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Modifications to the XRF autosampler at the Department of Mines Launceston Laboratory

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Abstract

Modifications to the autosampler on the Philips PW1400 XRF at the Department's Launceston Laboratory were carried out to enable 36 samples to be processed in one run (usually overnight, unattended). The optical card reading system was modified by replacing it with thumb wheel switches which allowed more reliable and practical use of the system.

INTRODUCTION

The existing autosampling system on the Philips XRF at the Department of Mines Launceston Laboratory could only handle a maximum of 18 samples, and this was carried out in a very primitive way. It was decided that a fully automatic system, capable of handling up to 36 samples, be either purchased or built in-house.

The latter was decided upon because of cost savings of about one-third compared with the cost of the system being modified by Philips. Two options existed, being to use the system Philips have used in the past (shuffling trays of samples around a table top), or to have a completely different approach of using a carousel-type sample holder. The advantage of a carousel system was that the system was cheaper and more reliable, and did not require complex tray shifting arrangements. The sample tray card-reading system also proved to be primitive, and this was replaced with a more reliable and flexible electronic system.

SAMPLE HOLDER CAROUSEL CONSTRUCTION AND CONTROL

As the carousel sample holder system was completely different to the original tray moving system, and as the control electronics were designed for the tray moving system, a number of control devices had to be included into the system which in normal circumstances would never be used. These control devices required modification to the **Tray Present** indicator, **Sample in Position** indicator, and the **Tray Ready to be Moved Into Position 1** indicator. In the normal construction of a carousel system some of these controls would not be used, however a complete redesign of the Philips control electronics was completely out of the question and adaptation of the existing electronics was more feasible.

The carousel itself was made of 5 mm thick aluminium cut into a circle of approximately 900 mm diameter with 36 sample holes cut near the perimeter, each sample hole being approximately 60 mm in diameter. The drive for the carousel is via a stepper motor controlled by the existing Philips drive electronics.

The existing control software divides the samples into groups of six samples per tray, giving a total of six trays per carousel. To mimic the tray system, notches are cut every six sample positions into the perimeter of the carousel, with a microswitch positioned on this perimeter to indicate the end or beginning of a sample tray. To position the carousel in the correct location to pick up and replace samples, holes are drilled between sample holder locations at a diameter of approximately 750 mm. An optical locator is aligned through these holes when the sampler is in the correct position for loading and unloading of samples. A further six holes are required for this locater to indicate the end and beginning of a sample tray. The locater should be positioned over the hole at the same time that the tray microswitch on the perimeter of the carousel is engaged. The reason for the extra hole positioning is that in the old tray system there was a gap of approximately one sample position between trays, so the carousel has to fool the electronics into believing that an extra sample location exists.

CIRCUIT CHANGES TO THE PW1400 SAMPLE CHANGER

Refer to circuit diagram Figure 4.11.3.3 and Figure 4.11.3.6 in the Philips service manual.

1. switch S11 (tray present) permanently wired to indicate tray present.
2. switches S17 and S19 (sample is in the load position) are operated via a relay on the sample in position optical detector circuit.
3. switch S15 moved to the perimeter of the carousel (detect if tray is ready to be loaded into position 1, i.e. the gap between trays).
4. sample detection circuit consisting of E1 and V1 (sample present in tray sensors) replaced with I.R. detection circuit.
5. motor M1 disconnected.
6. control signals TM1SR+ (motor counter-clockwise) and TM1SL+ (motor clockwise) redirected to the stepper motor control circuits.

REPLACEMENT FOR THE OPTICAL CARD READER

Complete replacement of the optical card reader was also required. This was accomplished by the use of thumb wheel switches and additional circuitry. Some problems did occur when it was found that the circuit diagrams supplied did not resemble the actual control circuits. The complete card reader was replaced with a box containing thumb wheel switches (6 sets in all), consisting of one level for the tray number and the other level for the program required. An LED is used to indicate which tray/program is being read. This box replaced all the circuitry at the end of the connector X3 on Figure 4.11.3.10. To synchronize the physical tray position of the carousel and the electronic tray position of the thumb wheel switches, a control pulse was needed to advance the electronically-set tray and program numbers. The control signal to advance the current tray position was EORTB- and not LORON- as might have been expected. One side effect of this is that the tray position indicated does not correspond to the program being read. It was found that the indicated program being read was in fact the next program to be read, but the tray numbers were correct. To fix this problem we were forced to physically move the program thumb wheel switches one position to the right on the switch housing (the tray and program indicator advances from left to right). It was also decided to allow manual advancement of the electronic indicator; this is provided via a push button switch on the front of the housing (1 press for 1 position—holding the button down will not advance the tray positions automatically).

