A Ridiculously Detailed Look at the Control Circuits for a Vandercook Universal I AB P Proofing Press

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At Saltgrass Printmakers in Salt Lake City, Utah, Sandy and Erik Brunvand have a Vandercook Universal I AB P proofing press (Serial number 27437 from 1968) (see Figure 1). The AB means Adjustable Bed – the press bed is adjustable with a range of 0.240" up and down to accommodate forms of different thicknesses (from 0.815in to 1.055in where 0.918in is American "type high"). The P means that the press carriage is powered and moves back and forth on the press bed using a motor and control circuits built into the base of the press. Vandercook sales literature claims that the power drive can achieve a speed of approximately 300 impressions per hour.

This document contains a ridiculously detailed look at the control circuit for the powered press carriage. The control is based on contactors, relays, transformers, and diode bridges so it's definitely an old-school vintage-style control circuit. I will describe in detail what I've been able to figure out about the control circuit, how it operates, and what I've done on our press to update and replace components that have failed.

1 - Vandercook Operation

If you're reading this document, I assume you're familiar with the control of a Vandercook proofing press with a powered carriage. The controls for the press are all on the front panel of the press by the feed board (Figure 2). A quick summary of the operation of a powered-carriage Vandercook follows.

- The POWER switch provides power to the press and starts up the 1/12 HP INK DRUM motor. This is an alternating current (AC) motor that turns the inking system on the press distributing the ink from the steel oscillator and rider to the inking rollers in the powered carriage. Ink is also distributed to the ink drum in the base of the press.
- It also provides AC power to the neon indicator to the right of the switch that indicates that power has been applied.

Figure 1: Our Vandercook Universal I AB P Proofing Press at Saltgrass Printmakers in Salt Lake City, Utah (www.SaltgrassPrintmakers.org).

Figure 2: Control Panel on our Vandercook Universal I.

- Once the press is on, the powered carriage is controlled with the following controls:
    - With the MAN/CYCLE knob in MANUAL mode, the carriage is controlled with the FORWARD/REVERSE lever at the top of the control panel.
        - Pushing the lever in the FORWARD direction makes the carriage move forward (from feed board towards the end of the press bed).
        - Pushing the lever in the REVERSE direction makes the carriage move in reverse (from press bed back towards the feed board).
        - Returning the lever to the middle position at any time stops the press carriage where it is.
    - With the MAN/CYCLE knob in CYCLE mode, and the lever in the FORWARD position, the carriage is controlled with the START button.
        - Pressing the start button in this configuration cycles the carriage through one full forward-reverse cycle. The bed moves from the feed board all the way to the end of the press bed, then automatically returns back to the feed board.
        - Note that in CYCLE mode, the FORWARD/REVERSE lever must be in the FORWARD position for the START button to be active. If the lever is in the middle (off) position, or REVERSE, the START button will have no effect.
- The SPEED CONTROL knob controls the overall speed of the press carriage as it moves back and forth on the press bed. As we'll see in the schematic, this knob is directly connected to a variable autotransformer (Variac) that adjusts the AC voltage given to an AC/DC bridge, and eventually provided as DC voltage to the carriage drive motor.
- The INCREASE BREAKING knob controls how quickly the carriage motor stops when the FORWARD/REVERSE knob is returned to the center (off) position, or when the press carriage travels to the far extent of its movement either to the end of the press bed or back to the feed board. As we'll see in the schematic, this knob controls a variable resistance (a rheostat) that controls how quickly stored charge on a capacitor is drained to the motor to provide a slower or faster braking (stopping) of the motor.

2 - Vandercook Powered Carriage Control Schematic

The behavior of the press carriage motion described in the previous section with the switches, levers, and buttons is controlled with a circuit built from relays, contactors, transformers, diodes, and other electrical components. Our press came with a (somewhat oily and hard to read) schematic of the controller pasted to the door that contains the control circuit (Figure 3). This schematic is detailed documentation of how this circuit is connected, how it operates, and gives information about how various components can be replaced if needed. To make things easier to follow, I've found a schematic from a Vandercook Universal III powered-carriage press online which is much easier to read. The Universal III is essentially the same circuit as our Universal I, but with some minor differences such as a larger carriage drive motor. I've modified this schematic to be a Universal I circuit and will use this for the remainder of the document (Figure 4).

The schematic is a logical description of the physical circuit found in the Vandercook (see Figures 5, 6, and 7). Each component in the schematic has a direct instantiation as a physical component in the circuit. The connections shown in the schematic are instantiated as wires in the circuit. In fact, every wire in the schematic has a number, and every physical wire in the actual circuit is also labeled with that same number. So, one can use the schematic to understand the behavior of the circuit and then map this behavior to physical components in the actual circuit. As I describe each section of the control circuit, I'll include figures that highlight that part of the controller on the schematic and in the physical circuit.

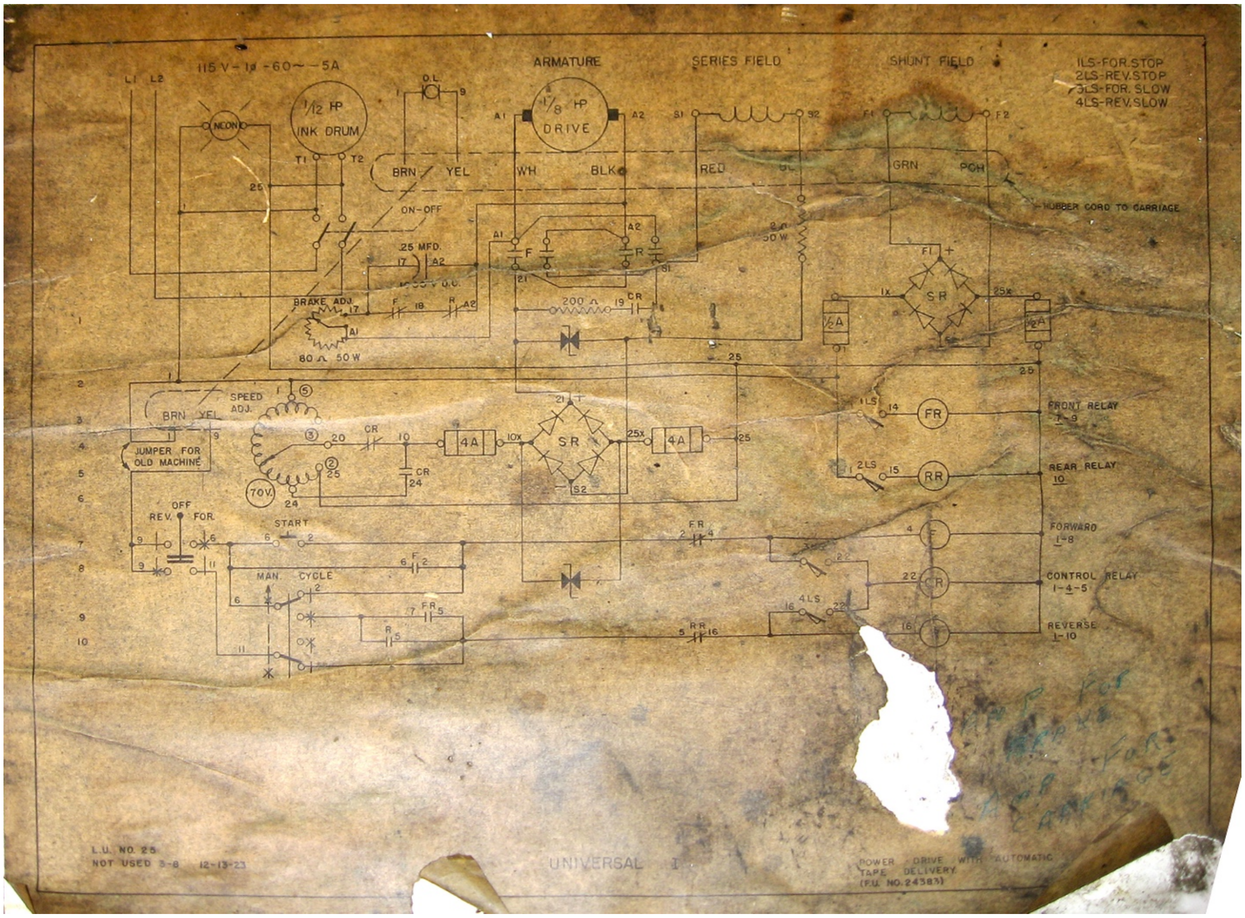

Figure 3: The (oily) controller schematic pasted to the inside of the control circuit door on our Vandercook Universal I.

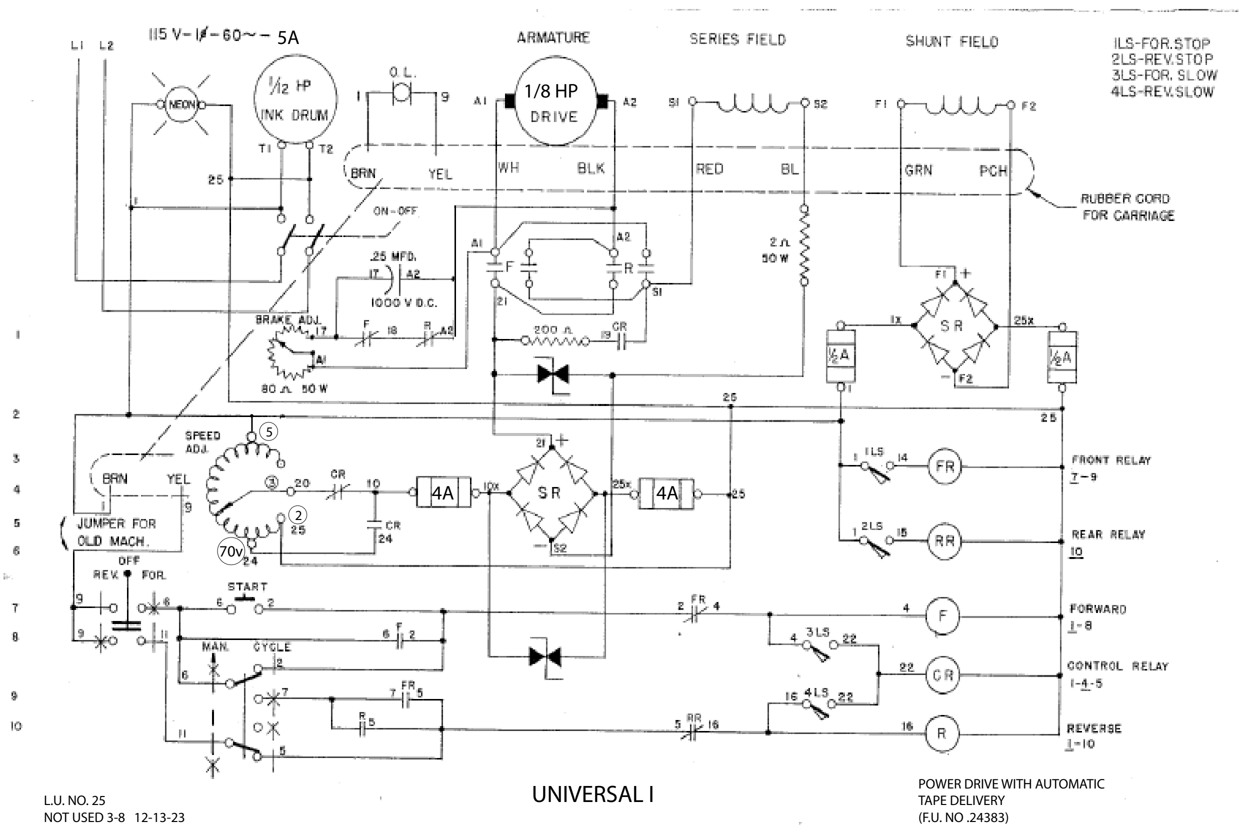

Figure 4: This is a much easier to read control schematic. This schematic actually started as a Universal III schematic. I have made some edits to turn it into a Universal I schematic that matches the oily schematic on the door to the control circuits on our press. The primary differences are that the Universal III has a slightly larger DRIVE motor (1/4 HP), and thus 5A fuses in that part of the circuit. There are also some minor differences in how the SPEED ADJ Variac is connected. Other parts of the circuit are the same on Universal I and Universal III.

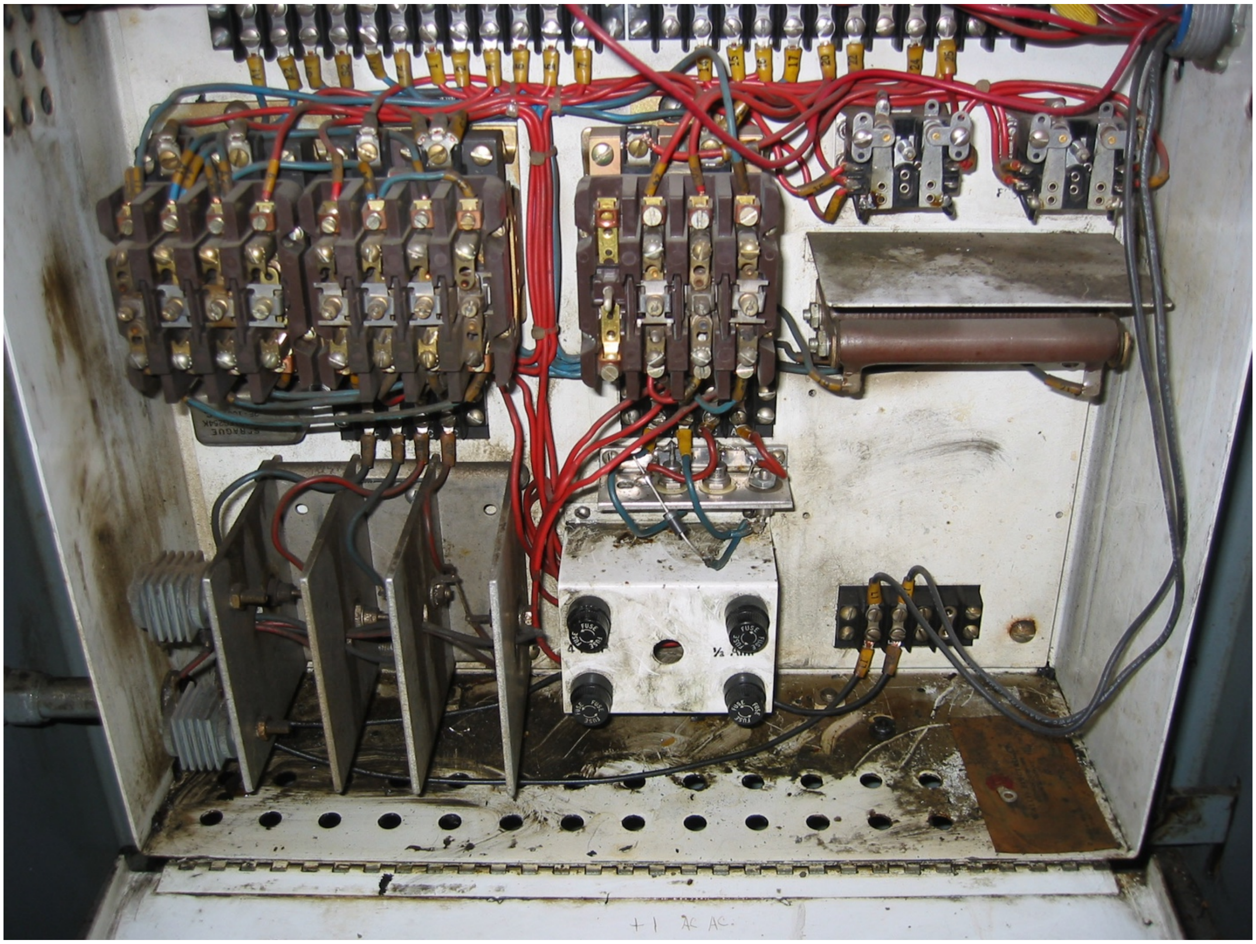

Figure 5: This is the control circuit that corresponds to the schematics in Figures 3 and 4. This is the original circuit from when we acquired the press. I have since cleaned things up and replaced some of the components. This portion of the circuit contains the contactors, relays, diodes, and fuses that make up the main logic of the controller. Details to follow.

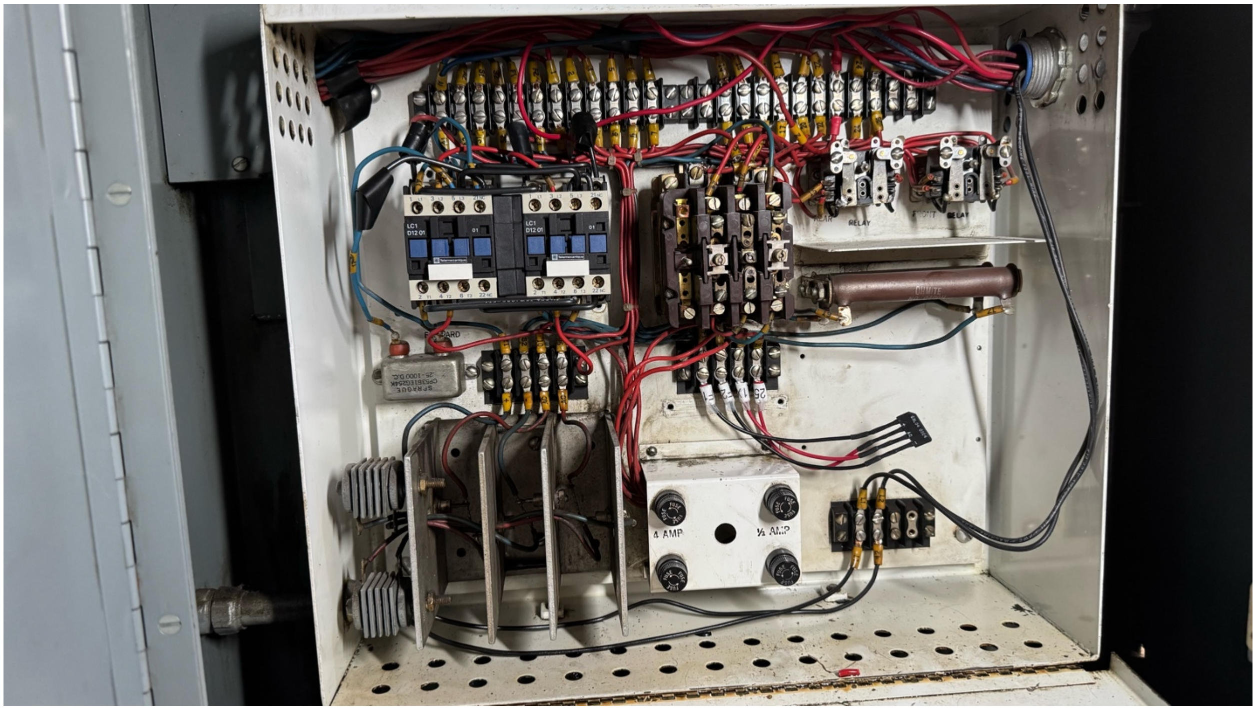

Figure 6: This is the current control circuit on our Vandercook Universal I. You can see that the contactors on the upper left have been replaced, and one of the AC/DC diode bridges has been replaced with a semiconductor version (lower right). Details to follow.

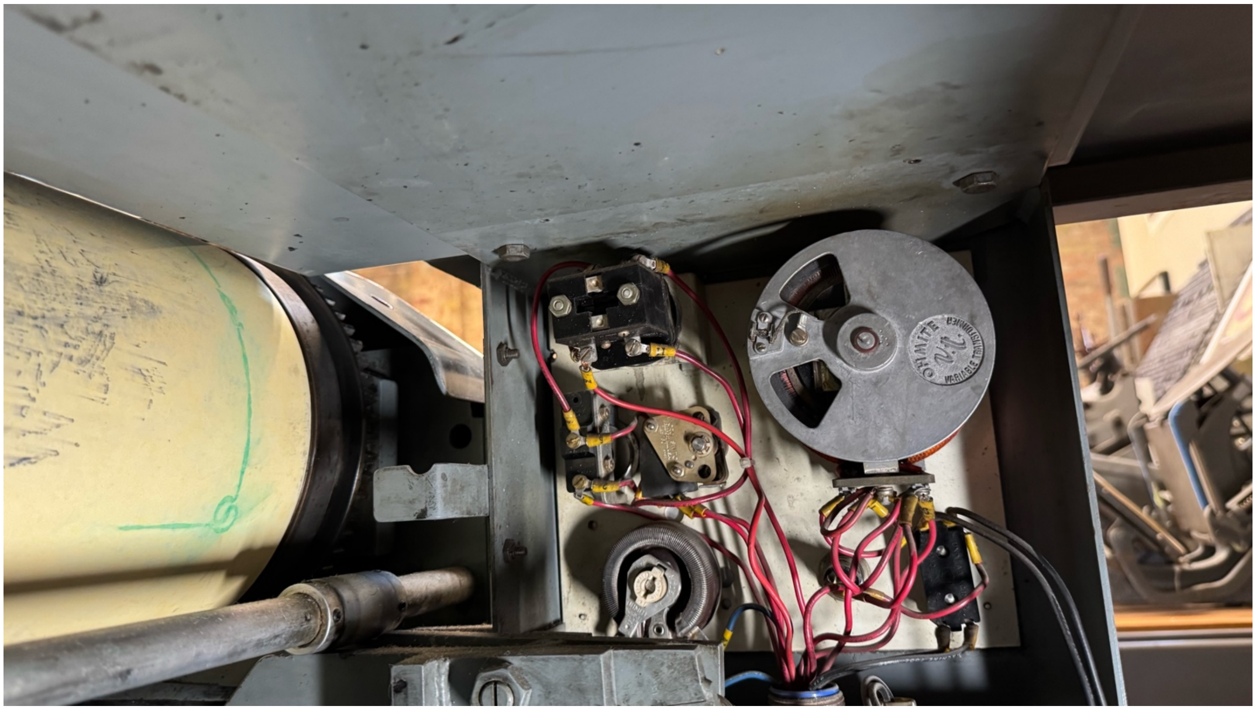

Figure 7: This portion of the circuit is directly behind the control panel. It consists of the switches, control knobs, and also the rheostat (lower left), and variable autotransformer (Variac) (upper right) that form part of the braking and speed adjustment circuits respectively. These are behind the control panel because they are connected directly to knobs on the control panel.

3 - Basic Electronics

To begin this ridiculously detailed description of the circuit, I'll start with a very basic electronics overview. If you're already knowledgeable about electricity, AC and DC power, and relays and contactors, you can skip ahead to Section 4.

3.1 Basic Electronics 101

Starting with the very basics, you can think about electricity as analogous to water moving in pipes.

- You can think of electrical current flowing in a conductor as like water (current) following in a pipe (conductor).
- The current is made up of charged particles (electrons) moving in response to a force (voltage).
- Voltage is the force that causes current to flow, like pressure causes water to flow in a pipe. Voltage is defined as the electrical potential difference (pressure difference) between any two points in a circuit. It's not an absolute quantity; it's a relative difference in the electrical potential between any two points in a circuit.
- For convenience, we define "ground" as the reference point from which to measure voltage and assign ground the value 0v. The reason it's called "ground" is that in your house (for example) this reference point is established by a metal spike stuck in the ground somewhere in your basement. It's literally the electrical reference point of the ground.
- Current is the movement of charge-carrying particles (electrons) in a conductor. An electrical potential difference between two points in the circuit (voltage) causes current to flow.
- Here's an odd subtlety – we define conventional current as positive current that flows from the higher voltage towards the lower voltage. Current flows from + to – in a circuit. But, in actuality, the primary charge carriers are electrons which have a negative charge. So, current moves from + to -, but the actual particles that make up the current are moving upstream from – to +! We can blame Ben Franklin for this confusion. In the 1740s, he guessed that electricity was a single fluid that moved from an excess (positive) to a deficit (negative). When electrons were discovered much later, they were found to move from negative to positive, but the convention was too established to change. But you can ignore this and think (like electricians do!) that positive current moves from + to – in a circuit.

- Back to current – electrical current is the movement of (positive!) charge in a circuit. The unit of charge is the Coulomb, and the unit of current is the Ampere or Amp. One Amp is defined as one Coulomb of charge moving past a point in one sec. So, 1C = 1A/sec.
- As another aside, a Coulomb is a lot of charge (a lot of charged particles). One coulomb is equivalent to the charge of approximately 6.241×10^{18} (6.24 quintillion) electrons! But we see 1A of current flowing in electrical circuits all the time! The electrical service to your house is likely rated at between 100-200A. Your hair dryer likely draws between 10-15A of current.
- OK – so current flows in response to a voltage…
- Resistance is a measure of how the conductor resists the flow of current. Think of this as the diameter of a water pipe. If the pipe is smaller (more resistance), then it takes more pressure (Voltage) to move the same amount of water (Amps) through the pipe (conductor). If the pipe is larger (less resistance), then more water (Amps) can flow with the same pressure (Voltage). Resistance is measured in Ohms and uses the symbol Ω.
- This relationship is captured in a wonderfully simple formula called Ohm's Law (Figure 8): V = IR. For reasons that nobody seems to know for sure, current is notated as I in electrical formulas (possibly because C was already used for Coulombs (charge)…). This law says that voltage (V) is equal to current (I) times resistance (R). This describes exactly the situation in the previous bullet. For the same voltage V, if you increase resistance R, then current I must go down. Or, if you increase the resistance, but want the same current, the voltage must go up. Etc.
- If you know any two of these quantities (Volts, Amps, Ohms), you can easily solve for the other. V = IR, I = V/R, or R = V/I.
- Electrical power is defined as the **rate** at which electrical energy (volts) is consumed or transferred. Power is measured in Watts, and is defined as Volts times Amps. Put in formula form, P = VI. How is this a rate? Because Amps (I) is defined as charge/sec (Coulombs/sec). So Power (Watts) is Volts * Coulombs / sec.
- Another way to define power uses Ohm's law which says that V = IR. So, if you take the power formula of P = IV, and substitute IR for V, you get $P = I^2R$.

