

THESIS

TEST OF TURBO-GENERATOR SET

FOR

THE DEGREE OF BACHELOR OF SCIENCE IN

MECHANICAL AND ELECTRICAL ENGINEERING

BY

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UNDER

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## TEST OF TURBO-GENERATOR SET

The set is located in the steam laboratory of the University of Tennessee. It consists of a Terry horizontal steam turbine, direct connected on the same shaft to a 15 K.W. compound wound General Electric direct current generator. The rated capacity of the turbine is only 10 K.W., but it is provided with an overload nozzle, which will easily care for 50 % overload, and can be cut out of service when the set is operated at normal load or below.

The turbine is of the single-stage impulse type with two or more velocity stages, and operates non-condensing. The compounding of the velocity permits of much lower peripheral velocity than with the single-velocity type. The rotor, a single wheel consisting of two steel discs held together by bolts, is fitted at it's periphery with pressed-steel buckets of semi-circular cross sections. The inner surface of the casing is fitted with a series of gun-metal reversing buckets arranged in groups, each group being supplied with a separate nozzle. The accompanying advertisement shows clearly how the steam works in this type of turbine.

The governor is of the fly-ball type, mounted directly on the turbine shaft and controls a specially constructed mitre throttle valve. A maximum speed variation of two percent is guaranteed. Should the main governor spring break, the governor valve would close instantly.



## How the steam works in The Terry

The principle illustrated above, made possible the first commercially successful small steam turbine for operation at moderate speeds. By means of a cleverly arranged set of "reversing chambers" the steam issuing from the expanding nozzle, is passed repeatedly through the buckets of a single wheel until its energy is exhausted. This permits the use of a simple, practically indestructible wheel, made from a single forging, with no end thrust.

The buckets are internal and as there is radial clearance only, the blades cannot foul.

The patented "efficiency chamber," directly back of the nozzle, catches and returns to the wheel a portion of the steam which would otherwise escape without doing its full share of useful work. The Terry Turbine was invented and patented by Mr. E. C. Terry of Hartford, Conn. The validity of his patent has recently been sustained by the U. S. Circuit Court of Appeals.

**The Terry Steam Turbine Company**  
Hartford, Connecticut

DIAGRAM OF CONNECTIONS  
FOR  
COMP. WOUND REG. POLE GEN.

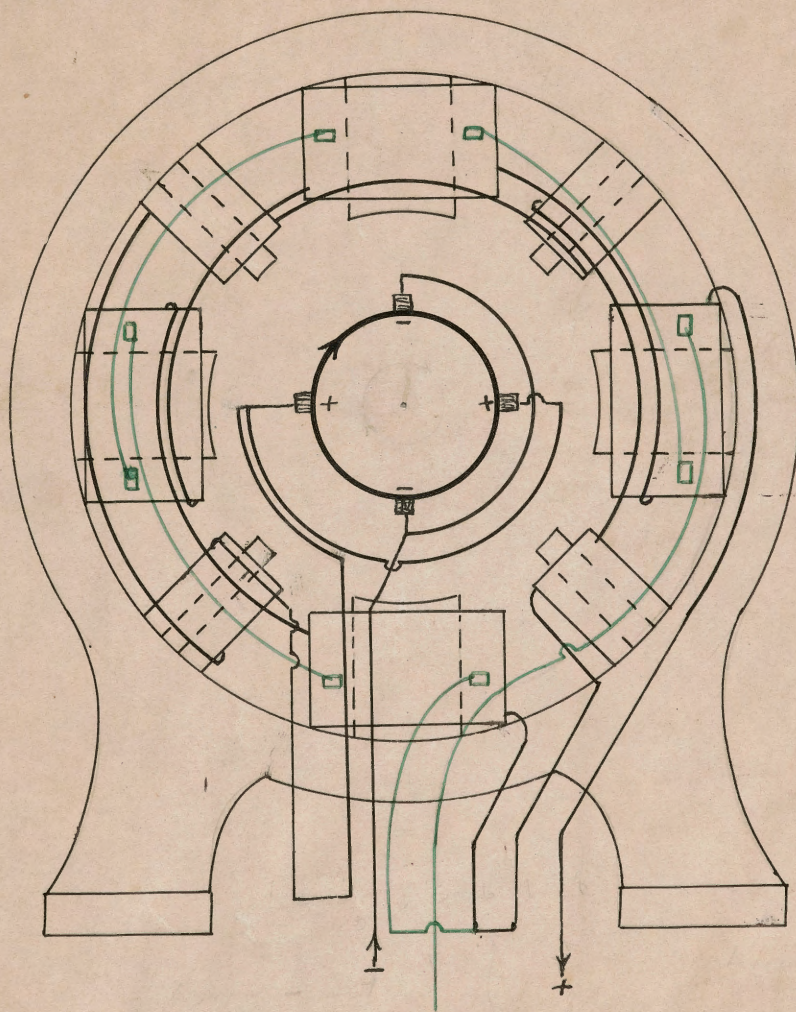


Figure No. 1

The casing and bearings are parted horizontally so that the entire turbine can be easily opened or inspected by merely lifting the cover, this being accomplished without disturbing the steam and exhaust connection. The bearings are self-lubricating, requiring only occasional filling.

The compound generator produces continuous current at 125 volts when running at it's normal speed of 3600 R.P.M. The machine is provided with interpoles, which eliminate any commutation troubles at this speed and maximum current of 120 amperes. The electrical connections are shown by the accompanying diagram, figure No. 1.

The efficiency of the generator was determined from it's losses and efficiency curve drawn.

The first half of the study of the turbine consists of five tests of one hour each with load varying from zero to 10 K.W. on the generator and with only one nozzle in service. The second half consists of eight tests of one hour each with load varying from zero to about 16 K.W., and with the two nozzles furnishing power. The generator was loaded by means of a rheostat, and the voltage and current read every five minutes.

The exhaust steam was condensed by means of a surface condenser and the net steam consumed by the turbine per hour was determined by weighing the condensate per hour.

