Heathkit of the Month #56:
by Bob Eckweiler, AF6C

HEATHKIT

WEATHER INSTRUMENTS
Heathkit® ID-2295
Relative Humidity Indicator.

Fig. 1: Heathkit ID-2295 Indoor / Outdoor Relative Humidity Indicator

Introduction:

In a letter in last month's HOM Justin-VK2CU asked for reviews on some of the kits that use Nixie or Panaplex displays. I have some instruments that use such displays, but none are Heathkits. Initially, I thought the ID-2295 Relative Humidity Indicator (Figure 1) used a two-digit planar gas tube display, but on further examination it uses seven-segment LEDs. Still, it is an instrument that I was planning on covering so it will be this month's Heathkit.

All my life I suffered from dry skin. When the humidity is above a certain point there is no discomfort, but let a Santa Ana winds strike, driving the outside humidity into the single-digit realm, and I know I have to be prepared before I go outside. Thus, on Christmas in 1987 I unwrapped a present to find a Heathkit box stamped ID-2295. A second Heathkit present, the HD-1420 VLF Converter (HOM #16) was also under the tree, and in my stocking was the freebie Heathkit flashlight covered last month. Overall, 1987 was a good Christmas.

Heathkit Weather Instruments:

Heathkit started in the business of weather instrument kits late in 1973. In the Christmas catalog that year they introduced the ID-1290 weather station for $89.95. It has four round analog displays on a simulated wood-grain plastic board measuring 20"L x 7"W x 2"D. (6-1/2"D when using the supplied desk stand). The four instruments are a barometer, a 16-point wind-direction indicator, a wind-speed indicator and an indoor/outdoor (I/O) thermometer. The instrument can be placed on a desk or mounted on a wall, either vertically or horizontally. A separate wind-speed and direction assembly mounts on the roof, usually on a TV mast. This assembly also contains the outdoor thermometer sensor. Cable to interconnect the two assemblies must be bought separately. In 1973 Heathkit offered three lengths of 8-conductor cable: IDA-1290-1 50' for $5.95; IDA-1290-2 100' for $9.95 and IDA-1290-3 150' for $14.95. Some of the later weather instruments use this same cable, and it remained in catalogs until Heathkit went out of business. By the winter of 1991 the cable prices had increased to $12.95, $22.95 and $32.95.

The same catalog that introduced the ID-1290 also introduced the ID-1390 Digital I/O thermometer. It sold for $59.95. and matched the then popular Heathkit GC-1005 digital clock that sold for $54.95; both use a Beckman planar gas tube display. In 1973 that was the extent of the Heathkit weather instruments.

By the end of 1976 two more weather kits were added: The short-lived ID-1490 combination digital clock and I/O thermometer ($124.95), and the ID-1590 digital wind speed and direction indicator ($69.95). Both also use Beckman planar gas discharge displays. The ID-1590 requires a length of the IDA-1290 cable.

In 1978 Heathkit introduced the ID-4001 Weather Station ($389.95), and in 1980/81 the ID-1790 Automatic Rain Gauge ($149.95), the ID-1890 Digital Wind Computer ($194.95), the

Model #	Description	Intro Catalog	Intro Price	Last Catalog	Last Price
ID-1290	Weather Station *	#800/79 Win. 1973	$89.95	#223 Winter 1991 >	$199.95
IDA-1290-1	50' 8 cond. cable	#800/79 Win. 1973	$5.95	#223 Winter 1991 >	$12.95
IDA-1290-2	100' 8 cond. cable	#800/79 Win. 1973	$9.95	#223 Winter 1991 >	$22.95
IDA-1290-3	150' 8 cond. cable	#800/79 Win. 1973	$14.95	#223 Winter 1991 >	$32.95
ID-1390	I/O Temperature Indicator	#800/79 Win. 1973	$59.95	#850 Fall 1980 >	$69.95
ID-1390B	I/O Temperature Indicator	< #855 Xmas 1981	$74.95	#223 Winter 1991 >	$99.95
ID-1490	I/O Temp Ind. & Dig. Clock	#812 Fall 1976	$124.95	#815 Spring 1977 >	$124.95
ID-1590	Dig. Wind Indicator *	< #807 Winter 1976	$69.95	#221 Summer 1990	$99.95
ID-1790	Automatic Rain Gauge	< #855 Xmas 1981	$149.95	#860 Winter 1983 >	$149.95
ID-1795	Digital Rain Gauge	< #217 Fall 1989	$99.95	#219 Winter 1990 >	$99.95
ID-1890	Dig. Wind Computer *	< #855 Xmas 1981	$194.95	#860 Winter 1983 >	$149.95
ID-1990	Computerized Barometer	< #855 Xmas 1981	$234.95	#865 Spring 1984 >	$99.95
ID-2090	Barograph	#855 Xmas 1981	$295.95	#863 Xmas 1983 >	$199.95
ID-2295	**Rel. Humidity Indicator**	**#880 Winter 1983**	**$99.95**	**#223 Winter 1991 >**	**$99.95**
ID4001	Digital Weather Station *	< #850 Fall 1980	$389.95	#223 Winter 1991 >	$449.95
ID-5001	Adv. Weather Station *	< #217 Fall 1989	$499.95	#217 Fall 1989 >	$499.95
ID-5001B	Adv. Weather Station *	< #218 Xmas 1989	$499.95	#219 Winter 1990 >	$499.95
ID-5001C	Adv. Weather Station *	< #221 Summer 1990	$499.95	#223 Winter 1991 >	#599.95
IDA-5001-1	Rel. Humidity Accessory	< #217 Fall 1989	$59.95	#223 Winter 1991 >	$59.95
IDA-5001-2	Rain Gauge Accessory	< #217 Fall 1989	$39.95	#223 Winter 1991 >	$39.95
IDA-5001-3	RS-232 Interface	< #217 Fall 1989	$49.95	#223 Winter 1991 >	$49.95
IDA-5001-4	Tech Manual	< #217 Fall 1989	$24.95	#223 Winter 1991 >	$24.95
IDA-5001-4	Tech Manual w/kit	< #217 Fall 1989	$9.95	#223 Winter 1991 >	$9.95
COLOR KEY	**DESCRIPTION**			*** This kit requires IDA-1290 8-conductor cable.**	
Lt. Blue	Kit is marked “NEW” in listed catalog.				
Lt. Yellow	Kit is Marked as “LAST CALL” in listed catalog.				
Lt. Green	Kit is Marked as “LAST CALL” in Christmas 1989 catalog yet reappears in later listed catalog.				
Lt. Red	Kit is Marked as “LAST CALL” in Summer 1990 catalog yet reappears in later listed catalog.				

