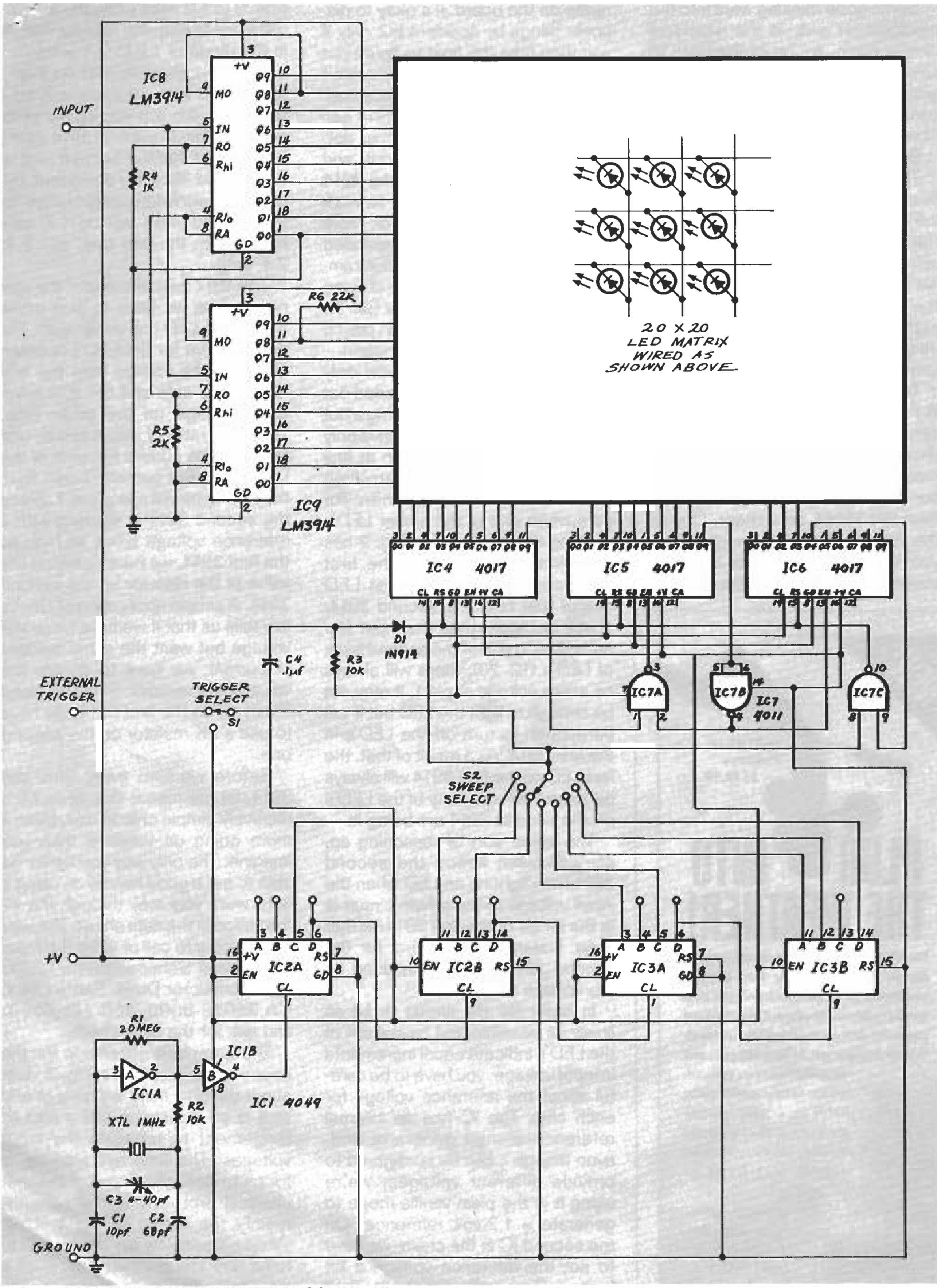

FIG. 3—COMPLETE SCOPE SCHEMATIC SO FAR. All we have to add is an input amp and a pad arrangement to prescale the input voltages.

