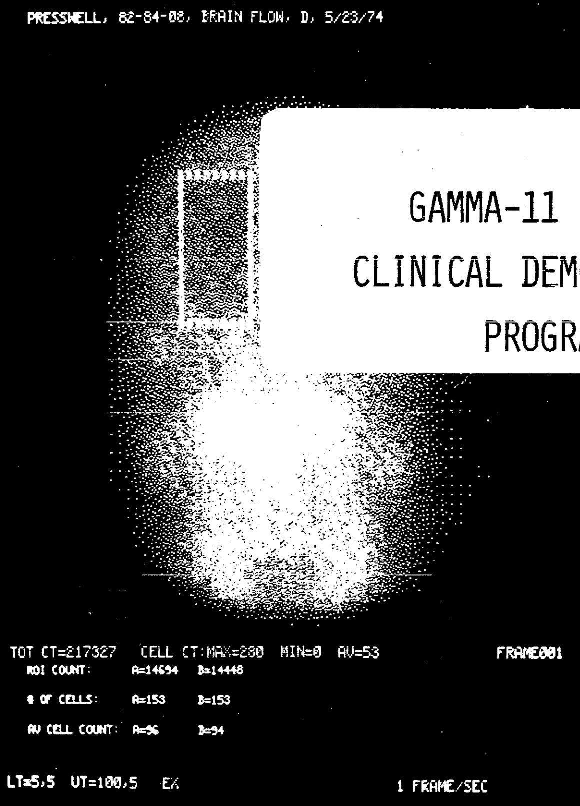
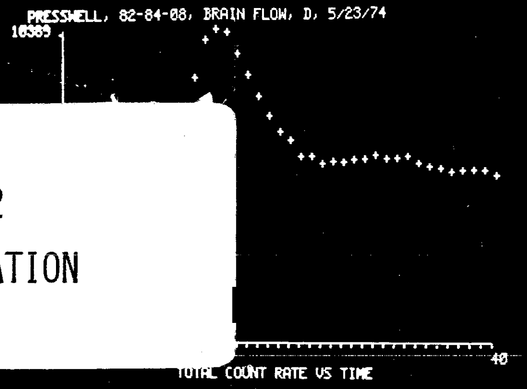
digital

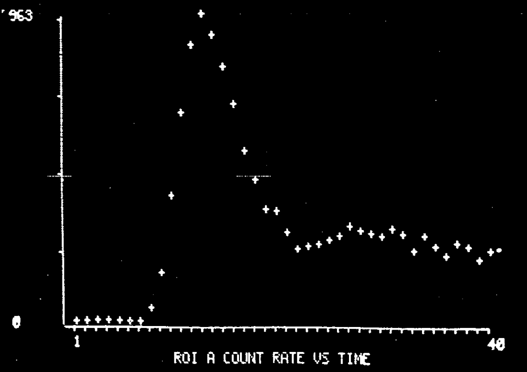
gamma11

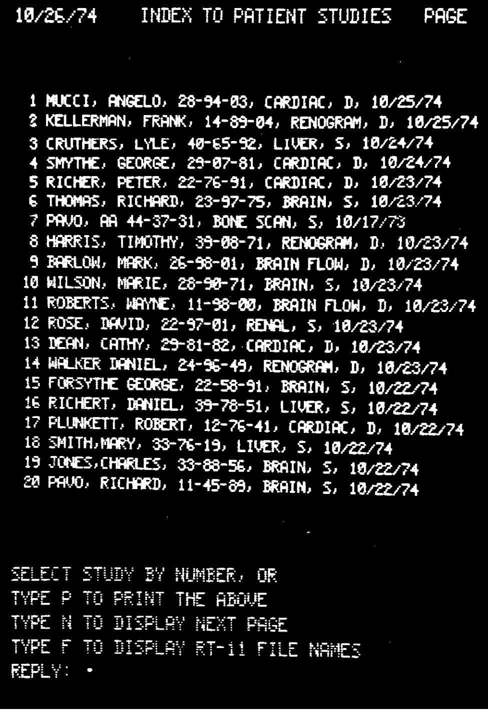
GAMMA-11 F/B V2
CLINICAL DEMONSTRATION
PROGRAMS



```
PRESSWELL, 82-84-08, BRAIN FLOW, D, 5/23/74

TOT CT=217327   CELL CT:MAX=280  MIN=0  AV=53           FRAME001
  ROI COUNT:      A=14694   B=14448

  # OF CELLS:     A=153     B=153

  AV CELL COUNT:  A=96      B=94

LT=5,5  UT=100,5   EX                        1 FRAME/SEC
```







```
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 2 KELLERMAN, FRANK, 14-89-04, RENOGRAM, D, 10/25/74
 3 CRUTHERS, LYLE, 40-65-92, LIVER, S, 10/24/74
 4 SMYTHE, GEORGE, 29-07-81, CARDIAC, D, 10/24/74
 5 RICHER, PETER, 22-76-91, CARDIAC, D, 10/23/74
 6 THOMAS, RICHARD, 23-97-75, BRAIN, S, 10/23/74
 7 PAVO, AA 44-37-31, BONE SCAN, S, 10/17/73
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20 PAVO, RICHARD, 11-45-89, BRAIN, S, 10/22/74


SELECT STUDY BY NUMBER, OR
TYPE P TO PRINT THE ABOVE
TYPE N TO DISPLAY NEXT PAGE
TYPE F TO DISPLAY RT-11 FILE NAMES
REPLY: •
```
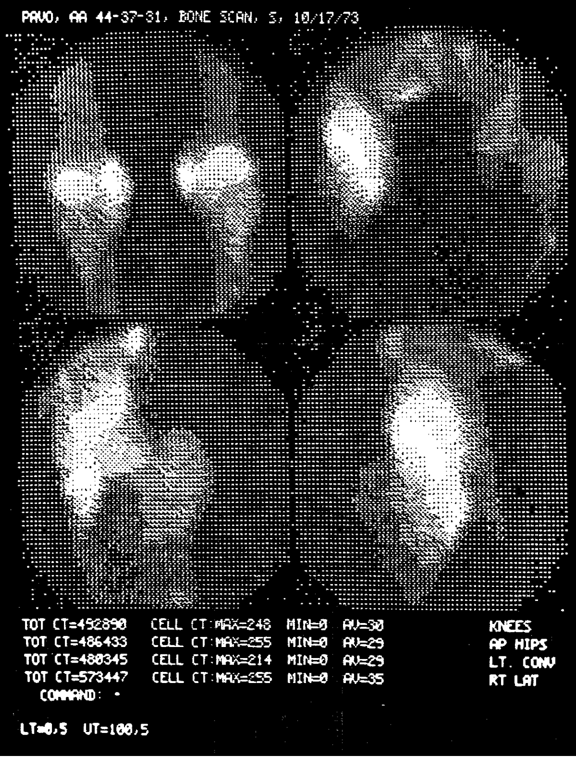



```
PAVO, AA 44-37-31, BONE SCAN, S, 10/17/73

TOT CT=492890   CELL CT:MAX=248  MIN=0  AV=30           KNEES
TOT CT=486433   CELL CT:MAX=255  MIN=0  AV=29           AP HIPS
TOT CT=480345   CELL CT:MAX=214  MIN=0  AV=29           LT. CONV
TOT CT=573447   CELL CT:MAX=255  MIN=0  AV=35           RT LAT
  COMMAND: •

LT=0,5  UT=100,5
```

GAMMA-11 F/B V2
CLINICAL DEMONSTRATION
PROGRAMS

CONTENTS

1. BASIC Programming

CLINICAL PROGRAMS WITH GAMMA-11

A) BASIC Programming

BASIC is loaded under the control of the RT-11 monitor by typing

```
 CTRL/C
.R BASIC <CR>
```

BASIC is then loaded and prints:

```
BASIC VØ1B-Ø2
*
```

and awaits the specification of the optional functions available to the system. The user should type a <CR> and BASIC will print:

```
USER FNS LOADED
READY
```

and waits for a user command. (NOTE: refer to the BASIC/RT-11 Reference Manual, section 1.1 for alternate responses to loading the user functions.)

To load and execute a GAMMA-11 clinical program, the user must issue the OLD command (refer to the BASIC/RT-11 Reference Manual, section 7.2) to erase the storage area and input the desired program. The user should type:

```
OLD <CR>
```

BASIC responds with:

```
OLD FILE NAME _ _
```

and waits for the program name and a carriage return.

BASIC will respond:

READY

after the program is loaded. To execute the program the user types:

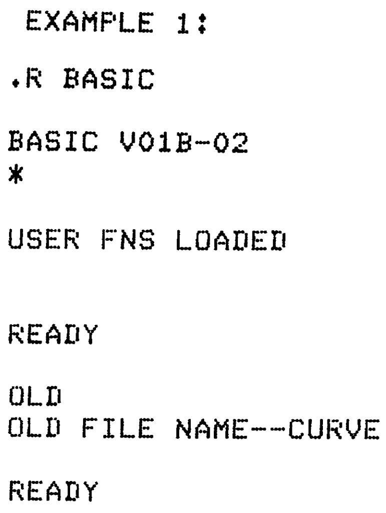
RUN <CR>

and the program begins. It is recommended that prior to re-executing any GAMMA-11 clinical program the user re-loads the program with the OLD command before issuing the RUN command.

Users who wish to edit the GAMMA-11 clinical programs or create their own programs are advised to read Chapter 7 of the BASIC/RT-11 Language Reference Manual for a complete description of the BASIC editting commands.

B) Program Descriptions

The following clinical programs are listed by their program names. These names should be used in conjunction with the OLD command in BASIC/RT-11 to load the program into memory. (See EXAMPLE 1)



```
 EXAMPLE 1:

.R BASIC

BASIC V01B-02
*

USER FNS LOADED


READY

OLD
OLD FILE NAME--CURVE

READY
```

2. EJECTS: Ejection fraction calculation (static method)

EJECTS - ejection fraction calculation (static method)

The ejection fraction can be calculated by saving two matrices in save areas, one matrix an image of end-diastole and the other an end-systolic image.

In both save areas, a region of interest (ROI) corresponding to the left ventricle must be included.

The program requests the save area number and the ROI corresponding to end-diastole. Then the program requests the end-systole save area number and ROI. The program will output the patient index line and the ejection fraction computed.

The method of determining the ROI of the left ventricle in end-diastole and the ROI in end-systole is completely up to the user. One such method is the technique of Kurtz, Ahnberg, Freed, LaFarge and Treves (to be published):

1) There are two methods for acquiring an end-diastole image, and then an end-systole image.
   a) gating the camera output to produce one end-diastole image and one end-systole image.*
   b) acquiring a fast (around 10 frames/sec) dynamic study. Save a curve over the left ventricle and call the BASIC program MARK. Pick the end-diastole frames (peaks) and

*such as a Brattle gate or a Riverside Bio-Engineering gate.

the end-systole frames (valleys) from the curve displayed. The frame numbers are printed on the output device. Add the 1st column frame numbers to create an end-diastole image. The end-systole image is the summation of the 2nd column. (Figure 6)

2) Display the end-diastole image, lower the upper threshold. (recommended setting is between 45 and 65%) (e.g. UT55)

3) Smooth the data (S9)

4) Enter irregular region of interest (IR), outline the left ventricle and save the matrix (SM_n). (Figure 1)

5) Display the end-systole image, lower the upper threshold (recommended setting is around 5% lower than threshold in step 2) (e.g. UT48) and repeat steps 3 and 4. (Figure 2)

6) Call program EJECTS.

