5-1971

A comparative study of Mackay-Marg, Durham-Langham and Tonomat tonometry

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Abstract

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Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Alfred Furie

Subject Categories

Optometry

A COMPARATIVE STUDY OF MACKAY-MARG, DURHAM-LANGHAM AND TONOMAT TONOMETRY

by

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IN PARTIAL FULFILLMENT OF THE
REQUIREMENT FOR THE DEGREE:
DOCTOR OF OPTOMETRY

APPROVED BY:

Alfred Furie, O.D.

Alfred Furie, O.D.

May 1971

The authors wish to express their appreciation to Dr. Alfred Furie for his help and guidance, to Dr. Richard Septon for the use of the tonometers, and to Dr. M. Jessen and Richard Rue for their assistance with the statistical computer program.

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INTRODUCTION

In recent years tonometry has become an important and indispensable part of optometric testing. The optometrist is generally held responsible for detecting rises in intraocular pressure, which is a diagnosis of glaucoma by medical definition.

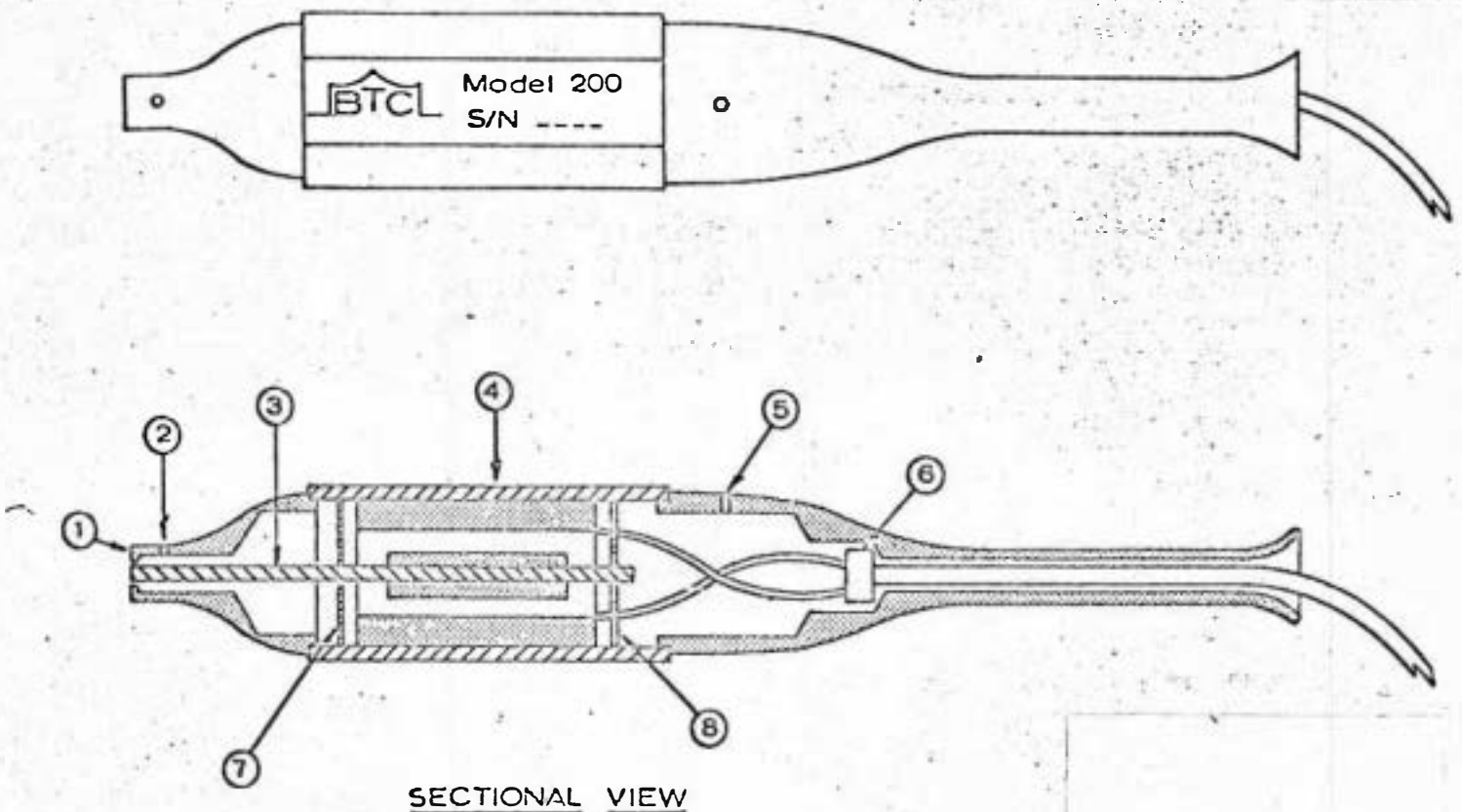
There have been several tonometers constructed to be used without corneal anesthesia. These are the ones that are of primary interest to the optometrist.

The purpose of this study is to make a comparison among the MacKay-Marg, the Durham-Langham, and the Tonomat. This study was done on 100 male optometry students at Pacific University.

DESCRIPTION OF TONOMETERS

MACKAY-MARG

The MacKay-Marg tonometer was invented by a physicist, Dr. Stuart MacKay, and an optometrist, Dr. Elwin Marg (1962). The goal of these men was to invent a fast acting, accurate tonometer which could be used on the unanesthetised cornea.



SECTIONAL VIEW

① Flat Tip Surface
② Equalizing Ventilation Port.
③ Stainless Steel Rod
④ Magnetic Shield
⑤ Atmospheric Vent
⑥ Strain Relief
⑦ Front Spring Suspension
⑧ Rear Spring Suspension

Fig. 1

PROBE - Showing venting & construction

There are two main parts to the MacKay-Marg tonometer, the probe and the recorder amplifier. The probe (fig. 1) is about 5 inches long and consists of a plunger (1.5 mm diameter) suspended within the probe body by springs and encircled by a magnetic field. The plunger extends 5 microns beyond the end of the probe. When the plunger moves, it induces changes in the magnetic field surrounding it. This change is transmitted via the chord to the amplifier recorder. The recorder translates the very small movements of the plunger into large amplitude waves which are recored on heat sensitive paper.

DURHAM-LANGHAM

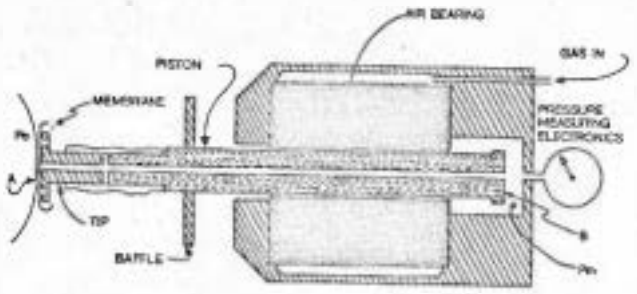
The history of the development of the Applamatic Tonometer goes back to 1960 when the officials of the Mercury Project asked the engineering department of the Dupont Company to work on the problem of measuring blood pressure of astronauts without the use of indwelling needles. As a result, a pressure-sensing instrument capable of measuring pressure at low levels with high sensitivity and accuracy was developed.

An ophthalmologist, Davis G. Durham M.D., extended this basic concept to the measurement of interocular pressure through the outer coats of the eye. As a result, the pressure balance Applamatic Tonometer(1966) was developed.

The design and construction of the Durham-Langham tonometer is complex, consisting of a gas supply, sensing system, transducer, amplifier and recorder.

The gas supply is provided by a replacable canister of liquefied gas which is located in a compartment in the rear of the instrument. The gas flows through a pressure regulator where its pressure is reduced and continues via a silicone rubber tube to the probe.

FIG 2



CROSS SECTION OF THE
APPLAMATIC TONOMETER SENSOR

P_m = Cone Chamber

The probe (Fig. 2), referred to as the sensor, is about 1/2 inch wide and 6 inches long. Gas flows from the cone chamber into the anterior rubber extension, into the tip extension, against the inner surface of the flexible membrane, and out to the atmosphere through the exit parts. Any restriction of this outflow during a continued inflow results in an increased pressure in the cone chamber.

