ABOUT SEMAPHORES

Presented by BOB VAN CLEEF
of the North River Railway
CONSIDER THE DEFINITIONS FOR THESE TWO RAILROAD DEVICES

• TELEGRAPH – A device, system, or process by which information can be transmitted over a distance.

• SEMAPHORE - From the Greek *sema*, a sign, and *pherein*, to bear
  – An apparatus for signaling, consisting of an upright with movable parts
  – A means of communicating by a machine with movable arms, which was later also adapted for use with hand-held flags.
First Optical Telegraph

- The **smoke signal** is one of the oldest forms of *long-distance* communication.
- It *is* a form of visual communication used over long distance.
- In general smoke signals are used to transmit news, signal danger, or gather people to a common area.
- Therefore, In essence, it was a primitive form of an optical telegraph.
MIDDLE AGES (5\textsuperscript{th} to 15\textsuperscript{th} Centuries)

- Smoke and fire signals were not dependable and could convey only simple, pre-arranged information.
- Advanced civilizations like Greece and Rome slowly developed relay systems using runners and/or horses to speed complex messages day and night much like the early American pony express.
- Runners became common in Europe during the Middle Ages (mid 5\textsuperscript{th} to mid 15\textsuperscript{th} centuries.)
“GALILEO’S” TELESCOPE

• Galileo Did NOT invent the telescope.
• That honor *generally* goes to a spectacle maker named Hans Lippershey around 1608 possibly to spy on his rival spectacle makers.
• Galileo DID make many improvements and used it in his studies of astronomy.
• The use of telescopes rapidly spread throughout Europe and especially the sea trades.
• So what does this have to do with semaphores?
THE RENAISSONCE (14th-17th Century)

• This period saw an explosion of new forms of communication due mostly to the invention of the telescope.
• Paddles or symbols were exposed to a viewer up to 10 miles away and more.
• These were “read” with the aid of a telescope.

Telegraphs and Semaphores (Pasley, 1823)
ROBERT HOOKE (1684)

- Hooke was the first to propose a practical telegraph that could reliably send complex messages.
- Symbols were stored behind a screen.
- They were exposed one at a time to “spell” the message.
- Symbols were used instead of letters to keep messages secret.
- Two sets of symbols were used. One for daytime, the other for nights.

Hooke wrote a detailed description of the various sized of telescopes required for his system based on the distance between stations.
CLAUDE CHAPPE (1793)

- Claude (and his brother) developed the first successful national telegraph systems in France.
- The network eventually covered over 3000 miles with 566 stations, many along the shore for ship to shore communications.
- A message could pass through 15 stations in only nine minutes by day or night.
SPELLING THE MESSAGE

• Chappe found it was easier to see the angle of a rod than to see the presence or absence of a panel.

• Each arm had (7) positions and the crossbar had (4)

• $7 \times 7 \times 4 = 196$ positions.

• Additionally, symbols could be combined two at a time for a total of 8,464 coded “words” and phrases.

• This allowed much faster transmission rates

Most of these double symbols were recorded in a secret code book to guarantee secrecy for military transmissions
MURRAY SHUTTER (1795)

• The Murray system followed the Chappe system but, as the Chappe brothers had suspected earlier, never enjoyed the same success.
• Shutters were slower, not as visible and could not compete with already existing systems.
DEPILLON 1803

- Depillon designed a system for ship to shore communications, also on the French Coast.
- This formed the basis of several similar designs that followed.
- It was a British Navel officer, Sir Home Popham, who coined the name “semaphore” in 1816.
- Note that lanterns could be hung from the arms for night-time use.
CHARLES PASLEY (1822)

- Pasley designed what was to be the last of the optical telegraphs.
- They were fast, efficient and easily constructed.
- Unfortunately the cost of tower erection and lack of skilled operators spelled their doom.
- Operations ended in 1847.
SO, HOW FAST COULD A MESSAGE BE SENT?