The quality of the steam entering the turbine was determined by means of the chart given in Babcocks and Wilcox edition of "Steam", making use of the calorimeter readings and steam pressure *at* the throttle, which were also read every five minutes. The steam was taken from the boilers of the University power plant through 150 or 200 foot steam line, hence we should expect a high percent of moisture, which is the case.

The speed was obtained by means of a speed counter and found to vary less than 2% and most of the time only a little over 1%. This is a very good speed regulation.

The data and results have been tabulated conforming as near as possible to the Code of 1915 by the "American Society of Mechanical Engineers". From the results the following curves have been plotted;

Curves with output in K.W. as abscissae and total steam and pounds of steam per K.W.-hour as ordinates.

Curves showing the water rate for one nozzle and the water rate for two nozzles as ordinates and output in K.W. as abscissae.

Curve for single nozzle and also one for the two nozzles between the break horse power for each load and the pound of dry steam per break H.P. per hour.

Curves between break horse power per hour and thermal efficiency.

## CONCLUSIONS

From the curves it is readily seen that the turbine operates most economically when only one nozzle is in service, that is when the load is not too great for one nozzle. The minimum number of pounds of steam per K.W. per hour output for the whole test was 73 pounds, the output being 15.78 K.W. and the thermal efficiency 5.45 %, both nozzles in service.

For the single nozzle the minimum water rate was 84 pounds per K.W. per hour and a thermal efficiency of 4.94 %. The above water rates are high compared with the water rates of an engine of similar size, but for a turbine of this low speed the determined rates are not abnormal.

The pounds of steam per K.W. shown by The Terry Steam Company is about 55 pounds per K.W. per hour for a similar sized turbine. Hence we see that this turbine has failed to prove such results. This failure is due in part at least to the fact that the turbine was not operated under it's rated steam pressure and also on account of very poor quality of steam supplied.

There was scarcely any vibration caused by the turbine or generator. The speed regulation as stated above was excellent for such service and at this speed the bearings and the simple oiling system gave perfect satisfaction.

The curves drawn show clearly the results of the test and need no explanations or further comment.

8  
TEST OF TURBO-GENERATOR SET ( One nozzle)

Test No. 2

Date 4-18-17

| Time    | Steam pressure<br># per Sq. inch | R.P.M. |
|---------|----------------------------------|--------|
| 2-33    | 95                               | 3645   |
| 2-40    | 96                               | 3640   |
| 2-45    | 95                               | 3648   |
| 2-50    | 91                               | 3648   |
| 2-55    | 92                               | 3672   |
| 3-00    | 95                               | 3662   |
| 3-05    | 95                               | 3638   |
| 3-10    | 100                              | 3636   |
| 3-15    | 97                               | 3627   |
| 3-20    | 95                               | 3575   |
| 3-25    | 95                               | 3560   |
| 3-30    | 92                               | 3550   |
| 3-33    | 92                               | 3550   |
| -----   |                                  |        |
| Average | 94.6                             | 3616   |

Calorimeter temperature 211° F.

Net Steam per hour 246 #

Zero load

Test No. 1

Date 4-14-17

Generator disconnected

Net steam per hour 116 #

R.P.M. 3650

Calorimeter temperature 211° F.

TEST OF TURBO-GENERATOR SET

( One nozzle)

Test No. 3

Date 4-18-17

| Time    | Steam Pressure<br>( # per Sq. inch) | R.P.M. | Volts | Amperes |
|---------|-------------------------------------|--------|-------|---------|
| 4-40    | 87                                  | 3590   | 117   | 12.5    |
| 4-45    | 85                                  | 3582   | 121   | 13      |
| 4-50    | 85                                  | 3583   | 121   | 13      |
| 4-55    | 85                                  | 3560   | 121   | 12.5    |
| 5-00    | 90                                  | 3585   | 121   | 12.75   |
| 5-05    | 92                                  | 3615   | 120   | 12.5    |
| 5-10    | 98                                  | 3615   | 120   | 12.5    |
| 5-15    | 102                                 | 3624   | 120   | 12.5    |
| 5-20    | 103                                 | 3605   | 119   | 12.5    |
| 5-25-   | 102                                 | 3620   | 121   | 12.5    |
| 5-30    | 102                                 | 3600   | 121   | 12.5    |
| 5-35    | 100                                 | 3617   | 120   | 12.5    |
| 5-40    | 99                                  | 3615   | 120   | 12.5    |
| Average | 94.6                                | 3600   | 120   | 12.6    |

Calorimeter Temperature 211° F.

Net Steam per hour 319 #

TEST OF TURBO-GENERATOR SET

( One nozzle)

Test No. 4

Date 4-18-17.

| Time    | Steam Pressure<br>( # per Sq. Inch) | R.P.M. | Volts | Amperes |
|---------|-------------------------------------|--------|-------|---------|
| 5-45    | 96                                  | 3605   | 123   | 30      |
| 5-50    | 94                                  | 3573   | 123   | 29      |
| 5-55    | 92                                  | 3590   | 123.5 | 28.5    |
| 6-00    | 87                                  | 3600   | 122   | 28.5    |
| 6-05    | 83                                  | 3583   | 122   | 29      |
| 6-10    | 81                                  | 3580   | 122   | 29      |
| 6-15    | 77                                  | 3605   | 122   | 29      |
| 6-20    | 72                                  | 3575   | 121.5 | 29      |
| 6-25    | 71                                  | 3555   | 121.5 | 29      |
| 6-30    | 75                                  | 3590   | 122   | 29      |
| 6-35    | 79                                  | 3580   | 123   | 29.5    |
| 6-40    | 83                                  | 3600   | 123   | 29.5    |
| 6-45    | 84                                  | 3580   | 123   | 28.5    |
| Average | 82.6                                | 3586   | 122.4 | 29      |

Calorimeter Temperature 211 F.

