USER'S MANUAL

ROTOCHEM III RESEARCH MODEL

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1.0   INTRODUCTION

The AMINCO/TENNECOMP Rotochem III Research Model is a software system written by Tennecomp Systems for the Rotochem analyzer produced by the American Instrument Company. Its chief purpose is to enhance the flexibility of the Rotochem by allowing the user a greater latitude of control over the device than was previously possible using the Rotochem II software.

Rotochem II software consists of a series of assembler language programs, each of which drives the Rotochem to do a specific task. Rotochem III differs in that it makes use of a foreground/background concept by which each user may achieve total control of the Rotochem device by writing his own applications programs in an extended version of FOCAL [1], 1969. By using a few English-like FOCAL instructions, the user may specify a manner of data collection and analysis of his own choosing. Further, he may create a library of collection and analysis routines on magnetic tape cartridges using the TP-1371 tape unit.

Rotochem III is available in three versions. Version A provides for the option of a digital display scope on which may be viewed scaled point plots of the data points collected for each cuvette in the Rotochem rotor or for display of up to 16 lines of a maximum of 32 characters each of user-determined alphanumeric data. Version B does not utilize the display scope. Except for those commands exercising the scope, it is compatible with the scope version; i.e., programs written on either Version A or Version B may be stored on tape cartridges and read back by either version. Version C is not compatible with Version A or Version B in that FOCAL program tapes are not interchangeable. Version C allows approximately 30% more core storage for user-written FOCAL than does Version A and B.

[1] FOCAL is a trademark of the Digital Equipment Corporation.

2.0 FOREGROUND/BACKGROUND CONCEPT – GENERAL DESCRIPTION

In the Rotochem III system there are two kinds of programs:

2.1 Foreground Program

The hidden FOREGROUND program consists of a series of routines which perform the functions of starting and stopping the Rotochem rotor, testing for proper rotor RPM and acceptable signal level, initiating the vacuum mix and wash cycle, acquisition, averaging, and storing of data from the analog-to-digital converter according to preset parameters, performing the input and output for the NCR printer/keyboard, the tape unit, (the digital display scope if present), and performing various mathematics routines. The FOREGROUND program is activated by selected routines set into action by commands in the BACKGROUND program.

2.2 Background Program

The BACKGROUND program is written by the user in FOCAL, an English-like language which permits the typing in of single commands for immediate execution or the preparation of a series of commands to constitute a program. These FOCAL commands trigger the execution of FOREGROUND routines according to arguments passed in the FOCAL instruction. Among other instructions, the user may issue FOCAL commands to:

- Determine the number of readings of each cuvette to be averaged for a single data point.

- Determine the time in seconds between each set of readings for each point.

- Determine the number of data points to be collected for each cuvette (up to 32).

- Determine the offset time to delay after starting the rotor and performing a vacuum mix before data collection is to begin.

- Accelerate the rotor for a selectable number of seconds.

- Perform a vacuum mix for a selectable number of seconds.

- Change the values to be tested for rotor RPM and signal intensity.

- Initiate a data collection run.

- Display a point plot of data points for any selected cuvette, (if digital scope present).

- Display alphanumeric data of the user's choosing, (if digital scope present).

- Stop the rotor.

- Disable the clock and the ADC.

- Perform a wash cycle.

- Call FOCAL programs from or write FOCAL programs to the tape unit.

- Access internal data storage buffers and manipulate the data mathematically.

- Format to the printer alphanumeric data with desired headings and simulate a point plot of data points.

- Change his Rotochem configuration from 60 cycle to 50 cycle current.

General details on FOCAL are given in the Digital Equipment Corporation publication "Programming Languages" (Volume 2 of the PDP-8 Handbook Series). Special details of extended FOCAL for the Rotochem III system are given in Section 3.0 of this manual.

3.0   FOCAL INSTRUCTION LIST

3.1   Changes and Additions to FOCAL

The FOCAL version used by this system is FOCAL, 1969. In addition, certain changes as described below have been introduced:

- The initial dialogue messages have been eliminated. The NCR printer/keyboard now types the message ?00.00 to indicate that FOCAL is loaded and functioning.

- The functions FSGN, FDIS, FADC, FATN, FSIN, FCOS, FNEW and FCOM have been eliminated.

- The functions FDDT and FPNT have been added. Their functions are as follows: [2]

    FDDT(A) obtains the integer value contained in cell A of lower memory (Field $\emptyset$).

    FDDT(A,B) sets cell A of lower memory to the integer value B.

    FPNT(A) obtains the floating point value stored in lower memory beginning at cell A [3].

    FPNT(A,B) sets the floating point value of B into lower memory beginning at cell A [3].

- The functions FSTT and FSTP have been added. Their functions are as follows:

    FSTT(N,T) where:

N = 1	Start the rotor and accelerate for T seconds.
N = 2	Initiate the vacuum mix and run it for T seconds.
N = 3	Initiate wash cycle.
N = 4	Reserved for future use.
N = 5	Reserved for future use.
N = 6	Initiate data collection.

