THE LIMITS TO GROWTH

AND THE MESSAGE FOR SUSTAINABLE DEVELOPMENT

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This paper was presented at an interdisciplinary conference "Preparing for a Sustainable Society" which was held at the Ryerson Institute, Toronto June 21-22, 1991. It was published in the pre-conference proceedings and will appear in the official IEEE publication of the Conference Proceedings expected in 1992.

Two decades have passed since the first report to the Club of Rome. *The Limits to Growth* examined the consequences of unchecked growth and warned of global catastrophe within a hundred years if then current trends continued. This paper re-examines the report and shows that the world has generally been following the patterns of growth forecast. Yet the implicit warning about continued growth has largely been ignored in the quest for sustainable development.

Introduction

In 1968, 30 scientists, educators, economists, industrialists and government officials from 10 countries met at the *Academia di Lincei* in Rome to discuss the present and future predicament of mankind. The first project of the "Club of Rome" examined the consequences of unchecked growth. A computer model developed at Massachusetts Institute of Technology seemed to confirm what many futurologists had been saying: existing growth patterns could not be sustained for long. There were absolute physical limits which, if ignored, would lead to sudden collapse. These results were published as the book *The Limits to Growth*[1] .

The World Model

The simulation, termed the *World Model*, examined five main parameters: population, industrial capital, food, non-renewable resources and pollution. Interrelationships were defined and then quantified using global data. As an indication of its complexity, the program had nearly 300 variables and over 100 feedback loops. Nevertheless, it was a grossly simplified view of world processes. No attempt was made to model individual nations or the flows of materials between nations. The contributions of the oceans and aquaculture to food supply were ignored. Nonrenewable resources were treated as one "average" resource and there was only one class of pollution. Also, many assumptions had to be made about processes, some of which are illustrated in Figure 1.

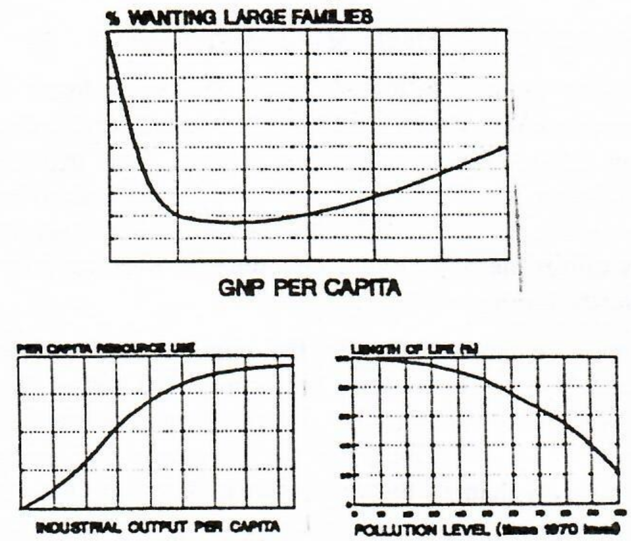

Figure 1 - Some Assumptions of the **World Model**

The *World Model* was run for the period 1900 to 2100. Its outputs were adjusted to agree with historical values up to 1970. The model was run many times for varying growth rates and resource levels and showed surprisingly consistent behaviour--one of growth and collapse.

Standard Run

The "standard run", shown in Figure 2, assumed no major changes in the physical, economic or social relationships that had operated for the previous century. In this scenario population and industrial output continue to increase exponentially. Industry grows to a level that requires enormous input of material. The resource base is rapidly depleted and prices rise sharply. More and more capital is devoted to extracting the dwindling resources and eventually depreciation outstrips investment leading to a

[1]Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, and William W. Behrens III, *The Limits of Growth*. Washington, DC: Potomac Associates, 1972.