Net Steam per hour 481 #

TEST OF TURBO-GENERATOR SET

( One nozzle)

Test No. 5

Date 4-21-17

| Time    | Steam Pressure<br>(# per Sq. Inch) | R.P.M. | Volts | Amperes |
|---------|------------------------------------|--------|-------|---------|
| 10-23   | 103                                | 3570   | 118   | 50      |
| 10-30   | 101                                | 3470   | 119   | 48      |
| 10-35   | 97                                 | 3420   | 116.5 | 48      |
| 10-40   | 92                                 | 3540   | 120   | 54      |
| 10-45   | 92                                 | 3550   | 120   | 52      |
| 10-50   | 92                                 | 3490   | 120   | 52      |
| 10-55   | 92                                 | 3553   | 120   | 52      |
| 11-00   | 89                                 | 3650   | 119   | 52      |
| 11-05   | 86                                 | 3620   | 119   | 51      |
| 11-10   | 82                                 | 3485   | 119   | 53      |
| 11-15   | 80                                 | 3572   | 118   | 50      |
| 11-20   | 86                                 | 3530   | 119   | 49.5    |
| 11-23   | 92                                 | 3630   | 119   | 52      |
| Average | 91                                 | 3544   | 117.4 | 51      |

Calorimeter Temperature 211° F.

Net Steam per hour 555 #

## TEST OF TURBO-GENERATOR SET

( One nozzle)

Test No. 6

Date 4-21-17

| Time    | Steam Pressure<br>( # per Sq. Inch) | R.P.M. | Volts | Amperes |
|---------|-------------------------------------|--------|-------|---------|
| 11-30   | 86                                  | 3533   | 123   | 68.5    |
| 11-35   | 81                                  | 3464   | 122   | 68      |
| 11-40   | 85                                  | 3552   | 125   | 69      |
| 11-45   | 87                                  | 3528   | 123   | 69      |
| 11-50   | 87                                  | 3605   | 124   | 70      |
| 11-55   | 88                                  | 3567   | 124   | 67      |
| 12-00   | 87                                  | 3540   | 122   | 70      |
| 12-05   | 84                                  | 3630   | 124   | 71      |
| 12-10   | 84                                  | 3555   | 122   | 69      |
| 12-15   | 81                                  | 3553   | 124.5 | 66      |
| 12-20   | 78                                  | 3505   | 121   | 70      |
| 12-25   | 76                                  | 3510   | 120   | 68      |
| 12-30   | 74                                  | 3490   | 119   | 69      |
| Average | 83                                  | 3517   | 122.6 | 68.6    |

Caldmeter Temperature 211° F.

Net Steam per hour 728 #

## TEST OF TURBO-GENERATOR SET ( Two nozzles)

Test No. 7

Date 4-21-17

| Time    | Steam Pressure<br>( # per Sq. Inch) | R.P.M. | Volts | Amperes |
|---------|-------------------------------------|--------|-------|---------|
| 12-40   | 67                                  | 3418   | 124   | 82      |
| 12-45   | 64                                  | 3467   | 123   | 80      |
| 12-50   | 61                                  | 3368   | 122   | 81      |
| 12-55   | 59                                  | 3494   | 121   | 82      |
| 1-00    | 58                                  | 3450   | 121   | 82      |
| 1-05    | 62                                  | 3540   | 122   | 75      |
| 1-10    | 67                                  | 3650   | 123   | 81      |
| 1-15    | 64                                  | 3586   | 123   | 78      |
| 1-20    | 60                                  | 3438   | 121   | 80      |
| 1-25    | 54                                  | 3428   | 120   | 76      |
| 1-30    | 47                                  | 3392   | 119   | 74      |
| 1-35    | 45                                  | 3000   | 103   | 74      |
| Average | 59                                  | 3436   | 120.2 | 78.8    |

Calorimeter Temperature 211 F.

55 minutes run, net steam 909 #

Net Steam per hour 1090 #

## TEST OF TURBO-GENERATOR SET

(Two nozzles)

Test No. 8

Date 4-28-17

| Time    | Steam Pressure<br>(# per Sq. In.) | R.P.M. |
|---------|-----------------------------------|--------|
| IO-33   | 73                                | 3567   |
| IO-38   | 75                                | 3600   |
| IO-43   | 76                                | 3600   |
| IO-48   | 77                                | 3570   |
| IO-53   | 78                                | 3563   |
| IO-58   | 80                                | 3563   |
| II-03   | 82                                | 3572   |
| II-08   | 86                                | 3555   |
| II-13   | 84                                | 3580   |
| II-18   | 80                                | 3564   |
| II-23   | 81                                | 3550   |
| II-28   | 82                                | 3552   |
| II-33   | 86                                | 3580   |
| Average | 80                                | 3575   |

Calorimeter Temperature 211°F.

Net Steam 365#

No Load.

## TEST OF TURBO-GENERATOR SET.

(Two nozzles)

Test No. 9

Date 4-28-17

| Time  | Steam Pressure<br>(# per Sq.In.) | R.P.M. | Volts | Amperes |
|-------|----------------------------------|--------|-------|---------|
| 11-40 | 86                               | 3557   | 128   | 12.5    |
| 11-45 | 86                               | 3550   | 127   | 12.6    |
| 11-50 | 87                               | 3540   | 127   | 12.4    |
| 11-55 | 85                               | 3548   | 126   | 12.3    |
| 12-00 | 80                               | 3535   | 125   | 12.2    |
| 12-05 | 79                               | 3500   | 124   | 12.2    |
| 12-10 | 74                               | 3535   | 123   | 12.2    |
| 12-15 | 77                               | 3570   | 124   | 12.3    |
| 12-20 | 80                               | 3550   | 123   | 12.2    |
| 12-25 | 80                               | 3530   | 123   | 12.2    |
| 12-30 | 77                               | 3550   | 122   | 12.0    |
| 12-35 | 75                               | 3560   | 121.5 | 12.1    |
| 12-40 | 76                               | 3587   | 122   | 12.2    |
|       | -----                            | -----  | ----- | -----   |
|       | 80                               | 3550   | 124.5 | 12.3    |