• This shows how a message could be sent 100 miles in 27 seconds.
• A spotter with a specially mounted telescope calls out to two or three operators of the signal blades.
• A second spotter would do likewise from the opposing direction.
END OF THE OPTICAL TELEGRAPH

• Electricity was first used in crude experiments in 1753 to send messages.

• Several attempts soon followed with varying amounts of success.

• It was the invention of Samuel Morse’s electrical telegraph in 1837 that ended both the optical telegraph in Europe and the pony express in America.
COMPARE SEMAPHORES

• It is easy to see how the modern railroad semaphore was similar to the vanishing optical telegraphs.
• They all were designed to convey information over long distances.
• Even the use of flags to spell out messages is the same in principal to their older ancestors.
18th CENTURY “TRAINS”

Most of these “trains” were used to haul coal from the mines to canal barges, a distance of no more than about 30 miles. All were created to haul heavy loads.

- Plankways were used when heavy loads were involved.
- By the 1800s planks were gradually augmented with iron fittings.
- Note the flangeless wheels and flanged rails they rode on.
- Train signals were basically “giddyap” and “whoa boy.”
FIXED SIGNS WERE EVERYWHERE

• These existed from the dawning days of man and a long time before there were railroads. They came in many forms.
• Most were simple signposts to show the way to the next town and how far it was.
• Look along any road or highway anywhere in the world today and you will find an occasional stone marker.
• These could be considered as fixed, single aspect signals.
MORE SOPHISTICATED SIGNALS

• Plankways were generally owned by companies.
• Companies found it was more efficient to maintain lanterns and flags to help regulate wagon traffic.
• Fixed signals (those that have one and only one aspect were sometimes placed by the roadside.
• This signaled when danger or something unusual lurked ahead.
• This could be anything from a washed out bridge to some other obstruction ahead to plague.
• Sometimes they were used to warn of on-coming traffic. This meant having to leave the plankway to allow another wagon train to pass.
The earliest documented railway signal was an “optical telegraph” at Middleton Colliery in 1825.

It was a simple black disc that could be rotated when coal wagons had been loaded and attached to the cable that would draw them to the summit of an incline.

The hoist operator would see the disk and know the cars were ready to be hoisted up a slope and out of the mine.

This was a 2-aspect signal
THE INFAMOUS BALL SIGNAL

• Ball signals were erected as English railroad station signals in 1840.
• They were based on American tide signals used to telegraph the depth of water over a sand bar to ships in the offing.
• The first railroad use of these signals was in England merely to indicate the on-time status of trains and not to control train movements.
• Later, Telescopes were used at each station to determine whether it was safe for a train to proceed to the next station.
• American railroads later adapted the practice mostly in New England.
Ball signals appeared with early railways in the United States, England and Germany.

They were used for only a short time in the United States mainly in New England.

While only used for a short time they have become both railroad jargon for “clear tracks ahead” and a popular drink.

The only known Ball Signal still in operation in New England is next to NH Route 3 in Whitefield. The wooden ball signal tower was erected by Maine Central Railroad in 1875.
EARLY “VANE” SIGNALS

Vane signals pivoted on post somewhat like a weather vane.

- These signals were first used on the Liverpool and Manchester while several versions of Robert Stephenson’s rocket rode the rails.
- The targets were non-standard and could be up to four feet in diameter.
- Red was used most often but sometimes any bright color would do.
FIRST RAILROAD SEMAPHORES

• The transition from vane signals to semaphores began in the mid 1850s.

• They combined both a light for night-time operation and a highly visible moving “blade” for daytime use.

• Note the green light used for caution.
TILTING SIGNALS NO LONGER TURNED

• The original of this replica was erected by the Central Vermont at Willimantic, CT to govern a junction with the New Haven around 1852.

• The arms were operated by rods moved by levers at ground level. There was a platform just below the arms to reach the lamps.

