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Introduction.

Several recent articles on the effective protection provided by a tariff system have reached quite different conclusions about the possible occurrence of something called "negative value added."[1] In the pure theory of international trade, the rate of effective protection measures the percentage change of value added in an industry as the economy moves from a free trade to a protected trade equilibrium and thus gives some indication of the direction in which factors would be expected to move, provided, of course, that a number of assumptions about the mobility of factors, the non-redundancy of tariffs and so on are satisfied. But much of the recent literature on effective protection has concerned itself with the actual calculation of effective rates of protection in the developed and developing countries. This reverses the perspective entirely since all economies today operate in protected markets and accordingly,

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1. For those favorably disposed see: Soligo, R. and Stern, J., "Tariff Protection, Import Substitution and Investment Efficiency," Pakistan Development Review, Vol. V, No. 2., Summer, 1965, and Lewis, S.R. Jr., and Guisinger, S., "Measuring Protection in a Developing Country: The Case of Pakistan," Journal of Political Economy, forthcoming. For those not favorably disposed, see Basevi, G., "The United States Tariff Structure: Estimates of Effective Rates of Protection of United States Industries and Industrial Labor," The Review of Economics and Statistics, Vol. XLVIII, No. 2, May 1966, and Ellsworth, P.T., "Import Substitution in Pakistan--Some Comments," Pakistan Development Review, Vol. VI, Autumn 1966, No. 3.

the rates of effective protection are used to describe the way in which tariff protection has affected past and current patterns of production. The actual calculation of rates of effective protection under these conditions obviously raises serious problems since so few, if any, countries can look back on an era of free trade equilibrium. The procedure followed in most empirical studies has been to approximate "free trade" value added by deducting the value of inputs from the value of outputs when both are measured at observable world prices. Several authors have noticed that in a number of cases, the "world" value of inputs exceeds the "world" value of outputs, hence "negative value added at world prices." This finding has stirred up considerable debate over the validity of negative value added as a meaningful economic concept. Basevi termed results involving negative value added as "absurd"[2] while P.T. Ellsworth has stated that "a negative value added implies a degree of inefficiency that is almost unbelievable."[3] The purpose of this article is to show that negative value added is neither an "absurd" concept nor does its occasional appearance in empirical studies need to be justified by any unusual assumptions about extreme inefficiency in production or monopoly pricing. Section I presents a simple two commodity, geometric model of effective protection. It is shown that after an economy has moved from free trade equilibrium to a protected trade equilibrium, two measures of effective protection exist owing to an important difference between the two kinds of value added that can be used in the formula: the value added at world prices (hereafter VAWP)

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2. Basevi, G., op. cit., p. 151
3. Ellsworth, P.T., op. cit., p. 397

and the value added at free trade equilibrium (VAFT). Section II further extends the model of section I by demonstrating that VAWP can take on negative values while VAFT is always greater than or equal to zero. The conclusion is reached that because a negative VAWP indicates an industry that could not exist without tariff protection, studies which eliminate rates of effective protection for these industries understate the average level of protection provided by a country's tariff system. However, the measurement of effective protection for industries where VAWP is negative raises serious problems and these are discussed in section III.

I

Consider an economy with the following resource endowments and production functions:

1. $x(Lx,Kx) = x$
2. $y(Ly,Ky) = y$
3. $Lx+Ly = \overline{L}$
4. $Ly+Ky = \overline{K}$

The conventional transformation curve for x and y is depicted by TT' in diagram 1. Now, assume that in addition to direct inputs of capital and labor, production of each good requires some input of the other commodity. Jaroslav Vanek[4] has suggested a simple technique for geometrically deriving the transformation curve of final goods, X and Y, from TT' when inter-industry flows exist. Vanek's two transformation curves of total output and final goods can then be used to depict rates of effective

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4. Vanek, J., "Variable Factor Proportions and Inter-Industry Flows in the Theory of International Trade," Quarterly Journal of Economics, February 1963, pp. 129-142.

protection after an adjustment is made in Vanek's original presentation, which is now summarized (for Vanek's own presentation see pp. 132-135).

Let the conditions of production for an economy be defined as follows:

5. $x(Lx,Kx) - a_1 \cdot y(Ly,Ky) = X$

6. $y(Ly,Ky) - a_2 \cdot x(Lx,Kx) = Y$

7. $Lx + Ly = \bar{L}$

8. $Kx + Ky = \bar{K}$

where X and Y are final goods; L and K are labor and capital; y(L,K) and x(L,K) are production functions for x and y; and a_1, a_2 are fixed coefficients representing respectively the physical requirements of x for producing y and of y for producing x. The new transformation curve of X and Y, FF', can be derived from TT' in the following manner. Pick a point, say B, on TT'. Construct a new set of axes BH and BD originating at B. Construct lines BG and BE such that the tangents of the angles DBE and GBH equal the inter-industry coefficients a_2 and a_1. Where BE and BG intersect the ordinate and abscissa erect perpendiculars EA and GA. The point of intersection, A, is on the new transformation curve of X and Y, and the locus of all such points A is the transformation curve itself. If the terms of trade are given by NP (tangent to FF' at A), the competitive economy will settle at A. At this point, a total of OD of y and OH of x will be produced, of which DE of y and GH of x will be used as inputs and OE of y and OG of x will be available for final demand.