The pneumatic to electronic transducer situated in the cabinet, senses alterations of the pressure in the cone chamber by the use of strain guages. These pressure changes which are transmitted by a readout tube, produce a proportionate variation of the electrical signal derived from the guages.[1]

The amplifier magnifies these electrical signals and relays them to the recorder where they are recorded on heat sensitized paper.

TONOMAT

In 1967 Posner and Inglima developed a modification of the Maklokov tonometer which they called the Tonomat.

Fig. 3

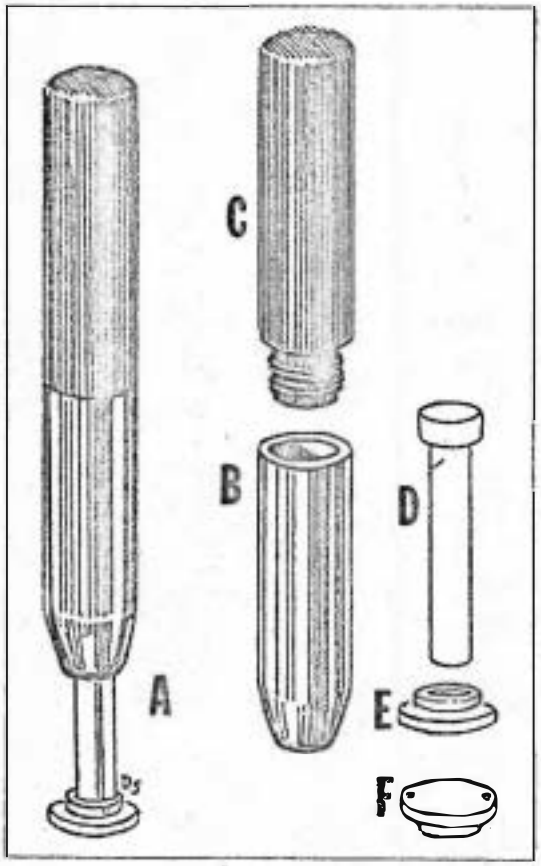


Fig. 1: The Tonomat applanation tonometer. A shows the instrument ready for use. B and C show the two-part tubular handle. D is the stainless steel probe, consisting of shaft and retaining collar. E and F present two views of the disposable plastic endplate; F shows the two orientation markers on the applanating surface. D and E (together) constitute the probe assembly; they weigh 5 grams.

Rosenthal, Jesse, and Werner, D. Leonard. Tonometry and Glaucoma Detection (Chicago: Professional Press, Inc., 1969), p. 131-137.

It consists of a two part tubular handle, and a certified 5 gm. stainless steel probe (fig. 3). The endplates are made of inexpensive disposable plastic.

Readings in mm of mercury are obtained by measuring the area of the cornea which has been flattened. This is accomplished by placing dye on the plate and measuring the diameter of the imprint that was formed by the contact with the cornea.

RESEARCH

The following figures are from the Berkely Tonometer Company and are published in the instruction manual for the Berkely MacKay-Marg Tonometer.

Up to 26mm of Hg -- Normal
26 to 30mm of Hg -- Questionable
Above 30mm of Hg -- Abnormally High

According to Rosenthal and Werner, the Biotronics MacKay-Marg Tonometer findings are 2mm lower than those published for the Berkely model.

Allen and Wertheim (1963) say a finding of 26mm of Hg is considered suspicious with 30mm of Hg as positive. A diurnal variation of over 5mm of Hg is likewise indicative.

Waggoner (1965) compared results of the MacKay-Marg and the Maklakov tonometers. He states his findings as follows:

	MacKay-Marg	Maklakov
Means=	21.69 ± 5.263	20.03 ± 3.149

A comparitive study done by Hill and Hill (1969) with the MacKay-Marg and the Tonomat shows these results.

	MacKay-Marg	Tonomat
Means=	19.17 ± 3.20	17.93 ± 3.14

The authors attribute the lower than normal mean of the MacKay-Marg to their technique.

Borish says that Maklakov findings of over 22 mm of hg and 3 mm of hg or more difference in the 2 eyes are considered suspicious.

Rosenthal and Werner state that none of the research that has been completed has indicated any systematic difference between the Durham-Langham and either the Goldman or corneal Schiotz tonometer, but the Durham-Langham does seem to give lower readings for higher pressures. On this basis, 22 mm of hg would be accepted as the ctitical value until such a time that future studies indicate otherwise.

Most, if not all, of the studies published to date that have been done with the Tonomat have been done on the anesthetized corneas.

PROCEDURE

Subjects for this study were 100 male optometry students at Pacific University. They were deemed by the experimenters to be normal healthy young male population.

The tonometers used were the Biotronics MacKay-Marg, The Bausch and Lomb Applamatic and the Tonomat (Ocular Products Inc.).

Techniques used were taken from the instruction manuals which accompanied each instrument.

A random rotation among the three experimenters and the three tonometers was used. Tonometry was done at various times of the day from 9:00 a.m. to 6:00 p.m. Two of the three tonometric procedures were taken in random sequence with the MacKay-Marg being last each time. This was done on the basis of the work done by Yamamoto (1968) and Marg who found that the MacKay-Marg tonometric procedure lowered other findings taken afterward. Doing the Applamatic or Tonomat tonometric procedure first had no observable effect on the MacKay-Marg findings.

Compilation of the statistics was done with the aid of the SIMLIN computer program at Oregon State University, Corvallis, Oregon.

RESULTS AND CALCULATIONS

RAW DATA

	Subject	Mackay-Marg		Tonomat		Durham-Langham	
		OD	OS	OD	OS	OD	OS
1.	J.P.	16	16	13	15	16	15
2.	L.J.	15	15	11	11	14	14
3.	D.G.	24	24	15	16	18	17
4.	J.D.	28	22	15	17	22	22
5.	D.G.	24	22	14	13	15	16
6.	M.E.	24	22	13	15	14	13
7.	T.M.	28	26	14	14	17	16
8.	L.F.	14	14	15	15	20	17
9.	J.S.	22	20	14	15	17	18
10.	J.R.	20	18	15	14	14	14
11.	L.G.	21	22	14	13	14	13
12.	B.E.	18	20	15	14	19	18
13.	C.S.	16	18	13	16	12	12
14.	G.S.	19	19	15	15	12	12
15.	J.W.	18	18	18	15	13	13
16.	J.D.	19	20	13	14	13	12
17.	D.B.	18	18	15	17	17	15
18.	J.W.	20	20	13	13	15	17
19.	B.L.	22	22	15	16	16	17
20.	G.T.	20	22	16	16	14	16
21.	R.H.	23	22	18	18	9	12
22.	R.R.	15	16	13	13	15	11
23.	W.M.	20	21	14	15	13	10
24.	M.O.	20	22	11	11	10	9
25.	D.W.	22	24	18	21	20	20
26.	J.H.	18	18	17	13	17	17
27.	M.C.	16	16	15	15	13	17
28.	J.B.	22	20	13	13	15	14
29.	R.S.	24	23	13	13	18	18
30.	W.B.	20	20	12	12	16	17
31.	R.R.	19	17	14	14	13	16
32.	P.N.	24	24	12	12	14	13
33.	M.B.	20	19	14	14	15	16
34.	R.B.	20	20	14	13	16	17
35.	G.I.	16	16	13	14	13	15
36.	S.B.	19	20	13	14	11	11
37.	D.G.	21	20	18	20	23	22
38.	K.B.	18	18	11	11	18	17
39.	D.A.	20	20	13	13	15	15
40.	J.O.	18	18	16	15	12	13
41.	J.M.	22	18	14	14	10	10
42.	J.Z.	18	18	16	16	17	14
43.	R.M.	19	20	16	17	12	9
44.	S.O.	28	30	15	15	25	23
45.	T.S.	20	22	17	16	18	15
46.							
47.							
48.							
49.							
50.							