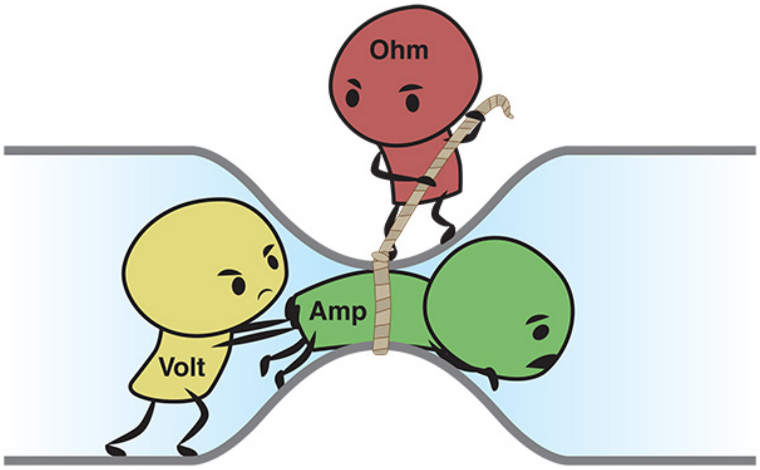

Figure 8: The relationship between Volts, Amps, and Ohms. This is exactly Ohm's law. Volts push the current (Amps) through the pipe, while resistance (Ohms) tries to resist that flow. At the same voltage, if you want more current, you need to reduce the resistance. Or, if the resistance (Ohms) is the same, and you want more current (Amps) you must push harder (more voltage). V = IR, or equivalently I = V/R, or R = V/I.

3.2 Alternating Current vs. Direct Current

Now that we have some basic definitions of electrical current, voltage, resistance, and power we can see how they're related in physical circuits. There are basically two forms of electrical power delivery: alternating current and direct current.

3.2.1 Alternating current (AC)

Alternating current is where the current direction alternates at some rate. By alternating, we mean that current first flows in one direction, then switches to flow in the opposite direction. This in and out behavior of the current is the standard for household and industrial power delivery. In the US the frequency of the in/out current direction switching is 60Hz, or 60 times per second (it's 50Hz in many other parts of the world). This means that the current delivery to your house alternates from in to out 60 times every second. Because current flows in response to a voltage, this means that the voltage that is driving this current also switches between a positive voltage and a negative voltage at 60Hz. This is shown in Figure 9. This figure shows the change in voltage from positive to negative, but would look exactly the same if the quantity shown was current changing from moving in the positive direction (e.g. in) to the negative direction (e.g. out). This push-pull of voltage and current is used to drive most of the electrical devices in your house like stoves, toasters, microwaves, etc.

In the US most wall sockets provide AC at 120v. This is what you plug most things into in your house. These sockets have two connections because electrical current needs to flow somewhere in a closed loop – it can't just flow into a dead-end road. The wires at your socket are called hot and neutral – the AC current flows from hot to neutral, and then reverses from neutral to hot as the current alternates. You could think of the current as if you had a string connected to a pully inside the socket. When you pull on one end of the string, the other goes in, then you can reverse and pull on the side that's currently in, and the other side of the string moves in. This in and out movement by pulling on alternate ends of the string is exactly the behavior of the voltage pushing current in alternating directions.

The service that comes into your house is actually a bit more complicated – it's called split-phase or single-phase three-wire power consisting of two separate 120v AC lines with a common neutral wire. That means that instead of a single hot wire and neutral wire for the current to move through, there are two AC hot wires that both alternate around the neutral wire, but with their frequency offset by 180 degrees (i.e. opposite phase) (see Figure 10). So, you can get 120v AC by connecting between either hot wire and the neutral. You can also get 240v AC by connecting to the two hot wires for the current to use. This 240v AC is used for higher-power devices in your home such as electric driers or electric stoves.

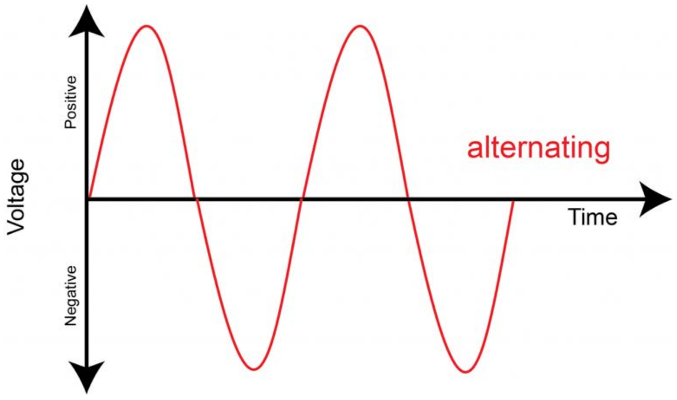

Figure 9: The voltage (and thus the current) in an AC circuit switches from positive to negative over time. In the US it makes the switch at 60Hz, or 60 times per second. Because voltage and current can't change instantaneously, you see curved patterns of voltage (and current) over time as shown here.

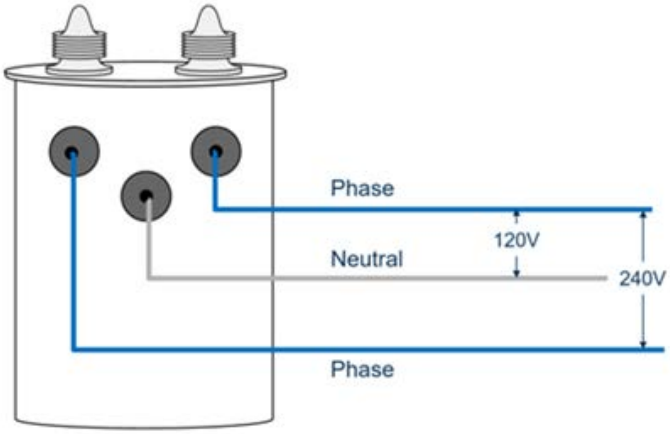

Figure 10: AC as delivered (from a transformer on the power pole) to most homes in the US is two separate "hot" wires at 120v measured against a common neutral (ground) wire. This is called split-phase or single-phase three-wire delivery. You can use either hot wire against the neutral to get 120v AC, or connect between the two hot wires to get 240v AC for higher-power appliances such as electric driers or electric stoves. The AC frequency of the two hot wires is offset so that they combine to form one 240v AC circuit such as shown in Figure 9.

3.2.2 Direct Current (DC)

DC current flows in only one direction at a constant rate. This is like a battery where once connected it provides power in the form of a constant voltage which pushes a fixed amount of current through the circuit. The amount of current is related (through Ohm's law) to the resistance in the circuit. Every battery-powered device that you use is using direct current as its power source. See Figure 11 for a comparison. DC current also needs to flow in a loop – you can't just push current into a dead end. That's why you have connections in a battery powered circuit to both the + and – side of the battery – so that the current has somewhere to go (under the push of the voltage).

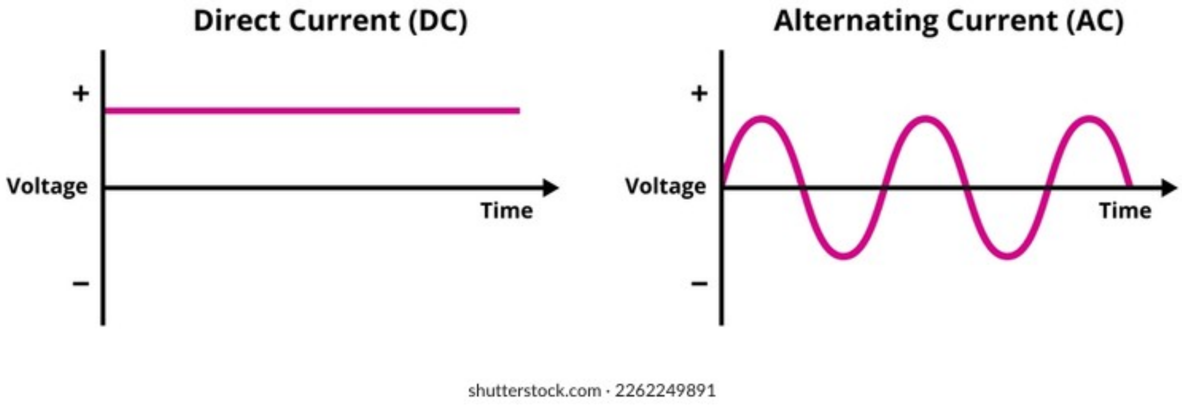

Figure 11: DC provides a constant voltage, as in a battery (at least until the battery is used up!). AC provides a voltage (and thus current) that is constantly changing direction at a fixed frequency (60HZ in the US, 50Hz in many other parts of the world).

3.2.3 Converting AC to DC

The components on the Vandercook press use both AC and DC power. The motor that drives the inking system is an AC motor, and the motor that drives the carriage back and forth is a DC motor. AC motors are simpler and less expensive motors, but they can only turn in one direction in response to the AC power. This is fine for the inking system where the ink drums and other parts of the inking system always turn the same direction. The carriage motor needs to be able to change direction to make the carriage move forward and in reverse. A DC motor will change direction if you reverse the voltage (and thus current) being supplied to the motor. If you connect the + and – of the DC power to the motor it spins in one direction, and if you connect the DC power as – and + it spins the other way.

But the wall power that the Vandercook is plugged into is 120v AC. So, if the carriage motor needs a DC voltage (that can be swapped to cause the motor to change direction), then we need some way of converting AC to DC for use in the motor circuit. The way this is done is to use an electrical component called a diode. A diode is like a one-way valve in a water circuit – it only allows electrical current to flow in one direction, and blocks current flowing the opposite direction. With a clever connection of diodes, you can take the AC signal, keep the up-going parts of the signal (as in Figure 9), and "flip" the down going parts of the signal to the top of the line. This (admittedly bumpy) circuit has voltage and current that is always in the positive direction (albeit bumping up and down above the line).

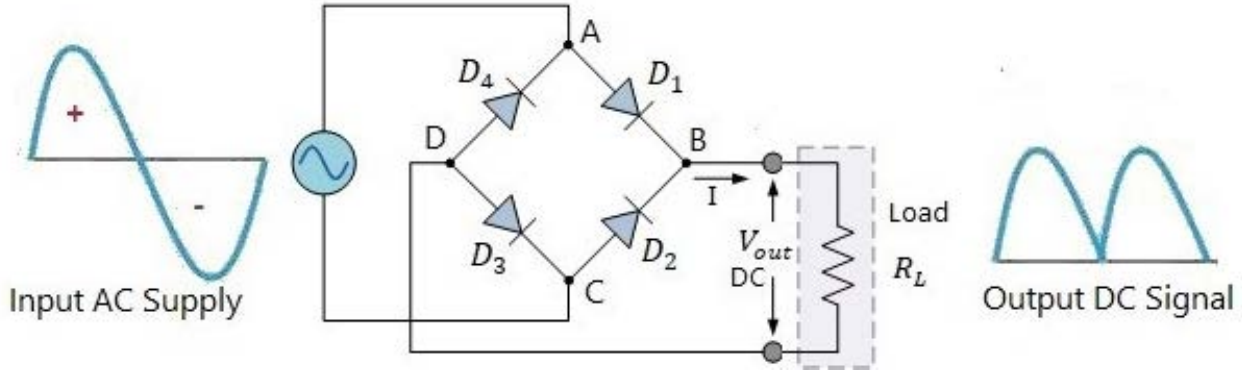

Figure 12: A simple bridge rectifier circuit of the type used in the Vandercook circuit. The DC output voltage is bumpy, but the DC motor "integrates" that bumpy voltage/current profile into something that feels more like a constant DC voltage and current.

A connection of diodes that makes this conversion is called a bridge rectifier circuit (see Figure 12). This circuit takes advantage of the one-way current behavior of the diodes. When the AC comes into the circuit in the + phase, it flows through diode D1, and then back through D3 to connect the circuit. When the AC is in the – phase, it flows through diode D2 and then back through D4 to complete the circuit. In this way the – part of the AC signal is "flipped" and becomes another positive DC "bump" in the output signal.

This is quite a bumpy DC signal, but it's always positive. It never goes below the ground line to become a negative DC voltage/current. This can be smoothed out using a capacitor, but it is also automatically smoothed by a DC load like a motor (known as an inductive load, but that's another story). The motor has internal behavior that sees that bumpy DC signal and, because it can't react instantaneously, it sees that bumpy signal as sort of smoothed out, with a lower average value than the full peaks of the bumpy signal. That is, the DC signal as seen by the motor looks like a less-bumpy DC signal about a third of the way down from the bumpy peaks.

There are two diode bridge rectifiers in the Vandercook circuit for different parts of the DC carriage drive motor. We'll see those in following sections.

3.3 Resistors

The most fundamental electrical law, as described previously, is Ohm's Law: V = IR. Of these measurable quantities, Voltage (Volts), current (Amps) and resistance (Ohms), voltage and current are properties of the overall system and seldom have specific components related to them in the schematic. Of course, there are exceptions. Battery powered systems often have a battery component in the schematic to show where the power source is, and, more importantly, the polarity of that power supply. Because a battery supplies DC voltage it's important to know where + and – are in the power supply.

In the Vandercook schematic the power supply is simply assumed to be 120v AC on the L1 and L2 input lines from the line voltage. This is also seen in the notation above the NEON indicator in the schematic (e.g. Figure 4) where it says "115v 1ø – 60~ - 5A". this means that the line voltage is specified as 115v min, single phase (1ø), at 60Hz AC (that's the 60~), and consuming 5A total.

But I digress. The third fundamental quantity in Ohm's Law is resistance, which relates to physical properties of materials. The resistance of any conductor can be measured, and you can also include a specific component called a resistor into a circuit to provide a fixed or variable amount of extra resistance. This is typically done to limit the amount of current used in a circuit. From Ohm's Law, if you have a fixed voltage V, and you want to limit the amount of current I, then your only remaining option is to adjust the resistance R of the circuit.

Resistors come in many shapes and sizes, mostly related to how much power they can dissipate. Back to our water analogy, you can think of resistance as the diameter of the pipe that current flows through, and you can also imagine that with a smaller pipe, there's more friction as the current flows. In a physical electrical resistor component, as more voltage is applied, and more current flows through the resistor, the resistance action of the component causes it to heat up as current flows. The amount of current that can flow through the resistor over time (the power) is related to how much heat the resistor can dissipate. Because the resistors in the Vandercook schematic are carrying a fairly high current, at fairly high voltages, they are specific as 50w resistors and are therefore in the category of “power resistors” because they can dissipate a significant amount (50w) of power. In the schematic (Figure 4) you can see two fixed 50w-rated power resistors of 200Ω and 2Ω, and a 50w rated variable resistor (called a rheostat) of 80Ω by the BRAKE ADJ. circuit.

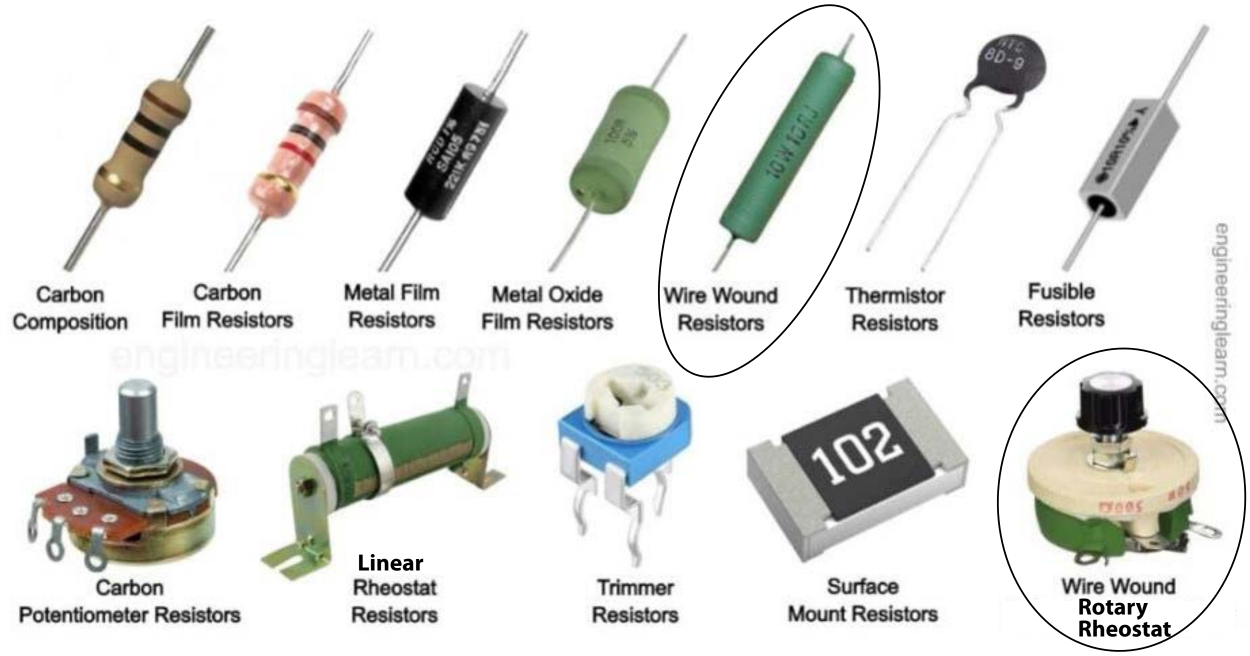

Figure 13: Pictures of various resistor types that might show up in an electrical schematic. The Vandercook circuit uses two wire-wound 50w rated power resistors (2Ω and 200Ω), and one wire-wound 50w rated rotary rheostat.

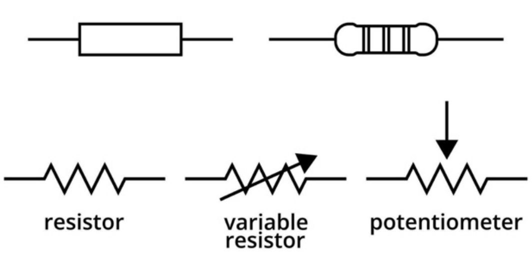

Figure 14: Schematic symbols for resistors look like a zig-zag line to indicate that the current has to navigate a component that resists a straight line flow of current. The variable resistor used in the Vandercook schematic as part of the BRAKE ADJ. circuit is shown as a semi-circle zig-zag to indicate that the specific component used is a knob-driven rotary rheostat as seen in the lower right of Figure 13.

3.4 Capacitors

Another basic electrical component that is very common in schematics is a capacitor. This is a component that stores electrical charge. When you apply a DC voltage across a capacitor, charge builds up inside the capacitor. Once the capacitor stores as much charge as it can (its capacity), it current stops flowing because the capacitor has reached maximum charge. When the voltage is removed, that a stored charge is released back into the circuit. That is, current flows in the reverse direction as the stored charge is released until the capacitor is empty. The water analogy is not quite perfect for this component but think of it as a water balloon connected to a pipe. As you apply water at a certain pressure (voltage), the water (electrical charge) builds up in the balloon until the pressure in the balloon is the same as the pressure driving the water in. At this point the system is in equilibrium and no further water flows. When you take away the water pressure (voltage), the water flows backwards in the pipe because of the elastic pressure of the balloon that was holding the stored water (stored electrical charge in the capacitor).

Capacitors are used to hold charge in a system which can then be released back into the system when the voltage is removed. They act like little batteries that are continually charging up and discharging as voltage is applied and removed. Importantly, this charging and discharging doesn't happen instantaneously – it takes time to fill up the capacitor with charge, and it takes time to discharge that stored charge. The time it takes is related to the size (capacity) of the capacitor, the voltage that is applied, and the resistance in the charging and discharging circuit that limits the current that is delivering the charge. Because this rate of charging and discharging is very precisely measurable, circuits with resistance R and capacitance C, known as RC circuits, are very often used to provide a time reference in a circuit. By sensing when charging is complete (the voltage across the capacitor has reached a known level) or sensing when discharging is complete (the voltage across the capacitor is 0v), a circuit designer can build in knowledge about timing to the circuit behavior.

A capacitor's capacity to store charge is rated in Farads. A Farad is defined as 1 Coulomb / Volt. That is, if you apply one Volt across a one Farad capacitor, you will store one Coulomb of charge. But remember from Section 3.1 that a Coulomb is a huge amount of charge. So, in practice, almost every capacitor you will see in practical circuits will be rated in microfarads (millionths of Farads), nanofarads (billionths of Farads), or even picofarads (trillionths of Farads).

Because a very simple capacitor can be made with two plates of conducting material separated by an insulator (called a dielectric in this case), the schematic symbol for a capacitor looks like two plates separated by a gap. Sometimes one of the plates is curved to indicate that this capacitor is a specific type of device that has a polarity on its inputs where one side is preferred for + and the other for – in a DC circuit. Capacitors used in a DC circuit will charge up and then block further flow of current in that circuit once they're charged. This is how the capacitor is used in the Vandercook circuit as will be seen later in a discussion of the BRAKE ADJ. circuit.

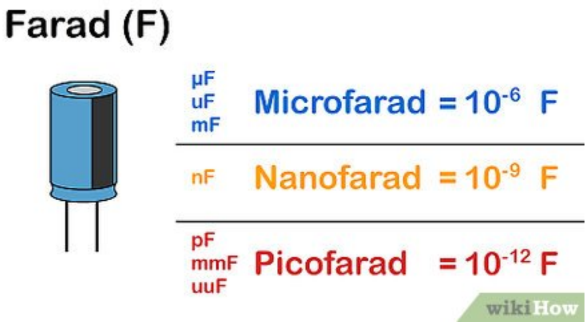

Figure 15: Practical capacitors are rated in extremely minute values of Farads - from millionths (micro) to billionths (nano) to trillionths (pico) of Farads.

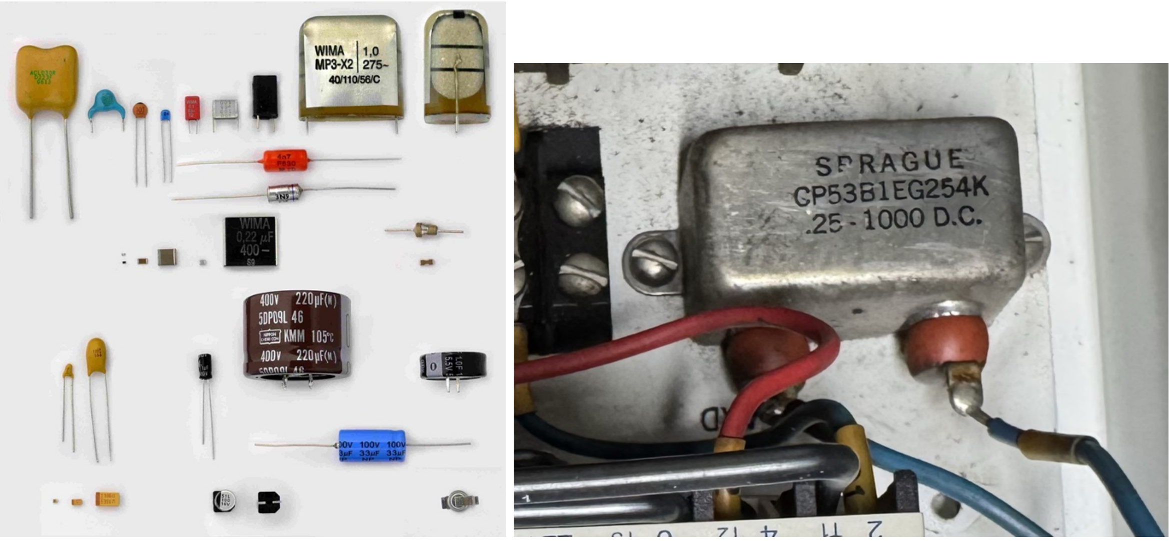

Figure 16: Physical capacitors come in many shapes and sizes depending on their internal construction, their capacity, and their uses. Smaller-voltage and smaller-capacitance devices look similar to those on the left. The only individual capacitor in the Vandercook schematic is a so-called bathtub capacitor in a metal case, shown on the right. It is rated at 1000vDC which is a much higher voltage than it will ever see in this circuit, but it doesn't hurt to have a "beefier" capacitor than needed. Its capacity is 0.25MFD (0.25 micro-Farads). (This photo has been rotated 180 degrees so that you can read the writing on the case of the capacitor.)

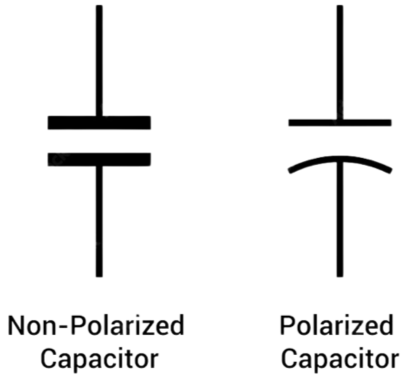

Figure 17: Schematic symbols for a capacitor. Non-polarized capacitors make no distinction of the + or - of the circuit on their two leads. Polarized capacitors prefer the DC + voltage on the straight side, and - voltage on the curved side of the symbol. This is also indicated on the physical capacitor device.

3.5 Contactors and Relays

The behavior of the Vandercook control circuit comes from a "switching circuit" connection of contactors and relays. Contactors and relays are variations of the same type of component: they have an electromagnet that closes or opens physical contacts (like a switch) when they receive a voltage on their control inputs. The main difference between a contactor and a relay is in the amount of current the mechanical contacts can support. The name relay is generally used for a device that switches a small number of relatively small voltages/currents on the contacts. A contactor uses the same electromechanical switches but allows for larger voltages and currents to go through those contacts. They also often have more physical contacts that are connected/disconnected using the same control input. See Figure 18 for a picture describing a relay vs. a contactor, and Figure 19 for the way these devices will be notated in the Vandercook schematic.

The notion of a switching circuit is a way to make logical control circuits through the series and parallel connection of switches that are controlled by other electrical signals. This type of circuit descended from railroad switching circuits that were used to control the physical switching of trains to different tracks. These were eventually used to make electrical connections in telephone switching circuits. Those telephone circuits are the basis for computer control circuits in the present. Old telephone switches made use of relays and contactors for switching the phone lines, but modern computer circuits use transistors as switches to achieve the same switching behavior without having to move mechanical contacts open and closed.

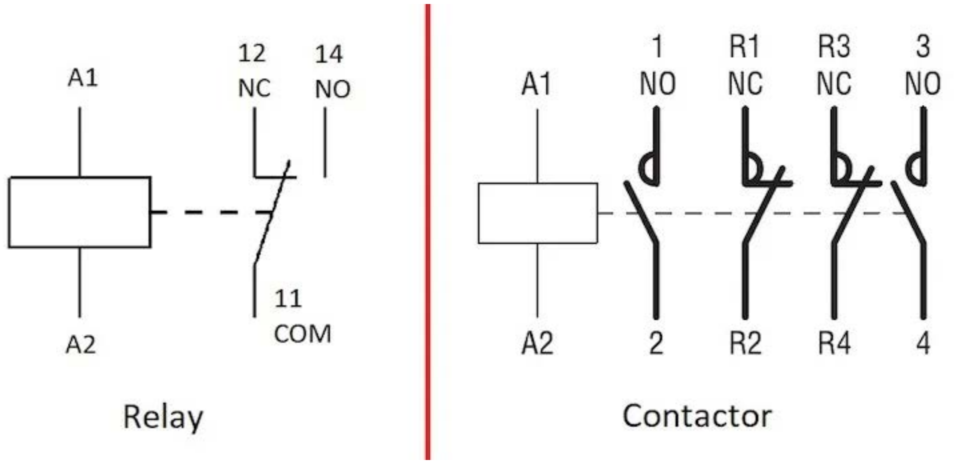

Figure 18: Schematic representations of a relay and a contactor are shown here. The relay shown has a single electro-mechanical switch that makes contact between the COM connection to either the NC or NO connection when the relay is activated on the A1/A2 interface (SPDT relay). The contactor has four connections that are made with the same A1/A2 control. Two are NO (normally open) connections that close (connect) when the contactor is activated, and two are NC (normally closed) connections that open (disconnect) when the contactor is activated (SPST switches).