From his Figure I on p. 133 and his discussion, Vanek apparently concludes that there is a one-to-one mapping of points on TT' to points on FF' and vice versa. Any combination of final goods is produced by a unique combination of total outputs of x and y, while any pair of output levels

on TT' results in some combination of final goods lying on FF'. The difficulties with this argument can best be seen with the aid of diagrams 2 and 3.

Suppose for the moment that the economy is closed to foreign trade. In diagram 2, it can be shown that segments TZ and LT' (indicated by the dotted lines) are unattainable because the required inputs are not available domestically. At Z, OZ' of y and OS of x are produced. MF of y is used as inputs into x (angle Z'ZF constructed equal to angle DBE), leaving OF for final demand. The total output of x, OS, is entirely exhausted by the demands for intermediate inputs into y (angle OZS constructed equal to angle GBH). Clearly, any attempt to increase production of y beyond OZ' would both increase the intermediate demand for x and reduce the total amount of x produced -- an impossible situation given that imports of x are not permitted.

By allowing trade in x and y to take place, which is assumed throughout Vanek's article, points on segments TZ and LT' become feasible output levels, since required inputs can be imported. But in this case, the transformation curve of final goods derived from TT' is not represented by FF'. Considering only segment TZ (a symmetrical argument will apply to LT'), the corresponding final demand curve will have these properties:
1) X will equal zero -- all domestically produced x will join imports of x as inputs into y; and 2) Y will exceed the amount of y available for final demand at Z (i.e. OF).

This final point is made clear by diagram 3 which is an enlarged version of the relevant portion of diagram 2. Consider first a situation where all domestic factors are devoted to the production of y. At point T, production of OT of y would require QO of x. If world terms of trade

equal the slope of the line IP, QO of x can be obtained on the world market for TP of y. This leaves OP of y available for final demand, either to be consumed at home or exported for more x. But it is not clear that OP represents the maximum Y obtainable when X = 0. At point W, RW' of x is required to produce OA of y. OW' is supplied by domestic production, leaving OR to be supplied from foreign production. Now, AJ' of y is used up in the domestic production of AW (equal to OW') of x. J'N of y is used to produce JJ' (equal to RO) of x. Thus RW' of x "costs" a total of AN of y, which, when subtracted from the total y produced, OA, leaves ON for final demand. Note that in this case, the net production of y corresponding to point W on the transformation curve TT' exceeds the net production corresponding to T. This is not always the case as seen by the situation displayed by the dotted lines in diagram 3. Here, the final goods are OK and OV for points T and W respectively, and OK exceeds OV in this case.

For any world terms of trade whose slope is less in absolute value than the tangent at F, the optimal level of output in the x-industry can be derived as follows.

Let the transformation curve TT' be defined by y=T(x). Whenever $a_1 \cdot y$, the intermediate demand for x, exceeds x, the total domestic output of the x-industry, the net production of y is given by:

9. $Y = y-(a_2 \cdot x)-p[(a_1 \cdot y)-x]$ where p for now

where p is world terms of trade, py/px.

To determine at what level of x, Y reaches its maximum, dY/dx is set equal to zero and solved for dy/dx. Let dy/dx equal y'.

10. $dY/dx = y'-a_2-(p \cdot a_1 \cdot y') + p = 0$

$$11.\quad y' = \frac{a_2 - p}{1 - p \cdot a_1}$$

For a given combination of p, a_1 and a_2 there is an x_o such that the slope of the transformation curve, y'_o, equals the R.H.S. of equation 11. The Y_o, corresponding to X_o, will represent a maximum, provided of course that d^2Y/dx^2 is negative:

$$12.\quad d^2Y/dx^2 = y''\left[1 - p \cdot a_1\right]$$

y'' is negative for normal, convex transformation curves. Therefore:

13. $p \cdot a_1$ must be < 1

In summary, wherever the line representing the world terms of trade is tangent to FF', the economy will produce a combination of x and y which lies on TT' between Z and L in diagram 2. Whenever the world terms of trade is smaller (in absolute value) than the slopes of the tangents to FF' at F, the attainable level of final demand, Y, lies somewhere on the y-axis above F. The exact point is determined only by solving equation 11 for X_o and Y_o, subject to the condition specified by 13. A similar argument applies at the other end of the transformation curve.

It is clear that the discontinuities in the transformation curve of final goods only become operative at "corner solutions" -- i.e. whenever there is net production of only one good. From the point of view of the pure theory of international trade, it might be argued that these are exceptional cases, but from the viewpoint of economic development theory, corner solutions are more often the rule than the exception. Infant industry arguments are widely used to justify high tariff protection for goods that would not be manufactured at all under free trade. It will be shown later that negative value added arises precisely from tariff protection in

a situation where free trade would have resulted in a "corner solution."

Given a situation where an economy has moved from a free trade equilibrium to a protected trade equilibrium -- i.e. to any position where tariffs or subsidies have distorted the price ratio facing domestic producers -- three different kinds of value added can be distinguished for each industry. For ease of exposition, these different kinds of value added will be calculated only for the x-industry, allowing the industry subscripts to be dropped. There is no loss of generality from the simplification since the same conditions obtain in the y-industry.

First, consider the economy depicted in diagram 1. Assume that the world terms of trade (equal to the domestic terms of trade) are represented by NP and the economy is in equilibrium at A. The value added in the x-industry can be calculated as follows. Construct DC parallel to NP. Since DE represents the y-inputs, measured in units of y, employed in the production of EM of x, EC measures the value of these same y-inputs but in units of x. By definition value added is the value of total output less the value of intermediate products, so that CM (i.e. EM less EC) is the value added in the x-industry. More specifically, CM represents the value added at free trade, VAFT, because the domestic and world terms of trade are identical.