RAW DATA (continued)

Subject	Mackay-Marg		Tonomat		Durham-Langham	
	OD	OS	OD	OS	OD	OS
46. A.S.	24	25	18	18	18	15
47. D.N.	20	20	16	16	22	22
48. R.E.	24	26	16	17	19	20
49. D.R.	20	24	20	20	19	20
50. W.M.	20	19	16	16	15	14
51. E.G.	20	20	16	14	15	13
52. G.S.	22	24	19	21	23	23
53. T.M.	14	16	14	14	14	12
54. B.G.	20	20	18	16	17	15
55. D.R.	18	18	16	14	20	16
56. G.P.	14	14	13	13	12	10
57. J.L.	20	20	19	19	13	14
58. J.S.	20	23	19	19	23	25
59. D.S.	18	19	17	16	21	19
60. D.C.	24	26	16	17	19	17
61. O.C.	16	16	16	17	16	18
62. M.S.	18	17	18	19	21	19
63. E.S.	18	17	14	12	18	17
64. J.T.	12	12	14	13	13	12
65. A.S.	14	14	13	12	13	12
66. S.S.	14	14	17	16	15	15
67. D.A.	18	18	21	18	25	23
68. T.M.	16	16	15	15	24	24
69. S.W.	18	18	18	17	25	22
70. M.M.	17	16	17	16	17	15
71. H.G.	22	19	23	22	27	25
72. I.S.	20	20	20	20	23	21
73. G.L.	15	14	17	16	15	13
74. J.R.	20	20	16	17	16	13
75. L.B.	16	16	18	18	17	16
76. B.W.	19	20	18	18	15	15
77. A.W.	15	18	16	18	14	14
78. J.M.	16	18	16	16	18	18
79. J.B.	17	20	15	18	18	17
80. E.B.	15	13	11	11	16	14
81. A.S.	24	23	24	23	27	31
82. J.L.	22	24	22	23	19	19
83. K.H.	16	16	18	17	15	17
84. B.M.	18	18	19	21	15	19
85. D.H.	16	16	18	16	23	23
86. D.M.	17	17	10	10	11	13
87. J.M.	20	20	18	18	22	18
88. D.S.	16	16	15	15	17	15
89. P.L.	14	16	15	16	17	17
90. L.L.	16	16	14	12	15	15

RAW DATA (continued)

Subject		Mackay-Marg		Tonomat		Durham-Langham	
		OD	OS	OD	OS	OD	OS
91.	J.S.	18	18	16	18	14	14
92.	S.R.	18	18	10	10	15	12
93.	T.R.	24	22	18	18	23	23
94.	R.C.	14	14	15	15	15	13
95.	D.G.	17	16	12	11	15	13
96.	C.B.	20	18	23	21	26	23
97.	W.M.	16	16	16	18	13	13
98.	R.D.	20	20	16	18	20	20
99.	H.B.	19	20	16	17	17	17
100.	J.J.	18	18	17	17	16	17

```
**SIMLIN
*** SIMPLE CORRELATION AND REGRESSION ***
PLEASE TERMINATE RESPONSES WITH CARRIAGE RETURN.
DO YOU WISH TO ENTER DATA FROM TELETYPE? NO
HAVE YOU EQUIPPED YOUR DATA FILE? NO
PLEASE ENTER NAME OF YOUR DATA FILE.
RG1
NAME OF DATA FILE IS RG1
CORRECT? YES
DO YOU HAVE A FREE FORM INPUT DATA FILE?YES
X = MacKay-Mare O.D.
Y = MacKay-Mare O.S.
```

EOU

```
**********************************************************************
*SIMLIN - CORRELATION AND SIMPLE LINEAR REGRESSION.        VER.3.0
OREGON STATE UNIVERSITY COMPUTER CENTER                DATE - 03/18/71
**********************************************************************

PROBLEM IDENTIFICATION - PROBLEM.

SAMPLE SIZE =        100

SUM OF X ..................        1905.00000
MEAN OF X .................          19.05000
STANDARD DEVIATION OF X ...           3.27949
STANDARD ERROR OF MEAN ....            .32795
MAXIMUM  X ................          28.00000
MINIMUM  X ................          12.00000
RANGE OF X ................          16.00000

SUM OF Y ..................        1912.00000
MEAN OF Y .................          19.12000
STANDARD DEVIATION OF Y ...           3.25136
STANDARD ERROR OF MEAN ....            .32514
MAXIMUM  Y ................          30.00000
MINIMUM  Y ................          12.00000
RANGE OF Y ................          18.00000

REGRESSION LINE   Y = A + B * X

A =        2.205353      STANDARD ERROR OF A =          .861115
B =         .887908      STANDARD ERROR OF B =          .044554

CORRELATION COEFFICIENT R  =    .895590973

        ANALYSIS OF VARIANCE

SOURCE OF       DEGREES OF        SUM OF          MEAN
VARIATION        FREEDOM          SQUARES         SQUARE

 TOTAL             99          1046.56000       10.5713
 REGRESSION         1           839.42819      839.4282
 ERROR             98           207.13182        2.1136


END OF PROGRAM EXECUTION
DO YOU WISH FURTHER TESTS?  NO
```

```
#*SIMLIN
*** SIMPLE CORRELATION AND REGRESSION ***
PLEASE TERMINATE RESPONSES WITH CARRIAGE RETURN.
DO YOU WISH TO ENTER DATA FROM TELETYPE?  NO
HAVE YOU EQUIPPED YOUR DATA FILE?  NO
PLEASE ENTER NAME OF YOUR DATA FILE.
RG1
NAME OF DATA FILE IS RG1
CORRECT?  YES
DO YOU HAVE A FREE FORM INPUT DATA FILE?YES
X = Applamatic  S.O.
Y = Applamatic  S.O.
```

AOU

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**********************************************************************
*SIMLIN - CORRELATION AND SIMPLE LINEAR REGRESSION.        VER.3.0
OREGON STATE UNIVERSITY COMPUTER CENTER                   DATE - 03/15/71
**********************************************************************

PROBLEM IDENTIFICATION - PROBLEM.

SAMPLE SIZE =          99

SUM OF X .....................          1662.00000
MEAN OF X ....................            16.78788
STANDARD DEVIATION OF X .\S:TZ.01089
STANDARD ERROR OF MEAN ....                .40311
MAXIMUM  X ...................            27.00000
MINIMUM  X ...................             9.00000
RANGE OF X ...................            18.00000

SUM OF Y .....................          1608.00000
MEAN OF Y ....................            16.24242
STANDARD DEVIATION OF Y ...                4.00533
STANDARD ERROR OF MEAN ....                .40255
MAXIMUM  Y ...................            31.00000
MINIMUM  Y ...................             9.00000
RANGE OF Y ...................            22.00000

REGRESSION LINE   Y = A + B * X

A =        1.088610      STANDARD ERROR OF A =          .748330
B =         .902664      STANDARD ERROR OF B =          .043367

CORRELATION COEFFICIENT R  =    .903915870

          ANALYSIS OF VARIANCE

SOURCE OF        DEGREES OF        SUM OF          MEAN
VARIATION         FREEDOM          SQUARES         SQUARE

 TOTAL              98          1572.18182        16.0427
 REGRESSION          1          1284.57301      1284.5730
 ERROR              97           287.60881         2.9650


END OF PROGRAM EXECUTION
DO YOU WISH FURTHER TESTS?  NO
```

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**SIMLIN
*** SIMPLE CORRELATION AND REGRESSION ***
PLEASE TERMINATE RESPONSES WITH CARRIAGE RETURN.
DO YOU WISH TO ENTER DATA FROM TELETYPE?  NO
HAVE YOU EQUIPPED YOUR DATA FILE?  NO
PLEASE ENTER NAME OF YOUR DATA FILE.
RGL
NAME OF DATA FILE IS RGL
CORRECT?  YES
DO YOU HAVE A FREE FORM INPUT DATA FILE?YES
```

X= Tenomat c.d.

Y= Tenomat c.s.

Tou

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**********************************************************************
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**********************************************************************

PROBLEM IDENTIFICATION - PROBLEM.

