The Modem Racks

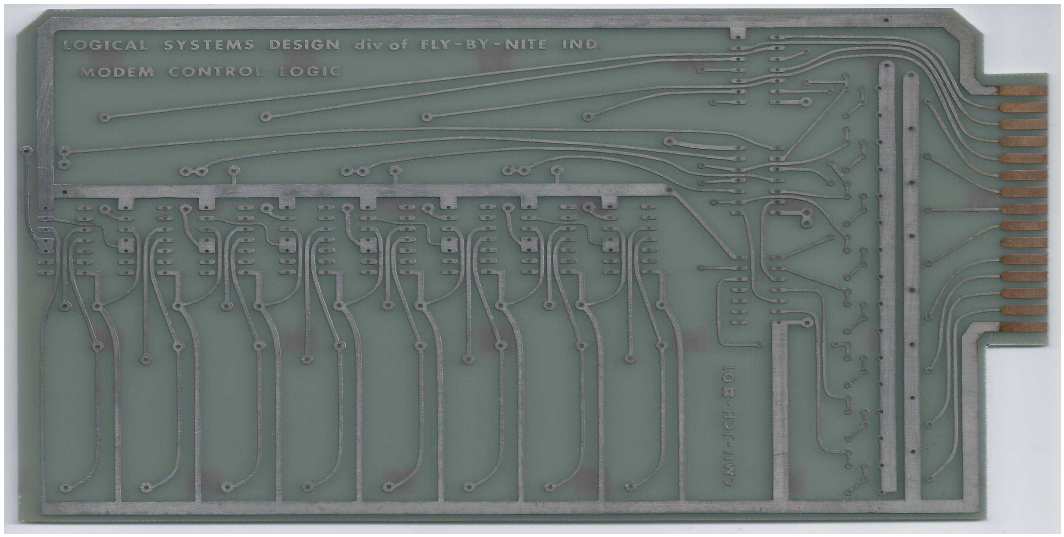
Sometime around the end of 1970 Bill, my boss in the CS Engineering Lab, directed me to evaluate a Bell 103 compatible modem card manufactured by Astrocom. They made both individual originate-only and answer-only cards and I was provided with an originate-only card to evaluate. I had become the "Modem Man" in the lab as I was already both evaluating acoustic couplers and repairing them (the ones from Omnitec worked best). Back then it was not allowed to directly connect a non Bell modem to the PSTN. One either had to use an acoustic coupler with a Bell desk set or rent what was called a Data Access Arrangement or DAA from Bell. It allowed a direct electrical connection from the modem through the DAA to the PSTN. This was a new development due to the 1968 Carterphone decision so Bell provided DAA's to allow this. The earlier Hush-A-Phone decision in the mid 50's was what allowed for acoustic coupler connections. The whole reason for doing this was that renting Bell 103's was expensive and so a less expensive way of connecting to the computers was desired.

So I was given a Bell DAA, what I will call a "Smart DAA". It did everything but automatically hang up the phone at the end of a connection. If you recall what a standard Bell 103 looked like, it was two separate devices, the modem itself in a rectangular box and something that looked sort of like a phone with a handset. The Smart DAA looked exactly like the Bell 103 phone part. So I connected up the originate-only modem card to the DAA and was able to successfully dial into the PDP-10 and IBM 360, the G-20's had already been removed.