Now suppose that tariffs are imposed on x, causing domestic terms of trade to shift to N'P' as shown in diagram 4. The economy will come to rest at A' where OH' of x and OD' of y are produced. OG' of x and OE' of y will be available for final demand either for consumption at home or for export at the world terms of trade, NP. Value added at domestic prices, W, can be calculated in the same way as before. E'M' is the x-value of total output while E'C' is the x-value of the y-inputs and the difference

between E'M' and E'C' is the value added in the x-industry at the new equilibrium level of output.

The recent literature on effective protection has introduced the third kind of value added -- the value added at world prices. In diagram 4, D'E' of y is used in the production of E'M' of x. If these inputs were instead sold on the world market, they could purchase E'S of x (D'S is constructed parallel to world terms of trade, NP). Subtracting the world value of the intermediate inputs from the world value of the output leaves SM' of x or the value added at world prices.

According to Corden, "The effective protective rate is the percentage increase in the value added per unit [of output] in an economic activity which is made possible by the tariff structure relative to the situation in the absence of tariffs but with the same exchange rate."[5] In terms of diagrams 1 and 4 the "situation in the absence of tariffs" is open to two interpretations. The first is the equilibrium at free trade where value added per unit of output is measured by CM/EM. The second is the equilibrium with tariff protection but where value added is measured as if there were no tariffs. Here, value added per unit of output is SM'/E'M'.

Corresponding to these two interpretations of value added per unit of output in the absence of tariffs, there are two measures of effective protection. With value added at domestic prices per unit of output equal to C'M'/E'M', the rate of effective protection for the x-industry under the first interpretation is:

$$14. \quad Z = \frac{\frac{C'M'}{E'M'} - \frac{CM}{EM}}{\frac{CM}{EM}}$$

5. Corden, W.M., "The Structure of a Tariff System and the Effective Protective Rate," Journal of Political Economy, Vol. LXXIV, No. 3, June 1966, p. 222. Italics mine.

$$15.\quad Z = \frac{C'M'}{CM} \cdot \frac{EM}{E'M'} - 1$$

The second interpretation yields another measure of effective protection:

$$16.\quad Z' = \frac{\frac{C'M'}{E'M'} - \frac{SM'}{E'M'}}{\frac{SM'}{EM'}} = \frac{C'M'}{SM'} - 1$$

It is obvious that with the proper combination of world terms of trade, tariff rate and shapes of the transformation curves of total and final output, the VAWP per unit of output, SM'/EM', might equal the VAFT per unit of output, CM/EM, in which case Z would equal Z'. But there is no certainty that this will be so, which casts some doubt on the usefulness of studies which employ rates of effective protection measured by Z' to draw conclusions about Z. Z' is a good indicator of the change in relative values of inputs to outputs due to the tariff system, but cannot measure the protection to primary factors in the same way as Z where factor allocations and output levels are allowed to adjust to truly free trade conditions.

It is this important distinction between Z and Z' that seriously limits the conclusions that one can draw about tariff-induced patterns of resource re-allocation. Corden has argued that "domestic production will shift from low to high effective-protective-rate activities."[6] This is, of course, completely true provided that effective protection is calculated by Z. But for quite obvious reasons, researchers cannot calculate Z but must use instead Z'. It is easy to see from equations 15 and 16 that Z and Z' could yield different rankings for a group of industries, and therefore give misleading indications as to the direction in which the tariff system has caused resources to move.

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6. Corden, W.M., op. cit. p. 224

Rates of effective protection calculated by Z' do serve a useful purpose by providing a convenient measure of comparative advantage. In their paper, "Effective Tariffs, the Domestic Cost of Foreign Exchange, and the Equilibrium Exchange Rate,"[7] Balassa and Schydlowsky have surveyed the conditions which must obtain for this to hold true. However, using Z' as an indicator of comparative advantage raises one serious problem. Recent empirical studies have turned up some industries where VAWP is negative -- i.e. the value of the inputs used up in the production process exceeds the value of the final output when values are figured at world prices. A negative VAWP causes Z' to become less than zero, a situation that is also found among export industries where domestic value added is depressed below VAWP by the action of the tariff system. Industries with negative VAWP are clearly much more inefficient than export industries since they require tariff protection just to exist while export industries are able to compete on world markets while being taxed by the tariff system. Consequently, some method of sorting out these two kinds of negative effective rates must be provided in order to assure a consistent ranking of industries by static comparative advantage. Finding such a measure is more difficult than it might at first appear for reasons that are given in Section III. First, however, it is necessary to show that negative value added at world prices is not an "absurd" result. This is done by way of an illustration in Section II.

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7. Balassa, B. and Schydlowsky, D., Journal of Political Economy, (forthcoming). See Section 4.

II

Suppose that world terms of trade are now represented by the line, WW' (with a slope smaller in absolute value than that of the tangent to FF' at F) as shown in diagram 5. Suppose, also, that the tariff on x has been increased so that the domestic terms of trade, N'P', are the same as in diagram 4. We can calculate the two types of effective protection as before. Domestic value added is C'M' and value added per unit, C'M'/E'M'.