Calorimeter Tempature 211° F/

Net Steam per hour 488 #

## TEST OF TURBO-GENERATOR SET

(Two nozzles)

Test No.10

Date 5-9-17

| Time    | Steam Pressure<br>(#per Sq.In.) | R.P.M. | Volts | Amperes |
|---------|---------------------------------|--------|-------|---------|
| 11-28   | 83                              | 3560   | 120   | 33      |
| 11-33   | 85                              | 3570   | 120   | 32      |
| 11-38   | 90                              | 3580   | 121   | 33      |
| 11-43   | 93                              | 3590   | 121   | 33      |
| 11-48   | 95                              | 3514   | 121   | 32      |
| 11-53   | 95                              | 3507   | 120   | 32      |
| 11-58   | 96                              | 3555   | 120   | 32      |
| 12-03   | 95                              | 3568   | 119   | 32      |
| 12-08   | 91                              | 3590   | 118   | 32      |
| 12-13   | 90                              | 3563   | 120   | 32      |
| 12-18   | 89                              | 3565   | 120   | 32      |
| 12-23   | 86                              | 3600   | 119   | 32      |
|         | -----                           | -----  | ----- | -----   |
| Average | 90.7                            | 3565   | 120   | 32.2    |

Calorimeter Temperature 211°F.

55 minute run, net steam 601 #

Net Steam per hour 720 #.

TEST OF TURBO-GENERATOR SET

(Two nozzles)

Test No. 11

Date 5-9-17

| Time    | Steam Pressure<br>(#per Sq.In.) | R.P.M. | Volts | Amperes |
|---------|---------------------------------|--------|-------|---------|
| 1-50    | 94                              | 3555   | 124   | 49      |
| 1-55    | 94                              | 3550   | 124   | 48      |
| 2-00    | 94                              | 3580   | 123   | 48      |
| 2-05    | 94                              | 3550   | 123   | 48      |
| 2-10    | 92                              | 3545   | 122   | 48      |
| 2-15    | 88                              | 3570   | 121   | 47      |
| 2-20    | 88                              | 3550   | 124   | 48      |
| 2-25    | 90                              | 3540   | 123   | 48      |
| 2-30    | 88                              | 3570   | 123   | 48      |
| 2-35    | 87                              | 3545   | 123   | 48      |
| 2-40    | 82                              | 3560   | 122   | 47      |
| 2-45    | 80                              | 3560   | 122   | 47.5    |
| 2-50    | 80                              | 3560   | 124   | 48      |
| -----   |                                 |        |       |         |
| Average | 88.6                            | 3555   | 123   | 47.8    |

Calorimeter Temperature 211°F

Net Steam per hour 787 #.

TEST OF TURBO-GENERATOR SET

(Two nozzles)

Test No. ~~42~~ 42

Date 5-9-17

| Time    | Steam Pressure<br>(# per Sq/In.) | R.P.M. | Volts | Amperes |
|---------|----------------------------------|--------|-------|---------|
| 3-00    | 82                               | 3555   | 131   | 70      |
| 3-05    | 86                               | 3570   | 130   | 70      |
| 3-10    | 86                               | 3580   | 130   | 70      |
| 3-15    | 83                               | 3550   | 129   | 70      |
| 3-20    | 79                               | 3555   | 128.  | 69.5    |
| 3-25    | 78                               | 3580   | 127   | 69.5    |
| 3-30    | 78                               | 3580   | 127   | 69.5    |
| 3-35    | 77                               | 3550   | 128   | 69.5    |
| 3-40    | 76                               | 3540   | 127   | 69      |
| 3-45    | 75                               | 3540   | 126.5 | 69      |
| 3-50    | 73                               | 3520   | 126   | 69      |
| 3-55    | 78                               | 3580   | 128   | 69.5    |
| 4-00    | 82                               | 3575   | 128   | 69.5    |
| -----   |                                  |        |       |         |
| Average | 79.5                             | 3565   | 128.1 | 69.6    |

Calorimeter Temperature 211° F

Net Steam per hour 1016 #

TEST OF TUBO-GENERATOR SET

(Two nozzles)

Test No. 13

Date 5-9-17

| Time    | Steam Pressure<br>(# per Sq. Inch) | R.P.M. | Volts | Amperes |
|---------|------------------------------------|--------|-------|---------|
| 4-15    | 92                                 | 3560   | 138   | 104     |
| 4-20    | 97                                 | 3580   | 138   | 101     |
| 4-25    | 98                                 | 3540   | 138   | 100     |
| 4-30    | 98                                 | 3520   | 137   | 99      |
| 4-35    | 95                                 | 3480   | 136   | 99.5    |
| 4-40    | 93                                 | 3470   | 135   | 99      |
| 4-45    | 88                                 | 3500   | 134   | 99      |
| 4-50    | 88                                 | 3475   | 135   | 99      |
| 4-55    | 91                                 | 3520   | 135   | 99.5    |
| 5-00    | 90                                 | 3530   | 135   | 99.5    |
| 5-05    | 92                                 | 3550   | 135.5 | 100     |
| 5-10    | 97                                 | 3530   | 136   | 100     |
| 5-15    | 98                                 | 3550   | 136   | 100     |
| Average | 93.6                               | 3522   | 136   | 100     |

Calorimeter Temperature 211° F.