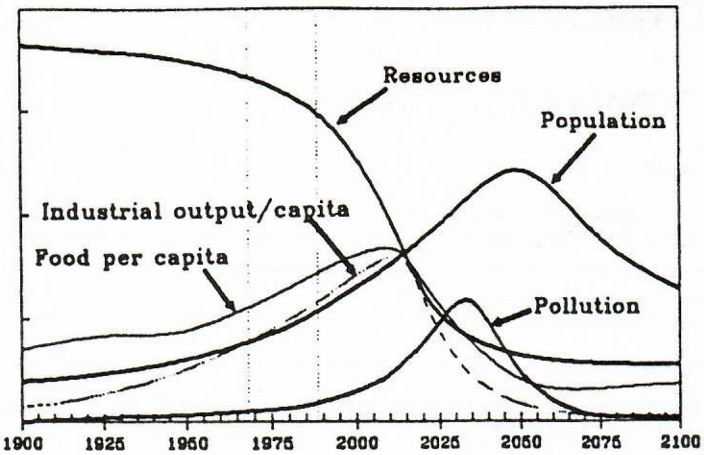

Figure 2 - **World Model *Standard Run Output***

collapse of the industrial base. The agricultural and service sectors, which are dependent on industry, collapse soon after. Food production drops. The increasing population and dwindling food supply soon lead to mass starvation. Combined with the lack of medical services, this causes the population to plummet in what can only be described as a global catastrophe.

It must be emphasized that the standard run was never intended to be an accurate prediction. The authors knew as well as anyone that type of forecasting was impossible. Their interest lay more in the overshoot and collapse mechanism than in the precise year of occurrence--their intent was to propose policy changes that would avoid the catastrophic collapse of the standard run.

Criticisms

Nevertheless, the book was widely received as a doomsday forecast and provoked considerable criticism. Much probably arose from the model's challenges to conventional economic assumptions[2]. The most detailed critique, from a group of specialists at the University of Sussex[3] was inconclusive. In retrospect, one is struck by how many of the arguments either relied on technology to overcome problems or revealed a basic distrust of computer models. Neither the criticisms nor the replies[4] shed much light on the validity of the model.

An acknowledged weakness of the model, however, was that the world was treated as a homogeneous system[5] A more complex, regionalized model was subsequently developed by Mesarovic and Pestel[6]. Although providing a better insight into the effects of policies, its limited 50-year forecast neither confirmed nor denied the conclusions of *The Limits to Growth.*

Some Comparisons

Since the validity of any model is best tested by its predictive powers, the question arises whether the standard run has provided a reasonable forecast of the growth patterns of the last 20 years. Some interesting comparisons can be made for each of the five main parameters.

Population: Figure 3 compares the population projections of the *World Model* standard run for the period 1960 to 2030 with recent UN. estimates[7]

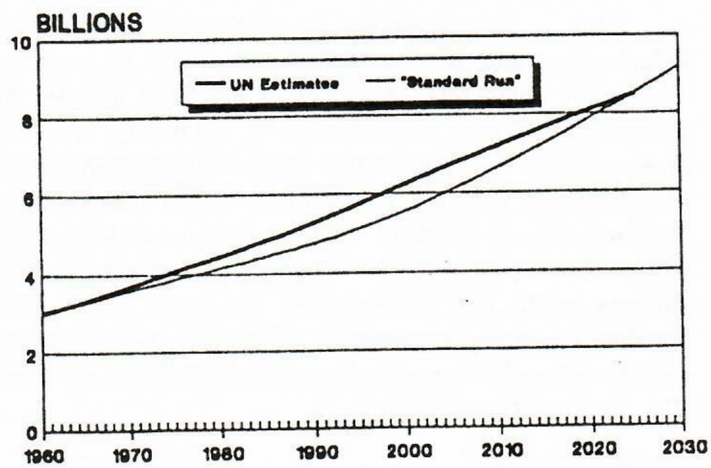

Figure 3 - World Population

[2]Eduard Pestel. *Beyond the Limits of Growth.* New York: Universe Books. 1989. p. 30

[3]H.S.D. Cole, Christopher Freeman, Marie Jahoda, K.L.R.. Pavitt, ed. *Thinking about the Future: A critique of The Limits to Growth.* London: Sussex University Press, 1973.

[4]H.S.D. Cole, Christopher Freeman, Marie Jahoda, K.L.R. Pavitt, ed. *Models of Doom: A critique of The Limits To Growth.* New York: Universe Books, 1973.

[5]Eduard Pestel, *Beyond the Limits of Growth.* New York: Universe Books, 1989. p. 28.