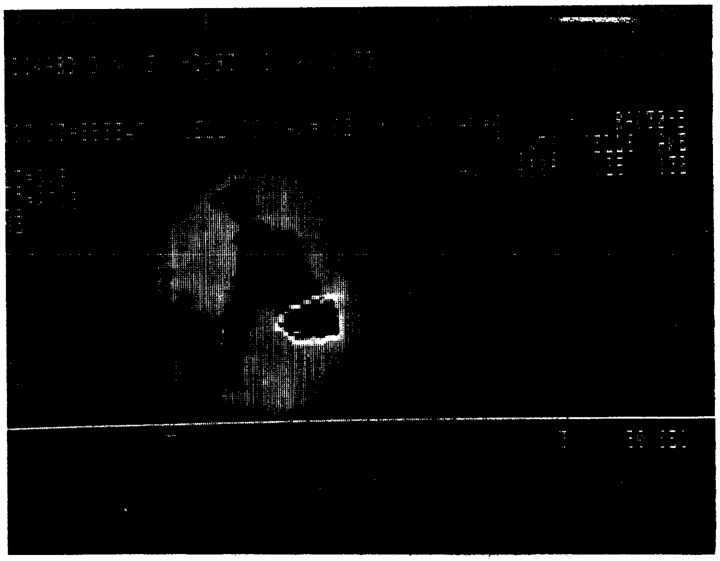


FIGURE 1. ROI defined over end-diastole left ventricle

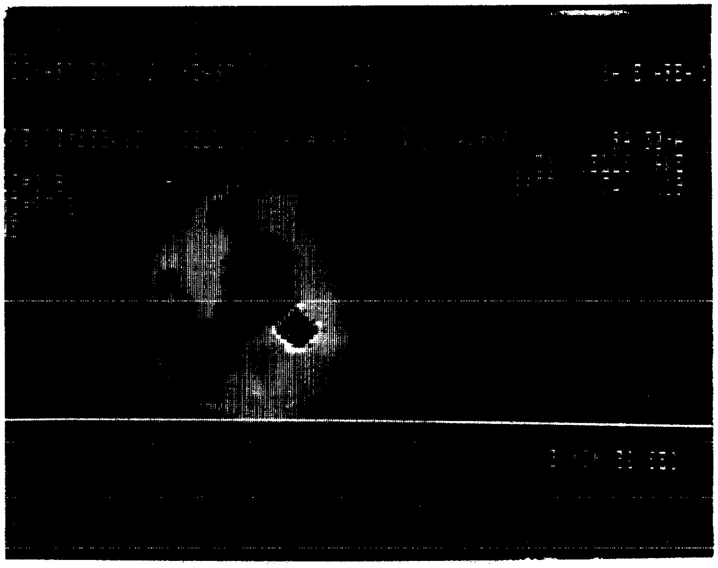


FIGURE 2. ROI defined over end-systole left ventricle

```
 R BCLR

BASIC V01B-02
*

USER FNS LOADED


READY

OLD
OLD FILE NAME--EJECTS

READY

RUN

EJECTS  16-JAN-76  BASIC V01B-02

PROGRAM TO COMPUTE EJECTION FRACTION

INPUT DIASTOLE SAVE AREA?2
WHICH ROI IS THE LEFT VENTRICLE??1

INPUT SYSTOLE SAVE AREA ?3
WHICH ROI IS THE LEFT VENTRICLE??1


PATIENT :HASKINS,CLEM, 23-54-92, RAC, D, 8/4/75
EJECTION FRACTION = .582
```

3. EJECT: Ejection fraction calculation (dynamic method)

EJECT - ejection fraction calculation (dynamic method)

The ejection fraction can be calculated from dynamic curves stored in a GAMMA-11 save area. The two curves necessary are curves of the left ventricle in end-diastole and end-systole. The technique for defining the regions of interest is the method of Kurtz, Ahnberg, Freed, LaFarge and Treves (to be published):

1) the method of creating end-diastole and end-systole images is described on page 3, section 1B. (Figure 6)
2) display the end diastole frames, smooth the data and lower the upper threshold. (See step 2 in program EJECTS)
3) enter irregular region of interest (IR) and outline the shape of the left ventricle. (Figure 3)
4) display the end-systole frames, smooth the data and lower the upper threshold (see step 5 in program EJECTS)
5) re-enter IR and outline the end-systole left ventricle. (Figure 4)
6) plot the two curves and then save the curves. (Figure 5)
7) call program EJECT.

The program will request the save area number and the curves corresponding to end-diastole and end-systole. The end-diastole curve is displayed and the user selects pairs of points corresponding to end-diastole and end-systole points (Figure 6). The ejection fractions for each pair of points is printed and the average ejection fraction for all the pairs is output on the terminal.

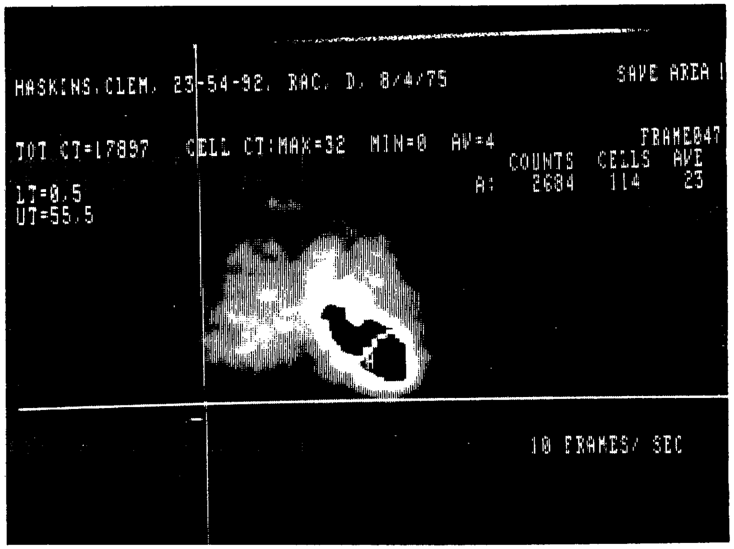

HASKINS,CLEM, 23-54-92, RAC, D. 8/4/75
SAVE AREA 1
TOT CT=17897 CELL CT:MAX=32 MIN=0 AV=4
FRAME047
COUNTS CELLS AVE
A: 2684 114 23
LT=0.5
UT=55.5
10 FRAMES/ SEC

FIGURE 3. ROI defined over end-diastole left ventricle

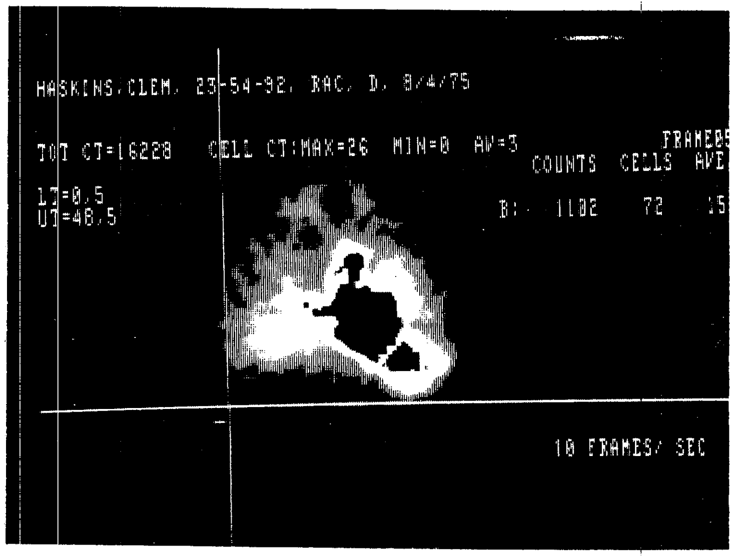

HASKINS,CLEM, 23-54-92, RAC, D. 8/4/75
TOT CT=16228 CELL CT:MAX=26 MIN=0 AV=3
FRAME05
COUNTS CELLS AVE
B: 1102 72 15
LT=0.5
UT=48.5
10 FRAMES/ SEC

FIGURE 4. ROI defined over end-systole left ventricle

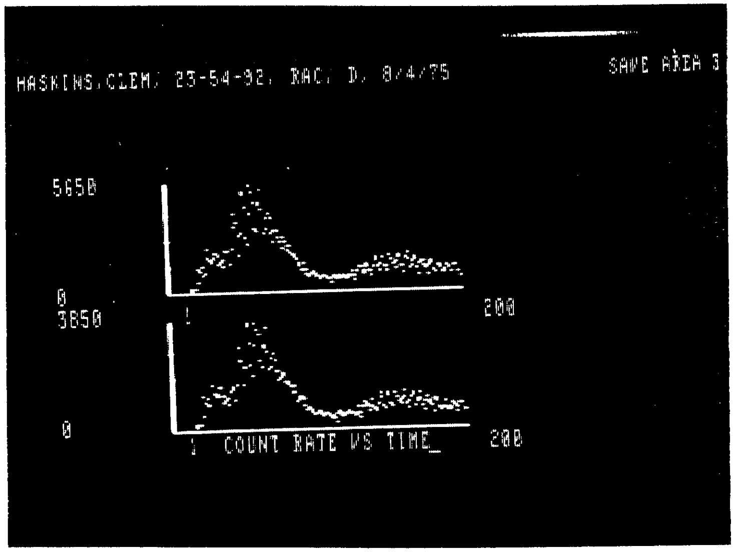


FIGURE 5. Dynamic curves of the two ROIs

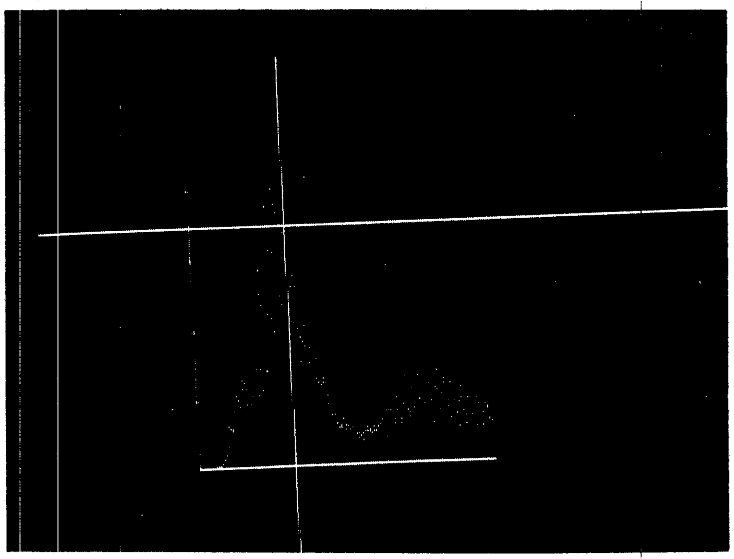


FIGURE 6. Pick pairs of points (1 diastole, 1 systole) on ROI curve of L.V.

```
 R DCLR

BASIC V01B-02
*

USER FNS LOADED


READY

OLD
OLD FILE NAME--MARK

READY

RUNNH
WHICH SAVE AREA ?
?1
WHICH CURVE ?
?1

PICK 1 END-DIASTOLE PT.,THEN 1 END-SYSTOLE
CHOOSE THE SAME POINT TWICE TO EXIT !

DIASTOLE       SYSTOLE
   47            50
   53            56
   58            62
   65            68
   70            73
   137           140
   142           145
```

```
USER FNS LOADED


READY

OLD
OLD FILE NAME--EJECT

READY

RUNNH
PROGRAM WILL CALCULATE EJECTION FRACTION

CARDIAC SAVE AREA =
?3
LEFT VENTRICLE CURVE (END-DIASTOLE):
?1
LEFT VENTRICLE CURVE (END-SYSTOLE):
?2

PICK ONE END-DIASTOLE POINT,THEN ONE END-SYSTOLE
BY PICKING THE SAME POINT TWICE YOU EXIT

PATIENT: HASKINS,CLEM, 23-54-92, RAC, D, 8/4/75           16-JAN-76

DYNAMIC EJECTION FRACTIONS:
      .595694
      .616541
      .584071
      .592391
      .350588
      .605839
AVERAGE EJECTION FRACTION = .557521
```

4. <u>QPQS</u>: Left to right cardiac shunt calculation

QPQS - left to right cardiac shunt calculation

The quantitation of left-to-right shunts can be calculated from GAMMA-11 curves stored in a save area according to the method of Maltz and Treves. The region of interest (ROI) is selected over either lung and free of contamination from the heart. The curve is plotted and saved and then the program can be executed. The curve of the lung is fit to the gamma variate function creating a curve simulating pulmonary flow. This curve is subtracted from the original curve to create a third curve representing pulmonary recirculation. This curve is fit with the gamma variate to simulate premature left-to-right recirculation.