Net Steam per hour 1199#

## TEST OF TURBO-GENERATOR SET

( Two nozzles)

Test No. 14

Date 5-12-17

| Time    | Steam Pressure<br>( # per Sq. Inch ) | R.P.M. | Volts | Amperes |
|---------|--------------------------------------|--------|-------|---------|
| 2-45    | 78                                   | 3550   | 132   | 123     |
| 2-50    | 78                                   | 3500   | 132   | 120     |
| 2-55    | 78                                   | 3520   | 133   | 120.5   |
| 3-00    | 83                                   | 3460   | 133   | 119     |
| 3-05    | 85                                   | 3540   | 134   | 119.5   |
| 3-10    | 86                                   | 3535   | 133   | 119     |
| 3-15    | 87                                   | 3530   | 132   | 118     |
| 3-20    | 88                                   | 3500   | 132   | 118     |
| 3-25    | 84                                   | 3540   | 132   | 117     |
| 3-30    | 80                                   | 3535   | 131   | 117.5   |
| 3-35    | 81                                   | 3537   | 133   | 118     |
| 3-40    | 82                                   | 3570   | 134   | 119     |
| 3-45    | 84                                   | 3535   | 133   | 119     |
|         | ---                                  | ----   | ---   | ---     |
| Average | 82.7                                 | 3535   | 132.5 | 119     |

Calorimeter Temperature 211° F.

Net Steam per hour 1199#

## EFFICIENCY OF GENERATOR

No load losses equals 1370 watts ( Const.)  $R_a$  equals .0512 ohms

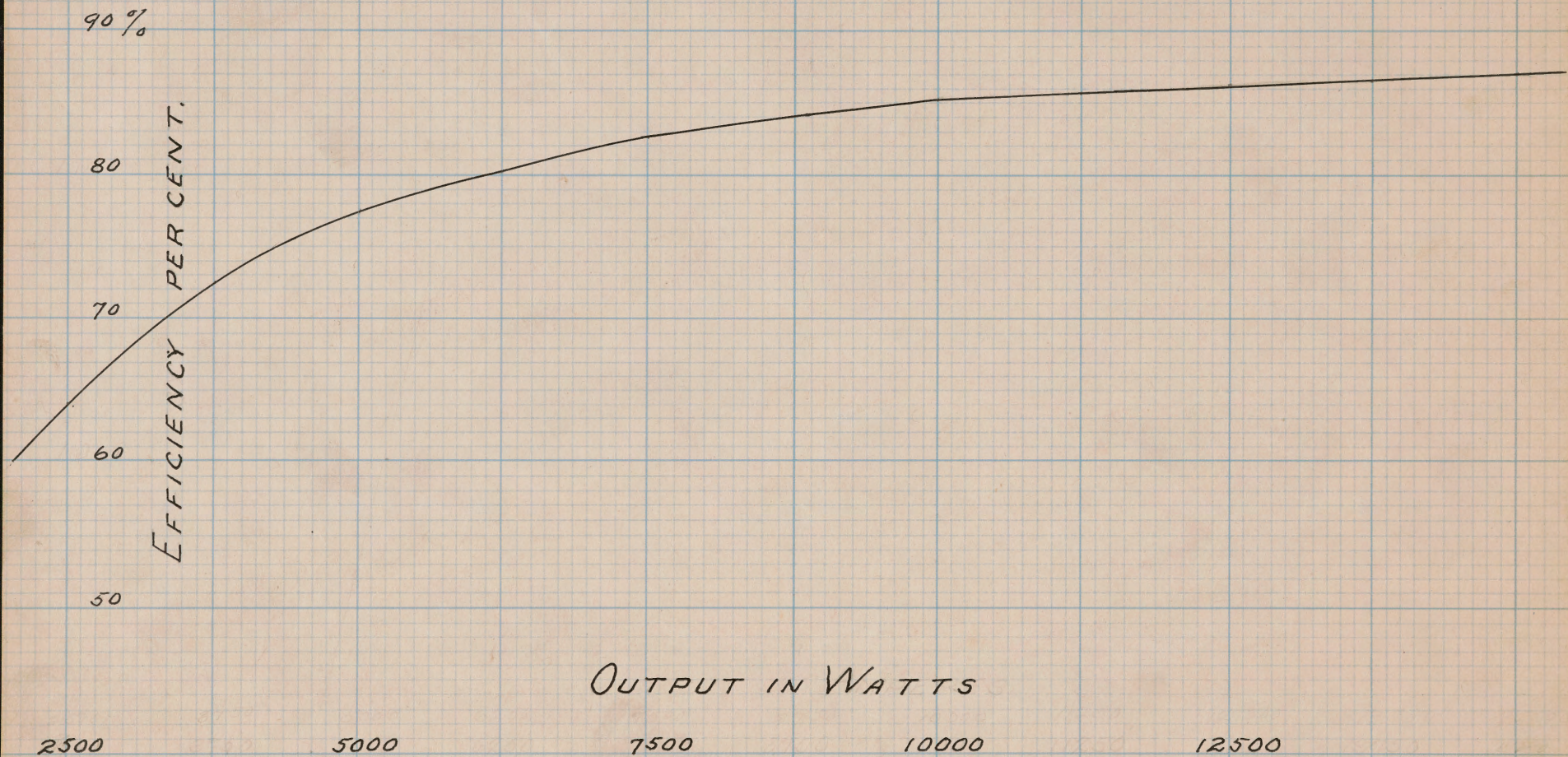
$R_f$  equals .0116 ohms.  $E$  equals 125 Volts.

| Output<br>(I) | $R_f I_f^2$ | $R_a I_a^2$ | Total<br>$R I^2$ |
|---------------|-------------|-------------|------------------|
| 10            | 1.16        | 5.12        | 6.28             |
| 20            | 4.46        | 20.48       | 25.12            |
| 30            | 10.44       | 46.01       | 56.45            |
| 40            | 18.57       | 81.8        | 100.37           |
| 50            | 29.0        | 128.0       | 157.0            |
| 60            | 41.8        | 184.1       | 225.9            |
| 70            | 56.9        | 250.9       | 307.8            |
| 80            | 74.3        | 327.9       | 402.2            |
| 90            | 94.0        | 415.0       | 509.0            |
| 100           | 116.0       | 512.0       | 628.0            |
| 110           | 134.3       | 619.5       | 753.8            |
| 120           | 159.9       | 737.0       | 896.9            |
| 130           | 187.7       | 865.0       | 1052.7           |