[14 September 1989]

APPENDIX 1

Circuit Diagrams

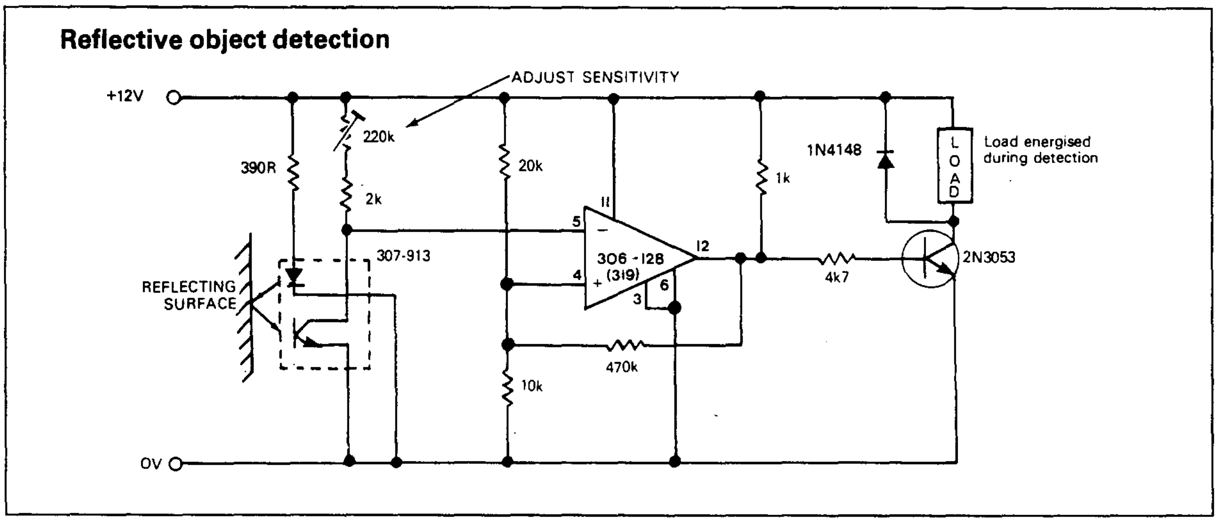


Figure 1a. *The above circuit is used, however the carousel cuts the beam rather than reflecting it.*