The relays and contactors used in the Vandercook circuit are controlled by a 120v AC control input. When 120v AC power is applied to the control (coil) of the relay/contactor, the electromagnetic switches change their state from their rest state to the activated state. The rest states are known as Normally Open (NO) which means that normally the switch is an open circuit (disconnected), and Normally Closed (NC) which means that normally the switch is closed (connected). When the relay/contactor is activated by 102v AC on the coil the switches change state from open circuit to closed circuit or vice versa.

Note that the schematic symbols used for the contactor and relay switches in the Vandercook schematic look a lot like a capacitor symbol (See Figures 17 and 19). In context it's easy to figure out the difference, partly because the relay/contactor switches are all labeled with the name of the contactor that they belong to, but it is important to know that in this relay/contactor-based circuit this will occur.

The was these circuits are used to enable a logical function, such as "only power up the motor if switch L2 is open and the F contactor is activated and the control lever is in the FORWARD position." Two switches that are connected in series are an "and" connection – the behavior is powered up only if switch1 AND switch 2 are engaged. Two switches that are connected in parallel are an "or" connection. Closing either switch1 OR switch2 will power up the behavior. Using these and/or connections is how the complex behavior of the Vandercook is enabled by the control circuit and will be described in detail in Section 5.

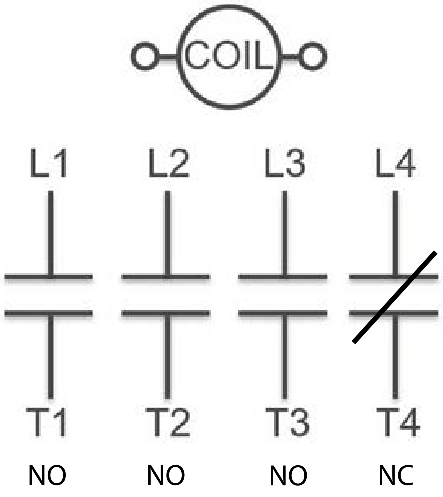

Figure 19: This is how a contactor/relay will be shown in the Vandercook schematic. The control input is shown as a circle (labeled COIL in this diagram). This contactor is similar to the F and R contactors in the Vandercook schematic and has four electromechanical switches: three are NO (normally open) and switch to closed, or connected, when the contactor is activated), and one is NC (normally closed) and switches to open (unconnected) when the contactor is activated. The COIL is a 120v AC activation voltage. The schematic symbols for the switches shows their normal, or inactivated, state. They switch to the opposite state when the COIL is activated. In the Vandercook schematic the relay/contactor coil will have an identifying name, and each of the switches controlled by the relay/contactor will also be noted as to which device it belongs to.

3.6 Variable Autotransformer (Variac)

One somewhat unusual component in the Vandercook control circuit is a variable autotransformer or Variac (which was a brand name but is now used generically). A transformer is a component that uses the fundamental connection between electricity and magnetism to decouple parts of a circuit from each other and also modify the AC voltage and current delivered to the two parts of a circuit. The fundamental principle of electromagnetics that makes this work is that if you put an electrical current through a coil of wire, you generate a magnetic field perpendicular to the electric field. This is the principle that makes an electromagnet work – putting current through a coil of wire generates a magnetic field. But the converse is also true – if you put a coil of wire in a (changing) magnetic field, you induce current in that wire. This is the reason that generators work. In a hydroelectric dam, for example, water pressure is used to turn generators. Generators essentially physically move coils of wire through magnetic fields and thus generate current. They're like motors in reverse, and in fact generators look almost exactly like motors, but with the spindle turned mechanically to generate electricity instead of applying electricity to turn the spindle. In order for this to work, the current and magnetic flux need to be constantly changing. It's the change in the current or magnetic flux that does the work. So, transformers only work with AC power.

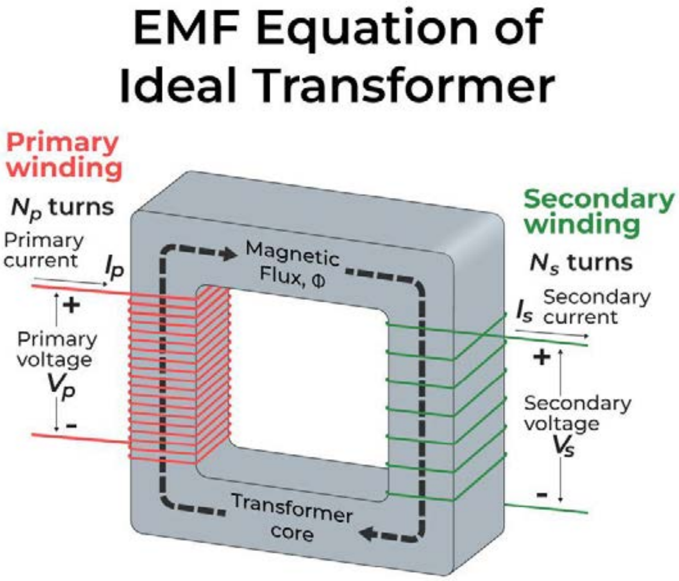

Figure 20: A basic transformer showing the input coil windings, iron core, and output coil windings. Based on the ratio of input windings to output windings the induced output voltage can be higher or lower than the input voltage (with a resulting current that is lower or higher, respectively).

A simple transformer makes use of this duality between electricity and magnetism. A simple transformer consists of an iron transformer core with insulated coils of wire wrapped around the input side, and different coils of insulated wire wrapped around the output side as shown in Figure 20. The input voltage results in current flowing through the input coil (you can use Ohm's law to figure out how much current if you know the input voltage and the resistance in the input circuit). The current in the input coil induces magnetic flux in the transformer core. That magnetic flux induces current in the output coil resulting in an output current and voltage (which again, you can determine using Ohm's Law). Based on the ratio of the input windings and the output windings, the output voltage can be stepped up or stepped down from the input voltage (with a corresponding step down or step up of current). Note also that although the input voltage/current causes an induced voltage/current in the output state (secondary windings), the two sides of the circuit are electrically isolated and not connected directly together. They "communicate" only through the magnetic flux caused by the flowing current.

Transformers are wonderfully simple ways to step-up or step-down voltages. There is a transformer on the power pole nearby your house that likely takes a quite high voltage from the AC lines on the power pole (typically 2000v – 33,000v AC or 2kV – 33kV) and uses a distribution transformer to reduce that power line voltage to 240v AC to deliver to your house (see Section 3.2.1). The trick with transformers is that Ohm's Law must apply. So, if you reduce the voltage, you increase the current (at a fixed resistance), and if you raise the voltage, you must reduce the current (again at a fixed resistance).

A tweak on the idea of a transformer is to use the same windings for both the input windings and output windings (Figure 21). This is simpler to build, and less expensive, than a dual-winding iron-core transformer, but doesn't provide the circuit isolation that a dual winding transformer provides. This single-winding transformer is called an autotransformer. These are used where circuit isolation is not required and are often used with multiple output taps to generate multiple different AC output voltages for a fixed input AC voltage.

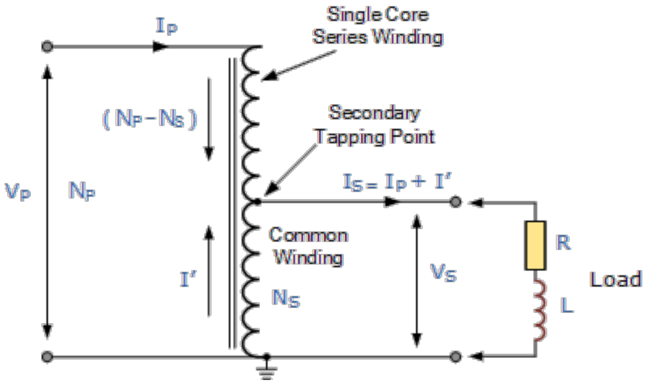

Figure 21: An autotransformer has only a single winding of wire that is used for both the input and output windings of the transformer. It can be less expensive and simpler to build, but does not provide circuit isolation from input to output.

Finally, a variable autotransformer can be built that has a movable output (secondary) tap. This is built by exposing the wires of the common winding and then letting an insulated knob of some sort change where the secondary output tap is connecting to the common winding coil (Figure 22). This lets the user change the output AC voltage smoothly by turning the knob to select where on the common winding coil the output is connected. This is known by the brand name of Variac, which is now a commonly used generic name for a variable autotransformer. These are used in situation where a user wants to manually adjust an AC voltage in a circuit. In the Vandercook circuit this is used in the SPEED ADJ circuit to control how much AC voltage is converted to DC to drive the carriage motor. These devices are a little scary because the windings that are required to vary the output AC voltage are exposed and would shock you (at up to full 120v AC line voltage) if you touched them. Luckily this component is hidden behind the control panel on the Vandercook, and the SPEED CONTROL knob is insulated!

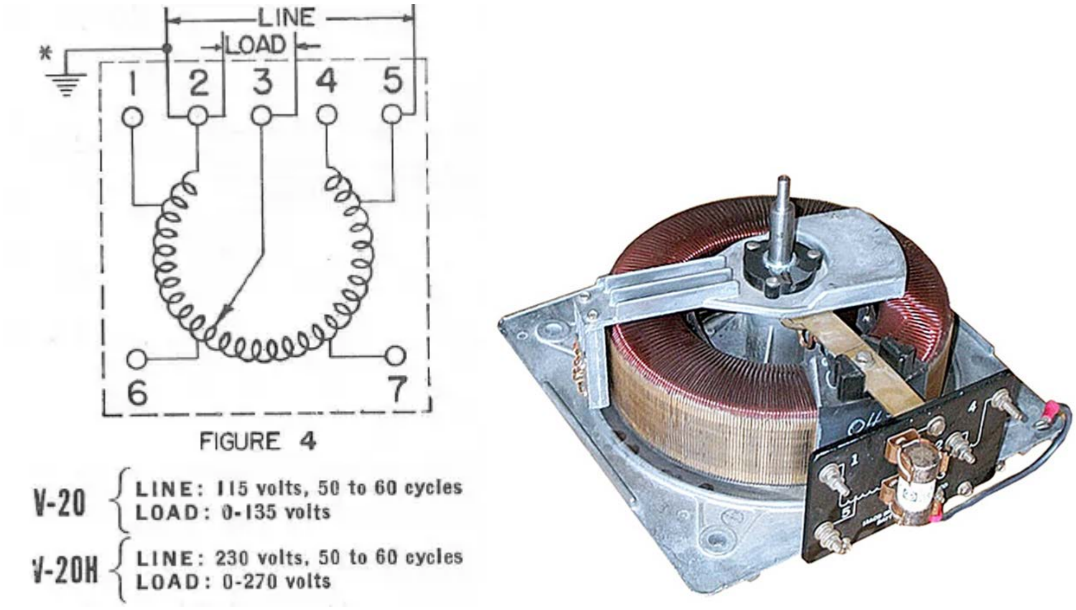

Figure 22: A schematic figure for a rotary Variac as used in the Vandercook is shown on the left. Note that there is a single winding (coil) of wire used for both the input and output side of the Variac, and there is a turnable knob attached to connection 3 used to select a variable output AC voltage. In the physical Variac shown on the right you can see the exposed wires of the common windings that are used to make contact for the output AV voltage connection.

3.7 Bidirectional Transient Voltage Suppressor diodes (TVS diodes)

The last oddball schematic component in the Vandercook schematic is a bidirectional transient voltage suppressor diode (TVS diode) (Figure 23). These devices are made from a particular type of diode (see Section 3.2.3 for a brief discussion of diodes as a one-way valve for electrical current) called a Zener diode. They behave like diodes in terms of passing current only one direction but also have a property that above a certain voltage (called a breakdown voltage) they conduct in the opposite direction and let current “break through” going the other way. By constructing a device with a pair of Zener diodes together and pointing in opposite directions, the TVS diode will clamp excessive voltage in either direction and protect the circuits attached to it from those voltage spikes. They are used in AC circuits where the voltage oscillates between + and -, or in DC circuits where the polarity of the DC voltage is reversed from time to time (such as in a reversing DC motor drive circuit used by the Vandercook).

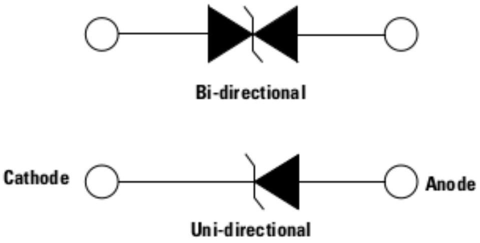

Figure 23: Bidirectional transient voltage suppressor (TVS) diode schematic symbols. These special diodes clamp voltages that exceed a specific value from moving further through the circuit. They are used as protective devices to make sure that high-voltage spikes (from electrical noise, or in response to circuit switching) are suppressed and not propagated to the rest of the circuit.

4 - Vandercook Control Circuit Components

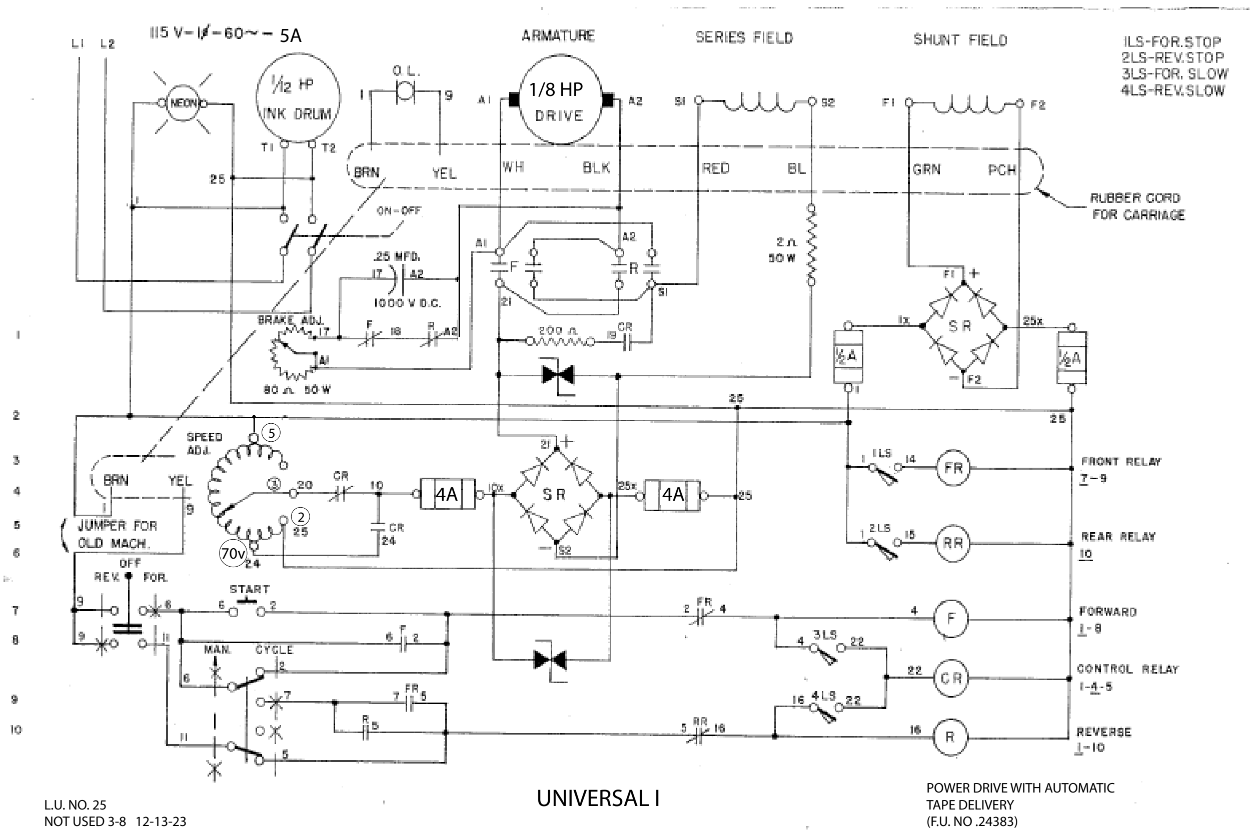

Figure 24: The Vandercook Universal I AB P control schematic - repeated from Figure 4.

Finally, we get to the actual Vandercook Universal I powered carriage control circuit (as seen in Figures 4 and 24). This schematic is an old-school control schematic sometimes known as a "ladder diagram". Because the controls are based on contactors and relays, the schematic shows the switches controlled by those relays on horizontal lines (that form a ladder). That's why those horizontal lines are numbered on the left of the schematic – so that you can refer to contactor and relay switches by which line they're on. As described in Section 3.5 these switches are used to implement the logic of the control using serial (AND) and parallel (OR) connections of the switches controlled by the contactor/relay control coils shown on the right side of the schematic and labeled FR (front relay), RR (rear relay) , F (forward), CR (control relay), and R (reverse).

4.1 AC and DC portions of Control Circuit

The first observation about this control circuit is that there are parts of the circuit powered by 120v AC from the line voltage, and parts that are converted to DC for the carriage drive motor (as described in Section 3.2.3). The part of the schematic that is powered up with 120v AC power when the press is turned on (and no control levers or buttons are pressed) is shown in Figure 25.

The line voltage of 120v AC comes in at the top of the schematic on the lines labeled L1 and L2. These wires go through the main ON-OFF switch and then power up the 1/12 HP INK DRUM motor (a 1/12 HP, 120v AC motor) that drives the inking system, and the NEON indicator that lights when the press is powered up. The red on L1 and blue on L2 are meant to indicate the hot and neutral wires respectively, but because of the alternating nature of AC it doesn't really matter which one is which, at least for this circuit.

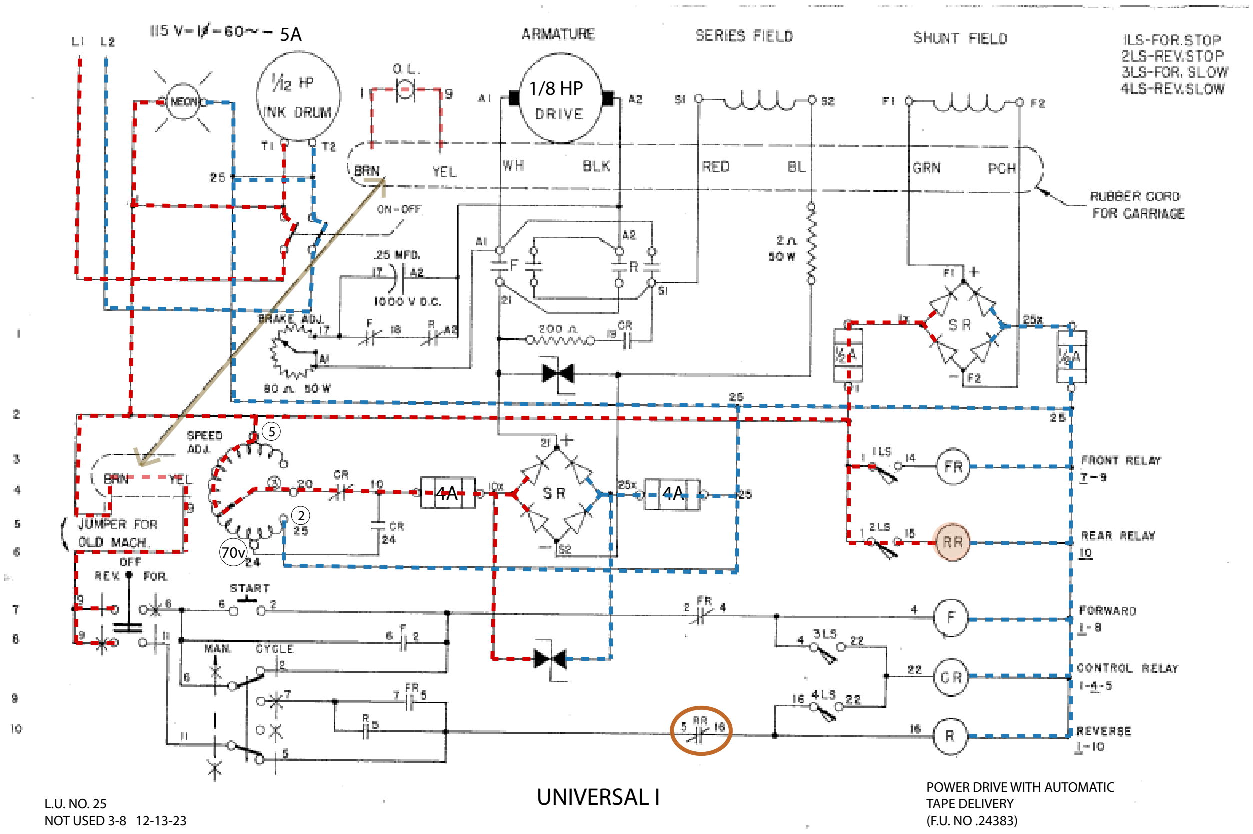

Figure 25: These parts of the circuit are powered up at 120v AC line voltage when the press is first powered up. The circuits at the bottom of this Figure are also AC powered but are not energized in the start-up state of the press when the carriage is not activated to move. The control switches (REV/FOR lever and MAN/CYCLE knob) are shown at the left on lines 7-10. If the press carriage is all the way to the feed board, then the 2LS and 4LS limit switches will be engaged, which will enable the RR relay. This stops the carriage from moving in reverse, so has no impact in the static state of the press before any controls are engaged.

Following the AC signals from the NEON indicator to the bottom half of the schematic you can see that the blue L2 AC wire goes to the right connection of both of the diode rectifiers (noted as SR in the schematic, and of the type described in Section 3.2.3). These rectifiers are used to generate DC voltages for the carriage DRIVE motor (more details in a bit). The L1 AC wire goes directly to the rightmost rectifier, but goes through a variable autotransformer (Variac) before going to the center rectifier (noted as SPEED ADJ. in the schematic). The Variac (see Section 3.2.6) is used to reduce the AC voltage smoothly (using the SPEED CONTROL knob on the front panel). Reducing the AC voltage to that central rectifier will also reduce the DC voltage to the DRIVE motor (through the diode bridge rectifier) and thus reduce the speed of the carriage travel.

The blue L2 AC signal also goes to the righthand terminal of all five of the relay/contactors that control the circuit. The relay/contactor coils (controls) are shown in the schematic as circles with the name of the relay/contactor in the circles (see Figure 19 for a generic example). The switches that are controlled by these relays/contactors are sprinkled throughout the schematic and are also labeled with the relay/contactor names.

Most of these relays and contactors are currently (in the quiescent case where the press is powered, but no controls are engaged) not energized because there is no AC signal connecting across the control coil of any of the relays and contactors. The relays and contactors will only be energized once there is a red AC signal on the left terminal and a blue AC signal on the right terminal completing the circuit (see Section 3.5). If the press carriage is at the feed board when you turn on the power, then the 2LS and 4LS limit switches are engaged by nature of the press being all the way at the feed board. This means that the RR relay is engaged when the oppress starts up. With no other controls enabled, this doesn't impact the carriage movement at the moment – the RR relay is used to stop the carriage when it's at the feed board, and because it's already stopped, it doesn't impact the carriage motor (many more details to come!).

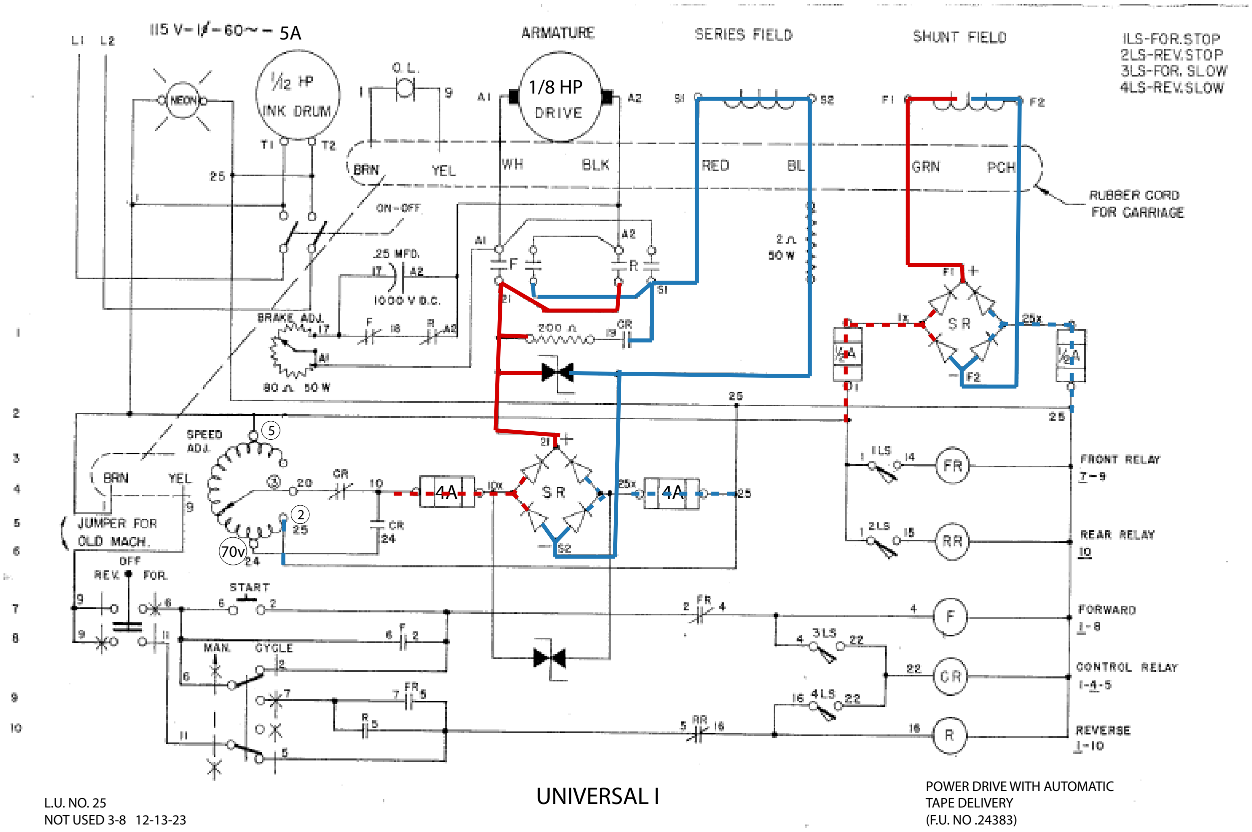

Figure 26: The sold red and blue lines show the static DC voltages generated by the two diode rectifier bridges (SR). Note that he DC voltage from the center rectifier goes through the static Series Field of the motor, and also to the A1 and A2 terminals of the armature of the motor. Depending on which of the contactors is engaged, the + and – of the DC voltage is connected to A1/A2 for forward motion, or A2/A1 for reverse motion. The Shunt Field is a static magnetic field that the armature "pushes against" to turn.

