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MAINTENANCE - OPERATING INSTRUCTIONS FAST BACKLEG WINDING SUPPLY

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Collider Accelerator Department

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AGS DIVISION TECHNICAL NOTE
No. 111

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MAINTENANCE - OPERATING INSTRUCTIONS
FAST BACKLEG WINDING SUPPLY

1. Description

The Fast Backleg Winding Supply (FBLW Supply) is used to generate a current pulse in windings on the backlegs of selected main ring magnets of the AGS thus deflecting the high energy proton beam toward the magnets used for the fast ejection of the beam from the AGS ring.

Each FBLW Supply consists of two cabinets; a constant current supply and a capacitor-switch cubicle. The constant current supply cabinet houses the components of a resonant circuit which transforms the 460 V, 3φ, 60 Hz voltage source to an ac current source similar to that of the RBD Supplies. Also included are the power transformer, the rectifier heat sink as well as the control panel assembly and the control electronics bucket. The constant current developed in this cubicle is used to charge the capacitor bank in the capacitor-switch cubicle. In addition to the two section capacitor bank, the capacitor-switch cubicle contains the SCR load switch heat sinks, the recovery inductor and other associated components.

The location of each of the FBLW supplies is indicated in Table II. In each case, the load current pulse is routed through the backleg winding cables via a terminal board in the house with a variable line arrangement and two fixed terminal boards in the ring.

2. Specifications

Beam Deflection Angle (nom, 1050 A)	3.1 mrad
* ½λ Beam Displacement (nom, 1050 A)	1.8 in.
Change in FBLW Magnet Bend (1050 A, nom)	62 kG-in.
½λ Beam Displacement (max, 1500 A)	2.5 in.
* Peak FBLW current (nom)	1050 A
Peak FBLW current (max)	1500 A (2BLW); 1100 A (4BLW)
Peak FBLW current (min)	250 A (2BLW); 110 A (4BLW,½C)

* No. of turns per magnet	5(90" magnet); 6 (75" magnet)
* FBLW Magnet Location	
A10 Bump	A4, A5; A18, A19
E10 Bump	E2, E3; E16, E17
H10 Bump	H2, H3; H16, H17
I10 Bump	I2, I3; I16, I17
FBLW Impedance (nom, 28 GeV, 4 BLW)	L = 1.55 mhy; ESR = 0.11Ω
FBLW Impedance (2 BLW; E2, E3)	L = .75 mhy; ESR = 0.12Ω
Half Period (C=11.5 mf)	10 msec (2 BLW); 14 msec (4 BLW)
Total Bank Capacitance (nom)	11,500 uf
Capacitor Voltage (max)	500 V
* Pulses per Magnet Cycle (max)	4
Pulse to pulse amplitude variation (max)	±0.5%
* Interval between Pulse Initiation (min)	100 msec
Cap Voltage Droop (C=11.5 mf)	1.5 %/min
Constant Current Supply Output (nom)	50 A
Input Power; 460 V, 3φ	
Charging (C to 500 V over 55 msec, av.)	21.5 kW
Standby (On, not charging, nom)	1.63 kW
Input Line Current: 460 V, 3φ, 60 Hz, (Standby, av.)	3.6 A

* Initial Requirements

3. Circuit Operation

3.1 Constant Current Supply

To develop the constant current required to charge the capacitor bank, the 460 V, 3φ line voltage is applied to a circuit composed of three capacitors and three inductors which are resonant at the 60 Hz line frequency. The primaries of the power transformer are connected across this network. (See Fast Backleg Winding Supply Schematic, D11-E268.) The circuit causes a very nearly constant ac current in the transformer primary, independent of load impedance, but the input line current is proportional to load impedance. The output from the delta connected secondary is rectified in a full wave bridge. Thus, when the rectifier output is shorted, the input line current is small and primarily the result of losses and minor mistuning of the resonant circuit. When charging the capacitor bank, the output voltage rises linearly with time while the current remains nearly constant. This voltage and current are reflected in the transformer primary as an increasing resistance resulting in increased line current.

When the stop-charge SCR clamps the current supply output at a low voltage, the voltage and current phase relationships in the resonant network are such that the voltage across each of the capacitors and inductors is within 5% of the line voltage. The voltage across each of the transformer primaries is then 13 - 20 Vac. This condition can be thought of as the result of a virtual connection of a parallel resonant LC pair across each input phase with minimum line current being drawn.

3.2 Charge - Discharge Circuitry (See Figure 1, and D11-E270, Control Electronics)

When the contactor is closed, the rising current supply output voltage is dropped across the charging SCR, Q2, causing gate current through CR8 to trigger Q2 on, thus beginning the charging of C1. When the required capacitor voltage is reached, the stop-charge SCR, Q1, is triggered halting conduction through Q2 and shunting the current supply output through L1, thus ending the charging process.

When the load switch, Q3, is triggered on, C1 discharges into the backleg winding load. The load current, i_L, flowing through the diode, D, back biases the gate of Q2 so that Q2 is not gated on until load current flow ends, even though the negative capacitor voltage forward biases Q2. At the end of the load current pulse, Q3 is turned off, and the negative capacitor voltage then causes Q2 to conduct. This reverse biases the stop charge SCR, Q1, causing it to cease conduction. Recovery current then flows from C1 through the CR7, L1, Q2 loop, changing the polarity of v_C and recovering most of the energy stored in C1 at the end of the load current pulse.

The current source output voltage, which is effectively shorted on itself during recovery, then rises to recharge C1 to the voltage required for the next load current pulse. When this voltage is reached, Q1 is again triggered and charging of C1 ceases.

The discharge trigger is transformer coupled to the gate of an SCR, Q37, generating a 0.5 A, 60 usec current pulse in the gate of Q3, the load switch. The gate of Q37 is clamped to a low level by K21 if the contactor is not closed. It is also held low by logic circuitry if the capacitor bank is not fully charged or if the contactor of a mating supply is not closed, thus inhibiting the trigger.

3.3 Reference Control; Stop Charge Loop (See D11-E270, Control Electronics and D11-E271 Control Panel, FBLW Supply)

A. Reference Voltage Generation

When the system is operated from the main control room, the reference generated by the DATACOM D/A converter is routed to the INT/REM REF control, S9, which should be in REM. The output of S9 goes to buffer, A31, on the REGULATOR card of the electronics bucket. Alternately, an internal reference generated on the REGULATOR card and routed to the INT/REM REF control via the reference level control, R19, will be applied to A31 if the control is in the INT position. The output of the buffer A31 is routed to the SINGLE / COUPLED switch (S11) on the bucket assembly which is normally left in the SINGLE position.

B. Dual System Reference

When two FBLW Power Supplies are used to generate an orbit bump it is possible to use the A31 reference output of one supply to control the level of both supplies and the reference output of the other supply to control the balance between the two. A Dual System Reference Interface card is plugged into J17 of either system which is then referred to as the MASTER supply. Coax cables are connected from G9 (out, M) on the electronics bucket of the MASTER to G7 of the mating supply, and from G10 (in, M) of the MASTER to G8 of the mating supply. See D11-E276-3, Interconnection diagram. The SINGLE/COUPLED controls of both systems are switched to COUPLED. The A31 output of the two systems are then combined in the multiplier and operational amplifiers of the Reference Interface card such that the A31 voltage of the MASTER supply will vary the balance between the two systems by up to $\pm$ 25% and the A31 voltage from the mating supply will determine the average amplitude of the two systems. Specific examples are given in the table below.

A31 Reference Output		Cap Bank Voltage		
Master Vdc	Mate Vdc	Master Vdc	Mate Vdc	
5.0	8.0	400	400	(Table I)
0	8.0	500	300	
10.0	8.0	300	500	
10.0	4.0	150	250	
5.0	4.0	200	200	

However, if this cross coupling mode of control is not desired, S11 must be left in the SINGLE position even if two supplies are used to generate an orbit bump.