In honor of Frank Johnson, a former Nutmeg member
SEMAPHORES CONTROLLED BY WIRE

- As signals moved further from stations a new form of control was needed.
- Wires could control a semaphore up to 1000 yards away.
- Pulling a wire would raise a counterweight and move the blade to a “safety” position.
- Releasing the wire allowed the counterweight to fall giving a “danger” signal.
- All signals from this point on were designed to be fail-safe in some manner.

Early signal lamps displayed either red or white light as at this time there was no satisfactory green glass.
EARLY INTERLOCKING

• The need to control signals and switches began to grow.
• Additionally, more complex trackwork raised the danger of conflicting routes even when both were out of sight.
• Sir Charles Hutton Gregory is credited with inventing both the semaphore and the first interlocking machine.
• His first 1843 machine, did not verify the actual movement of switch points.
• This flaw was corrected in his 1856 version and exported to America in 1870.
• Note the clocks that prevented the lever man from changing routes too soon after releasing a “safe” signal.
CONTROL RODS

• The first Interlocking frames were connected by wires and pullies to the switches, semaphores, derails and locks.

• Later, rods (usually 1” gas pipes) replaced the wires.

• They could run as far as 1500 yards although 900 yards proved to be a more practical limit.

• Some large towers eventually controlled close to 1000 such devices.
BELL-CRANKS

• Bell cranks were an important part of controls.
• They were used to compensate for expansion.
• A length of 100 yards of steel expands by 1.7" with a temperature change of 72°F.
• Here, the bell-crank routes the rods at right angles to run under the tracks to a semaphore.
CONNECTING TO A SIGNAL

- View showing the (2) bell-cranks that operate two semaphore blades. This was common from about 1890 to about 1950.
- Also shown is the power connection for illumination.
- Batteries were often located near the bass of such semaphores.
SIGNAL HEADS

- The rods end here.
- Note that the rods move only a couple of inches.
- There are no gears or other mechanical devices.
- A large battery at the signal base often provided power for the lamps like the two semaphores plus the light at the top of the mast.
PROTECTING A CROSSING

- These signals from different generations are protecting a crossing.
- Railroads began phasing out semaphores starting about 1935 and they were all but replaced by other types of signals by 1985.
ELECTRO-PHEUMATIC INTERLOCKING

• Most modelers know that Westinghouse invented air brakes and couplers.

• How many realize that he also developed the pneumatic/electric switch machine and improved interlocking?

• He also improved the searchlight signal.

Interlocking frame to control semaphores and switches.
TWO GREAT RIVALS

- Westinghouse and Edison were bitter rivals
- Edison lost the “power wars” of AC vs. DC to Westinghouse but went on to form General Electric.
- His more notable railroad inventions included the electric locomotive and multiple unit (MU) control.
- Westinghouse followed his inventions of the air brakes and couplers and went on to work with electro-pneumatic machines.
- He formed the Union Switch and Signal Company that dealt with signaling and control of train movements.
- Both men made countless improvements to the railroad industry.
Westinghouse acquired patents for the Robinson track circuit, insulated and bonded joints, and the Gassett and Fisher clockwork signal with his purchase of the Union Signal Company of Boston in 1881.

This brought electricity into the Union Switch and Signal's mechanical and pneumatic world. The magnetic valve made possible an electrically controlled, pneumatically operated semaphore signal.
ELECTRIC / HYDROLIIC CONTROL

• Here, twin magnetic valves admitted air to a piston that moved the points of a switch.
• Another valve, the *locking* solenoid was de-energized when the actuator was not being operated, and the valve was locked by a dog under spring pressure.
• Air was still supplied, so pressure continued to act, for increased security. The points were driven by a motion plate, ensuring that the points were locked.
AUTOMATIC BLOCK SIGNALLING

- Thomas Hall invented automatic block signaling and with it the disc signal.
- These were essentially a wooden box with a silk fabric shade to tint the color of a lamp fastened to the back of the box.
- Later, he transitioned into a type of rotating semaphore and grade crossing signals.
- Still Later still he invented the searchlight signal.