The DC portion of the schematic is shown in Figure 26. There are two diode rectifiers (see Section 3.2.3) used to convert the 120v AC line voltage to DC voltages to drive the motor. The bridge on the right of the schematic is fused to 1/2A AC and generates a static DC voltage for the shunt field of the motor. This voltage was measured at about 106.5v DC on our press. This is less than the AC voltage driving the bridge both because of voltage loss in the rectifier, and also resistive loss in the Shunt Field itself.

The DC voltage in the middle of the schematic goes to the series field of the motor, and then, depending on if the F or R contactors are enabled, passes that voltage to the armature of the carriage drive motor to make it move forward or in reverse. This DC voltage varies based on the setting of the SPEED CONTROL knob on the front panel (Figure 2) which controls a Variac to adjust the AC voltage input to the rectifier. This post-Variac AC voltage was measured between 0v AC and 140v AC on our press. Note that because the Variac is a transformer, the output voltage can actually be higher than the input AC voltage.

4.2 DC Carriage Drive Motor

The 1/8 HP DC motor shown in the top center of the schematic is the motor that drives the carriage back and forth. It is connected to the main press through a cable that contains eight wires. This cable assembly is shown at the top of the schematic and noted as “RUBBER CORD FOR CARRIAGE” (Figure 27). The advantage of a DC motor is that it is easily reversed simply by reversing the DC voltage polarity to the armature of the motor. The contactor switch logic that does this is known as an H-Bridge circuit and is a standard way of reversing a DC motor based on switch settings. In more modern circuits, or smaller motors, these switches might be implemented with switching transistors instead of physical contactor switches.

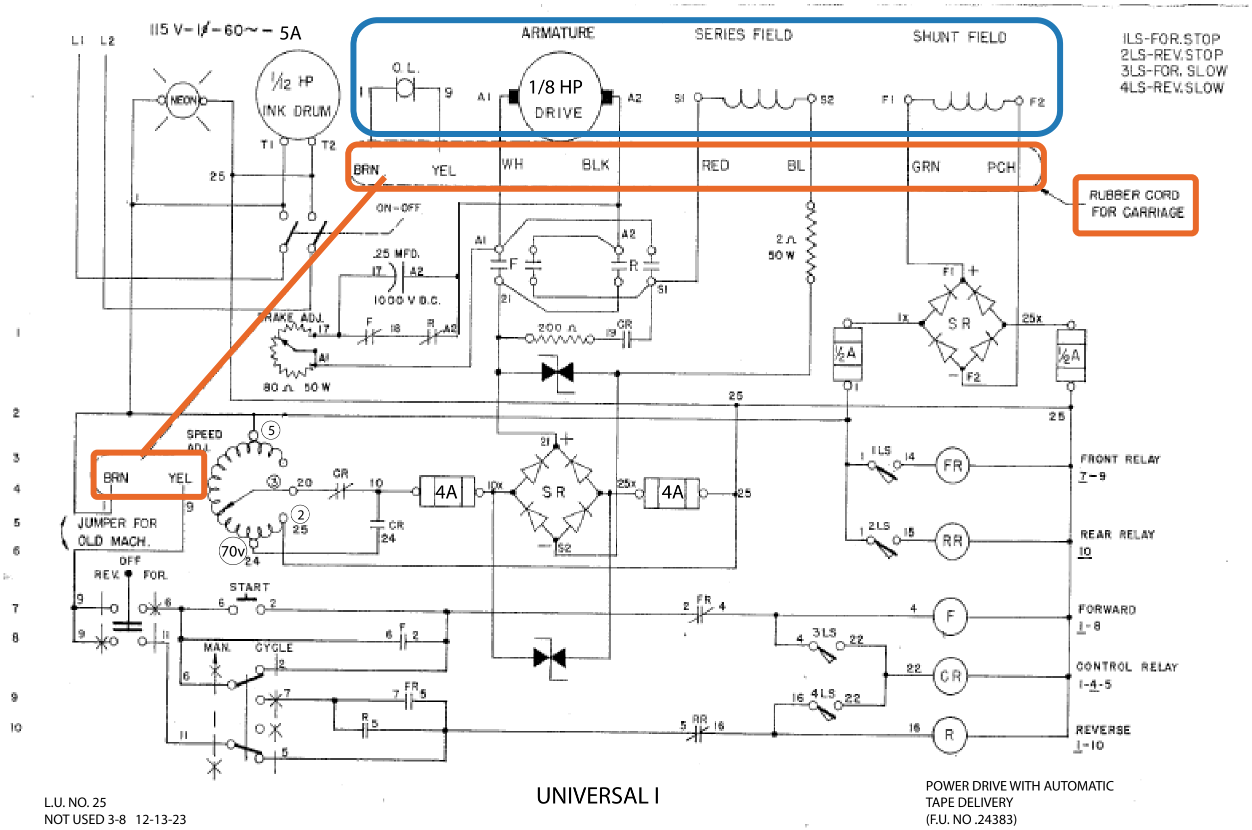

Figure 27: A “rubber cord” cable assembly with eight wires inside the cable connects the press to the carriage drive motor. The components in the blue square are all components of the drive motor. The connections are color-coded, and each individual wire is also labeled on our press.

The drive motor is of a type of DC motor called a compound-wound motor. Like many simple DC electric motors, the drive motor has an armature which is the part of the motor that, when energized, causes the motor to turn. The armature consists of coils of wire that (like a transformer) create a magnetic field when current is sent through the windings. The polarity of that magnetic field is related to the direction of the current which means that you can reverse the magnetic field by reversing the current. The armature is attached to electrical contacts called brushes inside the motor in a clever arrangement that causes the current, and thus the magnetic field, to switch at various points in the rotation of the armature. The armature of the drive motor is connected through the A1 and A2 wires in the cable.

To turn the motor spindle, the armature magnetic field pushes or pulls (depending on the polarity of the magnetic field) against other (static) magnets in the motor. As it spins the armature pulls towards a surrounding magnet until it gets aligned with that magnet, then switches to push to push away from that magnet and pull towards the next one. In a super simple motor these might be fixed magnets. In this compound-wound motor those static magnetic fields that the armature pushes/pulls against are themselves generated by electromagnets (current flowing in a coil of wire, wrapped around a magnetic core of some sort like iron). Some DC motors have only a series field generated with a coil of wire in series with the armature. This provides high torque when the motor starts up because the series field is being generated with the same current as the armature windings. Other DC motors have a static magnetic field generated by a coil of wire in parallel with the armature – a shunt field. This provides good speed regulation of the motor through a static unchanging magnetic field from the shunt coil. A compound motor has both a series field and a shunt field which means it has some of the good features of both types of fields. You can see the series field and shunt field of the motor in the schematic in Figure 27, and connected through the cable as S1, S2 for the series field, and F1, F2 for the shunt field.

This motor also has a thermal overload circuit that trips when the motor gets too hot. I don't know exactly what type of circuit this motor has, but I suspect it's some sort of bi-metallic switch that opens when it heats up and then closes again once it cools down. This is the O.L signal to the motor on the brown and yellow wires in the cable (wires 1 and 9). Note that the O.L signal will, when opened, disconnect the L1 line of the 120v AC signal so that the carriage will stop no matter what buttons/levers are engaged in the control system. The inking system will, however, still function as the O.L. disconnect happens downstream of the AC motor used in the inking system.

4.3 Limit Switches on the Back of the Press

On the back of the press are four limit switches. These switches are so-called micro-switches even though they're not actually all that small. They are small in terms of switches on machine tools I suppose. These lever switches are engaged when something (a metal rider, or cam) slides over the arm of the switch (that has a convenient roller on it) and that lever arm presses the switch.

The names of the limit switches in the schematic are a hint as to what they indicate:

- **1LS = For. Stop**: This switch indicates that the press has reached the far end of the press bed and should not go forward anymore.
- **2LS = Rev. Stop**: This switch indicates that the carriage has gone as far back to the feed board as it can, and it should not go in reverse anymore.
- **3LS = For. Slow**: This switch indicates that the carriage is getting close to the end of the press bed and it should slow down and prepare to stop when going forward.
- **4LS = Rev. Slow**: This switch indicates that the carriage is getting close to the feed board and should slow down to prepare to stop when the carriage is going in reverse.

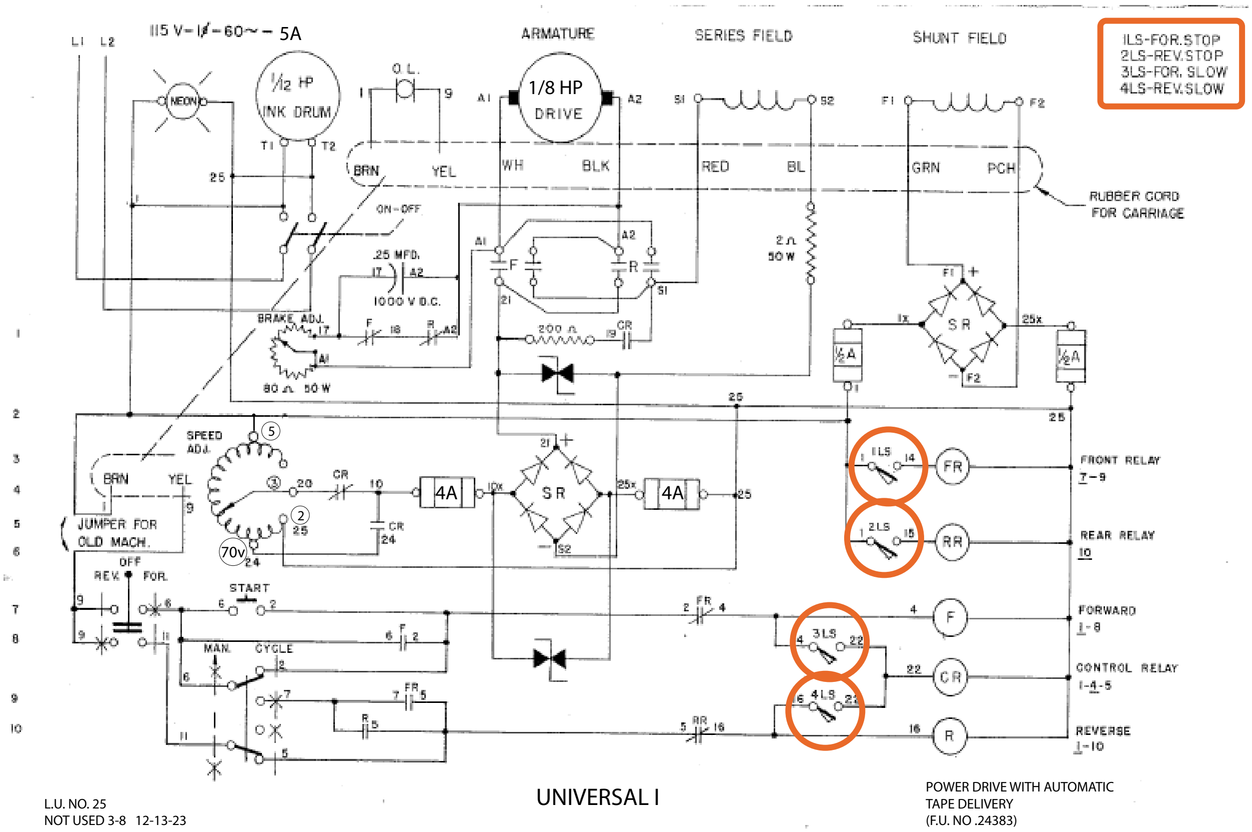

Figure 28: The limit switches are micro-switches on the back of the press. They are used, along with sliding cams on the carriage that engage the switches, to indicate positions of the carriage that should cause it to slow or stop its motion. This Figure shows where these switches are in the control schematic so that their function in terms of the control logic can be determined.

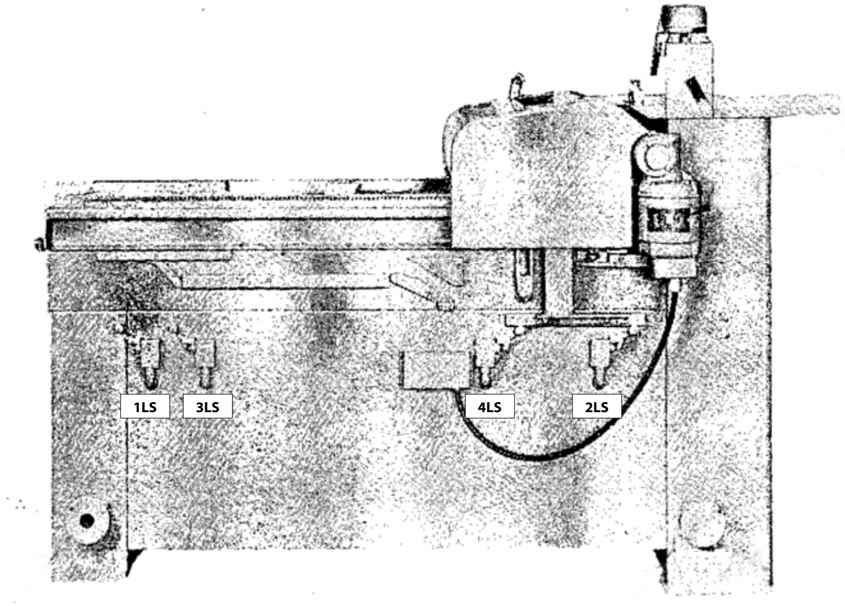

Figure 29: Limit switch positions on the back of the press.1LS = For. Stop, 2LS = Rev. Stop, 3LS = For. Slow, and 4LS = Rev. Slow. This is a very fuzzy capture from a poorly scanned Vandercook parts manual.

Figure 30: The micro-switches on the back of our press at the feed board end. These are switches 4LS - Rev. Slow (left) and 2LS – Rev. Stop (right) in the schematic. 4LS informs the control circuit that the carriage is approaching the feed board, and 2LS informs the control circuit that the carriage is all the way back to the feed board. These are replacement microswitches from those originally installed on the press and are shown in the position where they are both engaged (pressed) by the cams on the carriage. You can adjust where the carriage engages these switches by moving the cams back and forth.

Figure 31: View of the back of our Vandercook Universal I showing (replaced) microswitches 1LS – For. Stop (left), indicating that the carriage is all the way to the end of the press bed), and 3LS – For. Slow (right) indicating that the carriage is almost to the end of the press bed when moving forward.

4.4 SPEED ADJ. Circuit

In the center of the schematic (lines 3-6) is a portion of the schematic labeled SPEED ADJ. This circuit consists of a Variac (see Section 3.6) used to control how much AC voltage is provided to the diode rectifier that produces a DC voltage for the carriage motor armature. With more AC voltage, the diode bridge produces more DC voltage and the carriage moves faster. With less, the carriage moves slower. The CR Control Relay controls how the AC voltage is delivered though the Variac.

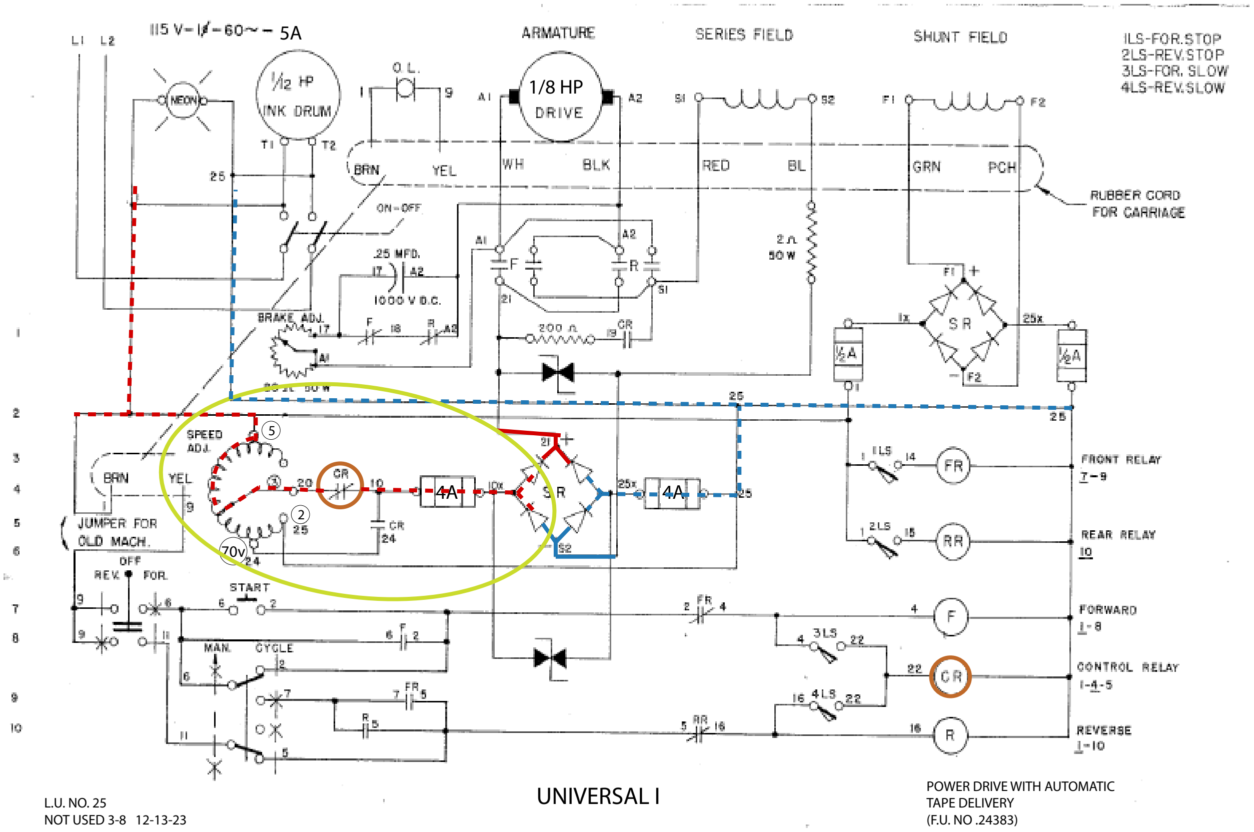

Figure 32: The SPEED ADJ. circuit shown in a state where the CR relay is NOT enabled, and therefore the AC voltage provided to the diode rectifier goes through the movable connection of the Variac. This is the "full speed" condition for the carriage motor, and the speed depends directly upon the position of the SPEED CONTROL dial on the front panel (see Figure 2).

Figure 32 shows the SPEED ADJ. circuit in the position when the CR Control Relay is **not** engaged. In this case the NC CR switch is closed (conducting) and the AC voltage delivered to the diode rectifier is determined by the position of the dial on the front of the press (see Figure 2). This allows the press user to control how much voltage is delivered, and thus how fast the carriage motor drives the carriage. This is the "full speed" setting where the speed of the carriage is determined by the SPEED CONTROL dial on the press control panel.

If the CR Control relay is engaged, then the NO CR switch shown at circuit node 24 changes to being a closed circuit (connected) and the AC voltage delivered to the rectifier (and eventually as DC to the motor) is at a fixed lower voltage to put the carriage into "slow" mode. This is the mode where the carriage is approaching the end of its travel (either forward to the end of the press bed or reversing back to the feed board) and should be moving slowly. There is a second NO CR switch on line 1 of the schematic that enables a 200Ω resistor between the + and – of the DC supply delivered to the motor. This also reduces the DC voltage to the motor and, with the Variac, puts the carriage motor into a fixed slow mode (Figure 33).

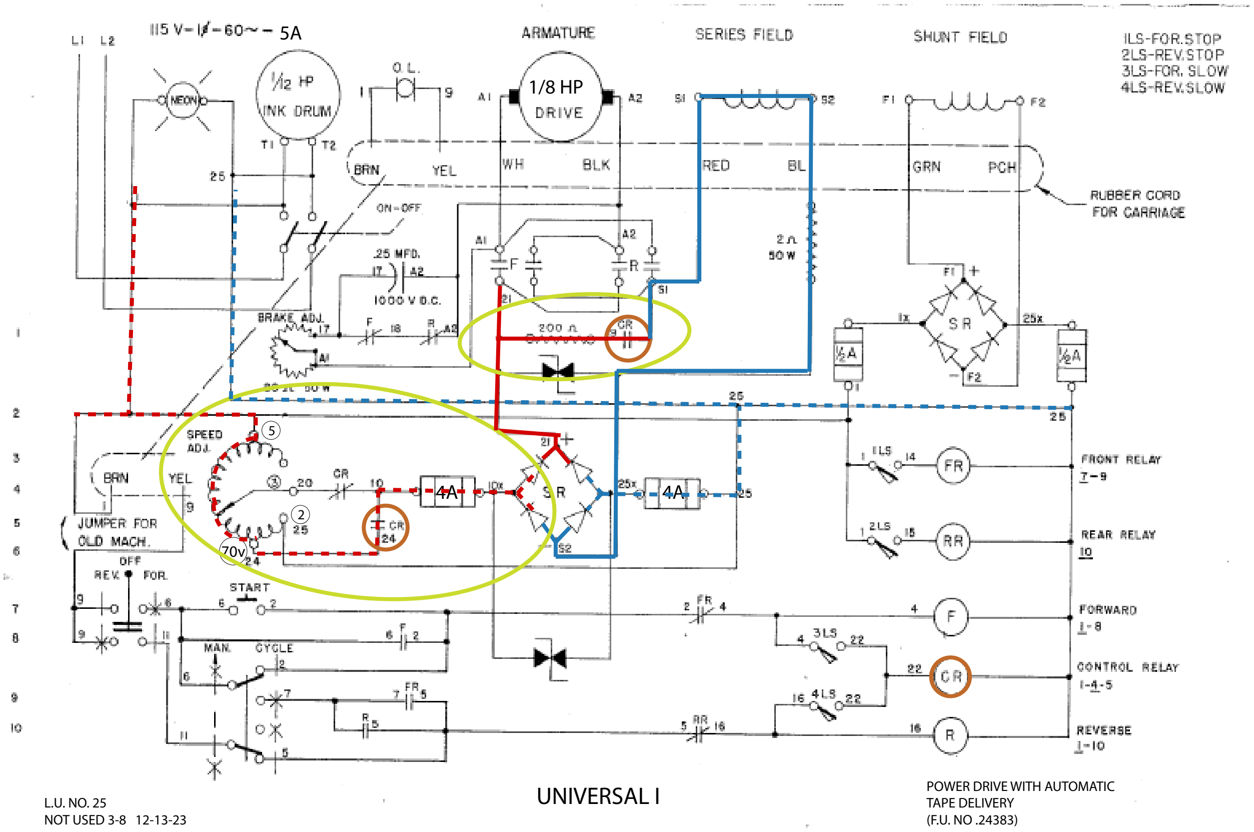

Figure 33: This shows the SPEED ADJ. circuit in slow mode. It is enabled when the CR Control Relay is engaged and the NO CR switches change to being closed (connected). Engaging the CR control relay causes two actions: it changes the AC voltage to a fixed, low, voltage by using a long path through the Variac (independent of the SPEED CONTROL dial setting), and it also engages a 200Ω resistor between the + and – of the DC supply sent to the motor, further reducing the DC voltage sent to the motor. The result is that the motor drives the carriage at a fixed slow speed.

4.5 Brake Adj. Circuit

On line 1 of the schematic is a circuit labeled BRAKE ADJ. this circuit provides some braking action for the carriage motor as the motor starts or comes to a stop (Figure 34). To give the motor a gentler starting or stopping the BRAKE ADJ. circuit contains a capacitor (see Section 3.4) and a variable resistor (or rheostat) (Section 3.3).

When the carriage is stopped, there is no DC voltage on the A1 and A2 connections to the motor, and, if the motor has been stopped for a while, there is no charge on the capacitor. When the motor starts moving, then one of the NC F or R contactor switches (on line 1) will open (become disconnected) and so the capacitor will be charged up by the voltage between A1 and A2 and through the resistance of the rheostat. This provides some gentleness to the starting of the motor as the capacitor charges. Once the capacitor is charged it no longer conducts DC current through the capacitor and so it’s as if that path is not part of the circuit and the motor moves at full speed.