SAMPLE SIZE =        99

SUM OF X ..................          1545.00000
MEAN OF X .................            15.60606
STANDARD DEVIATION OF X ...             2.73607
STANDARD ERROR OF MEAN ....              .27499
MAXIMUM  X ................            24.00000
MINIMUM  X ................            10.00000
RANGE OF X ................            14.00000

SUM OF Y ..................          1551.00000
MEAN OF Y .................            15.66667
STANDARD DEVIATION OF Y ...             2.81758
STANDARD ERROR OF MEAN ....              .28318
MAXIMUM  Y ................            23.00000
MINIMUM  Y ................            10.00000
RANGE OF Y ................            13.00000

REGRESSION LINE   Y = A + B * X

A =       1.350475      STANDARD ERROR OF A =          .752630
B =        .917348      STANDARD ERROR OF B =          .047509

CORRELATION COEFFICIENT R  =    .890809502

        ANALYSIS OF VARIANCE

SOURCE OF       DEGREES OF        SUM OF          MEAN
VARIATION        FREEDOM          SQUARES         SQUARE

 TOTAL             98            778.00000        7.9388
 REGRESSION         1            617.37534      617.3753
 ERROR             97            160.62466        1.6559


END OF PROGRAM EXECUTION
DO YOU WISH FURTHER TESTS?  NO
```

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**SIMLIN
*** SIMPLE CORRELATION AND REGRESSION ***
PLEASE TERMINATE RESPONSES WITH CARRIAGE RETURN.
DO YOU WISH TO ENTER DATA FROM TELETYPE? NO
HAVE YOU EQUIPPED YOUR DATA FILE? NO
PLEASE ENTER NAME OF YOUR DATA FILE.
RG1
NAME OF DATA FILE IS RG1
CORRECT? YES
DO YOU HAVE A FREE FORM INPUT DATA FILE?YES'
```

X = MacKay-Mint O.D.

Y = Applanatic O.D.

EH OD

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**********************************************************************
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PROBLEM IDENTIFICATION - PROBLEM.

SAMPLE SIZE =        100

SUM OF X .....................        1905.00000
MEAN OF X ....................          19.05000
STANDARD DEVIATION OF X ...           3.27949
STANDARD ERROR OF MEAN ....            .32795
MAXIMUM  X ...................          28.00000
MINIMUM  Y ...................          12.00000
RANGE OF X ...................          16.00000

SUM OF Y .....................        1691.00000
MEAN OF Y ....................          16.91000
STANDARD DEVIATION OF Y ...           4.02541
STANDARD ERROR OF MEAN ....            .40254
MAXIMUM  Y ...................          27.00000
MINIMUM  Y ...................           9.00000
RANGE OF Y ...................          18.00000

REGRESSION LINE   Y = A + B * X

A =      10.890397      STANDARD ERROR OF A =          2.315663
B =        .315990      STANDARD ERROR OF B =           .119812

CORRELATION COEFFICIENT R  =    .257435780

          ANALYSIS OF VARIANCE

SOURCE OF       DEGREES OF        SUM OF          MEAN
VARIATION        FREEDOM          SQUARES         SQUARE

 TOTAL             99          1504.19000       16.2039
 REGRESSION         1           106.31472      106.3147
 ERROR             98          1497.87523       15.2844



END OF PROGRAM EXECUTION
DO YOU WISH FURTHER TESTS?  NO
```

```
#*SIMLIN
*** SIMPLE CORRELATION AND REGRESSION  ***
PLEASE TERMINATE RESPONSES WITH CARRIAGE RETURN.
DO YOU WISH TO ENTER DATA FROM TELETYPE?  NO
HAVE YOU EQUIPPED YOUR DATA FILE?  NO
PLEASE ENTER NAME OF YOUR DATA FILE.
RG1
NAME OF DATA FILE IS RG1
CORRECT?  YES
DO YOU HAVE A FREE FORM INPUT DATA FILE?YES
```

X = MacKay-Mayo C.D.

Y = Tenerife C.D.

ET OD

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**********************************************************************
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PROBLEM IDENTIFICATION - PROBLEM.

SAMPLE SIZE =        100

SUM OF X ..................        1906.00000
MEAN OF X .................          19.06000
STANDARD DEVIATION OF X ...           3.27778
STANDARD ERROR OF MEAN ....            .32778
MAXIMUM  X ................          28.00000
MINIMUM  X ................          12.00000
RANGE OF X ................          16.00000

SUM OF Y ..................        1564.00000
MEAN OF Y .................          15.64000
STANDARD DEVIATION OF Y ...           2.74329
STANDARD ERROR OF MEAN ....            .27433
MAXIMUM  Y ................          24.00000
MINIMUM  Y ................          10.00000
RANGE OF Y ................          14.00000

REGRESSION LINE   Y = A + B * X

A =       12.680399      STANDARD ERROR OF A =          1.606432
B =         .155278      STANDARD ERROR OF B =           .083076

CORRELATION COEFFICIENT R  =    .185531540

        ANALYSIS OF VARIANCE

SOURCE OF       DEGREES OF        SUM OF          MEAN
VARIATION        FREEDOM          SQUARES        SQUARE

 TOTAL             99           745.04000        7.5257
 REGRESSION         1            25.64573       25.6457
 ERROR             98           719.39427        7.3408


END OF PROGRAM EXECUTION
DO YOU WISH FURTHER TESTS?  NO
```

```
#*SIMLIN
*** SIMPLE CORRELATION AND REGRESSION  ***
PLEASE TERMINATE RESPONSES WITH CARRIAGE RETURN.
DO YOU WISH TO ENTER DATA FROM TELETYPE?  NO
HAVE YOU EQUIPPED YOUR DATA FILE?  NO
PLEASE ENTER NAME OF YOUR DATA FILE.
RG1
NAME OF DATA FILE IS RG1
CORRECT?  YES
DO YOU HAVE A FREE FORM INPUT DATA FILE?YES
```

X = Tenemat e.g.

Y = Applematic e.g.

TA 00

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**********************************************************************
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**********************************************************************

PROBLEM IDENTIFICATION - PROBLEM.

SAMPLE SIZE =        100

SUM OF X ..................          1564.00000
MEAN OF X .................            15.64000
STANDARD DEVIATION OF X ...             2.74329
STANDARD ERROR OF MEAN ....              .27433
MAXIMUM  X ................            24.00000
MINIMUM  X ................            10.00000
RANGE OF X ................            14.00000

SUM OF Y ..................          1681.00000
MEAN OF Y .................            16.81000
STANDARD DEVIATION OF Y ...             3.99670
STANDARD ERROR OF MEAN ....              .39967
MAXIMUM  Y ................            27.00000
MINIMUM  Y ................             9.00000
RANGE OF Y ................            18.00000

REGRESSION LINE   Y = A + B * X

A =        3.308681      STANDARD ERROR OF A =          1.882178
B =         .863256      STANDARD ERROR OF B =           .118552

CORRELATION COEFFICIENT R  =    .592529173

          ANALYSIS OF VARIANCE

SOURCE OF        DEGREES OF        SUM OF          MEAN
VARIATION         FREEDOM          SQUARES        SQUARE

 TOTAL              99          1581.39000       15.9736
 REGRESSION          1           555.21151      555.2115
 ERROR              98          1026.17849       10.4712



END OF PROGRAM EXECUTION
DO YOU WISH FURTHER TESTS?  NO
```

```
*SIMLIN
*** SIMPLE CORRELATION AND REGRESSION  ***
PLEASE TERMINATE RESPONSES WITH CARRIAGE RETURN.
DO YOU WISH TO ENTER DATA FROM TELETYPE? NO
HAVE YOU EQUIPPED YOUR DATA FILE? NO
PLEASE ENTER NAME OF YOUR DATA FILE.
RG1
NAME OF DATA FILE IS RG1
CORRECT? YES
DO YOU HAVE A FREE FORM INPUT DATA FILE?YES
```

X = Mackay - Marg O.S.

Y. Tonomat O.S.

ET OS

```
**********************************************************************
*SIMLIN - CORRELATION AND SIMPLE LINEAR REGRESSION.        VER.3.0
OREGON STATE UNIVERSITY COMPUTER CENTER                   DATE - 03/18/71
**********************************************************************

PROBLEM IDENTIFICATION - PROBLEM.