The Hall Signal Company was based in Meriden Connecticut in 1871 and merged with the Union Signal Co in 1925.
Banjo Signals

• Many versions of Hall’s signals were built.
• Most were built with a wooden case and used colored silk disks instead of glass for color.
• The disks were withdrawn upward leaving the bottom edge partially exposed to show the disks had not simply fallen off their holder.
• These were illuminated by a kerosene lamp mounted outside the back wall.
• Most of these were soon replaced with the more familiar semaphores.
HALL SIGNAL ASPECTS

- The Banjo signal was used much like the searchlight signals today.
- It used a kerosene lamp, not a light bulb to illuminate a colored target.
- There was no lens and green was used much like yellow is used today.
- The white (absence of red or green target) was actually more yellow and used for the least restrictive indications.
**HALL SEARCHLIGHT SIGNAL**

- The Hall Signal Company was absorbed by Westinghouse’s Union Switch and Signal Co. in 1925 mainly because of its newly invented searchlight signal.
- This new type of signal was to gradually replace semaphores.

Note the metal housing on this “modern” Hall signal.
The official terminology for the parts of a semaphore.

- **The spectacle** is the body of the semaphore and can be compared to the frame of eyeglasses.
- **The hub** is that part of the spectacle used to mount the semaphore assembly to the mast and is the central pivot.
ROUNDELS

- These were the filters that changed the color of the light source.
- They were curved but only focused the light to a limited extent.
- Early roundels were commonly red and clear.
- There was no good blue or green glass available and some thought red and green would be confused by those who were color blind.
- Purple and clear were reserved for dwarf signals.
- Different lens colors were often used between electric and kerosene illumination.
BLADES

• Semaphore blades generally came in three shapes: square, rounded, pointed (out), or fishtail (pointed in).

• Square end blades were commonly used as an *absolute signal*, such as a home signal.

• Fishtail shaped blades forewarn an upcoming “*distant*” signal.

• Round-ended blades were often used as *train order signals*. 
MORE TERMS

• A signal is more than either the lights or the blades; it is the overall combination.
• This combination has three properties: aspect, name, and indication.
• The **aspect** or **appearance** is what is displayed, i.e. red over green.
• Three aspects of the same signal are shown here
• In some cases a signal will be comprised of even more parts often combined on a single mast.
ASPECT NAME AND INDICATION

The **name** is the formal name classification for that signal, i.e. STOP AND PROCEED.

The **indication** is the instruction conveyed by the signal, i.e. Train must stop before passing until a less restrictive indication is displayed.

<table>
<thead>
<tr>
<th>STOP AND PROCEED</th>
<th>PROCEED</th>
<th>PROCEED AT LIMITED SPEED</th>
<th>PROCEED, PREPARE TO STOP AT NEXT SIGNAL</th>
</tr>
</thead>
</table>

![Diagram showing different signal aspects and indications]
SIGNALS ARE NOT STANDARDIZED

- It must be understood that the name, indication, instructions and aspects are all defined differently between various roads.
- They also may change and differ slightly in time periods.
- These differences are usually increases in the vocabulary of signal language due to more complex trackwork, different speeds and signals placed closer together.

These 1912 Semaphores would appear similar to a PRR or B&O color target signal of modern times at night.
SPECTACLE OR MARKER LAMPS

Homing signals are placed at boundaries of different block control systems. Note the shape of the blades.

• These have served for a multiple purposes thru time.
• They were frequently on earlier systems to expand the meaning of a single blade.
• Sometimes they were used as train order board.
• In modern times they were used to replace a $2^{nd}$ or $3^{rd}$ expensive signal head.
• Alternately they can be used for diverging route.
• They can define entry or exit from different block control systems.
The position of the signal heads on a mast, like spectacle lamps, can also tell the engineer the kind of traffic control system used.