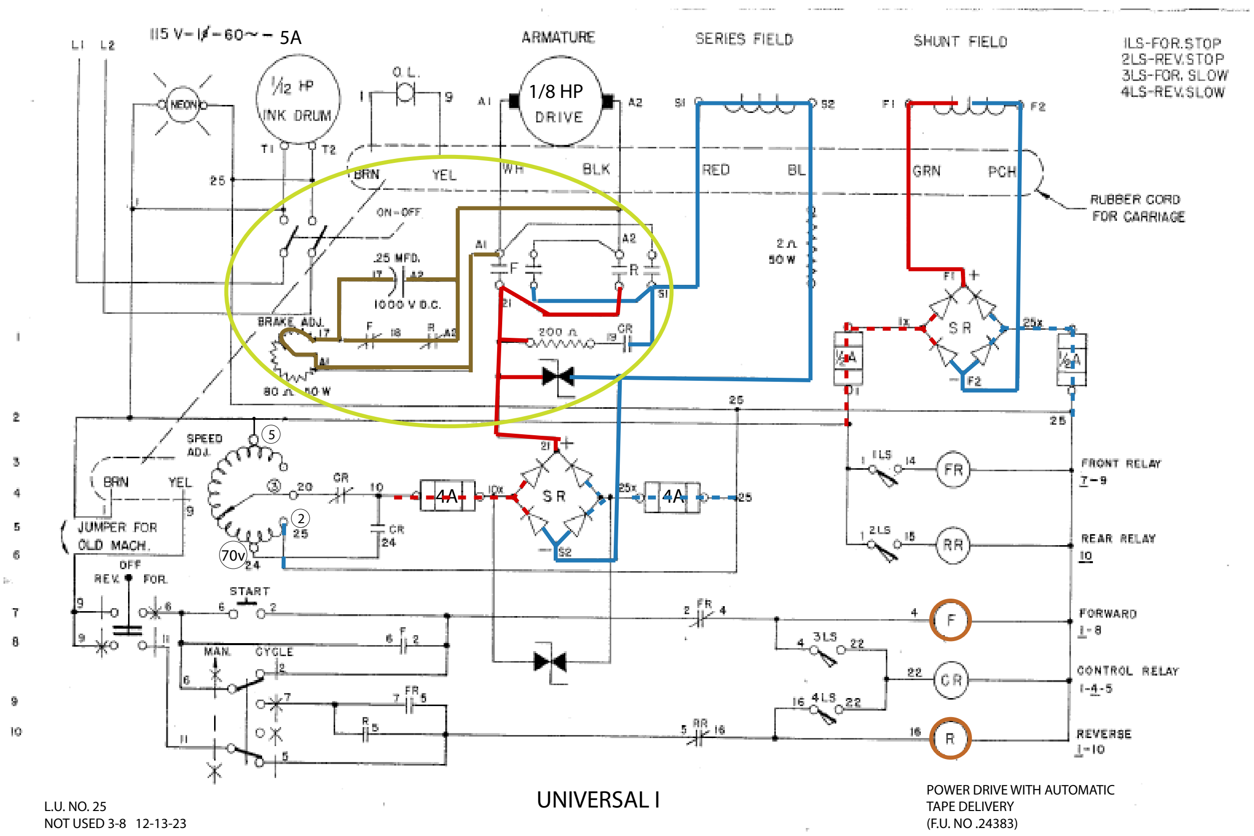

Figure 34: The BRAKE ADJ. circuit consists of a beefy capacitor and a variable resistor (rheostat). If the press is in motion (i.e. either the F or R contactor is enabled so one of those contactor switches is changed to open (disconnected)), then the capacitor is charged through the rheostat. This happens more slowly or more quickly depending on the resistance setting through the rheostat. Once the capacitor is charged, no current flows from wire 17 to A2. When the drive motor stops (the F or R contactors go back to disengaged), then the capacitor provides a little gentle ramp-down current to the motor so it stops (breaks) more gently.

If the capacitor is charged (the carriage has been moving) and the state switches to a stopped state (neither of the F or R contactors is engaged), then both NC switches are closed (connected) and simultaneously the resistor is re-connected across A1-A2, and the capacitor is discharged in the circuit providing a gentle ramp-down of the voltage as the capacitor discharges. This happens pretty quickly overall, but the amount of braking is controlled by the size of the apparent resistor implemented by the rheostat. More resistance is more braking and a gentler start/stop, and less resistance is less braking and a snappier start/stop reaction of the motor.

5 – Vandercook Control Relay/Contactor Logic

This finally brings us to the way that the contactors and relays are used to control the motion of the carriage. Relays and contactors control the movement of the carriage in response to the switches, knobs, and control dials on the control panel (Figure 2). These contactors and relays are controlled by 120v AC across the control connection of the relay/contactor, and they control the normally-open (NO) or normally-closed (NC) terminals of that device (see Section 3.5). The connections are shown in the schematic in the non-energized state of the relay/contactor. When the relay/contactor is engaged (there is 120v AC applied across the control terminals), then the switched terminals in the circuit change to the opposite state. That is, NO (normally open) terminals are closed (connected), and NC (normally closed) terminals are opened (disconnected).

As described in section 3.5 the terms "relay" and "contactor" are used to describe very similar electrical components – devices that make mechanical contact between electrical nodes based on an electrical control signal. The primary difference is that a relay is usually a smaller version typically with fewer contacts and less current-carrying capability of those contacts, and a contactor is a beefier device typically with more contacts and that can handle larger current. Relays often have double-throw switches so that they can have a single relay be either an NC or NO switch depending on how they're connected. Contactors usually have single-throw switches (see Figure 18 in Section 3.5). In the Vandercook control schematic, the F and R devices are classified as contactors and feed relatively larger direct current (DC) signals to the carriage motor, and CR, FR, and RR are classified as relays and are (except for one case) switching smaller alternating current (AC) signals. The contactors with their control shown in the lower right of the schematic are:

- The F and R contactors control the forward and reverse travel of the carriage respectively. In this context "forward" means that the carriage travels from the feed board towards the end of the press bed, and "reverse" means the opposite – the carriage travels from the end of the press bed towards the feed board.

- The CR relay (which I would have called a contactor, but it's described as the CONTROL RELAY on the schematic) controls the speed of the carriage motor, and thus the speed of carriage travel. It does this by controlling the amount of AC current that is delivered through the Variac as described in Section 4.4. The CR relay is engaged with the 3LS and 4LS switches on the back of the press which indicate that the carriage is approaching the end of its Forward or Backward travel and should slow down.

- The FR relay is controlled by the 1LS switch on the back of the press which indicates that the carriage has travelled forward as far as it should. That is, it is at the far end of the press bed and should stop moving forward.
- The RR relay is controlled by the 2LS switch on the back of the press which indicates that the carriage has travelled in reverse as far as it should. That is, it is at the feed board position and ready to make another impression by now moving forward.

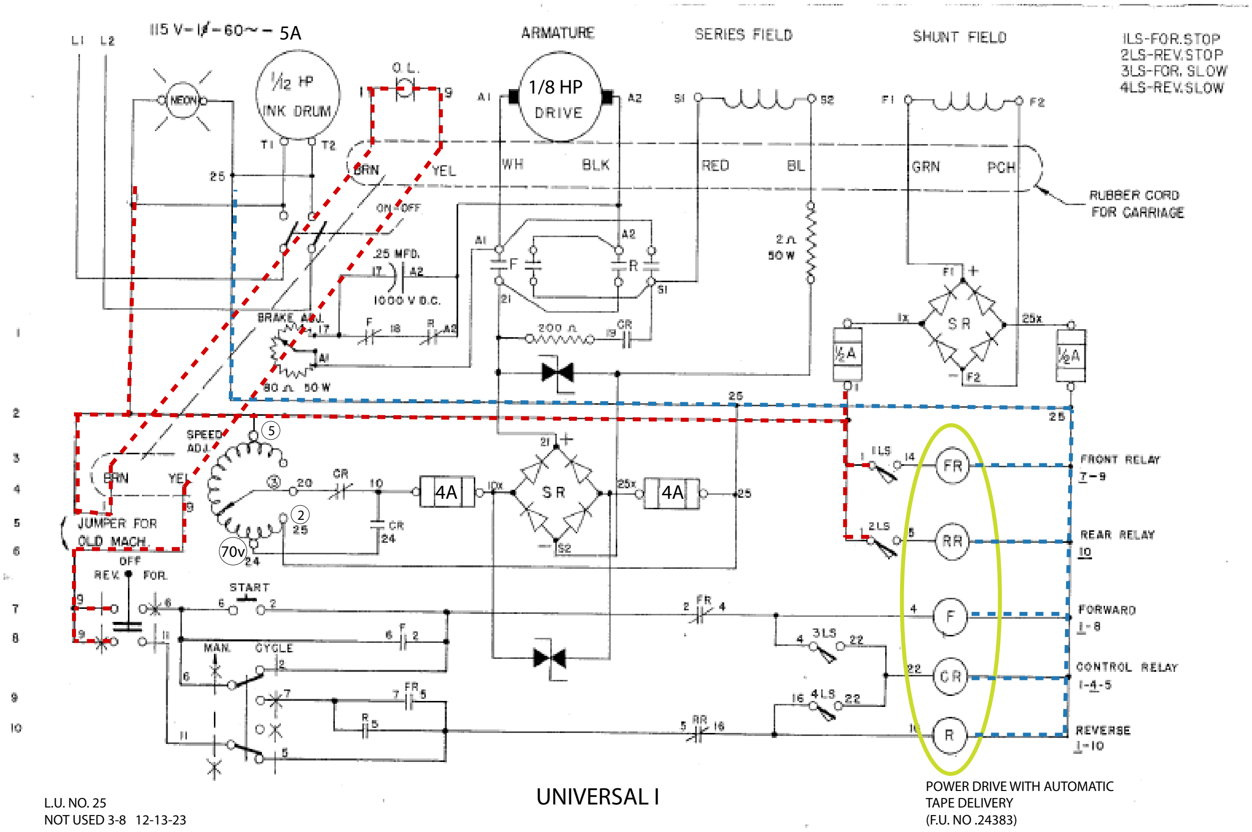

Figure 35: The coil (control) of the contactors and relays is shown here. Each of the contactors/relays has one side of the control coil connected to the L2 neutral side of the AC line voltage. In this state all the contactors/relays are non-energized and their switches are in the state shown in the schematic (NC or NO). When the contactor/relay is engaged (by providing the hot AC signal to the left side of the coil) then their switches will switch state.

Details follow of how these contactors and relays are connected into a logic circuit that drives the carriage forward and back under control of the FOR./REV. lever, the MAN/CYCLE switch, and the START button (Figure 2).

5.1 FORWARD (F) Contactor:

This relay passes current through the carriage drive motor to make it move in a forward direction – from feed board towards the end of the press bed. The primary action is to engage the two F normally-open (NO) contacts shown just below the 1/8 HP DRIVE motor in the schematic to send DC current through the A1 and A2 wires to the carriage motor. The

DC current is delivered with + on the A1 side and – on the A2 side to engage the carriage motor in the forward direction (from feed board to the press bed end). This DC power is provided through the AC/DC diode rectifier and is fused to 4A. As seen in Figure 36, the F contactor has three NO switches and one NC switch.

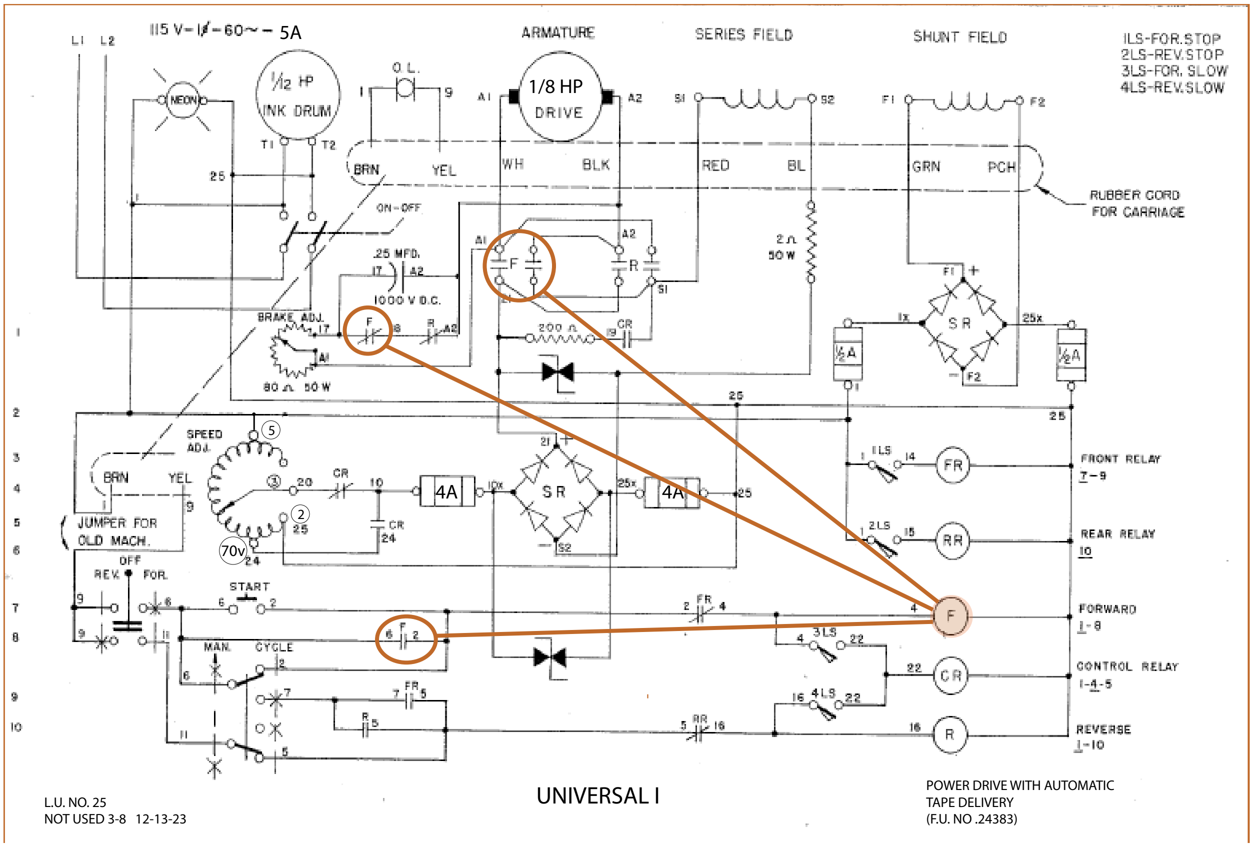

Figure 36: The F contactor has three NO switches and one NC switch.

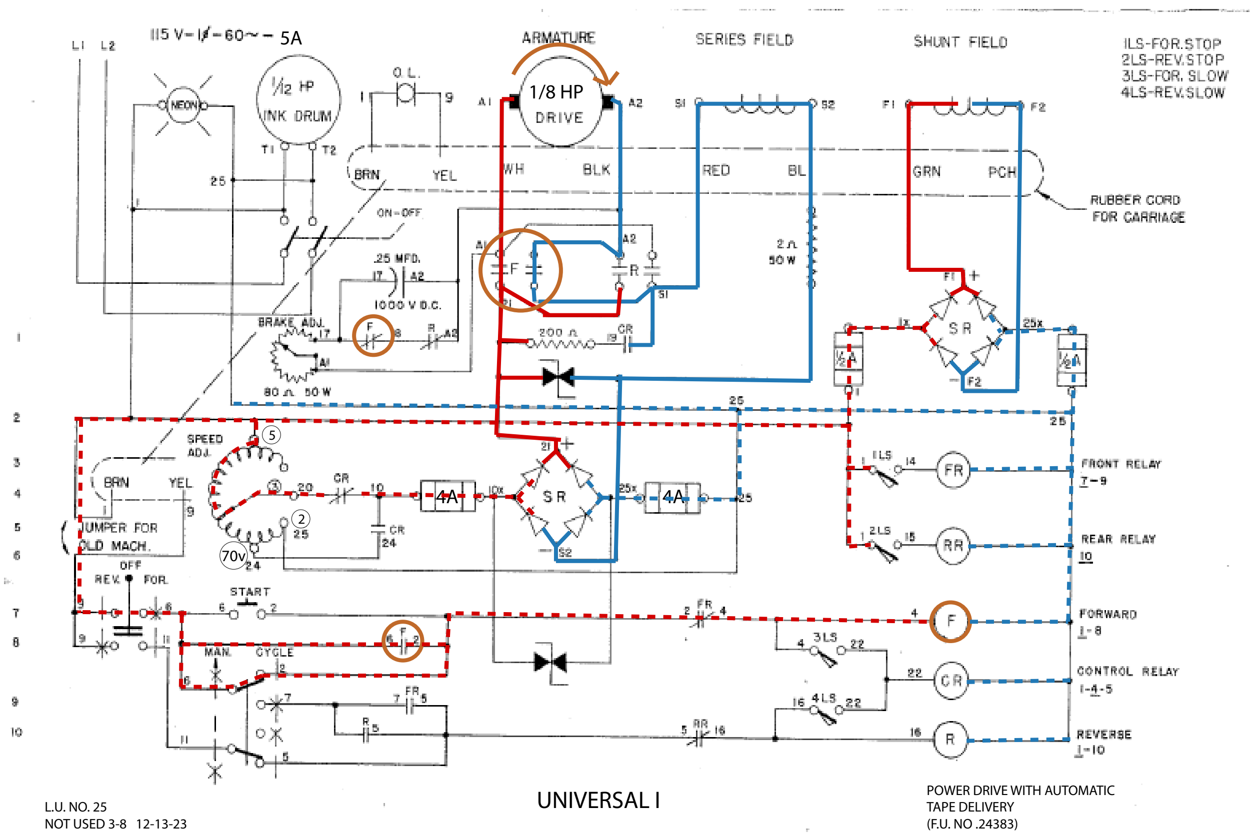

Figure 37: Control circuit in MAN FORWARD mode. The control lever is in the FOR position, and the MAN/CYCLE switch is in the MAN position. The F contactor is engaged sending DC current to the carriage motor in the forward direction. The 2LS and 4LS limit switches are engaged as the carriage starts out from the feed board, but they don't impact the carriage movement at the beginning of its travel. As the carriage starts moving, because CR is not engaged, the carriage gets a full speed AC voltage from the Variac, and the braking capacitor is charged as the motor starts up. When the carriage gets to the end of the press bed the 3LS switch will engage switching the Variac to a lower drive voltage, and then 1LS engages which stops the forward motion of the carriage.

Logic description- the F contactor is engaged if any of these conditions holds:

- **(a) IF** MAN/CYCLE is in MAN mode, **AND** handle switch is in FOR. position, **AND** FR relay is **NOT** engaged (1LS is not engaged)
- **(b) OR IF** MAN/CYCLE is in CYCLE mode, **AND** handle switch is in FOR. position, **AND** START is pressed, **AND** FR relay is **NOT** engaged (1LS is not engaged)
- **(c) OR IF** MAN/CYCLE is in CYCLE mode, **AND** handle switch is in FOR. position, **AND** F is already engaged, **AND** FR relay is NOT engaged (1LS is not engaged).

What this means:

(a) 1LS switch is NOT engaged (FR relay is not engaged) means that the carriage has NOT traveled all the way to the end of the press bed. If it has, then the 1LS switch IS engaged, which stops the forward travel of the carriage. The 1LS switch engages the FR relay, which changes the normally-closed (NC) FR connection to be an open circuit, which disengages F and the carriage stops its forward motion.

In other words, if MAN/CYCLE is in MAN mode, then the carriage moves forward as long as you keep the lever in the FOR. position, and the carriage hasn't made it to the end of the bed. It will stop automatically (through the FR relay) when it reaches the end of the bed. If it's banging into the end of the bed, adjust the cam on the back of the carriage to engage the 1LS switch earlier.

Note that there is another path to enable the F contactor that depends on the F contactor being engaged (the F switch on line 8). This is a redundant path for the F contactor in MAN mode (F is engaged if F is engaged) but becomes important in CYCLE mode.

(b) If MAN/CYCLE is in CYCLE mode, and you have the lever in the FOR. position, then the carriage starts to move when you press the START button. It continues to move if haven't yet come to the end of the press bed (1LS switch is engaged which means FR is engaged).

(c) Because the START action engages the F contactor, it continues to move forward after you release that button (F is now engaged), and until it gets to the end of the press bed and engages the 1LS switch and FR relay.

Note that in CYCLE mode you must have the switch in CYCLE position AND have the lever in the FOR. position to get things to work. Just pressing START without also having the lever in the FOR. position doesn't start the forward motion.

Also note that in CYCLE mode there's an automatic return of the carriage to the feed board. This is described in the next section on the REVERSE contactor.

5.2 REVERSE (R) Contactor

This relay passes current through the carriage drive motor to make it move in a reverse direction – from the end of the press bed back to the feed board. The primary action is to engage the two R normally-open (NO) contacts shown below the 1/8 HP DRIVE motor in the schematic to send DC current through the A1 and A2 wires to the carriage motor. The DC current is delivered with + on the A2 side and – on the A1 side (opposite of the F action) to engage the carriage motor in the reverse direction (from press bed end back to the feed board). As seen in Figure 38, the R contactor has three NO switches and one NC switch.

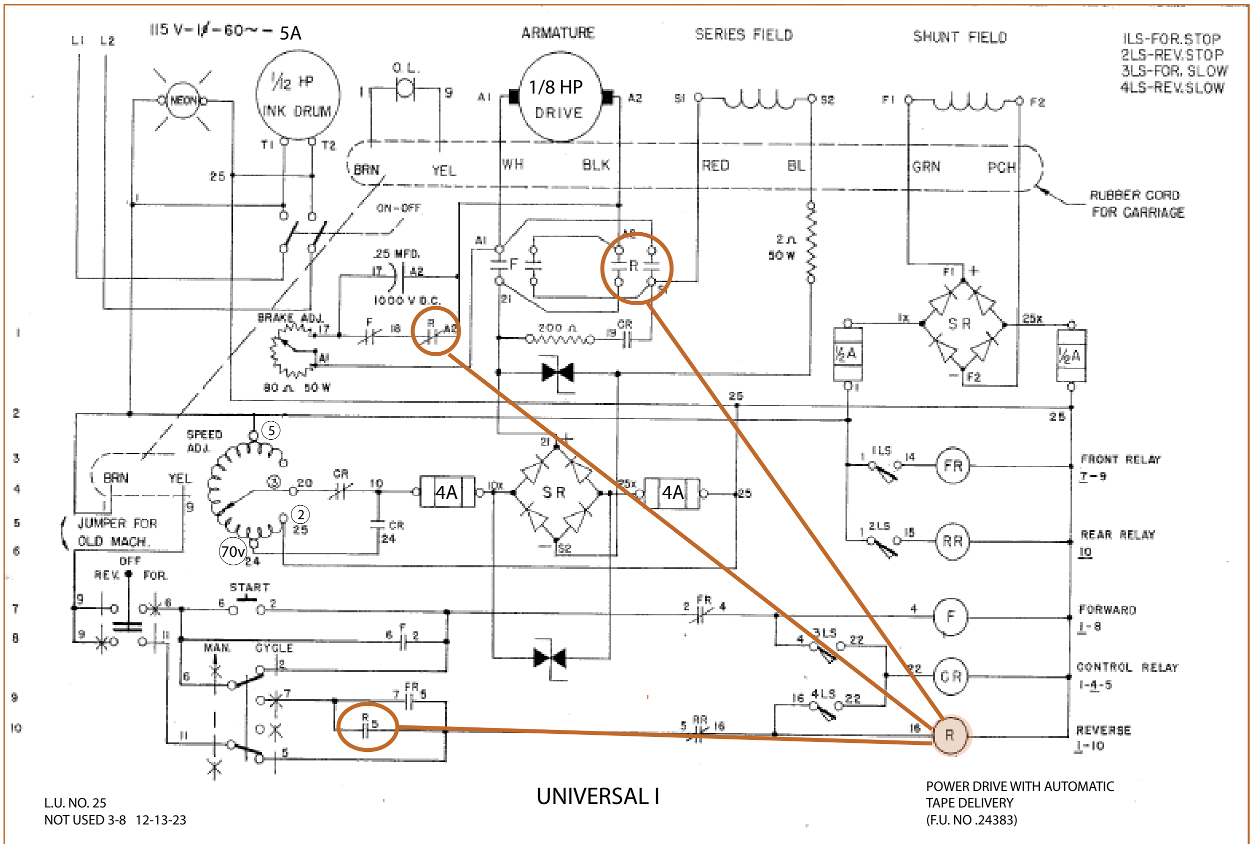

Figure 38: The R contactor has three NO switches and one NC switch.

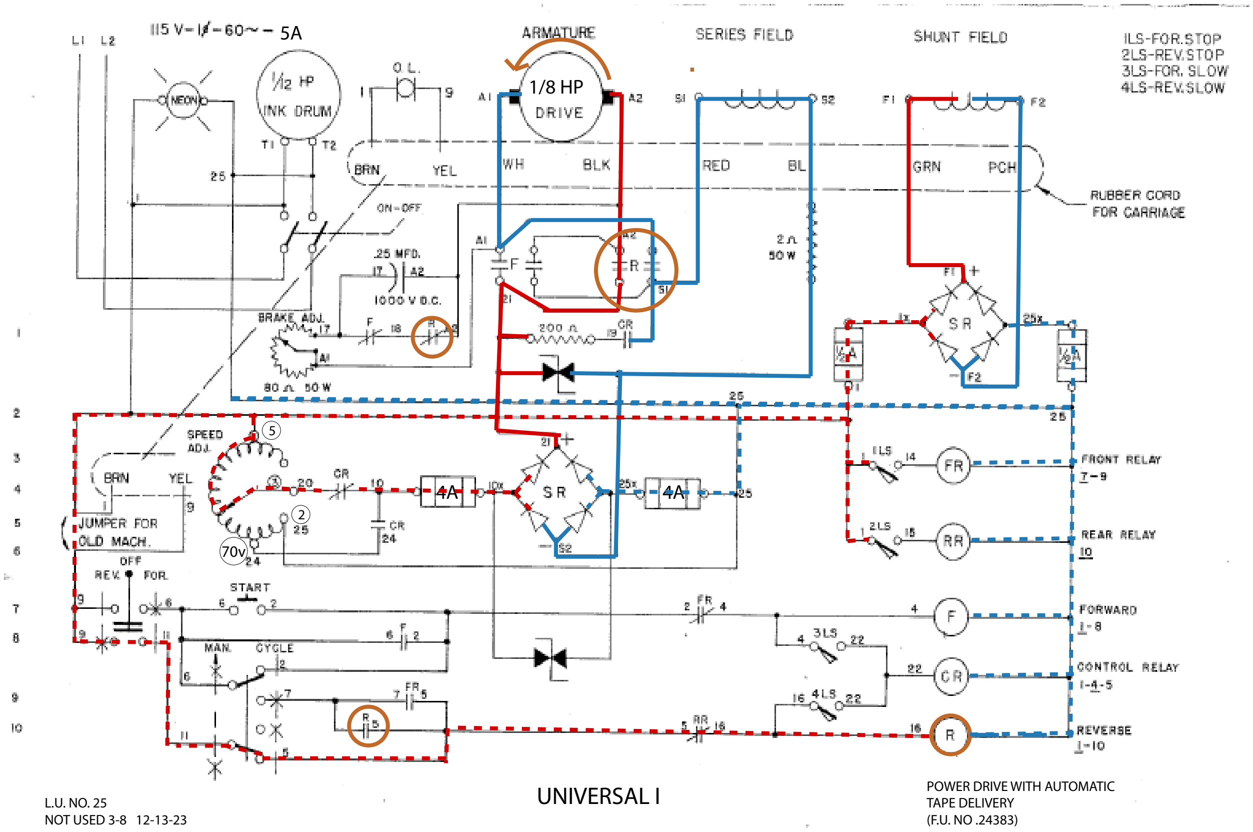

Figure 39: Control circuit in MAN REVERSE mode. The control lever is in the REV position, and the MAN/CYCLE switch is in the MAN position. The R contactor is engaged sending DC current to the carriage motor in the reverse direction (opposite current from the forward direction). If the carriage is at the press bed end, the 1LS and 3LS limit switches are engaged as the carriage starts out toward the feed board, but they don't impact the carriage movement at the beginning of its travel. As the carriage starts moving, because CR is not engaged, the carriage gets a full speed AC voltage from the Variac, and the braking capacitor is charged as the motor starts up. When the carriage gets back to the feed board the 4LS switch will engage switching the Variac to a lower drive voltage, and then 2LS engages which stops the reverse motion of the carriage.