TABLE I: HEATHKIT WEATHER INSTRUMENTS with DATES

ID-1990 Computerized Barometer ($174.95) and the ID-2090 Digital Barograph ($295.95). For these units Heathkit switched to seven-segment LED displays.

The ID-2295 I/O Relative Humidity was introduced in the Winter 1983 catalog, selling for $99.95. The final weather kit introduced (excluding updated version of the existing kits) was the ID-5001 Weather Station with its add-on IDA-5001-1 Relative Humidity Sensor kit, IDA-5001-2 Rain Gauge Sensor kit and IDA-5001-3 RS-232 Interface kit. Interestingly, the earlier ID-4001 was listed in the Christmas 1989 catalog as *Last Call*; yet it must have proven to be popular as it remained for sale, along with the ID-5001, until Heathkit shut down. Even the original ID-1290 Weather Station was still available into 1991, selling for more than double the original price. Table I lists Heathkit's weather instruments and the catalogs in my files where they first and last appeared. My collections of catalogs are limited so the < and > characters indicate that they may have appeared in catalogs before or after the dates mentioned; however the table gives a fair approximation of the actual dates.

The three weather stations (ID-1290, ID-4001 and ID-5001/B/C) deserve an article (or even articles) all their own. Maybe in the future....

The Heathkit ID-2295 Humidity Indicator:
The ID-2295 Relative Humidity instrument (Figs. 1 & 2) consists of a main cabinet measuring 7”W x 5”D x 2-1/2” wide, weighing about 1-1/4 pounds, and two sensors, each

measuring 4" x 4" x 1-1/2"H and weighing about four ounces each.

The main chassis has a display on the front panel consisting of two-digits of 7-segment LED readouts marked **RELATIVE HUMIDITY** and two LED lamps marked **INDOOR** and **OUTDOOR**. On the rear panel is a slide switch marked **ALTERNATE - HOLD** and a six-screw terminal strip marked:

	INDOOR			OUTDOOR	
GND	INPUT	5V	GND	INPUT	5V

This terminal strip connects to the sensor cables. No ON-OFF switching is provided and the 1/16 AMP fuse is located internally with clips on the main circuit board. The unit draws 3 watts. The rear panel also contains the AC cord exit with strain relief, and the famous Heathkit "blue and white" label.

The kit comes with two identical remote sensors. They connect with the display unit via two-conductor-plus-shield round cable. One-hundred feet of this cable is supplied with the kit. The cable is removable at the sensor end as well as at the display end.

The Heathkit ID-2295 accuracy is specified between 10% and 90% humidity. Having managed a large aerospace environmental test lab, I know the difficulties of accurate humidity measurements at the ends of the humidity scale. Heathkit specifies the accuracy as ±10 counts at 25°C and ±20 counts between 0°C and 55°C. Not great accuracy but neither were most of the home humidity instruments available on the market at the time.