[6]Mihajlo Mesarovic and Eduard Pestel, *Mankind at the Turning point: The Second Report to The Club of Rome.* New York: Reader's Digest Press, 1974.

[7]UN. Department of International Economic and Social Affairs, *World Population Prospects 1990.* United Nations: New York, 1990. Table 30 (medium variant).

Over the past 20 years, the world has experienced an even greater increase in population than that predicted by the standard run.

Nonrenewable Resources: The standard run assumed 250 years reserve of all nonrenewable resources at 1970 consumption rates. The actual reserves for selected resources in 1968[8] are shown in Figure 4

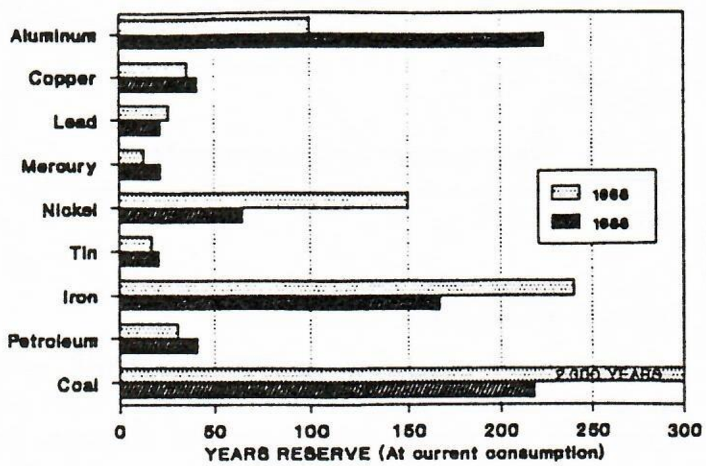

Figure 4 - Reserves of Nonrenewable Resources

They are compared with equivalent figures for 1988[9] (reserves are expressed as years of supply at current consumption rates and include only reserves that are economically extractable). Some reserves such as nickel and iron have decreased as would be expected, but some such as copper and aluminum have actually increased. It should be noted, however, that this apparent imprecision in assessing reserves is not too significant. The important parameter is the growth rate in consumption, as illustrated by Figure 5--at today's level of consumption, there are 41 year's reserve of copper, but even twice current reserves would be exhausted in 42 years given current growth rates of 3.2 percent[10]

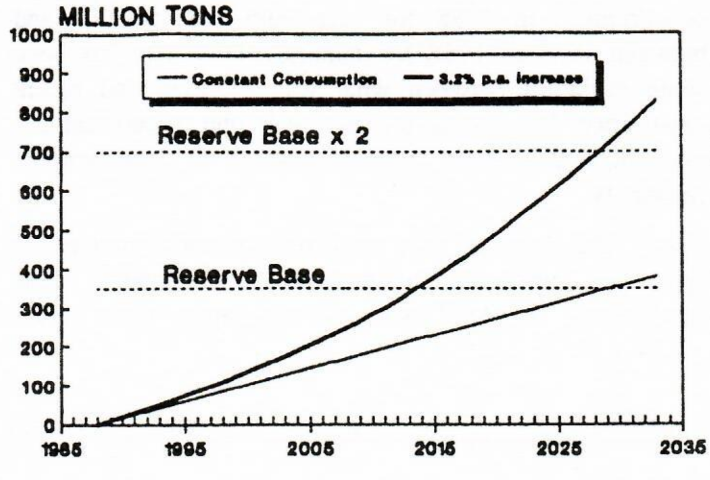

Figure 5 - Copper Consumption

Consumption growth rates are compared in Figure 6. The 1968 rates are taken from forecasts for 1968 to 2000[11] .