The original curve of the lung, the regression curve, the recirculation curve and its regression curve are all stored in a save area to allow visual observation of the fit. (See Figures 9,10,11)

The program will request the save area number and the curve to be examined and also the number of the save register to store the resultant curves. The original lung curve can be smoothed and have the background subtracted prior to performing the gamma variate fit. In many cases, these two operations will improve the statistics of the fit and are to be recommended. The point representing 70% of the maximum on the downslope of the data curve can be calculated either manually or automatically by the program. The peak of the recirculation curve can be chosen in a similar manner.

The program will print the values of the four curves on the terminal and also the QP/QS and C2/Cl ratios.

1) display an image of the lungs with the heart subtracted out

2) smooth the image (S9) and enter irregular regions of interest (IR). (Figure 7)

3) draw regions around either one or both of the lungs, and plot the curves. (Figure 8)

4) save the dynamic curves (SD_n).

5) call program QPQS

NOTE: Program available in BASIC and FOCAL.

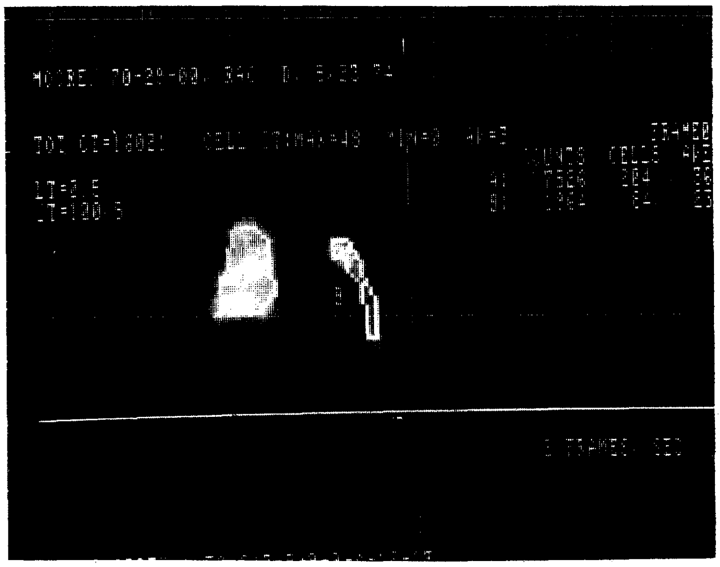


FIGURE 7. ROIs over left and right lungs

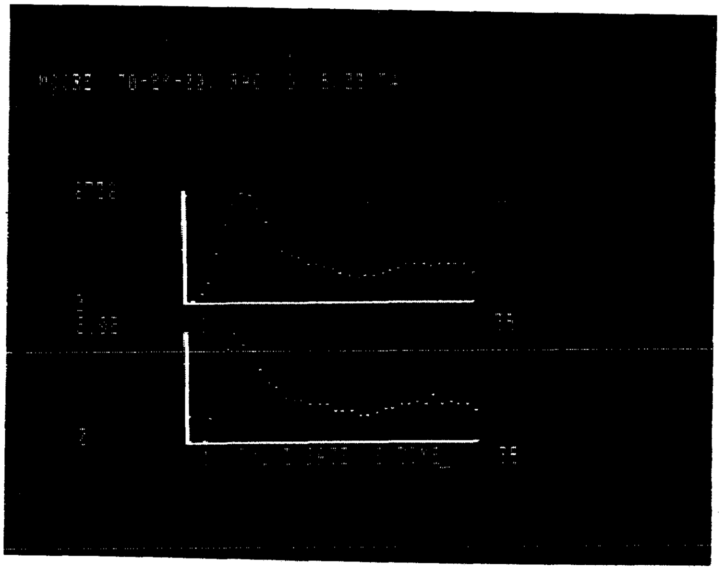


FIGURE 8. Dynamic curves of the two ROIs

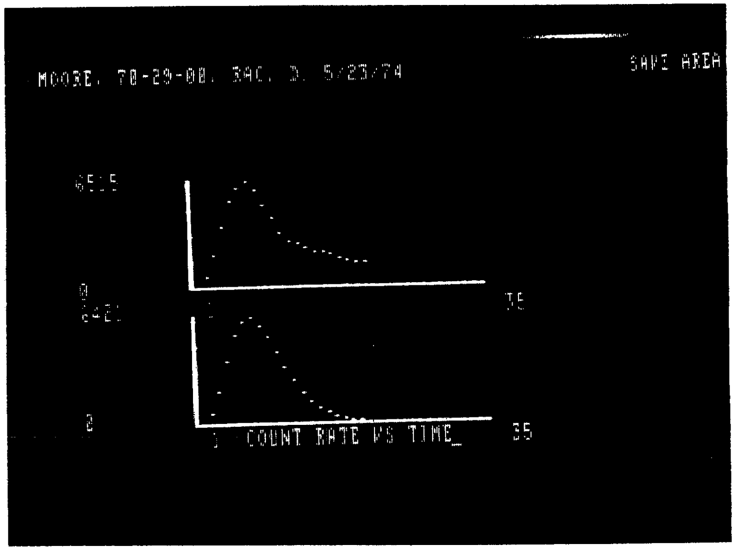


FIGURE 9. Top- Lung curve range that was fit
Bottom- Gamma variate fit curve

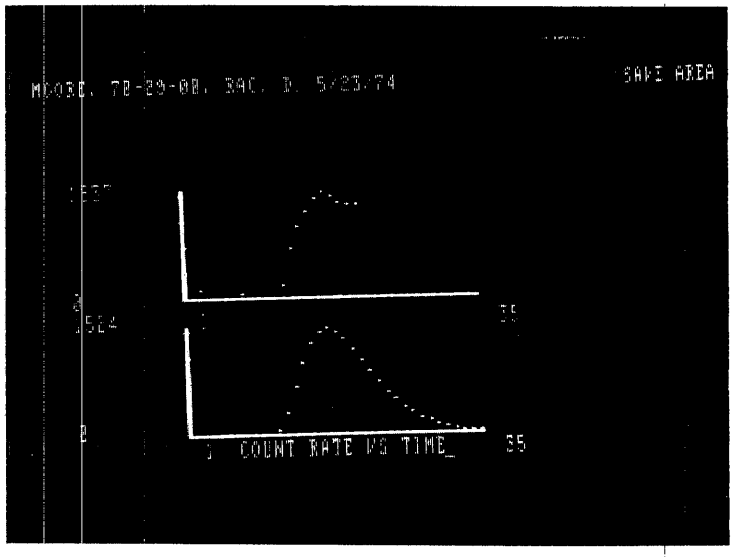


FIGURE 10. Top- Recirculation curve
Bottom- Fit of recirculation curve

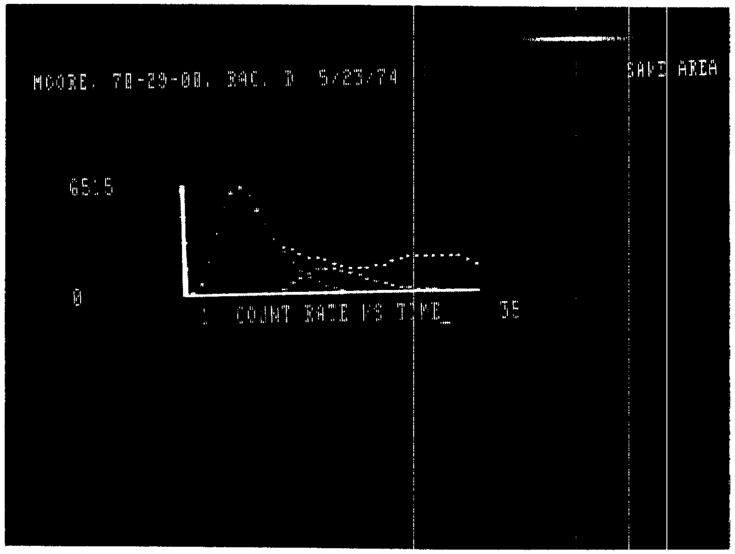


FIGURE 11. Original lung curve overlaid with
the 2 gamma variate curves.

```
READY

RUNNH
PROGRAM TO COMPUTE QP/QS
SOURCE: WHICH SAVE REGISTER?
?1
WHICH CURVE?
?1
DESTINATION: WHICH SAVE REGISTER?
?2
BACKGROUND ERASURE?
  1.YES  2. NO
?2
CURVE SMOOTHING?
  1. YES 2.NO
?2
WHICH LUNG IS REPRESENTED?
 1. RIGHT LUNG  2. LEFT LUNG
?1
MANUAL PICK FOR 70% OF CURVE 1?
 1. YES  2. NO
?2
PICK PEAK OF RECIRCULATION CURVE?
 1. YES 2. NO
?2
MOORE, 70-29-00, RAC, D, 5/23/74
CURVE DISPLAYED: PICK CURVE DELIMETERS
LEFT BOUND
RIGHT BOUND
CORRECTED CURVE DISPLAYED
ADVANCE PAPER TO NEW PAGE; TYPE <CR> TO CONTINUE
```

```
MOORE, 70-29-00, RAC, D, 5/23/74

CURVE 1         FITTED 1        CURVE 2         FITTED 2

 396             331             65              0
 1019            1037            0               0
 1911            1926            0               0
 2666            2687            0               0
 3120            3127            0               0
 3258            3211            47              0
 3024            3009            15              0
 2591            2629            0               0
 2134            2174            0               0
 1686            1720            1               32
 1420            1311            109             160
 1337            969             368             343
 1228            697             530             523
 1130            491             639             659
 1075            339             736             738
 999             230             769             762
 895             153             742             741
 799             101             698             688
 747             66              681             616
 732             42              689             536
QFQS = 1.43

C2/C1 = 43.57 %

RIGHT LUNG CURVE

CURVES SAVED IN REGISTER  2
```

5. <u>CARD</u>: Cardiac output, stroke volume and pulmonary transit time calculation

CARD - cardiac output, stroke volume + pulmonary transit time calculation.

The cardiac analysis program is calculated from dynamic flow curves saved in a GAMMA-11 save register. The two regions of interest (ROI) that are required are defined over the right and left ventricles. The curves are plotted and saved and then the program can be executed.

The area of a curve representing the first transit of the bolus is required. The right ventricle curve is displayed and then the log of the curve is plotted. The user chooses the bounds of a least squares linear fit which is performed on the log data displayed (Figure 15). The exponential of the curve is calculated and is combined with the original right ventricle curve to eliminate the washout portion of the data. This resultant curve represents the first transit and the cardiac output and stroke volumn is now computed. (Figure 16)

The program will request the number of the cardiac save area and the curve numbers of the right and left ventricles. The curves that are created in the program are stored in a save area also (Figures 16,17). The blood volumn, equilibrium counts and heart rate are also requested in the program.

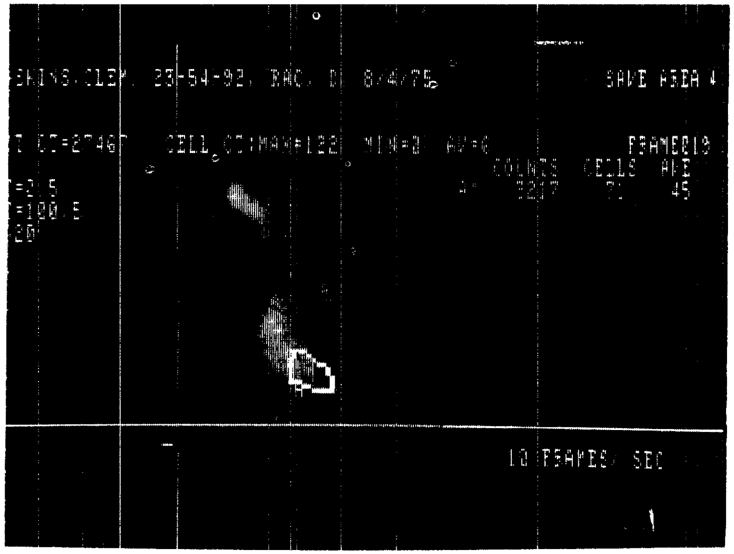
The program will print the patient index and the current data, then return the cardiac output, stroke volumn, and pulmonary transit time. The program returns directly to GAMMA-11 and redisplays the last image.