The kit can either display INDOOR or OUTDOOR humidity constantly, or alternate between them. The LED lights tell which sensor is being monitored. Control is by the HOLD - ALTERNATE slide-switch on the rear of the display. You can select HOLD and the display will halt and continue to display the currently selected sensor, or you can select ALTERNATE and the display will alternate

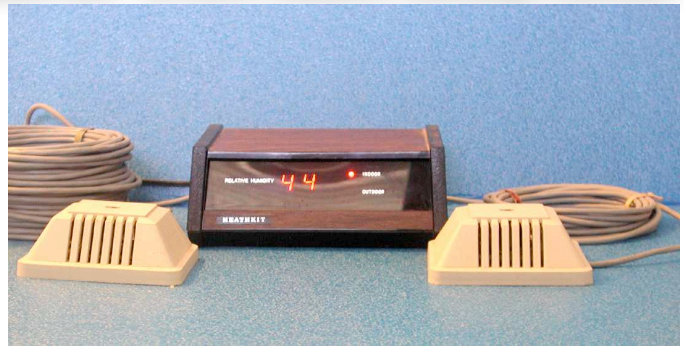

Fig. 2: Heathkit ID-2295 Relative Humidity Indicator with Remote Sensors

between the two sensors. The kit comes with two resistors that set the display alternating time. Install the 470KΩ resistor at R216 for 1.5 seconds or the 1.5 MΩ resistor for 5 seconds.

<u>ID-2295 Kit Assembly</u>:

The parts for this kit come in four 'parts packs'. Packs 1 through 3 are in numbered bags, pack 4 being the remaining parts. Part pack 1 is for assembling the two sensor assemblies; parts pack 2 is for assembling the display board; and parts pack 3 is for assembling the main circuit board. Parts pack 4 contains the parts needed for the final assembly; it also contains larger parts that may be required for previous assemblies.

The two sensor circuit boards are stuffed first, using parts pack 1. Each use eight resistors, two diodes, two IC sockets and their ICs, two connector pins (used during calibration), five capacitors including an electrolytic, a jumper wire and the humidity sensing sensor, A301. Finally three 4-40 screws terminals are soldered for connection of the wiring cable. The two sensor boards are then put aside until later.

Parts pack 2 is used next to assemble the display board. First 15 330Ω resistors are installed along with 6 jumper wires. Then five IC sockets are carefully oriented, soldered in and the appropriate IC or LED display is installed. The INDOOR and OUTDOOR LED indicators are installed using carefully measured teflon sleeving over a lead to set the right height off the circuit board. Finally, mounting brackets are

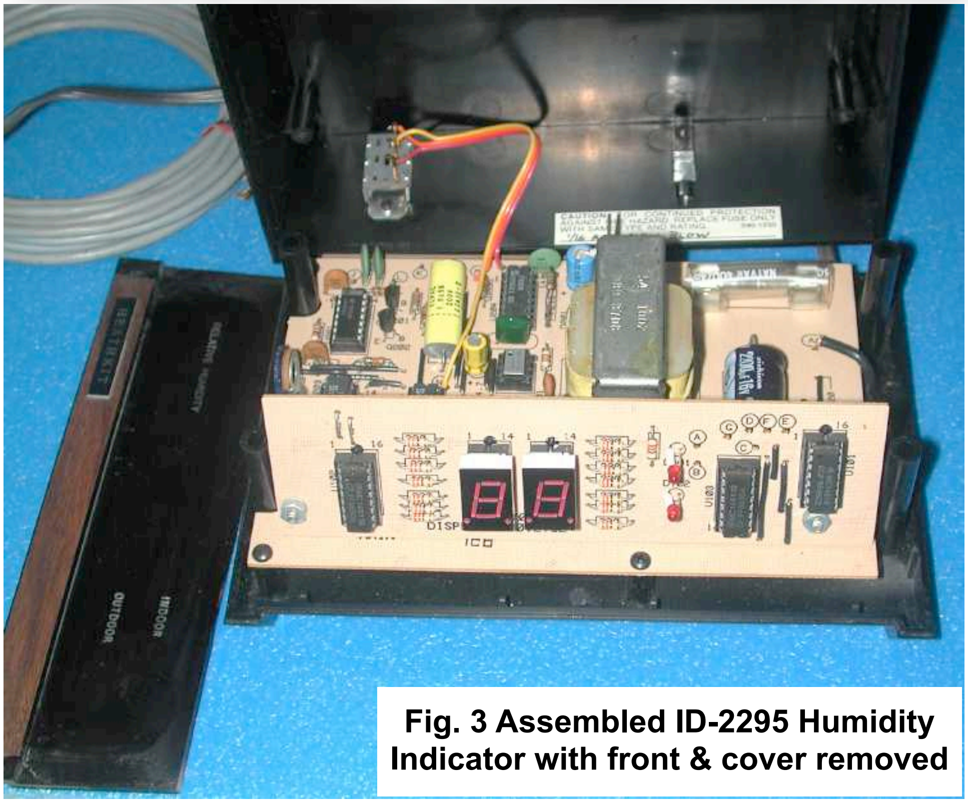

Fig. 3 Assembled ID-2295 Humidity Indicator with front & cover removed

bolted to the circuit board, and it too is set aside for later.

The main circuit board uses parts pack 3. It is the largest circuit board and is stuffed in two sections. All together 13 jumpers, 16 resistors, 13 capacitors, two potentiometer controls, four diodes, three transistors and seven ICs, six with sockets, one with a heat-sink, and a circuit-board-mounted power transformer are installed. One or two additional jumpers are then added depending upon whether the kit is being wired for 120 VAC or 240 VAC power.