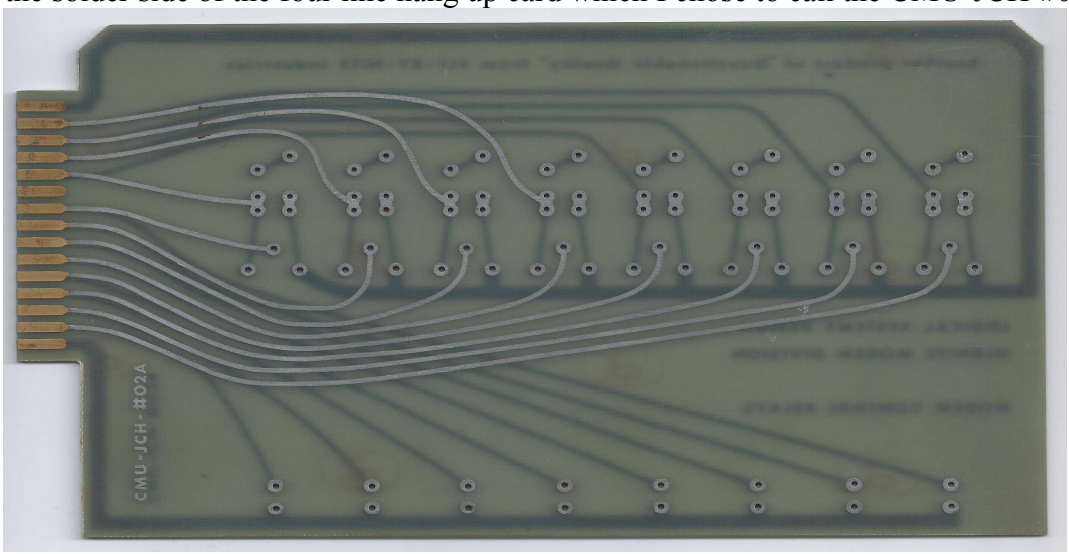
The proposed modem rack, however, would use the answer-only cards. Now all I had to figure out was how to hang up the line either when an incoming modem call failed to connect or when a successful modem communications completed. I was directed to acquire eight of the cards and build a rack mount unit to hold them and my hang up logic. Since many connections were using acoustic couplers, when connecting the originate signal would sometimes bobble a few times as the handset was placed into the acoustic coupler. To ignore these momentary losses of carrier, I chose to implement the hang up with a time delay. The delay would start either on reception of "Off Hook" from the Smart DAA or the loss of carrier from the modem at the end of a connection. No carrier signal present at the end of this delay time (I chose about 10 seconds) would cause the DAA to hang up. The way to make the Smart DAA hang up was to set the DTR (Data Terminal Ready) signal into the Smart DAA to a negative voltage. Normally the DTR signal came from the computer so I intercepted it with a relay which when not energized just passed the signal from the computer through to the DAA but when energized connected the DAA DTR to negative 12 volts for about a second or so (as I recall at least 3/4ths of a second was the minimum requirement). For each line this timing was done with two cascaded 74121 one-shots.

I was able to fit the logic for four lines on one single sided printed circuit card which had to match the form factor of the modem cards. This did require a number of wire jumpers on the component side of the card. So two hang up cards would be required for every rack unit. I was, however, able to get all eight relays on one card but to get all the necessary connections required constructing a double sided printed circuit card. This was before the system of using transparent blue and red tape along with opaque black tape was developed for laying out the artwork for double sided cards on one sheet. So two separate layouts using black opaque tape were required, one for each side of the double sided card.

The layouts were done at twice normal size and then sent out to a photo lab to be reduced to the one-to-one size negatives needed for production of the printed circuit cards. The negatives were then sent to a company which would etch and tin plate the cards as well as gold plating the card edge connectors and through-hole plating the double sided card. Photos of the results are on the next page.



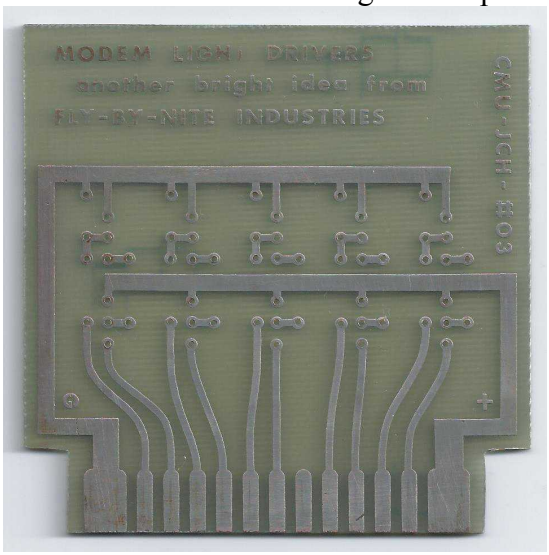
This is the solder side of the four line hang up card which I chose to call the CMU-JCH-#01 card.