---

[2] The values A and B in the FDDT and FPNT functions are interpreted as decimal values and translated to octal by FOCAL for internal manipulation.

[3] Floating point numbers require three cells of memory for storage.

FSTP(N) where:

N = 1   Stop the rotor.

N = 4   Disable ADC.

N = 5   Disable clock.

● In the version of Rotochem III which has the option for a digital display scope, the function FCRT(N) has been added and a new FDIS(A,B) included in place of the old FDIS. The new scope functions operate as follows:

S X=FCRT(N) with N = $\emptyset$

This will cause output from FOCAL TYPE statements to be sent to a buffer in Field $\emptyset$ rather than to the NCR printer. The buffer may then be displayed on the scope. The size of the scope display area limits the length of each line typed to 32 viewable characters, including spaces, plus the carriage return/line feed generated by the character "!" in a TYPE statement. Up to 16 such lines may be stored. If the buffer size is exceeded, the program will return all excess characters to output on the printer.

Issuing the FCRT command with N = 1 will cause output to be done on the NCR printer rather than stored for output to the scope. The FCRT(1) command should always be issued immediately following the FOCAL output commands which are sent to the text buffer. An example:

```
1.1∅    S X = FCRT(∅)
1.2∅    T ! "This is Text"
1.3∅    T ! "This is Text"
          .
          .
          .
1.7∅    T ! "This is the Last of Text"
1.8∅    S X = FCRT(1)
```

This function FDIS(A,B) serves two display purposes, that of display of the alphanumeric buffer created by the FCRT function and the display of a scaled point plot of the data points of each cuvette.

S X=FDIS(Ø)

> This will cause the display of the alphanumeric data buffer created by the FCRT command. Exit from the display is accomplished by typing CNTRL D. If the FDIS command was issued in immediate mode, this will cause a return to the FOCAL monitor. If the FDIS command was a line of a FOCAL, typing CNTRL D will cause the program to continue execution on the line of program text following the FDIS command.

S X=FDIS(A,B)

> This will cause a point plot of the data points for the cuvette identified by the argument "A", where "A" may range from 1-14. If the argument "B" is zero or missing, no scaling will be done. If present, the permissable value for "B" will cause the following scaling:

B = Ø	No scaling
B = 1	All Y values multiplied by 2
B = 2	All Y values multiplied by 4
B = 3	All Y values multiplied by 8
B = 4	All Y values multiplied by 16

Exit from a given point plot display follows the same procedure as exit from the alphanumeric display.

- FOCAL no longer types an equal sign when it types a value.

- The FOCAL text area has been greatly increased. In the non-scope compatible version 2831, words are available for user FOCAL text. In the scope and scope compatible versions 2015, words are available. The size of a given program depends on how it is written. For example, it is much more efficient to use an initial, where possible, instead of the full word for a FOCAL command. For example, the use of T in place of TYPE or E in place of ERASE, will cause a significant increase in the size of the program possible. Also, since FOCAL uses two words for each line of text, the programmer should include as many commands on a line as his logic permits. The size of a FOCAL program is given by the following equation:

$$\text{Core Used} = \frac{(\text{total number of characters including spaces})}{2} + (2 \times \text{number of lines})$$

● The number of variables allowed has been increased to 149. This number is not diminished as the size of the FOCAL program increases in itself, but only as variables are assigned.

● If an ASK statement is executed, the teletype no longer types a colon.

● If an attempt to find the logarithm of zero is made, the error message 2∅.26 will be typed .

● The command ERASE ALL will erase the user's FOCAL text but will not erase any variables assigned. To erase variables one must issue the command ERASE alone. Individual lines of FOCAL may also be erased by typing ERASE followed by the line number to be erased.

● The LIBRARY command has been modified as follows:

    1. LIBRARY OUT (or L O) stores text onto magnetic tape. The selected track number (1-4) follows the command. Thus, the command L O 2 would store the FOCAL text currently in core on track 2 of the tape cartridge in the unit.

    2. LIBRARY IN (or LI) reads text stored on magnetic tape into core after first having erased that text which may already have been in core. Thus, L I 3 would clear the FOCAL text area of core and read into it the FOCAL text stored on track 3 of the tape cartridge in the unit.

    3. A comma after a LIBRARY IN command will begin execution of the FOCAL program read in. Thus, L I 1 will read in the FOCAL program on track one of the tape cartridge and begin execution at the lowest numbered line of program text. If the command had been L I 1, 5.2∅, the program would have begun execution at line number 5.2∅.

    4. Using the LIBRARY IN command does not affect any variables which may have been set up by a preceeding program. This means that a number of programs may be read in, each of which access the variables left by the preceeding program. This makes possible segmenting very long programs so that processing may proceed by steps, if necessary.

    5. These commands can be either direct (used in response to the asterisk typed by FOCAL) or indirect (in a numbered line within the user's FOCAL program). If it is used directly, the LIBRARY command should be the last command on a line of text 4.