C. Reference Control of Stop Charge

The signal from S11 is applied to a follower, A33, developing the reference for the comparator, A35. The capacitor voltage is sensed by a 100:1 divider and applied to another follower, A32, furnishing the other input to the comparator. The output of either of these followers can be monitored on the CAP VOLTS/REF meter of the control panel. In the event that the reference follower output is zero, a diode-resistor network will supply a comparator input such that the capacitor bank will be charged to the 70 V minimum required for normal recycling of the capacitor voltage.

The rising capacitor voltage causes the generation of a positive step at the collector of Q42 when the capacitor voltage output of A32 reaches the reference level. The differentiated step forms the trigger for Q38 which generates the trigger for the stop charge SCR, Q1. The stop charge trigger circuit, like the discharge trigger, Q37, utilizes the damped oscillation of the transformer primary inductance, a charged 10 uf capacitor and the load to generate a 0.5 A, 60 usec current pulse into the SCR gate.

3.4 Control Circuitry (See D11-E271-4, Control Panel and D11-E269-5, Signal Flow Diagram)

A. Turn-On Controls

The FBLW supply controls require a 24 Vdc source usually supplied from and fused at, the applicable DATACOM cabinet as well as 115 Vac, 1φ power from a breaker box in the house which is fused at the control panel assembly. Also, the applicable 460 V, 3φ fused disconnect wall switch must be on in order to charge the capacitor bank.

When the LOCAL/REMOTE (L/R) switch, S8, on the control panel is in the REMOTE position, the OFF, STBY/RESET, and HV on switches on the panel are disabled. (However, in an emergency, a return to LOCAL will turn the supply off.) The supply is then operated via DATACOM or alternate hardwire remote control. A STANDBY command from the DATACOM system will first energize K24 then K25 which control K5 then K6 respectively. The 115 Vac power switched by K5 energizes the heat sink fan motors and the ±15 V supply and K7 (Security) picks up. If there are no faults or trips, K17 will energize, putting the supply in a READY state. An ON command will then energize K26, K18, K2 and K1 in that order. The normally closed contacts of K2 then open the capacitor bank shunt and the contactor, K1, applies 460 Vac to the current supply. In the event of a trip, a RESET command will cause K25 to be deenergized for 0.1 sec deenergizing K6 and K17. If the fault has been cleared, the supply will return to a READY state and will respond when an ON comand is present. An OFF command deenergizes K24, K26 and K25 thus turning OFF all the control relays.

When the LOCAL/REMOTE switch is in LOCAL, the DATACOM commands are disabled and the CONTROL PANEL switches are operable. Depressing the STANDBY/RESET switch (S6) will energize K5 and deenergize K6. When S6 is released, K6 will energize and K17 will pull in if there is no fault or trip condition, putting the supply in a READY state. Momentary depressing of the HV ON switch (S7) will then energize K18, K2 and K1 as in REMOTE operation. In the event of a trip or a fault, momentary depressing of S6 will deenergize K6 and K17 returning the supply to a READY state if the fault has been cleared. Depressing the OFF switch (S5) deenergizes K5 turning the supply off.

The supply can also be controlled by remote switches hard-wired in parallel with S5, 6 and 7 via J3. The jumpers indicated on D11-E271-4 must then be installed and the LOCAL/REMOTE switch must be in REMOTE.

B. Fault Circuitry - K17 (READY) will be deenergized by any one of nine conditions which causes the 460 V contactor to open and discharges the capacitor bank. In each case a RESET is required to return to the ON state.

(1) Security: If the security connection between J3-R, U (TBC-3,4) is lost, K7 will drop out, opening the interlock string. This security connection is lost whenever there is access to the main magnet buss through secured gates.

(2) Door: The door at the rear of the current supply and the front and rear doors of the CAP-Switch cubicle each are equipped with upper and lower cheatable interlock switches which are open when the doors are closed, and which are wired in parallel. When any door is opened the interlock switch closure will energize and latch K15, which opens the interlock string.

(3) O'T-1,O'T-3: Temperature controlled switches S2 and S3 are mounted on the heat sinks of Q1, the stop charge SCR, and Q3, the load switch, respectively. If the heat sink temperature rises above the controlled point (S2, $80^{\circ} \pm 3^{\circ}C$; S3, $70^{\circ} \pm 3^{\circ}C$) a relay is latched in, again opening the path to K17. S2 turns on K13; S3 energizes K12.

(4) O'V-S: In the event of failure of the stop charge loop, the constant current source output voltage will continue to rise until the zener voltage of the dc overvoltage circuit (700 V nom) is exceeded. At that point the zener current turns on Q4, an SCR which is in parallel with the stop charge SCR. This stops the charging of the capacitor bank and energizes K10 which latches K11, opening the interlock string and giving an indication of an overvoltage on the secondary side of the transformer (O'V-S).

(5) O'V-P: If neither the stop-charge loop or the O'V-S circuit operates, the current source output voltage will continue to rise until the striking voltage of the Surge Voltage Protectors (SVP) (1200 V nom) across the primaries of the transformer is reached. When the SVP's breakover, dropping the primary voltage, the current pulse is transformer coupled to the gate of an SCR which holds in K8. The contacts of K8 causes K17 (READY) to deenergize and gives an indication of an overvoltage at the transformer primary (O'V-P).

(6) O'I: In the event that input line current in any phase exceeds 27A for a period exceeding o.1 sec, a thermal overload switch in the contactor will open, triggering the gate of an SCR. This will hold K14 on, opening the interlock string.

(7) GND: The common of the supply (COM) is connected to building ground (GDF) through a 0.5 A fuse and a parallel 10 Ω resistor. If large ground currents flow, causing the voltage between COM and GDF to exceed $\pm$ 5V, an SCR in the ground fault circuit will be gated on causing K16 to latch. Contacts of K16 then deenergize K17.

(8) RCVY: If a discharge trigger is received during the charge or recovery part of the charge-discharge cycle, it is possible for the charging current to continue to flow in the BLW load distorting the main magnet field and preventing proton acceleration. In that case, the extended period of the load current gate is used to trigger an SCR which holds K9 on. Contacts of K9 then open, turning off K17.

3.5 Power Supply Monitoring

A. Status Indicators

All of the above faults are indicated on the CONTROL PANEL assembly. The O'V-P or O'V-S fault voltages, via diodes, will energize K23 which results in REG FAULT indication to the DATACOM system. In the same manner any one of the other fault voltages via diodes will energize K22 which results in an ELECT TRIP indication to the DATACOM system.

The control switches (S5, 6, 7) are illuminated to indicate the state of the system. K20, in parallel with the OFF lamps, gives an "off" indication to the DATACOM system if the 24 Vdc and 115 Vac inputs are supplied. K21, in parallel with the HV ON lamps gives an ON indication to the DATACOM system. This actually indicates closure of the 460 Vac contactor, not the presence of the 3φ, 460 V input.

B. Load Current Monitoring

The load current flows through a 100 A/100 mV (1000A/V) shunt. The shunt voltage can be monitored via unity gain buffer amplifiers either at a test point on the CURRENT MONITOR card or via a remote current monitor output. Also, the maximum current value is held by a peak detector circuit with a gain of 2.5 X the current peak, which forms the input to the DATACOM A/D converter. The resulting readback is scaled at .5A/COUNT $\pm$ 2% (2.0 COUNTS/AMP).

C. Test Points

Other test points available on the cards of the CONTROL ELECTRONICS assembly are as follows:

(1) CURRENT MONITOR card - v_D, the voltage across Q1, the stop charge SCR, at 10V/V; v_o, current source output, at 10V/V.