SAMPLE SIZE =        100

SUM OF X ..................          1912.00000
MEAN OF X .................            19.12000
STANDARD DEVIATION OF X ...             3.25136
STANDARD ERROR OF MEAN ....              .32514
MAXIMUM  X ................            30.00000
MINIMUM  X ................            12.00000
RANGE OF X ................            18.00000

SUM OF Y ..................          1570.00000
MEAN OF Y .................            15.70000
STANDARD DEVIATION OF Y ...             2.82307
STANDARD ERROR OF MEAN ....              .28231
MAXIMUM  Y ................            23.00000
MINIMUM  Y ................            10.00000
RANGE OF Y ................            13.00000

REGRESSION LINE   Y = A + B * X

A =      10.847653      STANDARD ERROR OF A =          1.626555
B =        .253784      STANDARD ERROR OF B =           .083879

CORRELATION COEFFICIENT R  =    .292285656

        ANALYSIS OF VARIANCE

SOURCE OF      DEGREES OF      SUM OF        MEAN
VARIATION       FREEDOM        SQUARES       SQUARE

 TOTAL             99          789.00000      7.9697
 REGRESSION         1           67.40498     67.4050
 ERROR             98          721.59502      7.3632


END OF PROGRAM EXECUTION
DO YOU WISH FURTHER TESTS?  NOT
```

*** SIMPLE CORRELATION AND REGRESSION ***
PLEASE TERMINATE RESPONSES WITH CARRIAGE RETURN.
DO YOU WISH TO ENTER DATA FROM TELETYPE? NO
HAVE YOU EQUIPPED YOUR DATA FILE? NO
PLEASE ENTER NAME OF YOUR DATA FILE.
RG1
NAME OF DATA FILE IS RG1
CORRECT? YES
DO YOU HAVE A FREE FORM INPUT DATA FILE?
YES

X = MacKay - Mark O.S.
Y = Applamatic O.S.

EROS

****
*SIMLIN - CORRELATION AND SIMPLE LINEAR REGRESSION. VER.3.0
OREGON STATE UNIVERSITY COMPUTER CENTER DATE - 03/18/71
****

PROBLEM IDENTIFICATION - PROBLEM.

SAMPLE SIZE = 100

SUM OF X	1912.00000
MEAN OF X	19.12000
STANDARD DEVIATION OF X ...	3.25136
STANDARD ERROR OF MEAN	.32514
MAXIMUM X	30.00000
MINIMUM X	12.00000
RANGE OF X	18.00000
SUM OF Y	1625.00000
MEAN OF Y	16.25000
STANDARD DEVIATION OF Y ...	3.96290
STANDARD ERROR OF MEAN	.39629
MAXIMUM Y	31.00000
MINIMUM Y	9.00000
RANGE OF Y	22.00000

REGRESSION LINE Y = A + B * X

A =	9.344175	STANDARD ERROR OF A =	2.280311
B =	.361183	STANDARD ERROR OF B =	.117592

CORRELATION COEFFICIENT R = .296332613

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
TOTAL	99	1554.75000	15.7045
REGRESSION	1	136.52729	136.5273
ERROR	98	1418.22271	14.4717

END OF PROGRAM EXECUTION
DO YOU WISH FURTHER TESTS? NO

```
]
#*SIMLIN
*** SIMPLE CORRELATION AND REGRESSION ***
PLEASE TERMINATE RESPONSES WITH CARRIAGE RETURN.
DO YOU WISH TO ENTER DATA FROM TELETYPE? NO
HAVE YOU EQUIPPED YOUR DATA FILE? NO
PLEASE ENTER NAME OF YOUR DATA FILE.
RG1
NAME OF DATA FILE IS RG1
CORRECT? YES
DO YOU HAVE A FREE FORM INPUT DATA FILE?YES
```

X = Tonomat OS

Y = Applomatic OS

THOS

```
**********************************************************************
*SIMLIN - CORRELATION AND SIMPLE LINEAR REGRESSION.        VER.3.0
OREGON STATE UNIVERSITY COMPUTER CENTER                DATE - 03/18/71
**********************************************************************

PROBLEM IDENTIFICATION - PROBLEM.

SAMPLE SIZE =        100

SUM OF X ..................        1570.00000
MEAN OF X .................          15.70000
STANDARD DEVIATION OF X ...           2.82307
STANDARD ERROR OF MEAN ....            .28231
MAXIMUM  X ................          23.00000
MINIMUM  X ................          10.00000
RANGE OF X ................          13.00000

SUM OF Y ..................        1628.00000
MEAN OF Y .................          16.28000
STANDARD DEVIATION OF Y ...           4.00273
STANDARD ERROR OF MEAN ....            .40027
MAXIMUM  Y ................          31.00000
MINIMUM  Y ................           9.00000
RANGE OF Y ................          22.00000

REGRESSION LINE   Y = A + B * X

A =       3.616527     STANDARD ERROR OF A =        1.878705
B =        .806591     STANDARD ERROR OF B =         .117792