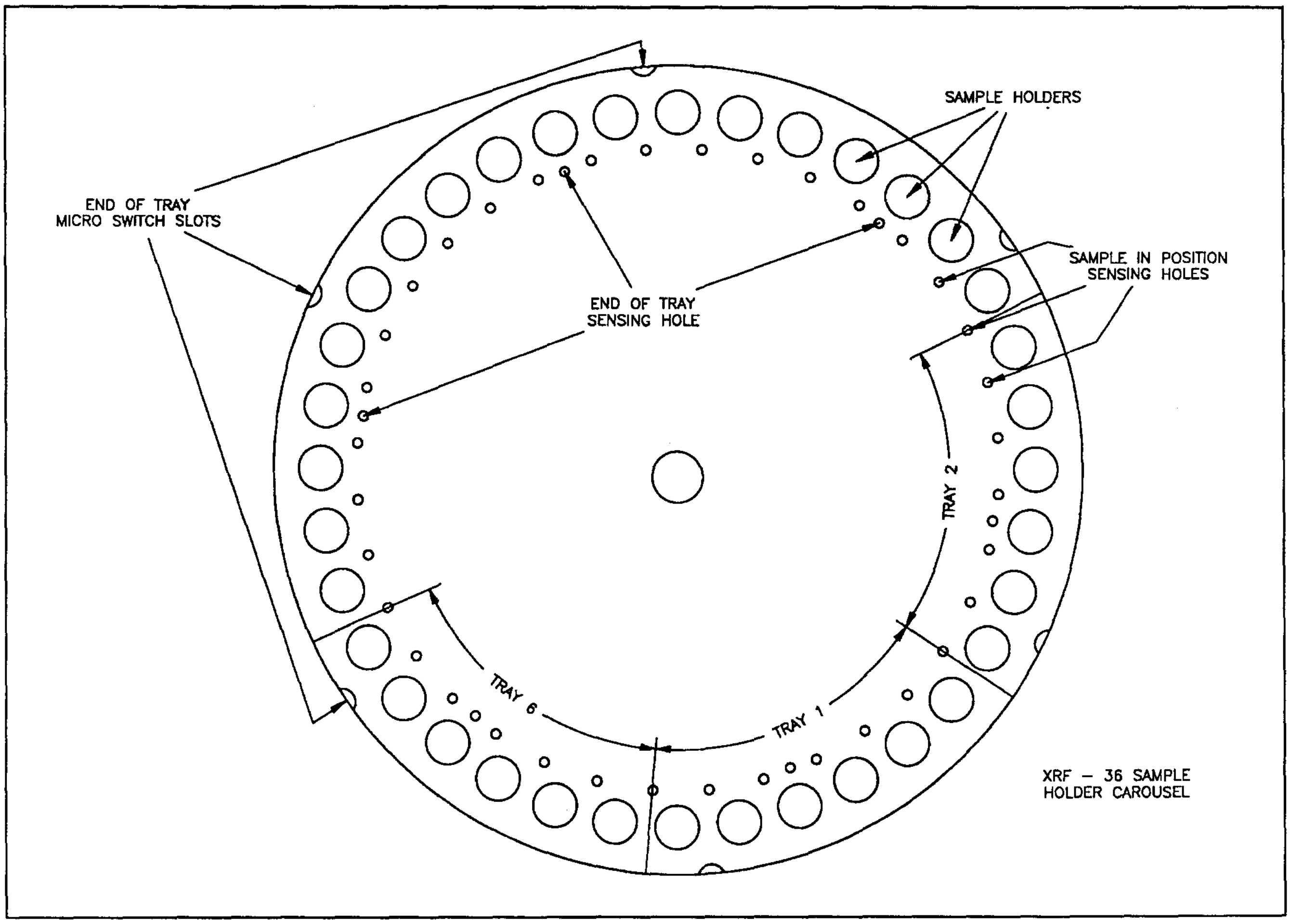
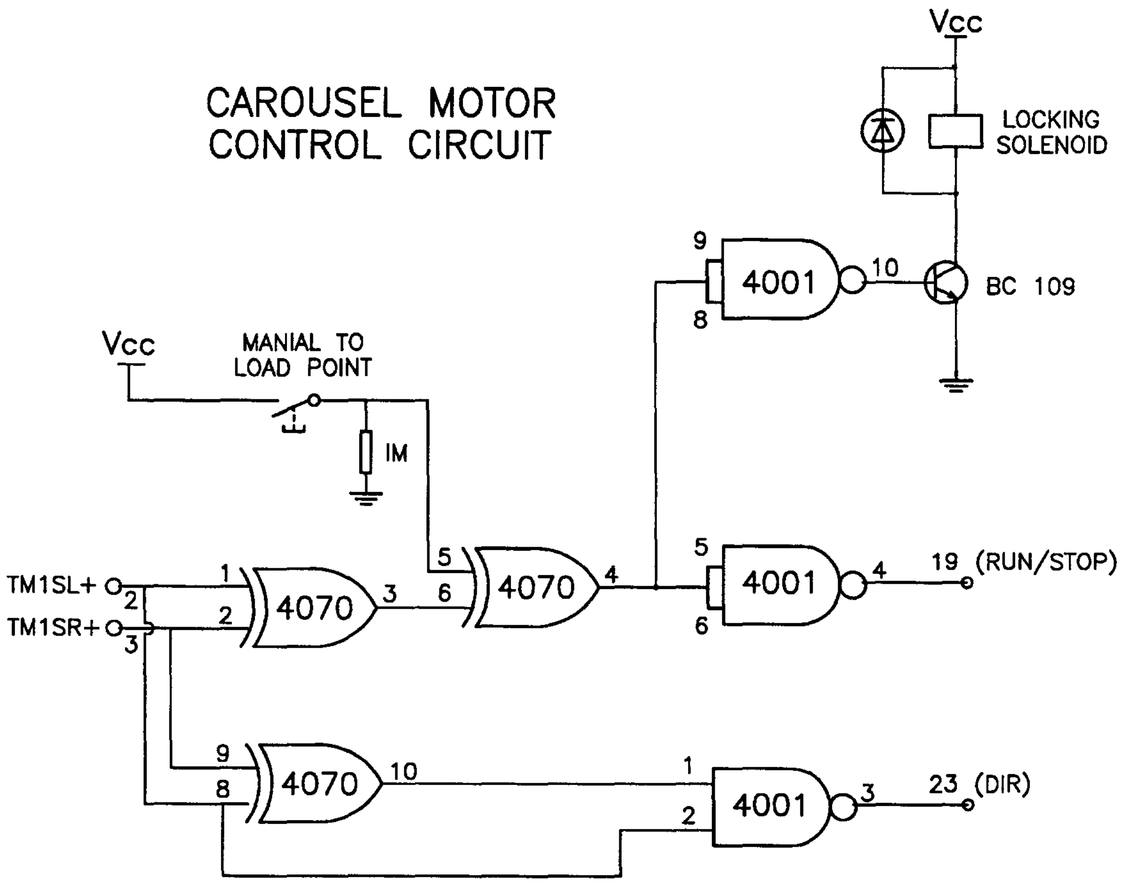
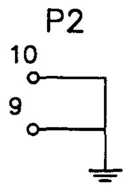