1) acquire a fast (around 10 frames/sec) dynamic study

2) display an image of the heart and mark an irregular region of interest (IR) over the right ventricle and an IR over the left ventricle. (Figures 12,13)

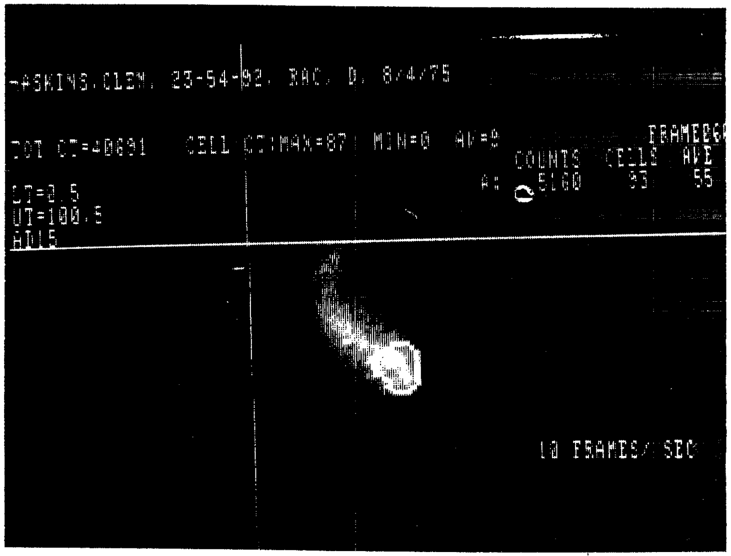
3) plot the curves and save them in a save area (SD_n). (Figure 14)

4) call program CARD



SKINS.CLEM. 23-54-92. RAC. D. 8/4/75
SAVE AREA 4
T CT=27467 CELL CT:MAX=122 MIN=0 AV=6
FRAME019
COUNTS CELLS AVE
3217 71 45
=2.5
=100.5
10 FRAMES/ SEC

FIGURE 12. ROI over the right ventricle



-ASKINS.CLEM. 23-54-92. RAC. D. 8/4/75
TOT CT=40691 CELL CT:MAX=87 MIN=0 AV=9
FRAME06
COUNTS CELLS AVE
A: 5160 93 55
LT=2.5
UT=100.5
AD15
10 FRAMES/ SEC

FIGURE 13. ROI over the left ventricle

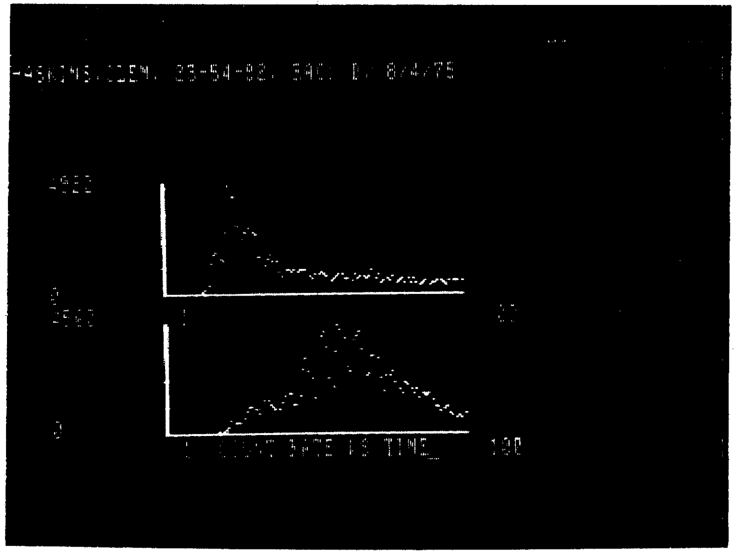


FIGURE 14. Dynamic curves of the left and right ventricles

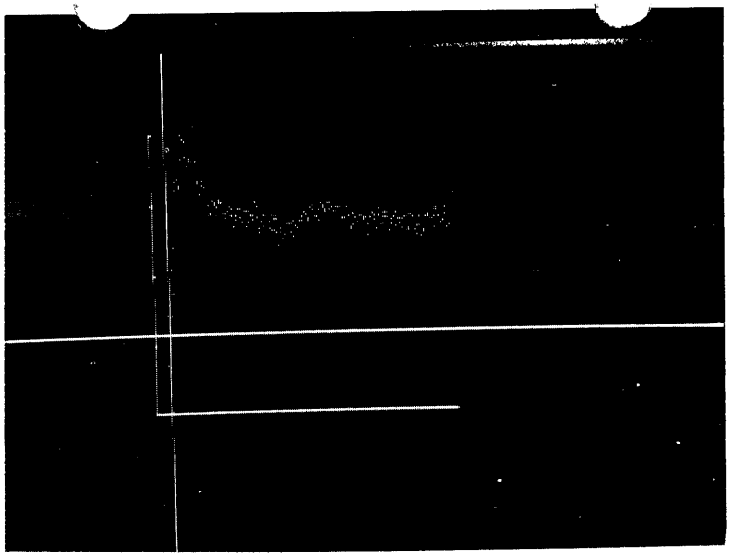


FIGURE 15. Pick the linear bounds of the log curve

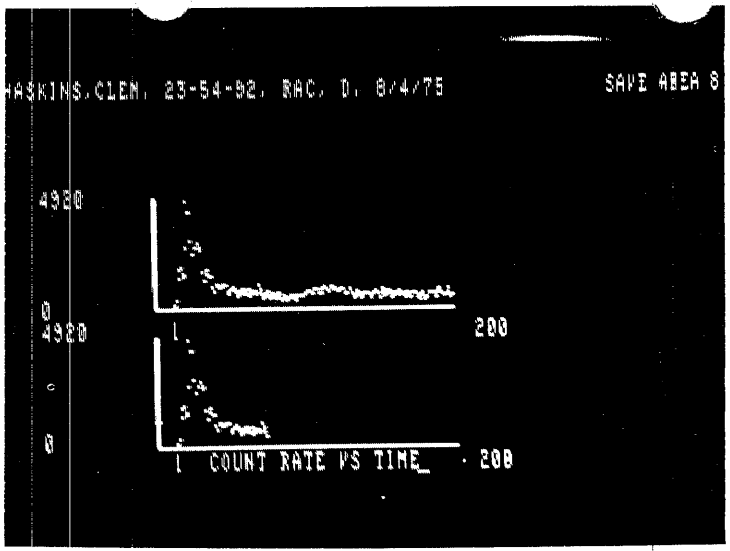


FIGURE 16. Top- Original right vent. curve
Bottom- Curve representing 1st trans.

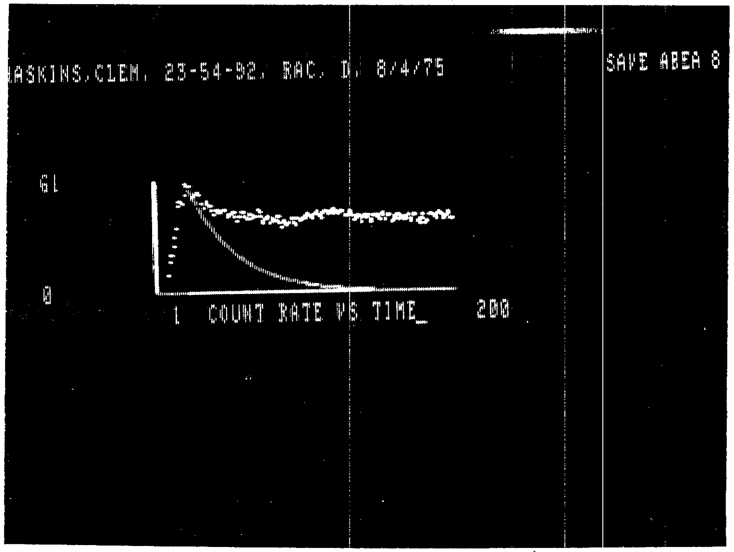


FIGURE 17. Log curve and exponential curve used during the fit

```
OLD FILE NAME--CARD

READY

RUNNH
CARDIAC ANALYSIS PROGRAM
PROGRAM WILL CALCULATE CARDIAC OUTPUT,STROKE VOLUME,
 AND PULMONARY TRANSIT TIME

CARDIAC SAVE AREA =
?9
RIGHT VENTRICLE CURVE:
?1
LEFT VENTRICLE CURVE :
?2
NEW CURVES SAVED IN AREA:
?8
BLOOD VOLUMN (LITERS):
?7.0
EQUILIBRIUM COUNTS (COUNTS/SEC):
?150
HEART RATE:
?75

LOG CURVE OF RAW DATA
PICK THE LIMITS FOR THE LINEAR FIT


                     CARDIAC ANALYSIS SUMMARY
                            22-JAN-76


PATIENT: HASKINS,CLEM, 23-54-92, RAC, D, 8/4/75

CARDIAC OUTPUT = 5.88595  LITERS/MIN
STROKE VOLUMN = 78.4794  MILLILITERS
PULMONARY TRANSIT TIME = 4.3 SECONDS
```

6. HEAD: Cerebral blood flow analysis

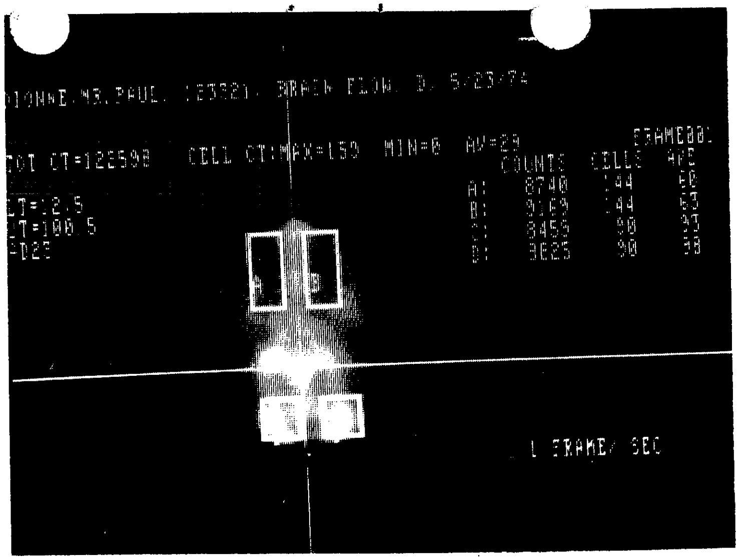
HEAD - cerebral blood flow program

Dynamic brain flow studies can be analyzed quantitatively with the program HEAD. The user should define regions of interest on either side of the head, then plot and store the curves in a save area.

The program asks the save area number and then whether or not the curves should be smoothed and normalized. The first pair of curves to be compared are requested and the ratio of the amplitudes, ratio of the slopes, ratio of the plateaus, and the difference in the times to peak are computed. The program asks if there are more curves to be compared and the user must respond with "YES", if further analysis is required.