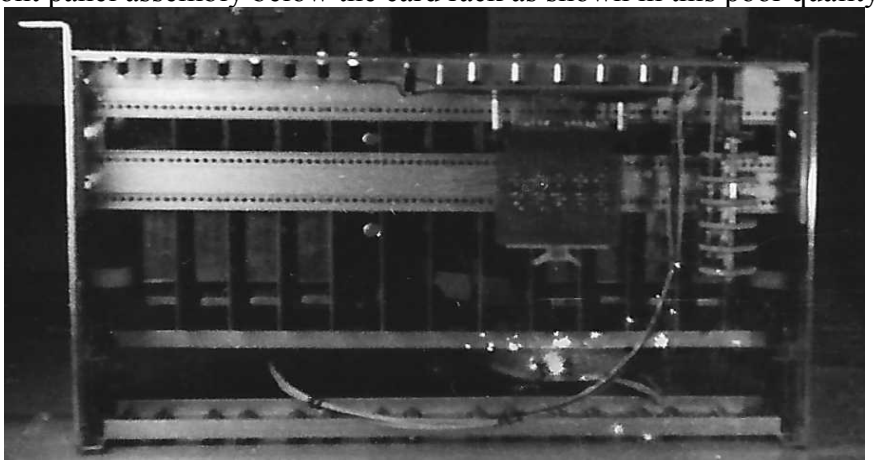
The above two photos show both sides of the double sided relay relay card which I chose to name the CMU-JCH-#02 card with a suffix of A for the component side and B for the solder side as shown.

I also needed to design a little “front panel” for manual control and monitoring of the modem rack unit. This was placed just below the row of cards and was made from a narrow strip of aluminum sheet which I roughed up to give a pleasing patina. I then drilled the holes and mounted and labeled the individual controls and displays on the panel with stick on lettering. Finally I sprayed it with a clear coat to protect the labeling and reduce finger prints. Mounted on the panel were eight “busy-out” switches, one for each line, a disconnect push button, five 12 volt incandescent lamps for status displays and a six pole ten position rotary switch. Five of the poles were to connect the selected line to the status displays and the sixth pole to connect the disconnect button to that line. Of the remaining two switch positions, one was for a lamp test function and the other just an overall “off” position for these functions. I was able to find a very nice rotary switch with ceramic wafers made by Mallory.

The statuses being monitored on the lamps were all RS-232 signals which wouldn't drive a 12 volt lamp directly so I had to design a lamp driver circuit. As I was already using some of these RS-232 signals to drive more than one input I was worried about loading them down too much so I designed a two stage circuit for each lamp using a high impedance resistor for the input. Each resistor connected to an MPS-6531 NPN transistor driving an MPS-6534 PNP transistor which switched the 12 volts to the lamp. The five circuits were etched onto one small single sided printed circuit card as shown:



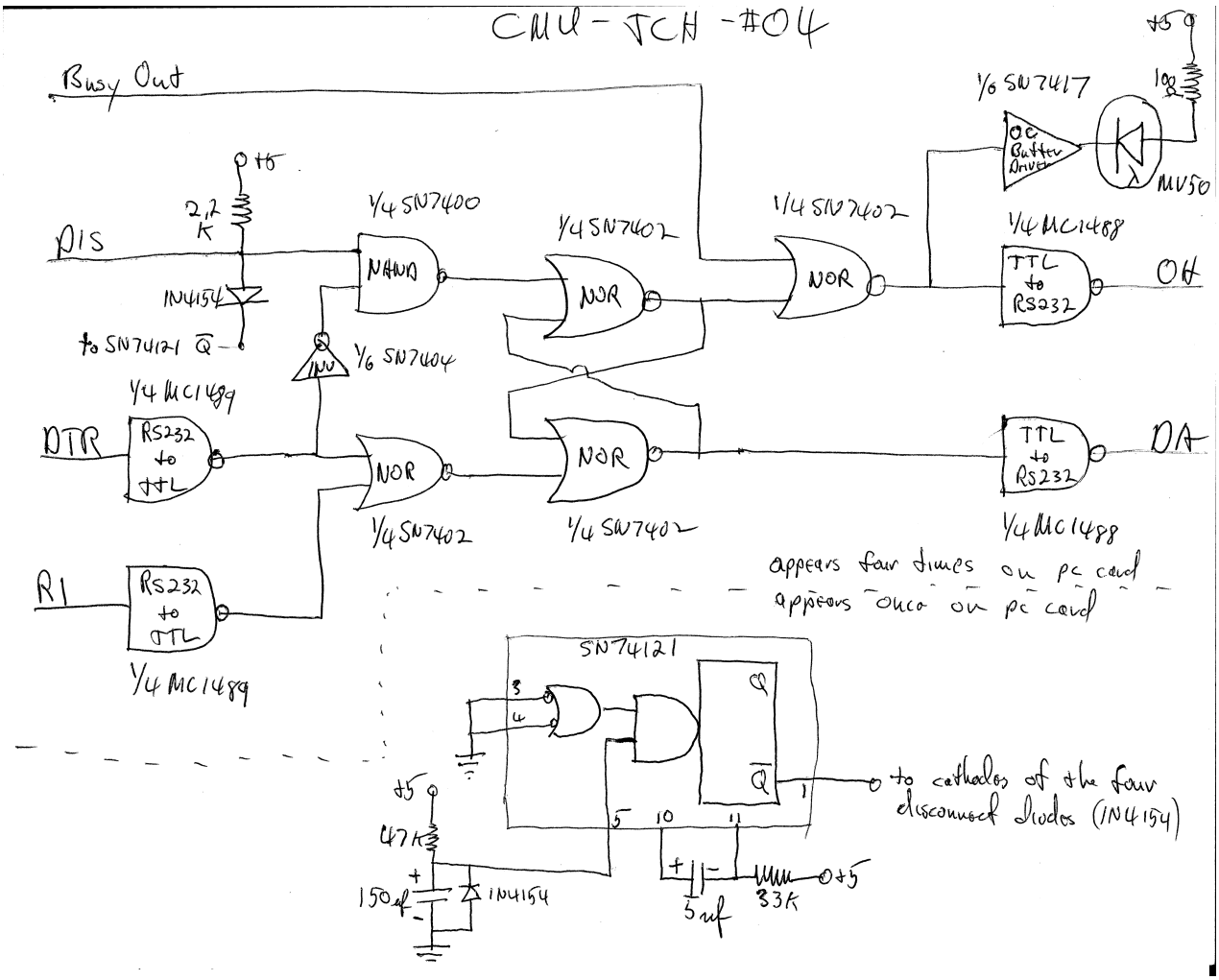
This too was done at twice normal size and then photo reduced. The difference was that I etched and tin plated the card myself rather than sending it out. However, I had no way of gold plating the edge connectors. But as I had designed it with a large input impedance I didn't believe that just having a tin plated edge connector would be a problem and it wasn't. This I called the CMU-JCH-#03 card. It was mounted on the front panel assembly below the card rack as shown in this poor quality Polaroid photo:



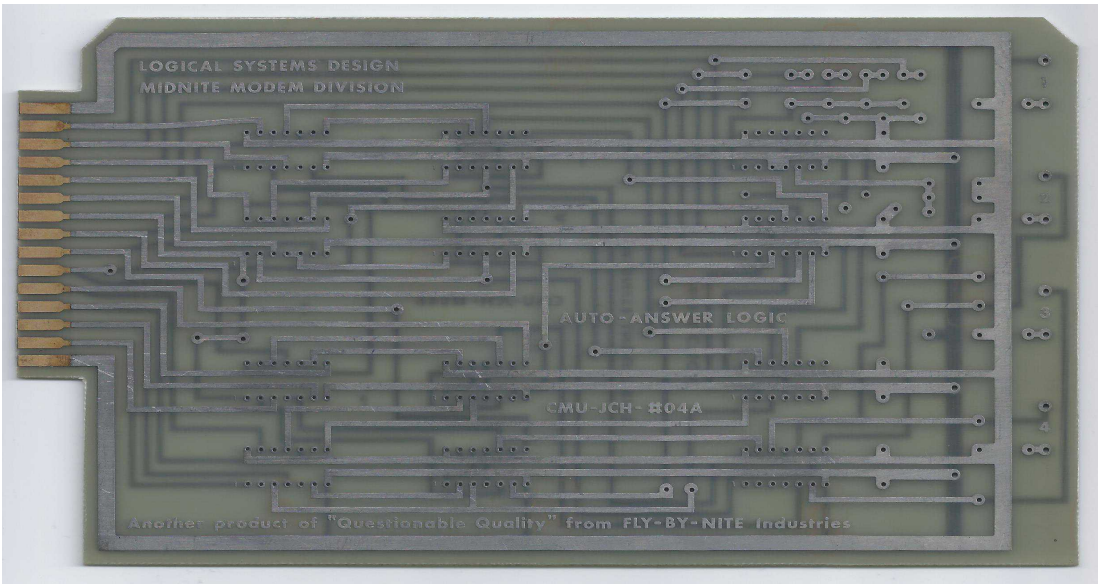
As can be seen from the photo the front panel was a partial sub-assembly done and mounted before the main wiring was started on the unit.