When the boards are all finished, the power cord is prepared, as are three multi-conductor cables stripped from a single length of 8-conductor ribbon cable. These cables are all soldered to the proper holes on the main circuit board. The instructions need to be followed carefully as some are soldered to the component side and others to the foil side of the circuit board. The other end of one cable is attached to the display circuit board, the second attaches to the six-screw terminal strip. The third attaches later. The display and main circuit board are then bolted together and onto the cabinet base, and the terminal strip is also mounted onto the base.

As a change of pace, the assembly is put aside and the sensor boards are installed into their housings. At this time you have to decide where you want to mount the two sensors and where you'll place the indicator. When this is decided you prepare the sensor cables. Add a few feet to give some slack. The cables are then attached to the appropriate sensors.

Going back to the main assembly, labels are attached to the cabinet bottom as are the feet. The fuse label and ALTERNATE - HOLD switch are mounted onto the cabinet top, the cabinet top is laid beside the bottom, and the third cable from the main board is soldered to it. Final trim is then added to the cabinet. Next the cabinet top is put loosely in place so it can be removed for calibration.

ID-2295 Calibration:

After following an initial checkout and being sure everything is working correctly, it is time to calibrate the humidity sensors. This is done in two steps. Heathkit supplies precision 118 pF and 160 pF silver-mica 1% calibration capacitors to set the span. The jumper to pin TP301 is removed and the calibration capacitors are connected between TP301 and TP302, one-at-a-time. These capacitors replace the humidity sensor with known accurate capacitances. The capacitors are used to adjust the span of each readout so the reading goes to 99 when the larger capacitor is installed and ~5 when the smaller capacitor is installed. The two trimpots mounted on the main board are used to make this adjustment (one for each sensor).

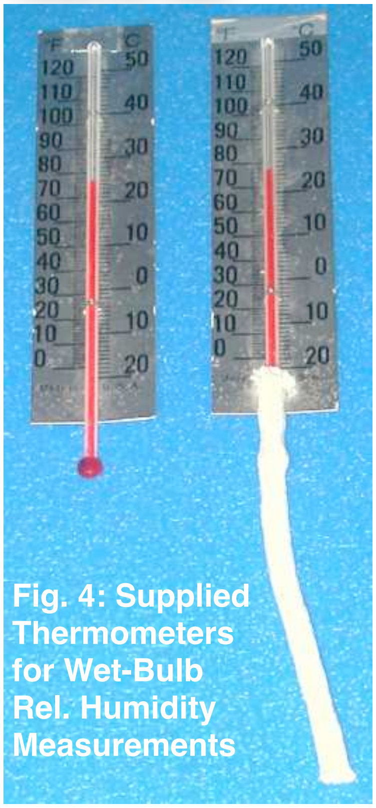

Fig. 4: Supplied Thermometers for Wet-Bulb Rel. Humidity Measurements

The second step is to set the trimpot in each of the sensor assemblies to the current humidity in the room. Heathkit assumes you don't have access to an accurate hydrometer so it developed a way for you to determine the humidity.

In the kit Heathkit supplied two inexpensive (but surprisingly accurate) bulb thermometers with cardboard scales (See fig. 4). Also included was a cloth wick that fits over the bulb of one of the thermometers. To measure humidity, mount the thermometers on a vertical surface about 5" above a table-top and about 8" apart. Place a 1/4-full cup of water under one of the thermometers After the thermometers stabilize note their readings;. in my case they read identically. Next, wet the wick thoroughly and cover one thermometer bulb with the wick. The other end of the wick should hang in the glass of water. A portable fan is then placed about a foot away so it blows on the two thermometers. Due to the evaporation of the water on the wick the "wet-bulb" thermometer will cool more than the "dry-bulb" thermometer. After eight-to-ten minutes read the difference between the two thermometers, correcting for any differences noted when the thermometers were dry. The corrected difference and the current dry-bulb temperature are then looked up on a chart in the manual, and the humidity is read. Google wet-bulb dry-bulb hydrometers for more information and charts. The trimpots in the sensors are adjusted so the readout agrees with the measured humidity and then the covers are laid atop the sensors. After two hours the final calibration is repeated, removing each cover only long enough to make the adjustment. That cover is then screwed in place.

<u>ID-2295 Circuit Operation</u>:

The circuit of the ID-2295 can be split into 5 sections: The power supply; the sensor assembly; the analog to pulse-width converter; the timing circuitry and the display counter itself. Generally, this circuit discussion will cover the outdoor sensor operation. The indoor circuit is similar.

The Power Supply:

The ID-2295 power supply circuit is shown in fig. 5. Only 5-volt DC power is required for the circuits. The transformer has a dual primary so it may be wired for 120V or 240V. The secondary is a low-voltage center-tapped winding that feeds a full-wave rectifier using two silicon diodes, D201 and D202 and is filtered by C212 producing about 9-1/2 VDC. This DC voltage is then fed to U207, a common 7805M voltage regulator chip. The 5V output from the chip is further filtered by C213 and C214, and fed to the various circuits.