1) acquire a dynamic brain flow study
2) display an image of the brain (AD_n), smooth the image (S9), and enter regions of interest (RI) or (IR)
3) mark regions on either side of the midline (Figure 18)
4) plot the curves (maximum of 12) and save the curves in a save area (SD_n) (Figures 19,20)
5) call program HEAD

NOTE: Program available in BASIC and FOCAL



```
DIONNE.MS.PAUL. 123321. BRAIN FLOW. D. 5/23/74
                                                      FRAME001
TOT CT=122598   CELL CT:MAX=159  MIN=0  AV=29
                                           COUNTS  CELLS  AVE
                                       A:   8740    144    60
LT=12.5                                B:   9169    144    63
CT=100.5                               C:   8459     90    93
FD23                                   D:   3625     90    38
```

FIGURE 18. ROIs marked over each hemisphere

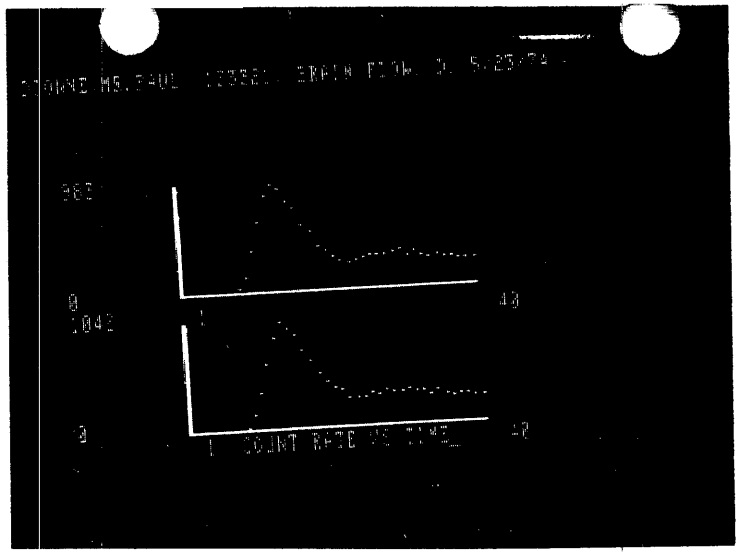


FIGURE 19. Dynamic curves of the ROIs

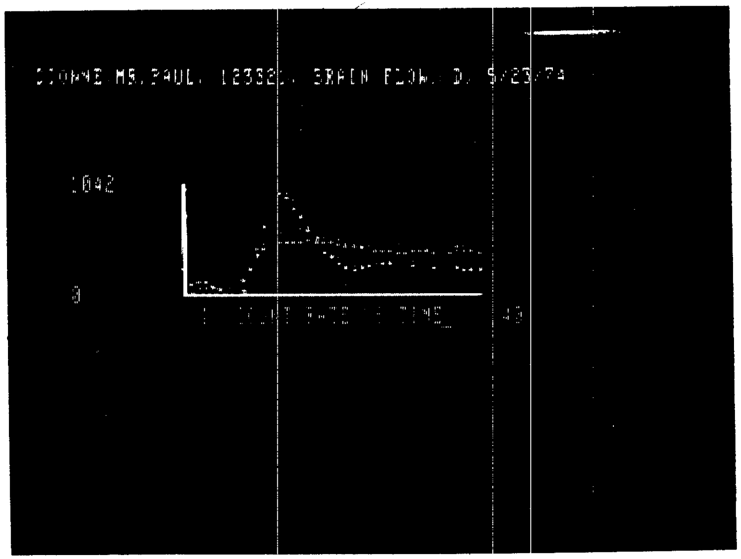


FIGURE 20. Dynamic curves after program HEAD (smoothed and normalized)

```
OLD
OLD FILE NAME--HEAD

READY

RUNNH
CEREBRAL BLOOD FLOW PROGRAM
WHICH SAVE AREA FOR THE CURVES?
?5

DIONNE,MR.PAUL, 123321, BRAIN FLOW, D, 5/23/74
DO YOU WISH TO SMOOTH AND NORMALIZE CURVES?
?YES
WHICH CURVES ARE TO BE COMPARED?
?1
?2

RATIO OF AMPLITUDES  1.01394
DIFFERENCE OF TIMES  0  SECONDS
RATIO OF SLOPES  .999599
RATIO OF PLATEAUS  .962475
DO YOU WISH TO CONTINUE?
?YES
WHICH CURVES ARE TO BE COMPARED?
?3
?4

RATIO OF AMPLITUDES  1.24522
DIFFERENCE OF TIMES  0  SECONDS
RATIO OF SLOPES  .916723
RATIO OF PLATEAUS  1.13199
DO YOU WISH TO CONTINUE?
?YES
WHICH CURVES ARE TO BE COMPARED?
?5
?6

RATIO OF AMPLITUDES  1.1466
DIFFERENCE OF TIMES  0  SECONDS
RATIO OF SLOPES  1.0583
RATIO OF PLATEAUS  1.168
DO YOU WISH TO CONTINUE?
?NO

STOP AT LINE 140

READY
```

7. XEBH: Percent distribution of regional lung ventilation, equilibration and perfusion

XEBH - percent distribution of regional lung ventilation, equilibration and perfusion

Xenon lung studies can be analyzed by using the program XEBH. The user should define regions of interest over the lungs. It is assumed that there will be an even number of ROI's, with the first half of them over the left lung and the second half over the right. Normally three regions (top of lung, bottom of lung, whole lung) for each lung is sufficient, however XEBH can support up to 6 ROI per lung (total of 12 curves). The curves are calculated and saved in a save area. (Figure 22)

The program requests the save area number and then displays the last curve calculated. The user is asked to interactively choose the ranges for perfusion, equilibration, background and ventilation (Figure 23). The program will print the patient index and then the percent distribution for each of the curves. The V/Q, V/E, and Q/E ratios are also calculated for every curve.

1) acquire a dynamic lung study

2) display an image of the lungs, enter irregular regions of interest (IR).

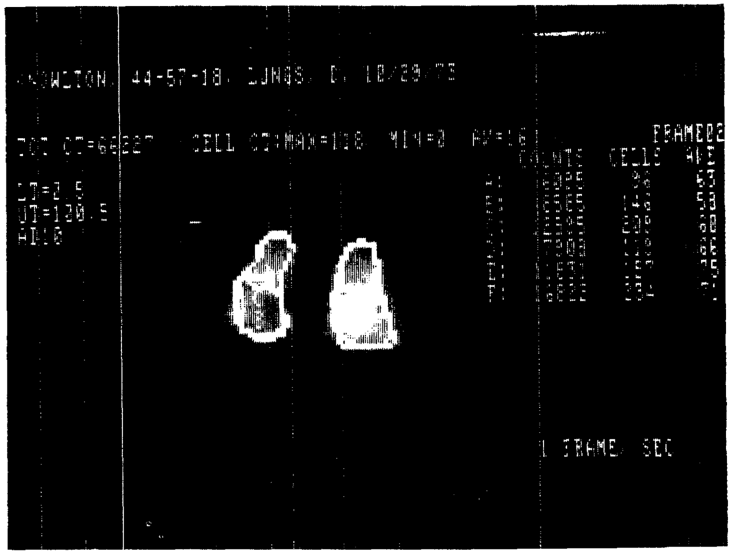
3) mark up to 6 regions over the left lung

4) mark up to 6 regions over the right lung (the number of regions for each lung should be equal) (Figure 21).

5) plot the curves and save them in a save area (SD_n) (Figure 22)

6) call program XEBH

NOTE: Program available in BASIC and FOCAL.



KNOWLTON, 44-57-18, LUNGS, D, 10/29/73
TOT CT=66227
CELL CT:MAX=118 MIN=0 AV=16
FRAME02
COUNTS CELLS AVE
LT=2.5
UT=120.5
AI10
1 FRAME/ SEC

FIGURE 21. 6 ROIs marked over the lungs

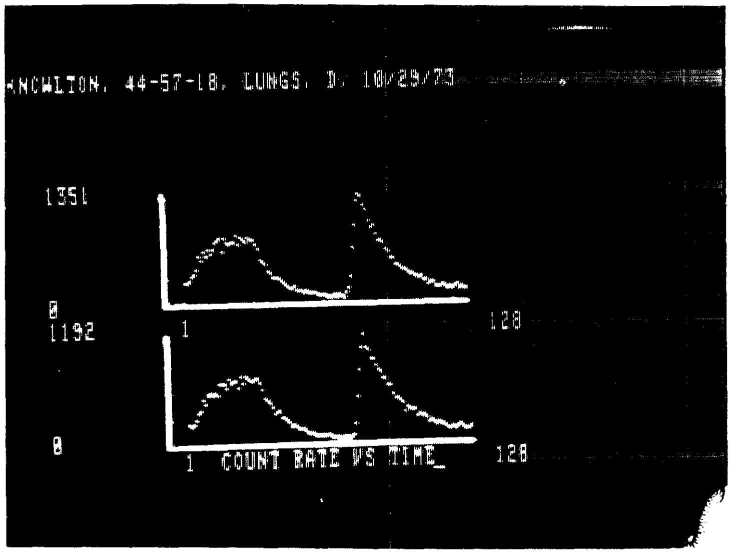


FIGURE 22. Dynamic curves of the lungs

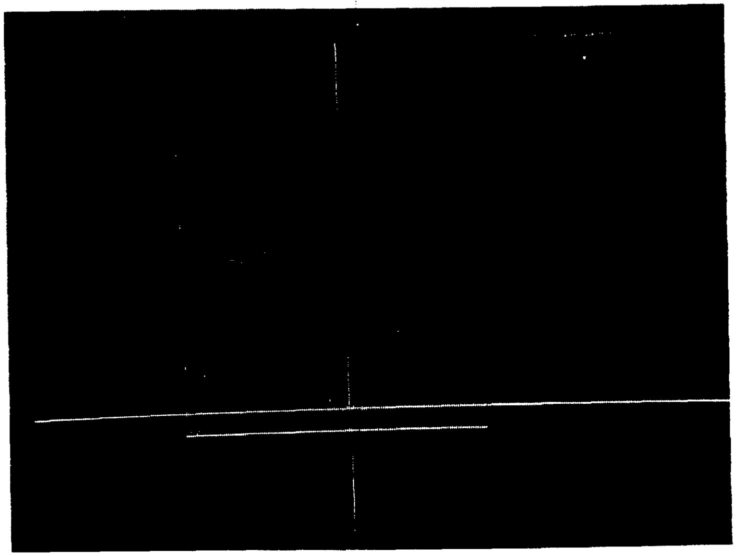


FIGURE 23. Pick the ranges for perfusion, ventilation, equil., and backgrd.

```
OLD FILE NAME--XEBH

READY

RUN

XEBH     16-JAN-76  BASIC V01B-02

XENON LUNG STUDY PROGRAM

WHICH SAVE AREA?
?9
PICK PERFUSION BOUNDS
PICK VOLUMN BOUNDS
PICK BACKGROUND BOUNDS
PICK VENTILATION BOUNDS
ADVANCE PAPER TO NEW PAGE !TYPE <CR> TO CONTINUE
?
```

DIVISION OF NUCLEAR MEDICINE
XENON LUNG STUDY
(BREATH-HOLDING)

Q=PERFUSION
E=EQUILIBRIUM
V=VENTILATION

KNOWLTON, 44-57-18, LUNGS, D, 10/29/73

PERCENT DISTRIBUTION

	LEFT			RIGHT		
ZONE	Q	E	V	Q	E	V
1	9.48	9.35	10.34	12.31	12.44	12.9
2	13.91	13.34	13.37	18.28	18.82	17.34
3	19.99	19.46	20.48	26.01	26.56	25.53
TOTAL	43.39	42.16	44.21	56.6	57.83	55.78

DISTRIBUTION INDICES

ZONE	V/E	Q/E	V/Q	V/E	Q/E	V/Q
1	1.1	1.01	1.09	1.03	.98	1.04
2	1	1.04	.96	.92	.97	.94
3	1.05	1.02	1.02	.96	.97	.98

8. <u>RENO</u>: Renogram analysis

RENO - renogram analysis

Renal studies can be analyzed within the curve analysis program in BASIC/RT-11. The user should define 3 regions of interest. The first two regions are over the left and right kidneys and the third ROI is an area representing the background. Normally, the background ROI is chosen in a small area between the left and right kidneys (Figure 24). The curves are calculated and stored in a GAMMA-11 save area.

Run the general purpose curve analysis program CURVE and execute the macro RENO (MR RENO). The program requests the save area number and the locations of the three essential curves. The 'pick' function is used to mark the bounds of the integrals to choose a point on the upslope, to choose a peak, and to choose the half life (Figure 26).
The program will subtract a normalized background curve from the two renograms, then print the total counts, maximum counts per minute, time to peak, peak to half-life, slope to peak, and slope from peak to half-life for both curves. Left-to-right ratios for these values are also returned. Finally, a new save area is created containing the three original curves and the adjusted left and right renograms with the background subtracted out (Figures 27,28).