4
When writing to the tape with the L O command, be sure there is a write/enable pin in the tape cartridge.

3.2   New FOCAL Error Messages

There are several new error messages relating to errors which could arise in using the new FOCAL functions. These are:

Error	Cause
19.27	N not in range of 1-6 in FSTT(N,T).
31.<1	No value for T if N is 1 or 2 in FSTT(N,T).
19.89	N not 1, 4, or 5 in FSTP(N).
31.72	N not Ø or 1 in FCRT(N).
18.<7	A not in range Ø-14 or B not in range Ø-4 in FDIS(A,B).
25.87	Format error in Library call statement.
25.;9	Illegal subcommand in Library call.
31.16	Checksum error on Library read.
30.80	TP-1371 hardware failure.

4.0   DETAILED SYSTEM DESCRIPTION

(all computer core locations in decimal numbers)

4.1   Setting of Parameters

Setting of parameters is accomplished by the special FOCAL function FDDT(A,B) which sets cell A of lower memory to the integer value of B, where:

Cell	Integer Value
A = 4	B = the number of readings per cuvette to be averaged for each data point.
A = 5	B = the number of data points to be collected (a maximum of 32).
A = 6	B = the time interval in seconds between the collection of sets of data for each data point.
A = 7	B = the offset delay in seconds before data collection begins after the vacuum mix.

Cells 4, 5, 6 and 7 must be set before an attempt is made to collect data. When the command is given to start data collection, whatever is in cells 4 through 7 have their negative values placed in cells 16 through 19, respectively. Cells 16 through 19 are then accessed by the foreground program to control data collection. The argument B must always be a positive number equal to or greater than 1 or control of data collection may be lost. Once the above parameters have been set, they need not be reset unless a change of parameters is desired or unless the Rotochem III program is reloaded into the computer by use of the Halt/Load and STD buttons on the Rotochem console.

The following are examples of the proper use of the FDDT command to set parameters in immediate mode:

S X=FDDT(4,4)	–	sets up to average four readings per cuvette for each data point.
S X=FDDT(5,8)	–	sets up to take eight data points per cuvette.
S X=FDDT(6,2)	–	sets up to delay two seconds between each set of readings for each data point.
S X=FDDT(7,30)	–	sets up for a thirty second offset before data collection begins after the vacuum mix.

All these commands could have been issued in a single line of FOCAL, again in immediate execution mode, as follows:

S X=FDDT(4,4); S X=FDDT(5,8); S X= FDDT(6,2); S X=FDDT(7,3∅)

4.2   Initiation of a Data Collection Run

Initiation of a data collection run is accomplished by the use of the FSTT FOCAL function once run parameters have been set. First the rotor must be set in motion, a vacuum mix performed, and then the command given to begin data collection. These commands should be given in the order stated. The FSTT command is of the following form:

S X=FSTT(1,T)   –   starts the rotor and accelerates for T seconds.

S X=FSTT(2,T)   –   performs a vacuum mix for T seconds.

S X=FSTT(6)   –   starts data collection according to the parameters previously set.

The following example is the efficient way of starting the rotor, accelerating it for two seconds, performing a four second vacuum mix, and then beginning data collection:

S X=FSTT(1,2); S X=FSTT(2,4); S X=FSTT(6)

It is important that the user understand what actually occurs when he issues the command S X=FSTT(6) to begin data collection. The program first takes the positive integer parameters in cells 4-7 (decimal), converts them to negative values, and then stores the negative values in cells 16-19 (decimal). After having set a number of internal pointers based on the values of the parameters, the program then checks to see if the rotor is turning at a minimum acceptable speed. Unless modified by the user (see Section 8.∅) , the program will check to see if the rotor is turning at 600 RPM or better. If not, the LOW RPM and HALT lights will come on on the Rotochem console. The user should adjust the rotor RPM upward on the Rotochem and press the START button on the Rotochem console. The program will turn off the LOW RPM and HALT lights and repeat the RPM test. If the RPM is again too low, the LOW RPM and HALT lights will be turned on and the user must again adjust the rotor speed.

When the RPM test is successful, the program proceeds to the test to determine if the signal level is within acceptable limits. Unless modified by the user (see Section 8.∅), the program assumes that the first cuvette is a water blank and tests to see if the signal received through it is between 70% and 90% of the maximum possible for the ADC (4096). If the signal level is outside those limits, the program will turn on the SIG ERR and HALT lights on the Rotochem console and wait for the operator to adjust signal intensity. When he has done so, pressing the START button on the Rotochem console will cuase the program to turn off the SIG ERR and HALT lights and recheck the signal level. The program will continue to cycle through these steps until the signal level is within acceptable limits.

Normally on a Rotochem device which has been adjusted properly, the rotor RPM and signal level tests will be accepted on the first check and no operator adjustment will be necessary.