It is clear from diagram 5 that if domestic terms of trade were given by WW', no x would be produced for final demand. This does not imply that no x is produced domestically. Following the argument presented in Section I, it may make economic sense to produce some x at home for inputs into y. If, however, world terms of trade are extremely favorable to the purchase of x, all factors will be engaged in the production of y with all inputs of x being purchased on world markets. In this situation VAFT in x will be zero and the effective rate will be

17. $$Z = \frac{\frac{C'M'}{E'M'} - 0}{0} \quad \text{or infinity}$$

Calculation of Z' in this situation produces a case of negative value added. D'E' of y are used in the production of E'M' of x and if sold on the world market, these inputs would be worth E'Y of x. The value of the inputs, E'Y, exceeds the total value of x produced by an amount M'Y. Thus, VAWP is equal to -M'Y and VAWP per unit, -M'Y/E'M'.

18. $$Z' = \frac{C'M'/E'M' - (-M'Y/E'M')}{-M'Y/E'M'} = \frac{C'M' + M'Y}{-M'Y}$$

Negative value added in this example required no special assumptions about monopoly pricing or an "unbelievable" degree of inefficiency,

although either may be sufficient to cause VAWP to become negative. The explanation of negative VAWP in this example rests squarely upon opportunity costs. The "corner solution" at W' in diagram 5 implies that at free trade, the domestic supply curve of net output for the x-industry lies totally above the world supply curve of x. The economy's comparative advantage is clearly in the production of y. When tariffs are imposed and resources drawn into the production of x, the appearance of a negative VAWP simply reflects the net loss in goods available for consumption because of the high opportunity cost of the factors employed in the x-industry.

III

At this point a dilemma appears. The analysis so far has established the fact that a negative VAWP is indicative of a high degree of protection provided by the tariff system. Basevi's study, which eliminated any industry having a negative VAWP, is misleading to the extent that the average level of effective protection for the economy is understated and the most highly protected industries are not even included.

Yet, there is no satisfactory way to measure effective protection when VAWP is less than zero. It can be shown that the two formulae which have been used in all studies of effective rates may give incorrect orderings of industries whenever negative VAWP is present.

Consider for a moment an abstract measure of effective protection, call it T. T is a function of W, domestic value added, and VAWP, the value added at world prices. In this case, it makes no difference whether T is a function of value added or value added per unit since both W and VAWP relate to the same total output. If for simplicity VAWP is represented by V, T can be written as $T = T(W,V)$.

T must satisfy certain logical conditions for it to measure the protective effects of a tariff system.

First, if tariffs are raised so that domestic value added is caused to increase, T should also increase--V being fixed in terms of world prices and constant technology. In mathematical terms this condition becomes,

19. $\frac{\partial T}{\partial W} > 0$

Second, if V were to increase due to a change in either technology or world prices while W was held constant by compensatory adjustments in the tariff system, T should decrease.

20. $\frac{\partial T}{\partial V} < 0$

Third, the scale of the industry should have no effect on the value of the rate of effective protection.[8]

21. $T = T(\lambda \cdot W, \lambda \cdot V)$ for any $\lambda > 0$

It can now be seen that Z' satisfies only one of these three conditions.

22. $\frac{\partial Z'}{\partial W} = \frac{1}{V}$; since V can take on both positive and negative value, $\frac{\partial Z'}{\partial W}$ is not uniformly > 0

23. $\frac{\partial Z'}{\partial V} = \frac{-W}{V^2}$

V can be equal to zero, causing $\partial Z/\partial V$ to become undefined and not uniformly < 0.

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8. Here "scale" refers to the level of value added in an industry compared with the level in other industries and not economies of scale within the industry itself. A small industry whose value added at domestic prices is double its value added at world prices is no different in terms of the rate of protection from an industry ten times as large but with the same ratio of values added.

24. $Z' = \frac{\lambda \cdot W - \lambda \cdot V}{\lambda \cdot V} = \frac{W-V}{V}$

Soligo and Stern[9] propose a new measure, U, as a way of avoiding the problems raised by negative VAWP. It is defined as $U = \frac{W-V}{W}$. The only difference is that W has replaced V in the denominator; effective protection is now the change in value added as a percent of domestic value added. As W is never negative, U can only be less than zero when W is less than V -- the "export industry" case. U thereby avoids the confusion of having two kinds of negative effective rates of protection. Nevertheless, U satisfies only two of the three conditions that a consistent measure must meet.

25. $\frac{\partial U}{\partial W} = \frac{V}{W^2}$

26. $\frac{\partial U}{\partial V} = \frac{-1}{W}$

27. $U = \frac{\lambda \cdot W - \lambda \cdot V}{\lambda \cdot W} = \frac{W-V}{W}$

$\partial U/\partial W$ is not uniformly positive, since V can assume negative values. This means that when V is negative, an increase in W actually causes U to decrease. Similarly, in a cross-section study, if two industries have an identical negative VAWP, the industry with the highest W would show the lowest effective rate of protection.

As U and Z' are currently the only alternatives for measuring effective protection, some inconsistency is introduced into empirical studies where industries are ranked by effective rates -- excepting those where negative VAWP does not appear. Corden's suggested treatment of non-traded good inputs[10] -- that the value added part of these non-traded inputs should

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9. Soligo, R. and Stern, J. op.cit. p. 255.
10. Corden, W.M. op.cit. p. 227

be joined with the value added of the user-industry--may reduce considerably the number of cases where negative VAWP will in actual practice occur. But in at least one study,[11] the application of Corden's method still left 3 of the 32 industry groups studied with a world market value of inputs exceeding the world market value of their output.