1) acquire a dynamic renal study

2) display an image of the kidneys and enter irregular region of interest (IR).

3) mark irregular regions over the two kidneys and a third region representing the background (Figure 24).

4) plot the curves and save them in a save area (SD_n) (Figure 25).

5) call program CURVE.

6) execute the program CURVE and for the 1st command insert: MR RENO ⟨CR⟩. This will execute the macro RENO which is set up for renogram analysis.

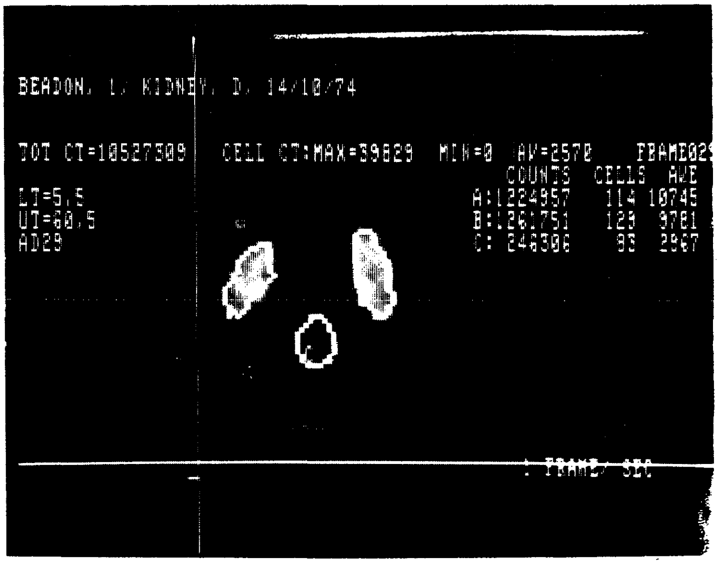


FIGURE 24. ROIs over the left and right kidneys, and a background ROI

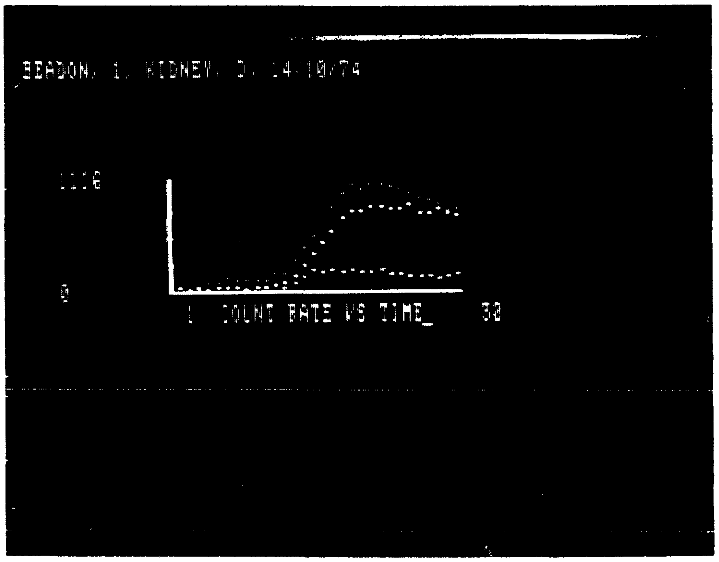


FIGURE 25. Dynamic curves of the 3 ROIs

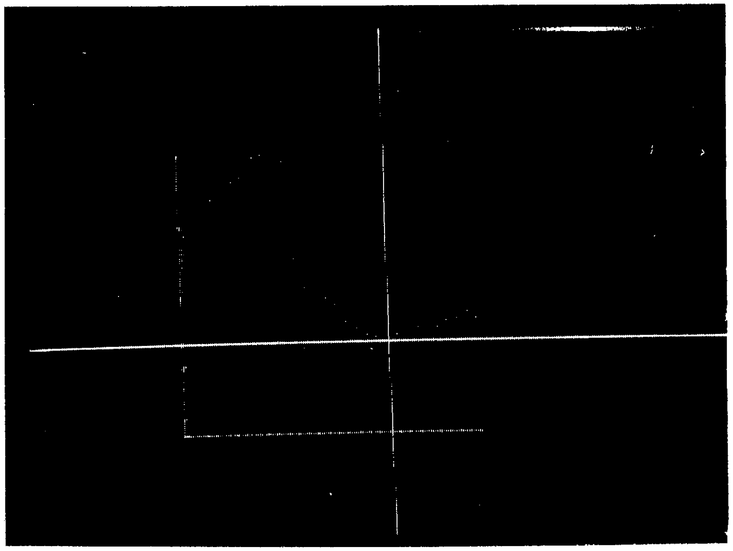


FIGURE 26. Pick the bounds of the integral, then mark the peak, a pt. on the upslope, and the half-life.

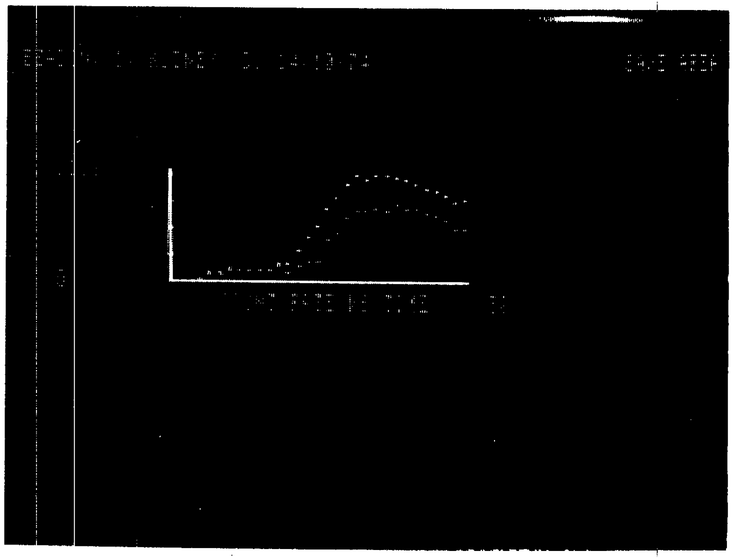


FIGURE 27. Left renograms: original curve and curve with background subtracted

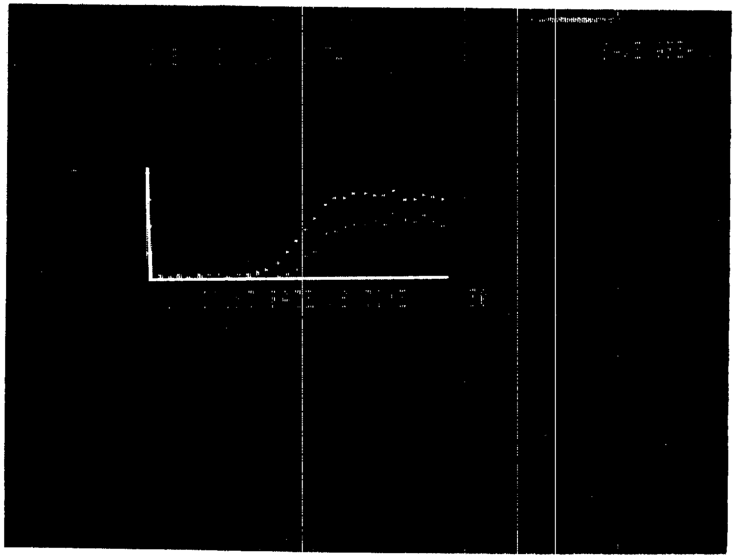


FIGURE 28. Right renogram: original curve and adjusted curve

```
OLD
OLD FILE NAME--CURVE

READY

RUN

CURVE    20-JAN-76  BASIC V01B-02

TYPE 'HELP' FOR A LIST OF COMMANDS

PLEASE ENTER COMMAND:
?MR RENO


MACRO PROGRAM RENO
RENOGRAM ANALYSIS PROGRAM
INPUT RENOGRAM SAVE AREA :?1
LEFT KIDNEY CURVE =?1
RIGHT KIDNEY CURVE =?2
BACKGROUND CURVE =?3
WHAT SAVE AREA TO STORE NEW CURVES??3



NOW THE CURVES WILL HAVE THE BACKGROUND REMOVED!
PICK THE BOUNDS OF THE INTEGRAL

PLEASE CHOOSE 4 POINTS (FOR BOTH LEFT AND RIGHT RENOGRAMS) :
1) MARK A POINT ON THE UPSLOPE FOR DETERMINING THE SLOPE TO MAX
   (USUALLY 4 OR 5 POINTS BELOW THE MAX)
2,3) MARK THE MAXIMUM POINT OF THE CURVE TWICE !
4) MARK THE POINT = 1/2 OF THE MAX ON THE DOWNSLOPE


BEADON, 1, KIDNEY, D, 14/10/74
                             LEFT         RIGHT      L/R
TOTAL COUNTS OF KIDNEY:     726785       728342     .99
PEAK COUNTS/MIN:            53334        51483.1    1.03
TIME TO PEAK (MIN):         8.5          5.5        1.54
PEAK TO 1/2 LIFE (MIN):     6            8          .75
SLOPE TO PEAK:              39.3098      55.0387    .71
SLOPE FROM PEAK TO T 1/2   -93.2048     -54.4922    1.71

PLEASE ENTER COMMAND:
?RN GAMMA
```

9. FILTER: Rib removal of myocardial infarct scintigrams

FILTER - Rib removed of myocardial infract scintigrams (FORTRAN) Imaging of myocardial infracts is subject to distortion caused by activity in the ribs overlying the heart. The ribs appear as a series of bars running horizontally across the image. The program will perform a band-reject digital filter on the scintigram and an additional lag filter on every column of the image.

The user must store the image to be filtered in a GAMMA-11 save area. When the program begins, the user inputs the RT-11 filename of the save area (e.g. SVARØ1.SYS, SVARØ2.SYS, etc.). The program also requests the centre frequency, the half-bandwidth, and the lag constant. The centre frequency is determined by counting the number of ribs appearing in the scintigrams and extrapolating the number over the entire matrix. The half-bandwidth is usually about 30-40% of the centre frequency and the lag constant used to smooth the data is usually around 50.

The program is currently designed for 128 x 128 matrices. Minor modifications can easily be made for 64 x 64 images, but matrices with low resolution do not benefit significantly from the filtering technique.

The digital filter program is an adaption of Stokely's program and uses the algorithm of Otnes and McNamee.

1) Acquire a static image of the myocardium

2) rotate the image so the ribs are horizontal (RO_n). (Most scintigrams will not have to be rotated) and save the image.

3) call program FILTER. (CTRL/C
.R FILTER)

NOTE: Program in FORTRAN only.

```
 R FILTER


IMAGE FILTER PROGRAM
 INPUT SAVE AREA NAME

*SVAR01.SYS

PLEASE CHOOSE CENTRE FREQUENCY (1-64)
6

PLEASE CHOOSE HALF BANDWIDTH (1-128)
4

LAG CONSTANT
50

STOP --

.
```

10. FUNC: Functional image program

FUNC - functional image program (FORTRAN)

The program FUNC will create a GAMMA-11 patient file consisting of a single image which in some way is representative of a GAMMA-11 dynamic flow study. In this program, either maximum counts or time of maximum counts are the criterion for creation of the functional image.

The user inputs the RT-11 filename of the dynamic study and the name of the new functional image patient file. (NOTE: GAMMA-11 patient files are required to have extensions beginning with an 'X' and followed by two digits <XØØ, XØ1, ...>). The program requests which criterion the user wishes for this image and the user responds with a 1 for time or a 2 for maximum intensity. The functional image can now be examined within the GAMMA-11 system.

1) acquire a dynamic study

2) call program FUNC (CTRL/C
   .R FUNC) (Figures 29,30)

NOTE: Program in FORTRAN only. The name of the functional image file must not be the name of an already existing RT-11 file on that device.