Figure 1b. *Diagram of carousel, showing sample and alignment holes.*

5 cm



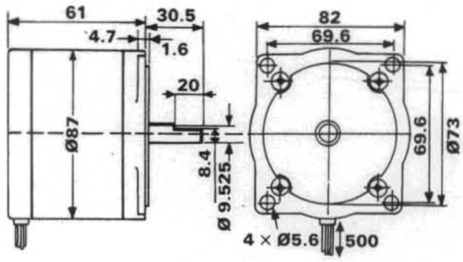


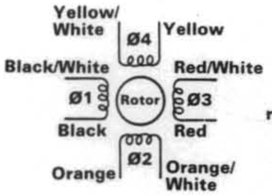
P2 "D" 15 CONNECTOR

1	NO CONNECTION	–	–
2	NO CONNECTION	–	–
3	NO CONNECTION	–	–
4	NO CONNECTION	–	–
5	END OF TRAY	GREEN	COMMON
6	END OF TRAY	RED	N/O
7	END OF TRAY	GRAY	N/C
8	GROUND	GREEN	–
9	DIRECTION	RED	CCW
10	DIRECTION	GRAY	CW
11	MANUAL TO LOAD POINT	YELLOW	–
12	MANUAL TO LOAD POINT	BLUE	–
13	TRAY DETECT	BLACK	COMMON
14	TRAY DETECT	YELLOW	N/O
15	TRAY DETECT	BLUE	N/C

Figure 2a.

Type 34 (344-631)





1.8° step drive sequence

step	Ø1	Ø2	Ø3	Ø4
0	ON	OFF	ON	OFF
1	OFF	ON	ON	OFF
2	OFF	ON	OFF	ON
3	ON	OFF	OFF	ON
4	ON	OFF	ON	OFF

repeat

CCW

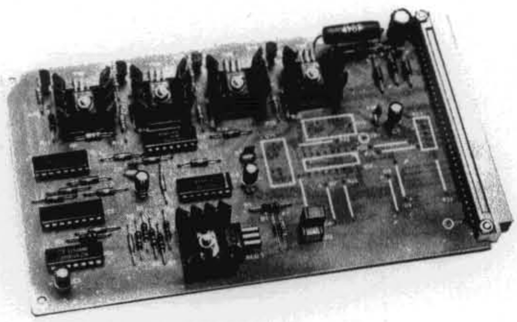
CW

2. Stepper motor drive board (332-098)

This board is capable of driving in the unipolar mode any 4-phase stepper motor up to 2A, 30Vdc/phase (including the RS 7.5° motors with much improved stepping rates over the driver IC).

- Directly compatible with any of the RS stepper motors.
- Eurocard system compatible. Alternatively it may be surface mounted.
- Full step and half step drive modes.
- External control inputs are CMOS and open collector TTL logic compatible.
- Pre-set control for setting predetermined motor phase excitation pattern.
- On-board 12V, 50mA dc output for external circuit energisation.
- Drive board and motor can share the same dc power supply.
- Provision for assembling on board oscillator (if external clock not available), having clock pulse output, base speed, running speed and stop/run controls.