Some good thinking went into the modification and, in the words of Jimmy Hatlo, a "Tip of the Hat" to Craig Shippee for a good job, a great letter, and taking the time to pass it on. Let me hear some more from you.

But back to the scope.

The next step we have to take is to expand the vertical display to the full twenty elements we specified in the design criteria. Since we're using an LM3914 as the LED driver, we'll have to add a second chip to the circuit. The 3914's were designed with that in mind, so it doesn't take much though to string two (or more) of them together.

The circuit for doing that is shown in Fig. 2. While the actual wiring is simple, there are a few points that should be made a bit clearer. I'll also mention here that all of that information (and a lot more) can be gotten from the 3914's data sheet. One of the most important things when you're designing circuits is to be absolutely familiar with the components on the board. It's okay to discover things by accident but only if you then take the time to figure out what happened and why. You can't control what you don't understand.

There are four ways the 3914 can be set to operate: single-chip dot, single-chip bar, cascaded dot, and cascaded bar. In order for the 3914 to reliably know what mode to work in (dot or bar) when two or more chips are cascaded for an expanded display, its internal mode-select amplifier has to watch the state of three pins: MODE SELECT (pin 9), +V (pin 3), and the cathode of LED9 on pin 11.

That last piece of information—the state of pin 11—is critical only when you're doing an expanded dot display. Remember that having a dot display means you want to have only one out of twenty LED's on at any one time. The 3914 controlling LED11—LED20 has to know for sure when one of the earlier LED's is being lit. The circuit in Fig. 2 has the MODE CONTROL pin of the first 3914 connected to the first LED output (pin 1) of the second 3914. That's because when the input signal is driving one of the second bank of LED's (12–20), there will always be some voltage at pin 1. It may not be enough to light the LED but it will be enough to turn off the LED's in the first 3914. As a result of that, the last LED on the first 3914 will always be turned off when any of the LED's on the second 3914 are being lit.

The same sort of reasoning applies to what keeps the second 3914 from lighting an LED when the input voltage to the whole circuit is in the range of the first 3914. In that case, however, the control for the second 3914 is being provided by the voltage on pin 11.

In order for the circuit to be as linear as possible and have each of the LED's indicate equal increments in input voltage, you have to be careful about the reference voltage for each chip. The IC has an internal reference-voltage generator and, even though it can be configured to provide different voltages, we're using it in the plain vanilla mode to generate a 1.2-volt reference. On the second IC in the chain, we have to set the reference voltage a bit higher. Remember that the first 3914 has to respond to input signals from 0 to 1.2 volts while the second 3914 has to respond to input signals in the range of 1.2 to 2.4 volts.

That sounds more difficult than it really is. All we have to do is use the voltage at the top end of the comparator chain in the first 3914 as the low voltage for the bottom end of the second 3914. By doing that, the absolute working-voltage range for the second 3914 will be 1.2 volts higher than the first one, or 1.2 to 2.4 volts.

This isn't quite the end of the story because we have to give some thought to LED current as well. The drive current for the LED's is determined by the voltage from the +V rail on one side and the IC's reference voltage on the other side. There's a ratio of about ten-to-one between the current for each of the LED's and the current drawn from the reference voltage at pin 7. Since the second 3914 is working with a reference voltage twice as high as the first 3914, we have to adjust the value of the resistor on the second 3914. A simple application of Ohm's law tells us that if we have twice the voltage but want the same amount of current, we have to double the value of the resistor. Since we used about 1K on the first 3914, we have to use a 2K resistor on the second one.

Before we turn away from the 3914, let me repeat that while it's a relatively simple chip to use, there's more going on inside it than you imagine. The only way you'll ever be able to get a good handle on using it is to work your way through the information in the data sheet. The way to do that is to call or write the folks at National Semiconductor (2900 Semiconductor Drive, Santa Clara, CA 95052-8090, 408-721-5000) and ask for the data sheet.

The complete schematic for the scope so far is shown in Fig. 3. Just about the only thing we have to add to it is an input amp and a pad arrangement to prescale the input voltages. The time has also come for us to deal with some of the mechanical problems in the scope—mainly the wiring of the display. While it's certainly not impossible to hand wire four hundred LED's, it's a lot easier to use a commercially available multi-LED module. **R-E**