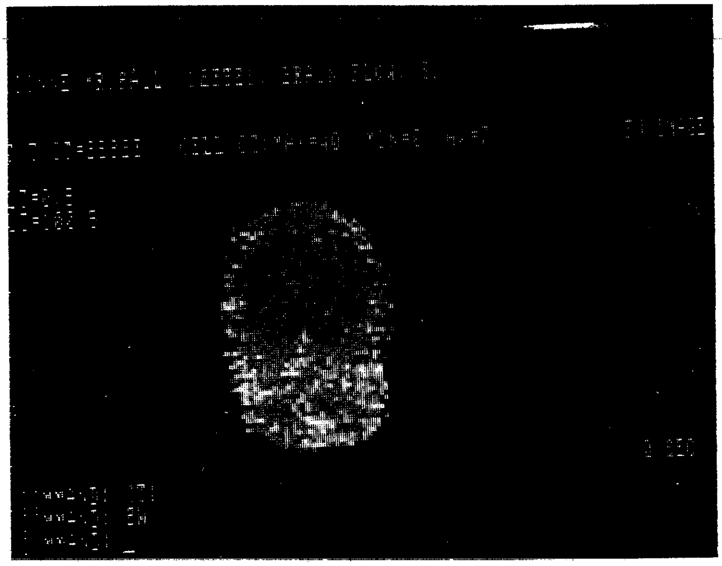


FIGURE 29. Functional Image based on time

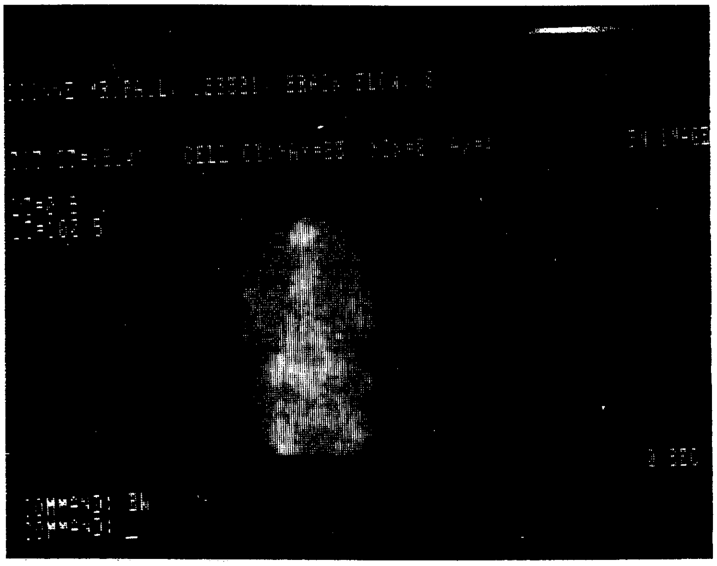


FIGURE 30. Functional Image based on counts

```
 R FUNC

INPUT PATIENT FILE AND NEW FILE NAME

*RK1:CRESSW.X00
*MAX.X00

DO YOU WANT TIME OR INTENSITY FOR THE MATRIX?
TYPE 1 FOR TIME,2 FOR MAX.INTENSITY


2

STOP --

.
```

```
 R FUNC


INPUT PATIENT FILE AND NEW FILE NAME

*RK1:EWINGM.X00
*TIME.X00

DO YOU WANT TIME OR INTENSITY FOR THE MATRIX?
TYPE 1 FOR TIME,2 FOR MAX.INTENSITY


1

STOP --

.
```

ADDENDUM

CURVE   Dynamic Curve Analysis

CURVE is a general purpose BASIC program which allows the user to display and manipulate dynamic curves. These curves have been saved in a save area and are directly accessible via the GAMMA-11 BASIC subroutine calls (see Chapter 13). Addition, subtraction, division, and multiplication of curves are possible. Normalizing a curve with respect to another, smoothing, plotting the exponetial or the log, and integrating are other functions immediately executed in this program. Certain functions return a specific value (e.g. integration,curve fitting) and these values may be stored in one of 20 parameters available to the user. CURVE allows the user to create macro programs from the list of commands, and also allows the user to overlay his own BASIC programs to the nucleus supplied by CURVE.

The first command usually executed during analysis will be to read in the save area (RS nl). Then a dynamic curve should be displayed on the terminal (DCnl). Any curve analysis command executed before these two commands are issued, will result in unpredictable results and probably fatal errors.

The other alternative at the start of CURVE is to type the response "HELP". This will list all of the available options in the program as well as give some general instructions in the operation of the system.

Once the save area and the first curve have been chosen, the user can then choose from the list of 33 possible instructions. The parameters for these instructions (nl) can be either real values or the storage parameters available in CURVE. They are referenced as PØ,Pl,...P9 and RØ,Rl,...R9.

Curve Analysis Commands

1. Input/Output Operations

    a) Read Save Area (RS nl) - read save area nl into the buffer. This command must be executed before any analysis can be performed on the curves.

    b) Write Save Area (WS nl) - Write the contents of the buffer into save area nl. This command stores the results of the analysis into one of the nine available dynamic curve save areas. This command is usually the last one to be executed during analysis.

c) Write Curve (SC nl) - Write the curve currently on the display into the buffer as curve nl. Any curve from Ø to 11 may be created or changed in the buffer with this command. Curve 12 is used by CURVE as the scratch curve.

2. Display Curves

a) Display Curve (DC nl) - plot curve nl on the display. This command should be executed immediately after reading a save area. Then proper analysis of the curves can be guaranteed

b) Display Overlaid Curve (PO nl) - plot curve nl on the display but do not erase the previous curve. The scale for the Y- axis remains the same for this curve as it was for the previous one. Therefore the overlaid curves may have a scale either too large or too small in order to accurately view it. There is no limit to the number of overlaid curves than can be viewed on the display terminal.

c) Display Normalized Curve (NO nl) - plot curve nl overlaid on the terminal after first normalizing. This function will adjust the counts of the curve by the ratio of the number of cells of the area currently displayed to the number of cells of the curve to be overlaid.

3. Printing Curves or Parameters

a) Print Curve (PT) - print on the output device the curve currently being displayed. The scratch curve (12` is drawn on the output device and the frame number and the count rate are also listed.

b) Print Parameters (PR nl,n2,...,nlØ) - print the parameters listed on the output device. There may be up to 10 parameters listed with this command, and there are a total of 20 storage parameters available for the user. The first lØ parameters are designated 'PØ','Pl','P2',...,'P9', and the next 10 parameters are 'RØ','Rl',...,'R9'. These parameters may be used as either input or output variables in the various commands within CURVE.

4. Arithmetic Operations

a) Add Curve (AD nl) - add curve nl to the scratch curve (12) and redisplay on the display terminal. The only curve actually changed is the scratch curve and the contents of the original curves are not altered.

b) Add Constant (CA nl) - add the constant nl to the scratch curve (12) and redisplay. The appearance of the curve will not be altered as a result of this command.

c) Add Normalized Curve (AN nl) - add curve nl to the scratch curve (12) after first normalizing the curve. Normalization is a procedure whereby the counts of curve nl are scaled by the ratio of the number of cells of the current curve to the number of cells of the curve to be added.

d) Subtract Curve (SB nl) - subtract curve nl from the scratch curve (12) and redisplay. The buffer curve after the subtraction will not contain any negative numbers. All negative numbers are set to zero.

e) Subtract Constant (CS nl) - subtract the constant nl from the scratch curve (12) and redisplay. Negative values are set to zero.

f) Subtract Normalized Curve (SN nl) - subtract curve nl from the scratch curve (12) after first normalizing. Normalization scales the counts of curve nl by the ratio of the number of cells of the displayed curve to the number of cells of the curve to be subtracted. Negative values are set to zero.

5. Multiplicative Operations

a) Multiply Curves (MT nl) - multiply curve nl by the scratch curve (12) and redisplay on the terminal. The scratch curve is the only curve altered by the command.

b) Multiply Constant (CM nl) - multiply the constant nl to the scratch curve and redisplay the curve. The appearance of the curve will not be altered as a result of this command.

c) Multiply Normalized Curve (MN nl) - multiply curve nl to the scratch curve after first normalizing the curve. Normalization scales the counts of curve nl by the ratio of the number of cells of the displayed curve to the number of cells of the curve to be multiplied.

d) Divide Curves (DV nl) - divide the scratch curve (12) by curve nl and redisplay on the scope. If either the dividend (curve 12) or the divisor (curve nl) is zero at a particular point, the resultant point of the curve is also set to zero.

e) Divide Constant (CD nl) - divide the scratch curve by the constant nl and redisplay. Negative constants are not allowed.

f) Divide Normalized Curve (DN nl) - divide the scratch curve by curve nl after it has been normalized. Normalization scales the counts of curve nl by the ratio of the number of cells of the displayed curve to the number of cells of the curve that was indicated.

6. Curve Manipulations

a) Plot the Log (LG) - plots the log (base e) of the scratch curve (12) on the scope. This log curve is now the scratch curve in the buffer file.

b) Plot the Exponetial (EP) - plots the exponetial of the scratch curve on the scope. It is very easy to exceed the bounds of allowable counts with this function. It is recommended that the command be issued only when the maximum count of the scratch curve is very small. (e.g. after the log is displayed, or after the curve has been scaled down via the constant divide command).

c) Smooth the Curve (SM) - smooth the scratch curve (12) and redisplay. The curve is smoothed with a weighting of 1-2-1 for every point and then is saved in the scratch area.

d) Integrate the Curve (IN nl,n2,i) - integrates the dynamic curve displayed over a specific designated range. The first two parameters (nl,n2) are input variables which determine the left and right bounds of the integral. The integral is computed and returned in the third parameter (i). The parameter i must be one of the storage parameters, since it is used solely as an output variable.

7. Linear Least-Squares Fit (FT nl,n2,S,Y)

A linear least-squares fit is performed on the scratch curve over a given range of points. The first two parameters (nl,n2) are input variables which determine the left and right bounds of the fit. The fit is then computed and it returns two values, the slope (S) and the Y-intercept (Y). Therefore, the third and fourth parameters must be two of the storage parameters, since they are output variables that returns a specific value. The third parameter will contain the slope of the line computed, and the fourth will contain the Y-intercept.

8. Point Manipulations

a) Pick an X value (PX n1) - pick a particular X value for the curve displayed on the scope. The cursor will appear over one of the points of the curve and the user can determine which point should be marked. Typing an "L" moves one point to the left, typing a "R" moves one point to the right. Typing a "J" will move the cursor 10 points in the last direction indicated. When the user decides upon a point, type an "M" and that point is chosen. The parameter n1 will return the X value (frame number) of the point in the storage parameter designated.

b) Pick a Y value (PY n1) - pick a particular Y value for the curve displayed on the scope. The cursor will appear over the points and the user can determine which point to mark. The keyboard commands "L", "R", "J", and "M" move the cursor in the same manner as the command PX. When the user marks the given point (by typing "M"), the parameter n1 stores the Y value (count rate) of that point.

c) Change a point (CH n1 n2) - changes a point to a new value. The point to be altered is determined by the first parameter (n1) and the second parameter contains the new value to be stored at that point (n2).

NOTE: The function PX is frequently used in conjunction with the linear fit command (FT) and the integration command (IN). By calling PX twice one can store the left and right bounds of the following operations into the area of storage.

```
1) PX P1; PX R1      2) PX P1; PX R1
   IN P1,R1,P2          FT P1,R1,P2,R2
```

MACRO Commands

A macro program is a sequence of curve analysis commands that are stored together under one RT-11 filename. The program CURVE can then execute all of the commands listed in the macro via one command: Macro Run (MR name). CURVE has all of the editing features necessary to create, edit, append, print or execute these programs within its system. Once a macro program has been created, it is stored as a RT-11 file and can be used as often as necessary during any future curve analyses.