(2) REGULATOR - v_c, capacitor bank voltage, at 100V/V; v_R, reference voltage.

(3) TRIGGER - Q1T, an auxiliary output of the transformer which couples the stop charge SCR gate current; Q3T, aux output of the load switch gate drive circuit.

(4) MISFIRE LOGIC - CGD, flip flop output that is high when the capacitor bank is charged; $T\bar{3}$ and $3\bar{T}$, negative triggers that cause triggering of the MISFIRE counter.

D. Metering

Three meters on the CONTROL PANEL are used to monitor the supply. M1 (0-50Aac) is switched by S13 to measure line current in any one of the three 460 Vac input lines. M2 is switched by S14 to indicate any one of the 460 Vac input phase voltages or the input 115 Vac. The 460 Vac is dropped by a factor of 4 to be compatible with the 0-150 Vac movement. M3 (0-5 Vdc) is switched by S15 to monitor either the reference voltage or the capacitor bank divider output.

E. Misfire Logic

Circuitry is included in the ELECTRONICS which generates a + 3V output when the capacitor bank is not charged, causing the CHARGED light on the control panel to be deenergized. The inverse of this output, together with a level dependent on the HV state of the mating supply (if used), is used to inhibit triggering of load switch. In addition, the circuit will trigger an SCR, Q14, if a load switch trigger occurs with the capacitor bank charged and there is no load current pulse ($T\bar{3}$) or if there is a load current pulse without a preceding load switch trigger ($3\bar{T}$). Q14 then momentarily energizes a misfire counter and the Q3 misfire light (Q3M).

4. Operating Instructions

4.1 Input Power

Each FBLW Supply requires a 24 V dc source usually supplied from, and fused at, the applicable DATACOM cabinet and 115 Vac, 1φ power from a breaker box in the house. The 115 Vac is fused in the control panel assembly. Both of these sources are required for indicator light operation or for any control operation. Also, the applicable 460 V, 3φ fused disconnect switch at the wall must be ON in order to charge the capacitor bank.

4.2 REMOTE Operation

To operate the supply remotely via DATACOM from the Main Control Room, the LOCAL/REMOTE switch and the INT/REM reference switch must be in the REMOTE position. The appropriate address is entered into the DATACOM system and the required reference level is set in. When the STANDBY command is sent, there should be a READY response. There should then be an ON response to a dc ON command and, unless there is a mating supply which is not ON, there should be a magnitude readback from the load current peak detector (2.0 counts/amp ± 2%).

The supply can be operated either via the manual DATACOM panel or via the PDP-10 "page 8" program.

4.3 LOCAL Operation

To operate the supply locally, the LOCAL/REMOTE switch is put in the LOCAL position with the REF switch in either the REM or INT position. After the STANDBY/RESET switch is depressed the READY light should light and meters will indicate the line voltage and the reference level. Depressing the ON switch will then close the 460 V contactor and the CHARGED light should come on indicating that the bank is charged. A meter indication of the current and voltage of each phase of the 460 V ac input is also available. Unless there is a mating supply which is not ON, input triggers applied to the rear of the CONTROL ELECTRONICS bucket will then cause firing of the load switch generating current pulses and recovery-recharge cycling. This is indicated on the Control Panel by the blinking of the CHARGED light, the dip of the CAP VOLTS X 100 meter indication and the pulsing of the LINE CURRENT meter. These indications can also be viewed when the system is operated remotely.

Depressing the STANDBY/RESET switch will put the supply in a ready state and discharge the capacitor bank. Depressing the OFF switch, of course, turns off everything.

4.4 Fault Conditions

The supply will be tripped off by any one of nine undesired conditions which are indicated on the front of the CONTROL PANEL. If the fault condition is cleared the supply can be reset to a READY state by sending a RESET command via DATACOM when operating in that mode, or by depressing the STANDBY/RESET switch when operating locally. Reference to 3.4.b. which details the conditions under which a given trip will occur and to the applicable schematic(s) of Table III can aid in the clearing of fault conditions.

4.5 Dual/Single System Operation

The FBLW Supplies can be operated either singly or in pairs. In the case of single system operation, a supply is connected to four series backleg windings (BLW) to generate a $\frac{1}{2}\lambda$ orbit perturbation of the proton beam. The connection is made at the FBLW Interconnection Terminal Board near the supply with connecting buss for that purpose. See figure 2. This hardware can be inverted to connect either the A or the B supply to the 4 BLW load. The peak current obtainable is then roughly 1000A. The $\overline{HV}$ signal to the G3 BNC at the rear of the Control Electronics bucket must be disconnected and the SINGLE/ COUPLED switch at the front of the bucket must be in the SINGLE position.

Alternately, one supply may be used to power the two BLW which generate the initial field deflection for the orbit perturbation and another supply to power the 2 BLW which generate the orbit restoring field. This gives the operator more flexibility in the control of the orbit perturbation or bump and greater range (1500 A, max). The required connection is made at the FBLW Interconnection Terminal Board with the connecting buss for dual system operation. See figure 2. In order to prevent one supply from triggering when the mating supply is not ON, which can result in a loss of the beam, the $\overline{\text{HV}}$ signal from the mating supply must be connected to the G3 BNC at the rear of the Electronics bucket of both systems. See D11-E276-3 Interconnection Diagram. The SINGLE/COUPLED switch (S11) may be left in the SINGLE position allowing independent adjustment of each supply. If a single amplitude adjustment of both supplies with a balance adjustment between them as described in paragraph 3.3 is desired, the supplies must be set up as outlined in that section.

5. Troubleshooting

In general, the circuitry is straighforward, simplifying the problem of localizing faulty components. Refer to the applicable circuit description in paragraph 3 and to the appropriate schematics in order to gain some insight into the circuit operation. Replacement parts which are not stock items are stored in a cabinet in the H-10 porta-kamp.

An oscilloscope and multimeter are required to localize most faults. However, some of the circuits, because of their feedback nature or other peculiarities can be difficult to troubleshoot. Some of those which have given trouble are the following:

5.1 Constant Current Supply

If the current supply output voltage does not rise to charge the bank to the required level although equal input phase voltages are observed on the input voltage meter indicating input switch closure and no blown fuses, the problem may be due to a short on the current supply output, a failed rectifier, or a failure in the resonant input circuit. Monitor the current supply output, v_o, syncing the scope on that signal. If the voltage rises to 100V - 150V in 20 msec then decays to a low value, a rectifier diode is shorted. If the voltage does not rise above 1 - 2V, disconnect the cables to the load at TBG-1,2 and replace the load with a 100 mV, 100 A shunt. If the shunt current is normal (65 - 70 Adc), look for a short circuit in the Capacitor-Switch Assembly. If the shunt current is not normal, look for a faulty component in the Constant Current Supply. Voltages in the primary resonant network can be checked as indicated in paragraph 3.2.

5.2 Operational Amplifiers

A number of uA741 operational amplifiers (op amps) are used in the Regulator and Current Monitor circuits. If an amplifier gain as determined by the input and feedback resistors is not proper, the op amp should be replaced. If there is no change in response, the voltages at the amplifier terminals (not at connector terminals) should be checked with a DVM or other high Z input device. Check the power supply voltages and verify that the voltages from the offset null potentiometer, if used, are adjustable within reasonable limits. If these are proper, the problem is usually found in the connection to, or the failure of, the input or feedback resistors.

5.3 Stop Charge Loop

The supply continually goes into a dc overvoltage state (O'V-S) at turn-on if there has been a failure of some component in the stop charge loop. Monitor the capacitor voltage and the reference voltage on the front panel meter proved (M3). The reference voltage, whether locally or remotely generated, is indicated on M3 in the REF position when the supply is not in the OFF state. If this voltage is not proper or does not respond normally, A31, A33 and the connections in that part of the loop should be checked.