## EFFICIENCY OF GENERATOR (CONTINUED)

| Total Losses | Output<br>(W I) | Input<br>Watts | Eff.<br>(%) |
|--------------|-----------------|----------------|-------------|
| 1376.28      | 1250            | 2626.28        | 47.6        |
| 1395.12      | 2500            | 3895.12        | 64          |
| 1426.45      | 3750            | 5176.45        | 72.5        |
| 1470.37      | 5000            | 6470.37        | 77.3        |
| 1527.6       | 6250            | 7777.0         | 80.2        |
| 1595.9       | 7500            | 9095.9         | 82.6        |
| 1677.8       | 8750            | 10427.8        | 84          |
| 1772.2       | 10000           | 11772.2        | 85.1        |
| 1879.0       | 11250           | 13129          | 85.7        |
| 1998.0       | 12500           | 14498          | 86.2        |
| 2123.8       | 13750           | 15874          | 86.6        |
| 2266.9       | 15000           | 17267          | 87.0        |
| 2422.7       | 16250           | 18673          | 86.8        |

## EFFICIENCY OF GENERATOR



## LOG OF TURBO-GENERATOR TESTS

Date April and May 1917  
 Duration of test Fourteen one hour tests

(1) Test of Terry Steam Turbine located at the University of Tennessee.

To determine the efficiency of set.

## DIMENSIONS ETC.

|                               |                                |
|-------------------------------|--------------------------------|
| (2) Type of turbine           | Impulse                        |
| (a) No. Of stages             | Single stage                   |
|                               | ( Two or more velocity stages) |
| (b) Non-condensing            |                                |
| (c) Diameter of rotor         | Twelve inches                  |
| (d) Type of governor          | Spring fly-ball                |
| (3) Class of service          | Electric power                 |
| (5) Rated capacity of turbine | 10K.W.                         |
| (a) Name of builder           | Terry Steam Turbine Company    |
| (b) Normal speed              | 3600 R.P.M.                    |
| (6) Capacity of generator     | 15 K.W.                        |
| (a) Name of builder           | General Electric Co.           |
| (b) Normal speed              | 3600 R.P.M.                    |
| (c) Volts at full load        | 125                            |
| (d) Amperes at full load      | 120                            |

# LOG OF TERRY STEAM TURBINE

(One nozzle )

| Date    | Test No. | Time   | Cal. Temp. |
|---------|----------|--------|------------|
| 4-14-17 | 1        | 1 hour | 211° F     |
| 4-18-17 | 2        | "      | "          |
| 4-18-17 | 3        | "      | "          |
| 4-18-17 | 4        | "      | "          |
| 4-21-17 | 5        | "      | "          |
| 4-21-17 | 6        | "      | "          |

(Two nozzles)

|         |    |   |   |
|---------|----|---|---|
| 4-21-17 | 7  | " | " |
| 4-28-17 | 8  | " | " |
| 4-28-17 | 9  | " | " |
| 5-9-17  | 10 | " | " |
| 5-9-17  | 11 | " | " |
| 5-9-17  | 12 | " | " |
| 5-9-17  | 13 | " | " |
| 5-12-17 | 14 | " | " |

## LOG OF TERRY STEAM TURBINE TEST (CONTINUED)

(One nozzle)

| Test No. | Output<br>(Watts)      | Quality of steam | Dry steam<br>(per hour (#) |
|----------|------------------------|------------------|----------------------------|
| 1        | Generator disconnected | 95.9             | 111                        |
| 2        | Generator connected    | 95.6             | 235                        |
| 3        | 1512                   | 95.6             | 305                        |
| 4        | 3555                   | 96               | 462                        |
| 5        | 5990                   | 95.7             | 532                        |
| 6        | 8430                   | 95.85            | 697                        |

( Two nozzles)

|    |                  |       |      |
|----|------------------|-------|------|
| 7  | 9490             | 96.5  | 1051 |
| 8  | (Generator only) | 96    | 350  |
| 9  | 1535             | 96    | 468  |
| 10 | 3880             | 95.75 | 688  |
| 11 | 5880             | 95.7  | 754  |
| 12 | 8940             | 96    | 975  |
| 13 | 13600            | 95.6  | 1147 |
| 14 | 15780            | 95.85 | 1147 |