- Signal heads are expensive, somewhere in the range of $20,000.
- Sometimes when traffic is light and signals are a mile or two apart a single head is used and it is assumed that if the other two were present they would always be red.
LETTER PLATES

• These can also take the place of the lower (2) signal heads
• They always allow a less restrictive movement
• The “R” shown here changes a red aspect from an “absolute stop and wait for the signal to change” to “stop then proceed but be prepared to stop”
• A letter “A” would mean an absolute stop.
SEARCHLIGHTS BLINK

• Modern searchlight signals expand the indications of old-time red-yellow-blue semaphores.
• Some systems use blinking lights to add to the vocabulary of signal language.
• A blinking light is always less restrictive than one constantly lit.

A yellow light here might mean to proceed at full speed to the next signal but expect it to be red.
A **blinking** yellow light would mean it was safe to proceed at full speed through this and the following block before meeting a more restrictive signal.
The middle light has the same meaning but to proceed at a medium speed, possibly due to a diverging route.
SEMAPHORES ARE NOW A MEMOERY

• Sadly, semaphores are now all but extinct.
• They have mostly been replaced by searchlight signals and left abandoned and gathering rust.
• Only a few museums use operating semaphores or even have a working one on display.
• Even modelers tend to shun the semaphore in favor of the easier to install searchlight signal.

You can now buy your very own semaphore for only $1,500 but some parts may be missing and the owners generally won’t deliver. You have to bring it home yourself.
A WORKING MODEL SEMAPHORE

- There is nothing like a semaphore to add a bit of life to any layout.
- They have always been part of toy train layouts from the earliest days of Ives Toys to the last days of Lionel.
- Interestingly, working 3-aspect semaphores have been virtually absent from model railroading.
- A Tomar, lower quadrant semaphore will be used here as it is a reasonably well detailed. Several others, however, will work just as well.
MOVING THE BLADE

• The Circuitron 6000 Tortoise will be used to slowly move our semaphores.
• Like many switch machines it has DPDT contacts.
• More importantly, Circuitron also has drive a mechanism for crossing gates that is perfect for the slow motion movement of semaphore blades.
• Servos and stepping motors can also be used to control semaphores but a lot more effort is required for their use.
INSIDE THE TORTOISE

- The Tortoise is designed to throw turnouts
- The DPDT contacts allow routing of track power to the frog of a turnout.
- Semaphores require the use of only one set of contacts.
- The unused set can be used for locking routes when used with an interlocking system or for outside control of other circuits.

<table>
<thead>
<tr>
<th>DEFAULT PIN ASSIGNMENTS</th>
<th>(top view from left to right)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MOTOR</td>
</tr>
<tr>
<td>2</td>
<td>NO AUX CONTACT</td>
</tr>
<tr>
<td>3</td>
<td>NC AUX CONTACT</td>
</tr>
<tr>
<td>4</td>
<td>AUX ARMATURE</td>
</tr>
<tr>
<td>5</td>
<td>FROG</td>
</tr>
<tr>
<td>6</td>
<td>STOCK RAIL</td>
</tr>
<tr>
<td>7</td>
<td>STOCK RAIL</td>
</tr>
<tr>
<td>8</td>
<td>MOTOR</td>
</tr>
</tbody>
</table>
TORTOISE ADJUSTMENTS

• When the Circuitron SD-2 is used with a Tortoise the motor will stop a bit offset to the middle.
• This is due to the wiper and gaps in the trace pattern inside the machine.
• Circuitron recommends modifying the Tortoise to correct this problem.
• This is easier said then done but a screw can be used in the stop block to make fine adjustments a bit easier.
• Installation can still be a bit tedious.
DRIVE MACHANISM

- The Circuitron 6100 remote signal activator will also be used for this project.
- The base plate can be mounted almost anywhere within two or three feet from the signal.
- The base plate and arm have several pivot holes such to provide a very wide range of movements or “throw”.
- Use the holes for the least amount of movement.
- An additional external bell-crank to further reduce the throw is recommended.
ACTUATOR