After the RPM and signal level tests have been successfully completed, the program goes into a wait counting down the seconds specified as the offset delay before data collection. It is important that the user understand the difference between offset time and total elapsed time. The offset time parameter is included to allow the user to introduce a delay time of his choosing to permit a reaction to advance to the desired stage before data collection begins. It does not represent the total elapsed time from the time the rotor is set in motion. The total elapsed time from the start of the rotor to the beginning of data collection is the sum of the rotor acceleration time, the vacuum mix time, the offset time, and the time required to successfully test the rotor speed and the signal level. On a properly adjusted Rotochem with the rotor turning at 600 RPM, the time to test RPM and signal level is approximately two seconds.

As soon as the offset time has elapsed, the program zeroes the average buffer (cells 512 through 543 in Field ∅) and begins to read in and average cuvette values. The average buffer provides for storage of 16 double precision values. As the program proceeds to take and average the number of readings per data point, this buffer is continually updated until the prescribed number of readings have been taken. The average buffer then represents the average values for the number of cuvette readings which have been done. The first value represents ths so-called dark value caused by the strobe which identified the next cuvette as cuvette number 1. The 15 values represent the values averaged from the 15 cuvettes on the rotor. All 16 values are moved to the absorbance buffer (cells 544-1055 in Field ∅). The program waits the prescribed number of seconds set by the parameter which was entered to set the time delay between sets of readings, zeroes the average buffer and repeats the cycle.

After sets of readings have been entered into the absorbance buffer, 16 values at a time, for all data points specified by the number of data points parameter, the absorbance buffer is compressed. The first value of each set of absorbance values, the dark value, is eliminated since it serves no purpose for future calculations. The second value is assumed to be a water blank, the standard value. This standard value is subtracted from each of the following 14 cuvette values and is then removed from the absorbance buffer. When this is done for each set of 16 originally contained in the buffer, the absorbance buffer is reduced to the region of cells 544 through 991 or less, since the region 544-991 presumes that the maximum of 32 data points were collected for each cuvette. The buffer is arranged so that cell 544 through 557 are found in order the first absorbance values for each of the specimen cuvettes, the next 14 cells contain the second absorbance, etc. through a maximum of 32 sets of 14 cells each. (See Section 8.0 for a method to avoid the subtraction of the water blank from each of the suceeding 14 cuvettes and for storing in the absorbance sets of 15 cuvette values at a time with the first of each 15 being the water blank standard value).

In the example given above, the end-of-data collection occurs when the absorbance buffer has been compressed. Since these example commands were given in immediate execution mode, the program would signal the end-of-data collection by typing an * on the printer. The rotor will still be in motion and no further processing would occur without further FOCAL commands.

4.3   To Clean Up the System After Data Collection

The rotor should be stopped, the ADC and the clock disabled, and a wash cycle started. A combination of FSTT and FSTP FOCAL commands is used to accomplish such a clean shutdown of the collection cycle. The following commands, in the order stated, should be used:

$$S \ X = FSTP(1) \ - \ \text{stops the rotor}$$

$$S \ X = FSTP(4) \ - \ \text{disables the ADC}$$

$$S \ X = FSTP(5) \ - \ \text{disables the clock}$$

$$S \ X = FSTT(3) \ - \ \text{initiate the wash cycle}$$

In immediate execution mode, the efficient way to issue the instructions is:

$$S \ X=FSTP(1); \ \ S \ X=FSTP(4); \ \ S \ X=FSTP(5); \ \ S \ X=FSTT(3)$$

In initiating a wash cycle, the computer has control of the device for only the first second. The wash cycle then proceeds under mechanical control until it terminates. This means that further FOCAL commands for processing the data can be going on during the time the wash cycle is in progress. The only commands which should not be issued while a wash cycle is in progress are those which deal with the rotor. These are commands to stop and start the rotor and the command to do a vacuum mix. If any of these three commands are issued while a wash cycle is in progress, the program will attempt to execute the command but will be overridden by the mechanical control of the wash cycle. Therefore, do not issue a start rotor, stop rotor, or initiate vacuum mix while the wash cycle is in progress. The end of the wash cycle will automatically stop the rotor. All other commands are executable during the wash cycle.

4.4   Processing Absorbance Values

The user may now process the absorbance values in a manner of his own choosing.

5.0   STORAGE BUFFERS - LOCATIONS AND ACCESS

(All locations are in decimal notation and are in Field Ø)

5.1   Average Buffer
      512-543

32 locations used to store and average input data on each reading of the rotor. The buffer is zeroed and overwritten on each set of readings.

5.2   Absorbance Buffer

      Originally
      544-1055

512 locations originally. Used to store sets of 16 average values representing the dark value, the water blank, and 14 cuvette absorbance values. The first set of 16 values represents the first data point for each cuvette, the second set represents the second data point for each cuvette, etc. through a maximum of 32 data points.

      Packed to
      544-991

The collection program packs this buffer by eliminating the dark value, subtracting the water blank value in each set from 14 cuvette absorbance values and restoring the buffer in sets of fourteen. The first set of fourteen values represents the absorbance values of the first data point, less the water blank value, for all fourteen cuvettes, the second set of fourteen represents the same values for the second data point, etc., to a maximum of 32 data points.

