthetics; after all, the cabinet is the "interface" between the user and the device. More is involved here than mere appearance. Careful design should consider the mechanical factors in the operation and mounting of the various potentiometers, trimmers, switches, jacks, meters, displays, or what have you. Some considerations are obvious—spacing between controls must be sufficient to allow for comfortable operation. Others, however, may not become apparent until after you've cut the mounting holes. What may be a relatively small knob on the exterior can be attached to a relatively large rotary switch on the interior. If spacing is too tight, there might be insufficient clearance to mount all of the controls. To avoid such problems, consider all of the physical requirements for the cabinet as you design the unit's appearance.

Chassis

That drawing indicates the relative location of circuit boards, includes hardware dimensions and mounting holes, and locates any other parts that are mounted inside the cabinet. The identification of the electrical components should match the identification in the schematic. For example, if the panel-mounted potentiometer that controls the frequency of a function generator is called R4 in the schematic, it should be labeled R4 in the chassis diagram. In the cabinet drawing that control might have been labeled FREQUENCY; such labeling is acceptable for that drawing only.

In the chassis drawing, the circuit board or boards, regardless of their actual component count, are treated as units. Components that are located off the circuit boards should be shown in their relative positions so that they are easy to spot, but interconnecting wiring should not be shown. Showing such wiring would add

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no additional information, as it is indicated in the schematic; instead, it would only clutter up the chassis drawing.

Circuit board and schematic

Many projects begin with a vague idea for a device followed by some rough circuit sketches. That's OK for the diddle stage, but when its time to generate the schematic, the diagram that will control the building stage of the project, the drawing must be exact and complete.

Once you've finished the schematic, you need to design the circuit-board layout. As you're no doubt aware, when you draw a schematic, the symbols used bear no relationship to the actual size of the components themselves. Thus, while a resistor and capacitor may appear to occupy areas that are roughly equal, in reality the resistor may be only a fraction of the size of the capacitor, especially if the capacitor is a large electrolytic. To be sure that you've allowed sufficient space for each component in your design, use the actual parts and lay them out on an actual-size drawing of the circuit board. That is especially important when designing PC-board layouts. See "Designing Double-Sided Printed Circuit Boards," in the September 1985 issue of **Radio-Electronics** for tips on laying out complicated circuitry. The circuit-board drawing should include identification of the connection points to any off-board components.

Procedure

You've prepared the paperwork, and you've assembled a kit with all of the parts. Now, you're ready to put the circuit together, turn it on, and watch for smoke. When the building process begins, you switch from designer to technician, with your paperwork guiding you every step of the way.

The following step-by-step procedure applies the paperwork to the construction job, and covers initial assembly to finished product. Steps 1 and 2 cover breadboarding individual circuits for design debugging, and will be repeated until each circuit works on the experimenter's solderless breadboard. Once the circuit operates correctly, final assembly requires repeating steps 1 and 2 to rebuild the circuit in its final form.

Step 1—Mount the components on your circuit board (solderless experimenter, perforated, wire wrap, or etched) using the circuit-board drawing as a guide.

Step 2—Do the wiring. When using wire-wrap or point-to-point techniques, as each connection is made, trace over the appropriate line on the schematic using a colored pencil.

For PC boards, the same technique should be followed, but is should be done while you are designing the board. As a trace is laid down, the line or lines on the schematic should be traced over.

Completely test the board using a temporary rig to mount any off-board parts. When the circuit passes all of your tests, it's ready for installation.

Step 3—Install the panel-mounted parts.

Step 4—Install the circuit board or boards.

Step 5—Wire the chassis.
Keep the wiring as short and as neat as possible. Use wiring ties, cable clamps, etc.

Step 6—Apply power. If you've been very careful, and followed the steps we've shown you, the odds of getting a correctly working circuit the first time are greatly improved. Of course, they are not.

Fortunately, if you've done your paperwork properly, you will have a paper trail to follow if you run into trouble. Very often that trail will lead you directly to the cause of your problem. **R-E**