Stepper motor drive board



Technical specification

Size	Standard Eurocard 168 × 100 × 15
Mating edge connector	Standard 32 Way DIN 41612 socket eg. RS 471-503 or 467-453
Supply (board and motor)	15-30Vdc + 10% max. Unregulated smoothed.
Current consumption:	
a) board only	60mA
b) motor windings	dependent on motor used – up to 2A/phase max.
On-board auxiliary output	12Vdc 50mA max. regulated
Switching logic control inputs	Level '0' 0V) CMOS and open collector Level '1' 12V) TTL compatible
a) Full/Half step	Level '1' full step Level '0' half step
b) Direction	Clockwise or anti-clockwise
c) Clock step	1Hz-25KHz, 10μs minimum pulse with negative edge triggered
d) Preset	Active level '0' Sets motor drive states to Q1 & Q3 OFF, Q2 & Q4 ON (full step mode) Q1, Q2 & Q3 OFF, Q4 ON (half step mode) – See Figure 11, Automatic preset at switch ON.

Figure 11 **Stepper motor drive board connections**

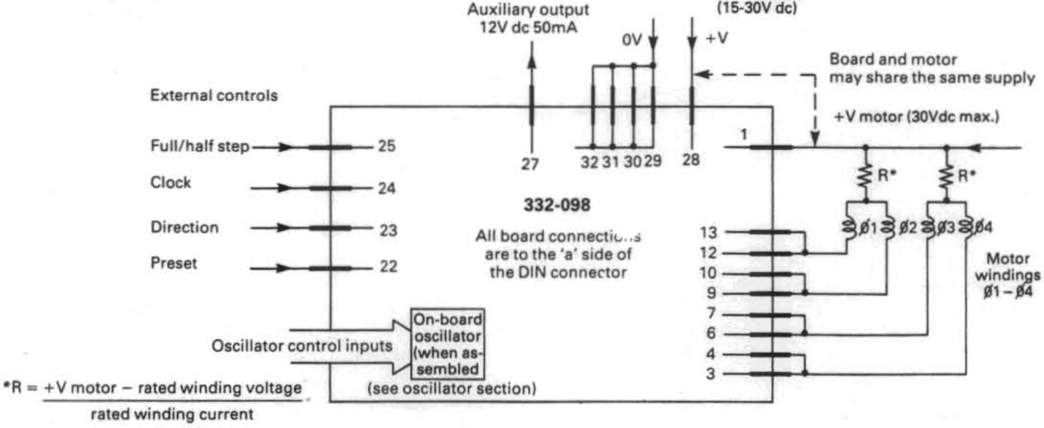


Figure 2b.

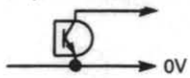
Maximum power dissipated through R = (rated motor current)^2 × R. If the power dissipation is high it is advisable to arrive at the required value of R by using a network of series or parallel resistors. The use of heat sinks and higher wattage resistors may be necessary in applications where power dissipation is excessive.

Maximum current consumption (motor + board) = 2x (current per phase) + 60mA. Thus ensure power supply cables used are sufficiently rated.

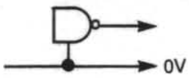
External control signal eg. full/half step, direction etc as well as the oscillator (if fitted) stop/run signal can be applied to the board in any of the methods of Figure 12.

Figure 12 **External control input applications**

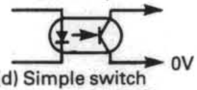
(a) Open collector T.T.L.



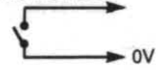
(b) C.M.O.S. (operating @ +12V)



(c) Opto-coupler



(d) Simple switch



Connection to RS stepper motor

When the windings of the RS stepper motors are assigned (01–04) as shown in Figure 13, they can be connected to the board according to Figure 11.

Figure 13 **Motor winding connections**

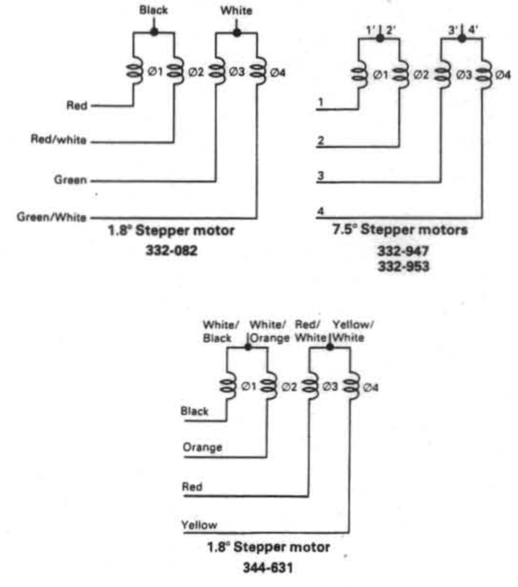


Figure 2c.