In the CAP VOLTS X100 position, the capacitor voltage indicated on M3 should be zero when the supply is in the READY state and rise when the supply is put into the dc ON state. If the capacitor voltage does not respond in that manner, A33, the divider, and connections in that part of the loop should be checked.

If those parts of the loop are operating normally, sync a scope on the voltage at the V_o test point of the current monitor card and monitor the stop charge trigger (Q1T) on the trigger card, a 15V, 60 usec pulse which should occur within 120 msec after the V_o trigger. If Q1T does not occur, check A35, Q42, Q38, the components and the connections in that part of the loop. If Q1T does occur, monitor the trigger directly at the gate of the stop charge SCR, Q1 on the heat sink behind the lower panel of the constant current supply.

At this point the trigger amplitude is 2V, occurring before the much larger O'V-S transient occurs at 150 - 170 msec after the V_o trigger. If the trigger is not present there, the problem could be due to a short at the gate of Q1 or a fault in the cable to it. If the trigger is present there, there must be an opening in the path through Q1 and L5 from the junction of Q2 and L1 to the lo of the rectifier output or in the gate of Q1 itself.

5.4 Peak Current Detector

If the load current signal (i_L) is present but the peak detector does not function either A40, A42 or Q31 is usually faulty. If replacing A40 does not cause the circuit to operate properly, remove A40, to break the feedback loop and check the voltages at A42. If the voltage across Q31, D to S, remains below $\pm$ 2 mVdc independent of the setting of the offset adjust, R48, remove Q31 and check for a drain to source short. If the A40 output is larger than $\pm$ 2 mVdc and cannot be adjusted to zero by R48 and the power supply voltages to it are proper A42 should be replaced. If A42 and Q31 are okay, the connections or the components of A40 must be faulty.

TABLE II

FBLW Supply Desig.	Supply Number (NWL)	DATACOM Control Channel	DATACOM Autodet Channel	Location
E10A	71-6	222	240	E10 House
E10B	71-1	220		
H10A	71-5	360	342	H10 Port-a-kamp
H10B	71-2	362		
I10A	71-4	364	344	
A10	71-3	064	-	A10 House

TABLE III

Dwg. #	Title
D11-E269-5	Signal Flow Diagram; FBLW Supply
D11-E276-3	Interconnection Diagram; FBLW Supply
D11-E268-3	FBLW Supply Schematic (Major Components)
D11-E270-4	Control Electronics; FBLW Supply
D11-E271-4	Control Panel; FBLW Supply
D09-E474-3	2X Reference Interface; FBLW Supply

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BY ______ DATE 3/74 SUBJECT CHARGE-DISCHARGE CKT SHEET No. ____ OF ____