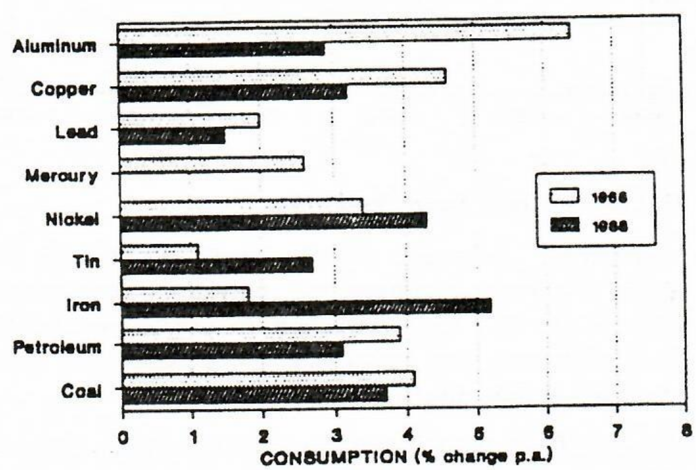

Figure 6 - Nonrenewable Resources Consumption Rates

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[8]Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, and William W. Behrens III, *The Limits of Growth.* Washington, DC: Potomac Associates, 1972, Table 4.

[9]World Resources Institute, *World Resources 1990-91.* New York: Oxford University Press, 1990, Tables 9.2 and 21.4.

[10]This is not to imply that the world will actually run out of copper in 42 years. For instance, one recent analysis (Robert B. Gordon, Tjalling C. Koopmans, Willia Nordhaus and Brian J. Skinner, *Toward a New Iron Age?: Quantitative Modeling of Resource Exhaustion.* Cambridge: Harvard University Press, 1987) predicts that copper ore bodies will not be exhausted until 2070--increased costs lead to conservation, replacement and more reserves becoming economic.

[11]Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, and William W. Behrens III, *The Limits of Growth.* Washington, DC: Potomac Associates, 1972, Table 4; US. Bureau of Mines, *Mineral Facts and Problems.* Government Printing Office: Washington DC, 1970.

The 1988 rates represent the annual growth in consumption in 1988 for petroleum and coal[12] and between 1983 to 1988 for minerals[13]. There has been some variation between what was expected and recent experience, but overall the picture is one of substantially unchanged growth in the consumption of nonrenewable resources.

Food: The standard run predicted a steady increase in food per capita in the medium term. Against these predictions, Figure 7 hows the per capita world cereal

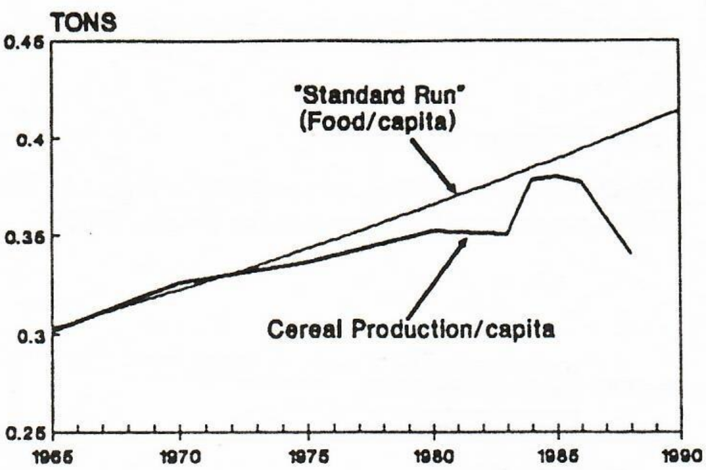

Figure 7 - World Food Production

production[14] --cereals, which supply about half of people's calorie requirements, provide a convenient indicator of world food production. As can be seen, actual food production per capita has not achieved the rates predicted, mainly due to downturn since 1985.

Industrial Production: A comparison here is more difficult given the ambiguity of data on world industrial production. However, on the assumption that industrial production is closely correlated with energy consumption[15], Figure 8 compares world energy

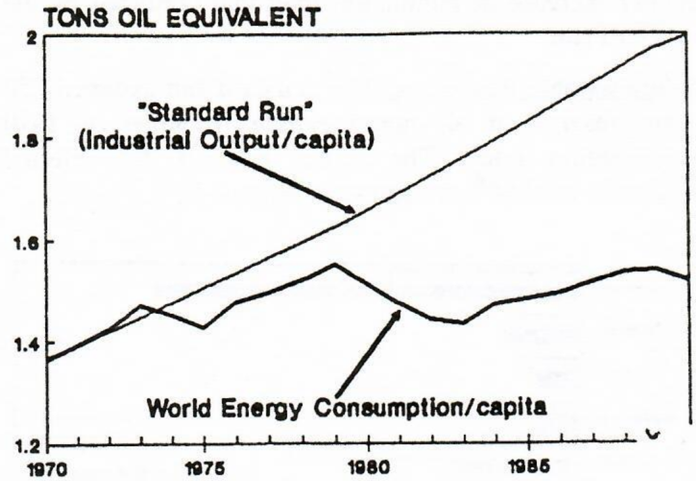

Figure 8 - World Energy Consumption

consumption per capita between 1970 and 1990[16] with the standard run rate-of-increase of industrial output per capita. The actual per capita output, as measured by energy consumption, continues to increase, but at a significantly slower rate than projected by the standard run.