IV

Summarizing briefly the points made above:

1. It is possible to derive a transformation curve of final goods from a transformation curve of total outputs once inter-industry coefficients are specified. Vanek's technique is modified to allow for imports of intermediate inputs.

2. The two transformation curves can then be used to represent geometrically the two different effective rates of protection which result from a distinction between the value added at free trade equilibrium (VAFT) and value added measured at world prices (VAWP).

3. Negative value added at world prices may occur when protection permits domestic production of a good which would not appear at free trade equilibrium. Negative VAWP is not necessarily caused by an unusual degree of inefficiency, although it can be, but is most likely to occur where there is "over" production of goods that are uneconomical from the standpoint of opportunity costs. Note that it is not irrational for a country to choose to invest in an industry where VAWP is initially negative provided it can be shown that productivity gains will, over time, convert this cost into a net benefit and that the discounted value of the

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11. Lewis and Guisinger, op.cit. See table II

stream of benefits will exceed the original capital cost. A negative VAWP indicates that the initial cost to an economy of a particular industry is high but does not pass judgment on the wisdom of the investment as does the benefit-cost calculation.

4. Given that empirical studies must resort to using VAWP instead of VAFT in the formula for the rate of effective protection and that VAWP can assume negative values, there is no correct way to rank and compare different rates of effective protection among industries having both positive and negative VAWP's. It is shown that each of the currently used formulae fail to meet one or more of the basic requirements for a meaningful measure of effective protection. It may still be necessary to exclude, or at least set aside, those industries where VAWP is negative from studies of the overall protective effect of an economy's tariff system, but not for the reason that a negative VAWP for an industry is "absurd" but because rates of effective protection involving negative VAWP are incommensurable with those of the remaining industries.

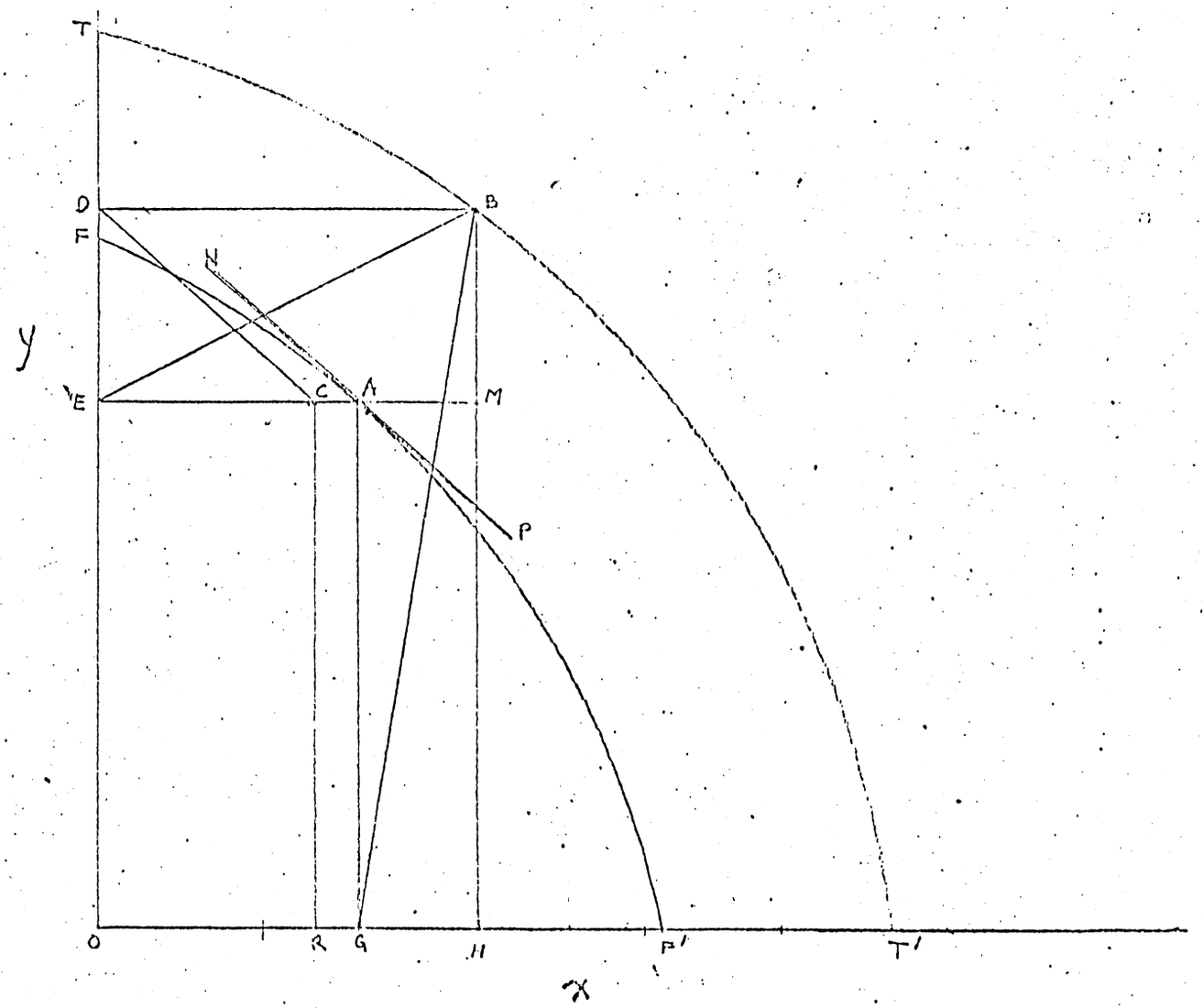

Diagram 1.