CHKD. BY ______ DATE ______ WAVEFORMS; FBLW SUPPLY JOB No. ______

DEPT. OR PROJECT ______

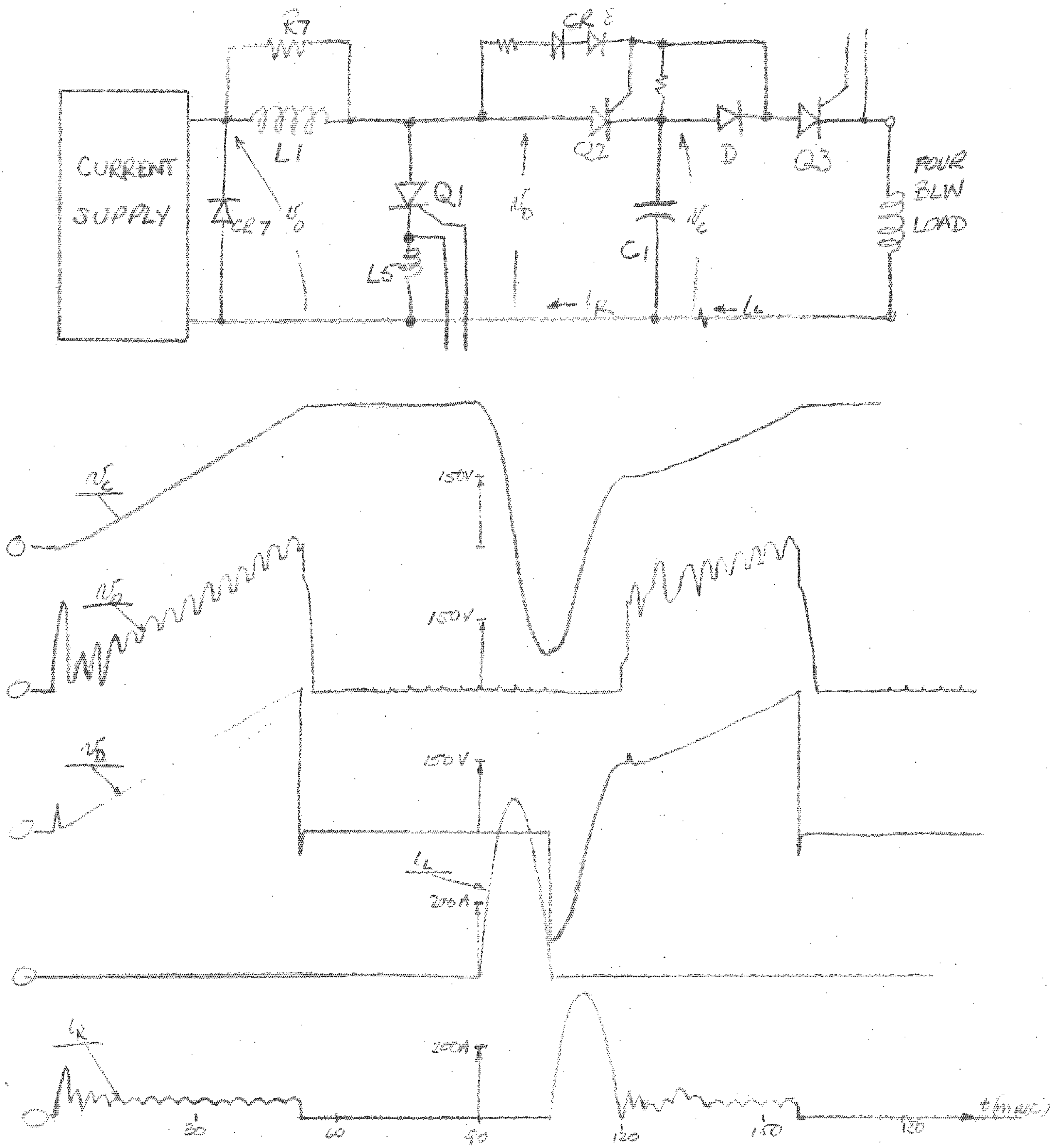


FIGURE 1

SP 11037A

BROOKHAVEN NATIONAL LABORATORY

BY ______ DATE ______ SUBJECT ______ SHEET NO. ______ OF ______

CHKD. BY ______ DATE ______ JOB NO. ______

DEPT. OR PROJECT ______

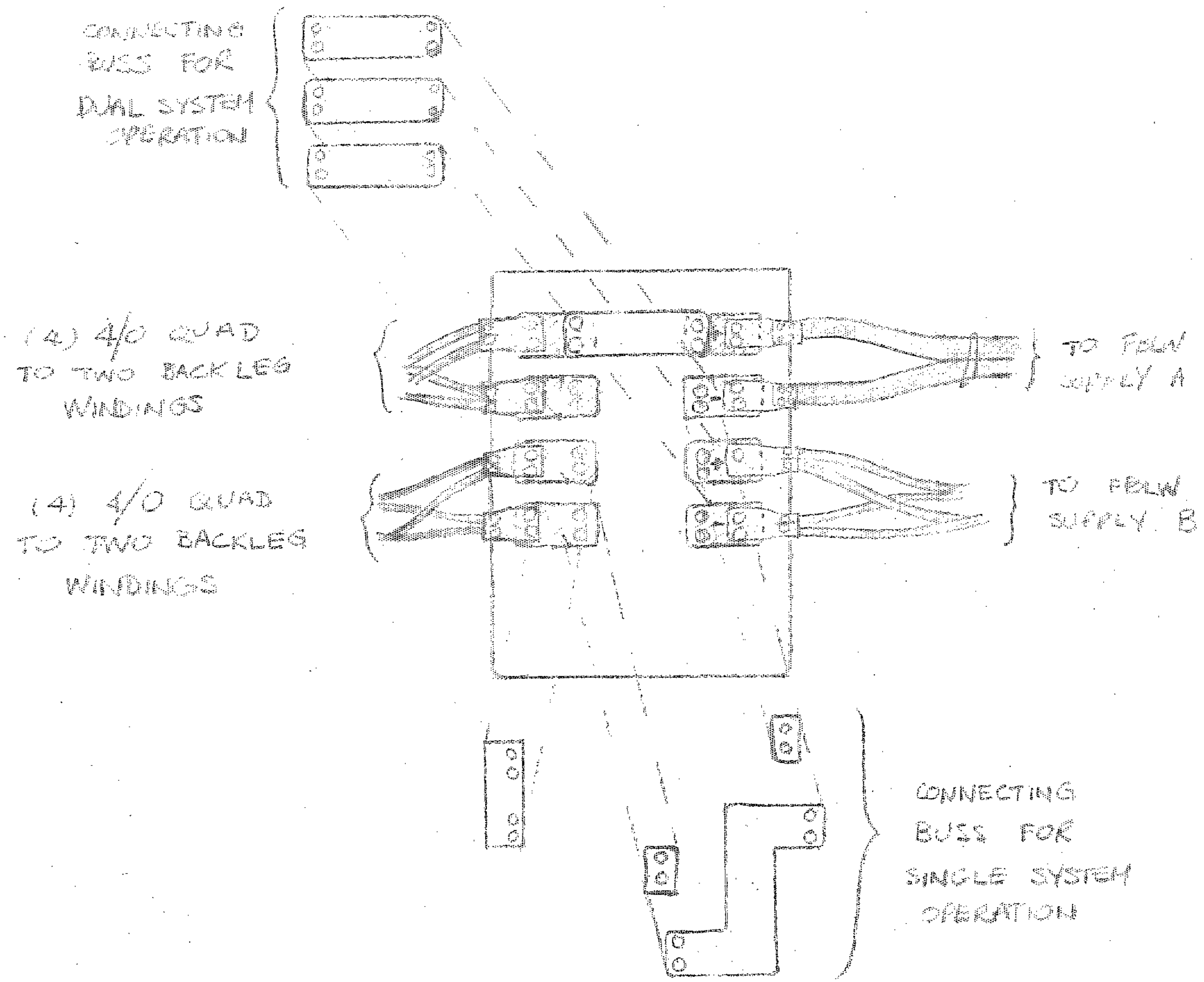
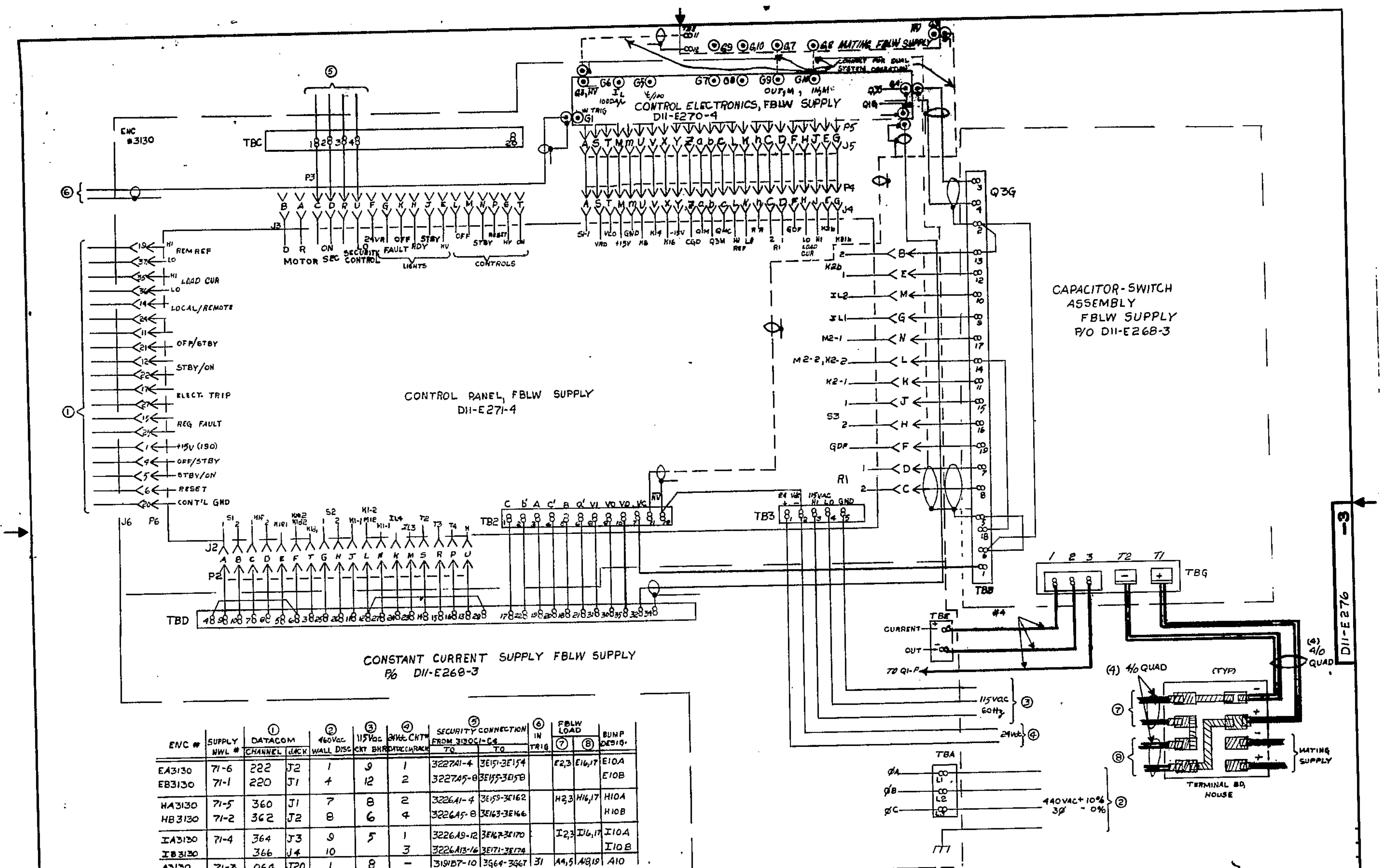


FIGURE 2

SP 11037A



ENC #	SUPPLY NWL #	① DATACOM CHANNEL	① DATACOM JACK	② 460Vac WALL DISC	③ 115Vac CKT BKR	④ 24Vdc CKT DATACOM RACK	⑤ SECURITY CONNECTION FROM 3190C1-C4 TO	⑤ TO	⑥ IN TRIG	FBLW LOAD ⑦	FBLW LOAD ⑧	BUMP DESIG.
EA3130	71-6	222	J2	1	9	1	3227A1-4	3E151-3E154		E2,3	E16,17	E10A
EB3130	71-1	220	J1	4	12	2	3227A5-8	3E155-3E158				E10B
HA3130	71-5	360	J1	7	8	2	3226A1-4	3E159-3E162		H2,3	H16,17	H10A
HB3130	71-2	362	J2	8	6	4	3226A5-8	3E163-3E166				H10B
IA3130	71-4	364	J3	9	5	1	3226A9-12	3E167-3E170		I2,3	I16,17	I10A
IB3130		366	J4	10		3	3226A13-16	3E171-3E174				I10B
A3130	71-3	064	J20	1	8	–	3191B7-10	3G64-3G67	31	A4,5	A18,19	A10