- The most difficult part of using the drive mechanism is the mounting of the actuator.
- This has to be mounted under the table.
- The end of the bell-crank should be centered as closely as possible to the signal mast but even a ½” offset does not seem to affect the smooth operation of the signal.
CIRCUITRON SD-2 CONTROLLER

- Circuitron manufactures a controller specifically to operate a 3-color semaphore.
- It does, however, require altering the tortoise with a mechanical stop to center the blade for the “caution” aspect.
- This can void the Tortoise’s warrantee.
- It is also a bit power hungry.
A HOME MADE CONTROLER

- This controller can operate semaphores for about 1/5 the cost of the SD-2 by using a simple PIC device.
- Simple changes in the program compensate for differences between any mechanical variations without any alterations to the Tortoise.
- It can also compensate for upper and lower quadrant signals.
- Blade movements can also be made to be more realistic.
HOW A SEMAPHORE MOVED

• “Modern” Semaphores were powered upward by motor and went from Green to yellow and yellow Red smoothly as shown in this schematic.
• Moving downward was done by gravity.
• When moving from red to yellow they always moved from Red to just PAST yellow then powered back upward to yellow. This "bounce" can be easily duplicated with a PIC device. WATCH CAREFULLY.

IF THIS ANIMATED GIF DOES NOT WORK HERE THEN GO TO http://signaldepartment.com TO SEE ANIMATIONS.
WIRING THE SEMAPHORES

Wiring both of these controllers is pretty straightforward as shown in the SD-2 instructions. The BD-1 or BD-2 are both train detection units that generate a signal as the train passes by.
TEST STAND FOR DRIVE SYSTEM

- This test stand was built for Semaphore programming and testing.
- The Circuitron switch machine, drive mechanism and actuator are shown here.
- Barely visible at the top and bottom is the “cable” that connect the two together.

Front view of test stand. Note the adjustment screws and other adjustments making the installation quite easy.
REAR VIEW OF TEST STAND

- The Tortoise can be seen to the left.
- Note the cable circling it. Care should be taken to not bend it less than a 2” radius or to allow kinks in any way.
- A MELabs U2 PIC programmer is seen to the right.
- The PIC device does not have to be removed from the board to be programmed.

Note the white coloring on the reverse side of the semaphore blade.
EARLY PROTOTYPE OF CONTROLLER

- This test circuit was built on Keyboard (a.k.a. Vectorboard)
- Parts can be moved and soldered with a minimum of time and waste, then soldered in place.
A simple control panel was used to develop and test the various semaphore circuits. Once they were developed, it helped to install and adjust the mechanical linkage. Tests were selected with the jumpers on the control board itself.
TESTING and ADJUSTMENTS

• Both boards can be mounted on the test stand.
• The two buttons simulate the RED and YELLOW signals from train detectors or whatever.
• The LED on the left middle represents the LED in the signal.
• The four LEDs are used to debug software or to simulate the control panel indicators.

The 4 jumpers on the main board select various testing programs used to make adjustments.
• Making printed circuit boards is best left to the experts.
• Several companies specialize in custom etching of small printed circuits in small batches.
• Advanced Circuits has free software that can be downloaded on-line and used to design, test, then create almost any board of complex or simple requirements.
• The first board requires expensive setup costs but re-orders are a small fraction of the original costs.
SHEMATIC, THE FIRST STEP

The same Advanced Circuits program that created this schematic was also used automatically assemble the makings of the printed circuit board.
CREATE A PCB LAYOUT

Most questions about PCB fabrication are answered promptly with ideas and corrections handled accurately.