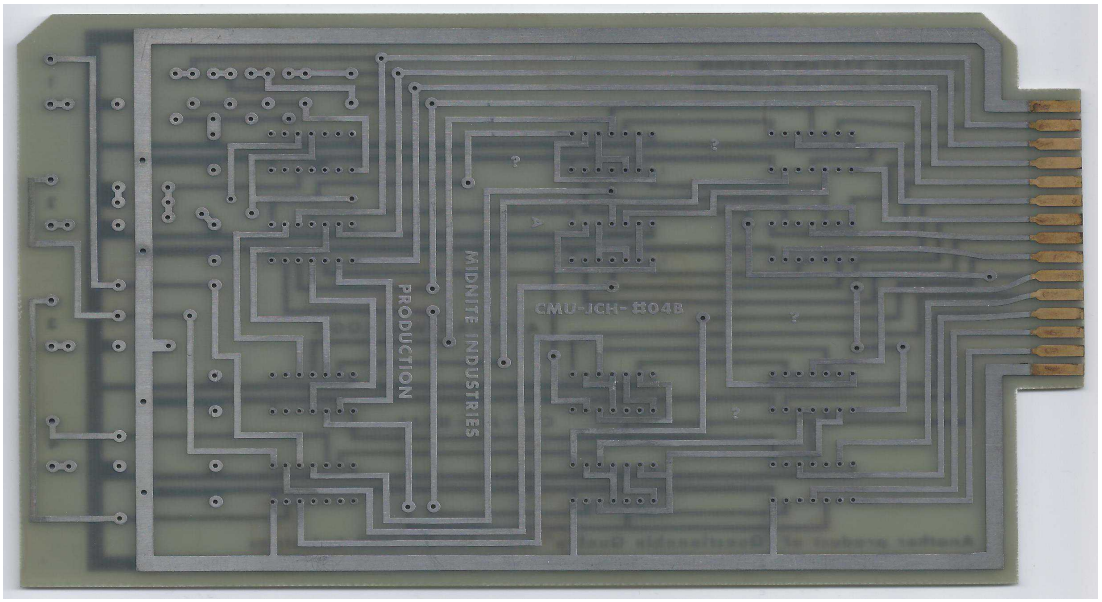
The next thing to do was to wire up the initial prototype unit and install and test it. I was literally siting at the bench in the lab waiting for my soldering iron to warm up (I used 22 gauge solid hook up wire to wire it, using the insulation color to color code the signals.) when my boss comes in and takes away the Smart DAA, providing me instead with what I will call a "Dumb DAA" to use in its place. The only thing it did was provide me with the RI signal to tell me the line was ringing. I now had to tell it when to go "Off Hook" when a call came in and to go back "On Hook" when a call was done.

Now, first off, before this project I hadn't done and real digital design so the whole process was a learn by doing situation. After I had completed the #01 card I was horrified to realize that I had not included any decoupling capacitors. I attempted to correct this by adding large capacitors to the rack unit on the power rails. Either it wasn't a problem or the large capacitors did their job as I never had a problem. Now I was going to have to design the answer logic to add to the hang up logic. What's more I was not allowed to redesign the hang up logic, so had to use the existing design. But this did require the scrapping of the relay card. The necessary answer logic would require two cards to replace the one relay card and again be double sided to get the necessary number of connections on the modem form factor cards. This would be a tight fit in the already crowed rack unit but I just squeezed it in. Here's my hand drawn schematic, which somehow survived, for what I called the CMU-JCH-#04 card:



And here's the photos of the two sides of the card, once again the A side is the component side, shown first, and the B side the is the solder side:

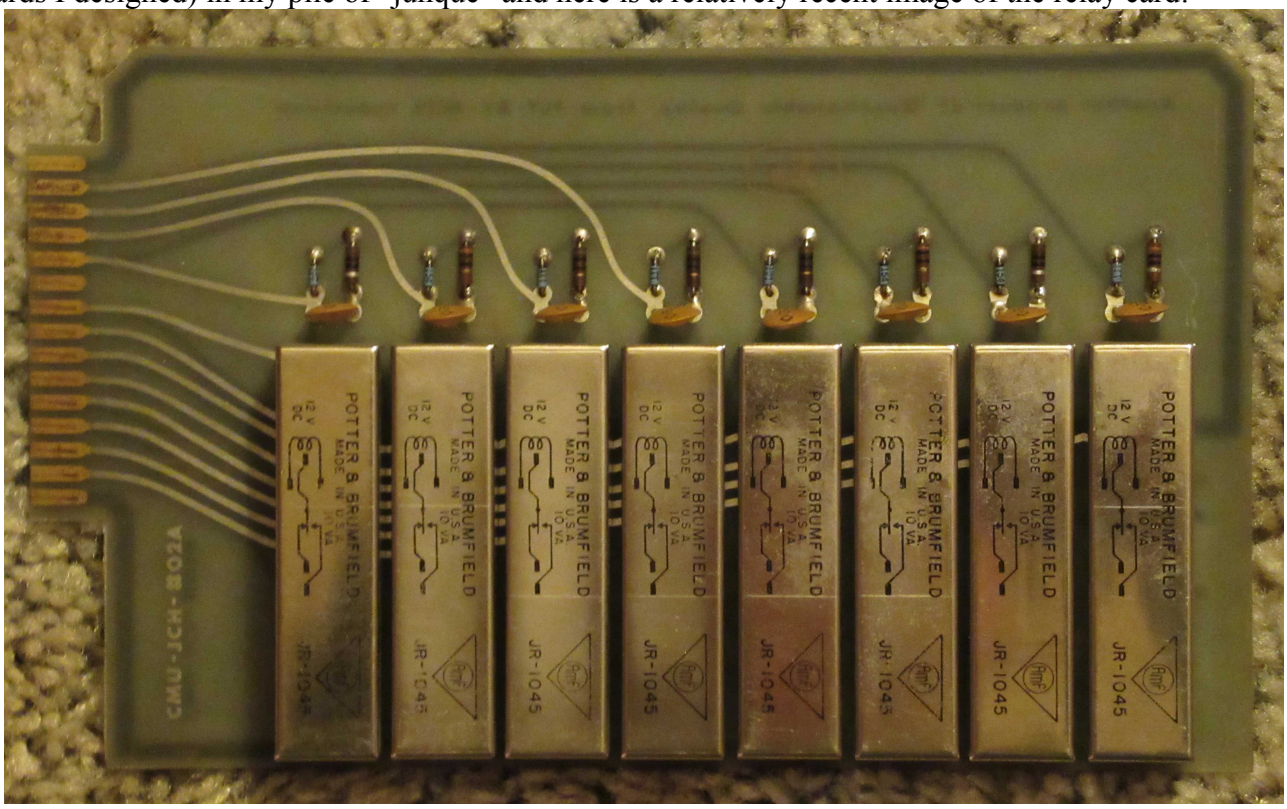




There were twelve integrated circuits on the card. Looking at the A side of the card the column of four chips immediately to the right of the edge connector are all quad TTL-RS-232 converter chips, the top and bottom ones MC-1489 RS-232 to TTL converters and the middle two MC-1488 TTL to RS-232 converters. The center column of 4 chips are all 7402 quad NAND gates, each chip used with just one of the four lines supported. Two of the four gates were cross wired as a flip-flop so to maintain the hook switch status to send to the Dumb DAA. The chips in the right most column as shown on the A side image from top to bottom are a 74121 “one-shot”, a 7400 quad NAND, one gate used with each line, a 7404 hex inverter, four of the six gates used one with each line, the other two unused, and finally a 7417 hex buffer driver, again four the the gates used, one for each line. This chip's entire purpose was just to drive the four MV50 LED's, which I believe was the first commercially produced LED. When lit, a LED indicated the associated line was “Off Hook”. The LED's were mounted along the outside edge of the card and thus easily visible from the front of the rack. The entire purpose of the 74121 one-shot was just to force the hook switch flip-flops on the card to the “On Hook” status when the unit was powered up. And on this card I certainly included a number of decoupling capacitors.

Because the answer card was more complex, to better assure correct alignment between the two sides I decided to lay it out at four times final size. And again I just used the black tape and pre-made connector patterns from Bishop Graphics on the two separate layout sheets. Further, the circuit card manufacturer had whined that when I had laid out the #01 card I had run some traces between the pads on the IC connectors which caused them some problems with close clearances when etching. So with this card I avoided doing that as well. Finally, because it was done four times size it seems my sense of size was somewhat off resulting that I used traces wider then they really needed to be.