Logic description - the R contactor is engaged if any of these conditions holds:

- **(a) IF** MAN/CYCLE is in MAN mode, **AND** handle switch is in REV. position, **AND** RR relay is **NOT** engaged (2LS switch is not engaged)
- **(b) OR IF** MAN/CYCLE is in CYCLE mode, **AND** handle switch is in FOR. position, **AND** FR relay is engaged (1LS is engaged), **AND** RR relay is NOT engaged (2LS is not engaged).
- **(c) OR IF** MAN/CYCLE is in CYCLE mode, **AND** handle switch is in FOR. position, **AND** R is already engaged, **AND** RR relay is NOT engaged (2LS is not engaged).

What this means:

- (a) Switch 2LS not engaged (relay RR is not engaged) means that the carriage is not yet all the way back to the feed board. When it does get all the way back, (and 2LS is engaged) it should not travel further in reverse.

In other words, if MAN/CYCLE is in MAN mode, then the carriage moves in reverse as long as you keep the lever in the REV. position, and the carriage hasn't made it back to the feed board.

(b) 1LS is engaged (FR engaged) means that the carriage has traveled all the way to the end of the press bed. This is an indication that it should not go forward anymore, but it IS in a position where it can be reversed and go back to the feed board.

So, if the MAN/CYCLE switch is in CYCLE mode, and you're all the way to the end of the press bed (switch 1LS is engaged), and you're not already all the way back to the feed board (2LS is NOT engaged), then you can start back by engaging the R contactor.

(c) In CYCLE mode, once R is engaged (the carriage has started its reverse travel), then you keep going in reverse until you get all the way back to the feed board (switch 2LS is engaged which means the RR relay is engaged).

Note that in cycle mode you must have the switch in CYCLE position AND have the lever in the FOR. position to get things to work, even when the carriage is making its reverse journey back to the feed board.

5.3 CONTROL RELAY (CR)

The control relay controls the SPEED ADJ circuit. The SPEED ADJ. circuit (controlled by the SPEED CONTROL knob on the control panel) is described in detail in Section 4.4. I would have called the physical component of the CONTROL RELAY a contactor because it is physically as large as the F and R contactors, and it has three switches (two NO and one NC). But, in the schematic it's called a relay, so I'll use that term.

When the CR relay is not engaged, then the carriage receives a full speed voltage from the Variac, and the 200Ω resistor (line 1) is not connected so it doesn't have any impact on the DC carriage drive motor. When the CR relay is engaged, then the drive motor receives a lower voltage through the Variac, and the 200Ω resistor is switched in between A1 and A2 odf the carriage drive motor. This combination causes the carriage motor to slow down to a fixed slow speed as it approaches the end of the press bed going forward, or the feed board when in reverse.

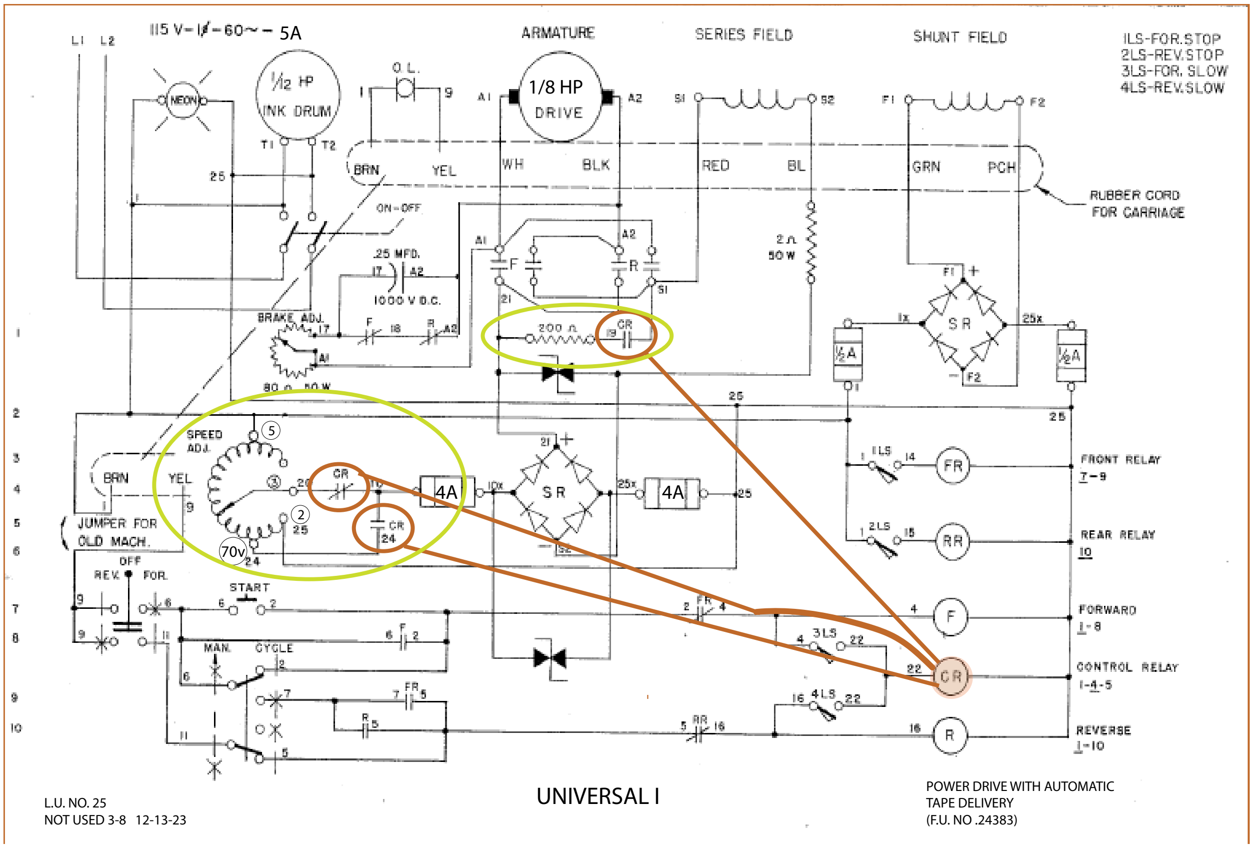

Figure 40: The CR relay (contactor) has two NO switches and 1 NC switch.

Logic description: The CR relay is engaged:

- **(a)** **IF** the carriage is moving forward **AND** the 3LS limit switch is engaged **AND** the FR relay is **NOT** engaged.
- **(b)** **OR IF** the carriage is moving in reverse **AND** the 4LS limit switch is engaged **AND** the RR relay is **NOT** engaged.

What this means:

(a) The 3LS limit switch (FOR. SLOW) indicates that the carriage is approaching the end of the press bed. So, if it's currently moving forward (towards the end of the press bed), the carriage should slow down. The carriage moving forward means that the F contactor is engaged (the wire labeled 4 on line 7 of the schematic is powered up). In that case, closing the 3LS limit switch will also engage the CR relay.

When the 1LS limit switch is closed, this engages the FR relay (line 3 of the schematic) which stops the forward motion of the carriage by cutting off the power to the coils of the F contactor and CR relay (lines 7 and 8 of the schematic).

(b) The 4LS limit switch (REV. SLOW) indicates that the carriage is approaching the feed board. So, if it's currently moving in reverse (towards the feed board), the carriage should slow down. The carriage moving in reverse means that the R contactor is engaged (the wire labeled 16 on line 10 of the schematic is powered up). In that case, closing the 4LS limit switch will also engage the CR relay.

When the 2LS limit switch is closed, this engages the RR relay (line 5 of the schematic) which stops the reverse motion of the carriage by cutting off power to the coils of the R contactor and the CR relay (lines 9 and 10 of the schematic).

5.4 FRONT RELAY (FR)

This relay is responsible for stopping the movement of the carriage if it is moving forward and gets to the end of the press bed. The NC switch on line 7 of the schematic will open (disconnect) when FR is enabled by the 1LS (FOR. STOP) limit switch closing. This cuts power to the F contactor and CR relay.

The second NO switch controlled by the FR relay (line 9 of the schematic) is to start the reverse cycle when in CYCLE mode. In this mode, the MAN/CYCLE switch is in CYCLE mode, and the press has moved forwards all the way to the end of the press bed. Once it reaches the end it should stop moving forward (as described in the previous paragraph), but it should also begin the reverse travel of the cycle. So, the NO switch will become closed when FR is enabled (by the 1LS limit switch) and cause the carriage to start reverse motion. Once set into reverse motion the R contactor is enabled, and the NO R switch on line 10 of the schematic keeps the carriage moving in reverse. This continues until the 2LS limit switch is enabled at the feed board which cuts off reverse power to the motor.

Note that there seem to be some Vandercook presses with an enhanced circuit that provides a variable delay between when the carriage reaches the end of the press bed and when it starts back in CYCLE mode. Our press does not have this circuit, so I don't have much to say about it.

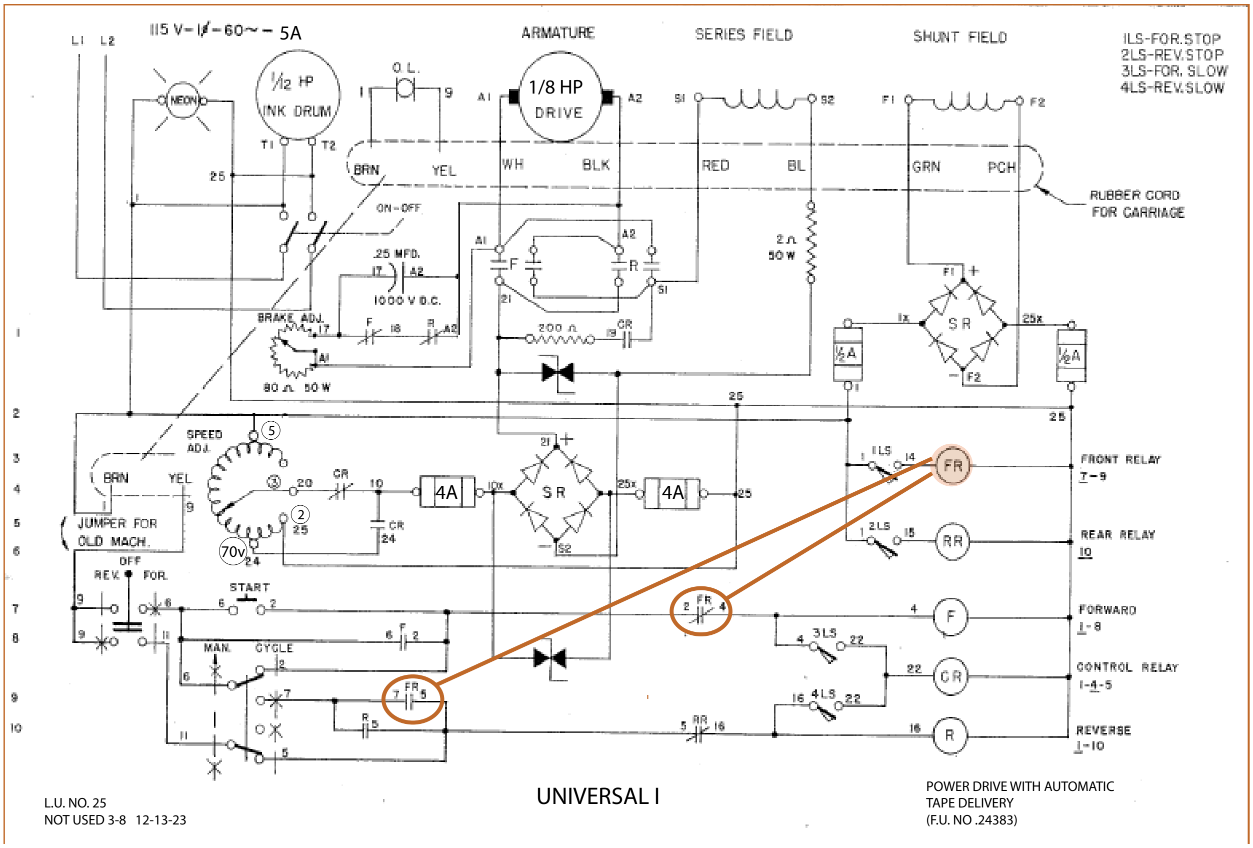

Figure 41: The FRONT RELAY (FR) controls one NO and one NC switch.

5.5 REVERSE RELAY (RR):

This relay is the simplest relay in the Vandercook control circuit. As seen in Figure 42 it has only one NC switch. The purpose of the RR relay is to cut off reverse power to the carriage motor when the carriage is in reverse and arrives at the end of the press bed (the 1LS limit switch is engaged). When the NC switch is opened (line 10 on the schematic), both the R and CR coils are cut off which stops the carriage at the end of the press bed (or starts a return cycle if the press is in CYCLE mode as described in the previous section).

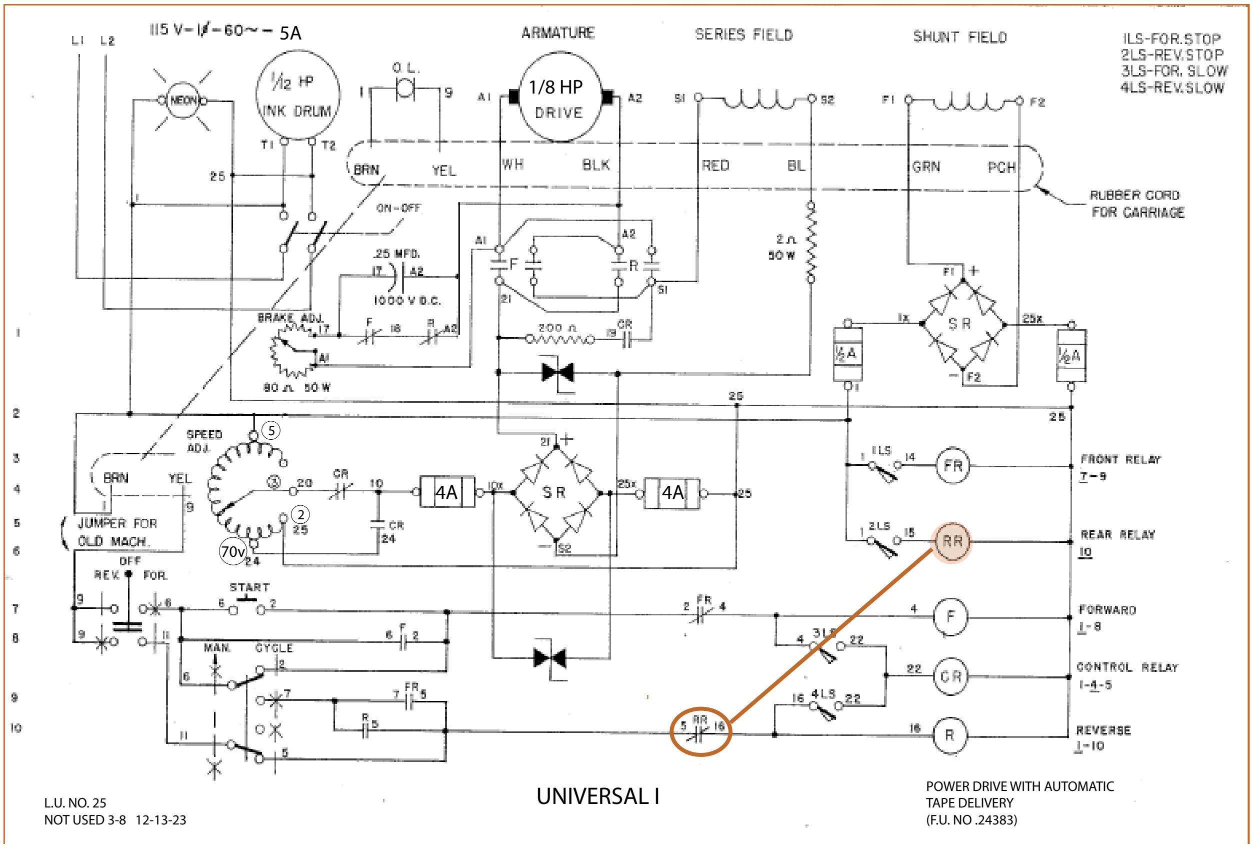

Figure 42: The REVERSE RELAY (RR) controls a single NC switch. It stops the carriage if it is traveling in reverse and has made it all the way back to the feed board.

6 Replacing/Repairing Parts on the Universal I with Power Drive

The control circuits on the Vandercook Universal I P are remarkably robust. This is partly a testament to the construction quality of the press when it was built (it was built for years of hard service in the pre-press department of commercial printing businesses), and partly due to the inherent robustness of these old-school contactor/relay-based control circuits. However, given the age of these presses, and whether they've seen a lot of service, parts in the control circuit can break. Luckily, even though these parts are old, there seem to always be a modern replacement, at least for the parts I've had to replace or repair on our press so far.

When you're trying to track down a problem or when you're replacing parts, please do be aware that there are a bunch of wires in the press that are energized with 120v AC line voltage when the press is turned on! **There are even some lines (shown as L1 and**

L2 at the top right of the press) that are powered by the line voltage even when the Vandercook switch is not yet turned on. ***This is dangerous stuff!*** I have a separate main power switch (a standard 120v AC light switch) on the back of our press that disconnects the L1/L2 line voltage to the press so that I'm not messing with anything that's powered up when I'm working on the press.

Once you decide to mess around inside the control bay, or behind the control panel, or with the carriage drive motor and the cable that connects it to the press, you'll be happy to find that all the node numbers (wire numbers) in the schematic are labeled on the wires themselves in the control circuit. The wires are also all connected through barrier blocks when they connect to different parts of the press. This lets you add or remove wires without re-wiring the whole press. You'll need to get a crimper with some crimp-on screw terminals if you want to keep things that neat when you're repairing things.

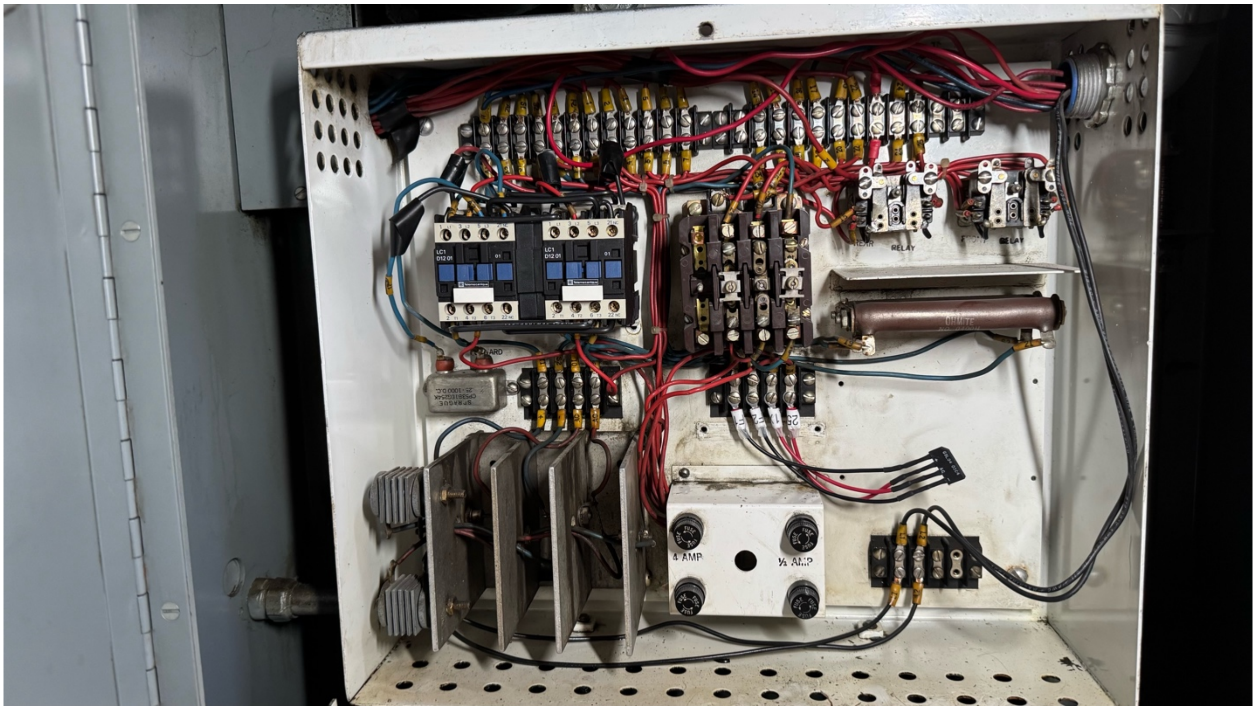

Figure 43: The current state of the control bay on our Vandercook Universal I AB P proofing press.

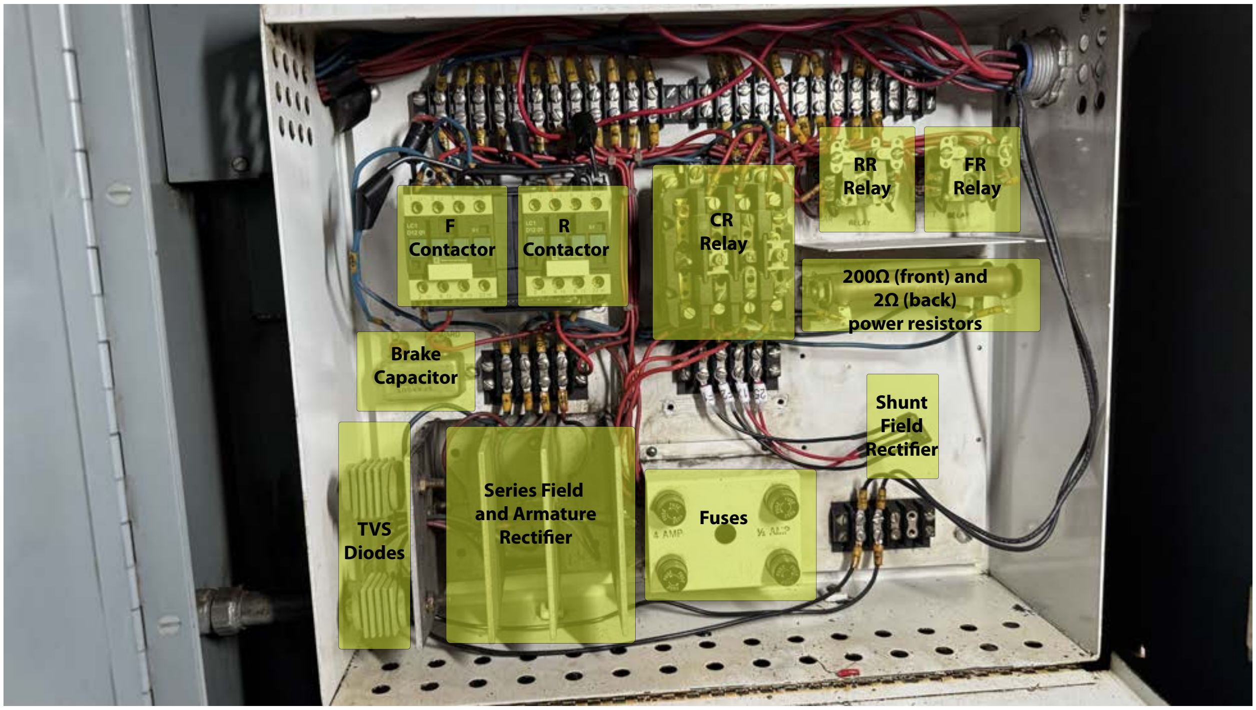

Figure 44: Control circuit labeled with the components from the schematic.

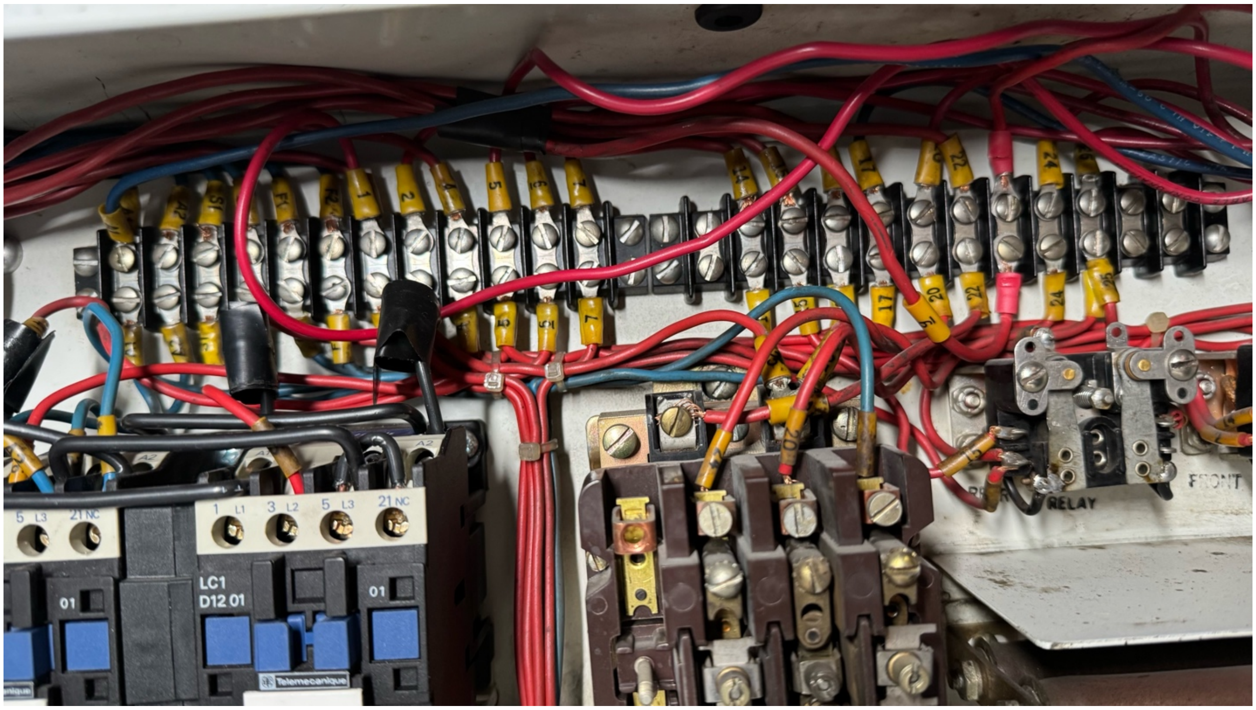

Figure 45: The top of the control bay in our press shows the barrier block at the top with crimp-on screw terminals on all wires, and all wires labeled at the factory with the same numbers are noted in the schematic. The barrier block is simply a way of connecting wires. The wire attached by the top screw and the bottom screw at any position on the block are connected together. This lets you replace one part of the wiring without re-wiring the entire circuit. For example, see the red crimp-on connectors third from the right. Those are connections that I made when repairing part of the wiring cable that goes from the press to the carriage. The bottom wire in that connection is labeled 9.