Sensor Assembly Operation:

Identical sensors are used to measure indoor and outdoor humidity. The actual sensor is a special capacitor that has a dielectric material between two gold plates. The dielectric mate-

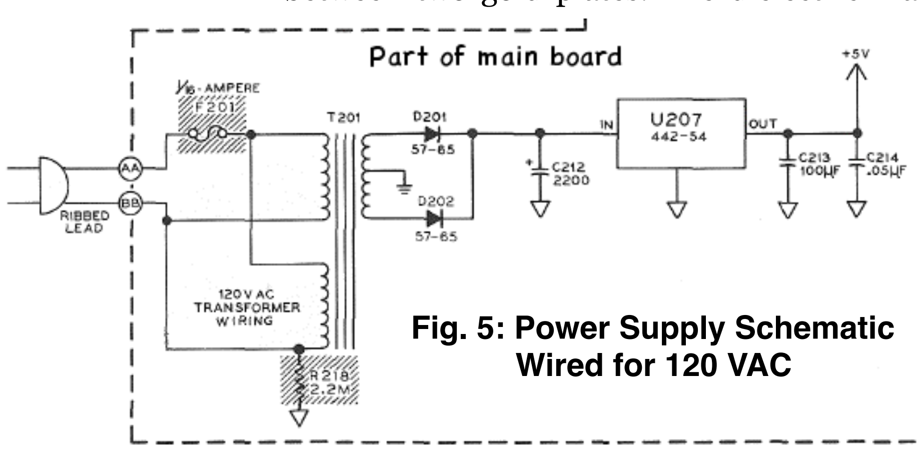

Fig. 5: Power Supply Schematic Wired for 120 VAC

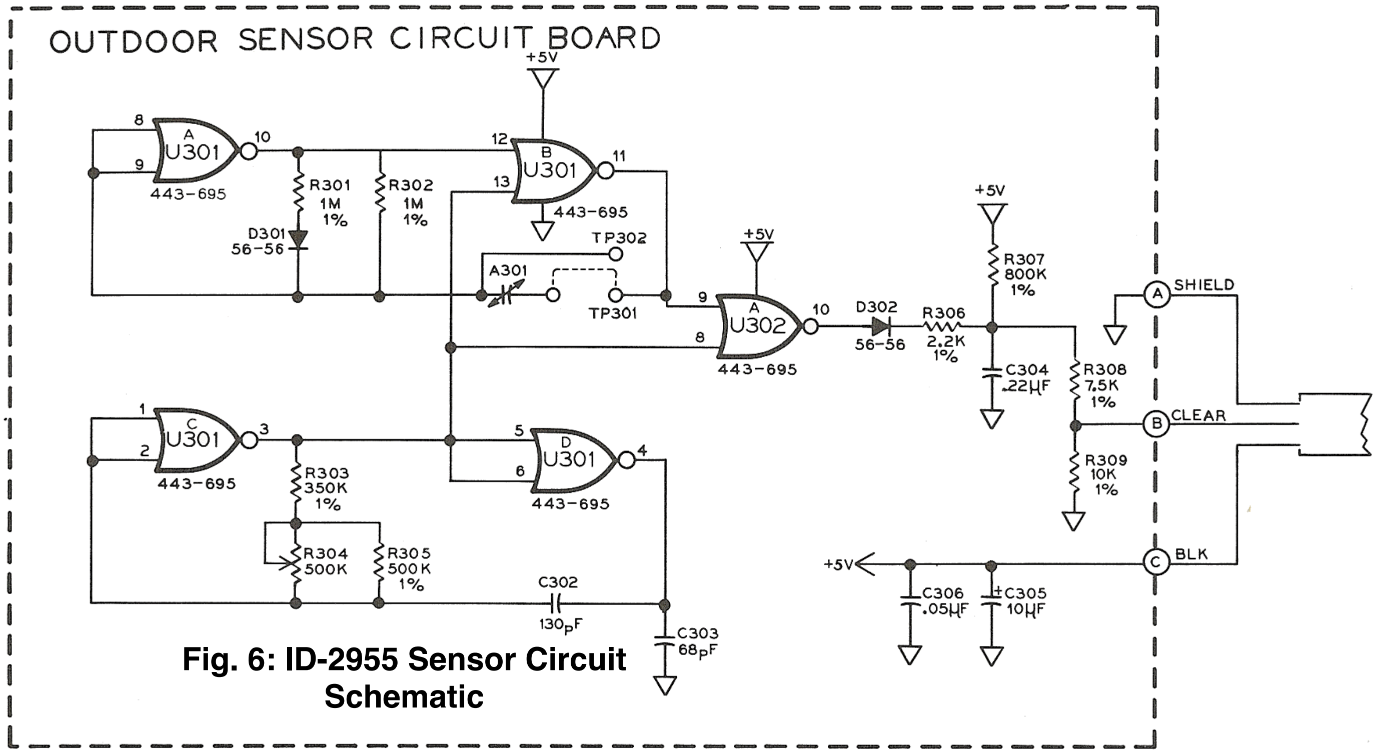

Fig. 6: ID-2955 Sensor Circuit Schematic

rial is exposed to ambient humidity and the dielectric constant varies with humidity, causing the capacitance to vary also.