If the supply voltage is set to 24Vdc then R values for use with the RS motors are given in Table 3.

Table 3

motor	Rated current (A)	Rated winding voltage (V)	R (Ω)	Power dissipation through R (W)
332-947	0.1	12	120	1.2
332-953	0.24	12	47	3
332-082	1	5	19	19
344-631	1.7	3	12.3	36

Here the 7.5° motors are driven in the L/2R mode while the 1.8° motors are driven in the L/5R and L/8R modes respectively.

Typical pull-out performance characteristics (under no-load conditions) for the RS motors when being driven by the drive board 332-098 using a 24Vdc supply and series resistance as in Table 3 are given in Figures 14 to 17.**

Figure 14 **Pull-out performance for 7.5° size 1 stepper motor (with RS drive board 332-098)**

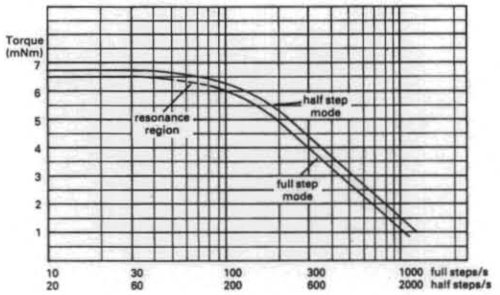


Figure 15 **Pull-out performance for 7.5° size 2 stepper motor (with RS drive board 332-098)**

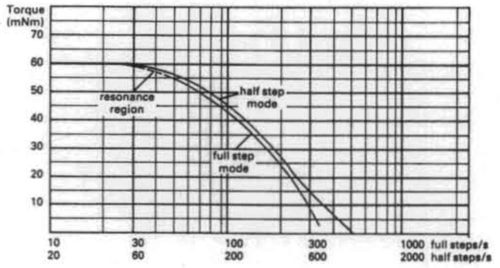
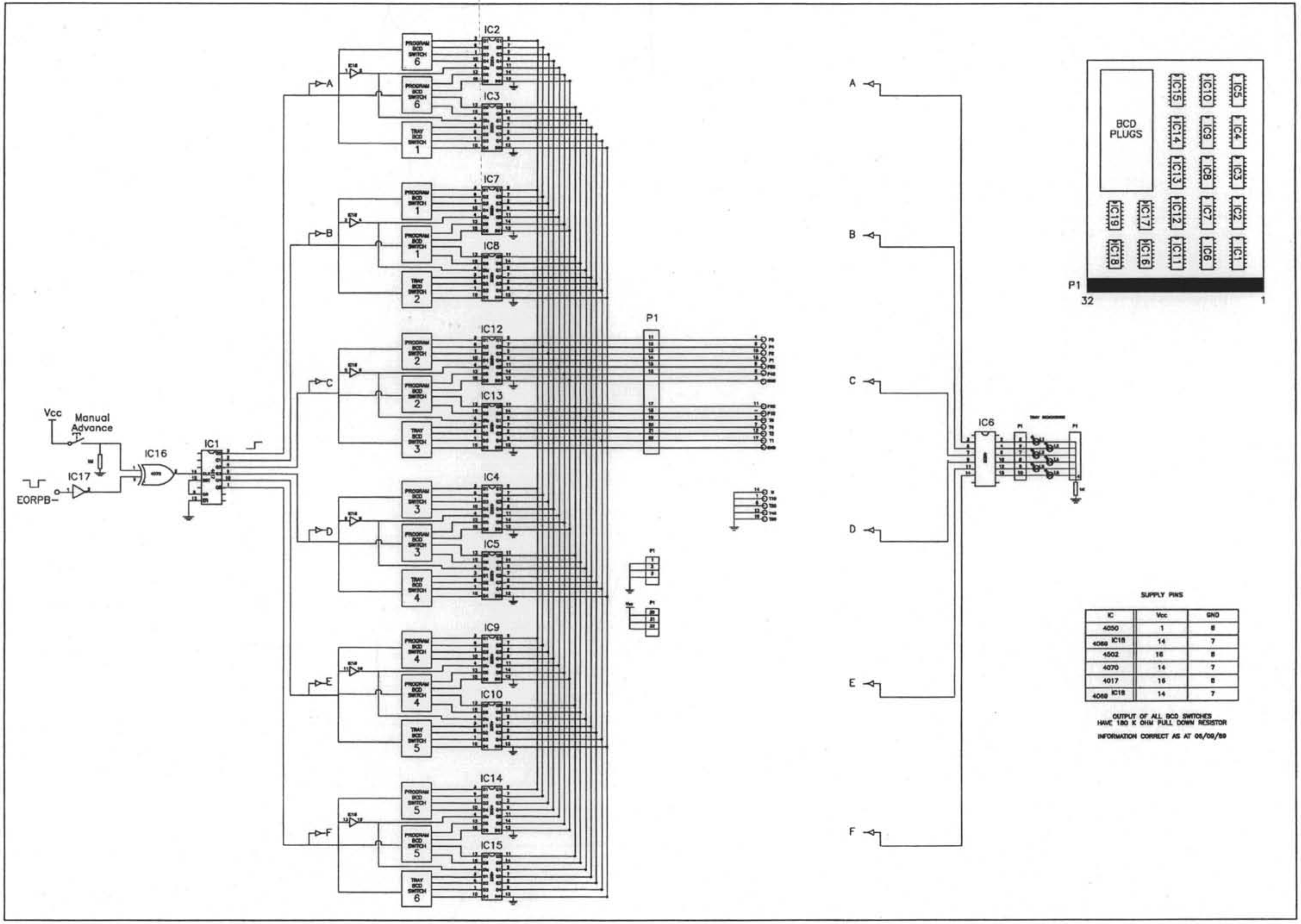