6.1 Contactor Replacement

One upgrade/repair I did to our press years ago is to replace the F and R contactors with new modern contactors. The original bakelite-body contactors were sticking so that the press carriage would occasionally travel (for example) forward to the end of the press bed and then keep trying to move forward even after the F contactor should have been disengaged. I tried removing and cleaning the contactors, but it didn't seem to fix the problem. Luckily, there are modern contactors with the same specs as the original Vandercook components.

The primary concern is that the contactors have a 120v AC control coil. And that they have four switches with three NO switches and one NC switch controlled by that coil. These specs are satisfied by industrial contactors meant to be used to switch 3-phase motors on and off – so they have three NO switches controlled by the coil. They often have a fourth switch (labeled auxiliary) that can be either NO or NC. I bought contactors made by Telemecanique, model LC1 D12 01 which have 3NO and 1NC switch, a 120v AC coil, and rated at 12A which is plenty (Figure 46). I believe that even the screw holes for mounting were the same as the Vandercook originals, but I don't remember exactly. In any case, I removed the original Vandercook contactors, attached the new ones, and wired them up as per the schematic (with the wires being nicely labeled). If you look closely on the F (left) contactor you can see the A1 and A2 wires coming from the L1 and L3 NO contacts. The 120v AC coil connections are on the top of the contactors and not directly visible in this figure. The black wires connect the A1 and A2 nodes from the F to the R contactors.

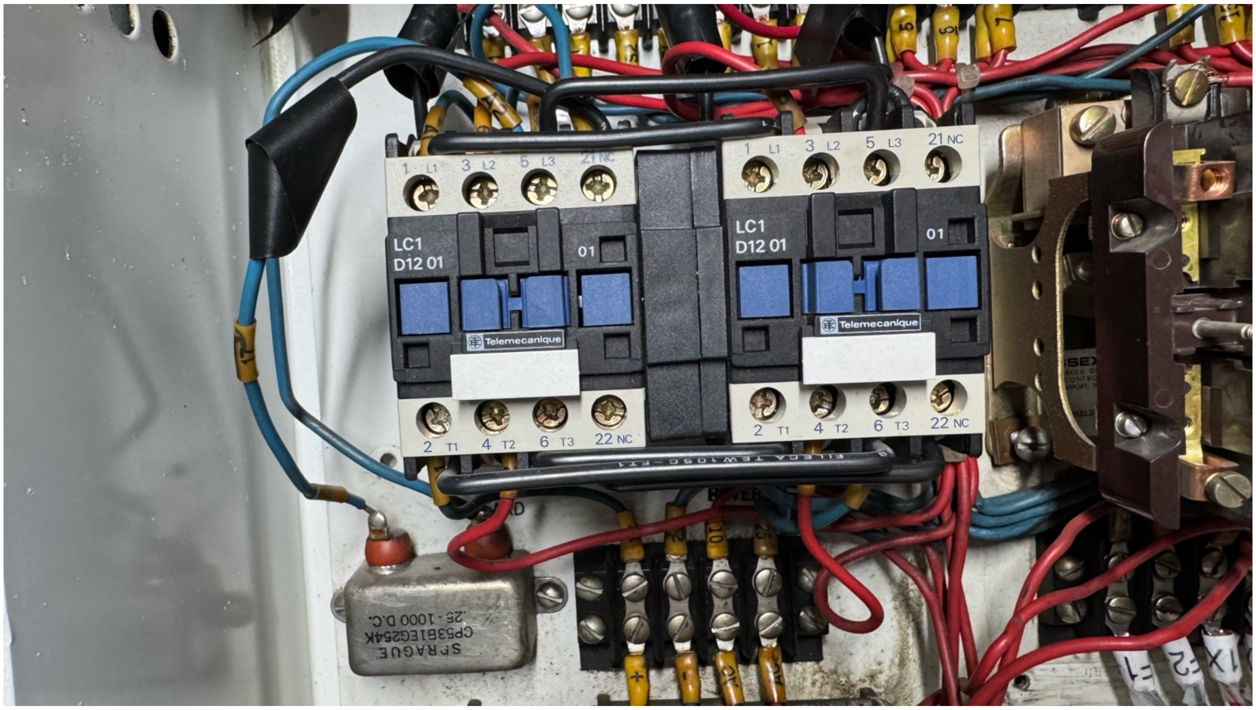

Figure 46: Replacement F (left) and R (right) contactors on our press. These are made by the French company Telemecanique and are model LC1 D12 01 contactors. The LC1 means that the coil is engaged by 120v AC. The D12 means that they can switch up to 12A (which is much more than needed in this circuit), and the 01 means that after the three NO contacts (labeled L1, L2, and L3), the "auxiliary contact" is an NC contact (labeled 21-22 NC).

Unfortunately, the Telemecanique LC1 D12 01 contactors do not seem to be being made any more as of April 2026 (I replaced these about 15 years ago). But, they're common enough that there are contactors available that are specified to exactly match these specs. There are likely many other contactors with 3 NO and 1NC contact with 120v AC coils too.

For example – if you're looking for LC1 D12 01 style contactors (as of April 2026):

- https://www.usbreaker.com/Telemecanique-LC1-Contactor/LC1-D1201-G6/NC1D1201-V120
- https://www.brahelectric.com/products/motor-controls/contactors/lc1d1201
- Or you can sometimes find original Telemecanique contactors on eBay: https://www.ebay.com/itm/375532432378?epid=169954562&itmmeta=01KPECNFYXPC10ZGJCEMVKFAS3&hash=item576f7a2bfa:g:BikAAOSwFJBmkEfi

These contactors have been working like champs in our press ever since they were replaced. If the CR relay ever starts showing signs of needing to be replaced, I'll likely replace it with a similar contactor and use only three of the connections on the contactor to match the characteristics of the CR relay (contactor). Be careful though – there are a lot of different variations on these contactors, and you need all the specs to be correct. For example, there are contactors that look similar, but use a 12v AC coil voltage rather than a 120v AC coil voltage.

6.2 Limit Switch Replacement

At the same time as I replaced the F and R contactors, I replaced all four limit switches on the back of the press (Figure 47). In retrospect, I'm not sure that this needed to be done, but it was easy once you find the right replacement switches. These types of "micro-switches" with rolling lever arm actuators are commonly available because they're used in all sorts of machines.

The micro switches used on the Vandercook use the modern Honeywell part number of BZE6-2RQ2. The BZ means that the switch is a basic single-pole single-throw (SPST) on/off switch that can handle 15A on the switch terminals. The E6 means that the enclosure is side-mount (as opposed to flange mount). The 2 is for the standard internal switch structure, and the R is for a standard single-break contact. The Q says that the switch uses no seal boot on the switch. If you would like a switch with the seal boot, you could use code N here (2RN2). Finally, the 2 at the end means that the roller lever is adjustable.

Figure 47 :The 4LS (left) and 2LS (right) BZE6-2RQ2 limit switches at the feed board end of the press. These micro switches with roller arm actuators are replacements from the original micro switches on the press.

When you buy the switch, the roller lever is pointed over the back of the switch. The lever is easily adjusted to point away from the switch body using the tightening nut at the switch base. The arm of the roller arm is 39.6mm from the center of the pivot to the center of the roller, and the roller itself is 19mm in diameter. These are standard measurements for the BZE6-2RQ2 micro switches.

For example (as of April 2026):

- https://www.mouser.com/ProductDetail/Honeywell/BZE6-2RQ2?qs=nFt9sTYf7TDSrW89euS%252BrA%3D%3D

6.3 Shunt Field Rectifier Replacement

In summer of 2025 our press suddenly stopped working and started blowing the 1/2A fuses in the rectifier circuit for the carriage motor's shunt field. After a long set of attempts at debugging this failure, it turned out that one of the diodes had failed in the diode rectifier. When I removed the entire rectifier assembly it turned out that sometime in the past another original diode had failed in this rectifier circuit and was replaced with a 1N400X silicon diode (Figure 48). This is a common series of silicon diodes where the X is the number of amps that the diode can handle safely. Given that this assembly is fused to 1/2 A, even a 1N4001 diode would work in this situation, but it wouldn't hurt to use a larger diode like 1N4002, or 1N4003.

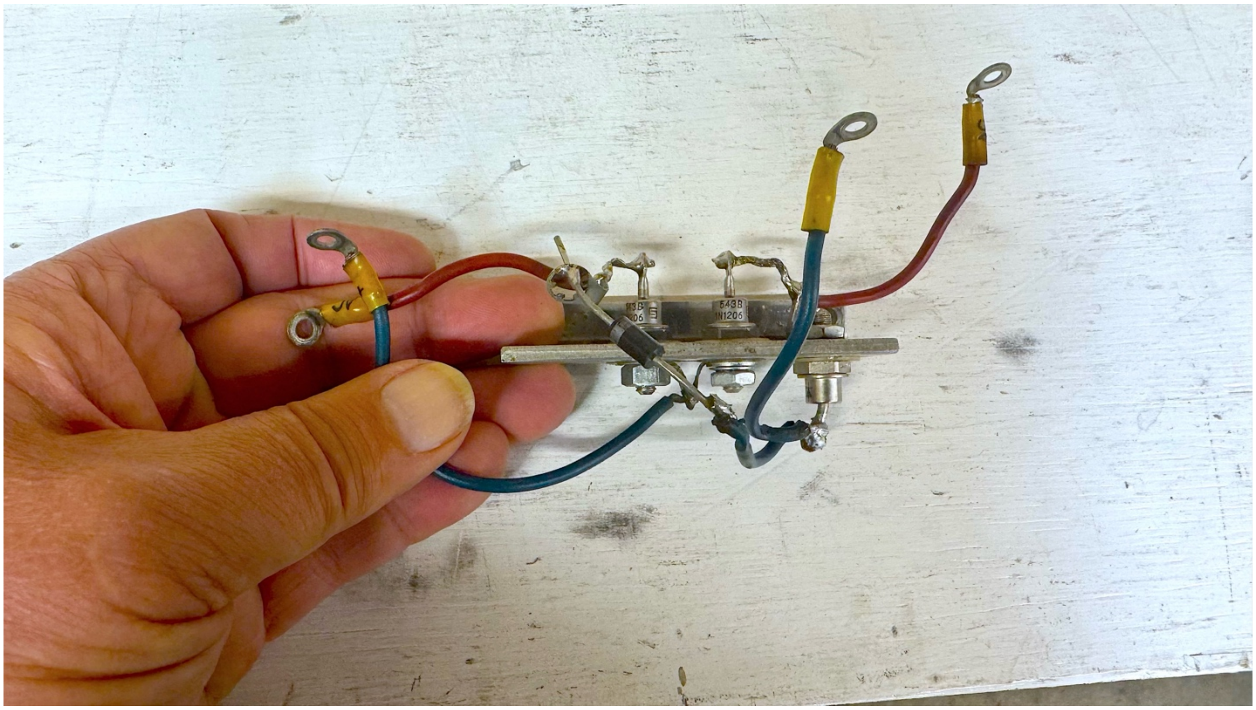

Figure 48: The original diode rectifier assembly for the carriage motor shunt field. This is shown on the right side of the schematic on line 1. At some time in the past the fourth screw-in diode that would have been where my fingers are must have failed and it was replaced by a silicon diode of the 1N400x series where x is the number of amps that the diode can handle. I didn't disassemble further to see which additional diode had failed. In this assembly the red wires were labeled AC and the blue DC wires were labeled + (by my thumb) and -. These were connected to F1 and F2 on the motor (Shunt Field) through the cable assembly.

Instead of bridging with yet another replacement silicon diode, I decided to replace the assembly completely with a silicon rectifier. These are components that have all four diodes connected inside a single package. I ended up using a GBL04 rectifier that can handle 4A of current making it more than up to the task of rectifying in a circuit fused to 1/2 A. It also can use a max AC input voltage of 400v, again making it more than sufficient (See Figure 49). I measured the DC voltage at the output of the new rectifier at 106.5v DC. This is less than the theoretical maximum from the rectifier, but the resistance of the shunt field itself also drops some DC voltage around this connected circuit. The bracket for the original circuit was likely serving as a heat sink to dissipate the generated heat. I tested this replacement and it was only getting very slightly warm so I didn't bother to reinstall any sort of heat sink on this component. You can see the bridge installed in the circuit in Figure 50, and back in Figures 43 and 44.

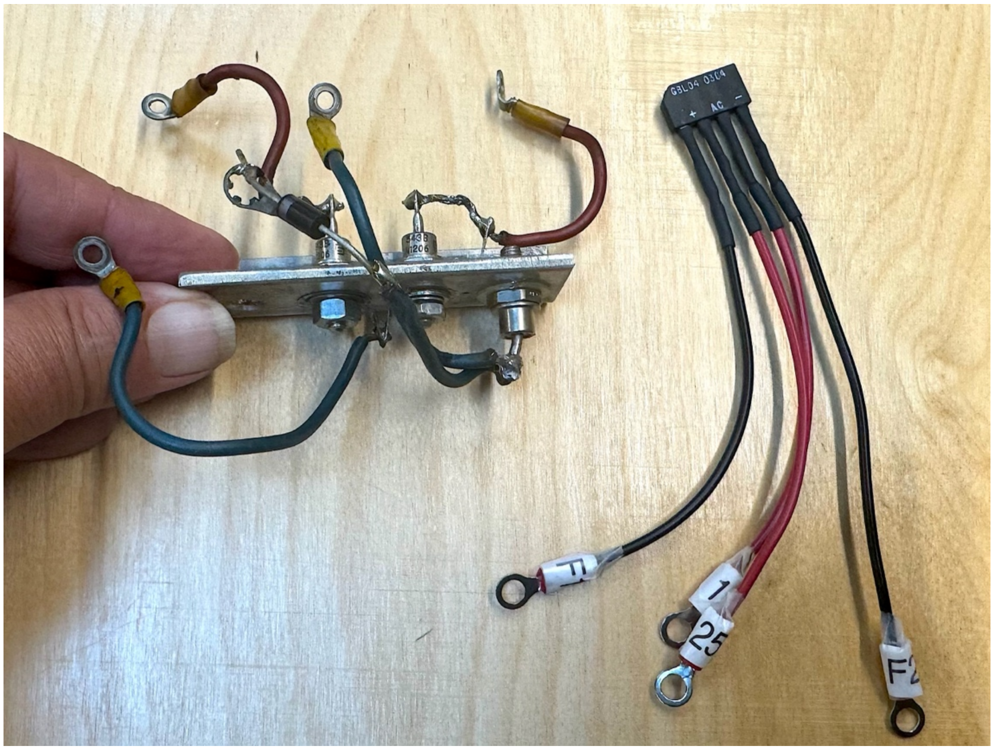

Figure 49: The original diode bridge made with four separate diodes, and my replacement using a GLB04 silicon rectifier chip.

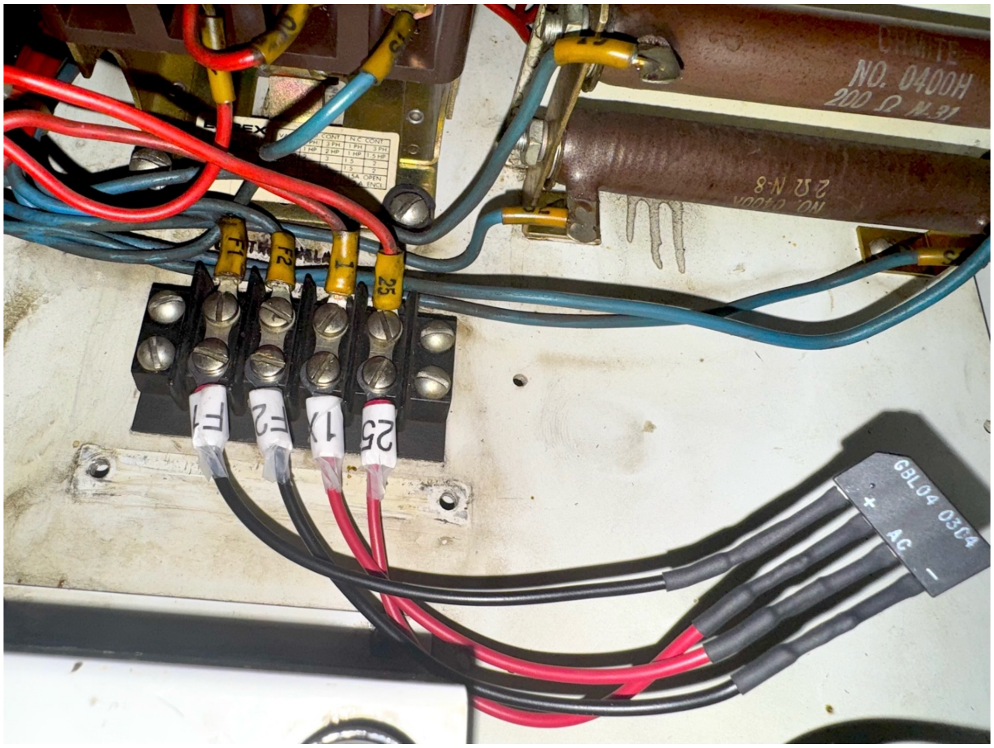

Figure 50: The new GBL04 rectifier installed in the circuit. The bracket for the original circuit was likely serving as a heat sink to dissipate the generated heat. I tested this replacement and it was only getting very slightly warm so I didn't bother to reinstall any sort of heat sink on this component. See also Figures 43 and 44.

Although I haven't seen any issues with the other diode bridge in the circuit – the one that drives the armature of the drive motor – I will keep an eye on it and be prepared to do a similar replacement on that bridge. In that case, because that circuit is fused to 4A, I'll need a beefier rectifier. Perhaps something like a KBJB1006 that can handle 10A of current. This is in a slightly larger package with a hole for attaching the chip to a heat sink but otherwise looks just like the GBL04.

These rectifier chips are common and readily available anywhere integrated circuits are sold. For example (as of April 2026):

- GBL04: https://www.mouser.com/ProductDetail/Taiwan-Semiconductor/GBL04?qs=tHU%2FlV7kTyQa1AZx%2Fcvk0g%3D%3D
- KBJB1006: https://www.mouser.com/ProductDetail/Panjit/KBJB1006_T0_00301?qs=VVKQmw408U9JEdfPkeqDfg%3D%3D

6.4 Carriage Cable Replacement

When I was figuring out the cause of the ½ A fuses blowing in our press, I also looked at the cable that connects the moving carriage to the man body of the press. This is the cable specified at the top of the schematic as the “rubber cord” (see Figure 27). This cable contains the eight wires that connect the control circuit to the drive motor. Because this cable is constantly moving and twisting as the press carriage moves back and forth, over time the cable, and especially the wires inside the cable, can fray and possibly short out.

When I asked for advice on the Vanderblog (https://vandercookpress.info/), some helpful advice from Dan at The Arm studio in Brooklyn (https://www.thearm.org/) was to check out the cable assembly. He pointed out that “A common point of failure is the shrouding where the individual wires exit the motor. It disintegrates to dust and the copper wire shorts against the other wires or against the motor body itself.” He also warned me that it’s easier to check this if you take the motor off and tip it on its side, but that the gearbox oil will then likely spill. He was right on all counts! (see Figure 51)

So, long story short, I decided to replace the “rubber cord” cable assembly completely. First, I removed the drive motor and set it on its side so that I could remove the plate hiding the wire connections (this did, in fact, drain the gearbox oil all over the place!). Then I disconnected the motor from the existing wiring cable (Figure 52 and 54 (left)).

Once everything was disconnected, I purchased a 10ft length of 8-wire 16 gauge cable from Amazon. This is slightly thinner than the Vandercook cable, but 16 gauge wire can carry 10 amps, so this should be more than sufficient (the motor is circuit is fused to 4A). I measured the cable that I removed from the press, and prepared my new cable with crimp-on screw connectors on the press end and stripped wires on the motor end (Figure 53). I used Wago lever splice connectors to make the connection to the motor. These are very handy, and very secure wire connectors that are also easily removed if, for some reason, you want to remove them (see Figures 53 and 55).

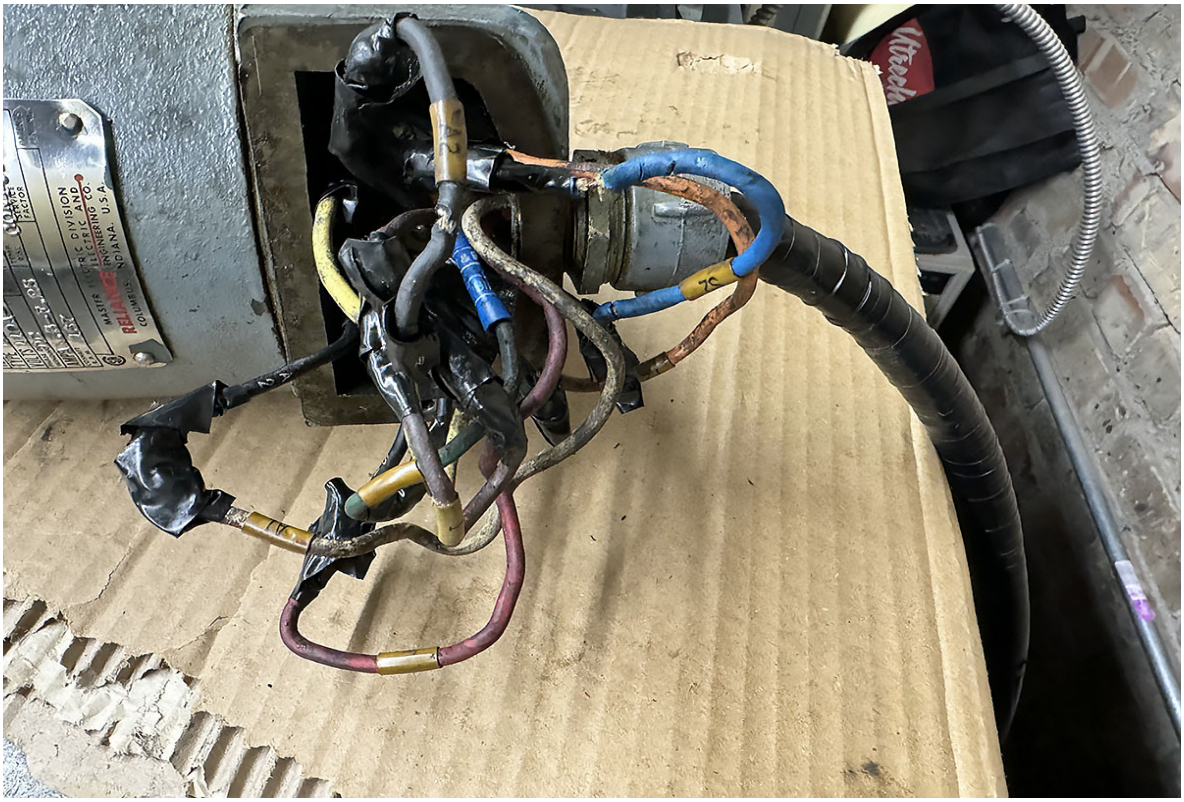

Figure 51: The ugly wiring connecting the carriage drive motor to the press on our Vandercook Universal I. The black wire labeled A2 is one of the motor wires. The (oily) colored wires are from the “rubber cord” connecting the motor to the press. You can see, for example, on the blue S2 wire that the wire has frayed almost to the point of failure.

Figure 52: The original "rubber cord" cable assembly fully removed from the press. The right end in this picture was attached to the motor and was in very bad shape with fraying wires and oily and disintegrating insulation. The left end was connected to the bottom of the press body through screw connectors to a barrier block.

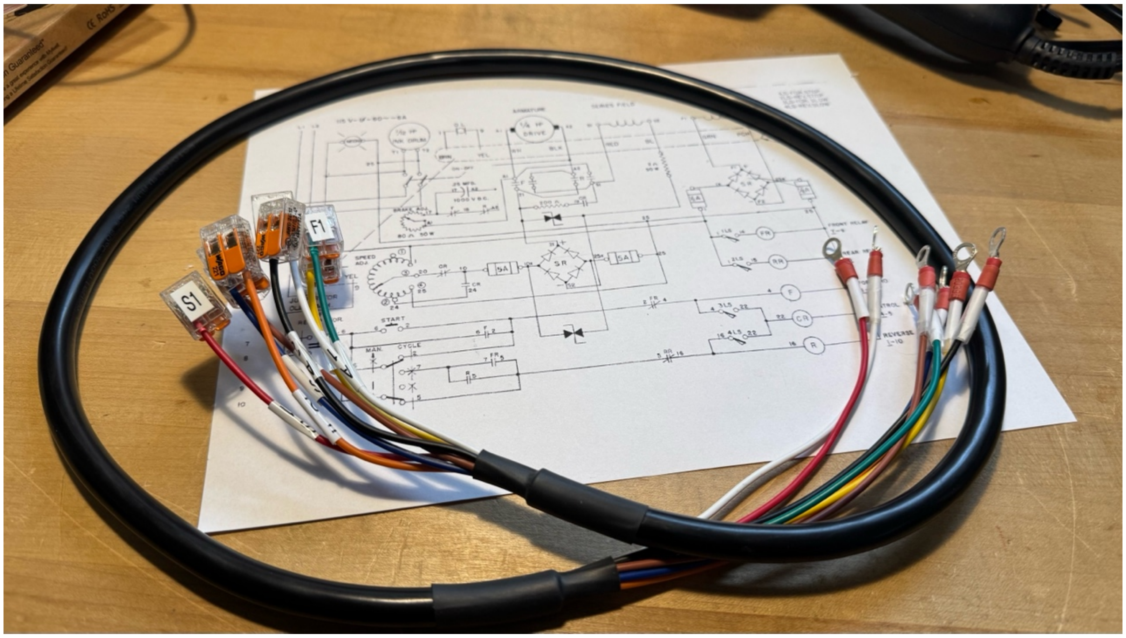

Figure 53: The new cable I built. I purchased an eight-wire cable on Amazon that happened to have exactly the same colors for the interior wires as the Vandercook cable. On the left in this photo are the connections to the motor with the Wago lever splices I will use to connect to the motor. On the right are the crimp-on screw connectors I'll use to connect to the barrier block on the press. Each end of the wire needs to also have a "thickening" ring added so that it can twist freely when the press carriage moves back and forth.