5.3   Work Buffer

      Slopes
      992-1033

      Y Values
      1048-1079

Originally 128 cells. Later used by FOCAL programs to store 14 floating point slopes (three words each). Also used to store scaled Y values for the scope version point plot display.

5.4   Calibration Buffer
      1080-1130

51 cells for the user to store any calibration values or constants he chooses.

5.5   <u>Alpha Display Buffer</u>   544 cells filled by the FCRT command in the scope
             <u>1408-1951</u>   version to be displayed on the scope by the FDIS
                                               command.

5.6   Other Useful
             <u>Locations in Field $\emptyset$</u>

Cell 4 – A positive integer not destroyed by running the program. It indicates the number of readings to be taken on each cuvette.

Cell 5 – A positive integer not destroyed by running the program. It indicates the number of data points to be taken for each cuvette.

Cell 6 – A positive integer not destroyed by running the program. It indicates the number of seconds delay between taking sets of readings for averaging, i.e., time interval between data points.

Cell 7 – A positive integer not destroyed by running the program. It indicates the delay in seconds the program will wait before starting data collection after the vacuum mix ends.

Note: Cells 4–7 are not directly used by the program. They receive the run parameters set by the user in FDDT commands. When the data collection run begins, the values in cells 4–7 are read, negated, and put into cells 16–19, respectively, which are used by the collection program.

5.7   <u>Access of Locations</u>   Procedures for setting run parameters in cells 4–7 with the FDDT command have already been discussed. The buffers which a user would normally wish to access are the packed absorbance buffer, the slope buffer, and possibly the user calibration buffer. The following discusses retrieving absorbance values for further processing and storing and retrieving slopes in floating point format.

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One of the most frequently accessed buffers will be the absorbance buffer. It is from this buffer that absorbance data must be obtained for any further processing to meaningful results. As an example of a simple access of this buffer, assume a data collection run has just been performed with eight data points per cuvette collected. There will be eight sets of 14 absorbance values each in the buffer in single precision. Suppose we wish to access the eight data points for the first cuvette. The instructions in FOCAL could be:

.
.
.
.
.

5.Ø2   S J=K; F I=1,8; D 6.Ø2

.
.
.
.
.

6.Ø2   S P(I)=FDDT(544 + J);   S J=J + 14

The results of executing command 5.Ø2 and 6.Ø2 would produce the variables P(1) - P(8) representing the absorbance values of the eight data points for cuvettes determined by a previously set value of "K":

K = Ø   Cuvette 1

K = 1   Cuvette 2

.
.
.
.

K = 13   Cuvette 14

The slope buffer has been provided as a convenient area to store up to 14 slopes in floating point format (three words each). Of course, the user may store the slopes as named variables but the use of the buffer achieves a saving in the variable storage area and allows for standardization among FOCAL programs. As an example, suppose the user has calculated slope values for each of the 14 cuvettes and has these stored as the variables SL(1) – SL(14). He can store these 14 slopes in the slope buffer as follows:

7.02 S J=Ø; F = I=1,14; S X=FPNT(992+J, SL(I)); S J=J + 3

Slopes may be retrieved from the buffer by the same or a different FOCAL program. To retrieve 14 slopes and store them in the variables SL(1) – SL(14), the following commands could be used:

8.02 S J=Ø; F I= 1,14; S SL(I) = FPNT(992 + J); S J=J+3

6.0   CORE ALLOCATION

(All numbers in decimal notation)

6.1   Scope Display and Scope Compatible Versions

Ø-511	Background Program	
512-1135	Data Buffers	
1136-1397	Background Program	Field Ø
1408-1951	Alpha Display Buffer	
1952-3967	FOCAL Text Area	

Ø-4Ø95

FOCAL Interpreter

and

Variable Storage

Field 1

6.2   Non-Scope Compatible Version

Ø-511	Background Program	
512-1135	Data Buffers	Field Ø
1136-3967	FOCAL Text Area	

Ø-4Ø95

FOCAL Interpreter

and

Variable Storage

Field Ø

7.0   LOADING AND RUNNING ROTOCHEM III

The Rotochem III system of programs is delivered on track 1 and track 2
of a Tennecomp tape cartridge. Track 1 contains the programs for Field $\emptyset$
of the computer, while track 2 contains the programs for field 1. The
system is loaded by inserting the system cartridge into the TP-1371 tape
unit, turning the track select to Auto, pressing the HALT/LOAD button
on the Rotochem console, and pressing the STD button. When the programs
have been read in, the system notifies the user by printing $?\emptyset\emptyset.\emptyset\emptyset$ on the
NCR printer. (Note, it is wise to remove the write enable pin from the
master system tape so that it would be impossible to inadvertently write on
the tracks containing the system programs.)

The act of reading in the system programs destroys any FOCAL programs
or variables which may have been in core from a previous run. Any
program modifications which may have been done by FOCAL commands
(see Section 8.0) are also removed. Once the system is read in, the user
may type in a FOCAL program and execute it, type in and execute
individual commands in immediate mode, store FOCAL programs on tape,
or read in previously written FOCAL programs from tape. The system
itself does nothing except by FOCAL commands.