Looking at the sensor schematic (fig. 6), five volt power comes in on pin-C and ground on pin-A. The output, which is an analog voltage, exits on pin-B. Figure 7 is a photo of the sensor board with the cover removed. The actual sensor element is the circular white component in the foreground.

U301 is a CD4001 CMOS quad 2-input NOR gate integrated circuit. If either of the two inputs is HIGH the output is LOW. This chip forms two multivibrators. Gates U301A and B form the sensor multivibrator whose frequency is controlled by the sensor A301 and resistors R301 and R302. Gates U301C and D make up a reference multivibrator whose frequency is controlled by C302 and resistors R303 - R305 and operates around 10 KHz. The output of the reference multivibrator, pin 3 of U301C, forces the sensor multivibrator low each time the reference multivibrator output goes high. Thus the two multivibrators are forced to operate at the same frequency, and sensor A301 actually controls the duty cycle of the sensor multivibrator. This will fail if the frequency of the sensor multivibrator becomes lower than the reference multivibrator. Diode D301 assures this won't happen.

The output of the two multivibrators are out of phase by 180° and are fed to U302A. Its output is is a pulse dependent on the difference in duty cycle between the two multivibrators. If they are the same, the pulse width is zero, but

Fig. 7: ID-2955 Sensor Ass'y Interior

as the humidity increases the pulse width gets longer. This pulse is isolated by D302 and charges C304 through R306 to a voltage that is determined by the pulse width. This network, including R308 and R309, makes the output voltage linear with respect to the humidity sensed by A301. This analog voltage is fed down the cable to the main display.

Analog to Pulse-Width Converter:

Figure 8 shows the schematic of the main circuit board, less power supply. This board contains the circuitry that processes the sensor signals and also the timing circuits.

The analog outdoor sensor signal enters on TS401-2, (J) and is fed to U201A. U201 is a quad-comparator, but only sections A and B are used, one for each sensor. The other input to comparator section A is a sawtooth ramp generated by the timing circuit. This ramp starts at zero and increases linearly in voltage over a period of several milliseconds. As long as the ramp voltage on pin-5 is lower than the signal on pin-4, the output of the comparator is low, switching to high when the voltages cross. Thus a low pulse is created that is dependent upon the voltage from the sensor. The pulse from U201A is fed to a simple switch composed of U203A and U203B. This switch is controlled by the timing circuits and only lets the pulse pass when the outdoor sensor is selected. U203A inverts the pulse, so U203B corrects this by inverting it back. The indoor circuit is identical using U201B, U203C, and U203D.

The Timing Circuits:

The timing circuits control the overall operation of the ID-2295. To simplify the operation, refer to the timing diagram of Table II. U205 is an NE555 timer. It is a free running multivibrator. The output is normally high with a negative going pulse of about 1-millisecond. Depending on your choice of R216 this pulse