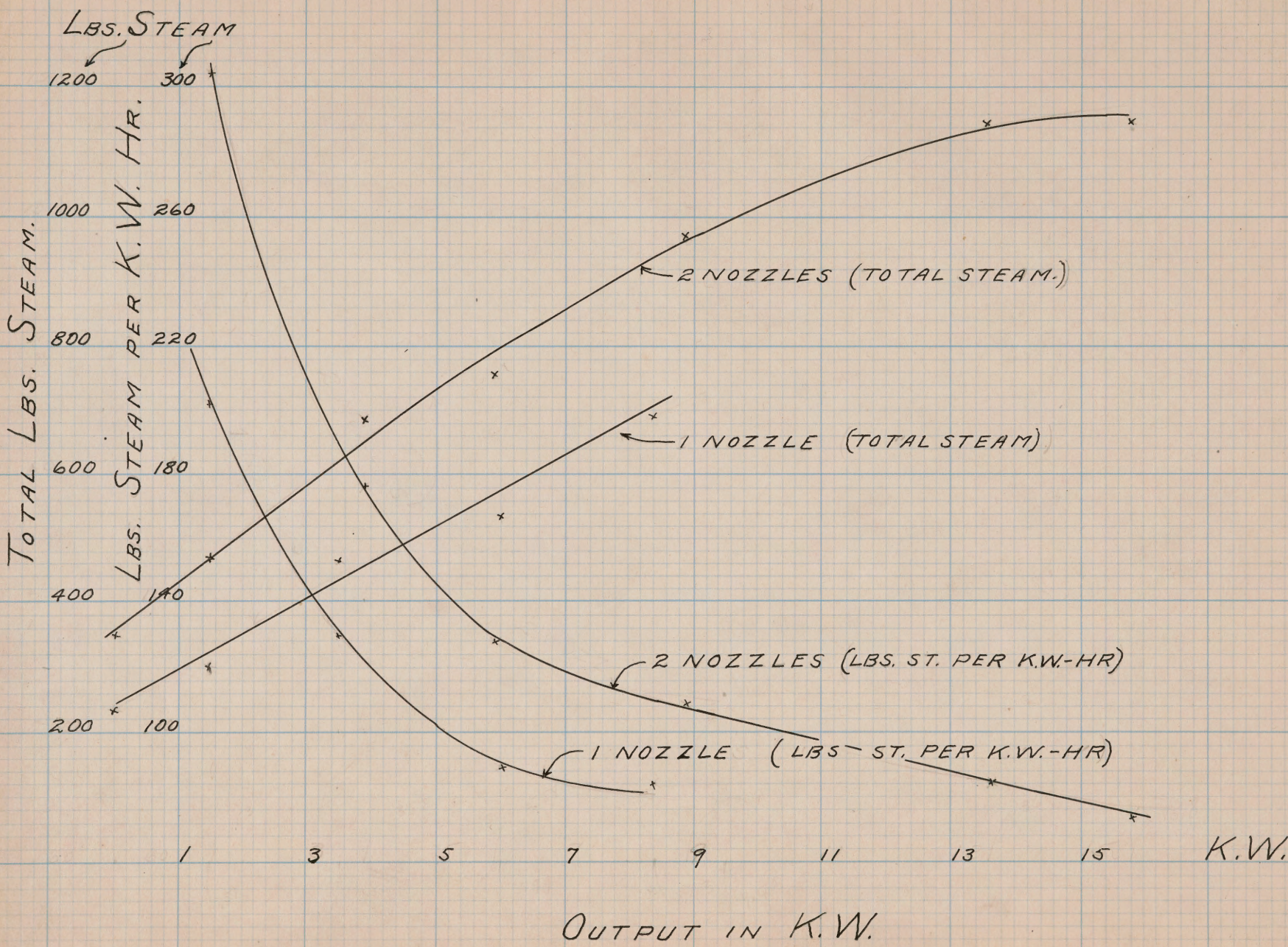
## LOG OF TERRY STEAM TURBINE TEST(CONTINUED)

( One nozzle)

| Test No. | Steam Pressure<br>(#per Sq. Inch) | R.P.M. | Weight of steam<br>(#) |
|----------|-----------------------------------|--------|------------------------|
| 1        | 85                                | 3650   | 116                    |
| 2        | 94.6                              | 3616   | 246                    |
| 3        | 94.6                              | 3600   | 319                    |
| 4        | 82.6                              | 3586   | 481                    |
| 5        | 91                                | 3544   | 555                    |
| 6        | 83                                | 3517   | 728                    |

(Two nozzles)

|    |      |      |      |
|----|------|------|------|
| 7  | 59   | 3436 | 1090 |
| 8  | 80   | 3575 | 365  |
| 9  | 80   | 3550 | 488  |
| 10 | 90.7 | 3565 | 720  |
| 11 | 88.6 | 3555 | 787  |
| 12 | 79.5 | 3565 | 1016 |
| 13 | 93.6 | 3522 | 1199 |
| 14 | 82.7 | 3535 | 1197 |



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LOG OF TERRY STEAM TURBINE TEST(CONTINUED)  
(One nozzle)

| Test No. | B.T.U.<br>(Consumed per hour) | B.T.U.<br>(Converted into<br>work) | Efficiency<br>of<br>Generator (%) |
|----------|-------------------------------|------------------------------------|-----------------------------------|
| 1        | 110500                        | 0                                  | 0                                 |
| 2        | 234000                        | 0                                  | 0                                 |
| 3        | 304000                        | 5160                               | 56.5                              |
| 4        | 460000                        | 12110                              | 71.5                              |
| 5        | 530000                        | 20210                              | 79.7                              |
| 6        | 695000                        | 28790                              | 83.6                              |

(Two nozzles)

|    |         |       |      |
|----|---------|-------|------|
| 7  | 1045000 | 32650 | 84.8 |
| 8  | 348600  | 0     | 0    |
| 9  | 466500  | 5240  | 56.6 |
| 10 | 685000  | 13240 | 73   |
| 11 | 750100  | 20050 | 79.5 |
| 12 | 971000  | 30520 | 84.3 |
| 13 | 1140000 | 46450 | 86.6 |
| 14 | 1140000 | 53800 | 86.9 |