CORRELATION COEFFICIENT R  =    .568876734

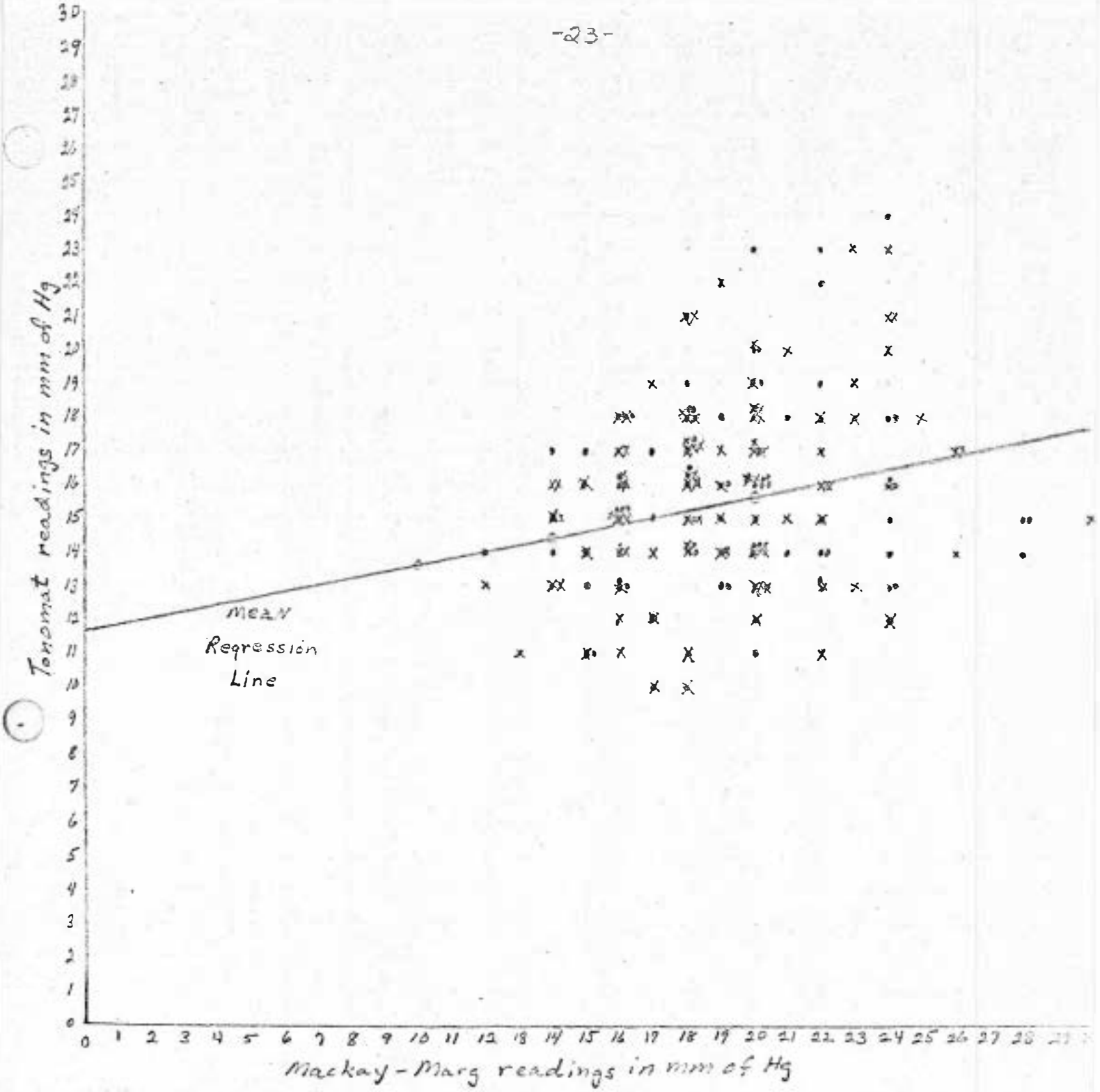
        ANALYSIS OF VARIANCE

SOURCE OF       DEGREES OF        SUM OF          MEAN
VARIATION        FREEDOM          SQUARES         SQUARE

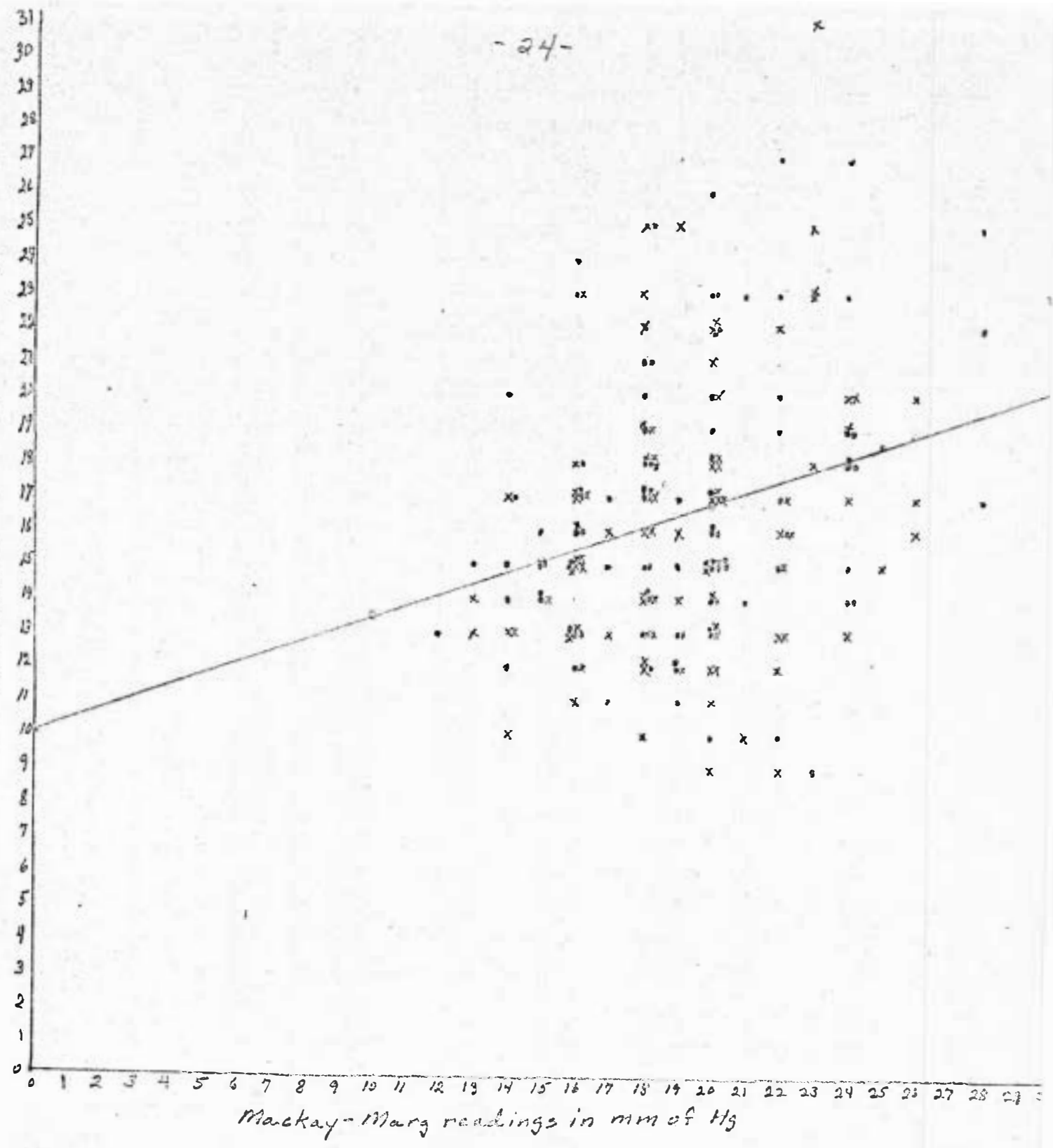
 TOTAL             99          1586.16000       16.0218
 REGRESSION         1           513.31427      513.3143
 ERROR             98          1072.84573       10.9474