8.0   MODIFYING THE FOREGROUND PROGRAM

8.1   Modifying Water Blank Subtraction

The Rotochem III system, as written, subtracts the water blank in the first
cuvette and repacks the absorbance buffer with sets of 14 readings of the
remaining 14 cuvette values with the water blank subtracted. This feature
may be changed by the user so that all 15 cuvette values are retained and
no subtraction of the value of the first cuvette from the remaining 14
cuvettes occurs. If this is done, the maximum number of data points
which may be acquired per cuvette is 29. These are stored in sets of
15 values each in the same fashion as the normal packed absorbance
buffer storage already discussed. Running the following FOCAL program
will modify to foreground program to perform as indicated above. The
program need only be run once unless the Rotochem III system itself is
reloaded. The FOCAL program to perform the modification is:

1.Ø2 C PATCH TO INCLUDE WATER BLANK IN PACKED ABSORBANCE

1.Ø4 C BUFFER. BUFFER NOW HAS VALUES FOR 15 CUVETTES

1.Ø6 C AND NO SUBTRACTION OF VALUE OF CUVETTE 1

1.Ø8 S X = FDDT (437,594); S X = FDDT (440,3584)

1.1Ø S X = FDDT (441,3584); S X = FDDT (442,3584)

1.12 S X = FDDT (443,3584); S X = FDDT (445,3584)

8.2   Modifying Rotor RPM Check

The RPM of the Rotochem rotor is checked for a spin rate of at least
600 RPM. The test may be altered to accept a different lower threshold
should the user desire. The method by which the RPM is checked is to
collect a number of sets of data and check the time required for the
collection. In checking for 600 RPM, eight sets of data are collected.
If the clock has ticked at most 48 times, the rotor is turning at 600 RPM
or better. The hardware of the Rotochem is normally set so that the rotor
will stabilize at just over 600 RPM. With some difficulty this stabilization
point can be changed, although it is wise to warn the user that he can set
the rotor speed so high that he outstrips the programs ability to perform all
its data averaging functions and still return in time to pick up the next
cuvette. In changing the RPM test, bear in mind how the 600 RPM check
was made: (60 cycle clock)

$$\frac{8 \text{ Revs.}}{48 \text{ Ticks}} = \frac{1 \text{ Rev.}}{6 \text{ Ticks}}$$

$$6 \text{ Ticks} = \frac{1}{10} \text{Second}$$

Therefore, there is 1 Rev. each $\frac{1}{600}$ minute, or 600 Revs. per minute

The most easily changed value in the algorithm is the number of ticks at
the proper RPM to be checked against the actual time for eight revolutions.
This can be arrived at as follows:

1. Time in minutes for 1 Rev. x 60 to convert to Rev. per Second.
2. Rev. per Second x 60 to convert to Ticks per Rev.
3. Ticks per Rev. x 8 for number of Ticks in 8 Revs. at proper speed.

An example of lowering the test level to 400 RPM would be:

1. $\dfrac{1}{400}$ x 60 = $\dfrac{3}{20}$ Revs. per Second

2. $\dfrac{3}{20}$ x 60 = 9 Ticks per Rev.

3. 9 x 8 = 72 Ticks for 8 Revs. at 400 RPM

Then the FOCAL command which follows could make the modification:

    1.02 S X=FDDT(120,-72); S X=FDDT(279,632)

For any other value required, it is only necessary to calculate the correct lower limit for the number of ticks and replace the negative 72 in the above FOCAL command with the negative number of ticks.

The RPM test may be eliminated by the command:

    1.02 S X=FDDT(196,3584)

As in the case of (a) above, this patch must only be made once unless the Rotochem III system itself is reloaded.

8.4   Modifying Signal Level Test

The signal level test normally tests to see if the signal received through the water blank is between 70% and 90% of the maximum possible for the ADC (4095). This can be altered by the user to reflect different light sources.

To eliminate the signal level test entirely, the following command could be given:

    1.02 S X=FDDT(197,3584)

The modification of the signal level test so that fixed values other than the 70% - 90% range are acceptable requires an understanding of the functioning of the logarithmic amplifier in the Rotochem hardware. (See the hardware manuals for the system.) The test for 70% to 90% depends on the fact that 49 milliabsorbance units represent 90% transmission and 155 milliabsorbance units represent 70% transmission. A count of one on the ADC represents approximately .63 millabsorbance units, therefore, to determine the high and low acceptable ADC values we convert the acceptable milliabsorbance units to ADC counts:

$$\frac{49}{.63} \quad = \quad \text{approximately 80 for 90\% transmission}$$

$$\frac{115}{.63} \quad = \quad \text{approximately 248 for 70\% transmission}$$

The ADC returns octal values so that a count of $80_{(10)} = 120_{(8)}$ and a count of $248_{(10)} = 370_{(8)}$. The 70% - 90% range test will thus accept ADC values only in the range of $120_{(8)}$ to $370_{(8)}$ inclusive.