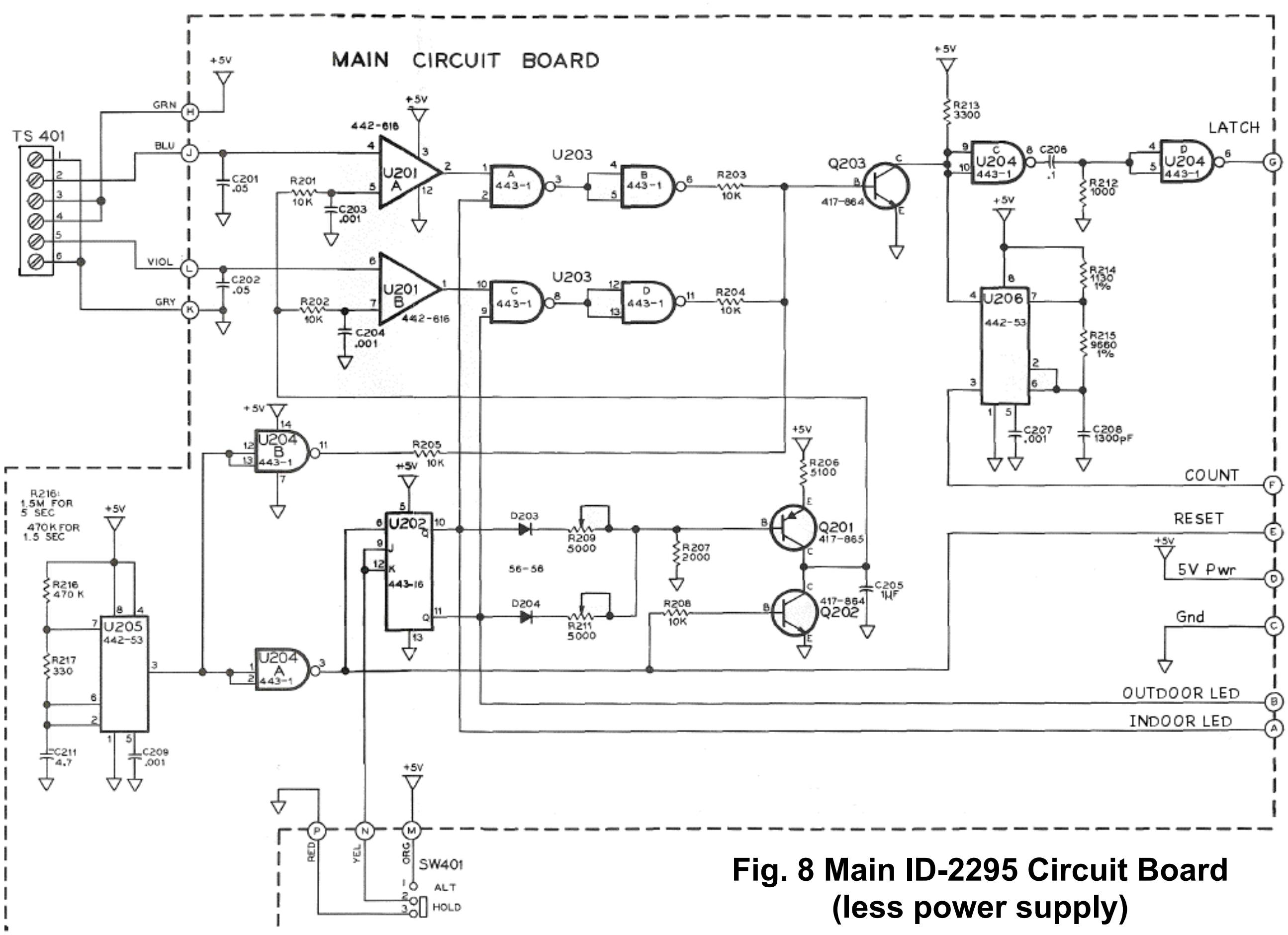

Fig. 8 Main ID-2295 Circuit Board
(less power supply)

occurs once every 1-1/2 seconds or once every 5 seconds. This is the main timing pulse. It is inverted by U204A. This pulse resets the counter board. (discussed in the next section), resets the ramp generator, and, if the ALT switch is active, toggles between the indoor and outdoor sensor. The timing pulse from U205 is also inverted by U204B producing a positive pulse that turns on Q203 during reset.

Sensor selection is controlled by U202, a JK flip-flop. Assuming the ALT-HOLD switch SW401 is in the ALT position, each timing pulse from U204A onto pin 6 of U202 causes Q and Q^ outputs to switch states. Q^ is always the opposite of Q. Should the ALT-HOLD switch be in the HOLD position the Q and Q^ outputs remain at the state they were when the switch was thrown. When Q^ is high it allows the low pulse from the from the outdoor sensor to pass U203A & B and reach Q203. Since Q is low at this time, it inhibits the indoor sensor pulse from passing U202C and the output of U203D remains low. It also is fed to the counter board where it turns on the OUTDOOR LED lamp.

The voltage ramp that drives the two comparators U201A & B is generated by Q201. At each reset pulse Q202 discharges C201. When the reset pulse ends Q203 begins charging C201 at a constant current. When Q^ is high D203 conducts and adjustable resistor R209 controls the rate of charge. Since Q is low, D4 is off and R211 has no effect. When U202 flips to the indoor mode the scenario reverses.

The base of Q203 connects to three voltage sources, (the outputs of U203B, U203D and U204B), each through a 10KΩ isolation resistor. Q203 is conducting when ANY of those three voltages are high.

U206 is another 555 timer chip running as a multivibrator at about 50 KHz. The frequency determining components are chosen for good stability, though the exact frequency is not important as long as has low drift. When pin-4 of U206 (chip reset) is high the multivibrator output appears on the COUNT line to the display board. However, pin-4 is only high when the base of Q203 is low. Thus the count oscillates for only as long as the current sensor pulse is low. The number of pulses can be calibrated to the humidity sensed by adjusting the ramp slope adjustment R209 (R211) and the calibration pot R304 in the proper sensor.

The output of U204D is normally high, the input being held low by R212. However, when the collector of Q203 goes low, signifying the end of a counting period, U204 pin-8 goes high. This causes U204 pins 4 and 5 to go high until C206 charges up causing a short 0.1 µS negative pulse on the LATCH line to the counter board.

The Display Counter Circuit:

The display counter mounts on the display board, which bolts to the main circuit board. The two boards are connected by 7 wires. power and ground, and the two INDOOR and OUTDOOR LEDs, leaving three wires to control the counter. They are ‘count’, ‘latch’ (which Heathkit refers to as ‘enable’) and ‘reset’. The schematic of the display board is shown in figure 9.