Pollution: Since the pollution parameter in the World Model was a gross simplification, it is difficult to make any meaningful comparison against the outputs. It is possible, however, to examine the input data that shaped the model. One very significant, globally-distributed pollution considered was carbon dioxide. The data then available showed atmospheric carbon dioxide levels were 318 ppm by volume and were predicted to be 353 ppm by 1990 as shown in Figure 9. This prediction has been surprisingly accurate--the figure for 1990 is 355 ppm [17]

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[12]World Resources Institute, *World Resources 1990-91*. New York: Oxford University Press, 1990, p. 142.

[13]Ibid. Growth rates for minerals calculated from consumption figures in Table 21.4.

[14]Ibid. From Table 6.1

[15]The correlation of energy consumption with GNP is not at issue here. The parameter used in the standard run is Industrial Output which is defined as "the total global stream of manufactured goods" (Dennis L. Meadows, William W. Behrens III, Donella H. Meadows, Roger F. Naill, Jorgen Randers, Erich K. O. Zahn, *Dynamics of Growth in a Finite World*. Cambridge: Wright-Allen Press, Inc., 1974, page 204). It seems reasonable to assume that Industrial Output in this context is closely correlated with energy consumption.

[16]The British Petroleum Company, *BP Statistical Review of World Energy*. BP: London, July 1989 pp. 31 & 32 and June 1991 p. 33

[17]F.Soos, J.L. Sarmiento, U. Siegenthaler, "Estimates of the Effect of Southern Ocean Iron Fertilization on Atmospheric CO_2 Concentrations," *Nature*, Vol. 349, No. 6312, p. 773, Feb28, 1991.

It would be a mistake to read too much into the above indicators--they are, after all, only a sampling of today's data against a model that was not intended to provide quantitative outputs. The interesting point, however, is

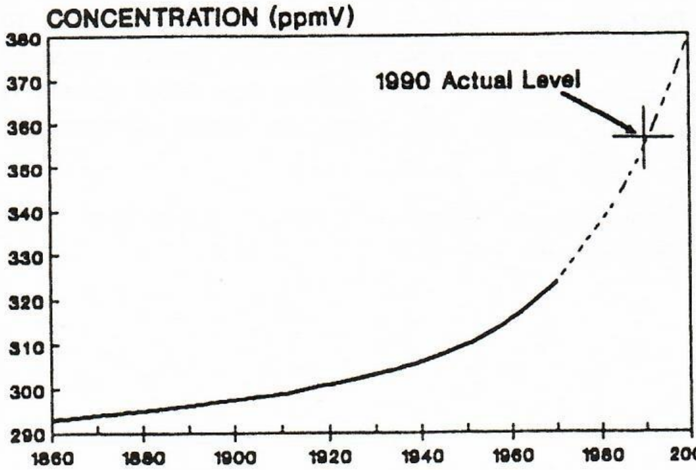

Figure 9: Atmospheric Carbon Dioxide

that the world is more or less following the growth patterns forecast by the standard run. This not only lends support to the validity of the model but also suggests that the changes necessary to avoid the catastrophic overshoot and collapse have not yet been made.