REV	DESCRIPTION	BY	DATE	CHK	APP
C	A INHIBIT OF B; QI-P CHG.	G.M	5-17-…		
B	REVISED AND REDRWN	G.M	8-12-73		

CODE #03

CODE #03

D11-2E3130

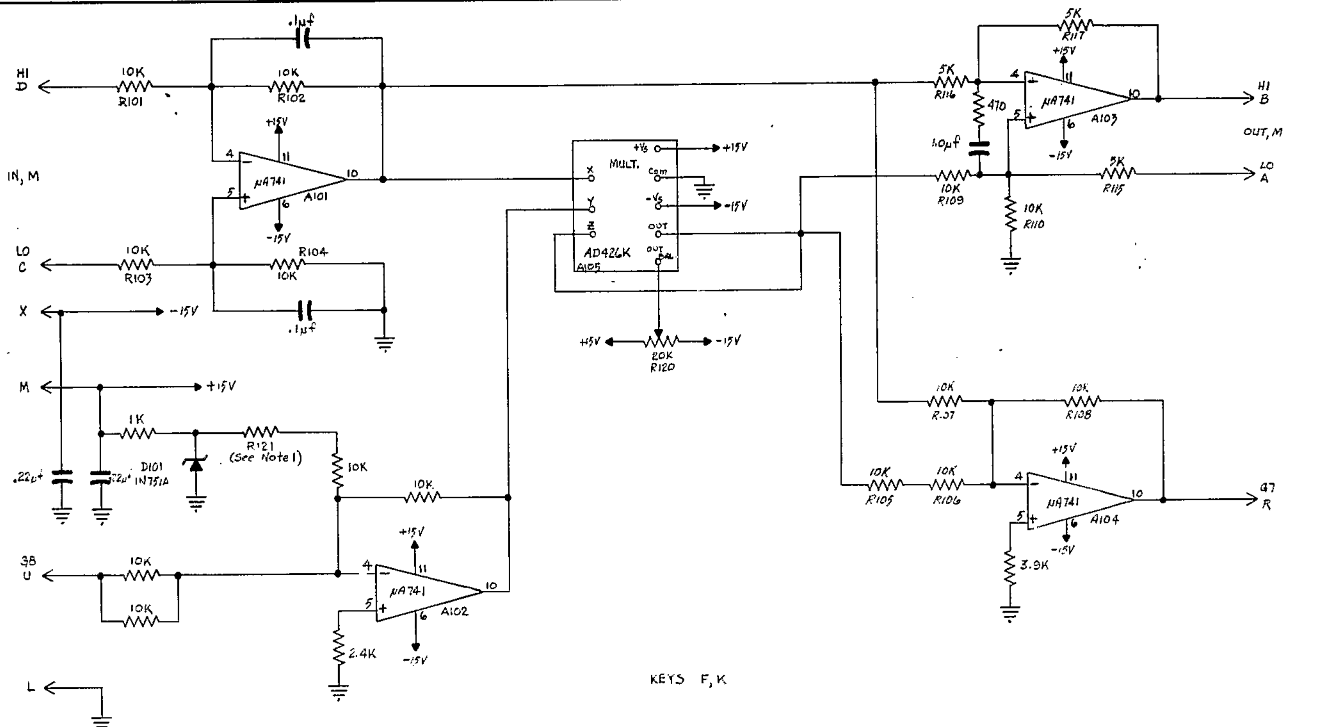
BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, N.Y. 11973

INTERCONNECTION DIAGRAM
FBLW SUPPLY

DATE: 8-12-73
DRAWN BY: G. MACK

DRAWING NUMBER: D11-E276 −3
REV.: C

D11-E276 -3



NOTES:

1. ALL RESISTORS ½W, 2% FILM EXCEPT:

R101 - R110	10K ± .1%, ⅓W GEN. RESISTANCE BEIL	
R115 - R117	5K ± .1% ⅓W GEN. RESISTANCE BEIL	
R120	20K ± 10%	(A11211)
R121	½W 2% FILM, SELECT TO OBTAIN A102 OUT ≈ -5.0 VDC WITH PIN U @ 0 VDC.	

2. D101 1N751A (A-42231)

3. A101 - A104 μA741 (A-26718)

4. A105 426K, MULTIPLIER, ANALOG DEVICES.

CODE #03

D09-OE 3336

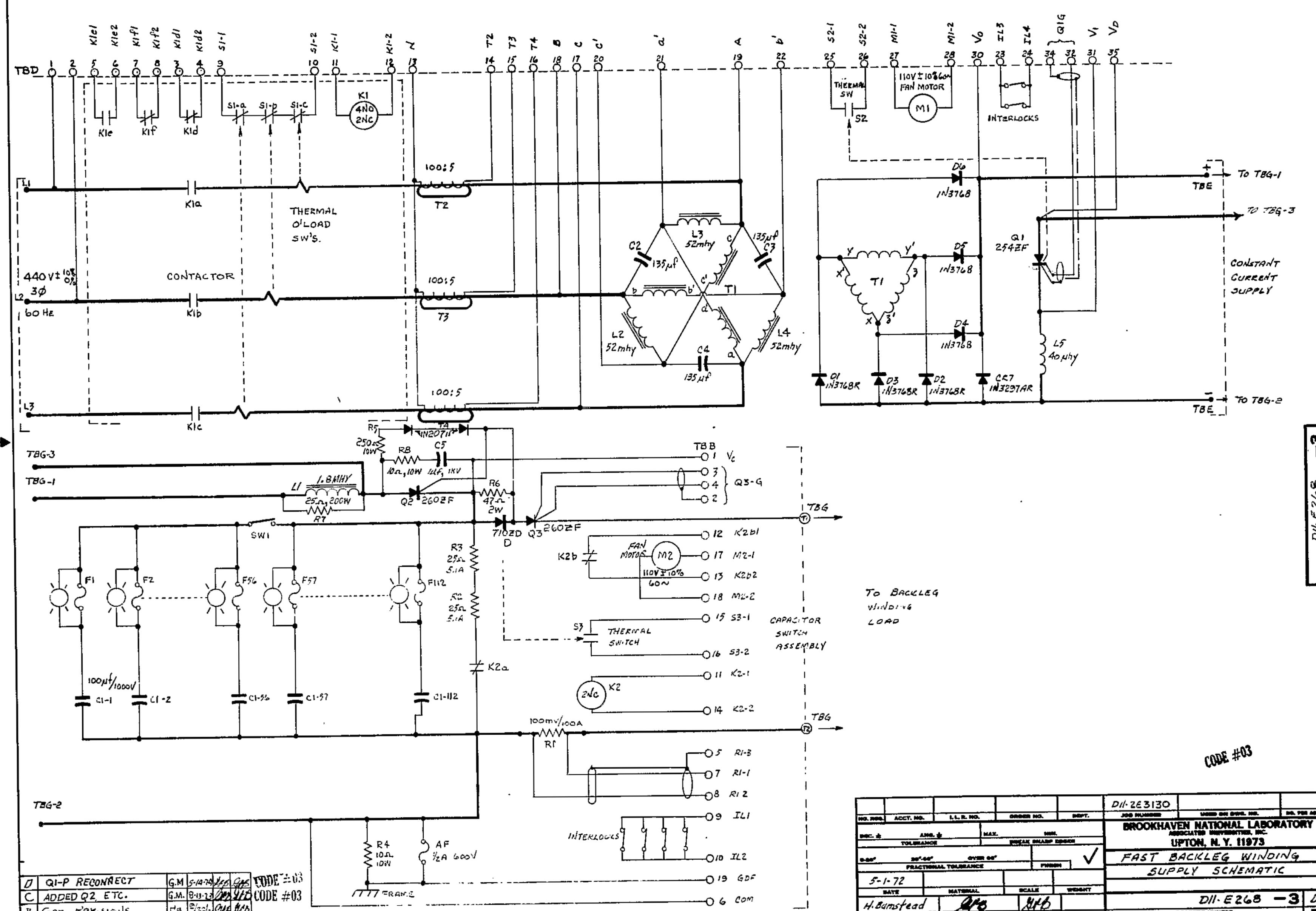
BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, N. Y. 11973