Once the acceptable ADC values were determined, it was necessary to calculate two constants in the Rotochem III program so that the test could be performed in the most efficient manner possible. The constants are:

Low Limit located at $87_{(10)}$

High Limit located at $88_{(10)}$

The test depends on the fact that the PDP-8 computer translates an octal number of 4000 or greater as a negative, i.e., $7777_{(8)}$ becomes -1, etc. The test is performed as follows:

Actual Reading of a Water Blank Plus Low Limit = Result 1
(must be negative or test fails)

Then Result 1 Plus High Limit = Result 2
(must be positive or test fails)

In the case of the 70% – 90% acceptable range, it was necessary to select a Low Limit such that when added to an ADC reading of $120_{(8)}$ to $370_{(8)}$, inclusive, the result would be negative, i.e., greater than $4000_{(8)}$; and a High Limit such that when added to the result of the first addition the result will be positive, i.e., less than $4000_{(8)}$.

The Low Limit can be calculated by determining the negative number which when added to the greates acceptable ADC value ($370_{(8)}$), will yeild a negative number, thus:

$$
\begin{array}{r}
7777_{(8)} \\
- \ 370_{(8)} \\
\hline
7407_{(8)}
\end{array}
$$

Then......

$$
\begin{array}{r}
7407_{(8)} \\
+ \ 370_{(8)} \\
\hline
7777_{(8)}
\end{array}
$$
  (a negative and thus acceptable)

And.......

$$
\begin{array}{r}
7407_{(8)} \\
+ \ 120_{(8)} \\
\hline
7527_{(8)}
\end{array}
$$
  (a negative and thus acceptable)

The Low Limit is thus $7407_{(8)}$.

The High Limit is calculated by determining the positive value which when added to the lowest negative result above, will yield a positive number. The lowest negative number would occur if the ADC value were $120_{(8)}$, that is $7527_{(8)}$.

Then.......

$$7777_{(8)}$$

$$- 7527_{(8)}$$

$$\overline{250_{(8)}}$$

So, $250_{(8)} + 1_{(8)}$ is the High Limit and would pass the signal level test in either acceptable extreme. Testing the Low and High Limits in the acceptable extremes yields:

$7407_{(8)}$ Low Limit

$+ \quad 120_{(8)}$ Least Acceptable ADC Value

$\overline{\quad 7527_{(8)}}$ (Negative and thus acceptable)

$+ \quad 251_{(8)}$ High Limit

$\overline{\quad 0000_{(8)}}$ (Positive and thus acceptable, the leftmost digit truncated by the computer)

$7407_{(8)}$ Low Limit

$+ \quad 370_{(8)}$ Greatest Acceptable ADC Value

$\overline{\quad 7777_{(8)}}$ (Negative and thus acceptable)

$+ \quad 251_{(8)}$ High Limit

$\overline{\quad 0250_{(8)}}$ (Positive and thus acceptable, the leftmost digit truncated by the computer)

Note that any ADC values outside the $120_{(8)}$ – $370_{(8)}$ range will fail one of the tests. Suppose that a user has calculated different High and Low Limits and wishes to modify the Rotochem III program to insert a new test range. He must translate the new limits from octal to decimal and issue the following command:

(Line Number)   S X=FDDT (87, Low Limit$_{(10)}$);   S X=FDDT (88, High Limit$_{(10)}$)

As is the case with other program modifications, the new limits will remain in effect until the Rotochem III program is reloaded from the tape cartridge.

8.5   Modifying to Fifty Cycle Current

The Rotochem systems are available in both 60 cycle and 50 cycle configurations. For those users with 50 cycle electrical current, the followng FOCAL fix should be run:

S X=FDDT (86,-62);   S X=FDDT (85,-40)

The fix need only be run once unless the system is reloaded using the HALT/LOAD and STD buttons on the control panel.

9.0   PERIPHERAL INSTRUCTION LIST

The following list itemizes the special IOT instructions utilized in the Rotochem III system.

9.1   ADC Interface

63ØØ   Skip if ADC flag is set.

63Ø1   Enable revolution strobe. This allows revolution strobe to enter ADC. After the first revolution strobe is received, the cuvette strobe is automatically enabled.

63Ø2   Disable revolution and cuvette strobes.

63Ø4   Enable ADC interrupt. This instruction sets the ADC interrupt flag.

63Ø6   Clear ADC flag.

63Ø7   Read ADC data. Transfers the digitized data into AC Ø-11.