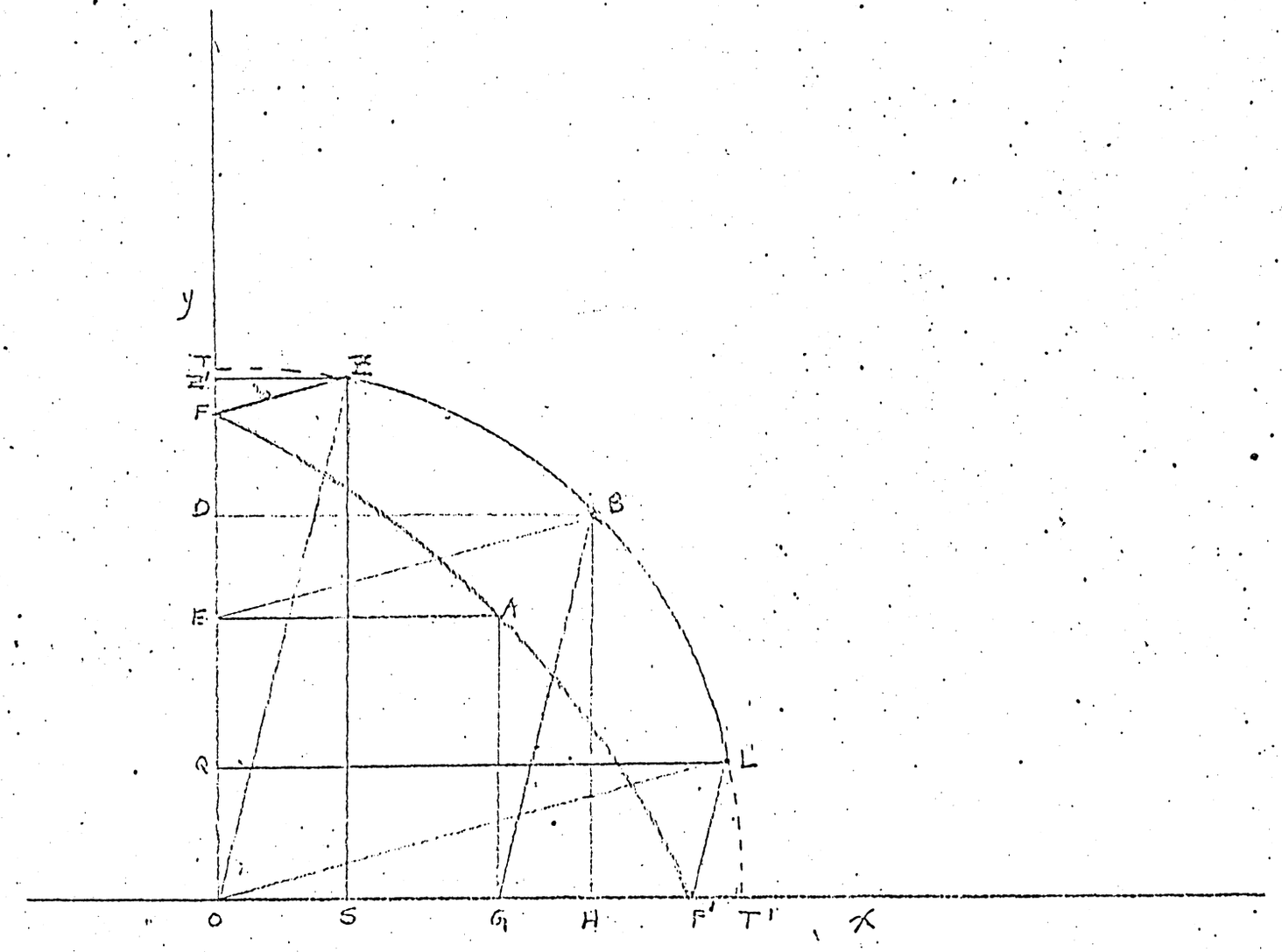

Diagram 2