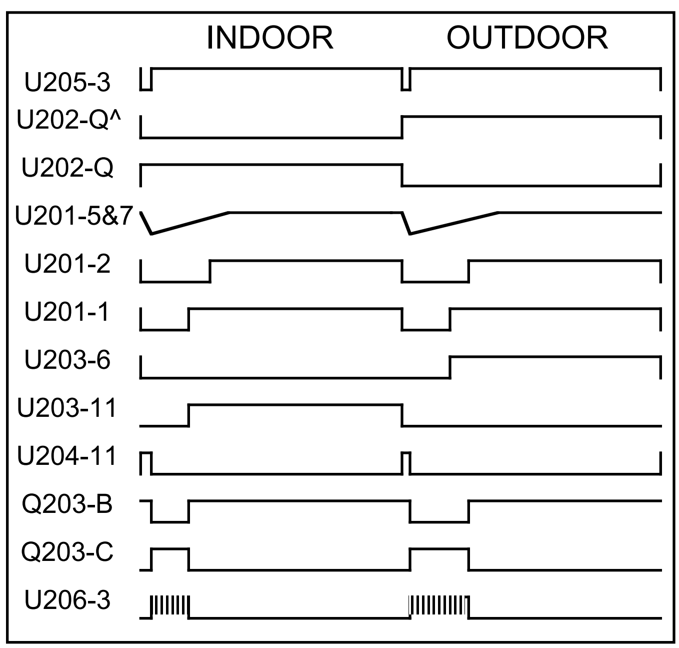

Table II: ID-2295 Main Board Timing Diagram.

The counter consists of three ICs; one 4518 CMOS dual binary coded decimal (BCD) counter and two 4511 CMOS 'BCD to seven-segment' drivers that drive two seven-segment LED displays. The dual BCD counter can count from 0 to 99. Each positive transition on the 'count' line causes the counter to increment one count. The four lines of output from the counter's first digit go to one of the the 4511 drivers, and the other four lines go to the second driver. The 'reset' line is normally low; when it is high it forces the 4518 counter back to zero.

The two 4511 drivers have internal latches. When the latch line is low, data on the BCD inputs appear immediately on the outputs and hence on the LED display. However, when the latch input is high the display continues to display the count present on the inputs at the time the display went high, and is not affected by any changes to the input lines.

Over one display cycle the 'latch' input starts high with the display showing the previous count; the 'reset' line is then pulsed high, resetting the counter. Counting pulses are then sent on the 'count' line for a of period time, ending by the latch line pulsing low for a short period, transferring the new count to the display.

Conclusion:

One thing that makes building Heathkits fun to build is learning from their circuits. I remember that this kit offered a challenge, and I had to look deeper than I normally do to find how it works. An afternoon with IC data sheets and a quad-pad to work out a timing diagram cleared things up. That is why I went into more circuit detail in this write-up than I usually do.

This kit, despite its wide specifications, provided good service for many years, and was accurate within 2 humidity counts against a certified instrument I borrowed to check it out. This from the range of about 20% to 80% relative humidity and room temperature. The unit sat in the closet for the past few years, having been replaced by an indoor/outdoor wireless humidity/temperature and clock instrument. Now that it has been re-calibrated I might just put it on display?

I am currently debating what Heathkit I should do next. I have some Heathkit stereo gear and it's been awhile since I covered any of their audio line. The SB-303 is also on my list. Any suggestions?

73, from AF6C

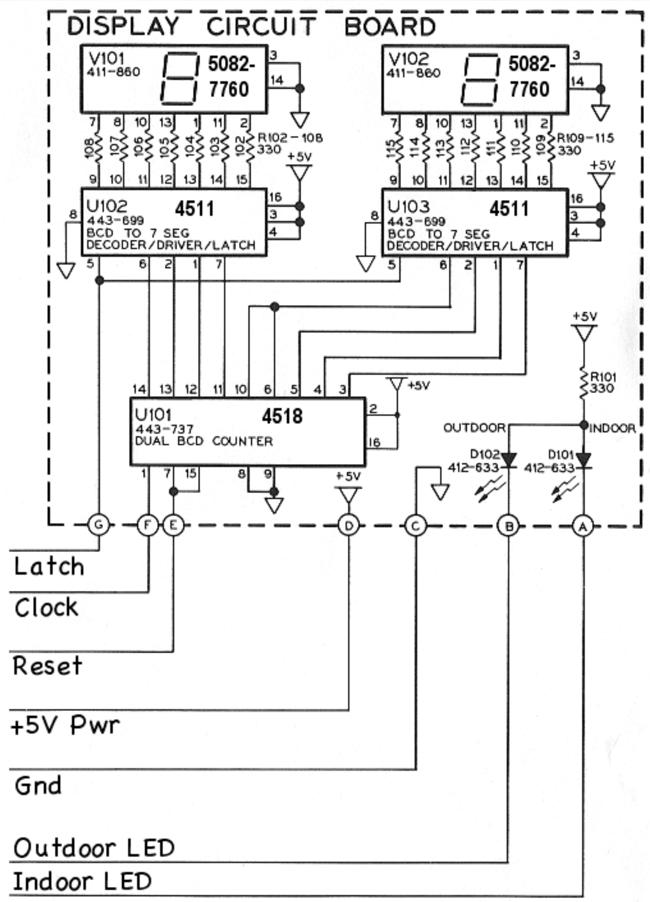

Fig. 9: ID-2955 Counter Board Schematic

This article originally appeared in the May 2014 issue of RF, the newsletter of the Orange County Amateur Radio Club - W6ZE.

Remember, if you are getting rid of any old Heathkit Manuals or Catalogs, please pass them along to me for my research.

Thanks - AF6C