6311   Out Transfer: depending on the contents of the accumulator, the following functions occur:

AC = 4ØØØ	Start rotor acceleration
AC = 2ØØØ	Stop rotor rotation, stop ON
AC = 1ØØØ	Start wash cycle
AC = 4ØØ	Start vacuum mix
AC = 2ØØ	Stop rotor acceleration
AC = 1ØØ	Stop OFF
AC = 2Ø	Stop vacuum mix

9.2   Magnetic Tape Unit (MiniDek TP-1371) Interface

6365	Clear BOT 1 flag
6373	Skip on status and read status
6374	Transfer a word and clear write flag
6375	Clear and load command register
6376	Read a word and clear read flag

9.3 Clock Interface

6330	Skip on clock flag
6331	Clear clock flag
6334	Enable clock flag and interrupt flag
6335	Disable clock flag and interrupt flag

9.4 Functional Control Panel Interface

6320	Skip on pushbutton flag
6321	Clear pushbutton flag
6322	Read pushbutton into the accumulator
6324	Enable pushbutton interrupt
6325	Disable pushbutton interrupt
6326	Set indicator light. This instruction sets the light corresponding to bits set in AC $\emptyset$-11 according to the following arrangement:

AC2	SIG ERR light
AC7	LOW RPM light
AC1$\emptyset$	HALT light

6327   Read indicator light. This instruction will turn off the light according to the above arrangement.

9.5 NCR Printer/Keyboard Interface

6341	Skip if keyboard flag is set
6346	Clear keyboard flag and AC, read keyboard buffer into AC, set keyboard flag when complete
6351	Skip if printer flag is set
6352	Clear printer flag
6354	Load printer buffer, select and print, do not clear flag
6356	Clear flag, load printer buffer, select and print, set flag when complete

9.6 Digital Display Scope Interface

6060	Load X DAC for point plot, 10 bits loaded from AC2(MSB) to AC11(LSB) (0 is left, 1777 is right).
6061	Load X DAC as 6060, then clear AC.
6062	Load X DAC as 6060, intensify point.
6063	Load X DAC as 6060, intensify point, clear AC.
6064	Load Y DAC for point plot, 10 bits loaded from AC2 (MSB) to AD11 (LSB) (0 is down, 1777 is up).
6065	Load Y DAC as 6064, then clear AC.
6066	Load Y DAC as 6064, intensify point.
6067	Load Y DAC as 6064, intensify point, then clear AC.
6070	Set character done flag.
6071	Skip if character done flag set.
6072	Clear character done flag.
6073	Load character position register as follows:

> Horizontal Position: AC7 (MSB) to AC11 (LSB) in binary number of characters from left margin.
>
> Vertical Position: AC3 (MSB) to AC6 (LSB) is binary number of lines down from top of screen.

6074	Load character buffer with ASCII character in AC5 (MSB) to AC11 (LSB). AC4 is ignored. Display character.
6075	Set interrupt status (and optional control bits) from AC as follows:

> AC11 = 1 Enable interrupt on character done flag.
> AC10 = 1 Enable interrupt on intensify done flag.
> AC9 = 1 Reserved for future options.
> AC8 = 1 Reserved for future options.

6076	Load character buffer as in 6074, display character, and clear character done flag (during IO command).
6077	Skip if point intensify done flag is set, then clear point intensify done flag.

Flag Operation

1. Point Intensify Done

    This flag is set at the end of the intensify pulse when plotting points. This flag will come up approximately five microseconds after the following commands: 6062, 6063, 6066, 6067. This flag is cleared by init pulse and by the 6077 command. Note that I/O's for point plotting which do not intensify the point will not set any flag.

2. Character Done Flag

This flag is set when the character generator has completed a character as a result of 6Ø74 or 6Ø76 command. This will be approximately 1ØØ microseconds after the I/O command. The Character Done Flag can be set by the 6Ø7Ø command. It can be cleared by the 6Ø72 command or the 6Ø76 command. Init clears this flag.

Interface Status After Init

(Power Up or Clear Key)

Flags:	Cleared
Interrupts:	Enabled
Point Position Registers:	Cleared (lower left corner)
Character Position Registers:	Unknown

Note: Displaying a character (6Ø74 or 6Ø76) clears the point plot X and Y registers. Loading either X or Y point plot register or checking the point intensify flag will clear the character position registers.

10.0   DIAGNOSING PROBLEMS

- If NCR printer/keyboard does not respond when the foreground program is loaded, make sure the printer ON button has been pushed.

- The sounding of the sonalert while reading in the Rotochem III system indicates a bad read of the tape. Check to see that the track select switch on the tape unit is set to AUTO. Press the HALT/LOAD and STD buttons on the control panel and attempt to read again. Continued failures result from the following reasons in order of probability:

  1. The tape containing the program is worn, damaged, or has been accidently overwritten.
  2. The tape unit read head is dirty.
  3. The tape unit read head is mis-aligned.
  4. Hardware failure.

- If the magnetic tape unit does not respond when the HALT/LOAD and STD buttons on the control panel are pushed, make sure the tape cartridge is securely inserted into the tape unit. Check that the track select switch is on AUTO. Repeat the loading procedure.

- If the magnetic tape unit does not respond to the Library commands, make sure that the tape cartridge is securely inserted into the tape unit. Check that the track select switch is on AUTO. For LIBRARY OUT, make sure that the file protect pin is installed in the tape cartridge.

- If the LOW RPM light comes on, adjust the speed of the rotor and push START on the functional control panel.

- If the SIG ERR light comes on, make the necessary adjustment to correct the signal level, and push START on the functional control panel.