As the relay card design was no longer used, only three copies had been etched and only one of those was ever actually populated. Since it wasn't ultimately used, I saved it (as well as a bare copy of all the cards I designed) in my pile of "junque" and here is a relatively recent image of the relay card:

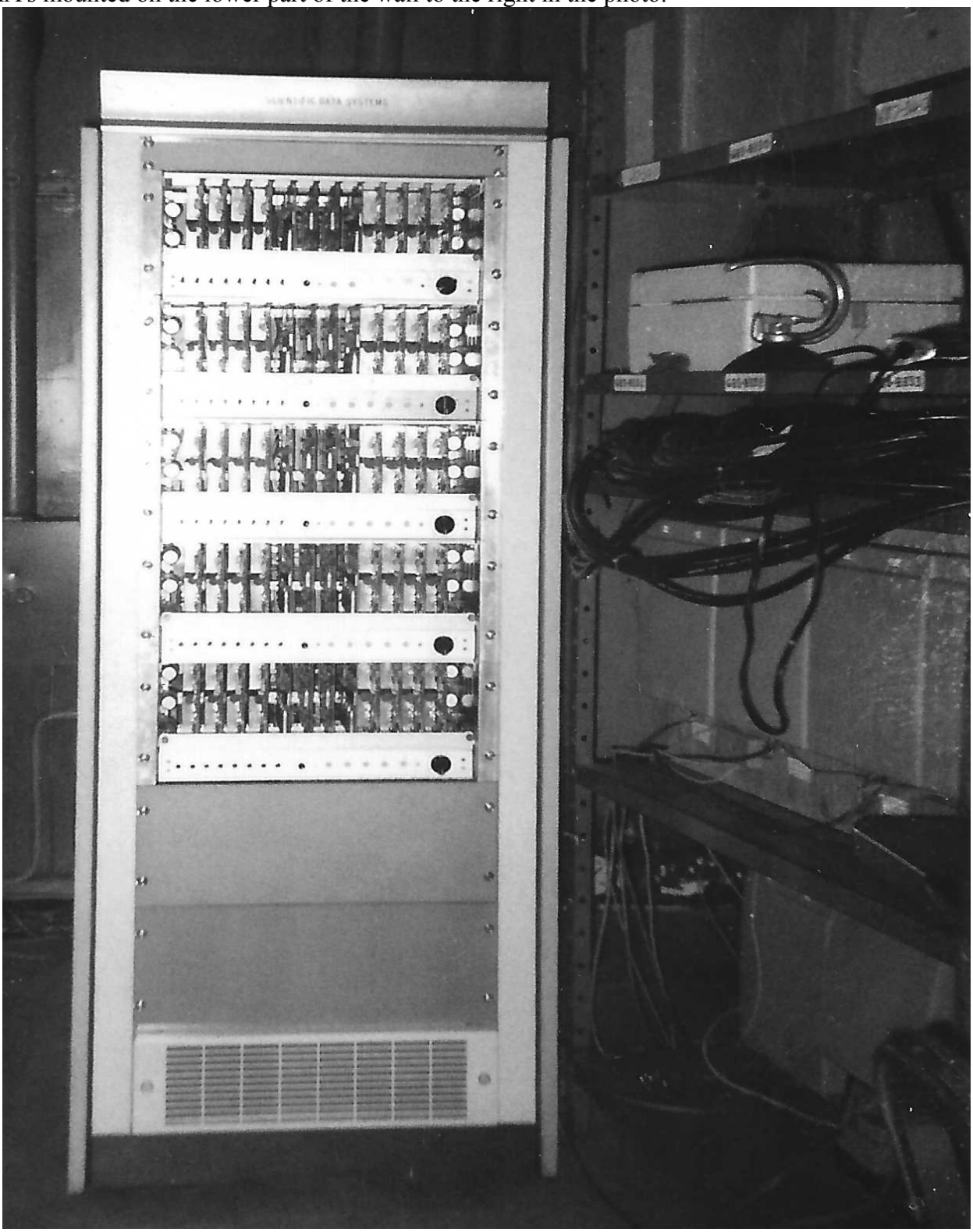


The actual rack hardware assemblies were purchased units but the side plates which came with them were of insufficient size to fit the modem and logic cards and the front panel. So based on the adjustable design of the purchased units, I designed higher deeper side plates which were locally manufactured to my specifications. However I used the card support bars and guides as well as the back plane support bars which came with the purchased units for both the edge connectors and DB-25's. Two sets of DB-25's were required for each modem card, one (female) for the RS-232 connection to the computer and one (male) for the connection to the associated Dumb DAA.