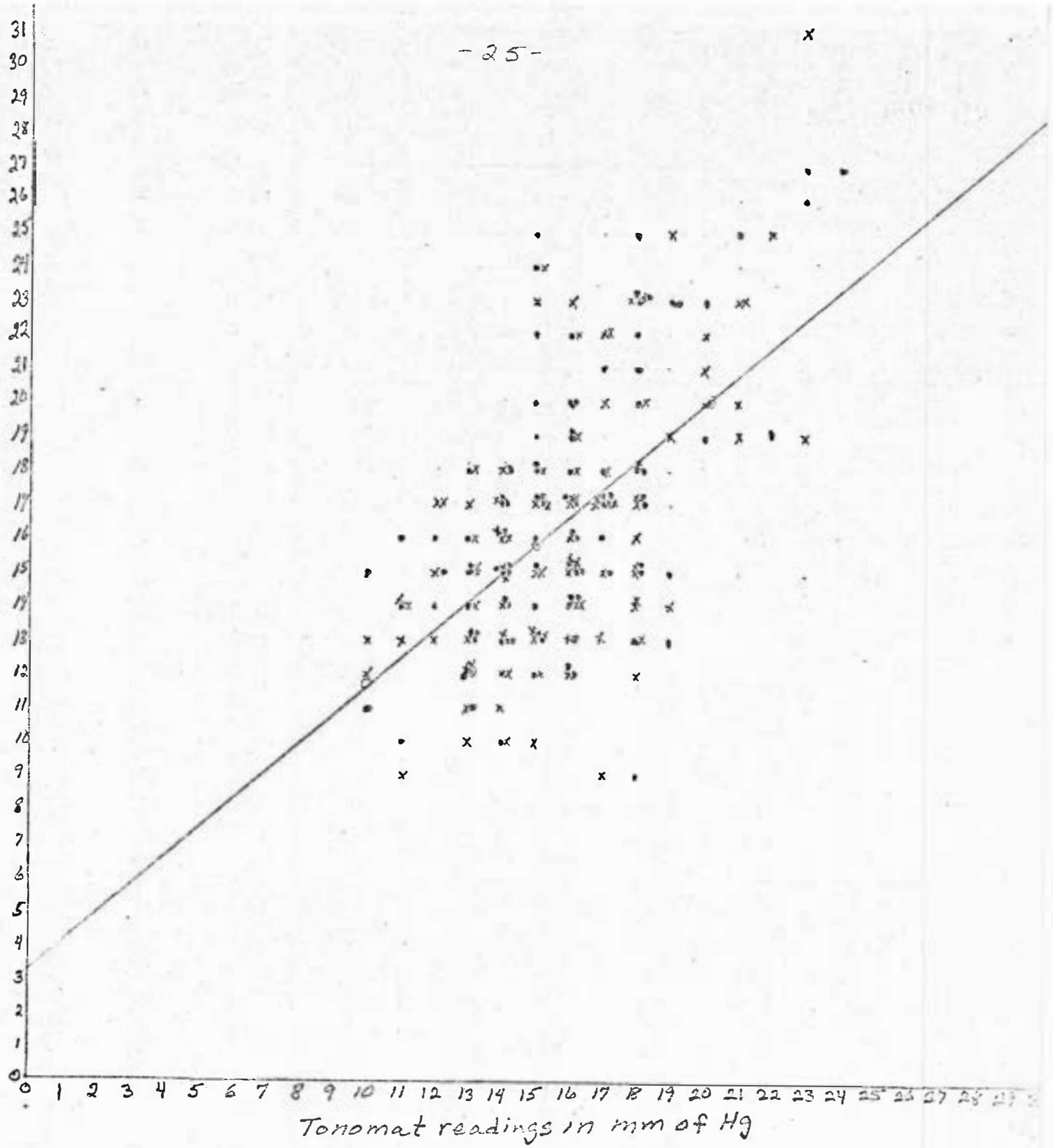
END OF PROGRAM EXECUTION
DO YOU WISH FURTHER TESTS?  GOOD
```


Tonomat readings in mm of Hg
Mackay-Marg readings in mm of Hg
mean
Regression
Line

• OD
× OS

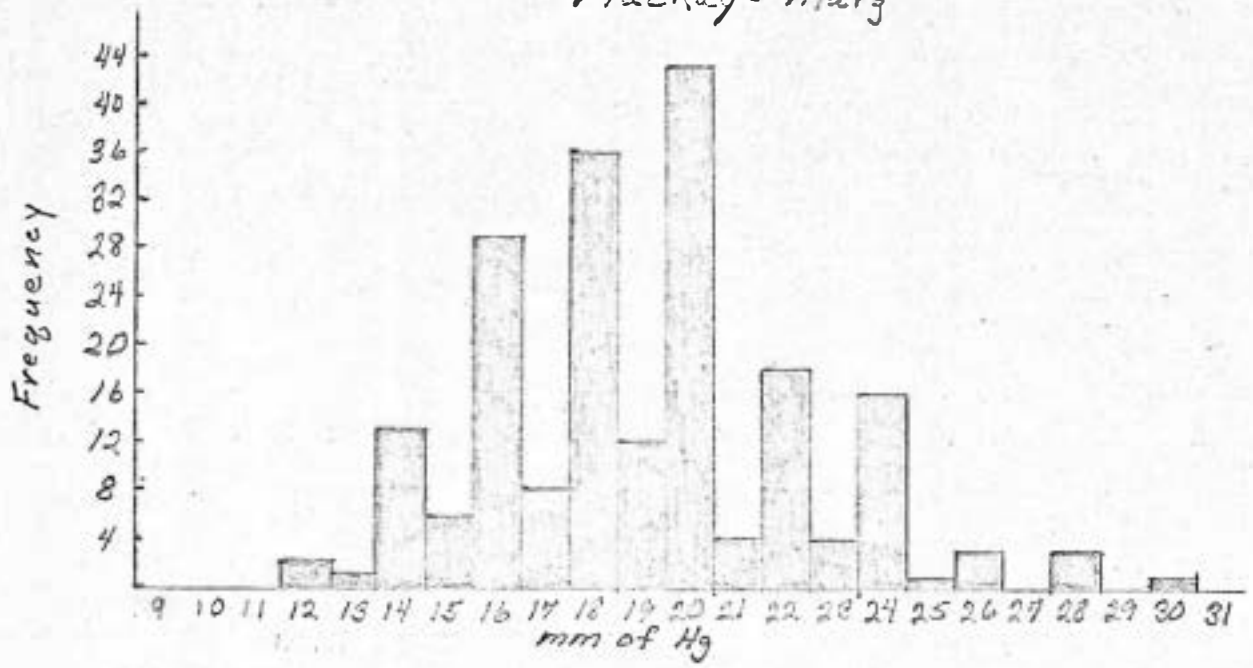

Durham-Langham readings in mm of Hg
Mackay-Marg readings in mm of Hg
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

• OD
x OS

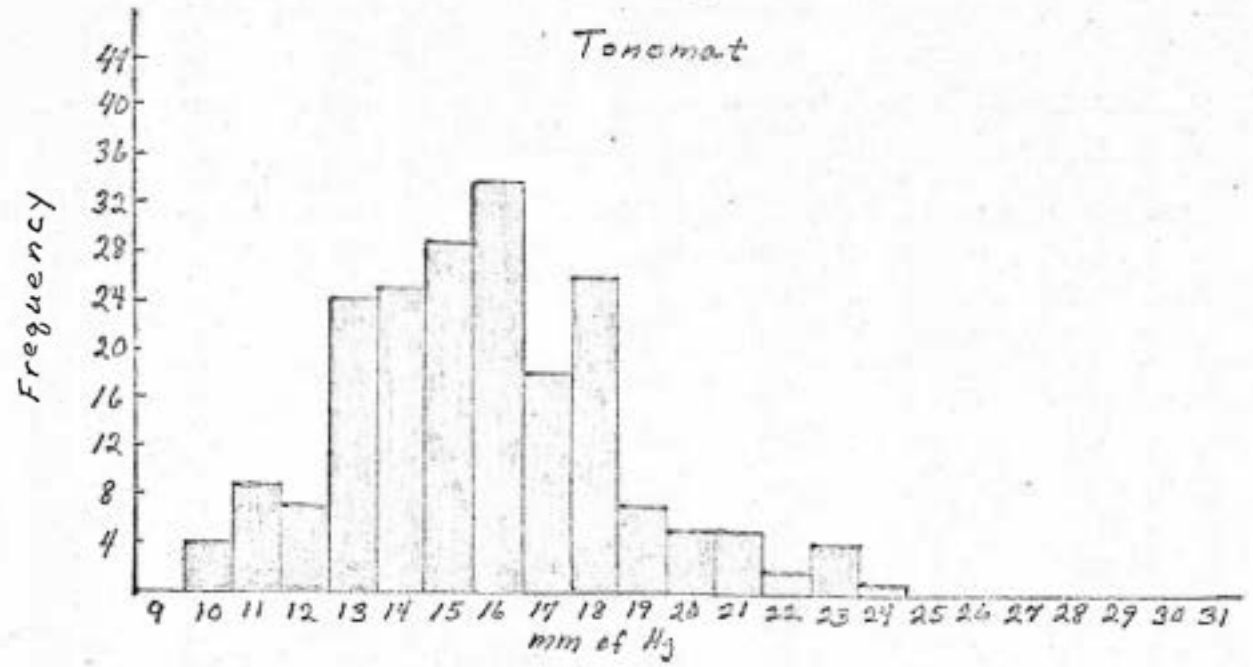

Durham - Langham readings in mm of Hg
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Tonomat readings in mm of Hg

• OD
× OS

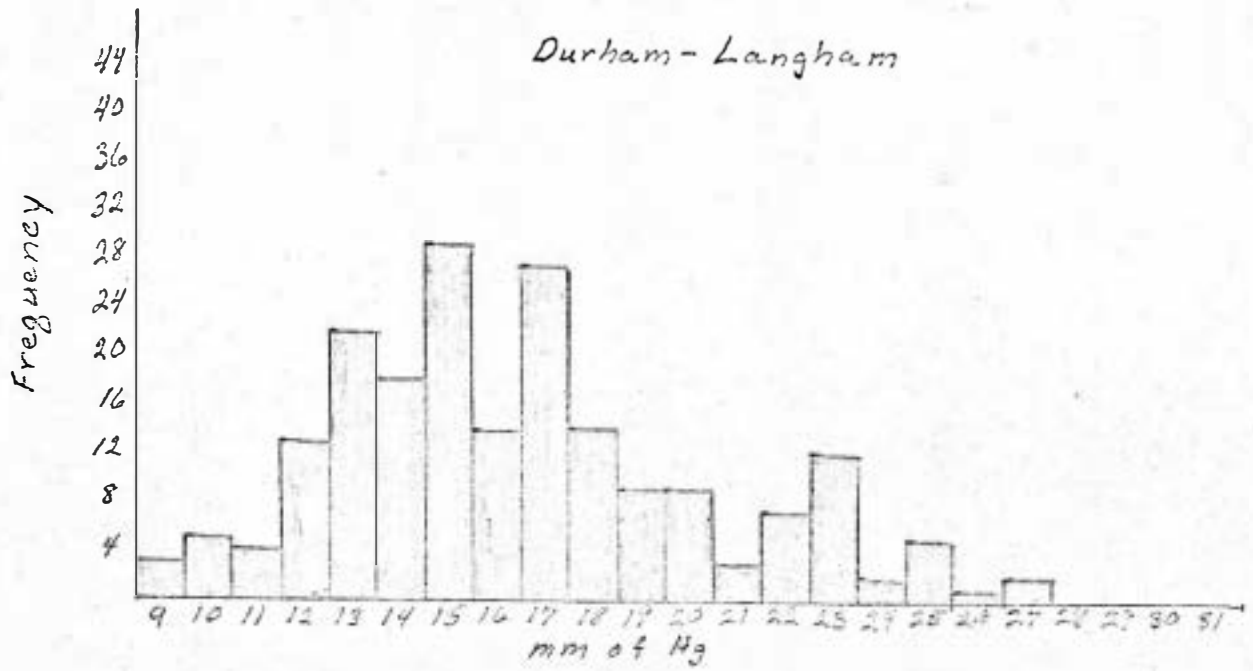
Mackay - Marg

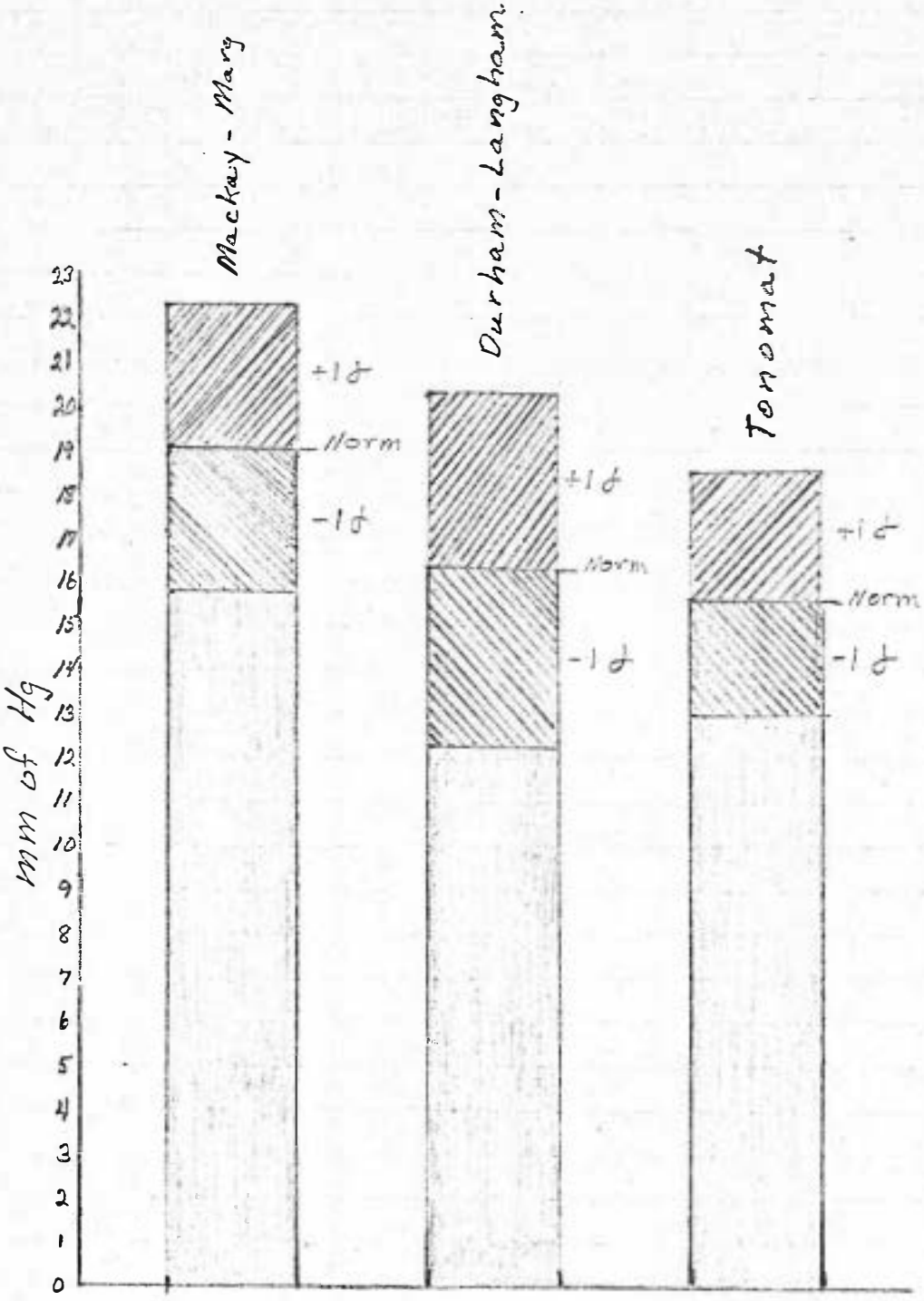


Tonomat



Durham - Langham




Mackay - Mary
Durham - Langham
Tonomah
+1σ
Norm
-1σ
mm of Hg
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

SUMMARY OF FINDINGS

MACKAY-MARG

mean = 19.08 mm of hg

standard deviation = 3.26 mm of hg

DURHAM-LANGHAM

mean = 16.51 mm of hg

standard deviation = 4.00 mm of hg

TONOMAT

mean = 15.63 mm of hg

standard deviation = 2.77 mm of hg

CORRELATIONS:

Mackay-Marg to Tonomat = .2388

Mackay-Marg to Durham-Langham = .2768

Tonomat to Durham-Langham = .5802

DISCUSSION AND CONCLUSIONS

There are few published norms for the Tonomat and the Bausch and Lomb Applamatic Tonometer.

Normal readings for the Biotronics MacKay-Marg Tonometer (Rosenthal and Werner) is up to 24mm of Hg with 24 to 28mm of Hg considered questionable and above 28mm of Hg considered abnormally high. The same authors consider a reading of 22mm of Hg as critical for the Bausch and Lomb Applamatic Tonometer.

Waggoner (1965) found the mean for the MacKay-Marg to be 21.69 mm of Hg $\pm$ 5.263.

Means derived from this study are as follows:

MacKay-Marg 19.88mm of Hg $\pm$ 3.26
Durham-Langham 16.51 mm of Hg $\pm$ 4.00
Tonomat 15.63mm of Hg $\pm$ 2.77

The correlation between the MacKay-Marg and the Tonomat is .2388, between the MacKay-Marg and the Applamatic is .2768, and between the Tonomat and the Applamatic is .5802. These correlations are all statistically significant to the .05 confidence level but the correlation between the Tonomat and the Applamatic is by far the best.