2X REFERENCE INTERFACE
FAST BACK LEG WINDING SUPPLY

H Bumstead

D09-E474 -3 A

D09-E474 -3



REV	DESCRIPTION	BY	DATE	CKR	APP
D	Q1-P RECONNECT	G.M.	5-14-74	[illegible]	GHS
C	ADDED Q2, ETC.	G.M.	8-13-73	[illegible]	HB
B	Gen. Revisions	HB	2/22/73	[illegible]	HB

CODE #03
CODE #03

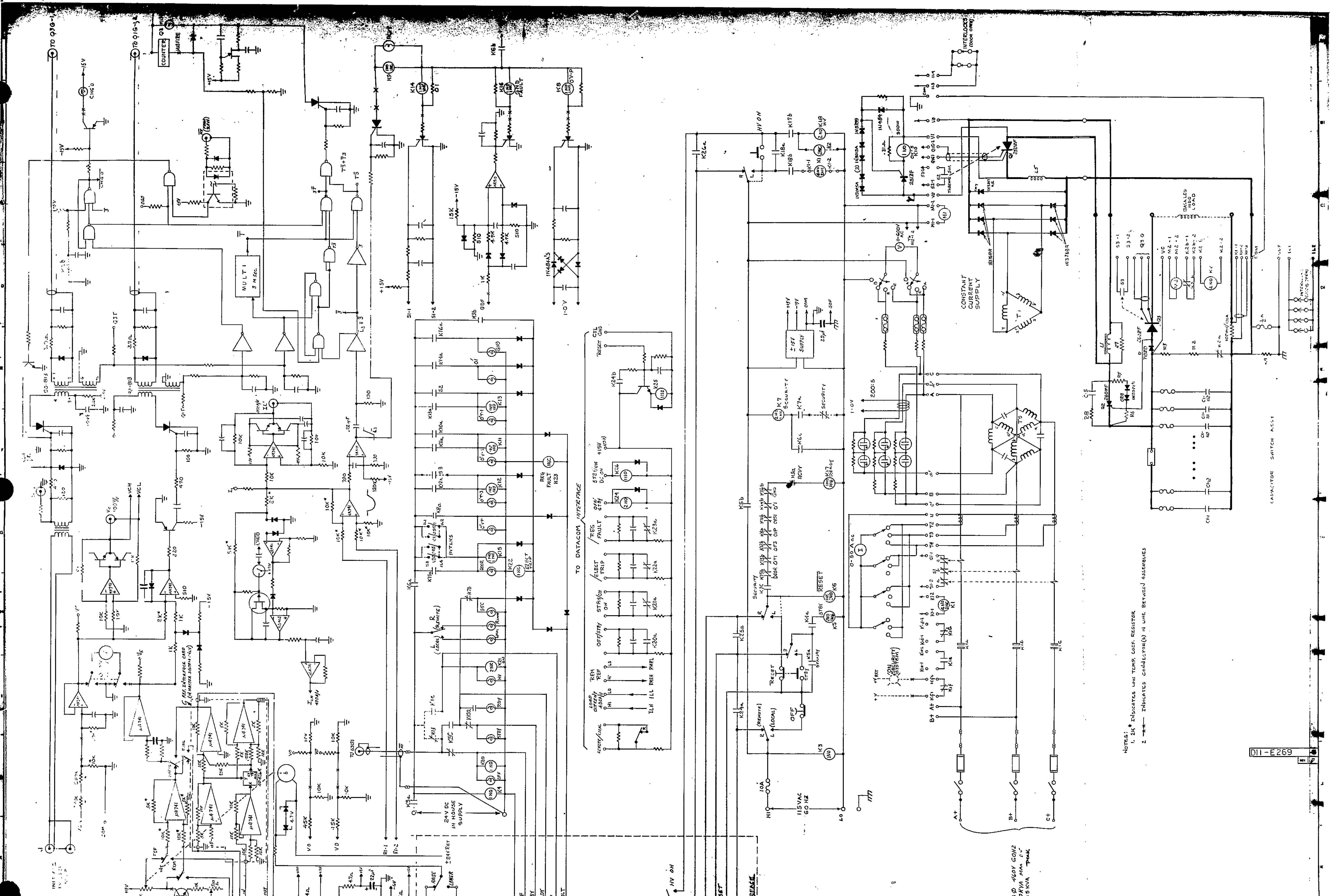
D11-2E3130

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, N. Y. 11973

FAST BACKLEG WINDING SUPPLY SCHEMATIC

DATE: 5-1-72
DRAWN BY: H. Bamstead

DRAWING NUMBER: D11-E268 -3 REV. D



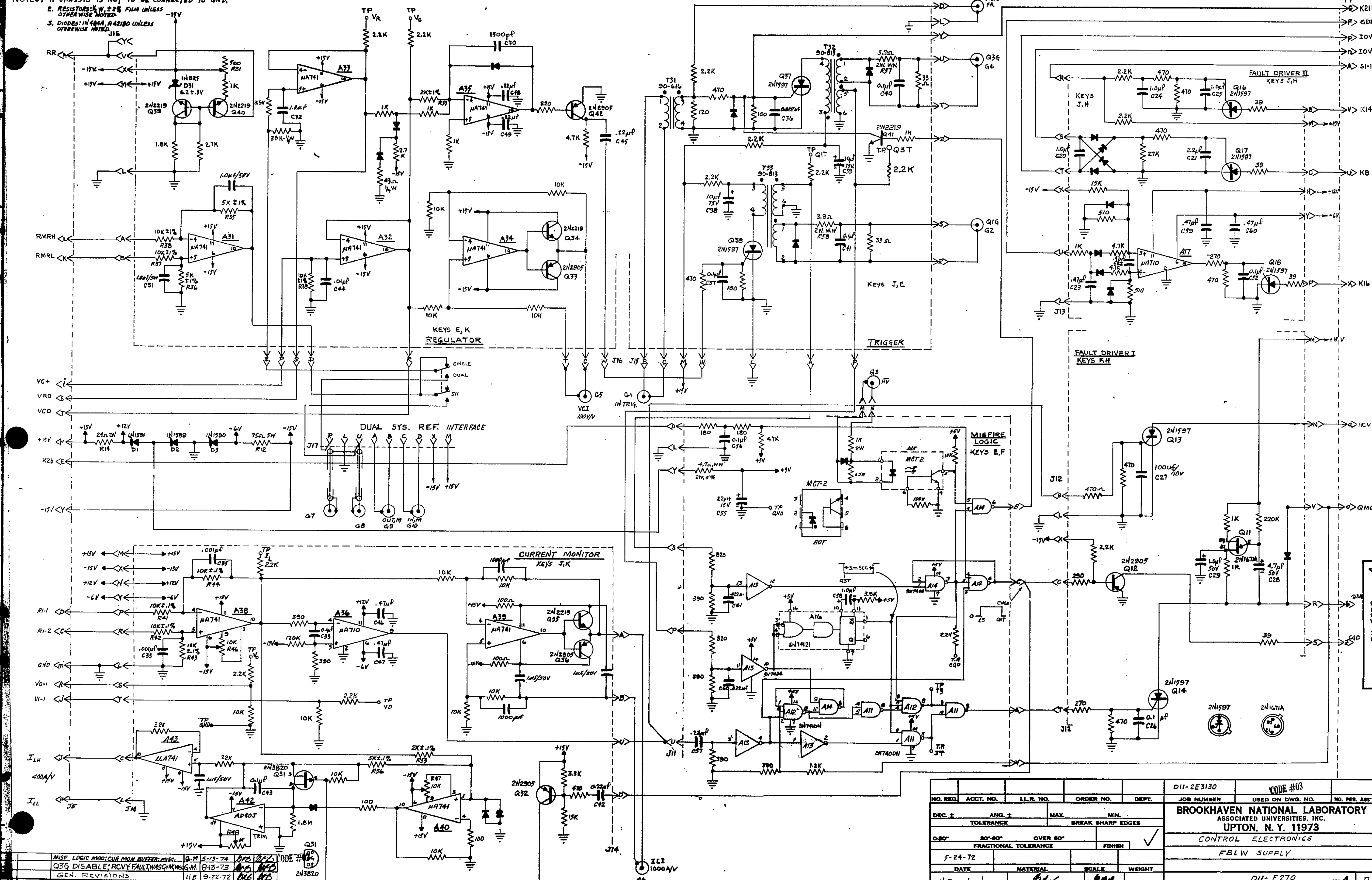
BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, N. Y.