Shifts in Concerns

Have we then been ignoring the central message of *The Limits to Growth*? An answer to this question can be found in three publications: *World Conservation Strategy*[18] ; *Our Common Future*[19] , and *Caring For The World* (2nd Draft)[20]. Each represents a consensus among leading world experts and is therefore a good barometer of environmental opinion. The shifts in focus over the last two decades are summarized in Figure 10. In contrast to the broader view of *The Limits to Growth*, *World Conservation Strategy* focused on human's total dependence on the ecosystem. It pointed out that while population was rapidly increasing, the ecosystem resource was just as rapidly decreasing due to soil loss or degradation, devastation of forests, destruction of aquatic habitats, pollution and loss of genetic diversity. In

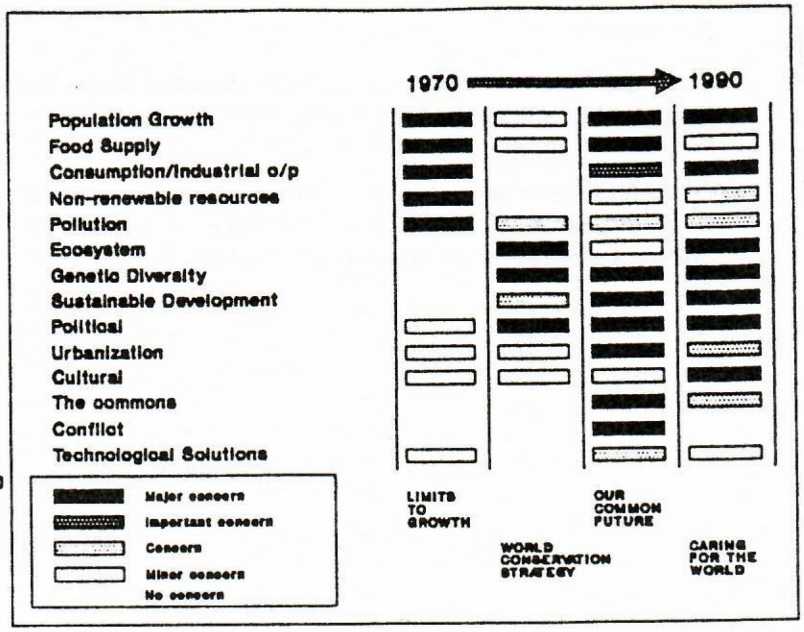

Figure 10 - Shifts in Environmental Focus

offering a solution, *World Conservation Strategy* introduced the idea of sustainable development. However, despite showing that the problems were real and urgent, it made no attempt to quantify the relative urgency.

By 1983, the United Nations had recognized the criticality of environmental issues and called for "a global agenda for change"[21] A commission, chaired by Gro Harlem Brundtland, was established and in 1987 published *Our Common Future*. It was a wide-ranging view of global problems that, in tying growth and sustainability together, popularized the concept of sustainable development. Although based on the premise that growth was essential if brute poverty in the underdeveloped world were to be overcome, it avoided the question of how much growth was possible.

Caring for the World is the successor to *World Conservation Strategy*. Its principle aim is to provide a strategy for sustainability. It builds on the preceding three works and focuses on three main obstacles that have undermined sustainability over the last decade: the lack of an ethical commitment to the concept, the inequitable

[18] International Union for Conservation of Nature, *World Conservation Strategy: Living Resource Conservation for Sustainable Development*. 1979.

[19] World Commission on Environment and Development, *Our Common Future*. Oxford: Oxford University Press, 1987

[20] World Conservation Union, United Nations Environment Program and World Wide Fund for Nature, *Caring for the World: A Strategy for Sustainability* (Second Draft). June 1990.

[21] World Commission on Environment and Development, *Our Common Future*. Oxford: Oxford University Press, 1987. p. ix.

distribution of power, resources and information, and "the notion that conservation and development can be managed separately"[22]. Like its predecessors, it relies on illustrative data and anecdotal evidence.

Conclusion

Over the past two decades, the environmental focus has shifted from concerns about finite limits of growth to the problems of implementing sustainable development. But we appear to be no closer to defining how much growth can be absorbed, how much development is sustainable. As recently noted by Alexander King, President of the Club of Rome, "it appears that many of the warnings of *The Limits to Growth* are as valid as ever"[23]. If we are to truly achieve sustainable development, policies must be based on hard data which defines how much growth is possible without foreclosing on future generations.

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[22]World Conservation Union, United Nations Environment Program and World Wide Fund for Nature, *Caring for the World: A Strategy for Sustainability* (Second Draft). June 1990, p. 4.

[23]Eduard Pestel, *Beyond the Limits of Growth*. New York: Universe Books, 1989. p. 9.