When this study began, the authors were interested in any significant difference between the two eyes which could be attributed to the technique used. Upon examination of the correlations and standard deviations between left and right eye taken on all three instruments, it was found that variables in the technique had no significant effect.

A subjective evaluation of the three tonometers is included in the following paragraphs.

The MacKay-Marg is a fast, easy to use instrument. The disposable probe tip covers offer a maximum in sterile technique. The disadvantages must include patient discomfort, repeatability of the findings and the chance of corneal abrasion.

Among the disadvantages of the Tonomat is the fact that the patient must be reclining or have his head so positioned so the probe is perpendicular to the cornea which necessitates the head being almost parallel to the floor. The Tonomat requires more time to use but is equally sterile because of the disposable plastic endplates. Very little patient discomfort was encountered.

The Applamatic Tonometer had the least amount of patient discomfort probably because the procedure was scleral and not corneal. Sterilization is accomplished by applying the tip of the probe to an alcohol pad. Care must be taken to allow the alcohol to evaporate before applying the tip to the eye. To be completely sterile, the tip should be resterilized when changing from one eye to the other. This is a time consuming procedure. The authors found some doubt about the complete sterility of the tip with the procedure suggested by the manufacturer. It is the opinion of the authors that a mechanism for sterilization of the probe tip could and should be included in the probe holder.

The tip of the probe and its membraneous covering are very delicate and great care must be taken when removing and replacing the probe in its holder.

In summary, the authors found the means of their instruments to be lower than those found in the published data. This could be a function of the age and sex of our subject population. The best correlation was found to be between the Tonomat and the Applamatic. All three instruments were found to have their individual advantages and disadvantages but none was decidedly more advantageous than the other.

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