SIGNAL FLOW DIAGRAM
FAST BACKLEG
WINDING SUPPLY

DATE	DRAWN BY	CHECKED BY	APPROVED BY
8/72	BKropp		G.Bagley

DRAWING NUMBER: D11 - E269 -5

NOTES: 1. CHASSIS IS NOT TO BE CONNECTED TO GND.
2. RESISTORS: ¼ W, ±2% FILM UNLESS OTHERWISE NOTED.
3. DIODES: 1N484A, A42180 UNLESS OTHERWISE NOTED.



MISF LOGIC MOD; CUR MON BUFFER; MISC.	G.M.	5-13-74		
Q3G DISABLE; RCVY FAULT; WAS Q1N; MOD	G.M.	8-13-73		
GEN. REVISIONS	HB	9-22-72		
ZONE / DESCRIPTION	BY	DATE	CKR	APP

CODE #03

CODE #03

D11-2E3130

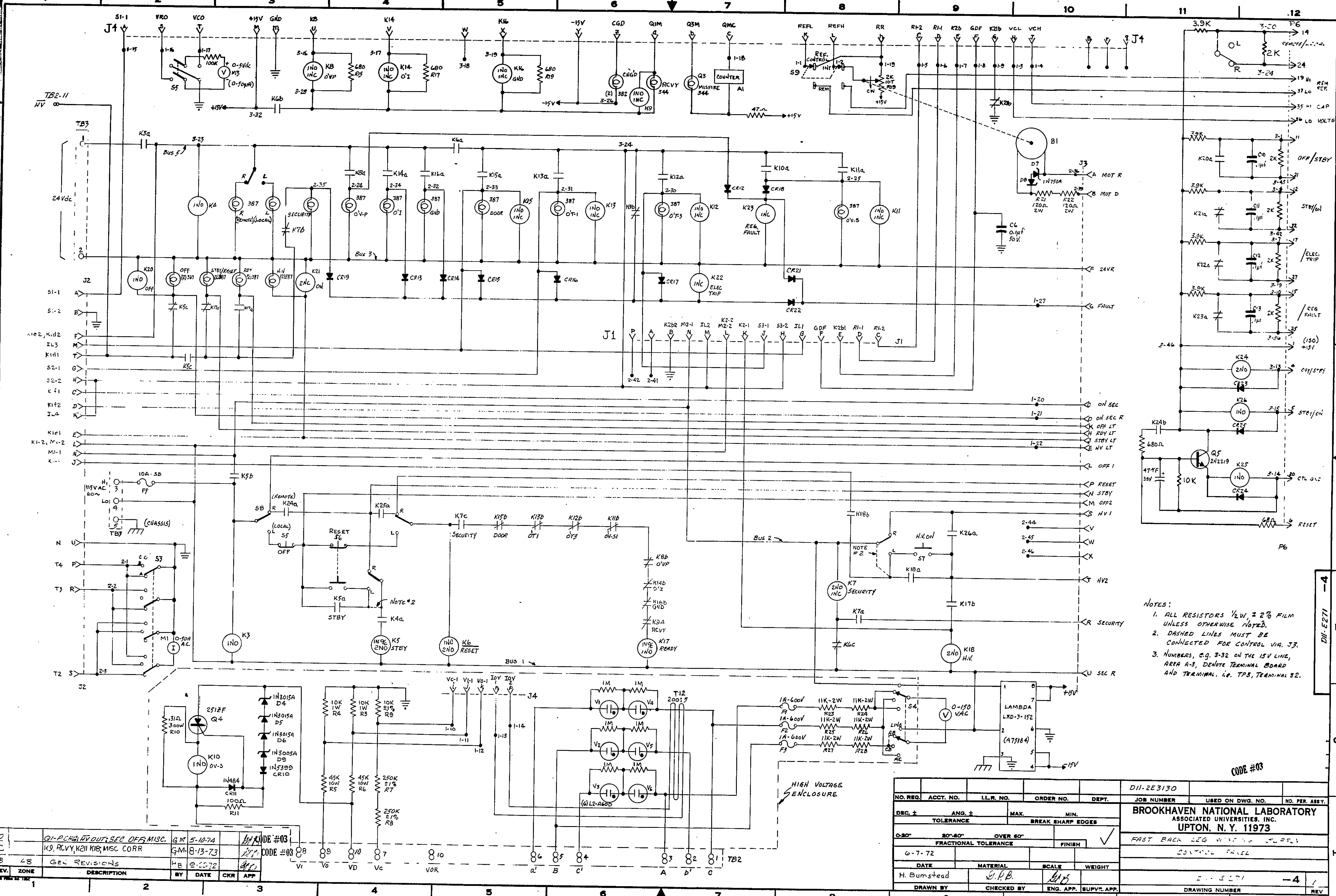
BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, N. Y. 11973

CONTROL ELECTRONICS
FBLW SUPPLY

5-24-72

H. Bumstead

DRAWING NUMBER: D11-E270 -4 D


NOTES:
1. ALL RESISTORS 1/2W, ± 2% FILM UNLESS OTHERWISE NOTED.
2. DASHED LINES MUST BE CONNECTED FOR CONTROL VIA J3.
3. NUMBERS, e.g. 3-32 ON THE 15V LINE, AREA A-3, DENOTE TERMINAL BOARD AND TERMINAL. i.e. TP3, TERMINAL 32.
HIGH VOLTAGE ENCLOSURE
LAMBDA LXD-3-152 (A75184)
CODE #03
D11-2E3130
BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, N.Y. 11973
FAST BACK LEG WINDING SUPPLY
CONTROL PANEL
6-7-72
H. Bumstead
D11-E271
-4
D | Q1-PCHG; HV OUT; SEC OFF; MISC. | GM | 5-10-74
C | K9, RCVY, K211 K18, MISC CORR | GM | 8-13-73
B | 48 | GEN REVISIONS | HB | 9-22-72
REV. | ZONE | DESCRIPTION | BY | DATE | CKR | APP