Figure 3.



SUPPLY PINS

IC	Vcc	GND
4050	1	8
4069 IC18	14	7
4502	16	8
4070	14	7
4017	16	8
4069 IC19	14	7

OUTPUT OF ALL BCD SWITCHES
HAVE 180 K OHM PULL DOWN RESISTOR

INFORMATION CORRECT AS AT 06/09/89

APPENDIX 2

Alignment Procedure

The alignment of the carousel is very simple and accurate if the procedures given are followed closely and correctly.

Sample in correct position alignment:

(1) Turn the power to the carousel motor off at the power point (do not disconnect any part of the sampler unit from the XRF).

(2) Position the carousel manually to a position where the grab arm can pick up a sample holder without the sample holder rubbing up against the sides of the sample holder locating hole on the carousel.

(3) Do not move the carousel from this position, and turn on the power at the power point. This will lock the motor and carousel into this position.

(4) Adjust the "optical sample in position source and sensor" over the positioning hole drilled in the circumference of the carousel. Correct alignment is obtained when a piece of paper is passed over the hole and a click can be heard coming from the sampler unit.

End of tray alignment:

(1) Turn the power to the carousel motor off at the power point.

(2) Rotate the carousel by hand to the end of tray optical positioning hole.

(3) Turn on the power to the carousel motor at the power point; this will lock the motor in this position. Be careful not to move the carousel during this procedure.

(4) Slide a piece of paper over the optical positioning hole and listen for a click from the sampler unit; this will ensure that you are in the correct position. If no click is heard then move the carousel slightly until this occurs.

(5) Adjust the end of tray microswitch on the perimeter of the carousel so that it is released in the slotted groove; this can be checked by manually depressing the switch to see if it is actuated when pressed. Again check that the optical sensor is aligned by placing a piece of paper over the hole and listening for a click from the sampler unit.

(6) Turn the power off to the carousel motor at the power point. Check that the end of tray microswitch is engaged before the optical sensor detects the end of tray hole in both clockwise and anticlockwise directions. This can be done by simply rotating the carousel back and forth, listening for the click of the microswitch before the click of the optical sensor circuit in the sampler unit.

(7) Procedure 6 should be carried out on all six end of tray grooves, so that the alignment position is correct for all tray positions without adjustment for each individual tray.

(8) Turn the power on to the carousel motor at the power point.

Final check:

(1) Run a simple program which will pick up all the samples, put them in the XRF, and then unload them back into the carousel. This should be carried out on all 36 sample positions to ensure that the alignment of the carousel is correct. If this test is successful the carousel is ready to be used. If not then the the above procedures should be followed much more carefully.