- A user must move the various components to the final location, then make the connections.
- An extensive error checking program helps locate any errors such as missing connections and traces that are too close.
- It takes as little as (2) days to have The final PCB be etched by Advanced circuits and received by the user although this rapid turnaround can be costly.
BARE BOARD BEFORE ASSEMBLY

This 2” x 3” x 1/16” type FR4 PC board has no special features. It is clad with (2) layers of 1 oz copper and finished with solder mask on both sides.
ABOUT PIC DEVICES

- **Peripheral Interface Controllers (PIC devices)** Manufactured by Microchip Technology come in many sizes and configurations.
- They all work about the same way. You learn one and you will know them all.
- They contain a self-contained microprocessor and a number of additional stock components. The main difference between PICs are the memory sizes and the components included in the package.
CONTENTS of the PIC18F2420

- PIC devices vary in size and contents.
- Each pin multiplexes up to six components depending on how the device is configured.
- Certain aspects of the configuration can be changed dynamically within a program.
- Each separate pin can be used for either input or for output when assigned as a port.
- A resistor, for example, may be added to pull an input to a normal high.
- The same pin could be used as part of a voltage comparator or some other component in the package.

**Serial Programming Interface**
- In Circuit Debugger

**In Circuit Debugger**
- (3) 8-bit ports plus 1-bit port
- 2 Analog to Digital Converter
- 2 voltage Comparators
- 8K x 16 bit Flash RAM
- 768 bytes Static memory
- 256 bytes EEPROM
- 13 level stack
- Synchronous serial port
- Self programmable

**OTHER FEATURES**
- Harvard Construction
- 4 Timer modules
- Watch Dog Timeout
- Priority level interrupts
- Internal or external clock
- 8 x 8 multiplier
- Voltage reference
- Capture/compare/PWM modules
• The upper half of this PIC diagram is that of a basic microcontroller.
• The lower half shows the additional components including timers, comparators and converters.
• There are dozens of other features within other PICs such as UARTS, LED display drivers, step motor controllers and several more.
MELABS U2 PROGRAMMER

*Another term for this is “In Circuit Serial Programming” (ICSP)

- PIC Devices do have to be programmed.
- This low cost Serial In-Line Programmer (SIP*) will program virtually all PIC devices.
- PICs need not be removed from the circuit to be programmed.
- It can write and read data from any PIC device, debug programs that support debugging, and even examine key aspects the device.
USING THE PROGRAMMER

- This shows the typical connections used for programming most PIC devices.
- Pin 1 is used for the higher voltage programming pulse required.
- The last two pins are reserved for the clock and data signals used in programming.
- These pins can still be used after programming for I/O under certain conditions.
Custom Computer Services (CCS)

• CCS provides everything required to program PIC devices and all aspects of their support.
• This includes an Integrated Development Environment (IDE) for any combination of your favorite languages, debuggers and programmers including the MELabs U2 programmer.
• They support Languages such as “C”, Basic and assembler.
• They also have a line of prototyping circuit boards.

All you need is this, a USB port on your computer, and a MELabs U2 programmer to program any PIC DEVICE.
ABOUT PROTOTYPING

• This MELabs USB prototyping board makes learning to work with PICs easy.
• Note the (2) PIC device outlines. This demonstrates the pin to pin compatibility of most PIC devices.
• The lower portion is sort of a breadboard to create test circuits and test how PICs operate.
• It also can be purchased with or without the parts.
A MINIMAL CONFIGURATION

These (5) components alone are enough to control one semaphore but the PIC device must be pre-programmed before being soldered directly to the board.
MINIMUM CONFIGURATION

The board *could* then be directly wired into the circuit as shown here but any mistakes in wiring would be hard to correct.
Adding terminals and connectors doubles the cost of the project, but makes installation so much easier.
SOCKETS ARE NICE TOO

Two reasons for sockets are 1) if you want to use a separate programmer or 2) If you might want to salvage and re-use the PIC for other projects. Otherwise the PIC can be soldered directly to the PCB.
The power supply and programming circuits are optional. A single card can be fully populated for the workbench. With these parts omitted for signals installed on the layout.
5v POWER SUPPLY