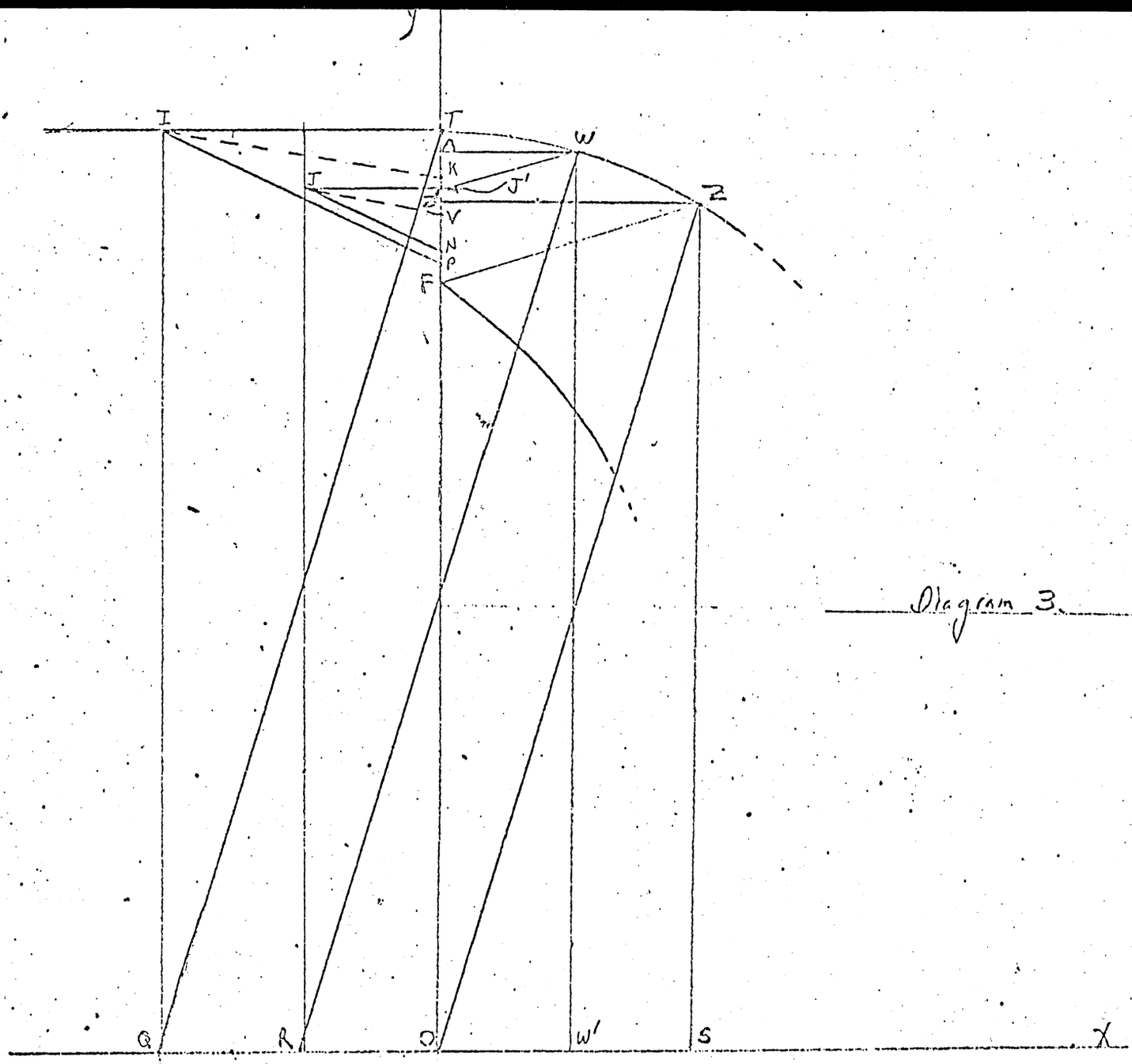

Diagram 3.