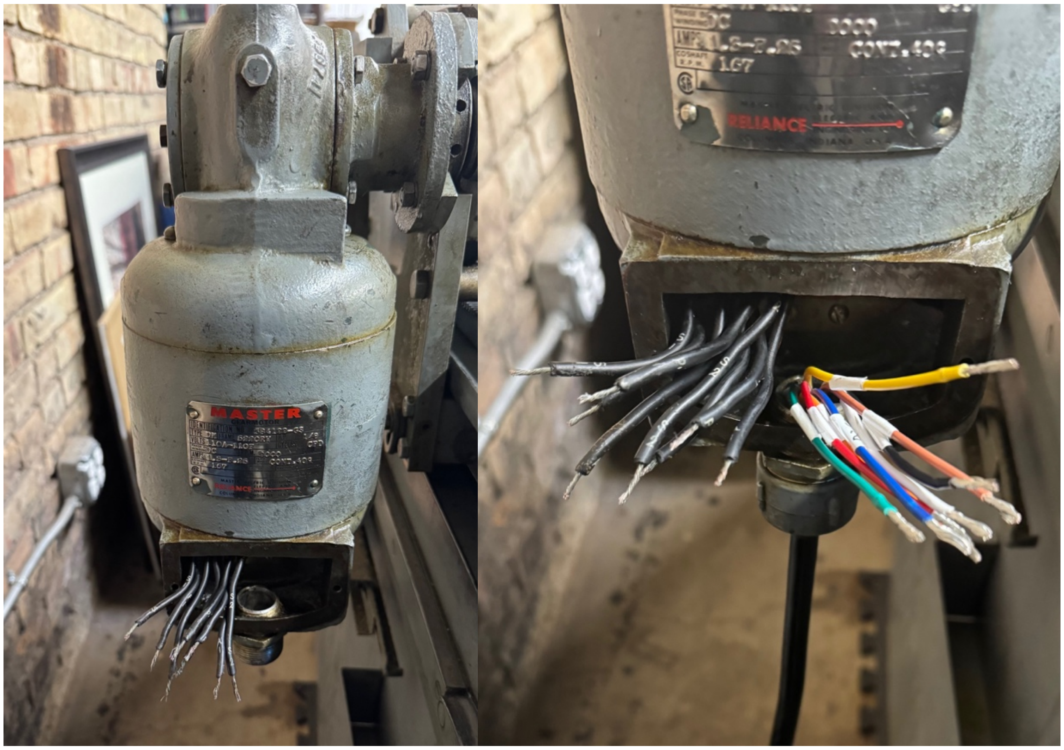

Figure 54: Left shows the eight motor wires disconnected from the old cable and cleaned up. Right shows the new cable wires threaded through the motor connection and ready to be connected.

Figure 55: This shows the cable wires connected to the drive motor using Wago lever splices. These are very handy and very solid connections and are easily removable if, for any reason, you want to change things. I stuffed them all in the motor wiring cavity and replaced the plate on the outside.

Figure 56: This shows the thickening ring on the press-end of the cable. I used a cardboard ring which I then wrapped with rubber self-fusing tape. This ring sits on the mounting flange and lets the cable rotate freely as the press carriage moves back and forth, but does not allow the cable to pull directly on the screw connections to the barrier block.

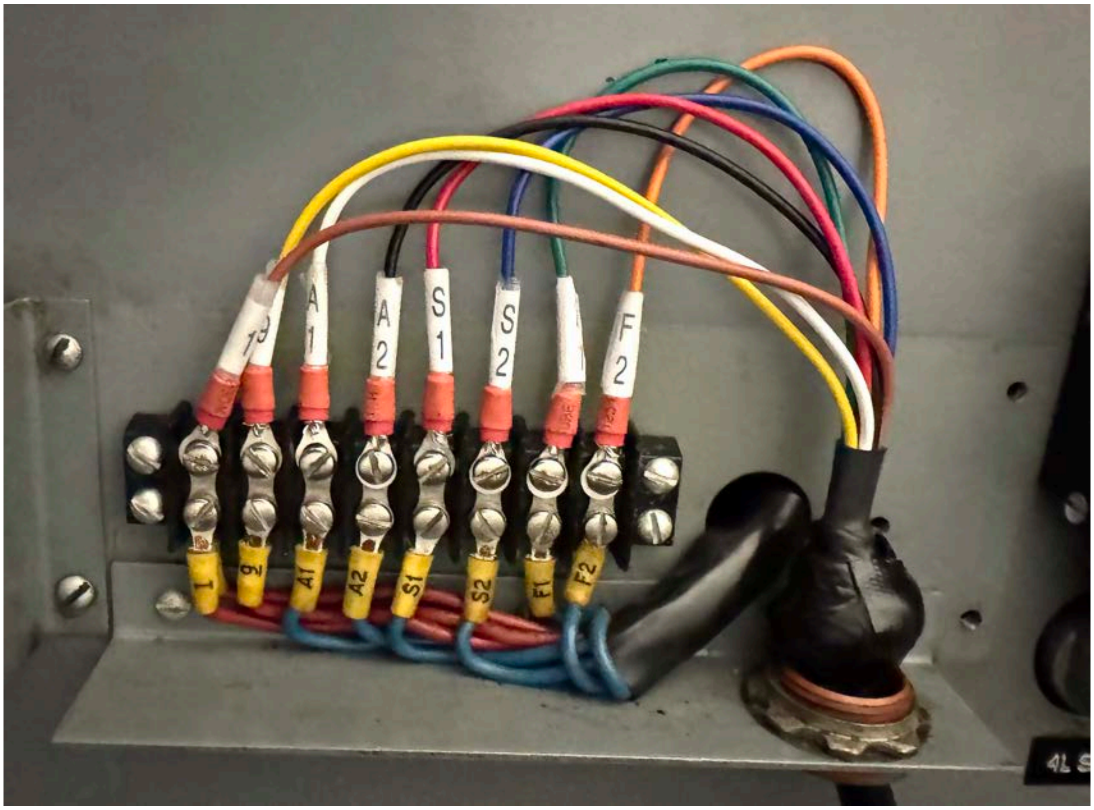

Figure 57: The barrier block connection between my new cable and the press body. Note that all the wires on the press are again labeled with their node number from the schematic. There is a metal cover that is screwed on to protect this connection once the wires have been connected.

Once everything was reconnected (Figures 55 and 57), the new cable worked just as I hoped and now makes a much more solid connection from the press body to the press carriage.

Pointers to the materials I used (as of April 2026):

- 16 gauge 8-conductor wire cable: https://www.amazon.com/dp/B0FBG2G779?ref=ppx_yo2ov_dt_b_fed_asin_title&th=1
- Wago 221-412 2-conductor compact splicing connectors: https://www.amazon.com/dp/B00JB3U7Y6?ref=ppx_yo2ov_dt_b_fed_asin_title&th=1
- Self-fusing electrical tape (just one example – there are many options): https://www.amazon.com/dp/B005298APQ/?coliid=IGMWNWSTZW10P&colid=VW6QMMEH2C0U&psc=1&ref_=list_c_wl_lv_ov_lig_dp_it
- Crimp connectors (just one example – there are many options): https://www.amazon.com/dp/B0BZC9JLFT/?coliid=IPBJ3LMP9QG0I&colid=VW6QMMEH2C0U&ref_=list_c_wl_lv_ov_lig_dp_it&th=1

6.5 Full List of Replacement Parts

Although I haven't needed to replace any other parts than the ones described in the previous sections, all of the electrical components *should* be available in modern replacement versions if needed. The Vandercook part numbers are not all that useful unless you're ordering from Fritz at NA Graphics (https://nagraph.com/). NA Graphics in Silverton Colorado is the current provider of all existing original Vandercook parts, and many replacements, as well as a host of other general letterpress supplies and parts.

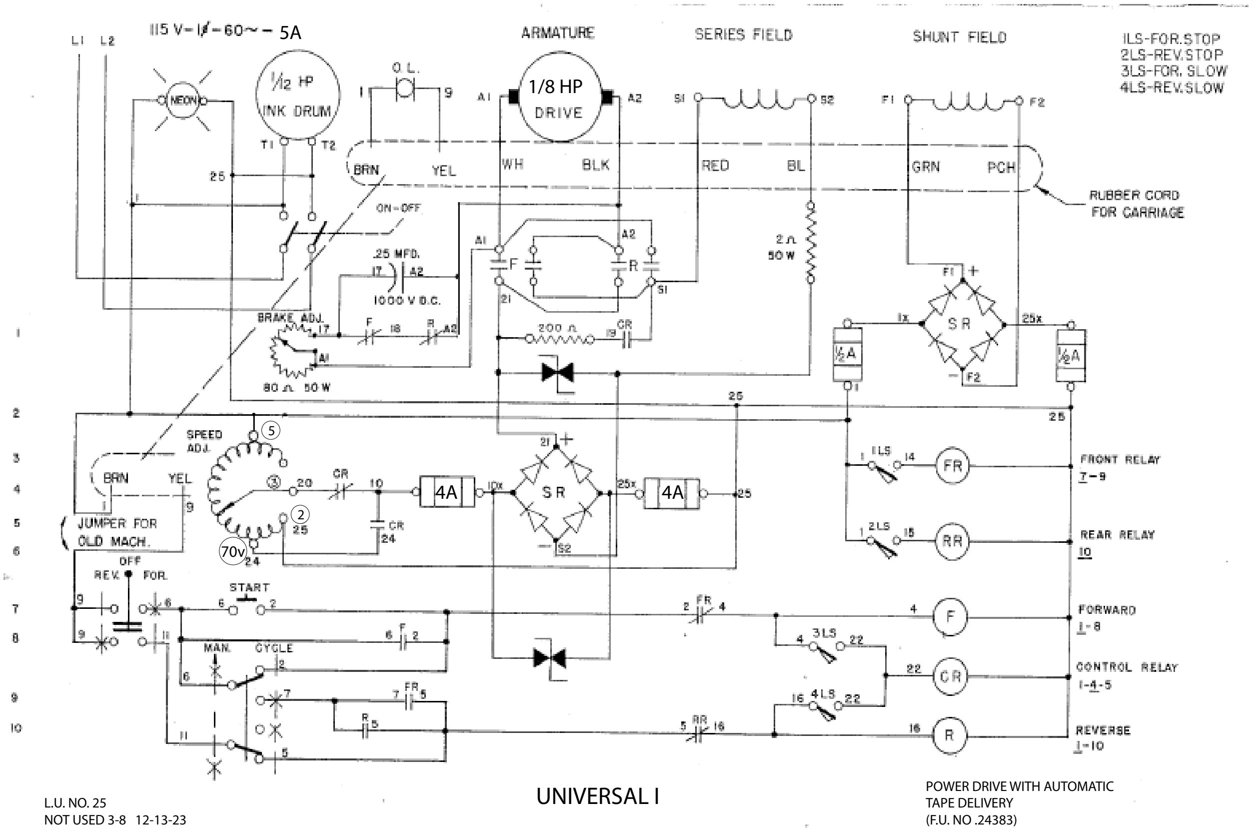

Figure 58: Another view of the Vandercook powered-carriage schematic. I've repeated this here for ease of correlating the parts to the schematic.

As for replacements – there is a great starting point at https://vandercookpress.info/power-carriage-parts/. This page gives original part numbers which may or may not help get to a modern replacement. Here are some additional thoughts on replacement parts (all links were valid as of April 2026):

- **Bridge rectifiers**: See Section 6.3 for my replacement and suggestions for replacing these individual-diode rectifiers with semiconductor rectifier chips:
    - Shunt field rectifier: GBL04, a 400v, 4A standard bridge rectifier - https://www.mouser.com/ProductDetail/Taiwan-Semiconductor/GBL04?qs=tHU%2FlV7kTyQa1AZx%2Fcvk0g%3D%3D
    - Drive motor series/armature rectifier: KBJB1006, a 600v, 10A glass passivated bridge rectifier - https://www.mouser.com/ProductDetail/Panjit/KBJB1006_T0_00301?qs=VVKQmw408U9JEdfPkeqDfg%3D%3D

- **Brake circuit capacitor**: This is a 0.25MFD 1000VDC metal "bathtub" capacitor with the part number Sprague CP53B1EG254K. These seem to be available on eBay, or through specialty electronics vendors such as:
    - https://www.tedss.com/2020106024?srsltid=AfmBOopxMmcTRvY-b18ckoar4m1Oge4ldnbd7QOYy8XRZKTaCRfKEXwr
      (Note that the capacitor listed on the at https://vandercookpress.info/power-carriage-parts/ of Mallory FP 119A does not seem to be the correct capacitor...)

- **Forward (F) and Reverse (R) contactors**: These are 115-120 VAC coil, 3NO, 1NC contactors. These are standard industrial contactors used for 3-phase motor control. This means that they have three NO contacts used to turn a 3-phase motor on and off. They also have one "auxiliary" contact that can be either NO or NC depending on the contacted used. The contactors used in the Vandercook (F, R, and CR) all use an NC switch as the auxiliary (fourth) contact.

  When I replaced the F and R contactors on our press I used Telemechanique LC1 D12 01 contactors (see Section 6.1).

    - LC1 D12 01 replacement :https://www.usbreaker.com/Telemecanique-LC1-Contactor/LC1-D1201-G6/NC1D1201-V120
    - A different LC1 D12 01 replacement: https://www.brahelectric.com/products/motor-controls/contactors/lc1d1201
    - Or you can sometimes find original Telemecanique contactors on eBay: https://www.ebay.com/itm/375532432378?epid=169954562&itmmeta=01KPECNFYXPC10ZGJCEMVKFAS3&hash=item576f7a2bfa:g:BikAAOSwFJBmkEfi

- **Control Relay (CR) contactor**: This is a 115-120 VAC coil, 2NO, 1NC contactor. I would probably use the same LC1 D12 01 contactor as for Forward and Reverse, with only connecting 2 out of 3 of the NO switches. As mentioned in the previous bullet, these contactors are made for 3 phase power switching so they all have 3NO switches with one auxiliary switch. Make sure that any contactor you choose has an NC switch as the auxiliary (fourth) switch.

- **Front Relay (FR) and Rear Relay (RR):** The file at https://vandercookpress.info/power-carriage-parts/ says that these are both Ohmite DOSX-7T DPDT 115 VAC 15A relays. These are old-school open-frame double-pole double-throw (DPDT) relays. This means that there are two switches controlled by this relay, and each switch can be connected as a NO or a NC switch depending on which pins you connect to (Figures 59 and 60).

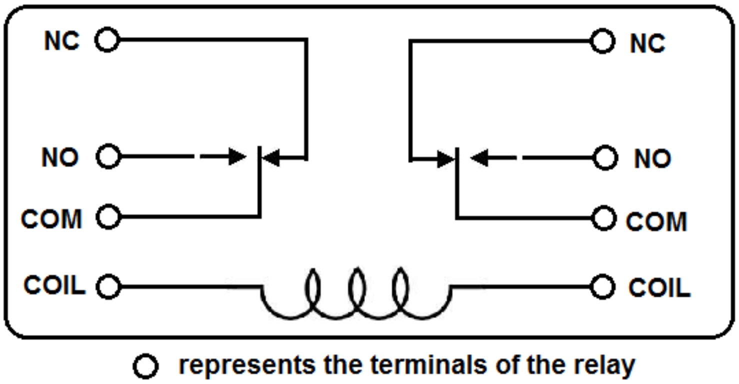

Figure 59: Looking down from the top, these are the connections on the Ohmite DOSX-7T DPDT relay. Note that there are two switches, and each switch can be connected as a NO switch (connect to the NO and COM terminals) or an NC switch (connect to the NC and COM terminals). This can be used for either the FR or RR relays in the Vandercook circuit.

  - If you're looking for the Ohmite DOSX-7T you can find those on eBay: https://www.ebay.com/sch/i.html?_nkw=DOSX-7T&_sacat=0&_from=R40&_trksid=m570.l1313
  - You can likely find other relays that would work fine. The specs are that the coil should be 115-120VAC, and the relay should be DPDT and rated at 10-15A current.

  - Robert Meehan at Pier Six Press (https://piersixpress.com/) has reported good results using OMRON MY2N-J AC110 relays. I couldn't find that exact part number, but here's another OMRON MY2N relay that should work: https://www.mouser.com/ProductDetail/Omron-Automation-and-Safety/MY2N-GS-R-AC110-120?qs=iLKYxzqNS76j7Ut2pi%252Bmwg%3D%3D

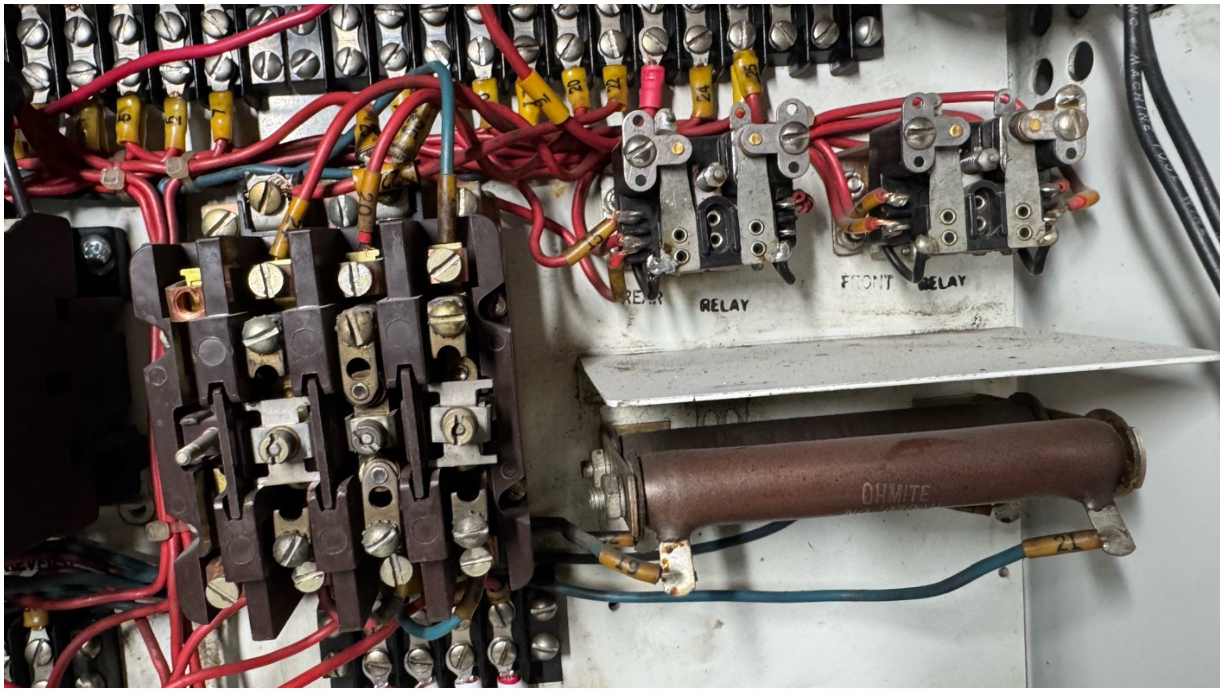

Figure 60: The Front Relay (FR) and Rear Relay (RR) are both Ohmite DOSX-7T 115 VAC 15A relays. In this picture you can also see the CR Control Relay (contactor) on the left and the two Ohmite power resistors (the brown tubes at the bottom right).

- **Limit switches** (1LS, 2LS, 3LS, and 4LS): These are readily available Honeywell BZE6-2RQ2 (no rubber boot) or BZE6-2RN2 (with rubber boot) micro switches with roller arms to make contact with the switch (see Section 6.2).
  - For example: https://www.mouser.com/ProductDetail/Honeywell/BZE6-2RQ2?qs=nFt9sTYf7TDSrW89euS%252BrA%3D%3D

- **Power resistors:** There are two power resistors in the Vandercook circuit (see Section 3.3 and the brown tubes at the bottom right of Figure 60). These are clearly marked as to their resistance and (at least on one) power rating. Note that the https://vandercookpress.info/power-carriage-parts/ list appears to have these with incorrect values. The correct values (verified visually and through measurement on our press) are as follows:

  - The Series Field resistor is a 2Ω 50w resistor in line with the S2 wire in the schematic. For example: https://www.mouser.com/ProductDetail/Vishay-Huntington/FVT05006E2R000JE?qs=sGAEpiMZZMtlubZbdhIBIP8Qe7E0Dg4c6PvIuv0%252BUIs%3D
  - The Speed Control resistor on line 1 of the schematic (between nodes 21 and 19) is listed on the schematic as 200Ω with no wattage rating. But, it's the same physical size as the Series Field resistor, so I would guess it's also a 50w resistor. Certainly there's no harm in going for more wattage than is technically required: https://www.mouser.com/ProductDetail/Ohmite/D50K200E?qs=sGAEpiMZZMtlubZbdhIBIFJnMSLa3LlK5jJMG1Pafg0%3D

- **Brake Adj. circuit rheostat**: This is listed in the schematic as an 80Ω, 50w rheostat. The https://vandercookpress.info/power-carriage-parts/ list says that this is an Ohmite 319 rheostat.
  - The Mouser catalog has exactly one rheostat that matches these specs – the Ohmite RJS80RE. Beware – this is a $297.58 part as of April 2026: https://www.mouser.com/ProductDetail/Ohmite/RJS80RE?qs=bq0YycR9F1It40mu3DteDA%3D%3D

- **Speed Control Variac**: The https://vandercookpress.info/power-carriage-parts/ list says this is an Ohmite VT 8X part. This is a part number of a "vintage" 7.4A Variac designed to adjust voltages from 0 to 140 VAC based on a 120v AC input (which is what I measured on our press).
  - There was one vintage Ohmite VT8X listed on eBay as of April 2026: https://www.ebay.com/itm/147262706084?itmmeta=01KPMJR29BYZSBJQE9F78YKQEE&hash=item22498a91a4:g:AcMAAeSwpQZp4aVq
  - I found a modern version that seems to have the same (or largely similar) specifications ($420 as of April 2026 – yikes!): https://iseinc.com/_shop/variabletransformers/variac-single-phase/variacsinglephase120vacinput0-140voutput/501-cvariabletransformer120vacsinglephaseinput0-140vacoutput50amanualormotoroperated.html

- **Bidirectional Transient Voltage Suppressor diodes (TVS diodes):** These diodes are not specified in the schematic as to exactly what transient voltages they are rated for. They are also not listed specifically in the https://vandercookpress.info/power-carriage-parts/ list. Without knowing what voltages these diodes are rated to clamp, it's hard to suggest a replacement. If I can find someone who can help imagine what voltages these might be rated for, I'll update this document. The TVS diodes on the AC side of the Drive motor bridge, for example, will see working voltages of 0-140 VAC.
    - For example, a bidirectional TVS diode with a 140V working voltage, clamping to 226.8V is https://www.mouser.com/ProductDetail/Comchip-Technology/A5KP140CA-G?qs=vdiGlTBG6JuDoDfry0Hq5Q%3D%3D . This seems plausible, but I have *no idea* if these are close to the specs from the original Vandercook parts. Also this is a non-stocked part that has a lead time of 16 weeks from Mouser!

- **Control switch/button replacements**: I would go with the suggestions in https://vandercookpress.info/power-carriage-parts/ . There seem to be modern versions of each of these buttons and switches.
    - Start button – just about any push button momentary switch would work. Mouser carries the Honeywell 12MA7 used in the Vandercook: https://www.mouser.com/ProductDetail/Honeywell/12MA7?qs=76clDfzSCJQB2AHrULFk%2FA%3D%3D
    - Power switch – just about any 115-120 VAC rated SPST toggle switch will work. For just one example: https://www.amazon.com/dp/B000HEIY1Q/?coliid=I2Y1CN4QH02GT2&colid=VW6QMMEH2C0U&ref_=list_c_wl_lv_ov_lig_dp_it&th=1
    - Run bulb – just about any 115-120 VAC rated bulb will work. The B2A neon bulb used in the Vandercook is available many places. For example: https://www.amazon.com/dp/B0DYPJY6BH/?coliid=IEWBX32EMJK0F&colid=VW6QMMEH2C0U&psc=1&ref_=list_c_wl_lv_ov_lig_dp_it
    - Allen Bradley 800T T2MB21 lever used for the FORWARD/REVERSE lever: https://www.radwell.com/en-US/Buy/ALLEN%20BRADLEY/ALLEN%20BRADLEY/800T-T2MB21

References

There are a number of valuable resources on the internet. These are some of the primary sources I used in preparing this document:

- https://vandercookpress.info/ - this is a wonderful web site for all things Vandercook including the Vanderblog where the community can ask and answer questions.
    - It includes the list of powered carriage parts referenced in Section 6.5: https://vandercookpress.info/power-carriage-parts/
    - This web site is run by the uber-knowledgeable Paul Moxon who literally wrote the book about Vandercook maintenance: https://vandercookpress.info/product/maintenance-book/

- NA Graphics at https://nagraph.com/ is where to go for new-old-stock Vandercook parts. Fritz Klinke knows just about everything about Vandercooks and general letterpress printing.

- The Dutch letterpress site https://drukwerkindemarge.org has a great collection of high-quality scans of Vandercook manuals and literature at https://drukwerkindemarge.org/techniek/documentatie/#vandercook
    - This is the highest quality scan of the Vandercook Universal I/III manual I've seen: https://drukwerkindemarge.org/download/documentatie/vandercook-u1-and-u3-manual.pdf

- Robert Meehan at Pier Six Press (https://piersixpress.com/) has a wonderful series of blog posts (from 10/3/2022 to 6/4/2023) about the Vandercook Universal I powered carriage circuit – very similar in spirit to this document (although less wordy!). He intends to spec out a complete electrical replacement package for these presses in the future.
    - The Electrical Upgrade Package blog is at https://piersixpress.com/blogs/universal-i-vandercook-electrical-upgrade-package/upgrading-vandercook-universal-i

- My favorite vendor of electrical parts is Mouser Electronics: https://www.mouser.com/