## ECONOMY RESULTS

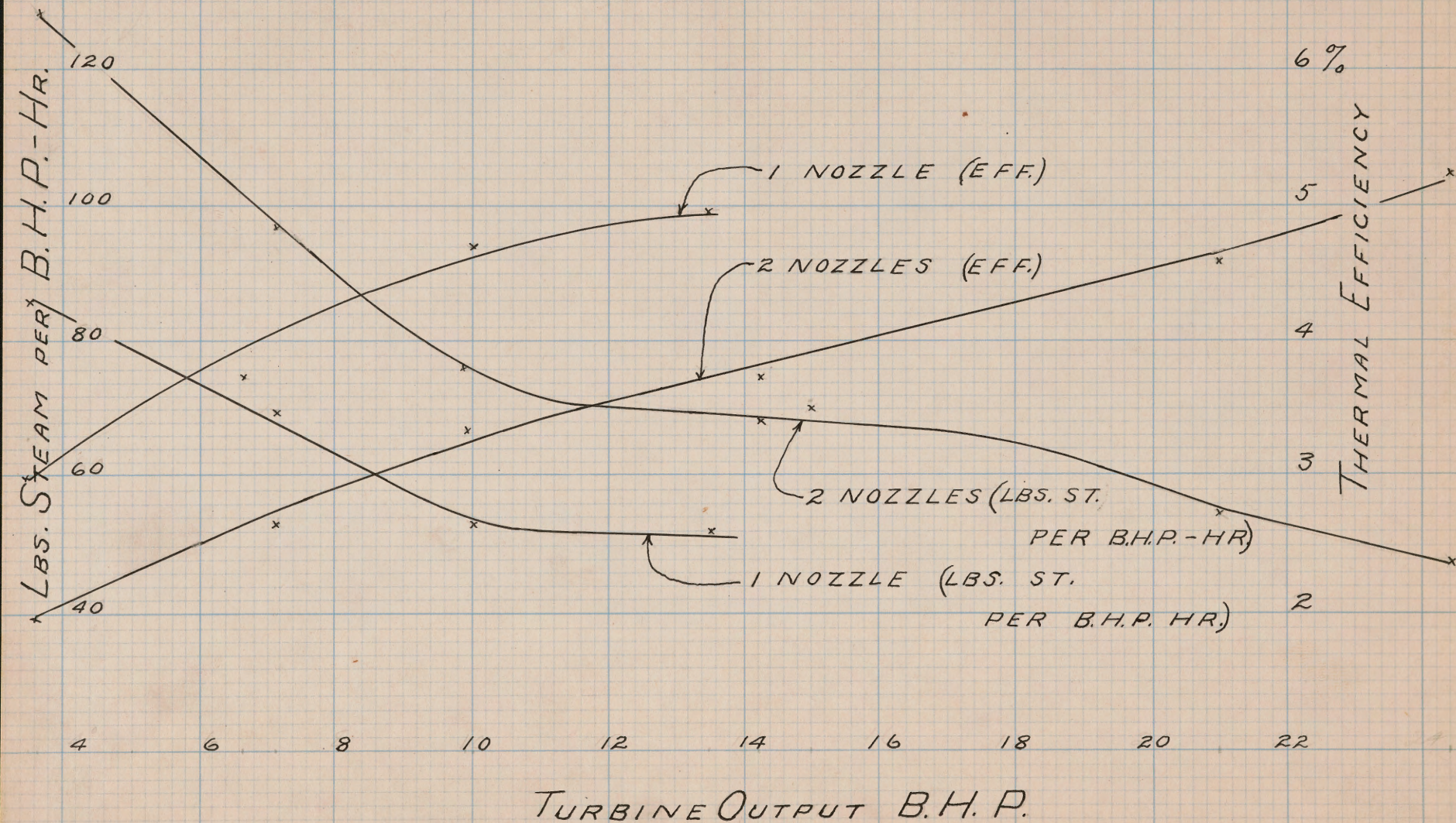
(One nozzle)

| Test No. | Output K.W. | B.H.P.of<br>Turbine | # steam per<br>K.W.hour |
|----------|-------------|---------------------|-------------------------|
| 1        | 0           | 0                   | 0                       |
| 2        | 0           | 0                   | 0                       |
| 3        | 1.51        | 3.57                | 202                     |
| 4        | 3.55        | 6.63                | 130                     |
| 5        | 5.99        | 10.61               | 89                      |
| 6        | 8.43        | 13.49               | 84                      |
| 7        |             |                     |                         |

( Two nozzles)

|    |       |       |     |
|----|-------|-------|-----|
| 7  | 9.49  | 14.98 | 111 |
| 8  | 0     | 0     | 0   |
| 9  | 1.53  | 3.64  | 305 |
| 10 | 3.88  | 7.12  | 177 |
| 11 | 5.88  | 9.90  | 128 |
| 12 | 8.94  | 14.20 | 109 |
| 13 | 13.60 | 20.97 | 84  |
| 14 | 15.78 | 24.40 | 73  |

140 LBS. STEAM



ECONOMY RESULTS (CONTINUED)  
(One nozzle)

| Test No. | # Steam per<br>B.H.P. hour | B.T.U. per<br>K.W. hour | B.T.U. per<br>B.H.P. hour |
|----------|----------------------------|-------------------------|---------------------------|
| 1        | 0                          | 0                       | 0                         |
| 2        | 0                          | 0                       | 0                         |
| 3        | 85.5                       | 200900                  | 85150                     |
| 4        | 69.7                       | 129350                  | 68400                     |
| 5        | 53.2                       | 88450                   | 53000                     |
| 6        | 51.8                       | 82500                   | 51600                     |

( Two nozzles)

|    |       |         |        |
|----|-------|---------|--------|
| 7  | 70.2  | 110200  | 69900  |
| 8  | 0     | 0       | 0      |
| 9  | 128.6 | 303500  | 128000 |
| 10 | 96.6  | 1766400 | 96200  |
| 11 | 76.2  | 127700  | 75800  |
| 12 | 68.6  | 108400  | 68400  |
| 13 | 54.7  | 83850   | 54500  |
| 14 | 47.0  | 72400   | 46800  |

## ECONOMY RESULTS (CONTINUED)

(One nozzle)

| Test No. | Thermal eff.<br>(%) | B.T.U per<br>B.H.P. hour | Work (Ft. #)<br>per B.T.U. |
|----------|---------------------|--------------------------|----------------------------|
| 1        | 0                   | 0                        | 0                          |
| 2        | 0                   | 0                        | 0                          |
| 3        | 2.99                | 85150                    | 23.2                       |
| 4        | 3.73                | 68400                    | 28.9                       |
| 5        | 4.71                | 53000                    | 37.4                       |
| 6        | 4.94                | 51600                    | 38.4                       |

( Two nozzles)

|    |      |        |      |
|----|------|--------|------|
| 7  | 3.54 | 69900  | 28.4 |
| 8  | 0    | 0      | 0    |
| 9  | 1.99 | 128000 | 15.5 |
| 10 | 2.65 | 96200  | 20.6 |
| 11 | 3.36 | 75800  | 26.2 |
| 12 | 3.73 | 68400  | 29.0 |
| 13 | 4.68 | 54500  | 36.4 |
| 14 | 5.45 | 46800  | 42.3 |