1. Macro Create (MC name) - creates a macro program from the curve analysis commands. All macro commands are illegal within a macro. There is no limitation upon the number of commands within a macro and the number of commands per line is only limited by the number of characters allowed per line (usually 80 or 132)

2. Macro Edit (ME name) - edits the macro program designated. The program asks the user which line is to be edited. If the user types Ø, the program exits. The lines of the macro up to the edited one are printed, and then the user inserts the new line. After one line has been changed, the user can change more lines if it is necessary. After exiting the program, the remaining lines are printed on the output device and control returns to CURVE.

3. Macro Append (MA name) - adds lines to the macro designated. The program prints the macro out to the output device and then requests the additional lines of commands. By typing a null line, the program exits and returns control to CURVE.

4. Macro Print (MP name) - print the macro designated on the output device and then return control to CURVE.

5. Macro Run (MR name) - execute the macro designated. Only curve analysis commands and the overlay command are valid within a macro program. If an error occurs within the macro, an error message will appear and the macro will exit. After completion of the macro, control returns to the program CURVE.

Overlay User Programs (OV name)

CURVE allows user programs to be overlaid with the BASIC curve analysis system. The overlaid program is executed immediately and then control can return back to CURVE. The statement numbers must begin at 1ØØØ and be incremented by one. The form of the overlaid segment should be that of a subroutine instead of a separate program. This means that RETURN rather than STOP should be the last executable statement.

In most overlay segments, the user will access some of the storage parameters and system variables within the curve analysis system. Certain system variables should not be altered in any overlay subroutine (e.g. B9$,I9,O9$,...). The storage parameters are readily available in the overlay by directly accessing the array S.

PØ,P1,...,P9 are stored in S(Ø),S(1),...S(9), and RØ, R1,...,R9 are stored in S(1Ø), S(11),...,S(19). Therefore the overlay can be easily used to output the results of curve analysis in the user's own unique format.

e.g. IN 1,20,P5; FT 1,20,R4,R5; OV OUTPUT

```
     1ØØØ PRINT  "INTEGRAL OF CURVE ="; S(5)
     1ØØ1 PRINT  "SLOPE OF LINEAR FIT ="; S(14)
     1ØØ2 PRINT  "Y-INTERCEPT ="; S(15)
     1ØØ3 RETURN
```

<u>CURVE System Variables</u>

S(19)	storage parameters
X(128),Y(128)	curve buffers
A$(28,2)	subroutine name array
D9(10),K9(10)	command parameter arrays
B1(4),E1(4)	curve pointer arrays
B$	command string
B9$	command string or macro command string
O9$	overlay name in core
E$,T$	new overlay name
C$	command
C9$	command or macro command
X9	parameter value
G	parameter number
I8	character position of B$
I9	character position of B9$
K$	position of ";" in B$
K9	position of ";" in B9$
E4	error flag (E4 = 1, then ERROR)

```
PLEASE ENTER COMMAND: HELP

LIST OF COMMANDS

MACRO COMMANDS:
MC NAME         MACRO CREATE
ME NAME         MACRO EDIT
MA NAME         MACRO ADD
MR NAME         MACRO RUN
MP NAME         MACRO PRINT

CURVE ANALYSIS COMMANDS:
OV NAME         OVERLAY USER PROGRAM
RS N1           READ SAVE AREA  N1
WS N1           WRITE SAVE AREA  N1
SC N1           SAVE CURVE  N1
DC N1           DISPLAY CURVE  N1
PO N1           DISPLAY CURVE  N1 (OVERLAY)
NO N1           DISPLAY CURVE  N1 (NORMALIZED)
PT              PRINT CURVE ON TERMINAL
PR N1,N2,...,N10     PRINT STORAGE PARAMETERS
AD N1           ADD CURVE  N1
CA N1           ADD CONSTANT  N1
AN N1           ADD NORMALIZED CURVE  N1
SB N1           SUBTRACT CURVE  N1
CS N1           SUBTRACT CONSTANT  N1
SN N1           SUBTRACT NORMALIZED CURVE  N1
MT N1           MULTIPLY BY CURVE  N1
CM N1           MULTIPLY BY CONSTANT  N1
MN N1           MULTIPLY BY NORMALIZED CURVE  N1
DV N1           DIVIDE BY CURVE  N1
CD N1           DIVIDE BY CONSTANT  N1
DN N1           DIVIDE BY NORMALIZED CURVE  N1
LG              PLOT LOG OF THE CURVE (BASE E)
EP              PLOT EXPONTIAL OF THE CURVE
FT N1,N2,N3,N4       LINEAR LEAST-SQUARES FIT
          N1=LEFT BOUND, N2=RIGHT BOUND, N3=SLOPE, N4=Y-INTERCEPT
PX N1           PICK X-VALUE
PY N1           PICK Y-VALUE
CH N1,N2        CHANGE POINT N1 TO N2
SM              SMOOTH THE CURVE
IN N1,N2,N3     INTEGRATE CURVE
          N1=LEFT BOUND, N2=RIGHT BOUND, N3=INTEGRAL

THERE ARE 20 STORAGE PARAMETERS FOR THE USERS
P0,P1,P2,P3,...,P9,R0,R1,R2,...,R9
THESE ARE USED IN THE CALLING SEQUENCE OF SOME ROUTINES,
AND MAY BE PRINTED WITH THE 'PR N1,N2,...,N10' COMMAND

THE SEMICOLON (;) MAY BE USED TO SEPARATE COMMANDS ON
THE SAME LINE. NO OTHER CHARACTER IS RECOGNIZED
AS A COMMAND TERMINATOR EXCEPT FOR A CARRIAGE RETURN.

SPACES ARE REQUIRED BETWEEN A MACRO COMMAND
AND THE MACRO FILE NAME. FOR CURVE ANALYSIS
COMMANDS THEY ARE OPTIONAL.

USER PROGRAMS ARE OVERLAID AT LINE 1000 WITH
AN INCREMENT OF 1. STORAGE PARAMETER VALUES CAN BE
STORED AND READ IN THE MATRIX S(19). P0,P1,...,P9
ARE STORED IN S(0),S(1),...,S(9), AND R0,R1,...,R9

PLEASE ENTER COMMAND:
```

EXAMPLE #1: INTEGRATION OF A CURVE

```
RUNNH
TYPE 'HELP' FOR A LIST OF COMMANDS

PLEASE ENTER COMMAND:
?RS9;DC1                                   read save area 9,display curve 1

PLEASE ENTER COMMAND:
?PX P1;PXP2;IN P1,P2,R1                    pick left and right bounds,
                                           then integrate
PLEASE ENTER COMMAND:
?PR P1,P2,R1                               print the  values

PARAMETER 1 :       3
PARAMETER 2 :       43
PARAMETER 11 :      32897

PLEASE ENTER COMMAND:
?

STOP AT LINE 10

READY
```

EXAMPLE #2 : CURVE FITTING, THEN CREATING A MACRO

```
RUNNH
TYPE 'HELP' FOR A LIST OF COMMANDS

PLEASE ENTER COMMAND:
?RS8;DC2;NO1                                     read save  area 8,display  curve
                                                 2,plot  normalized curve 1
PLEASE ENTER COMMAND:
?AD 1                                            add  curve  1

PLEASE ENTER COMMAND:
?LG;PX P9      .;PX P8                           plot the  log,pick 2  x  values

PLEASE ENTER COMMAND:
?FT P9,P8,R9 ,R8                                 linear least-squares  fit

PLEASE ENTER COMMAND:
?PR P9,P8,R9,R8                                  print the values
PARAMETER 9 :       9
PARAMETER 8 :       21
PARAMETER 19 :     .053261
PARAMETER 18 :     6.08133

PLEASE ENTER COMMAND:
?MC DEMO1                                        create  a  macro


MACRO PROGRAM DEMO1
INPUT MACRO PROGRAM
TYPE A NULL LINE TO EXIT
?RS8;DC2;NO1;AD1
?LG;PX P9;PXP8
?FT P9,P8,R9,R8
?PR P9,P8,R9,R8
?

PLEASE ENTER COMMAND:
?

STOP AT LINE 10

READY
```

EXAMPLE #3 : MACRO COMMANDS

```
RUNNH
TYPE 'HELP' FOR A LIST OF COMMANDS

PLEASE ENTER COMMAND:
?ME DEMO1                                    edit  macro  demo1


MACRO PROGRAM DEMO1
EDIT MACRO:  (TYPE 0 TO EXIT)
WHICH LINE ?                                 replace line 3
?3
LINE  1        RS8;DC2;NO1;AD1
LINE  2        LG;PX P9;PXP8
LINE  3        FT P9,P8,R9,R8
INSERT NEW LINE:
?IN P9,P8,P7;FT P9,P8,R8,R9                  new  line inserted
WHICH LINE ?
?
?0
LINE  4        PR P9,P8,R9,R8

PLEASE ENTER COMMAND:
?MR DEMO1                                    execute the  macro


MACRO PROGRAM DEMO1
PARAMETER 9 :      12
PARAMETER 8 :      29
PARAMETER 19 :     6.50975
PARAMETER 18 :     .0257111

PLEASE ENTER COMMAND:
?PR P7                                       print  parameter 7
PARAMETER 7 :      126.663                   (integral of the curve)

PLEASE ENTER COMMAND:
?MP DEMO1                                    print the  macro


MACRO PROGRAM DEMO1
LINE  1        RS8;DC2;NO1;AD1
LINE  2        LG;PX P9;PXP8
LINE  3        IN P9,P8,P7;FT P9,P8,R8,R9
LINE  4        PR P9,P8,R9,R8

PLEASE ENTER COMMAND:
?

STOP AT LINE 10

READY
```

EXAMPLE #4 : PRINTING THE CURVE ON THE TERMINAL

```
RUNNH
TYPE 'HELP' FOR A LIST OF COMMANDS

PLEASE ENTER COMMAND:
?RS9;DC1;PT          ————————————————→   read save area 9;display curve ;
                                         print curve on the terminal


               ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 1     2       ++
 2     11      ++
 3     14      ++
 4     465     +             +
 5     1046    +                              +
 6     1901    +                                                       +
 7     1386    +                                        +
 8     1442    +                                          +
 9     1122    +                                +
 10    973     +                            +
 11    878     +                         +
 12    764     +                      +
 13    843     +                        +
 14    1014    +                             +
 15    923     +                           +
 16    1051    +                              +
 17    1047    +                              +
 18    959     +                            +
 19    862     +                         +
 20    722     +                     +
 21    729     +                     +
 22    663     +                   +
 23    685     +                    +
 24    626     +                  +
 25    694     +                    +
 26    627     +                  +
 27    592     +                 +
 28    599     +                 +
 29    630     +                  +
 30    641     +                   +
 31    666     +                   +
 32    593     +                 +
 33    584     +                 +
 34    661     +                   +
 35    720     +                     +
 36    789     +                       +
 37    684     +                    +
 38    699     +                    +
 39    672     +                   +
 40    668     +                   +
 41    773     +                      +
 42    758     +                      +
 43    732     +                     +
 44    748     +                      +
 45    624     +                  +
 46    661     +                   +
 47    660     +                   +
 48    668     +                   +
 49    716     +                     +
```

EXAMPLE #5 : USE OF USER OVERLAY PROGRAM

```
 RS9;DC2
```

read save area 9,display curve 2

```
PLEASE ENTER COMMAND:
?PX P6;PX P7;IN P6,P7,R2;OV DEMO2
```

pick left and right bounds of the integral, integrate,call user overlay program !

```
LEFT BOUNDS OF INTEGRAL = 6
RIGHT BOUNDS OF INTEGRAL = 40

PATIENT NAME:CAYER, 49-06-81, CARDIAC, D, 11/15/73
INTEGRAL = 5245

PLEASE ENTER COMMAND:
?

STOP AT LINE 10

READY

OLD
OLD FILE NAME--DEMO2

READY
```

list the user overlay program

```
LISTNH
1000 PRINT \PRINT "LEFT BOUNDS OF INTEGRAL ="$S(6)
1001 PRINT "RIGHT BOUNDS OF INTEGRAL ="$S(7)
1002 CALL "GSAG"(1,A3$)
1003 PRINT \PRINT "PATIENT NAME:"$A3$
1004 PRINT "INTEGRAL ="$S(12)
1005 RETURN

READY
```