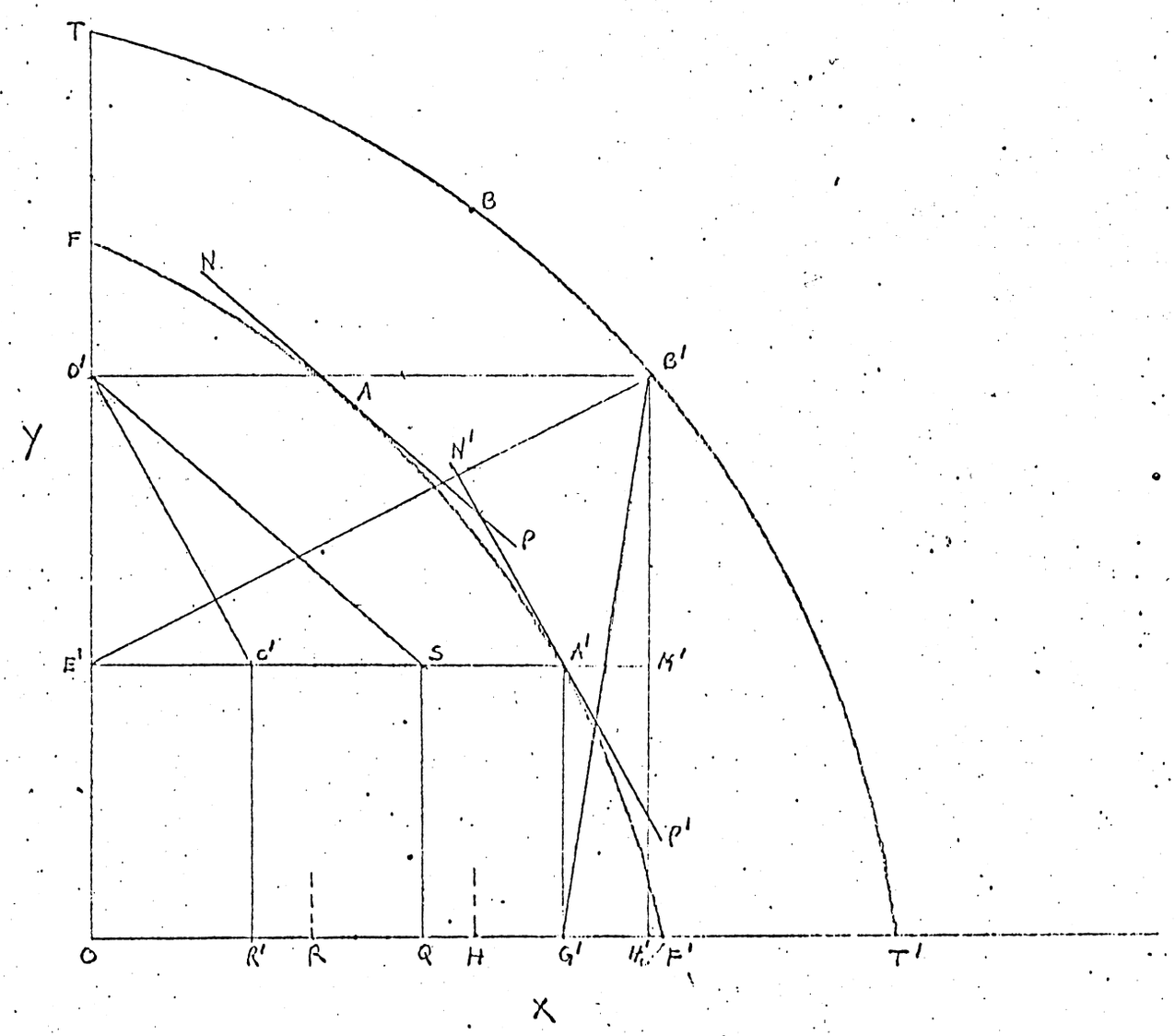

Diagram 4

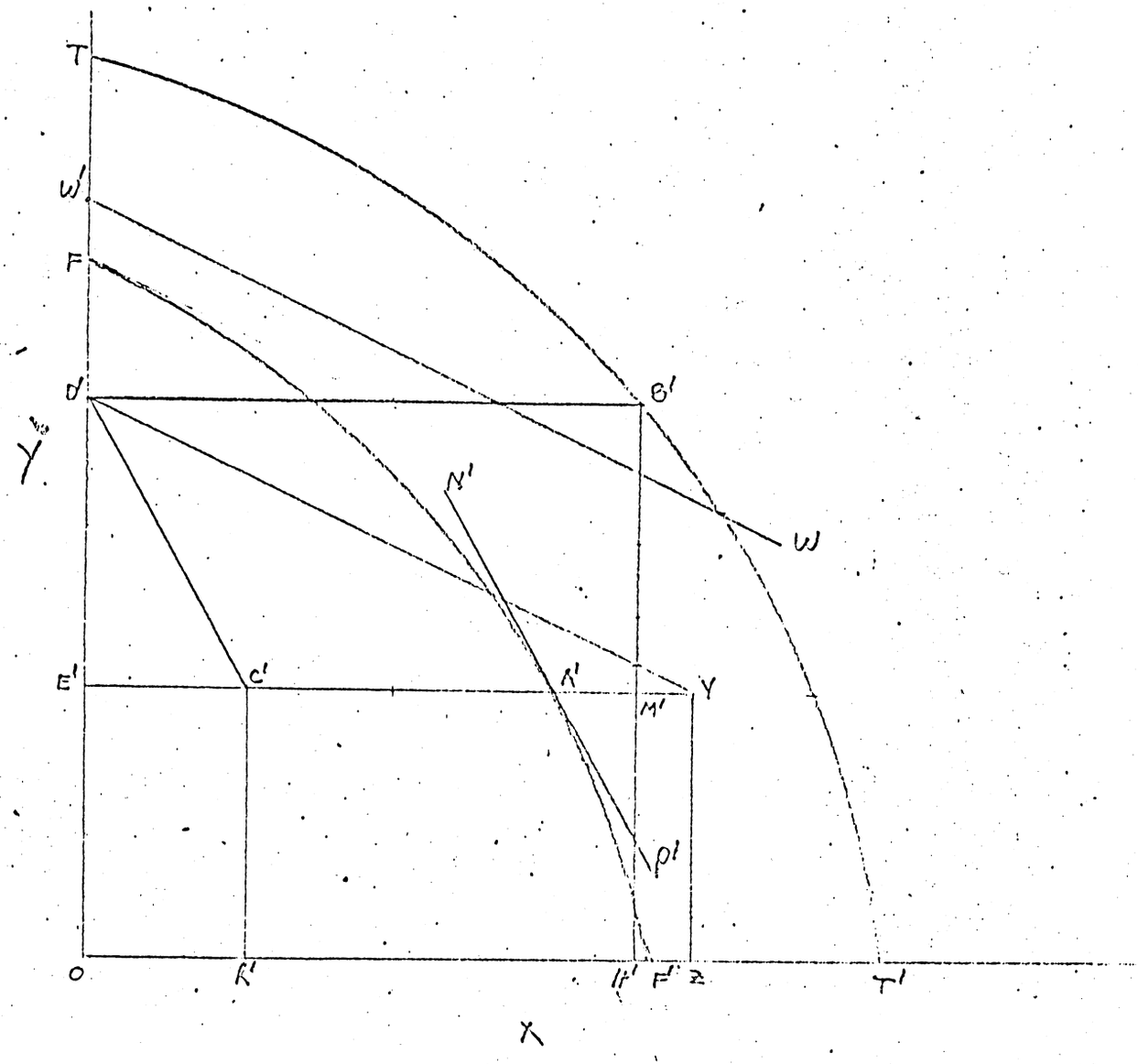

Diagram 5