- The PIC device runs on 5 volts.
- This will be available when a U2 programmer is used.
- If the programmer is NOT used but there is a source of 5v available then it can be connected through JP1.
- Otherwise, this circuit will convert any 18-8v (AC OR DC) to the 5v required.
- One power supply can power up to (5) additional boards.
- Jumper JP2 selects which source is used.
AUXILLARY FUNCTIONS

• This section is not used for basic semaphore operations BUT ...
• It is used during software development as a way to “see” what is going on.
• It can also be used as a “mode” control. Such as Normal operation vs. Demonstration.
• It could also be used for control panel indicators.
• Remember, The jumper and (4) LEDs can be programmed as any combination of input or output
A TYPICAL CONFIGURATION

A board like this might typically be used for the layout.
• The controller draws a maximum current of .044 amps when the Tortoises are running.
• It draws as little as .011 amps when idle mostly to power the two signal LEDs and the main power indicator.
• A 1.0 amp wall transformer will in theory run well over 150 semaphores!
• Fewer than 20 semaphores can be controlled from the same power supply using the SD-2.
COMPONENT SIDE (left) shows components placement. Drill template (right) is used to drill holes for parts components side. The BOARD MEASURES EXACTLY 2” X 3”. This Layout was created using free software from ADVANCED CIRCUITS who will also manufacture the boards for a reasonable fee.
Blue lines represent copper traces on the component side of the PCB. Red lines are on the solder side. Solder pads around holes are on both sides.
TEMPLATES FOR ETCHING PCB

These templates show the copper traces on the component and foil sides of the PCB. Image on left must be reversed before using.
Schematic of NR-104 Dual Semaphore controller
TEST PANEL SCHEMATIC

Screw #4

J2

RN1

TB1

TB2

SW1

SW2

RN2

Screw #4

NR-104A SEMAPHORE CONTROL PANEL
Bobby Van Cleef MMR
Nov 22, 2014

Screw #4
• This panel and a couple of jumpers can be used to test both semaphore circuits one at a time.
• The (2) switchers can be connected to either circuit and the signal’s LEDs can also be tested.
RESOURCES

• THIS AND OTHER CLINICS MAY BE DOWNLOADED FROM:  http://www.northriverrailway.net

Also available

• ADVANCED CIRCUIT files used to design and fabricate the printed circuit boards shown in this clinic.
• “C” SOURCE CODE AND/OR HEX FILE READY TO LOAD INTO PIC DEVICE.
• PRINTED CIRCUIT BOARD
For More Information...

   Printed circuit board design and manufacturing. Do it yourself or let them do it and everything in between

Digikey  http://www.digikey.com/
   Source for wide variety of electronic related parts and hardware including LEDs, Wire, Solder, Copper wire, printed circuit board and headers.

Foamer’s guide to reading signals  https://www.youtube.com/watch?v=tJpR93kp44I
   Multipart series in reading CP searchlight signals

History of Signals  http://mysite.du.edu/~etuttle/rail/sigs.htm
   Assorted bits of railroad history, especially signals

Internet Trains  http://www.internettrains.com/merchant2/merchant.mvc
   Source for semaphore parts and other railroad items

MicroEngineering Labs (ME)  http://melabs.com/
   Full range of PIC devices, programming devices and software development.
NYC Signals  https://www.youtube.com/watch?v=ygt3ktpmQyE
  A 1948 documentary by which railroad signals are implemented

Railroad Signals of the United States
  http://www.railroadsignals.us/signals/sem/#PARTS_OF_A_SEMAPHORE
  An extensive archive containing all aspects of Semaphore information

Signal Department  http://signaldepartment.com
  detailed drawings and animated GIFs on the inner workings of semaphores.  MUST SEE

Tomar Industries https://tomarindustries.com/index.html
  excellent assortment of semaphores and semaphore related parts for all scales.

Walters  http://www.walthers.com/
  Largest single supplier of model railroad supplies including stripwood, brass telescopic tubing, ladder stock, brass wire and paint.