Each rack chassis held eight modem cards and two each of the hang up and answer cards. The answer cards were located together at the center of the rack, each flanked by its associated hang up card in turn flanked by the four modems those two cards controlled. Each rack chassis thus held two logically separate four modem units.

These units required a fair amount of current at both plus and minus 12 volts DC and even more current at 5 volts DC. So I purchased appropriate sized commercially manufactured power supplies and mounted them on an aluminum panel which was then mounted on the back side of the rack.

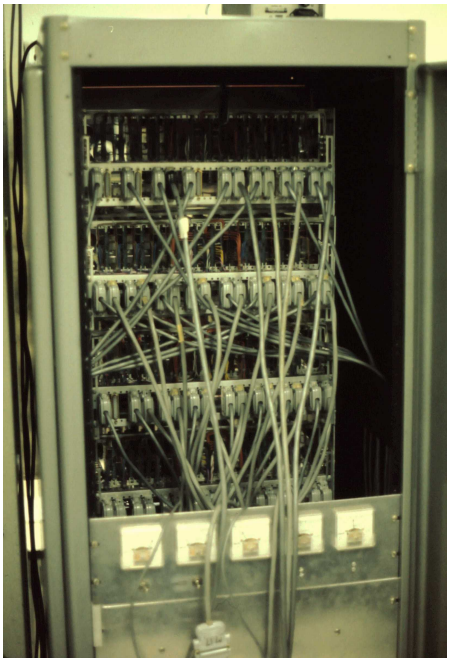
With the prototype unit apparently working correctly I was told to manufacture four more units and proceeded to do so. To make my life easier along the way I wrote a sort of “Heathkit” manual which documented each and every wire run in the chassis unit including, again, wire insulation color. This photo shows the five completed units mounted in a re-purposed Scientific Data Systems rack in Scaife Hall in the PDP-10 machine room (former G-20 machine room). You can see some of the Dumb DAA's mounted on the lower part of the wall to the right in the photo:



In mid spring 71 while I was doing all this my boss told me that as my salary was funded by a government grant and the information was that the grant was going to end sometime that summer I might not have a job past the summer. With this information I started a plan to move out of Pittsburgh and back to my home town of Rochester, NY, initially to live with my parents. So starting in mid May every weekend I would drive back to Rochester on Saturday hauling more of my "junque" with me on each trip and return on the Sunday. The apartment lease I then had with Pat and Carol in East Liberty, both of whom had left at the end of May, ran out at the end of June. Thus for my last month in "da burg" in July, I moved in with a number of other students in their rented house on Squirrel Hill.

By this time both the CS engineering lab and the computer center had been moved to the new building, what became Ween Hall. Shortly after I completed the five units my boss told me that they needed a sixth unit. Although I did the mechanical assembly and the front panel sub-assembly for this final unit, since I understood that my job was to end and some other techs would still be employed I showed my "Heathkit" manual to my boss and strongly suggested that one of the other techs wire up the final unit thus to demonstrate the fact I had made a good job of it, including writing up documentation. This was what was done. The only problem I had was that the Mallory six pole ten position rotary switch with its nice ceramic wafers was no longer available. I was able to find another compatible rotary switch but it used cheap phonelic wafers. Further, I had to split up the six units, four in a new Bud rack to be connected to the 360/67 and the two remaining still in the re-purposed SDS rack to be connected to the PDP-10. This required me to construct a second set of power supplies for the additional rack.

I learned much later that apparently the grant that had funded my salary continued and I could have kept my job in the CS lab. In hindsight, however, I don't think I was cut out to work in an academic environment and am quite happy I left and went out into the "real world" for the rest of my career.



I first returned to campus in fall 1976 along with Pat and Russ for Homecoming. The two photos above were taken during that visit. The left photo shows me next to the rack of four units originally connected to the 360 (but by then to a PDP-11 acting as a front end terminal processor as to my mind the IBM mainframe world never really seemed to figure out asynchronous serial communications). The photo on the right shows the back of this unit and part of the power supply set-up. As far as the modem racks go, as Paul Harvey used to say, "Now you know (most of) the rest of the story".